

**BULLETIN NO. 16**

**FIELD IDENTIFICATION OF MINERALS  
FOR OREGON PROSPECTORS AND COLLECTORS**

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### Foreword

Numerous textbooks on descriptive and determinative mineralogy have been published - all to a great extent following along the lines of the pioneer work of Dana. Such books for the most part have been written for students or technically trained people and are not easily available to or understood by the average prospector or layman. With these thoughts in mind, the State Department of Geology and Mineral Industries has prepared Bulletin 16 for the use of Oregon prospectors and collectors. It is designed to be an elementary reference book containing, as far as possible, the essentials of field identification of minerals by simple physical means only; the less easily understood chemical and blowpipe tests are not given. It is realized that physical tests as outlined will not in many cases give a final determination, but such simple tests should assist the prospector to familiarize himself with the more common minerals.

In giving an outline for each of the minerals described, and in presenting again some of the same information in tabular form, some repetition occurs, but it is believed to be in the interest of clearness.

All members of the staff of the Portland office assisted in the compilation; particular mention should be made of the work of Wayne R. Lowell and John Eliot Allen.

F. W. Libbey,  
Acting Director

Portland, Oregon  
July 1940

### Foreword to Second Edition

The first edition of this bulletin was exhausted within a few months after publication. Some requests came in from schools in various parts of the country where the bulletin was desired for instruction in the elementary classes in mineralogy or geology. On this account principally the Department decided to reissue only after going over the manuscript rather carefully for elimination of technical errors as far as possible. Dr. Lloyd W. Staples of the Department of Geology and Geography at the University of Oregon was kind enough to check the manuscript and make minor corrections and additions in numerous places. We are pleased to acknowledge Dr. Staples' painstaking work. In some cases we have foreborne from carrying descriptions or definitions to hairbreadth technical accuracy in order to maintain the simplicity of treatment desired in this type of bulletin.

Earl K. Nixon,  
Director

Portland, Oregon  
May 1941

### Foreword to Fourth Printing

The first two editions of "Field Identification of Minerals," issued in 1940 and 1941 respectively, were exhausted in 1947 and a third edition was then issued. That edition is now out of print, so that this, the fourth printing, is required in order to meet a continuing demand.

F. W. Libbey,  
Director

Portland, Oregon  
August 1949

INTRODUCTION

## PURPOSE

Need for a bulletin of this type is shown by the numerous inquiries that are received requesting information on the identification of rocks and minerals. These inquiries indicate that such information should include:

1. Mineral identification information written especially for Oregon prospectors and collectors.
2. Minerals described should be common in Oregon, or if not common, should be of economic importance.
3. Tests for minerals that involve the use of materials at hand; blowpipe, chemical, and microscopical tests should be omitted because the necessary equipment is seldom with the man in the field.
4. A low publication price to permit wide distribution.

This bulletin is compiled from various texts on mineralogy and from the experiences of the Department's staff. The terminology is as non-technical as possible, and where technical terms are used, they are explained in the text or glossary. Only simple mechanical aids to identification (field equipment) are suggested, to avoid the necessity of chemical and blowpipe tests. Those who wish more detailed descriptions and technical discussions may find such information in various books on mineralogy (see selected bibliography). The United States Geological Survey and the United States Bureau of Mines have many publications dealing with specific minerals and containing pertinent suggestions concerning the economics of mining and marketing.

This bulletin is one of a series designed to provide authentic information about the mineral resources of the State of Oregon, to indicate what to seek, to give instruction on the identification of minerals and how to develop and finance a mineral deposit, as well as to outline the economics of marketing the product.

## THE PROSPECTOR AND THE COLLECTOR

Several groups may find this bulletin or another of this series of value. The prospector desires to identify minerals that have a possible commercial value. The collector also wants this information and, in addition, data on how to make a collection of minerals for his own enjoyment and financial benefit. The recreationist wishes general information that will permit him to enjoy his surroundings just as he wishes to know the names of flowers and trees, but has no desire to start a herbarium, or a mineral collection.



## ASSAY AND MINERAL IDENTIFICATION SERVICE

One purpose of the Oregon State Department of Geology and Mineral Industries is to help residents become more familiar with the rocks and minerals occurring in the state by identifying samples submitted to the Department. A short summary of the services relating to the analysis of ores and minerals is given here.

Assays

The Department will make two free assays of ore or mineral samples for the common metals in any thirty day period for any citizen or group of citizens of the state provided the samples are collected within the state. Each sample must be accompanied by a properly filled-in information blank (fig.2).

The material or sample to be assayed should be representative, that is, a channel sample. A channel sample consists of the material taken from a channel of uniform width and depth across a vein or formation containing the ore or mineral.

Samples for assay should be sent to the nearest State Assay Laboratory. These are located at Grants Pass and Baker.

Mineral Identification

Free mineral identification service is provided citizens of the state at the Baker and Grants Pass laboratories and also at the Portland office. Specimens sent in will be classified, and the enclosed minerals will be identified and described, if possible, and the commercial importance and uses of the material represented will be indicated.

An information blank (fig.2) or letter should accompany each specimen, giving location (the place of collection), an estimate of the amount of material present, and such other specific information about the specimen as the sender can supply.

Qualitative Tests

The Department will be pleased to make qualitative tests for the common metals like lead, zinc, copper, chrome, manganese, etc., and encourages prospectors and collectors to have these tests made. Tests for gold and platinum require regular fire assays. Because of the time and expense involved, the Department does not ordinarily make fire assays unless the samples are properly taken or cut from a ledge.

The Department does not have the facilities to test for the rare metals, such as beryllium and gallium. Few assay laboratories do have these facilities. Such samples should be sent to some laboratory which has adequate spectroscopic equipment.

Sample information blanks are provided by the Department for your convenience. The "Law Relating to Free Analysis of Ores, Minerals, etc.", is listed on the back of figure 2.

At all three of the Department's offices (Portland, Baker and Grants Pass) mineral collections are maintained for study purposes. These collections are open to the public during office hours.

#### MINERALS DEFINED

A mineral is defined as a "natural inorganic substance and, when pure, has a definite chemical composition, usually a definite crystal form and specific physical properties, such as cleavage, fracture, color, hardness, luster, and specific gravity". This bulletin is concerned chiefly with the physical properties.

Examination of minerals shows that they usually crystallize in definite geometrical forms when conditions permitted. For example, quartz forms crystals in cavities.

Unfortunately, from the standpoint of simplicity, minerals are not always pure, and their chemical composition and crystal form may vary within certain narrow limits. Their variations usually are easily detected by use of tests for physical properties and will not be discussed herein.

Although tests for chemical composition are not described in this bulletin, the chemical composition is given for the reader's information. This composition is usually written as a series of symbols - a sort of chemical shorthand. For example, the formula of calcite,  $\text{CaCO}_3$ , indicates that one atom of calcium, one atom of carbon, and three atoms of oxygen are used to form the  $\text{CaCO}_3$  molecule. The list of "Radicals" given in the table includes a few groupings of elements and it will be noted that  $\text{CO}_3$  is carbonate. So the mineral is calcium carbonate. The following table may serve as an aid in interpreting this shorthand. (See Figure 1, following page).

#### ACKNOWLEDGEMENTS

Data contained in this bulletin have been taken from the standard texts on mineralogy, and supplemented with facts and ideas supplied by the staff of the State Department of Geology and Mineral Industries. Especial acknowledgement is made to Earl K. Nixon, Leslie M. Motz, F. W. Libbey, and A. M. Swartley, for their careful criticism of the manuscript and many helpful suggestions, and particularly to H. B. Wood and Wayne R. Lowell for carefully checking the tables and mineral descriptions.

Dr. Lloyd W. Staples, of the University of Oregon, has carefully corrected and amended this revised second edition.

Figure 1.

## ELEMENTS AND THEIR SYMBOLS

Actinium . . . . .	Ac	Indium . . . . .	In	Samarium . . . . .	Sm
Aluminum . . . . .	Al	Iodine . . . . .	I	Scandium . . . . .	Sc
Antimony (stibium) . . . . .	Sb	Iridium . . . . .	Ir	Selenium . . . . .	Se
Argon . . . . .	A	Iron (ferrum) . . . . .	Fe	Silicon . . . . .	Si
Arsenic . . . . .	As	Krypton . . . . .	Kr	Silver (argentum) . . . . .	Ag
Barium . . . . .	Ba	Lanthanum . . . . .	La	Sodium (natrium) . . . . .	Na
Beryllium (glucinum) . . . . .	Be	Lead (plumbum) . . . . .	Pb	Strontium . . . . .	Sr
Bismuth . . . . .	Bi	Lithium . . . . .	Li	Sulfur . . . . .	S
Boron . . . . .	B	Lutecium . . . . .	Lu	Tantalum . . . . .	Ta
Bromine . . . . .	Br	Magnesium . . . . .	Mg	Tellurium . . . . .	Te
Cadmium . . . . .	Cd	Manganese . . . . .	Mn	Terbium . . . . .	Tb
Calcium . . . . .	Ca	Masurium . . . . .	Ma	Thallium . . . . .	Tl
Caesium . . . . .	Cs	Mercury (hydrargyrum) . . . . .	Hg	Thorium . . . . .	Th
Carbon . . . . .	C	Molybdenum . . . . .	Mo	Thulium . . . . .	Tm
Cerium . . . . .	Ce	Neodymium . . . . .	Nd	Tin (stannum) . . . . .	Sn
Chlorine . . . . .	Cl	Neon . . . . .	Ne	Titanium . . . . .	Ti
Chromium . . . . .	Cr	Nickel . . . . .	Ni	Tungsten (wolframium) . . . . .	W
Cobalt . . . . .	Co	Nitrogen . . . . .	N	Uranium . . . . .	U
Columbium (niobium) . . . . .	Cb	Osmium . . . . .	Os	Vanadium . . . . .	V
Copper . . . . .	Cu	Oxygen . . . . .	O	Xenon . . . . .	Xe
Dysprosium . . . . .	Dy	Palladium . . . . .	Pd	Ytterbium . . . . .	Yb
Erbium . . . . .	Er	Phosphorus . . . . .	P	Yttrium . . . . .	Y
Europium . . . . .	Eu	Platinum . . . . .	Pt	Zinc . . . . .	Zn
Fluorine . . . . .	F	Polonium . . . . .	Po	Zirconium . . . . .	Zr
Gadolinium . . . . .	Gd	Potassium (kalium) . . . . .	K		
Gallium . . . . .	Ga	Praseodymium . . . . .	Pr		
Germanium . . . . .	Ge	Protoactinium . . . . .	Pa		
Gold (aurum) . . . . .	Au	Radium . . . . .	Ra		
Hafnium (celtium) . . . . .	Hf	Radon (niton) . . . . .	Rn		
Helium . . . . .	He	Rhenium . . . . .	Re		
Holmium . . . . .	Ho	Rhodium . . . . .	Rh		
Hydrogen . . . . .	H	Rubidium . . . . .	Rb		
Illinium . . . . .	Il	Ruthenium . . . . .	Ru		

<u>Common Radicals</u>	
Ammonium . . . . .	(NH <sub>4</sub> )
Carbonate . . . . .	(CO <sub>3</sub> )
Phosphate . . . . .	(PO <sub>4</sub> )
Hydroxyl . . . . .	(OH)
Sulphate . . . . .	(SO <sub>4</sub> )

## ROCKS DEFINED

A rock is an aggregate of minerals, so it is necessary to be able to identify minerals before much can be done with rock determination. One definition of a rock states that it is "any naturally-formed mass of mineral matter, whether or not coherent, constituting an essential and appreciable part of the earth's crust." Thus, quartz is a mineral, but should it form a large and appreciable mass it may be a rock. For example, sandstone is an aggregate of quartz grains cemented together by some kind of natural cement such as silica, lime carbonate, iron oxide, etc. A complete description of various rock types is given in the bulletin on prospecting.

STATE DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

2033 First Street  
Baker, Oregon

1069 State Office Building  
Portland 1, Oregon

239 S.E. "H" Street  
Grants Pass, Oregon

REQUEST FOR SAMPLE INFORMATION

The State law governing analysis of samples by the State assay laboratory is given on the back of this blank. Please supply the information requested herein fully and submit this blank filled out along with the sample.

Your name in full \_\_\_\_\_

Street or P.O. Box \_\_\_\_\_ City & State \_\_\_\_\_

Are you a citizen of Oregon? \_\_\_\_\_ Date on which sample is sent \_\_\_\_\_

Name (or names) of owners of the property \_\_\_\_\_

Are you hiring labor? \_\_\_\_\_ Are you milling or shipping ore? \_\_\_\_\_

Name of claim sample obtained from \_\_\_\_\_

Location of property or source of sample (If legal description is not known, give location with reference to known geographical point.)

County \_\_\_\_\_ Mining District \_\_\_\_\_

Township \_\_\_\_\_ Range \_\_\_\_\_ Section \_\_\_\_\_ Quarter section \_\_\_\_\_

How far from passable road? \_\_\_\_\_ Name of road \_\_\_\_\_

	<u>Channel (length)</u>	<u>Grab</u>	<u>Assay for</u>	<u>Description</u>
Sample no. 1	_____	_____	_____	_____
Sample no. 2	_____	_____	_____	_____

(Samples for assay should be at least 1 pound in weight)

(Signed) \_\_\_\_\_

DO NOT WRITE BELOW THIS LINE - FOR OFFICE USE ONLY - USE OTHER SIDE IF DESIRED

Sample Description \_\_\_\_\_

Sample number	GOLD		SILVER					
	oz./T.	Value	oz./T.	Value				

Report issued \_\_\_\_\_ Card filed \_\_\_\_\_ Report mailed \_\_\_\_\_ Called for \_\_\_\_\_

LAW RELATING TO FREE ANALYSIS OF ORES, MINERALS, ETC.  
CHAPTER 179, Section 10, Oregon Laws 1937.

The department shall make, or cause to be made, quantitative determinations of ores and minerals when submitted for the purpose, that are from original prospects or properties within the state of Oregon, and shall mail to the sender the results obtained within 10 working days after receipt of samples; said service shall be performed by the department without charge to the sender and shall be rendered in exchange for information for the records of the department, stating the name and residence of the sender together with a history of the ore or mineral, giving as nearly as possible the location from which the sample was taken, including the name of the county, and any other matters that may be beneficial touching the same. All determinations shall be performed under the following rules and regulations and subject to the following restrictions:

(a) No sample submitted by engineers sampling prospects or mines for the purpose of evaluation, or submitted by operating mines milling or shipping ore, or hiring labor, shall be accepted by the department for assay and/or analysis, except they be taken in the field by members of the department's staff in conducting the work of the department within the scope of this act.

(b) The number of samples which any single person or group of persons may submit shall be limited to two in any 30-day period and all samples shall be assayed or analyzed by the department in the order received, as far as possible.

(c) All information received and results of determination sent out shall be open to public inspection and may be published by the department.

(d) Before any work is done on the material submitted, all information required must be possessed by the department and the 10-day limit for reports will count from the time such data are received by the department.

### EQUIPMENT

Advice on equipment is given as an answer to the many requests for such information. Cost is always important and it should be remembered that with careful buying one usually gets just about what he pays for. A good workman should have good tools. Cheap tools may suffice for a time but usually prove to be more expensive. Individual preference and need vary, and for this reason many beginners use less expensive equipment until they can decide from experience what they prefer. Used equipment frequently can be acquired, but the purchaser should know his materials and be certain of getting what is represented.

### FIRST AID KITS

A good first aid kit to be used in the field should be included with every outfit. Any physician or reliable druggist can give excellent advice on the purchase of such a kit. The contents should be checked at frequent intervals to make sure that the materials are in good condition. A first aid manual also is important; the "Manual of First-Aid Instruction" issued by the U. S. Bureau of Mines, obtainable from the Superintendent of Documents, Washington, D.C., for 20¢, is recommended.

A snake-bite kit, either of the hypodermic type which is expensive, or the "suction pump" type which is less expensive, is important and very effective. A person bitten by a poisonous snake should remain as quiet as possible. Stimulants should be avoided as they tend to accelerate the distribution of the poison thru the system. For this reason a physician's advice should be received before alcoholics are administered.

Spotted fever from tick bites is a danger anywhere east of the Cascade Mountains. Antitoxic serum shots may be obtained from a physician or from a Public Health Service and should be taken a month before going into the field. It is effective only for one year. Early spring is the time when tick poison is particularly dangerous. In event the serum is not available, careful examination of the entire body should be made at least twice daily and any ticks removed with tweezers. Ticks take 2 to 4 hours to settle down to serious biting.

Before going into the field one should have his general physical condition checked by a physician to determine whether he is susceptible to any particular diseases or ailments. Such action may save others from being inconvenienced, or actually endangered, by one's inability to withstand the rigors of trips.

Training by a competent instructor in methods of administering first aid is valuable.

### HAND LENS

A hand lens, or pocket magnifier, is one of the collector's and prospector's best friends. The magnifying power should be about 10, and the lens surface should be protected with <sup>some</sup> sort of case.

The type of hand lens should be adapted to the individual user. The most popular type is the "doublet" or "triplet" lens, as it has a very short focus, requiring the lens close to the object and the eye close to the lens.

#### Single Lens Magnifying Glass

The single lens magnifying glass (fig.7) is the inexpensive "reading glass" type, but its magnification is seldom over four diameters (dimensions increased four times). It is not recommended for mineral identification.

#### Magnifiers in Vulcanite Cases

These magnifiers (fig.5) consist of single magnifying lenses mounted in hard black rubber cases, and magnify about four diameters. Other models have two and even three of these lenses fastened together in such a manner that they can be used singly or together, giving magnifications of four to twenty diameters (fig.5). The cost varies from \$1 to \$2.

#### Coddington Magnifier

The Coddington lens (fig.3) is a cylinder of glass, the ends of which are spherically-ground so that the unit behaves as a lens. The cylinder is enclosed in a metal or vulcanite case. The lens is quite efficient, but the "field" (area visible) is small. A lens of 10 diameters magnification should cost about \$3.50-\$4.00.

#### Doublet Magnifier

The general appearance of the doublet magnifier is similar to that of the Coddington lens (fig.4). However, the optical glass consists of two simple lenses mounted in a case. The field is much flatter than the field of the Coddington lens, that is, the visible area in focus is larger, and the magnification may range from 6 to 20 diameters. Doublet magnifiers sell for about \$3.00-\$3.50.

#### Triplet Magnifier

The triplet magnifier is much like the doublet except that it has three lenses instead of two, and more care is used in its manufacture. Much distortion is eliminated and the field is quite flat. Magnification is similar to that of the doublet type. The cost ranges from \$4.00 to \$7.50.

#### Coat Pocket Microscope Magnifier

The coat pocket microscope magnifier (fig.8) is really a small microscope that may be held in the hand. There is a small mirror at the lower end to reflect light into the tube and give a brighter image. Magnifications of 40, 50 and 60 diameters are common, but at these higher magnifications any unsteadiness of the hand or body produces vibrations that make vision difficult. The cost is about \$5.00.

## HAMMER

If the hand lens is the prospector's and collector's best friend, a hammer is his "rod and staff". A common type is the prospector's pick (fig.6) having a hammer and a sharp pointed pick on opposite ends of the head. Certain models have a steel shank that is continuous with the head and extends through the entire length of the handle.

Prospector's picks may be obtained at any first-class hardware store at a cost varying from \$1.50 to \$3.50.

## KNIFE

A husky knife, fairly large to withstand severe use, is an important accessory. The blades should be made of good steel and kept well sharpened. One blade should be magnetized to serve as an emergency magnet. A leather-reamer or punch blade will be found useful for testing the relative hardness of minerals. Knives of the "Boy Scout" type are very handy; the extra "gadgets" will more than repay the gibes leveled at such an instrument.

## MAGNET

A magnet is necessary to test the magnetic attraction of certain minerals, and to remove black sand (magnetite) from gold pannings. The horseshoe type is most satisfactory. A new magnet, made by the Crucible Steel Company, has more magnetism and therefore more power than the ordinary kind. It costs about 50¢.

## GOLD PAN

A gold pan, with its flat bottom and widely flaring sides, is valuable for concentrating the heavier minerals (fig.9). Some pans are made of polished sheet steel, some of aluminum, and others are of sheet steel with copper bottoms for amalgamating gold. The standard-sized plain iron gold pan 16 inches in diameter is recommended. It sells for about \$1.10. A smaller size, 12 inches in diameter, is convenient, especially when weight is an item. Prices vary from 60¢ to \$1.00 for the iron pans.

## STREAK PLATE

A streak plate is a piece of unglazed porcelain, usually about 2" x 3" x  $\frac{1}{4}$ " thick, used to detect the color of mineral powders. It costs about 15¢ and unless broken will last a number of years. The rough side of interior-trim tiles, or the broken edges of pottery and stoneware, serve the purpose of a streak plate.



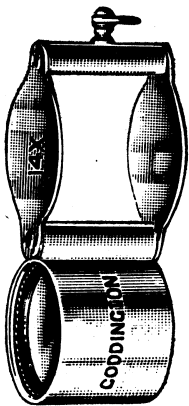


Figure 3 Coddington Lens



Cross section

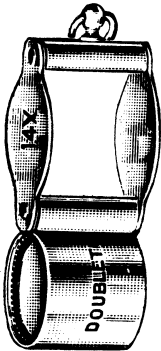


Figure 4 Doublet Lens

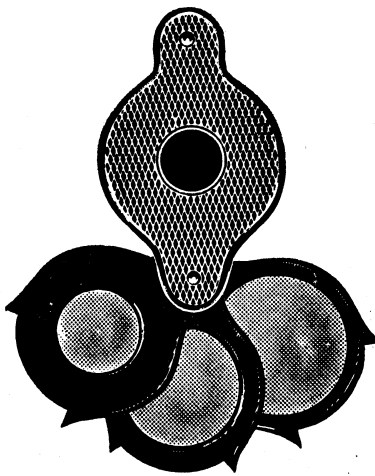


Figure 5 Vulcanite Magnifier

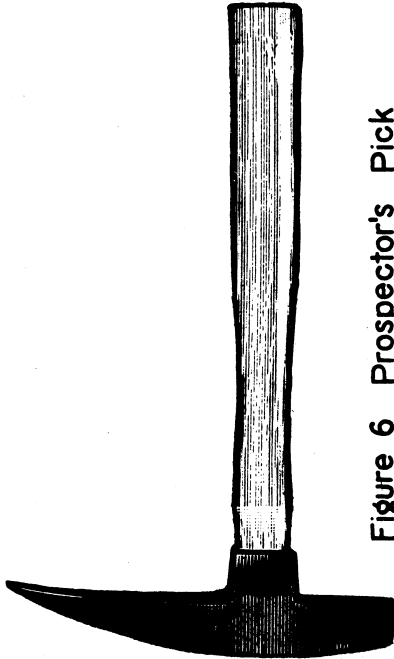


Figure 6 Prospector's Pick

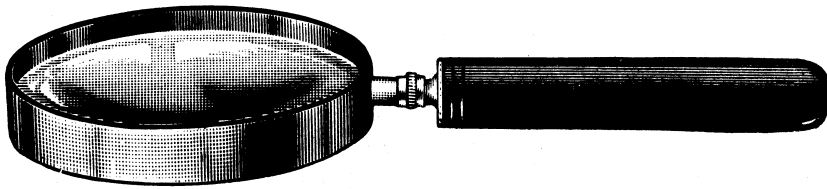


Figure 7 Reading Glass



Figure 8 Coat Pocket Magnifier

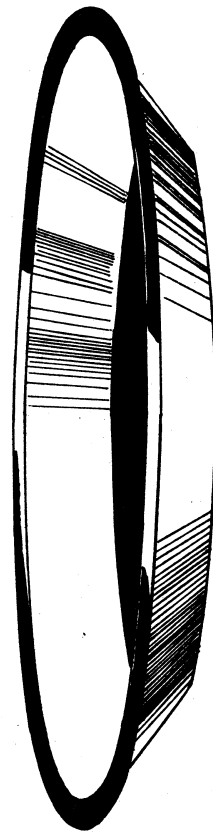


Figure 9 Gold Pan

### ACID BOTTLE

An acid bottle is a glass bottle having a ground-glass stopper, and preferably having a capacity of about two ounces. Hydrochloric muriatic acid diluted in the proportion of two parts of acid to three parts of water is customarily used although sulfuric acid, diluted 1 to 4, may be used. In an emergency, strong vinegar may serve the purpose of a weak acid. Nitric acid, diluted with one part acid to one part water, is used for cleaning gold dust and separating gold from amalgam.

### MAPS

Good maps are essential to the prospector. Those commonly available are described below.

#### Forest Maps

Maps of the National Forests are issued in two scales, 1/4 inch to the mile, and 1/2 inch to the mile. They show roads, trails, streams, cultural features, and are known as planometric maps. They may be obtained, free of charge, from the Forest Supervisor of the particular National Forest, or from the office of the Regional Forester, U. S. Forest Service, Portland, Oregon. Figure 10 shows areas covered by these maps.

#### Topographic Maps

The United States Geological Survey has undertaken to map the entire United States and show topography by means of contour lines. About half of Oregon is covered in this manner. These maps are printed as quadrangles. The scales are 1/2 inch to the mile, covering an area 24 miles by 36 miles, and 1 inch to the mile, covering an area 12 miles by 18 miles. These maps are quite accurate. They may be obtained from stationery stores or by writing the U. S. Geological Survey in Washington, D.C., and forwarding 10¢ for each map desired. Figure 11 shows the quadrangles in Oregon which were available in July 1939.

#### County Maps

County maps and township ownership maps, costing about \$1.00 each, have been prepared by Metzger Map Company, Swender Blue-print Company, Hansen Blue-print Company, and others, of Portland. County engineers of many counties have prepared county road maps, copies of which they sometimes sell. The cost will average about \$1.00 each.

#### Oil Company Road Maps

Road maps issued free by the various large oil companies are useful, particularly in showing the main roads and the mileages between towns, but are too small-scaled for detailed use.

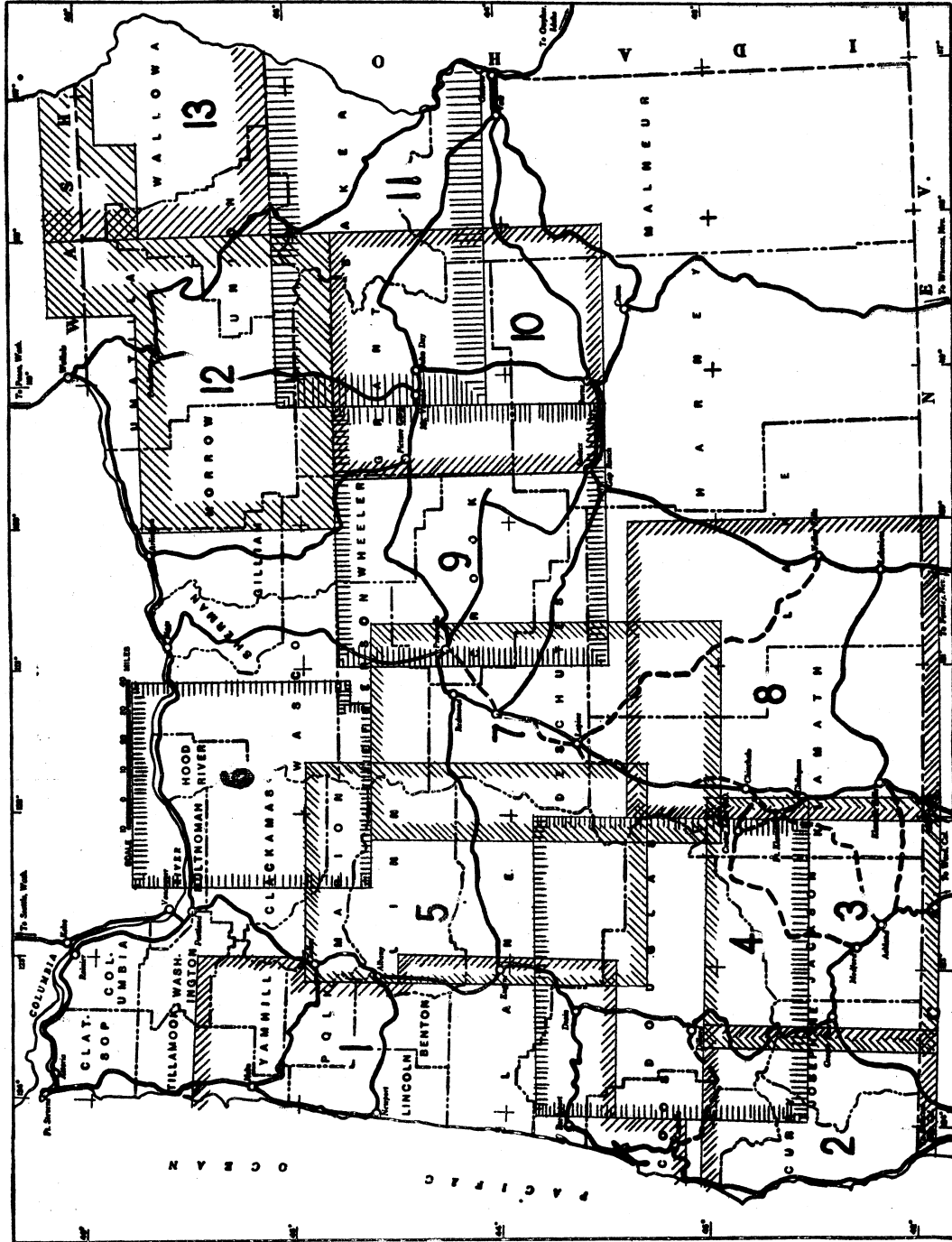


Figure 10. Index Map Oregon U. S. Forest Service Maps

# TOPOGRAPHIC MAPS OF OREGON 1958

## 15-Minute Quadrangles (Scale 1:62,000)

Name	Location	Date	Name	Location	Date
Abbott Butte	N-8	1947	Goodwin Peak	J-3	1956
Agness	O-2	1956	Grand Ronde	E-4	1955
Albany	G-6	1944 A	Grants Pass	P-5	1954
Aldrich Mountain	H-21	1943	Gross Valley	D-15	B
Alesea	H-4	C1942 A	Halfway	F-30	A
Anlauf	K-4	1939	Halsey	H-6	1941 A
Ashland	Q-8	1954	Hardesty Mountain	J-8	1955
Astoria	A-3	C1939	Hart Butte	D-31	1954
Bandon	M-1	1944	Harney 2	J-23	B
Bates	G-24	1951	Hebo	E-3	1955
Battle Ax	F-10	1956	Heceta Head	I-2	1956
Birkenfeld	B-5	1955	He Devil	D-32	1922 A
Blaichly	I-4	C1942 A	High Rock	E-11	1956
Blaine	D-4	1955	Hillsboro	C-7	1943 B
Blue River	I-9	1955	Homestead	E-31	A
Bonanza 1	P-14	B	Hood River	C-12	A
Bonanza 2	P-13	B	Hood River 3	C-11	B
Bonanza 3	Q-13	B	Huntington	H-29	1951
Bonanza 4	Q-14	B	Hyatt Reservoir	Q-9	1955
Bone Mountain	N-3	1954	Illehee Rock	L-8	1955
Boring	D-9	1944	Imnaha	C-31	1954
Bridal Veil	C-10	1954	Ivers Peak	L-3	1955
Brownsville	H-7	1952	Izee 3	I-21	B
Burns 1	J-22	B	Izee 4	I-22	B
Burns 2	J-21	B	Jamieson	I-29	1950
Butte Falls	O-8	1954	John Day	H-23	1943
Cactus Mountain	B-32	B	Joseph	D-30	A
Calimus Butte	O-12	A	Kalama	A-7	C1943
Camas	C-9	1941 A	Kernan Point	C-32	1954
Camas Valley	M-4	1955	Kimberley	F-20	1953
Cannon Beach	B-3	1955	Klamath Falls 2	P-11	B
Canyon City 1	H-24	B	Klamath Falls 3	Q-11	B
Canyon City 3	I-23	B	Klamath Falls 4	Q-12	B
Canyon City 4	I-24	B	Klamath Marsh	N-12	A
Canyonville	N-5	1956	Lakecreek	P-8	1954
Cape Blanco	N-0	1956	Lake O' Woods	P-10	1955
Cape Ferrela	Q-1	1956	Langlois	N-1	1954
Cape Foulweather	F-2	1944 A	Leaburg	I-8	1951
Cascadia	H-9	A	Lebanon	G-7	C1944 B
Cathlamet	A-5	1941	Long Creek	G-22	1951
Cave Junction	Q-4	1954	Lookout Mountain	H-17	1951
Cherryville	D-10	1955	Lowell	J-7	1955
Checco Peak	Q-3	1954	Lucile	C-33	B
Chiloquin	O-11	A	Lyns	F-8	1951
Chucksney Mountain	J-10	1955	Mace Mountain	L-7	1955
Clatskanie	A-6	1952	Madras 1	F-14	B
Collier Butte	P-2	1954	Madras 2	F-13	B
Colton	E-9	1955	Madras 3	G-13	B
Coos Bay	L-2	1945	Madras 4	G-14	B
Copperfield	F-31	B	Mapleton	I-3	1945 A
Coguille	M-2	1945	Marcola	I-7	1952
Cornucopia	E-30	A	Marial	O-3	1954
Corvallis	G-5	C1942 A	Marys Peak	G-4	1942 A
Cottage Grove	J-6	1921 A	McKenzie Bridge	I-10	A
Courtoeck	G-21	1956	McMinnville	E-6	1943
Crow	J-5	1945	Medford	P-7	1954
Culp Creek	K-7	1955	Mill City	F-9	1955
Cuprum	E-32	B	Mineral	G-30	A
Dale	F-23	1951	Molalla	E-8	C1943
Dallas	F-5	C1942 A	Monroe	H-5	C1942 A
Days Creek	N-6	1954	Monument	F-21	1951
Dead Horse Butte	B-31	B	Moores Hollow	I-30	1951
Desolation Butte	F-24	1951	Mount Angel	E-7	1943
Detroit	G-10	1956	Mount Emily	Q-2	1954
Diamond Lake	M-10	1956	Mount Hood 1	D-12	B
Dixonville	M-6	1954	Mount Hood 2	D-11	B
Drain	K-5	1954	Mount Jefferson 1	F-12	B
Dufur 1	D-14	B	Mount Jefferson 2	F-11	B
Dufur 2	D-13	B	Mount Jefferson 3	G-11	B
Dufur 3	E-13	B	Mount Jefferson 4	G-12	B
Dufur 4	E-14	B	Mount McLaughlin	P-9	1955
Durkee	G-29	A	Mount Vernon	H-22	1943
Dutchman Butte	N-4	1948	Mount Wilson	E-12	1956
Eagle Cap	E-29	1954	Nahalem	C-3	1955
Eagle Rock	I-16	1948	Oakridge	K-9	1956
Echo Mountain	H-10	A	Ochoco Reservoir	H-16	1950
Elk Mountain	C-30	A	Olds Ferry	H-30	1952
Elkton	K-4	1955	Oregon Caves	Q-5	1954
Elmira	I-5	C1942 A	Oregon City	D-8	1945 A
Empire	L-1	1944	Pearsall Peak	P-3	1954
Enright	C-4	1955	Pelican Butte	O-10	1955
Enterprise	D-29	A	Picture Gorge	G-20	1955
Euche Mountain	F-3	1957	Portland	C-8	A
Eugene	I-6	1949	Port Orford	O-1	1954
Fairdale	D-5	1955	Post	I-17	1951
Fairview Peak	K-8	1955	Powers	N-2	1954
Fish Creek Mountain	E-10	1956	Prospect	N-9	1956
Flora 1	B-30	B	Prospect 1	N-10	B
Forest Grove	C-6	A	Quartz Mountain	M-8	1955
Fort Klamath 2	N-11	A	Quartzville	G-9	1956
Galice	O-4	1948	Red Butte	M-7	1955
Garwood Butte	M-9	1956	Reedsport	K-2	1956
Glendale	O-5	1954	Richmond	G-19	1953
Glide	L-6	1954	Riley 1	J-20	B
Gold Beach	P-1	1954	Ritter	F-22	1952
Gold Hill	P-6	A	Roman Nose Mount.	J-4	1945

## 7½-Minute Quadrangles (Scale 1:24,000)

Name	Location	Date	Name	Location	Date
Roseburg	M-5	1955	Amity	49	A
Ruch	Q-6	1954	Astoria	3	C1949
Rusiler Peak	O-9	1955	Ballston	48	1956
Saddle Mountain	B-4	1955	Beaverton	27	1954
Salem	F-6	1940 A	Camas	22	1954
Sardine Butte	J-9	A	Canby	36	1954
Scottsburg	K-3	1955	Carlton	32	1957
Selma	P-4	1954	Cathlamet Bay	4	C1949
Sheridan	E-5	C1942 A	Clatsop Spit	1	1951
Sillico Lake	J-2	1942 A	Colton	46	1955
Sitkum	M-3	1955	Corbett	23	A
Sled Springs	C-29	A	Damascus	30	1954
Snow Peak	G-8	1951	Dayton	41	A
Sparta	F-29	A	Deer Island	12	1954
Spray	F-19	1953	Dixie Mountain	14	1956
Stayton	F-7	C1944 A	Dundee	33	1956
St. Helens	B-7	1954	Estacada	39	1954
Summit Lake	L-10	1956	Forest Grove	17	1956
Surveyor Mountain	Q-10	1955	Gaston	24	1956
Susanville	G-23	1951	Gearhart	5	C1949
Sutherlin	L-5	1954	Gervais	51	A
Svensen	A-4	1955	Gladstone	29	1954
Sweet Lake	P-12	A	Green Mountain	7	C1949
Sweet Home	H-8	1951	Hillsboro	18	1954
Sycan Marsh 1	N-14	B	Kalama	11	1953
Sycan Marsh 2	N-13	B	Kelso	9	1953
Sycan Marsh 3	O-13	B	Laurelwood	25	1956
Sycan Marsh 4	O-14	B	Linnton	19	1954
Talent	Q-7	1954	Malheur Butte	60	1951
The Dalles	C-14	A	McMinnville	40	A
Three Sisters 1	H-12	B	Mission Bottom	50	1957
Three Sisters 2	H-11	B	Molalla	45	1954
Three Sisters 3	I-11	B	Moores Hollow	58	1951
Three Sisters 4	I-12	B	Mr. Tabor	21	1954
Tidewater	H-3	1945	Newberg	34	1954
Tillamook	D-3	1955	Olds Ferry	56	1952
Tiller	N-7	1946	Olds Ferry NW	55	1952
Timber	C-5	1955	Olds Ferry SE	57	1952
Toketee Falls	L-9	1956	Olney	6	C1949
Toledo	G-3	1946 A	Oregon City	37	1954
Trail	O-7	1945	Oswego	28	1954
Tualatin	D-7	1943	Payette	61	1951
Tyee	L-4	1955	Portland	20	1954
Valseltz	F-6	C1942 A	Rainier	10	1953
Vernonia	B-6	1955	Redland	38	1954
Vistillas 2	P-15	B	Sandy	31	1954
Vistillas 3	Q-15	B	Sauvie Island	15	1954
Waldo Lake	K-10	A	Scholls	26	1954
Waldport	H-2	C1942 A	Scotts Mills	53	1954
Wasco	C-16	A	Sheridan	47	1956
White Salmon	C-13	A	Sherwood	35	1954
Wimer	O-6	1954	Silverton	52	1956
Wishram	C-15	A	St. Helens	13	1954
Yamhill	D-6	C1942	St. Paul	42	1956
Yaquina	G-2	1946 A	Tillamook Head	8	C1949
			Vancouver	16	1954
			Warrenton	2	C1953
			Weiser South	59	1951
			Wilhoit	54	1955
			Woodburn	43	A
			Yoder	44	1955

### Special Map

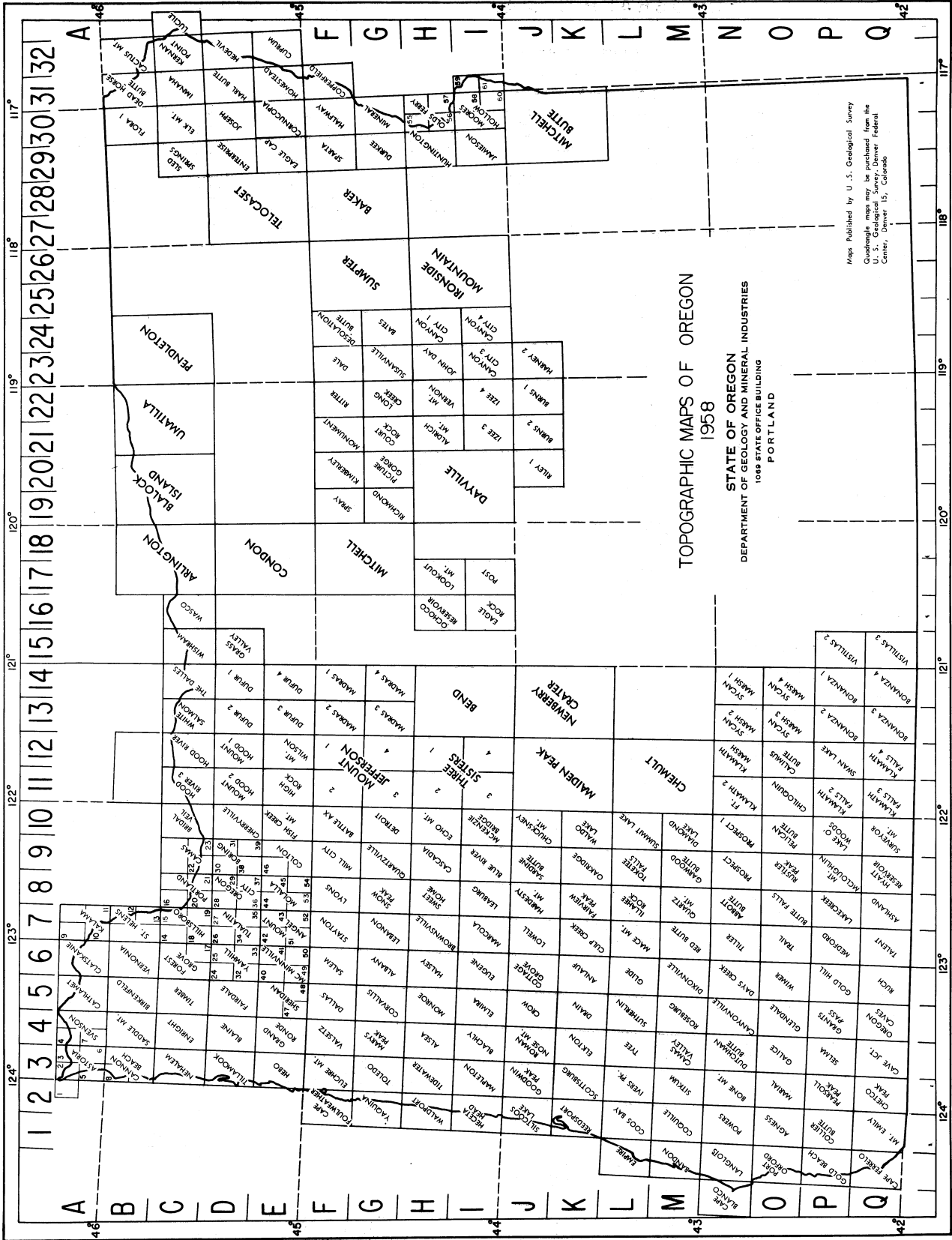
Crater Lake	N-10
National Park	1:62,000

### 30-Minute Quadrangles (Scale 1:125,000)

Name	Location	Date
Arlington	C-18	1941
Baker	G-28	1934
Bend	I-14	1940
Blalock Island	C-20	1944
Chemult	M-12	1941
Condon	E-18	1916
Dayville	I-20	1936
Dufur	E-14	1945
Hood River	C-12	1940
Innside Mountain	I-26	1908
Madras	G-14	1931
Maiden Peak	K-12	1944
Mitchell	G-18	1926
Mitchell Butte	K-30	1921
Mount Hood	E-12	1944
Mount Jefferson	G-12	1938
Newberry Crater	K-14	1935
Pendleton	C-24	1935
Sumpter	G-26	1939
Telocaset	E-28	1932
The Dalles	C-14	1941
Three Sisters	I-12	1941
Umatilla	C-22	1921

STATE DEPARTMENT OF GEOLOGY  
AND MINERAL INDUSTRIES  
1088 STATE OFFICE BUILDING  
PORTLAND 1 OREGON

KEY TO SYMBOLS  
A Map scheduled for publication  
7-1-58 to 6-30-59  
B Map scheduled for publication  
7-1-59 to 6-30-60  
C Map published by U. S. Army  
29th Engineers



REVISED 1956

TOPOGRAPHIC MAPS OF OREGON  
1958  
STATE OF OREGON  
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES  
1089 STATE OFFICE BUILDING  
PORTLAND

Maps Published by U.S. Geological Survey.  
Quadrangle maps may be purchased from the  
National Center, Denver 15, Colorado.

# TOPOGRAPHIC MAPS OF OREGON—1948

15-Minute Quadrangles (Scale 1:62,500)				30-Minute Quadrangles (Scale 1:125,000)				River Surveys (Various scales and contour intervals)			
Name	Location coordinates	Contour interval	Date last printed	Name	Location coordinates	Contour interval	Date last printed	Name	Location coordinates	Contour interval	Date last printed
* Abbott Butte	O 8	50	1947	* Arlington	GD 17-18	50	1941	Applegate River, 4 sheets	QR 5-6		1940
** Albany	H 6	25	1944	* Baker	GH 27-28	100	1934	Catherine Creek, 1 sheet	F 28		1933
* Aldrich Mountain	I 21	50	1943	* Bend	IJ 13-14	50	1940	Chewaucum, 3 sheets	Pq 16		1938
o Alsea	I 4	50	1942	* Blalock Island	GD 19-20	50	1944	Clackamas River (W.S.P. 349)	F 10		1914
o Astoria	B 3	20	1939	* Chemult	MN 11-12	50	1941	Columbia River	B-D 3-22		1929-30
* Bandon	N 1	50	1944	* Gandon	EF 17-18	50	1916	Coquille River	N 1-2		1926
* Bates	H 24	Underway		* Coos Bay	MN 1-2	100	1937	Crooked River	O 6		1939
o Beachly	J 4	50	1942	* Dayville	IJ 19-20	100	1936	Deep Creek and Canas Creek, 4 sheets	I 14-15		1926
** Spring	E 9	25	1944	* Diamond Lake	MN 9-10	100	1926	Deschutes River (W.S.P. 344)	R 18-19		1939
o Bridal Veil	D 10	100	1942	* Dufur	EF 13-14	100	1945	Evans Creek, 2 sheets	D-J 14-15		1911
x Brownsville	I 7	25	1938	* Estacada	EF 9-10	100	1938	Gales Creek, 1 sheet	PQ 6		1938
* Canas	D 9	25	1942	* Grants Pass	QR 5-6	100	1930	Grande Ronde River, 7 sheets	CD 27-29		1937
o Cape Falcon	C 3	50	1940	* Hood River	CD 11-12	100	1940	Grave Creek, 1 sheet	F 6		1938
* Cape Foulweather	G 2	50	1944	* Ironside Mountain	IJ 25-26	100	1908	Hood River, 4 sheets	DE 12		1939
o Cathlamet	B 5	20	1941	* Jarby	QR 3-4	100	1942	Illinois River (see Rogue River)			
o Clatskanie	B 6	25	1942	* Lowell	KL 7-8	100	1942	John Day River (W.S.P. 377)	D-C 16-20		1909
* Coos Bay	M 2	50	1945	* Madras	GH 13-14	100	1931	Jump-off Joe Creek, 1 sheet	P 5		1937
* Coquille	N 2	50	1945	* Maiden Peak	KL 11-12	100	1944	Klamath River, 16 sheets	R-T 5-10		1926
o Corvallis	H 2	50	1942	* McKenzie Bridge	IJ 9-10	100	1940	Little Butte Creek, 3 sheets	K 7-8		1938
* Cottage Grove	K 6	25	1921	* Medford	QR 7-8	100	1945	Lookout Point, 4 sheets	Q 9		1938
* Crow	K 5	50	1945	* Mill City	GH 9-10	100	1941	Luckiamute River, 1 sheet	GH 4-5		1938
o Dallas	G 5	50	1942	* Mitchell	GH 17-18	100	1926	McKenzie River, 6 sheets	J 6-10		1926
* Dutchman Butte	O 4	Underway		* Mitchell Butte	KL 29-30	50	1921	Metolius River	H 12-13		1912
* Eagle Rock	I 16	50	1948	* Mt. Hood	EF 11-12	100	1944	Nehalem River, 7 sheets	C 4-6		1938
o Elmira	J 5	50	1942	* Mt. Jefferson	GH 11-12	100	1938	North Santiam River, 2 sheets	GH 8-11		1944
* Empire	M 1	50	1944	* Newberry Crater	KL 23-24	100	1935	North Umpqua River	M 5-10		1923
o Enright	D 4	100	1941	* Pendleton	ND 23-24	50	1935	Rogue River, 14 sheets	O-Q 1-9		1925
** Bucher Mountain	G 3	50	1945	* Pine	GH 29-30	100	1941	Sandy River (W.S.P. 348)	E 11		1927
o Eugene	J 6	5 & 10	1940	* Port Orford	EF 1-2	100	1944	Santiam River (W.S.P. 349)	GH 8-11		1914
o Fairdale	E 5	100	1942	* Riddle	OP 6-6	100	1942	Santiam River (see North and South Santiam)			
o Galice Creek	D 6	25	1943	* Roseburg	MN 5-6	100	1942	Separation Creek	J 10		1928
* Galice	F 4	50	1948	* Sumpter	GH 25-26	100	1939	Siletz River	GH 3		1926
o Gimber Peak	E 4	100	1942	* Telocasset	EF 27-28	100	1932	Snake River, 17 sheets	C-K 30-33		1939
* Goodwin Peak	K 3	50	1943	* The Dalles	CD 13-14	50	1941	South Santiam River, 5 sheets	I 8-9		1938
** Halsey	I 6	10 & 25	1941	* Three Sisters	IJ 11-12	100	1941	South Umpqua River, 3 sheets	O 6-7		1938
** Hegeta Head	J 2	50	1944	* Umatilla	CD 21-22	50	1921	South Yamhill River, 2 sheets	F 4		1938
x He Devil	E 32	50	1922	* Waldo Lake	KL 9-10	100	1944	Umatilla River, 3 sheets	D 25		1938
* Hillsboro	D 7	25	1943	* Weiser	IJ 31-32	100	1916	Umpqua River, 9 sheets	LM 3-4		1926
* John Day	I 23	50	1943					Walla Walla River, 4 sheets	C 25-26		1932
o Kalama	E 7	20	1943	SPECIAL MAPS				White River, 3 sheets	F 12-14		1932
o Keassey	C 5	100	1943	Name	Location coordinates	Contour interval	Scale	Willamette River (W.S.P. 349 and 378)	KL 9-10		1938
** Lebanon	H 7	25	1944					Willamette River (see Lookout Point)			
* Long Creek	H 22	Underway		Crater Lake	NO 9-10	50	1:62,000*	Willamina Creek, 1 sheet	F 5		1937
* Mapleton	J 3	50	1945	Nat'l Park				Yamhill River (see South Yamhill)			
o Marys Peak	H 4	50	1942								
* McMinnville	F 6	25	1943	Crater Lake and vicinity	NP 9-11	50	1:48,000				
o Molalla	F 8	25	1943								
o Monroe	I 5	50	1942	Mt. Hood and vicinity	DE 10-11	100	1:125,000				
* Mount Angel	F 7	25	1943								
* Mount Vernon	I 22	50	1943	Picture Gorge (advance)	HI 20	5	1:24,000				
o Nehalem	D 3	100	1943								
o Nestucca Bay	F 3	100	1942	Squaw Butte Ranch (advance)	M 19-20	50	1:48,000				
* Ochoco Reservoir	I 16	Underway									
* Oregon City	E 8	25	1945								
* Portland	D 8	25	1940								
* Post	J 17	Underway									
** Reedsport	L 2	50	1942								
* Roman Nose Mountain	K 4	100	1944								
o Saddle Mountain	C 4	100	1943								
** Salem	G 6	25	1940								
x Seven Devils	F 32	50	1920								
o Sheridan	F 5	100	1942								
** Siltcoos Lake	K 2	50	1942								
o Spirit Mountain	F 4	100	1942								
* Stayton	G 7	25	1944								
o St. Helens	C 7	25	1943								
* Susanville	H 23	Underway									
o Swensen	B 4	20	1940								
* Tidewater	I 3	50	1945								
o Tillamook	E 3	100	1942								
* Tillier	O 7	50	1946								
o Timber	D 5	100	1941								
* Toledo	H 3	50	1946								
* Trail	F 7	50	1945								
** Tualatin	E 7	25	1943								
o Valsetz	G 4	50	1942								
o Vernonia	C 6	25	1943								
* Waldport	I 2	50	1942								
* Yamhill	E 6	100	1942								
* Yequina	H 2	50	1946								

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PORTLAND 5, OREGON

KEY TO SYMBOLS

- \* Map published by U.S. Geological Survey, obtainable from the Director, U.S. Geol. Survey, Washington, D.C.
- x Map published by U.S. Geological Survey, quadrangle incomplete.
- o Map printed by the U.S. Army, 29th Engineers.
- \*\* Map revised by U.S. Army, 29th Engineers, on U.S. Geol. Survey topographic base.

## CARRYING SACK

Some sort of packsack for tools and equipment and for bringing out specimens, is necessary. Some persons prefer a packsack of the Trapper Nelson, or rucksack, type; others, a knapsack with a single shoulder strap. The packsack should be stout and serviceable, waterproof, good-sized, and comfortable to the wearer.

## NOTE BOOK AND PENCIL

A note book and pencil are essential to one who wishes to jot down observations. Data should be recorded as to the exact locality, map used, township, range, section, sub-division of section, and, if possible, a description of the locality, and a field identification of the rock or specimen. The locality should be given some sort of distinguishing number.

Many collectors prefer a loose-leaf note book of pocket size. A six-ring binder is preferable to a three-ring, as it tends to hold the paper more satisfactorily. Note books bound with a spiral binder are very good. The loose sheets may then be torn out to serve as a label to accompany the specimen or sample.

A specimen label is illustrated in figure 12. This label has been extensively used and found satisfactory.

Figure 12. Specimen Field Label.

LOCATION: County . . . . . Date . . . . .  
 Quadrangle . . . . . Elevation . . . . . Sample No. . . . .  
 Section \_\_\_\_\_, T. \_\_\_\_\_, R. \_\_\_\_\_  
 Notebook  
 Page . . . . .

## FIELD DESCRIPTION:

Property Owner . . . . . Collector . . . . .

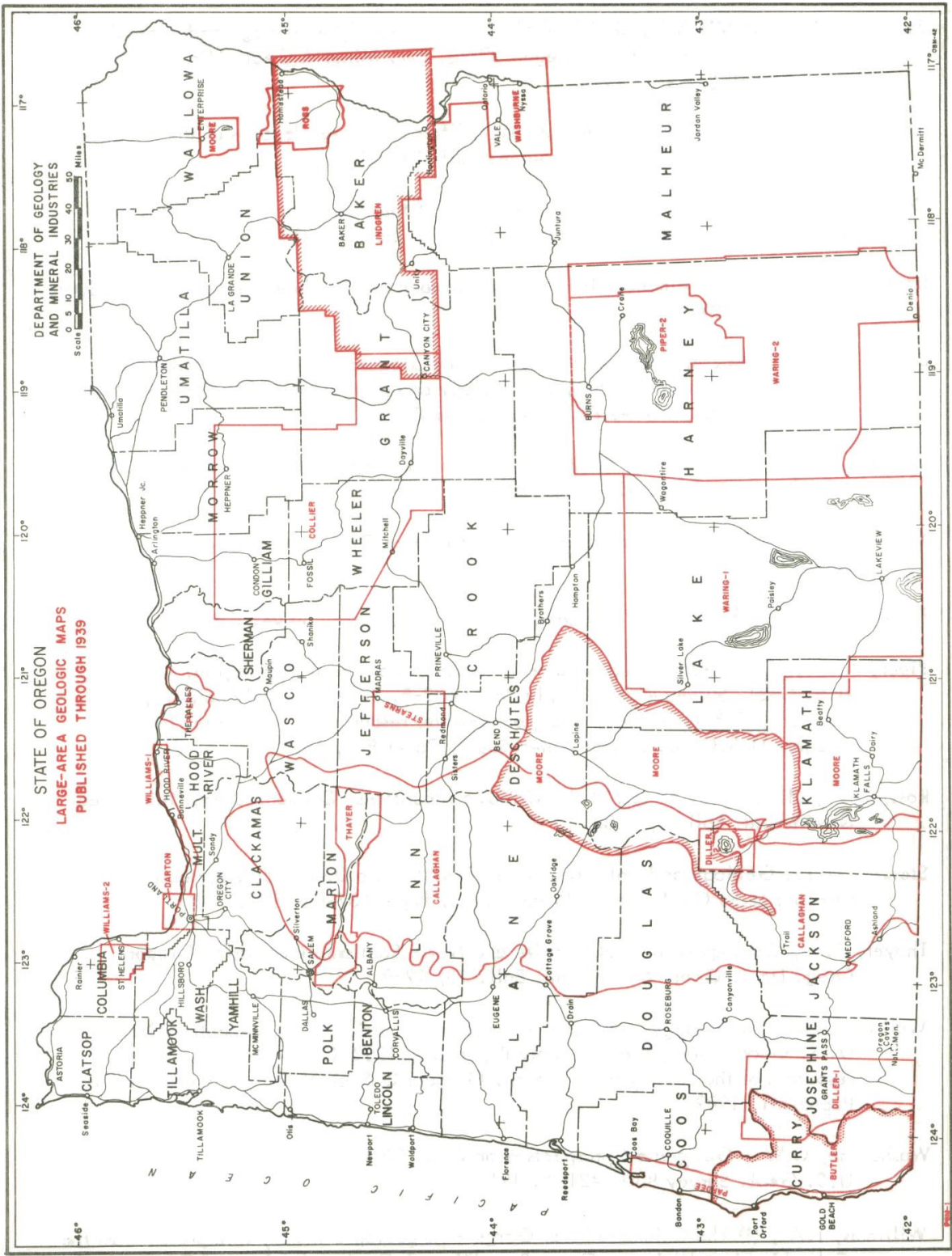
## WRAPPING PAPER.

It is advisable to use paper for wrapping specimens. Some collectors prefer paper sacks of the "nail-sack" variety in "four-pound" and "twelve-pound" sizes. The specimen is placed in the sack with the label, and the extra paper

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Scale  
0 5 10 20 30 40 Miles

STATE OF OREGON  
LARGE-AREA GEOLOGIC MAPS  
PUBLISHED THROUGH 1939





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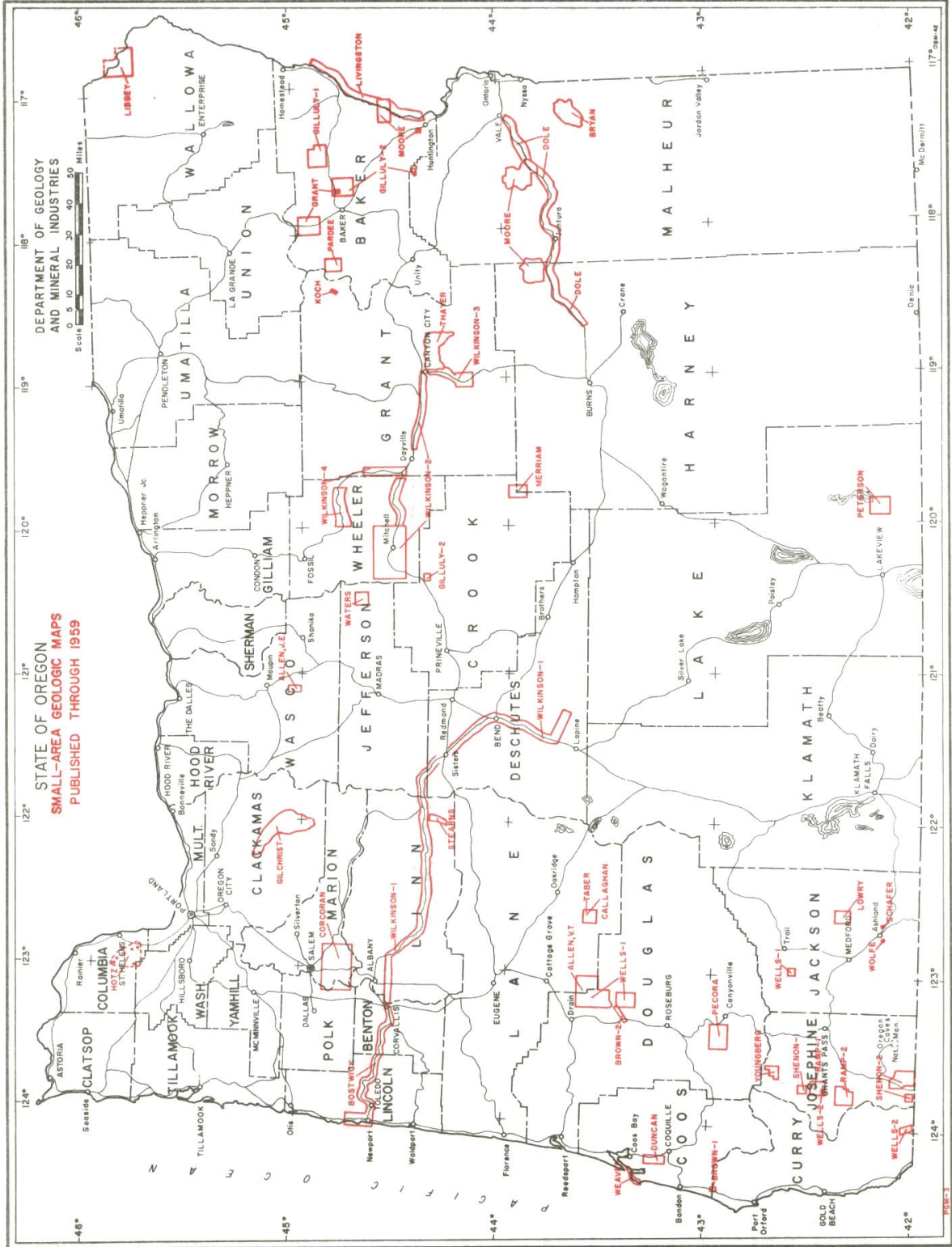


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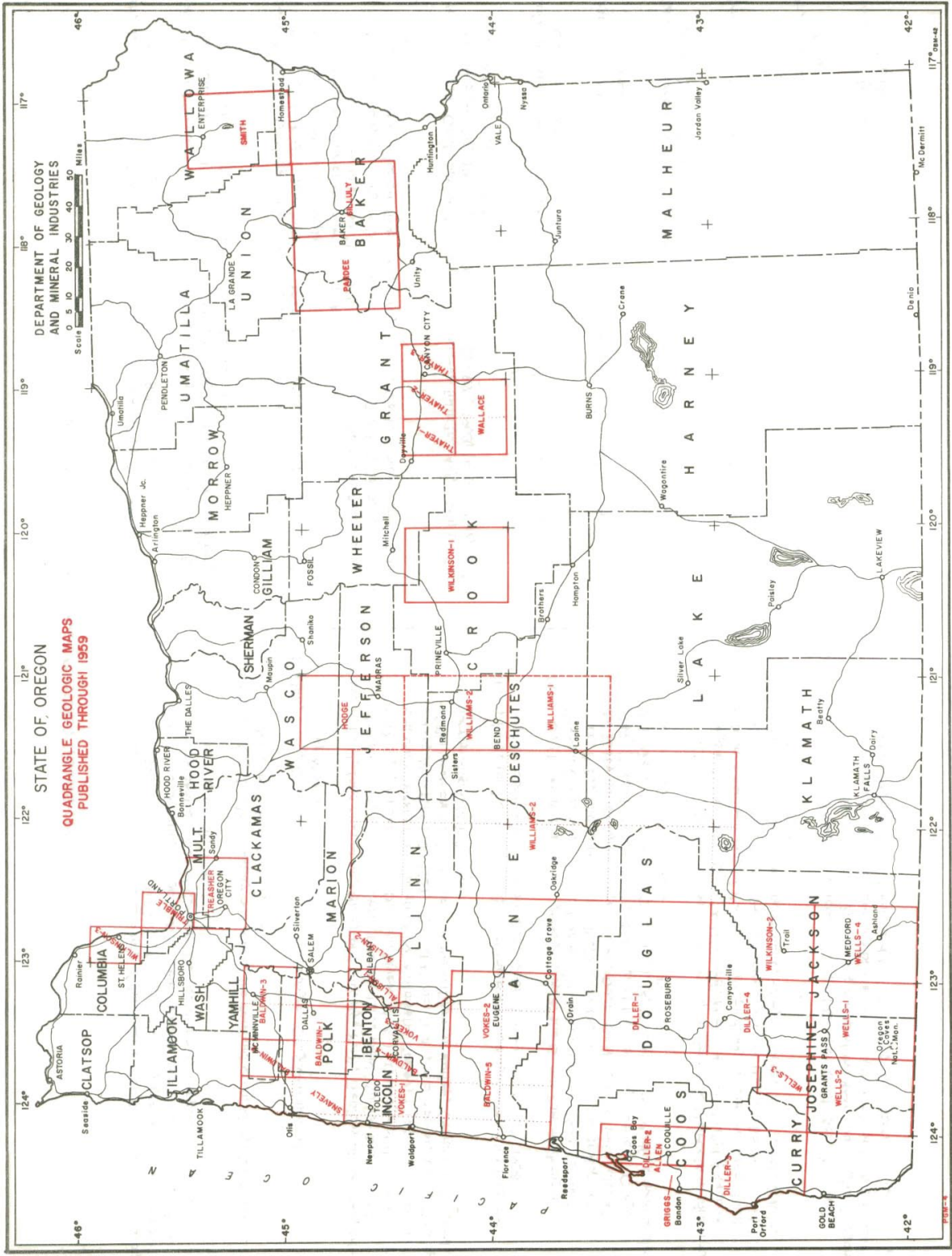
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is folded over and around the specimen.

Wrapping paper, newspaper, or magazine paper the size of the Saturday Evening Post will serve satisfactorily. A ball of string for tying will prove useful.

#### MISCELLANEOUS

Matches kept in a waterproofed container may save many an embarrassing moment. If no match safe is available, heat some paraffin until it is liquid, then throw in a handful of wooden matches and allow them to soak in the liquid paraffin for several minutes. Take them out and stand them upright to drain, the untreated end down. The match will then stand soaking in water for days and still be usable. Another method used by some woodsmen who wish to protect themselves against setting forest fires with matches is to stand the lower two-thirds of the match stick in water-glass; the water-glass is non-inflammable and fireproofs that end of the match. The matchhead is then paraffined, care being used that the paraffin covers the margin of the water glass. When ignited, the match will burn brightly until the flame encounters the water-glassed portion, where it dies. Another fire-prevention trick is as follows: Carry an empty tobacco can; place all match sticks, tobacco ashes, cigarette butts and pipe heels in the can; and keep can closed.

A small piece of "fat wood", that is, pitchy wood, in the pack is a distinct aid in starting a campfire. "Kindlesticks", a patented product, are most excellent, and can be purchased for a small sum at most "dime stores". They burn sufficiently long and with enough heat to ignite damp wood.

It is probable that a great deal of mineral prospecting will be done on public lands. The U. S. Forest Service officials are usually willing to assist and in return they ask that reasonable precautions be used to prevent setting fire to the forests. The Forest Officers comprise a body which has been charged with the protection of public property, in which we as taxpayers have an interest. If one tries to assist them in their work, he will find them a most helpful group. Give them a fair trial, and ask for an explanation of the various "regulations".



TESTS, GENERAL DESCRIPTION

A mineralogist uses a number of tests which may provide the necessary clues to the identification of a mineral. A well-trained and experienced person may pick up a mineral and tentatively identify it without making tests but one may rest assured that it is a wide experience that enables him to see the answer to many of the tests without actually performing them.

It should be understood that these field tests necessarily do not give a final and complete determination. The collector or prospector frequently may be at a loss to determine a mineral accurately; this should not be discouraging, as there are many minerals - about 1600 - and even experts are often forced to make chemical and microscopic tests. The tests given herein, however, provide means for a tentative determination subject to later check.

There may or may not be a relationship between a mineral name and its composition. . . . . The nomenclature exists and each mineral name must be memorized.

The collector may have difficulty in understanding some of the tests. It can be said that adamantine luster is a very high luster with a peculiar, bright oily flash characteristic of diamond, but this means little if adamantine luster has never been studied. Certain mineral supply houses put out small, low-cost mineral sets to illustrate these features, and many persons may find it desirable to purchase these for study. The principal sets are:

	<u>Approximate Cost</u>
Hardness	\$1.50 - \$3.50
Luster	2.00 - 12.00
Cleavage	1.75 - 3.00
Tenacity	1.25 - 3.00
Fracture	1.00 - 3.00

Specimens purchased from well-established supply houses may be slightly higher in price but one has more confidence in the accuracy of their identification.

The correct name of a mineral is determined by a process of elimination. Each test is applied in turn, and a great number of possibilities are thus eliminated. For example: if a mineral has a determined hardness of 7, all minerals having a hardness greater or less than 7 are eliminated. Next, the mineral may have a metallic luster, so all minerals of hardness 7 having a non-metallic luster are eliminated. The final result after all tests are applied, is one mineral the name of which is sought. It is seldom that one test alone will identify a mineral, and several, or all, must be applied.

## COLOR

Color of a mineral is usually the first feature to be noticed, and may prove the most important. There are certain warnings that should be given, since a given mineral may occur in different colors. Calcite may be colorless, white, blue, pink, amber, or almost any color. On the other hand, epidote has a peculiar pistachio green color that is quite diagnostic.

Most people are aware that the color of a substance seen in artificial light may be quite different from its color in daylight. The color observed is reflected from the surface and all other colors are absorbed. A red article will appear black in a blue light as there are no red rays reflected.

Another difficulty is that individuals differ in their ability to distinguish color. This may range from true color-blindness, in which one color cannot be distinguished from another, to slight differences in observation. One eye may have different color perception than the other.

Therefore, when color is to be used as a test, the following points should be carefully considered:

1. Does this mineral have more than one common color occurrence?
2. Is the light in which the specimen is studied, a true white light such as daylight?
3. Is my color perception standard, and if not just what is the variation?

## LUSTER

Luster is the "shine" or "sheen" or "look" of the surface of a mineral under light reflected from its surface.

The two main kinds of luster are metallic and non-metallic.

### Metallic Luster

Metallic luster is the peculiar, brilliant shine reflected from metal surfaces and "looks that way" because the mineral is opaque even on the thinnest edges. Galena, pyrite, and many others have this luster. It is important that the amateur become familiar with metallic luster as it is one of the first tests used to separate minerals into different groups.

### Non-Metallic Luster

Non-metallic luster is luster other than metallic, and is subdivided into groups characterized by the luster of well-known objects.

#### Adamantine Luster

Adamantine luster is that bright, somewhat "oily" appearance so characteristic of diamond.

### Vitreous luster

Vitreous luster is characteristic of broken glass, and is the most common of all the non-metallic lusters.

### Resinous and waxy luster

Resinous luster is similar to the greasy appearance of resins and amber, and may grade into greasy luster. Waxy luster is what the name implies.

### Pearly luster

Pearly luster is the luster of pearls, and is caused by innumerable thin, transparent plates piled one on another. Pile several sheets of clear cellophane on each other to secure the effect of pearly luster. This luster may be caused by innumerable cleavage cracks giving the same effect as a series of thin plates piled on each other.

### Silky luster

Silky luster is the luster of silk, and is the result of a fibrous structure. It does not have a common occurrence but is very diagnostic when found.

### Dull or earthy luster

Dull or earthy luster is similar to that of earth. It has a dull lifeless appearance.

## CLEAVAGE

Cleavage is a quite important property of minerals and is defined as the tendency of certain crystals or crystalline material to break in definite directions.

One of the better known examples of cleavage is that of mica, which is perfect in one direction, and can be cleaved into very thin, paper-like sheets. Others, like calcite, break easily in three directions to yield a blocky figure. Instead of breaking clear across, one plane may break for a distance, discontinue, and be continued along another plane parallel to the first. Galena is also a good example of a mineral which shows such cleavage.

It is difficult to determine cleavage when the crystals are surrounded by other crystals. Tiny parallel cracks may give clues as to the cleavage. One should turn the specimen slowly this way and that, watching carefully all the time for brief flashes that are reflections from cleavage surfaces or crystal faces. The grains that "flash" can be studied under a hand lens and the cleavage details determined. Cleavage surfaces may be confused with crystal faces. Cleavage surfaces result when a mineral is broken, and the cleavage faces are repeated. Crystal faces exist only on unbroken surfaces. Two common types into which some cleavable minerals fall are:

Good cleavage in only one direction, such as mica. These minerals tend to break into sheets, or flat surfaces like a table top, folia, or scales.

Good cleavage in two directions. Such minerals usually are found in elongated forms, or prisms, but other forms are also important. The two cleavage surfaces may meet at right angles, or at oblique angles, and are characteristic of certain minerals.

Some minerals show cleavage in three (calcite) and four (fluorite) or six (sphalerite) directions

### FRACTURE

Fracture is a term used to describe the manner, other than cleavage, in which minerals break. It is not as diagnostic as cleavage, but it is important. Descriptive terms are:

Conchoidal (pronounced kon-koid'-al: derived from the Greek konche, a shell, and eidos, form.) It has a shell-like shape, similar to that on large, broken chunks of glass, and is characteristic of extremely fine-grained and glassy rocks and lavas. Quartz is an example. Sub-conchoidal fracture is poorly developed conchoidal fracture.

Hackly: is rough and uneven. There is some regularity to the break but the surface is rough.

### FORM

Most minerals are crystalline, and when free to form with no outside interference, take some regular, geometric shape, such as a cube, a prism, or any one of a host of other shapes. The smooth surfaces are called crystal faces.

Examine some table salt with a hand lens! Many "grains" will be seen as tiny cubes, having six faces, each of which is usually a square. It is true that some of these faces may be slightly rounded, or perhaps elongated, but these are natural imperfections. For our purpose, it can be said that table salt (the mineral halite) crystallizes in the cubic system. The cube is the crystal form of halite.

Use of crystal form as a test is limited to specimens which have well-developed crystals, - otherwise this test should be avoided. If a mineral crystallizes under crowded conditions, its growth is hampered by the growth of other minerals and the crystal faces may not be developed, and if only partial development of crystal faces took place, it would be very difficult to identify this mineral by its crystal form alone. A great deal may be inferred about a mineral, however, if it occurs in its natural crystal form. The six-sided quartz crystal (hexagonal) and the pyrite cube or its modifications are examples.

The six crystal groups, or systems, include: isometric, tetragonal, hexagonal, orthorhombic, monoclinic, and triclinic. Each of these systems has a simple basic prism form that is generally considerably modified by the development of other forms. Care must be taken not to confuse crystal faces with cleavage and fracture planes. Cleavage and fracture surfaces develop when a mineral is broken, and occasionally may be parallel to a crystal face.

## SPECIFIC GRAVITY

Pure minerals have a definite weight per unit volume (such as 1 cubic inch, 1 cubic foot, etc.). The ratio of this weight to the weight of an equal volume of water is the specific gravity of the mineral. Thus a specific gravity of four means that the mineral is four times as heavy as an equal volume of water.

The determination is based on the fact that a body immersed in water displaces an amount of water equal to its own volume. If its volume is four cubic inches it will displace four cubic inches of water, and the weight of this water divided into the weight of the object will give the specific gravity of the object. Furthermore, it is well known that an object "weighs" less in water than in air. It can be proven that this loss in weight is equal to the weight of the displaced water.

If an object is weighed in air and then immersed in water and the weight of the object in air is divided by the loss of weight when immersed in water, the answer is the specific gravity of that object. (Loss of weight in water is figured by subtracting the weight in water from the weight in air). It is therefore essential to have a reasonably accurate balance or scale with which to make weight determinations. Such a device is described in a following paragraph and is illustrated in figure 13.

A small portion of the pure mineral is placed in the pan, and the deflection of the beam is read at the right and recorded as the first reading, "A". Then the water is held so that the mineral and the pan are completely submerged, the mineral is placed in the second pan in the water and the deflection read and recorded as the second reading, "B". (Be sure that the pan does not touch the side of the glass). The second reading "B" is subtracted from the first reading "A", and the result of this subtraction is divided into the first reading "A".

$$\frac{\text{weight in air}}{\text{loss of weight in water}} = \frac{\text{weight in air}}{(\text{weight in air}) - (\text{weight in water})} = \frac{A}{A-B} = \text{specific gravity}$$

The weighing device is made of two old hacksaw blades and some scrap lumber. The hacksaw blades are riveted or brazed end to end to form a flexible arm (1). A wooden base (2) about 3" wide and 10" or 12" long is mortised to support an upright (3). A slanting groove is cut in the side of (3) so that the free end of the blade (1) with its pan (4) is horizontal. A second upright (5) is mortised into the base (2) so that a graduated scale may be put on it. The pan (4) is made of a circular piece of thin metal, preferably copper, but a circular, smooth tin can top will serve, or the top with its rim, of a small baking powder can. Four holes are punched or drilled at quarter-points in this pan, and the pan is suspended from the flexible arm (1) by fine wire, such as window screen wire. Another similar pan (6) is suspended from the first so that it is always submerged in a water container (7).

The weighing device must have a set of graduations marked on (5) marked to indicate values, such as ounces, drams, or grams, etc. The calibration, as it is called, is accomplished by placing a weight of known value in pan (4) and marking the position of the flexible arm (1) on the paper. The first action is to mark the position of flexible arm (1) when no weights are in the pan; then mark the position of (1) as the smallest, and successively heavier weights are added

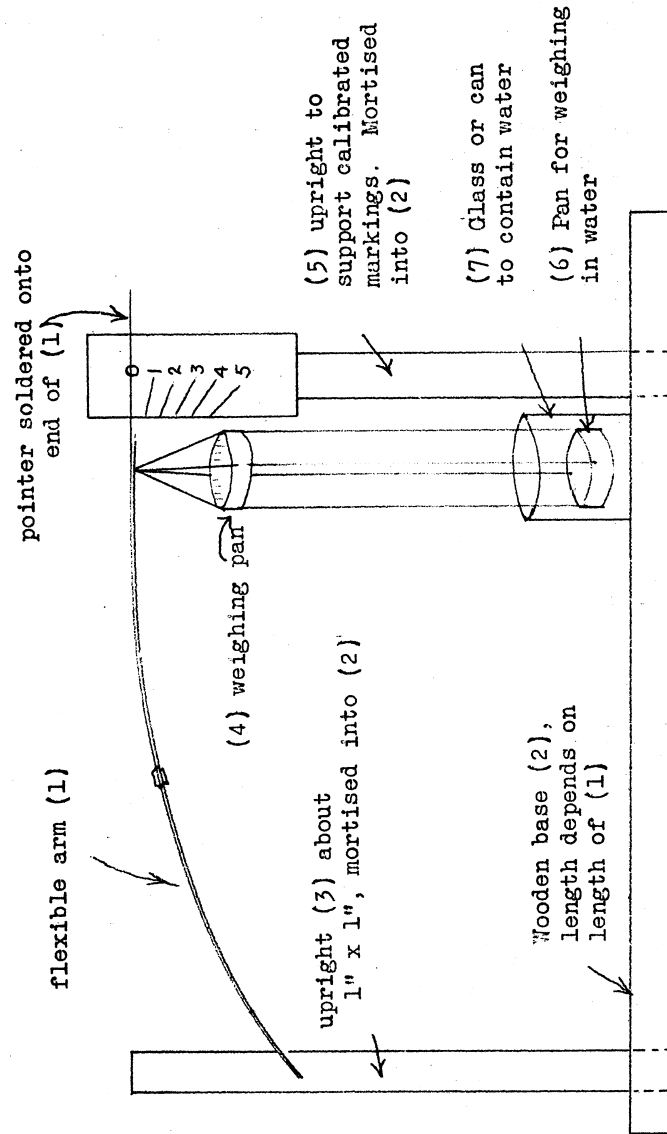


Figure 13. Weighing device.

to the pan. Each mark on (5) should have the value of the weight placed after it. When an object whose weight is unknown is placed in pan (4), the amount of deflection of (1) is read in ounces, or whatever unit was used for calibration.

The scale may be knocked down for packing by removing arm (1), pulling (3) and (5) from base (2), and stowing all parts to make a flat package.

#### HARDNESS

Hardness is one of the most diagnostic of all the tests. It is based on the fact that materials differ in their degree of hardness. Diamond is harder than glass, will therefore scratch glass, but glass will not scratch diamond.

A scale of hardness is called the Mohs scale, and ranges from 1 to 10. The numbers indicate the comparative hardness; 5 is harder than 4, 7 is softer than 8.

Mohs scale number	Representative Material
1.	Talc, graphite.
2.	Gypsum Finger nail
3.	Calcite Brass pinpoint, copper penny
4.	Fluorite
5.	Apatite Knife blade, window glass
6.	Feldspar
7.	Quartz
8.	Topaz
9.	Corundum
10.	Diamond

Talc and graphite represent the softest minerals. Gypsum is harder, but not necessarily twice as hard as talc; in other words, the numbers do not represent an arithmetical progression in hardness. The finger nail has a relative hardness of about 2.5; it will scratch gypsum and talc, will not scratch calcite, but calcite will scratch all three. An average knife blade is usually softer than window glass, but both will scratch apatite; feldspar will scratch both of them.

In actual practice, a knife blade is generally used and the ease or difficulty in making a scratch gives an idea of the comparative hardness. If the groove is deep, the mineral is soft and may be below 3. If the material is just barely scratched it may be 5. If not scratched, the hardness is 6 or greater. Let us assume that the mineral is scratched but not easily. A brass pin will indicate if it is above or below 3.5. Other testing agents may be used until the specific hardness is determined.

A small hardness set, consisting of small bits of mineral of specified hardness set in metal holders, is a very convenient testing device. Such a set may be purchased from Ward's Natural Science Establishment, Rochester, New York, for about \$6.00. A fair general idea of hardness may be obtained by using the finger nail, a brass pin, a knife, and a piece of quartz.

Oftentimes a mineral surface appears to have been scratched but in reality the scratching tool has left a mark. If this is the case the streak will disappear when rubbed. Usually a scratch can be detected by dragging the finger nail across the surface. An examination of the surface with a hand lens before and after scratching will generally help to avoid errors, especially if there are already scratches on the surface. If the mineral appears to be scratched, look carefully to determine if it is a true scratch or whether the mineral crumbles so easily that you are actually grinding it to bits instead of scratching it. An example is sandstone: the grains are usually quartz with a hardness of 7 and therefore are not scratched by a knife blade, yet apparently they are scratched with ease. Actually, the cementing material may be quite soft and the sand grains are separated rather than scratched. Another case is that of galena in which the cleavage is so marked that a knife breaks out the cleavages instead of cutting them.

The minerals to be tested should be fresh and unaltered. Feldspar is 6 in the Mohs scale; it alters to kaolinite which is 2, and any gradation between may be found.

#### STREAK

Streak is the color of the powder of a mineral obtained by scratching the surface of the mineral with a knife or file, or, if not too hard, by rubbing it on an unglazed porcelain surface such as a streak plate. The resultant "streak" is finely powdered mineral.

Frequently streak color is different from the natural color of the specimen as viewed in daylight. An iron mineral, called hematite, has many forms and colors. Some are black, some are deep red, some are brick red; but in all cases the streak, or powdered mineral, is cherry to reddish brown. Calcite may have any color, yet its streak is always white. Graphite and molybdenite are so similar as to be easily confused; both are greasy black, nearly the same hardness, and have a cleavage like mica. Yet the streak of graphite is iron black while that of molybdenite is bluish to greenish black.

The most satisfactory way to obtain a streak test is to use a streak plate, as previously described. The plate may be used over and over again by wiping with a damp cloth to remove streaks.

In the event that it is impractical to secure a streak plate or piece of unglazed porcelain, the mineral may be finely powdered by crushing or by scraping with a knife. The resultant powder should be examined with a hand lens using a piece of white paper for a background.



## ASSOCIATION OR OCCURRENCE

Certain minerals have definite rock associations, although rare exceptions to these rules may occur. For example, platinum and chromite are characteristically associated with ultra-basic rocks, that is, rock without free silica (quartz), and little feldspar. Chromite deposits occur so generally with serpentine that their association is considered axiomatic. Many of these characteristic associations will be given under specific mineral descriptions.

## ALTERATION

Many minerals have very distinctive alteration products, and these will be discussed under each mineral. Areas that have been subjected to extensive weathering are difficult to prospect, partly because the outcrops are soil covered, and partly because the minerals are so altered as to be unrecognizable unless a particular study has been made of the alteration products.

## OTHER PHYSICAL PROPERTIES

There are several other physical properties which from time to time are of value in the identification of minerals. Some minerals (magnetite is the best example) are attracted by or even form a magnet. Others (halite or rock salt) have a definite taste. Certain minerals have a characteristic "feel" (talc, graphite). Others have a characteristic odor (kaolin has an "earthy" odor; barite a "fetid" odor when struck).

DESCRIPTION OF MINERALS

## INTRODUCTION

Data used in describing the various tests for minerals have been taken from texts on mineralogy and from the experiences of the Department's staff. Frequently it has been necessary to search several texts to get complete information for each mineral, and in some cases, to supplement it with personal experience. Differences of opinion about any particular test, such as specific gravity and hardness, have been settled by use of Dana's "Textbook of Mineralogy".

Phonetic spelling is used to indicate accepted pronunciation of mineral names. A certain amount of freedom with syllabification has been used to form syllable-words that have common usage and pronunciation.

## PROCEDURE

The prospector or collector should devise some systematic method of identifying a specimen. It is recommended that the mineral be examined and all of its characteristics determined before looking in a table or text. A check list may prove valuable; it can be outlined in your notebook and the various items filled in as the determinations are made:

1. Color
2. Luster
3. Cleavage
4. Fracture
5. Form
6. Specific Gravity
7. Hardness
8. Streak
9. Occurrence

Then, start with some certain test say "hardness". If the mineral has a hardness of "7", then all others are eliminated. Next try "cleavage", and those not on the hardness-of-7 list are automatically eliminated. Proceed with this method until the answer is found.

Should the prospector or collector perform one test and then try to determine the mineral without additional tests, there is danger that something important may be overlooked. It is so easy to "want" a specimen to be a certain mineral, that it is difficult to make an impartial decision.

Finally, when you feel that the mineral is determined turn to the full description of that particular mineral and see if all points check.

DESCRIPTION OF MINERALS

AMPHIBOLE  
(am'-fi-bole)

Amphibole is a name for a group of rock-forming minerals. Megascopically (seen with the naked eye or hand lens as opposed to seen through a microscope) they may be described and identified as a unit. Included in this group are:

Tremolite	Hornblende
Actinolite	Glaucophane
Nephrite (jade)	Crocidolite
Anthophyllite	Arfvedsonite

The amphiboles are usually dark-colored minerals that may occur in light-colored granitics. Usually they appear as slender crystals or needles, often singly, although they may occur in clumps, and look much like jet. The lighter colored varieties (tremolite, actinolite, crocidolite, etc.) frequently occur in bladed, fan-shaped masses, and alter to asbestos.

Amphiboles are complex silicates, and may contain calcium, magnesium, iron, sodium, and sometimes aluminum and fluorine. . . . . These are in such chemical combination that it is not practical to separate any of the elements for commercial production.

Color: varies with the amount of iron present, the more iron the darker the mineral. Tremolite may be almost white, actinolite is green, and hornblende may be dark green, brown, or usually black.

Luster: is bright and vitreous to somewhat pearly on cleavage faces. The acicular varieties may be silky.

Cleavage: is one of the better megascopic tests. Cleavage is good in 2 directions, parallel to the length of the crystal, and the two planes meet at angles of  $125^\circ$  and  $55^\circ$ , approximately those of a hexagon. (The hexagon angles are  $60^\circ$ ). Note whether the cleavages develop surface angles that are separated by approximately two-thirds of a right angle, and if the surfaces have striations parallel to the length of the crystal.

Fracture: is uneven, and produces jagged sharp blades when broken across the cleavage.

Form: crystals are usually long and slender, have cross-sections that are nearly hexagonal (6-sided,  $60^\circ$  between faces) and the sides have striations (grooves) parallel to the length. The crystals in basaltic rocks may be shorter, but are still hexagonal in shape. Some varieties, notably tremolite and actinolite, are bladed or acicular (long needle shapes in slightly fan-shaped masses), and in radiated-columnar masses.

Specific Gravity: varies with the amount of iron, from 3 to 3.5.

Hardness: varies from 5-6; some specimens can be scratched with a knife and others cannot, but the general range is that of a knife-blade.

Streak: white to pale colors

Distinguishing Features: Amphibole may be confused with pyroxene, tourmaline, and epidote. It is distinguished from pyroxene mainly by cleavage, which is about 55° for amphibole and 90° for pyroxene, and by the brighter luster of the amphibole cleavages. Amphibole is frequently striated and pyroxene is not. Amphiboles are usually slender, pyroxenes are short and chunky. In many cases it is impossible to distinguish between them and then the name pyribole, a combination of both words, is used. Amphibole and tourmaline have similar cross-sections but tourmaline is usually triangular. Epidote has perfect cleavage in one direction, only. (See chart under pyroxene).

Occurrence: The amphiboles are found in igneous and metamorphic rocks. A general rule is to expect amphibole in the silic rocks like granite, and another similar mineral called pyroxene in the femic rocks like basalt. Examine specimens carefully, however, as amphibole (basaltic hornblende) may occur in basalts. Amphibole is common in gneisses and schists, and tremolite in limestone. Alteration: amphiboles may alter to serpentine, chlorite, asbestos, and sometimes epidote and with continued weathering to limonite, carbonates, and quartz. Thus on greatly-weathered rock surfaces, only rusty-looking spots and holes may be left to show the former presence of amphiboles.

Similarities: Pyroxene. Tourmaline. Epidote.

Uses: The altered varieties, particularly asbestos, have commercial uses. (See asbestos).

#### ANGLESITE (ang'-gli-site)

Anglesite, the lead sulphate ( $PbSO_4$ ), is one of the minor ores of lead, containing when pure 68.3% lead. It is usually a white to grey mineral, found in the "oxidized zone" of lead deposits and therefore should have no appreciable depth. It may be a good indication of lead sulfide (galena) underneath. Anglesite may be found on timbers and walls of old lead mines where the sulfide has been taken into solution and deposited as a secondary mineral.

Color: white, tinged, gray, yellow, green, and sometimes blue.

Luster: <sup>adamantine</sup> . . . to glassy; massive forms are dull; and transparent to translucent.

Cleavage: imperfect and not important.

Fracture: massive to conchoidal; brittle.

Form: crystals, banded masses.

Specific Gravity: 6.3.

Hardness: 3.

Streak: white.

Distinguishing features: it is found in oxidized zones and is distinguished from cerussite (lead carbonate). It does not effervesce in acid.

Occurrence: anglesite is a secondary mineral (found in the oxidized zone of lead deposits).

Similarities: cerussite; barite.

Uses: minor ore of lead.

#### ANHYDRITE (an-high'-drite)

Anhydrite and gypsum are closely related. Both are essentially calcium sulfate ( $\text{CaSO}_4$ ), but gypsum has in addition two molecules of water that anhydrite does not have. Anhydrite has no commercial use at present.

Color: white, grey, and tinted bluish and reddish.

Luster: cleavage faces have pearly to glassy luster, but massive varieties are dull.

Cleavage: 3 directions at right angles, producing cube-like forms.

Fracture: uneven, in massive forms; brittle.

Form: granular masses of sugar-like texture; crystals are rare. When crystals do occur they are orthorhombic.

Specific gravity: 2.9; somewhat higher than gypsum.

Hardness: 3-3 $\frac{1}{2}$ , and higher than gypsum which is 2.

Streak: white.

Distinguishing Features: its higher specific gravity and hardness distinguish it from gypsum. Its cube-like cleavage, when it can be distinguished, is also distinctive.

Occurrence: deposited from solutions; associated with gypsum; in sedimentary deposits, such as cavities in limestones. Large masses are found that can be quarried like limestone. It also occurs as a metamorphic rock. Gypsum may change to anhydrite at depth.

Similarities: gypsum.

Uses: Anhydrite has little commercial use at present. Experimental work suggests that anhydrite may become valuable for certain uses when the occasion arises. See U. S. Bureau of Mines Information Circular 7049 for details.

APATITE  
(ap'-a-tite)

Apatite is a rock-forming mineral, sometimes difficult to identify megascopically. It is calcium phosphate and is one of the principal sources of phosphate in the analyses of igneous rocks, but is not an important source of agricultural phosphate in this country.

Color: Occurs as a light green, white, reddish-brown mineral with some variations.

Luster: vitreous to subresinous.

Cleavage: imperfect.

Fracture: uneven; brittle.

Form: hexagonal crystals and compact masses, sometimes granular.

Specific Gravity: 3.2.

Hardness: 5.

Streak: colorless.

Distinguishing Features: inferior hardness to beryl, about the same hardness as glass, and subresinous luster.

Occurrence: in salic igneous rocks such as granite. It is also a product of metamorphism, and further, it may be found in high temperature veins.

Similarities: beryl.

Uses: preparation of superphosphate for fertilizer.

ARGENTITE (silver glance)  
(ar'-jen-tite)

Argentite is probably the most important ore of silver, and is chemically a silver sulfide (Ag<sub>2</sub>S). It is called "silver glance" by miners.

Color: Dark lead gray to dull black.

Luster: metallic.

Cleavage: unimportant, sometimes forming octahedral or cubic crystals.

Fracture: uneven to hackly.

Form: As massive crusts or coatings, and also in rough cubic crystals.

Specific Gravity: 7.3, high.

Hardness: 2-2 $\frac{1}{2}$ . It is sectile, meaning that it can be cut easily, but is not malleable (flattened by a hammer blow).

Streak: Shining dark lead grey.

Distinguishing Features: Its low hardness, high sp. gr. and sectility are its most important distinguishing features.

Occurrence: As a vein mineral with other silver, lead, copper and iron sulfides.

Similarities: Chalcocite.

Uses: Important ore of silver.

ARSENOPYRITE (mispickel)  
(are'-see-no-pie-rite)

Arsenopyrite is a silvery white to light steel mineral that may be confused with pyrite and other yellowish sulfides. Chemical tests may be necessary to prove its identity, but a common field method often used is to rub the mineral vigorously and a sort of garlic odor is given off, indicating the presence of arsenic.

Chemical Composition: Iron- arsenic-sulfide (FeAsS)

Color: Silver-white to steel gray and often with a brassy tinge.

Luster: metallic.

Cleavage: not important.

Fracture: uneven.

Form: Orthorhombic crystals, often twinned, but usually granular compact masses and columnar forms.

Specific Gravity: 6.

Hardness:  $5\frac{1}{2}$ -6.

Streak: Dark grayish-black.

Distinguishing Features: It is very similar to pyrite and may be distinguished if a garlic odor is noted when the mineral is rubbed or broken. It is only distinguished from smaltite by blowpipe tests.

Occurrence: Widespread; associated with the common sulfides.

Similarities: Pyrite; marcasite, smaltite.

Uses: Chief source of arsenic.

ASBESTOS  
(as-bess'-toss)

Asbestos is a commercial term applied to certain minerals that have a well-developed fibrous structure. Chunks of these minerals may look much like serpentine but scratching or picking will separate the mass into individual fibers that feel much like coarse "wool".

Asbestos is formed by alteration and is classed as a secondary mineral. Amphibole alters to asbestos (anthophyllite) under certain conditions and produces a kind of fiber known commercially as non-spinning fiber. This asbestos occurs in radiating masses like a sheaf of broom-straws tightly held at one end. The fibers have unequal lengths, tend to be brittle, and cannot be woven, or "spun", into cloth. It has a lower market value than the "spinning" variety.

Alteration of serpentine may produce "cross-fiber" asbestos (chrysotile) of "spinning" quality. Commonly the asbestos occurs in veins, with roughly parallel walls. Fibers are of equal length, and as a rule are quite flexible and separate into fine threads. This material may be carded and spun much like regular organic fibers, and is used to prepare the asbestos cloth of commerce. It rates the highest price of all asbestos fiber.

References are:

Bowles, Oliver: Asbestos, General Information: U.S. Bureau of Mines, Information Circular 6817, January 1935.

Bowles, Oliver: Asbestos: U.S. Bureau of Mines, Bulletin 403, 1937.

Color: variations of creamy gray, brown and green.

Luster: silky and glassy to dull.

Cleavage: perfect in some amphibole varieties and rare in others.

Fracture: splintery.

Form: acicular, slender crystals, in either radiating masses, or with fibers at right angles to wall rock.



Specific Gravity: 2.2 - 3.2.

Hardness: Varied, 2.5 - 5.5.

Streak: colorless.

Distinguishing Features: separates into fine slender fibers, that are somewhat flexible.

Occurrence: Asbestos is an alteration product of pyroxene or amphibole.

Similarities: Many zeolites have radiating structure, but the fibers are brittle.

Uses: various, mainly as fire-resistant products.

AZURITE (blue copper carbonate)  
(az'-u-rite)

As its name suggests, this mineral has an azure-blue color. It contains a certain amount of chemically combined water and is properly called a hydrous copper carbonate ( $\text{Cu}_3(\text{OH})_2(\text{CO}_3)_2$ ). It is characteristic of oxidized portions of copper deposits and ordinarily is superficial.

Color: azure-blue.

Luster: vitreous and velvety.

Cleavage: unimportant.

Fracture: conchoidal.

Form: azurite occurs in nodular groups of slender, needle-like acicular crystals and as crystalline coatings, frequently intergrown with green malachite.

Specific Gravity: 3.8.

Hardness:  $3\frac{1}{2}$  - 4.

Streak: Light blue.

Distinguishing Features: The azure blue color, crystalline structure, and association with other copper minerals are all distinctive characteristics.

Occurrence: oxidized zone of copper deposits, associated with malachite.

Similarities: sodalite, lazulite, lapis lazuli (lazurite), haunynite.

Uses: minor ore of copper and as gem material.

BARITE (heavy spar)  
(bare'-ite)

Barite has a non-metallic luster as well as a comparatively high specific gravity; it is used in the manufacture of white paints and barium salts. It may also be used to produce "green fire".

Chemical Composition: barium sulphate,  $BaSO_4$ .

Color: colorless, white, grey to tints of brown, blue, green, yellow, etc., depending upon the amount of impurities present.

Luster: vitreous.

Cleavage: perfect in 3 directions; two of the planes meet at right angles and one at an oblique angle. (With calcite, all planes meet at oblique angles).

Fracture: uneven.

Form: tabular and platy crystals; globular and granular masses.

Specific Gravity: 4.5. The mineral is sometimes called "heavy spar".

Hardness: 2.5 - 3.5.

Streak: white.

Distinguishing Features: Barite may be confused with calcite and dolomite.

Barite has a higher specific gravity, does not effervesce in acids, and breaks into tabular forms. Celestite and strontianite are best differentiated by flame tests.

Occurrence: found in separate veins and as a gangue mineral in deposits of lead, zinc, copper and iron sulfides, and also in limestone and sandstone beds.

Similarities: calcite, dolomite, celestite, strontianite, and scheelite.

Uses: in the manufacture of paint pigment; barium salts; "green fire"; and in the refining of sugar and as a heavy medium in well muds.

BAUXITE  
(bokes'-ite)

Bauxite is an earthy mineral with a high alumina and low silica content. As a rule, chemical analyses are necessary to confirm this composition. Characteristically, the mineral has a pisolitic or oolitic structure, with rounded, concretionary grains set in a clay-like groundmass. However, bauxite occurs without such oolitic texture and may have a homogeneous, earthy appearance. It may be either compact, or porous, rarely crystalline.

Bauxite is hydrous aluminum oxide with formula  $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ , of which 73.9 percent is alumina ( $\text{Al}_2\text{O}_3$ ), and 26.1 percent is water ( $\text{H}_2\text{O}$ ). All bauxite may contain such impurities as silica ( $\text{SiO}_2$ ), iron sesquioxide ( $\text{Fe}_2\text{O}_3$ ), titanium oxide ( $\text{TiO}_2$ ), iron sulfide ( $\text{FeS}_2$ ), iron carbonate ( $\text{FeCO}_3$ ), and calcium carbonate ( $\text{CaCO}_3$ ). Typical bauxite contains 2 to 10 percent silica, 10 to 30 percent water, 55 to 65 percent alumina, 0.5 to 25 percent iron sesquioxide, and 1 to 2 percent titanium dioxide. Diaspore ( $\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$ ) has a similar composition to bauxite, but it is much harder and is usually brown or red in color.

Bauxite is the only commercial ore of aluminum in the United States, at present. It is the low silica content of bauxite rather than the high alumina content that is important, as silica is soluble in the same solutions as alumina. Many clays have high alumina content, even higher than commercial bauxite, but clays are not used in the United States for aluminum-production as the cost of extraction is greater. A German company has been producing aluminum from high-alumina clays for over a year, but no data are available as to comparative costs. <sup>1/</sup>

Color: shades of brown, yellow, and red.

Luster: earthy.

Cleavage: none.

Fracture: earthy to conchoidal.

Form: occurs in clay-like masses which contain small "oolites", or "pisolites".

Specific Gravity: 2.5; fairly light of weight.

Hardness: soft; 1-3.

Streak: colorless

Distinguishing Features: clayey odor and clayey fracture. Chemical tests are usually necessary for exact identification.

Occurrence: an alteration product from the desilicification of clay.

Similarities: clay and laterite.

Uses: ore of aluminum, refractories and abrasives.

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<sup>1/</sup> Harder, E.C.: Industrial Minerals and Rocks, Seeley W. Mudd Series, A.I.M.E., 1937, pp.111-128.  
Minerals Yearbook, U.S. Bureau of Mines, 1935, p.420.  
Mineral Trade Notes, U.S. Bureau of Mines, vol.7 no.2. Feb.20 1938, p.2.

BENTONITE <sup>1/</sup> (Clays)  
(ben'-ton-ite)

Bentonites are clays that usually have been derived from the weathering of volcanic ash and contain the clay mineral "montmorillonite" as their chief constituent. Some varieties do and some do not increase in volume when placed in water; also plasticity varies considerably.

Color: light shades of gray, green and red.

Luster: earthy.

Cleavage: none.

Fracture: earthy and conchoidal like clay.

Form: massive microcrystalline aggregates of the clay mineral "montmorillonite".

Specific Gravity: variable.

Hardness: soft, 1-2.

Streak: colorless.

Distinguishing Features: dry surfaces adhere to the tongue; has a clayey odor when breathed on; and most varieties swell when placed in water. Some varieties may "slack or break down" to fine particles in water. A chemical analysis is necessary for an exact determination.

Occurrence: as a bedded deposit.

Uses: such clays have various uses, particularly those in which it is desired to take advantage of the swelling properties, namely: in dam construction where it is necessary to seal a pervious sand layer, and in well drilling to seal off a water stratum. Other uses are as a filter, a de-colorizer, and as an ingredient of molding sands; as a bonding agent in combination with clays for making ceramic materials, as an adhesive and emulsifying agent, as a purifier of sewage, and as an ingredient in molding sand. An important property, called thixotropy, has proven of value in the oil fields. This is the property of a gel that permits it to solidify, and then become fluid, or viscous when agitated. If such a material were pumped down an oil well hole, it would tend to seal off harmful areas, and when drilling is resumed, the gel under the drill would become viscous and flow out of the way. <sup>2/</sup>

<sup>1/</sup> Bechtner, Paul, Industrial Minerals and Rocks, Seeley W. Mudd Series, A.I.M.E.; 1937, chap.VI, pp.129-134.  
Davis, C.W. and Vacher, H.C., Bentonite, Its Properties, Mining, Preparation, and Utilization: U.S.Bureau of Mines, Technical Paper 438, 1928.

<sup>2/</sup> Mineral Trade Notes. U.S. Bureau of Mines, vol.8 no.5, May 20,1939, pp.28-29.

BERYL  
(ber'-il)

The mineral beryl is a beryllium aluminum silicate ( $\text{Be}_3\text{Al}_2(\text{SiO}_3)_6$ ) and is the source of the metal beryllium. Theoretically, the mineral contains 14 percent beryllium oxide. No commercial deposits of beryl have been found in Oregon, although occurrences have been reported but not verified. Exceptional specimens may be used as gems; emeralds are a deep green variety; a lighter green is aquamarine; a beautiful rare pink beryl has been named morganite.

Color: commonly green, but sometimes white, yellow, pink, blue, or brown.

Luster: vitreous to greasy.

Cleavage: indistinct and imperfect.

Fracture: conchoidal or uneven; brittle.

Form: hexagonal crystals (six-sided prisms), or as compact columnar masses.

Specific Gravity: 2.7.

Hardness:  $7\frac{1}{2}$  to 8, harder than quartz (H.7) and apatite (H.5) and softer than corundum (H.9).

Streak: none; it is too hard.

Distinguishing Features: beryl is harder than apatite and quartz, softer than corundum and chrysoberyl. Otherwise, its hexagonal crystals are distinctive, when found.

Occurrence: in granite pegmatites, more rarely in mica schists and gneisses, and in calcite veins in limestone. Large crystals are found in pegmatites.

Similarities: Quartz, apatite, corundum, and chrysoberyl.

Uses: source of beryllium metal, used in beryllium alloys. Use of these alloys is discussed in Mineral Trade Notes, U.S. Bureau of Mines, Feb. 20, 1939, vol. 8 no. 2, pp. 3-5. Pure forms when of good color are used for gems.

BIOTITE  
(see Mica)

BLEACHING CLAYS

Bleaching clays are varieties similar to bentonite. Whereas bentonite may have the property of absorbing large quantities of water, bleaching clays as a rule do not. They have a general waxy appearance, slake or disintegrate rapidly in water, generally lack plasticity, and have varying colors. These characteristics

are not definite, however. Since it is necessary to meet specifications of buyers, the reader is referred to the literature for these specifications:

Bell, J. W., and Funsten, S. R., Industrial Minerals and Rocks, Seeley W. Mudd Series, A.I.M.E., 1937, chap.VII, pp.135-148 (contains excellent bibliography).

**BORAX**  
(bo'-raks)

Borax is a sodium tetraborate,  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ , which usually results from the repeated evaporation of intermittent shallow lakes. Borax is one of a large number of borate minerals which serve as source material for the preparation of refined compounds of boron. Other commercial borates are kernite, colemanite, and ulexite.

Color: Colorless and white when pure, commonly a dirty grey and blue.

Luster: Glassy and vitreous to dull.

Cleavage: Imperfect.

Fracture: Uneven

Form: Found as individual crystals, as aggregates of poorly-developed crystals, and as compact glassy masses.

Specific Gravity: 1.7.

Hardness: 2-2½.

Streak: White.

Distinguishing Features: Soluble in water and has a feeble sweetish alkaline taste.

Occurrence: In waters of saline lakes and in salt deposits resulting from the evaporation of such lakes. Associated with other borates, nitrates and similar salts.

Similarities: Other borates, epsomite, melanterite, and alum.

Uses: Source of boron. It is also finding use as a washing compound, as a water softener, and as a fireproofing agent for textiles.

**BORNITE (Peacock ore)**  
(born'-ite)

Bornite is a copper iron sulfide, sometimes called "peacock ore" by miners, from its peculiar purple tarnish. The color is similar to that which develops on the weathered surfaces of chalcopyrite. Bornite occurs both as a primary and a secondary mineral.

Chemically, it is similar to chalcopyrite, being a compound of copper, iron, and sulfur ( $\text{Cu}_5\text{FeS}_4$ ). It contains 63.3 percent Cu, as compared with 34.5 percent in chalcopyrite.

Color: is a copper red and brownish bronze on the fresh surface, but readily tarnishes purple.

Luster: metallic.

Cleavage: none.

Fracture: usually uneven, but the purer more homogeneous varieties show conchoidal fracture; brittle.

Form: usually is found in massive form and in scattered (disseminated) specks through other copper ores; very rarely in rough cubic crystals.

Specific gravity: 5.

Hardness: 3.

Streak: grayish black.

Distinguishing Features: has a distinct purple tarnish.

Occurrence: in veins, in contact metamorphic deposits, and, less commonly, in disseminated deposits usually associated with pyrite, chalcopyrite, chalcocite, covellite and pyrrhotite.

Similarities: chalcopyrite, chalcocite, and covellite.

Uses: An important ore of copper.

CALAMINE  
(kal-a-mine)  
or  
HEMIMORPHITE  
(hem-i-more'-fite)

Calamine, or hemimorphite, is a silicate of zinc with water, having the chemical composition of  $\text{Zn}_2(\text{OH})_2\text{SiO}_3$ . It is very similar to smithsonite, the zinc carbonate, with which calamine may occur.

Color: colorless, white, and pale colors.

Luster: vitreous to pearly.

Cleavage: perfect in one direction.

Fracture: uneven to sub-conchoidal; brittle.

Form: massive, colloform, rounded forms, like smithsonite. Crystals are tabular, (flat, like a table, laminated).

Specific Gravity: 3.4 - 3.5.

Hardness:  $4\frac{1}{2}$  - 5.

Streak: white.

Distinguishing Features: distinguished from smithsonite by cleavage parallel to the length of the crystals.

Occurrence: in the oxidized zone, usually derived from sphalerite, and associated with smithsonite.

Similarities: smithsonite.

Uses: ore of zinc.

CALCITE  
(kal'-site)

Calcite, calcium carbonate ( $\text{CaCO}_3$ ), is a common mineral. It may form as an alteration product in igneous rocks; it may be deposited from cold ground water or from hot spring waters; it may be deposited in sedimentary beds on the sea floor or it may form from the accumulation of calcareous sea shells which were relics of former marine life.

Some varied rock occurrences of calcite are:

Limestone, massive bedded dense and crystalline calcite.

Chalk, is a fine-grained, soft, porous limestone. Usually it is composed of the microscopic shells of marine organisms.

Marble, crystalline limestone resulting from metamorphism.

Coquina, is a limestone bed consisting of shells.

Travertine, is a cold ground water and hot spring deposit.

Oolite, is a limestone composed of small concretions ranging from the size of buckshot to the size of a pea. Sometimes it is reworked to form oolitic sandstone.

Iceland Spar, is clear, transparent calcite, free from chemical impurities and physical imperfections.

Color: colorless and transparent crystals and rhombs to dull opaque masses. It may be found in almost any color.

Luster: vitreous.

Cleavage: perfect in 3 directions. Cleavage directions are not at right angles, but form rhombohedrons that appear like a rectangular frame that has been pushed askew at one corner. The cleavage is so perfect that the large rhombs break easily into smaller individual rhombs.



Fracture : Indistinct or absent; brittle.

Form: Found in a great number of varied crystal habits; commonly as twins forming arrowheads and dog-tooth crystals. Found as crystal coatings or druses in round cavities and veins and as imitative shapes such as stalactites and stalagmites.

Specific Gravity: 2.7.

Hardness: 3.

Streak: white.

Distinguishing Features: Calcite effervesces (bubbles) in cold dilute muriatic acid (HCl). Its cleavage is characteristic.

Occurrence: Widespread secondary and primary mineral, found in sedimentary beds and with igneous rocks. Common as cavity and vein fillings deposited from circulating ground water.

Similarities: Aragonite, dolomite, siderite, anhydrite, rhodochrosite, magnesite, and gypsum.

Uses: Iceland Spar has optical use. Calcite is the main constituent of limestone rock, which is used in agriculture; in the paper, cement, and chemical industries. It is used as road metal; as building stone; as monumental stone; and as flux for the smelting and refining of metals.

CASSITERITE (Stream Tin), (Tin Stone)  
(ka-sit'-er-ite)

Cassiterite is tin dioxide ( $\text{SnO}_2$ ), commonly called "stream tin" or "tin-stone", from its usual occurrence in placers. Very little cassiterite is known to exist in commercial quantities in the United States. It is found in the New England States; in the southern Appalachian Mountains; in South Dakota; in Riverside county, California; and in the placer gravels of Pine Creek, south of Baker, Oregon.

Tin consumed in the United States is imported.

Color: brown or black and sometimes grey, red, or yellow.

Luster: submetallic to adamantine; crystals usually splendid.

Cleavage: imperfect.

Fracture: subconchoidal to uneven; brittle.

Form: it is found as crystals, as stream-worn pebbles, as mammillary nodules and sometimes as slender needles.

Specific Gravity: 7.

Hardness: 6-7.

Streak: white to gray and sometimes brownish from surface stains.

Distinguishing Features: high specific gravity, hardness, streak, and infusibility.

Occurrence: The most common primary origin is in quartz veins and granitic pegmatites. About 2/3 of the world's production of tin is derived from placer deposits.

Similarities: Rutile, wolframite, zircon . . . .and some varieties of garnet.

Uses: Source of tin.

CERARGYRITE (Horn Silver)  
(sir-rar'-jer-rite)

Cerargyrite is a silver chloride (Ag Cl) and is known to the western miners as "horn silver" because of its softness and waxy or resinous appearance. When exposed to light it darkens or tarnishes to a peculiar violet-brown color.

Color: white to pearl grey, green, and sometimes a violet tinge.

Luster: submetallic, waxy and resinous to adamantine.

Cleavage: none.

Fracture: unimportant, subconchoidal.

Form: massive, as thin crusts or coatings; rarely as cubic crystals.

Specific Gravity: 5.5.

Hardness: 1-1 $\frac{1}{2}$ , highly sectile.

Streak: white, difficult to obtain.

Distinguishing Features: sectility, waxy appearance and sometimes the violet tinge.

Occurrence: It is a secondary mineral found in oxidized parts of silver deposits.

Similarities: Some copper carbonates.

Uses: Ore of silver.

CERUSSITE (White Lead Ore)  
(ser'-oo-site)

Cerussite is the white lead ore, lead carbonate ( $PbCO_3$ ) containing 77.5% lead. It is very brittle and commonly forms silky, milk-white masses of inter-lacing fibers, due to repeated crystal twinning.

Color: white, greyish brown, yellowish brown, and some darker tints.

Luster: adamantine and silky to dull.

Cleavage: in two directions, but not prominent.

Fracture: conchoidal; brittle.

Form: in compact masses, in fibrous and reticulated forms, and sometimes in crystals.

Specific Gravity: 6.5 (high).

Hardness: 3-3½.

Streak: uncolored or white.

Distinguishing Features: high specific gravity; bubbling in dilute nitric acid; and adamantine luster.

Occurrence: as a secondary mineral in the oxidized zones of lead deposits.

Similarities: anglesite, barite, witherite, and strontianite.

Uses: ore of lead.

CHALCEDONY

(kal-sed'-ony)

(varieties, -onyx, agate, . . . . plasma, etc.)

Chalcedony is a very fine-grained (cryptocrystalline) variety of silica or quartz, and usually represents deposition from low temperature solutions. Use of gem varieties has been the mainstay of the lapidary industry of the State of Oregon. A variety of trade names is given to the different colored varieties of chalcedony and to those with peculiar impurities and structure differences. Some of the most common are petrified or agatized wood, banded agate (irregular color bands), moss agate (smoky, dendritic), sagenitic agate (acicular or needle-like inclusions), carnelian agate (reddish yellow), chrysoprase (green nickel oxide stain), enhydras (sealed water bubbles), onyx (straight color bands) and . . . . . plasma (bright green or leek green; false jade).

Color: white with varied color tints; commonly a cloudy appearance.

Luster: waxy to dull.

Cleavage: none.

Fracture: conchoidal; brittle.

Form: as a secondary silica it may assume almost any form; usually massive and banded concretionary nodules.

Specific gravity: 2.6.

Hardness: 7.

Streak: none.

Distinguishing Features: hardness; conchoidal fracture. It shatters when broken and is finer grained than quartz and harder than opal.

Occurrence: a secondary mineral found as cavity and vein fillings in nearly all kinds of rocks, especially common filling amygdaloidal cavities in lavas; similar to zeolite occurrence.

Similarities: quartz, opal.

Uses: gem stone, and abrasive.

CHALCOCITE (copper glance)  
(kal'-ko-site)

Chalcocite is often called "copper glance" by miners. Chemically it is cuprous sulfide,  $\text{Cu}_2\text{S}$ , and contains 79.8% copper when pure. It is the most important copper ore mineral of most of the world's largest copper mines.

Color: dark lead grey with a dull black or bluish tarnish which gives it the name of "sooty copper" or "copper glance".

Luster: dull metallic.

Cleavage: indistinct.

Fracture: hackly and granular to imperfect conchoidal.

Form: compact masses, sometimes granular, rarely in false-hexagonal crystals.

Specific Gravity: 5.7.

Hardness:  $2\frac{1}{2}$ -3, sub-sectile.

Streak: dark lead-grey to black.

Distinguishing Features: high specific gravity and association with other copper minerals; softer than bornite and tetrahedrite; less brittle than tetrahedrite; and more brittle than argentite.

Occurrence: commonly found in the enriched sulfide zone of copper deposits where it is clearly secondary in origin, but is known to occur as a primary mineral. It is frequently intermixed with bornite, covellite, chalcopyrite, and pyrite.

Similarities: tetrahedrite, argentite, and bornite.

Uses: high-grade ore of copper.

CHALCOPYRITE (fool's gold)  
(kal'-ko-pie'-rite)

Chalcopyrite is a copper iron sulfide ( $\text{CuFeS}_2$ ), containing when pure 34.5% copper. It has a yellowish metallic sheen and like pyrite has been mistaken for gold by inexperienced people. It is a common ore of copper in the United States and Canada.

Color: brass yellow to a silvery yellow; often tarnished with an irridescent purple color.

Luster: metallic.

Cleavage: none.

Fracture: uneven to sub-conchoidal; brittle.

Form: compact masses and crystals that look like tetrahedrons.

Specific Gravity: 4.2.

Hardness:  $3\frac{1}{2}$ -4.

Streak: greenish black.

Distinguishing features: it is softer than pyrite; is brittle while gold is malleable. Pyrrhotite is magnetic and chalcopyrite is not. Its surface tarnish has a purple sheen like bornite but its fresh surface is golden yellow.

Occurrence: with pyrite and metallic sulfides in many type of ore deposits and with various rock associations. Usually it is a primary copper mineral from which higher grade copper ores may be formed by alteration and replacement.

Similarities: pyrite, pyrrhotite, bornite, and gold tellurides.

Uses: most important ore of copper.

## CHERT

Chert (or flint) is a term applied to hornstone and flinty rocks. It is a metamorphosed sedimentary deposit, occurring in stratified layers associated with limestone chalk and shale. Beds of chert 100 feet thick are found but usually such beds occur as oblong lenses and nodules distributed through sediments. The most common varieties are:

Flint, a black chert colored by organic matter, which disappears upon heating.

Jasper, a red and brown chert colored by iron oxides.

Novaculite (whetstone), a remarkably fine-grained, dense-appearing white chert which has been slightly metamorphosed and fractured.

Taconite, ferruginous chert of the Minnesota iron district.

Color: white, grey, green, red and black.

Luster: dull.

Cleavage: none.

Fracture: conchoidal (typical); brittle.

Form: rounded compact nodules and lenses to stratified beds; breaks with a sharp cutting edge.

Specific Gravity: 2.6.

Hardness: 7.

Streak: none.

Distinguishing Features: hardness, typical conchoidal fracture showing sharp cutting edges, and very fine-grained texture, often containing marine fossils or fragments.

Occurrence: in sedimentary beds; associated with limestone, dolomite, chalk, and shale. When pieces are rubbed or struck together, sparks fly and a peculiar odor is given off.

Similarities: chalcedony and quartz.

Uses: No typical modern use. It was used by ancient man to make arrow heads and flint tools.

CHLORITE  
(klor'-ite)

The name chlorite includes an indefinite group of minerals that are always formed as alteration products from other minerals. Chlorites may resemble mica, particularly biotite, because of their green color. The general composition is

a hydrous, magnesium, ferrous, aluminum silicate, with varying quantities of each.

Chlorites are found generally in foliated masses, that is, similar to a mat of leaves on a forest floor. The leaves are sometimes flat, but may be bent or curled.

Color: dark green.

Luster: vitreous to pearly.

Cleavage: one direction, basal, perfect but not as good as mica.

Fracture: splintery.

Form: foliated and scaly masses.

Specific Gravity: 2.6 - 2.96.

Hardness: 1-2 $\frac{1}{2}$ .

Streak: grayish green.

Distinguishing Features: scaly flakes not as elastic as mica, but more elastic than gypsum; distinct green color; . . . feel like that of talc.

Occurrence: an alteration product found in many igneous rocks; such minerals as biotite, amphibole, pyroxene, etc., alter to chlorite.

Uses: none.

#### CHROMITE

Chromite is the principal ore of chromium and is found in varying quantities in southwestern and northeastern Oregon. It has always been found associated with either greenstone, peridotite, or serpentine. The chemical composition is ferrous chromium oxide ( $\text{FeO} \cdot \text{Cr}_2\text{O}_3$ ) with varying amounts of magnesium and aluminum. To be commercial, chromite should contain better than 40% chromic oxide, or should be concentrated to that grade before shipping.

Color: black and brownish black.

Luster: metallic.

Cleavage: none.

Fracture: uneven.

Form: commonly in compact masses, sometimes granular, and as scattered black grains in the country rock.

Specific Gravity: 4.4.

Hardness:  $5\frac{1}{2}$ .

Streak: greyish brown and blackish brown.

Distinguishing Features: Sometimes it is feebly magnetic; has a dark brown streak, and is commonly associated with serpentine and magnetite.

Occurrence: found with the more basic igneous and metamorphic rocks, such as greenstone and peridotite or its altered equivalent, serpentine. Chromite deposits probably were formed as original magmatic segregations or were intruded into shear zones soon after solidification. <sup>1/</sup>

Similarities: franklinite, magnetite, specular hematite, and ilmenite.

Uses: ore of chromium, which is used in the manufacture of stainless steel and other alloys; in making refractories, and in chemical industries.

CHRYSOCOLLA  
(kris-o-kol'-a)

Chemically, chrysocolla is a hydrous copper silicate ( $\text{CuSiO}_3 \cdot 2\text{H}_2\text{O}$ ), containing when pure 36.1 percent copper and 20.5 percent water.

Color: pale blue to greenish blue.

Luster: vitreous, greasy to dull.

Cleavage: none.

Fracture: conchoidal to earthy, having an opal-like or enamel-like texture. Translucent varieties are brittle.

Form: found as <sup>minutely</sup> . . . crystalline mineral in veins and seam fillings, and sometimes as botryoidal nodules.

Specific Gravity: 2.2.

Hardness: 2-4.

Streak: white when pure; impure varieties are light blue and light green.

Distinguishing Features: the light "glassy" blue color, inferior hardness, and the absence of any effervescence in dilute hydrochloric acid.

Occurrence: it is a secondary mineral often found in the leached and oxidized zones of copper deposits.

Similarities: turquoise, malachite, and genthite.

Uses: Minor ore of copper and gem stone.

<sup>1/</sup> Allen, John Eliot, The Chromite Deposits of Oregon: State Department of Geology & Mineral Industries, Bull. no. 8, 1938, pp. 29-31.



CINNABAR (Quicksilver)  
(sin'-a-bar)

Cinnabar is mercuric sulfide (HgS). It contains 86.2 percent mercury (quicksilver) when pure. Prospecting frequently is done by means of panning either gravels or crushed samples since the mineral is heavy and like gold hangs back in the pan.

Color: commonly orange to crimson red and brownish-red; - a very distinct physical property. Rarely, the color may be dark gray to black.

Luster: adamantine when pure; dull when in powdery masses and scattered through country rock.

Cleavage: rhombohedral (perfect in three directions), but this is not an important distinguishing property.

Fracture: Uneven.

Form: found as crystals disseminated through the rock and in massive and earthy forms.

Specific Gravity. 8; is exceptionally high and with color, the best distinguishing property.

Hardness: 2-2 $\frac{1}{2}$ .

Streak: scarlet or vermilion always a very brilliant red from the fairly pure mineral.

Distinguishing Features: its bright red color, scarlet streak, and high specific gravity.

Occurrence: cinnabar is usually a near-surface (low temperature hydrothermal) mineral, and may be deposited as irregular veins and seams, or as disseminated specks in rocks of various kinds and ages. It is usually found associated with or near recent igneous intrusions. Certain hot springs in volcanic regions are depositing cinnabar at the present time.

Similarities: hematite, cuprite, and realgar.

Uses: the most important source of quicksilver.

## CLAY

The term "clay" is usually applied to certain earthy rocks whose most prominent property is that of plasticity when wet. This permits molding into various shapes, which are retained when dry.

The clays consist of a group of secondary minerals intermixed with varying amounts of impurities (which consist mainly of quartz, calcite, limonite, muscovite, and rutile). The clay minerals are (essentially) hydrous aluminum silicates, and may be distinguished from each other by optical methods. The most common are:

Kaolinite	$\text{Al}_2\text{O}_5 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$
Dickite	$\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$
Nacrite	$\text{Al}_2\text{O}_5 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$
Halloysite	$\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot n\text{H}_2\text{O}$
Nontronite	$\text{Fe}_2\text{O}_3 \cdot 3\text{SiO}_2 \cdot n\text{H}_2\text{O}$
Beidellite	$\text{Al}_2\text{O}_3 \cdot 3\text{SiO}_2 \cdot n\text{H}_2\text{O}$
Montmorillonite	$(\text{MgCa})\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 5\text{SiO}_2 \cdot n\text{H}_2\text{O}$

Kaolinite is a common alteration product derived from the weathering of feldspars. Dickite and nacrite are usually the result of hydrothermal action. Both montmorillonite and beidellite are common as an alteration product of the glassy particles of volcanic ash and are thought to increase the bonding qualities of clay rock.

Clay particles are mostly below 0.002 mm. diameter, and are considered to be mostly of colloidal size, which permits them to stay in suspension in quiet water for a long period of time.

Clays may have an alumina content which is sufficiently high to arouse speculation as to their use as ores of aluminum. As explained under Bauxite, it is the silica content, rather than the alumina content, that determines an ore of aluminum. Clays usually have high silica content, and therefore are not considered as ores of aluminum in the United States. A German company has been producing aluminum from high-alumina clays since 1938, but it is believed that the cost of production is greater than if bauxite were used. Germany is deficient in bauxite reserves and must use some aluminum-bearing mineral no matter what the cost of extraction. <sup>1/</sup>

**Color:** varied, from white, gray, pale yellow, blue and pink to black and dark red. Most of the colored clays burn red, but, due to organic content, some black clays burn white.

**Luster:** dull and earthy.

**Cleavage:** none.

**Fracture:** uneven, the blocky clays break with a fairly even surface; some of the flint clays have conchoidal fracture.

**Form:** massive and bedded.

**Specific Gravity:** 2.6 .

**Hardness:**  $1\frac{1}{2}$ - $2\frac{1}{2}$ , easily cut with the fingernail.

**Streak:** usually absent, but some of the red clays give yellow streak due to the limonite content.

<sup>1/</sup> Mineral Trade Notes, U.S. Bureau of Mines, vol.7 no.2, Feb.20 1938, p.2.

Distinguishing Features: earthy appearance; clayey odor when breathed upon; sticks to the tongue when the specimen is dry; sticky, slippery and soapy feel when wet.

Occurrence: Clays may originate from various kinds of rocks, either by the ordinary process of surface weathering or by the action of solutions which may be either igneous or indirectly of surface origin. In both cases the alteration product is a residual clay. The removal of the clays so formed by various agents of erosion and their deposition elsewhere form a large group of transported clays, found in stratified layers and in pockets.

Similarities: bauxite, bentonite clay, siltstone, and shale.

Uses: as refractories and for making bricks, pottery, etc.; as a paper filler and a multitude of other uses. It is difficult to tell much about the value of a clay by visual inspection. Physical properties such as color when fired, fusibility, shrinkage, etc., are the most important. Oregon specimens may be submitted to one of the offices of the State Department of Geology and Mineral Industries for certain tests. 1/

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- 1/ Mellor, J.W., Clay and pottery industries: vol.1, p.158, 1914. Lippincott.  
 Ries, Heinrich, Clays, Their Occurrence, Properties, and Uses: John Wiley & Sons, 3rd ed., 1927.  
 Ries, Heinrich, Clay, Industrial Minerals and Rocks: Seeley W. Mudd Series, A.I.M.E., 1937.  
 Wilson, Hewitt, Ceramics; Clay technology: McGraw-Hill Book Co., 1927.  
 Tyler, P.M., Marketing clay: U.S. Bureau of Mines, Information Circular 6998, 1938.  
 Wilson, Hewitt, and Treasher, Ray C., Refractory Clays of Western Oregon: Oregon State Dept. of Geology & Mineral Industries, Bull.no.6, 1938.
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## COAL

Coal is a term used to designate the more solid types of natural hydrocarbons; other forms of solid hydrocarbons are resins (amber), waxes (ozocerite), and asphaltum (gilsonite, wurtzilite, paraffin). Coal is in general the result of gradational change which has taken place in organic deposits, chiefly vegetable, by geologic processes, and form and composition of coal depend upon the extent of change caused by these processes. The resulting product consists of carbon, hydrogen, and oxygen with small amounts of nitrogen, sulfur and ash. Four general classifications representing different stages of change in the original deposit are recognized:

Peat is a brown to yellowish matted mass of interlaced, fibrous material, strongly resembling compressed tobacco. The remains of plant leaves, stems, roots, etc., in peat are still recognizable.

Lignite (brown coal) is a chocolate brown earthy material in which the texture and grain of wood and plant fibers are still distinct. It contains 55-75 percent carbon and burns readily with a smoky yellow flame and strong odor.

Bituminous coal is a compact, brittle coal breaking into cubical blocks with a gray-black to velvet-black color and brownish-black streak. It burns with a yellow flame, and very little of the original woody structure is evident. Carbon varies from 75 to 85 percent.

Anthracite coal is a compact, dense coal, iron-black to jet-black in color, with a vitreous luster, and conchoidal fracture. It usually has a hardness of more than 2, and burns with a pale blue flame. Carbon content varies from 80 to 95 percent.

Color: brown to black.

Luster: vitreous to submetallic and sometimes dull.

Cleavage: none.

Fracture: cubical or blocky with even surfaces and conchoidal fracture; earthy. Lignite, bituminous, and anthracite varieties are brittle.

Form: blocky jointed fragments with sharp edges and smooth fracture; often faintly banded.

Specific Gravity: 1.2 - 1.7.

Hardness: 1-2 $\frac{1}{2}$ .

Streak: brown, brownish-black, and jet-black.

Distinguishing Features: inflammability, light weight, brittleness.

Occurrence: in stratified layers; may be interbedded with sedimentary rocks, and may range from small seams up to beds several feet thick.

Similarities: other solid hydrocarbons; oil shale.

Uses: fuel; by-products. 1/

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1/ Minerals Yearbook, U.S. Bureau of Mines, 1932-1936.

Ladoo, R. B., The Natural Hydrocarbons: U.S. Bureau of Mines, R.I.2121 (1920).  
Libbey, F.W., Progress Report on Coos Bay Coal Field: Oregon State Department of Geology & Mineral Industries, Bulletin no.2, 1938.

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COBALTITE (Cobalt Glance)  
(ko-ball'-tite)

Cobaltite is a cobalt-arsenic-sulfide (CoAsS) that may contain as impurities small amounts of nickel and iron. The mineral has been found in the ores of several Oregon mines.

Color: silver-white with a reddish tinge; grayish black.

Luster: metallic.

Cleavage: perfect, cubic.

Fracture: uneven, brittle.

Form: granular massive, compact. Crystals shaped like those of pyrite, i.e., cubes and pyritohedrons.

Specific Gravity: 6 -6.3.

Hardness:  $5\frac{1}{2}$ .

Streak: greyish black.

Distinguishing Features: cobaltite is found in crystalline form more often than is smaltite. Its cubic cleavage is distinctive, and it can be distinguished from galena by its color and hardness.

Occurrence: in veins with silver and other cobalt and nickel minerals. In the the Standard Mine, Quartzburg district, Grant county, it occurs with chalcopryrite, pyrrhotite, pyrite, and some smaltite.

Similarities: arsenopyrite; smaltite; pyrite; galena.

Uses: ore of cobalt.

#### COPPER MINERALS

There are many minerals which contain varying amounts of copper. Only a few of those which are important as ores are described, under the following names: Chalcocite, covellite, chalcopyrite, bornite, cuprite, malachite, azurite, tetrahedrite, and chrysocolla. Other copper minerals of less importance which are not described here may be found in any standard textbook of mineralogy. Some of these are: native copper, polybasite, enargite, atacamite, brochantite, linarite, chalcantite, turquoise and diopase.

#### CORUNDUM (see p.98a)

#### COVELLITE. (ko'-vel-ite)

Covellite is cupric sulfide (CuS) and may occur with chalcopyrite, bornite, and chalcocite.

Color: indigo-blue or darker.

Luster: submetallic to resinous.

Cleavage: basal perfect, in one direction.

Fracture: none.

Form: massive; thin hexagonal plates.

Specific Gravity: 4.6.

Hardness: 1.5-2.

Streak: lead-gray to black.

Distinguishing Features: indigo-blue color; moistened with water turns purple.

Occurrence: secondary zone with other copper minerals.

Uses: ore of copper.

CUPRITE (Red Oxide, Ruby Copper)  
(cue'prite)

Chemically cuprite is cuprous oxide ( $\text{Cu}_2\text{O}$ ), containing when pure 88.8 percent copper. It occurs in the oxidized zone of copper deposits associated with other oxidized copper minerals, and often forms a coating on native copper.

Color: dark red and brownish red to ruby red.

Luster: adamantine, submetallic, or earthy.

Cleavage: imperfect.

Fracture: uneven; brittle.

Form: octahedral and cubic crystals, crystalline aggregates, and fine-grained masses.

Specific Gravity: 6.0.

Hardness:  $3\frac{1}{2}$  to 4.

Streak: brick red and cochineal-red.

Distinguishing Features: association with other copper minerals; the absence of perfect cleavage; adamantine luster; streak is a brighter red than that of hematite.

Occurrence: In the oxidized zone of copper deposits, associated with native copper, malachite, azurite, limonite, etc.

Similarities: hematite, cinnabar, realgar.

Uses: minor ore of copper.

DIAMOND

Diamond is a chemically pure form of carbon; is one of the most desired of precious stones; is commercially by far the most important gem; is one of the few gems produced commercially by modern mining and milling methods. It cleaves perfectly parallel to the octahedron (8-sided, pyramid points). Diamonds have a very

high refractive index, much higher than quartz and when rough quartz and diamond are dropped in a heavy oil medium, the diamond will show up much more plainly than the quartz. It is transparent to X-rays, and its light ray dispersion is greater than that of any other mineral. 1/

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1/ Ball, S. H., Industrial Minerals and Rocks, Seeley W. Mudd Series: A.I.M.E. 1937, pp.318-328.

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Color: colorless and various shades of red, yellow, blue, green, and sometimes black. The black varieties are known as carbonado and bort.

Luster: adamantine to greasy.

Cleavage: perfect in four directions forming octahedrons.

Fracture: conchoidal.

Form: usually found as small loose crystals with rounded faces, curved edges, and a greasy to glassy appearance. Twin crystals are common.

Specific Gravity: 3.5.

Hardness: 10; hardest known substance.

Streak: none.

Distinguishing Features: extreme hardness; brilliant light ray dispersion, especially in the cut stones; greasy appearance, especially with rough stones. Diamonds have reportedly been found in Oregon stream gravels.

Occurrence: a most common occurrence is as a small grain or pebble in gravel, from which it is mined as is placer gold. The source rock of the placer deposits and the present source of approximately 32 percent of the production is from Kimberlite (blue ground), an altered ultra-basic rock.

Similarities: quartz, topaz, zircon, and corundum.

Uses: as a precious gem. Black diamonds (bort) are used as abrasives, in diamond drill bits, and various machine tools.

#### DIATOMITE (Diatomaceous Earth) (dye-at'-tom-ite)

Diatomite is composed of the siliceous skeletons, tests, or frustules of diatoms, which are microscopic one-celled plants that live in both fresh and salt water. After dying they fall to the bottom of their habitat where the organic parts decompose and the silica skeletons may accumulate in beds of varying thickness. In time these beds become part of the sedimentary strata, usually mixed with small quantities of clay, carbonaceous matter, and other insoluble materials.

Chemically diatomite is essentially hydrous silica, containing 2 to 10 percent combined water and some impurities of organic and inorganic matter.

Diatomite is usually white when pure, frequently iron-stained along cracks, and very light of weight, because of the large amount of pore space. It is difficult to distinguish from fine-grained pumicite (volcanic ash) without the aid of a microscope. But when a small amount of pumicite or diatomite is ground between the teeth, the pumicite is distinctly gritty and brittle, whereas the diatomite is soft and crushes like chalk or clay.

Color: white and gray; colored by impurities.

Luster: dull to earthy.

Cleavage: none.

Fracture: roughly parallel to bedding planes and joint planes.

Form: massive bedded deposits which have a powdery chalk-like appearance.

Specific Gravity: 1.9 to 2.35 for pure hydrous silica. Diatomite is quite porous, however, and its apparent density is about 0.45 for blocks, and 0.12-0.25 for powder.

Hardness: 1 to  $1\frac{1}{2}$ , but the microscopic mineral particles are much harder, 4 to 6.

Streak: white.

Distinguishing Features: light weight, soft powdery feel between the fingers, and practically no grit or sand when crushed between the teeth.

Occurrence: it is found as stratified deposits in ancient lake basins, often interbedded with sedimentary rocks and volcanic lava flows.

Similarities: pumicite, clay, chalk, and weathered chert (tripoli). Chalk will effervesce in acid, while diatomite will not.

Uses: in general, its uses include heat and sound insulation; filtering medium; catalyst; absorbent; filler; mild abrasive; structural material; bleaching; chemical uses, etc. <sup>1/</sup>

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<sup>1/</sup> Cummins, A. B., and Mulryan, H., Industrial Minerals and Rocks, Seeley W.

Mudd Series: A.I.M.E., 1937, pp.243-260.

Moore, B.N., Non-metallic Mineral Resources of Eastern Oregon: U.S.G.S.

Bull.875, 1937, pp.17-117.

Smith, W.D., Diatomaceous Earth in Oregon: Econ.Geol., vol.27 no.8, 1932, pp.704-715.

Hatmaker, P., Diatomite: U.S.B.M., Information Circular 6391. 1931.

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DOLOMITE  
(doe'-lom-ite)

Dolomite is a calcium magnesium carbonate,  $\text{CaMg}(\text{CO}_3)_2$ , with (theoretically) 54.4 percent calcium carbonate and 45.6 percent magnesium carbonate, or roughly half calcite and half magnesite (see discussion under calcite). The proportion of calcium to magnesium in dolomitic rocks may vary over a wide range. It is very abundant in certain regions, forming widespread thick sedimentary beds, such as those in the upper Mississippi and Missouri River valleys and in northeastern Washington.

Color: white or light gray when pure, often colored pink and bluish black by impurities.

Luster: pearly to vitreous.

Cleavage: forms rhombohedrons, similar to calcite. Cleavage is perfect in 3 directions at oblique angles, developing a figure which looks like a deformed rectangular prism. The sides, or faces of the dolomite rhombs are slightly curved; those of calcite are straight.

Fracture: subconchoidal; unimportant.

Form: massive beds or deposits and as crystal coatings or crystal aggregates in cavities, in veins, and as an accessory mineral.

Specific Gravity: 2.8 to 3.0, increasing with iron content.

Hardness:  $3\frac{1}{2}$  to 4, slightly more than calcite (3).

Streak: none.

Distinguishing Features: only the powdered material effervesces in cold dilute HCl; the rhombic cleavage faces are curved; and sometimes there are twinning striations parallel to both diagonals; while in calcite the striations are parallel to the long diagonal. Rhodochrosite, barite, and siderite are heavier than the colored varieties of dolomite, and barite ( $\text{BaSO}_4$ ) is insoluble in acids.

Similarities: calcite, magnesite, siderite, rhodochrosite, and barite.

Uses: refractory material for furnace lining; building and ornamental stone; filler for fertilizer.

EPIDOTE  
(ep'-i-dote)

Epidote is a green mineral resulting from alteration or metamorphism of impure calcareous sedimentary rocks or igneous rocks containing much lime. The presence of this mineral is evidence of either contact metamorphism, hydrothermal alteration, or dynamic metamorphism.

Color: pale greenish yellow to pistachio green and greenish-black.

Luster: vitreous.

Cleavage: perfect in one direction.

Fracture: uneven.

Form: crystals usually elongated prisms, deeply striated; also fibrous, acicular, granular and massive.

Specific Gravity: 3.25 - 3.5.

Hardness: 6-7.

Streak: colorless.

Distinguishing Features: pistachio-green color and deeply striated prismatic crystals. See pyroxene for chart.

#### FELDSPAR GROUP (feld'-spar)

Feldspar is a name applied to a group of rock-forming minerals which makes up about 60 percent of the igneous rocks. They are silicates with varying amounts of potassium, sodium, calcium, and aluminum, and are usually colorless or light colored. Varying amounts of impurities may impart some color. They have a white streak; cleavages in two directions, nearly at right angles; vitreous luster; hardness of 5.5 plus; and a specific gravity of 2.5 to 2.7.

Feldspars may be distinguished from quartz by their inferior hardness ( $5\frac{1}{2}$ - $6\frac{1}{2}$  as opposed to 7 for quartz), and cleavage. (Quartz has no cleavage). In a coarse-grained igneous rock, feldspars may be detected by the light which is reflected from their flat cleavage surfaces, and which gives such surfaces the appearance of a shellacked table top. When broken, . . . . . feldspar surfaces . . . . . develop a step-like appearance.

Feldspar crystals may have peculiarities of structure that result from what is known as twinning. They may look like crystal intergrowths, appear compound as if built of two halves, or, as in the plagioclase feldspars, exhibit multiple twinning which looks on cleavage surfaces like a series of parallel lines or fine striations.

Alteration: Slight alteration of the feldspars may cloud cleavage surfaces to a degree that they no longer are shiny and reflect light. In such a condition they might be overlooked and experience is necessary in order to distinguish those weathered minerals. Complete alteration results principally in the formation of kaolin which, if in deposits of commercial size, may be mined for china clay. A greenish tinge is due to the development of saussurite.

#### Alkali Feldspars

Orthoclase	$KAlSi_3O_8$
Microcline	$KAlSi_3O_8$
Anorthoclase	$(NaK) AlSi_3O_8$

## Plagioclase (Soda-lime feldspars)

Albite		NaAlSi <sub>3</sub> O <sub>8</sub>
Oligoclase	)	
Andesine	)	Mixture of albite
Labradorite	)	and anorthite
Bytownite	)	
Anorthite		CaAl <sub>2</sub> Si <sub>2</sub> O <sub>8</sub>

Color: dominantly white and grey; sometimes colored (pink, green, yellowish green, cream yellow, and blue) by impurities. A play of colors (blue and green) is characteristic of certain labradorites.

Luster: vitreous and pearly, specially on the cleavage surfaces.

Cleavage: in 2 directions almost at right angles.

Fracture: uneven, poorly determined because of the good cleavage.

Form: common as single crystals, as twinned crystals, and as granular masses embedded in igneous rocks.

Specific Gravity: 2.5 to 2.7.

Hardness:  $5\frac{1}{2}$  to  $6\frac{1}{2}$ .

Streak: white or grey, usually hard to obtain.

Distinguishing Features: crystalline structure, good cleavage, twin intergrowths. The plagioclase feldspars can be distinguished from the alkali feldspars by parallel twinning lines or striations.

Occurrence: they are found in all classes of rocks, but are most abundant in igneous rocks. The commercial potassium feldspars occur mostly as large crystals (single crystals may be larger than a man) in pegmatites. The plagioclase feldspars are more characteristic of the basic igneous rocks and basic lava flows.

Similarities: apatite, . . . . and rhodonite.

Uses: feldspars are very important in the ceramic industry; also used in the glass industry and for making scouring soaps. 1/

1/ Wilson, Hewitt, Some Feldspathic Materials of the Pacific Northwest: U.S. Bureau of Mines, Report of Investigations 2794, February 1927.

Aitkens, I., Feldspar Gems (Amazon Stone, Moonstone, Sunstone): U.S. Bureau of Mines, Information Circular 6533, November 1931.

Bowles, Oliver, and Lee. C.V.. Feldspar: U.S. Bureau of Mines, Information Circular 6381, October 1930.

Burgess, B.C.: Industrial Minerals and Rocks, Seeley W. Mudd Series, A.I.M.E. 1937, pp. 261-282.

FLUORITE (Fluor spar)  
(flu'-o-rite)

Fluorite is calcium fluoride having the chemical formula  $\text{CaF}_2$ .

Color: . . . . colorless, or some pale tint of violet, green, blue, etc.

Luster: vitreous; some specimens are fluorescent, that is, when viewed in ultra-violet light, the mineral emits a peculiar glow. Occasionally, the mineral is phosphorescent, that is, when treated with ultra-violet light, it will glow for a time after the light source has been removed.

Cleavage: its perfect octahedral cleavage in four directions is the most important characteristic. . . . .

Fracture: sub-conchoidal; compact kinds splintery; brittle.

Form: One of the distinguishing features. The mineral crystallizes in the isometric (cubic) system and is usually found as cubes or sometimes as the octahedron, which is a modification of the cube. Also found as coarse or fine granular masses.

Specific Gravity: 3.0 to 3.2.

Hardness: 4.

Streak: white.

Distinguishing Features: harder than barite, celestite, and calcite, and softer than apatite; does not effervesce in cold HCl like calcite and strontianite. It forms cubic crystals, and has perfect octahedral (pyramidal) cleavage.

Occurrence: fluorite occurs as a gangue mineral with deposits of galena, sphalerite, calcite, barite, and cassiterite; and as fissure veins in limestones and dolomite.

Similarities: calcite, barite, strontianite, celestite, and apatite.

Uses: manufacture of glass, enamels, and hydrofluoric acid. Pieces free from flaws may be used for optical lenses. As a flux in steel smelting, in the electrical extraction of aluminum; and in assaying.

GALENA (Lead Glance)  
(ga-lee'-nah)

Galena, or lead sulphide ( $\text{PbS}$ ), contains 86.6 percent lead when pure. It is the most important ore of lead, and frequently contains enough silver to make it an ore of silver. Galena is a heavy greyish-black mineral, with perfect cubic cleavage having a silvery sheen on the cleavage surfaces.

Color: lead grey, often tarnishes to bluish white.

Luster: metallic.

Cleavage: very perfect in 3 directions at right angles (cubic). Smaller cubes may be easily broken from the larger cubes.

Fracture: undeveloped.

Form: commonly in cubes, less often as octahedrons modifying cubes, or as octahedrons. In ore bodies usually as cleavable masses.

Specific Gravity: 7.5 (heavy).

Hardness:  $2\frac{1}{2}$ .

Streak: lead grey.

Distinguishing Features: high specific gravity, cubic cleavage, and persistent lead grey color.

Occurrence: found as vein, contact metamorphic, and replacement deposits, associated with barite, fluorite, quartz, and the sulfides of copper, zinc and silver. Galena may alter to cerussite ( $\text{PbCO}_3$ ), or to anglesite ( $\text{PbSO}_4$ ).

Similarities: stibnite and argentite.

Uses: most important ore of lead and when silver-bearing it is an important source of silver.

#### GARNET (gar'-net)

The name "garnet" is given to a group of minerals possessing similar physical properties and crystal forms, though their chemical compositions vary widely. The general chemical composition of the garnet group is  $(\text{CaMgFeMn})_3(\text{AlFeCr})_2(\text{SiO}_4)_3$ , and the more important members of the group are summarized as follows:

Grossularite	$\text{Ca}_3\text{Al}_2(\text{SiO}_4)_3$ , white, pale green, or yellow.
Pyrope	$\text{Mg}_3\text{Al}_2(\text{SiO}_4)_3$ , deep red or reddish black.
Almandite	$\text{Fe}_3\text{Al}_2(\text{SiO}_4)_3$ , common garnet, red or brownish red.
Spessartite	$\text{Mn}_3\text{Al}_2(\text{SiO}_4)_3$ , hyacinth red, sometimes a violet tinge.
Andradite	$\text{Ca}_3\text{Fe}_2(\text{SiO}_4)_3$ , brownish red, green, and black.

Color: white, green, brownish red, brownish yellow, red, and black.

Luster: vitreous to resinous.

Cleavage: usually absent, parting due to fracturing is common.

Fracture: uneven to sub-conchoidal; brittle.

Form: usually as distinct 12-sided crystals (dodecahedrons and trapezohedrons),  
..... in the isometric (cubic) system of crystallization.  
Sometimes as granular masses or as rounded or sub-rounded grains in sand.

Specific Gravity: 3.1 to 4.3.

Hardness: 6 to  $7\frac{1}{2}$ .

Streak: white; difficult to obtain.

Distinguishing Features: hardness, absence of cleavage, 12 sided crystal habit,  
and high specific gravity, which is a little higher than similar appearing  
hard gem minerals.

Occurrence: common as accessory minerals in a large variety of rocks all over  
the world, but particularly common in contact deposits and in gneisses and  
schists. Also found in crystalline limestone, serpentines, granite, and  
occasionally in volcanic rocks; and because of its resistance to weathering  
it is often found as rounded grains in river and sea sands.

Similarities: zircon, beryl, corundum, spinel, staurolite, epidote, and olivine.

Uses: most important in the manufacture of abrasives, especially abrasive-coated  
papers and cloths. Flawless garnets may be used as gem stones or "jewel"  
mounts.

#### GEMS (PRECIOUS AND SEMI-PRECIOUS)

There are a large number of precious and semi-precious stones and a complete  
list is not given in this bulletin. Most of the commercial forms found in Ore-  
gon are varieties of silica, (quartz, chalcedony, opal) and are discussed in Bull-  
etin no. 7, Gem Minerals of Oregon.

#### GOLD

Gold is a metal whose chemical symbol is Au, and it is found most commonly  
in the free state, alloyed with a minor proportion of silver.

Color: deep to pale yellow, with sometimes a silvery tinge.

Luster: metallic.

Cleavage: none.

Fracture: hackly; malleable and ductile.

Form: usually finely disseminated through the containing rock, but megascopically  
seen as rolled grains, flakes, wire stringers, nuggets, and rarely as isometric  
crystals, rounded or subrounded as placer gold.

Specific Gravity: 15 to 19; pure Au is 19.3.

Hardness:  $2\frac{1}{2}$  to 3.

Streak: pale yellow, gold-yellow (same as the color).

Distinguishing Features: uniform pale yellow color, high specific gravity, malleability and ductility. Pyrite and chalcopyrite are harder and are brittle. Golden colored mica is scaly and has a much lower specific gravity.

Occurrence: Gold is widely distributed in the earth's crust, occurring in quartz veins along with pyrite, chalcopyrite, galena, sphalerite, arsenopyrite; etc.; and in stream and beach placers along with such heavy minerals as magnetite, ilmenite, garnet, zircon, platinum, etc.

Similarities: pyrite, chalcopyrite, phlogopite (golden) mica.

Uses: basis of currency; in the arts.

GRAPHITE  
(graf'-ite)

Graphite is one of the softest minerals, and is a component of "lead" in lead pencils. When pure, it contains 100% of the element carbon, thereby having the same chemical composition as the diamond; but often it has impurities of ferric oxide, clay, etc. The mineral has rather limited distribution in Oregon, mainly in graphitic schists.

Color: steel grey to black.

Luster: metallic to dull.

Cleavage: basal; perfect in one direction, separating the mineral into thin scales, which are flexible and sectile.

Fracture: unimportant.

Form: usually found as foliated (like matted leaves) masses, as minute disseminated scales, or as granular earthy masses.

Specific Gravity: 2.2.

Hardness: 1-2; soft greasy feel.

Streak: black or dark steel grey.

Distinguishing Features: its softness, greasy feel, black stain on the fingers, and its black streak, which is different from the greenish or bluish grey of molybdenite.

Occurrence: graphite is widespread in nearly all kinds of metamorphic rocks. It has been found as beds, veins, and embedded masses, as laminae or scales in

granite, gneiss, crystalline schist, quartzite, limestone, and also in basic eruptive rocks.

Similarities: molybdenite, specularite, and solid hydrocarbons.

Uses: graphite is used in the manufacture of pencils, crucibles, lubricating oils, and stove polish.

GYPSUM (Selenite, Alabaster)  
(gyp'-sum)

The mineral gypsum is calcium sulphate ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ), containing two molecules of water. When one molecule of the water is driven off by heating, a powder - called Plaster of Paris - is formed. If water is added to the powder, the mixture will harden when allowed to stand for a few hours, and form a cake or cement. Should the heating process be carried too far, all water is driven off and the mineral anhydrite ( $\text{CaSO}_4$ ) is formed, which has little commercial use.

Gypsum occurs in various forms:

1. Selenite: the clear, colorless crystalline form.
2. Satin Spar: a fibrous variety.
3. Alabaster: a fine-grained variety used for statuary.
4. Rock gypsum, or gypsite: the more common commercial source.

Color: white, grey, pink, brown, etc.

Luster: pearly, silky, sometimes dull.

Cleavage: some varieties have perfect cleavage in one direction, imperfect in another, and are fibrous in a third.

Fracture: fibrous and sub-conchoidal; brittle.

Form: gypsum varies from foliated, fibrous, columnar, and granular masses to soft white powdery coatings (gypsite) and to single platy and fish-tailed crystals.

Specific Gravity: 2.3.

Hardness:  $1\frac{1}{2}$  to 2.

Streak: white.

Distinguishing Features: softness (easily scratched with fingernail); one perfect cleavage in crystallized kinds; and non-effervescence in acids. To distinguish it from anhydrite the specimen should be carefully weighed, strongly heated for considerable period of time, and if it loses weight markedly, it is gypsum.

Occurrence: as bedded deposits associated with salt and limestone; formed directly by the evaporation of inland seas. Secondary gypsum may originate through the interaction of sulphuric acid or other sulphate compounds with



limestone or some other calcareous sediment.

Similarities: anhydrite, calcite, zeolites, talc, and mica.

Uses: for the manufacture of calcined gypsum (plaster of paris); for the manufacture of cement; for a soil stabilizer; for a paint filler; for a flux; and for ornaments.

HALITE (Rock Salt)  
(hay'-lite)

Halite is the natural form of sodium chloride (NaCl), or common table salt, which is so essential to the health of man. It is also essential to the chemical industry, and fortunately the United States has extensive reserves.

Color: transparent or white when pure; often tinted yellow, pink, or blue.

Luster: vitreous.

Cleavage: cubic perfect and easily developed.

Fracture: conchoidal; brittle.

Form: halite is found as cubic crystals, as cubic fragments of larger crystals, and as granular to compact masses.

Specific Gravity: 2.1 to 2.6.

Hardness:  $2\frac{1}{2}$ .

Streak: white.

Distinguishing Features: its salty taste, perfect cubic cleavage, and softness.

Occurrence: most common in solid form as rock salt; found in beds or as salt domes (salt structures) associated with limestone, gypsum, anhydrite, as well as calcium and magnesium chlorides. Also occurs in sea water and in brines of inland or coastal lakes which have no outlet.

Similarities: such chlorides as sylvite (KCl) or carnalite ( $KMgCl_3 \cdot 6H_2O$ ), which are often found with halite. Fluorite is much harder and occurs differently.

Uses: for table salt and in the chemical, glass, and ceramic industries.

HEMATITE (Specular Iron, Red Iron Ore, Kidney Stone)  
(hem'-a-tite)

Hematite is an iron (ferric) oxide ( $Fe_2O_3$ ), containing when pure 70% iron. It is the most important ore of iron in the Great Lakes region and in the southern Appalachian Mountains. Some hematite occurs in Columbia county, northwest of Portland, Oregon, but most of the iron ore of this region is limonite. Hematite is found in many forms:

Specular iron (specularite) is steel grey, dark brown, or brownish black foliated or flaky hematite.

Kidney ore (red hematite) is often red or dark brown, occurring in columnar, fibrous or reniform (mammillary) masses.

Oolitic hematite is the red sedimentary iron ore of the southern Appalachian Mountains. It looks like cemented buckshot, and consists of small, rounded concretionary grains.

Massive hematite is important in the Lake Superior region.

Color: steel grey, brown, red, and black.

Luster: metallic, sometimes dull.

Cleavage: none.

Fracture: earthy, hackly, and sometimes conchoidal.

Form: as described above, the form is variable.

Specific Gravity: 5.0.

Hardness:  $5\frac{1}{2}$  to  $6\frac{1}{2}$ .

Streak: a bright brownish red or dark red, and is a distinctive physical property.

Distinguishing Features: brownish red streak, non-magnetic character, and low water content or complete absence of water.

Occurrence: both as disseminations and massive with various rock associations as contact metamorphic deposits; as residual alteration deposits; as metasomatic replacements of cherty iron carbonate; and as hematite schists in metamorphic rocks. It is very widely distributed in small deposits.

Similarities: limonite, magnetite, chromite, ilmenite, and franklinite.

Uses: the most important iron ore.

#### ILMENITE (ill'-men-ite)

Ilmenite is titaniferous iron oxide ( $\text{FeTiO}_3$ ). It is very common in coarse-grained basic igneous rocks and has many characteristics similar to magnetite, hematite, and chromite.

Color: iron black.

Luster: sub-metallic and metallic.

Cleavage: none.

Fracture: conchoidal; brittle.

Form: it is found as tabular crystals and flat plates; as disseminated grains in compact masses; and as loose rounded sand grains.

Specific Gravity: 4.5 to 5.

Hardness: 5-6.

Streak: black to brownish black, but darker than hematite. Its composition is similar to hematite except that one molecule of titanium has replaced one molecule of iron.

Distinguishing Features: brownish black streak. Non-magnetic or weakly magnetic. Chromite occurs in octahedrons.

Occurrence: in basic coarse-grained igneous rocks and in black sands; associated with magnetite, hematite, chromite, pyrite, garnet, etc.

Similarities: magnetite, hematite, franklinite, chromite, wolframite, etc.

Uses: ore of titanium, used in paints, and in steel alloys.

LIMONITE (Brown Hematite, Bog Ore, Yellow Ocher)  
(lie'-moe-nite)

Limonite is hydrated ferric oxide ( $2\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ ), containing when pure about 60 percent iron and about 14 percent water.

Color: ocher-yellow to yellowish brown, to brown.

Luster: in compact varieties often silky to sub-metallic, but generally dull or earthy.

Cleavage: none.

Fracture: uneven, conchoidal.

Form: variable, occurring as botryoidal, nodular, pisolitic, and porous.

Specific Gravity: averages 3.8.

Hardness: 1 to 5; about  $5\frac{1}{2}$  when pure.

Streak: yellowish brown.

Distinguishing Features: its yellowish brown streak, its high water content, and its structure or form.

Occurrence: . . . as a secondary mineral formed by the breaking down of iron-bearing minerals and rocks. It has the same general chemical composition as common rust which forms on metallic iron when exposed to a humid atmosphere. It may occur as a sedimentary bedded deposit, as a metasomatic replacement of limestone, and as pseudomorphs.

Similarities: hematite and other iron oxides, manganese oxides, bauxite.

Uses: as an ore of iron and as a yellow pigment.

MAGNESITE  
(mag'- neh-site)

Magnesite is magnesium carbonate ( $MgCO_3$ ), containing 47.6 percent magnesia ( $MgO$ ). Sometimes it is hard and tough owing to admixed silica. In sedimentary deposits it may be mechanically mixed with calcite and dolomite, which have very similar physical properties; sometimes it contains a little siderite. Extensive deposits occur in Stevens county, Washington, and in California and Nevada.

Color: snow-white to grey; also reddish or brown.

Luster: vitreous to dull.

Cleavage: in the crystalline varieties, rhombic like calcite.

Fracture: conchoidal in fine-grained compact masses.

Form: most common in compact, porcelain-like masses; sometimes coarsely crystalline and granular as in the Washington deposit.

Specific Gravity: 3.0.

Hardness:  $3\frac{1}{2}$  to  $4\frac{1}{2}$ , sometimes harder when silica is admixed.

Streak: white.

Distinguishing Features: its fairly high specific gravity and hardness, its toughness, its very fine-grained texture; and its mild effervescence in cold dilute HCl.

Occurrence: the larger deposits are lenses in sediments formed by hydrothermal replacement of dolomite; some deposits are formed by the alteration of rocks rich in magnesia, and are associated with metamorphic minerals such as talc, chlorite, serpentine etc.

Similarities: calcite, dolomite, and rhodochrosite.

Uses: the greatest demand is for refractory purposes; other uses are as a chemical accelerator in rubber, and for cements.

MAGNETITE (Magnetic Iron Ore, Lodestone)  
(mag'- neh-tite)

Chemically magnetite is iron oxide  $Fe_3O_4$ , sometimes written  $FeO.Fe_2O_3$ . It is usually strongly magnetic and will deflect a compass needle.

Color: dark grey to iron-black.

Luster: metallic, sometimes rather dull.

Cleavage: not distinct, but it breaks or parts parallel to the octahedral faces.

Fracture: sub-conchoidal; brittle.

Form: most commonly occurs as small crystalline or non-crystalline grains either embedded in a massive rock or loose in black sands. Sometimes found as octahedral crystals and as granular masses.

Specific Gravity: 5.1.

Hardness:  $5\frac{1}{2}$  to  $6\frac{1}{2}$ .

Streak: black.

Distinguishing Features: magnetite is strongly magnetic, that is, it is attracted to a magnet, and the "lodestone" variety will act as a magnet. It has a black streak which differentiates it from chromite or hematite. Both franklinite and ilmenite have a similar streak, but are only weakly magnetic.

Occurrence: magnetite is very widely distributed, being very common in crystalline basic igneous rocks as small grains and as segregated masses. It is also common in highly metamorphosed rocks and in contact metamorphic deposits. Magnetite is usually the principal constituent of "black sand".

Similarities: ilmenite, franklinite, hematite, and chromite.

Uses: an iron ore.

#### MALACHITE (mal'-a-kite)

Malachite is a hydrous copper carbonate,  $\text{Cu}_2(\text{OH})_2\text{CO}_3$ , containing when pure 57.4 percent copper and 8.2 percent of chemically combined water.

Color: emerald green.

Luster: vitreous and velvety, often dull or earthy.

Cleavage: unimportant.

Fracture: uneven, sometimes sub-conchoidal; brittle.

Form: commonly mammillary or kidney-shaped with banded structure; also massive; stalactitic; crystals rarely distinct, but when present their form is slender or acicular.

Specific Gravity: 3.9 - 4.0.

Hardness:  $3\frac{1}{2}$  to 4.

Streak: pale green.

Distinguishing Features: uniform emerald green color; effervescence in cold dilute HCl; fibrous or acicular crystal structure.

Occurrence: malachite results from oxidation of other copper minerals and is found in the upper oxidized zone of copper deposits.

Similarities: weathered azurite, chrysocolla, turquoise, and smithsonite.

Uses: ore of copper; some varieties used as gem stones.

#### MANGANESE MINERALS (man'-gan-ease)

There are six fairly common manganese minerals. Each is described under a separate heading, as follows: manganite, psilomelane, pyrolusite, rhodochrosite, rhodonite, and wad. The last is a soft mixture of several of the other oxides.

#### MANGANITE (man'-gan-ite)

Manganite is a hydrous manganese oxide,  $Mn_2O_3 \cdot H_2O$  containing when pure 62.4 percent manganese. It is a secondary mineral commonly filling veins and cavities.

Color: iron-black or dark grey.

Luster: submetallic.

Cleavage: when present, in one or two directions parallel to the length of the crystals.

Fracture: uneven.

Form: in columnar and fibrous masses and in prismatic crystals, which are vertically striated and often grouped in bundles.

Specific Gravity: 4.3.

Hardness: 4.

Streak: reddish brown to black

Distinguishing Features: its crystalline structure; harder than pyrolusite, softer than psilomelane; streak.

Occurrence: most commonly as a secondary mineral filling veins and cavities associated with barite and calcite and also found in residual clays with psilomelane.

Similarities: psilomelane, pyrolusite.

Uses: an ore of manganese.

## MERCURY (Quicksilver)

Metallic mercury, or quicksilver, occasionally occurs free in nature as small globules, usually associated with cinnabar, in quicksilver deposits.

Mercury minerals are: mercury, cinnabar, metacinnabarite, and calomel.

## MICA MINERALS

These minerals are included in a group which have similar physical properties with the general chemical formula  $R Al SiO_2 H_2O$ , (the "R" standing for K, Mg, Fe, Li or Ti), and are as follows: muscovite, biotite, phlogopite, vermiculite, and lepidolite. Their physical characteristics:

Color: various; water clear to dense black.

Luster: cleavage surfaces are pearly to vitreous.

Cleavage: perfect basal cleavage; mica may be split into thin sheets.

Fracture: seldom developed.

Form: when crystallized, most micas form squat pseudo-hexagonal prisms.

Specific Gravity: 2.7 - 3.1.

Hardness: 2.5 - 3.5.

Streak: white to pale green, usually lighter than the solid mineral.

Distinguishing Features: perfect basal cleavage.

Occurrence: mica is found in nearly all of the acid igneous rocks such as granite, syenite, diorite, and pegmatite. Commercial sheet or book mica is found in granitic pegmatite. Mica flakes are a common constituent of many sands. Mica is also generally contained in schists.

Similarities: chlorite, gypsum, talc.

Uses: muscovite and phlogopite are used as insulating materials in electrical apparatus. Phlogopite can withstand up to  $1000^{\circ} C$ . Vermiculite after heat treatment is used for insulating purposes in building construction. Powdered vermiculite and muscovite are used in roofing compounds.

The mica minerals as outlined above have individual characteristics as follows:

Muscovite ( $H_2K Al_3(SiO_4)_3$ ), is usually practically colorless, but is sometimes grey, light green and yellow. It is commonly found in foliated masses and scales. In pegmatites it may occur as large books. Muscovite is usually

flexible, and resistant to weathering. The fine-grained variety of muscovite is called sericite, and gives a golden sheen to the rock in which it appears.

Biotite: ( $(\text{HK})_2(\text{MgFe})_2\text{Al}_2(\text{SiO}_4)_3$ ) is the most common form of mica, and is usually dark green or black in color. It has less flexibility and is less resistant to weathering than muscovite.

Vermiculite: this mineral, which resembles biotite, is considered to be a hydrated form of biotite. It possesses the peculiar property of exfoliating or expanding to a remarkable degree when heated, even with a match. This characteristic is due to the formation of steam between the separate layers.

Phlogopite (Magnesian mica): this is a brown or amber colored mica, composition of which is closer to that of biotite than to muscovite. Its color appears golden on cleavage surfaces and is sometimes mistaken for gold flakes when finely divided in sand.

Lepidolite (lithia-iron mica): this mineral is rather rare. It has been found in pegmatites and is mined as an ore of lithium. It is easily recognized by its rosy lavender color, which is almost unique among minerals.

#### MOLYBDENITE (moe-lib'-de-nite)

Molybdenite is molybdenum sulfide ( $\text{MoS}_2$ ); it has an appearance very similar to that of graphite.

Color: bluish lead grey.

Luster: metallic.

Cleavage: perfect in one direction, almost micaceous. The sheets are slightly flexible and sectile.

Fracture: none.

Form: hexagonal, but molybdenite is seldom found in crystal form. It usually occurs as foliated masses or as disseminated (scattered) scales.

Specific Gravity: 4.7 - 4.8.

Hardness:  $1-1\frac{1}{2}$ , slightly greater than graphite; easily scratched with the finger nail.

Streak: greenish to bluish black, but makes a bluish-grey to greenish grey mark on paper.

Distinguishing Features: molybdenite is very similar to graphite, but may be distinguished particularly by its greenish to bluish streak on a streak plate. Graphite streak is lead colored. Molybdenite also has higher specific gravity and a brighter color.



Occurrence: found in the more siliceous rocks, such as granites and pegmatites, in veins, in contact deposits, and as disseminations in country rock.

Similarities: graphite.

Uses: ore of molybdenum.

MONAZITE  
(mon'-a-zite)

Monazite is . . . . a phosphate of the cerium metals with a formula which may be represented as  $(\text{Ce,La,Nd,Pr})\text{PO}_4$ . but thoria and silica are nearly always present. The importance of monazite commercially is due to the thoria content.

Color: honey yellow, brown, reddish.

Luster: resinous, translucent in grains; large crystals in rocks dull to opaque.

Cleavage: parting (similar to cleavage) may be prominent in one direction.

Fracture: conchoidal to uneven.

Form: usually in the form of grains in various sands; sometimes in prismatic crystals and in masses in gneissoid rocks and pegmatites.

Specific Gravity: 4.7 - 5.3.

Hardness: 5.

Streak: grains usually too small to give a streak.

Distinguishing Features: color, mineral association. Monazite possesses radioactive properties strong enough to affect a photographic plate. If an unexposed photographic plate or film is wrapped in black photographic paper, without exposing it to the light, and a key, coin or other small, distinctly shaped metal object having a small amount of the supposed monazite sand on top of it is placed on the outside of the black paper, the radioactive rays given off by the monazite will pass through the black paper but not through the metal object, and the photographic negative will be fogged except where covered by the metal object. The plate or negative is then developed in the usual manner; a fogged plate will indicate the presence of radioactive material.

Occurrence: in some sand deposits, and in gneisses and pegmatites.

Similarities: sphene (titanite) and zircon; usually optical tests are necessary to detect the presence of monazite in sands.

Uses: as a source of thorium which when made into a nitrate is used in incandescent mantles.

MUSCOVITE  
(muss'-ko-vite)  
(see Mica)

NICCOLITE (Copper Nickel)  
(nick'-ko-lite)

Niccolite is nickelarsenide, having the chemical formula  $\text{NiAs}$ . It usually contains a little iron, cobalt, sulphur, and antimony.

Color: pale copper red.

Luster: metallic.

Cleavage: none.

Fracture: uneven.

Form: nearly always massive.

Specific Gravity: 7.33 - 7.67.

Hardness: 5 -  $5\frac{1}{2}$ .

Streak: pale brownish black.

Distinguishing Features: color, specific gravity, mineral association.

Occurrence: found associated with native silver and smaltite and more rarely with copper and other metallic sulphides.

Similarities: pyrrhotite.

Uses: ore of nickel.

#### NITRATES

Nitrates include such minerals as contain the nitrate radical, and are usually soluble in water. The principal mineral, nitratine, is commonly known as soda niter. Chemical composition: usually sodium nitrate, although impurities may also be present.

Color: white or colorless.

Luster: earthy.

Cleavage: practically identical with calcite, that is, at angles of  $73^{\circ}30'$ . This is known as rhombohedral cleavage. (See Calcite).

Fracture: not apparent.

Form: nitratine crystallizes in rhombohedrons (see Calcite) very similar to calcite. Usually, however, the mineral is massive and the crystal form is distinguished with difficulty. As the mineral is soluble in water, if the water is evaporated, crystals may form that will permit identification.

Specific Gravity:  $1\frac{1}{2}$  - 2.

Hardness:  $1\frac{1}{2}$  - 2.

Streak: white.

Distinguishing Features: its cool, saline taste.

Occurrence: nitratine is soluble in water. Therefore deposits are usually found in arid regions, such as southeastern Oregon. In that region, it is associated with rhyolites, and occurs in cavities as incrustations. There have been efforts made to mine the nitrates on a commercial scale, but they have met with no great success because the deposits are not extensive.

Similarities: none.

Uses: nitratine or nitrates are valuable for fertilizers and in the manufacture of potassium nitrate.

#### OLIVINE (ol'-i-vene)

Olivine is a silicate with varying amounts of iron and magnesium and a general formula of  $(Mg, Fe)_2SiO_4$ . It is the chief rock-forming mineral of the ultra-basic rocks, making up a large percentage of such coarse-grained types as peridotite. Pure olivine rock is called "dunite". Olivine appears as crystals in many basalts.

Color: yellowish green to bottle green. Weathering may give it a reddish to rust yellowish green color.

Luster: vitreous.

Cleavage: not distinct.

Fracture: conchoidal, brittle.

Form: usually found in disseminated masses (grains scattered through the rock) or segregations of granular masses. The crystals are orthorhombic and tabular.

Specific Gravity: 3.3.

Hardness:  $6\frac{1}{2}$  - 7.

Streak: colorless.

Distinguishing Features: its olive-green color and the absence of cleavage.

Occurrence: basic, or femic, igneous rocks such as peridotite and basalt. Segregations of sizeable masses may be commercially important.

Similarities: epidote.

Uses: large masses of dunite have important use in the manufacture of refractories. Low iron content is required, as presence of iron seems to cause its fusion at lower temperatures. Clear crystals are used as gems, under the name of peridot.

OPAL  
(O'-pal)

Opal is an hydrous form of silica. When pure it may be used as a gem. More frequently it is mixed with clay and other impurities. It is silicon dioxide with water ( $\text{SiO}_2 \cdot 2\text{H}_2\text{O}_x$ ).

Color: any color. Precious opal has a play of colors due to minute fracturing.

Luster: greasy to pearly.

Cleavage: none.

Fracture: conchoidal. Very brittle, the most fragile of all gems.

Form: amorphous (non-crystalline) silica in lumps and masses.

Specific Gravity: 2 to 2.3.

Hardness:  $5\frac{1}{2}$  to  $6\frac{1}{2}$ .

Streak: none.

Distinguishing Features: its softness and lower specific gravity distinguish it from quartz and chalcedony, as does its greasy luster.

Occurrence: opal is deposited from alkaline solutions and has no crystalline structure (amorphous). It may alter to chalcedony through loss of water and by becoming cryptocrystalline (microscopic crystals).

Similarities: chalcedony.

Uses: certain varieties are important gem materials.

ORPIMENT  
(or'-pih-ment)

Orpiment is an arsenic sulfide, with a lemon yellow color. Some realgar is usually present. Its color and association with realgar make it an easy mineral to identify. (See Realgar).

Color: lemon-yellow.

Luster: dull.

Cleavage: not distinct.

Fracture: none.

Form: foliated masses, or powdery incrustations.

Specific Gravity. 3.4 - 3.5.

Hardness:  $1\frac{1}{2}$  - 2.

Streak: pale lemon-yellow.

Distinguishing Features: yellow color.

Occurrence and Association: a vein mineral usually associated with realgar.

Similarities: none.

Uses: synthetic arsenic trisulfid, known as "king's yellow" is used as a pigment.

#### ORTHOCLASE

(or'-tho-klaze)

(see also Feldspar and Plagioclase)

Orthoclase is the most common member of a group of feldspars called potassium, or alkali, feldspars on account of their composition. Orthoclase is found in the more acidic or siliceous rocks.

Color: white, grey, pink or red.

Luster: vitreous to pearly. The succession of thin cleavage planes that give rise to the step-like appearance provide the conditions necessary for pearly luster.

Cleavage: in two directions at right angles. The cleavages may have a step-like appearance which results from the break across tiny cleavage surfaces, and may be best observed by holding the rock or specimen toward the light and turning it in various directions. Light is reflected from these surfaces as from a mirror. It may be noticed that only half the crystal reflects light, that a slight turn or rotation will reflect light from the other half as the first goes dark. This feature is a result of what is known as Carlsbad twinning.

Fracture: In some white varieties the fracture may be conchoidal.

Form: orthoclase occurs disseminated through rock masses and as attached and embedded crystals.

Specific Gravity: 2.54 to 2.6.

Hardness: 6 to 6.5.

Streak: white.

Distinguishing Features: orthoclase is difficult to distinguish from plagioclase. If an example of Carlsbad twinning can be found, the feldspar is probably orthoclase while polysynthetic twinning is certain to be developed in plagioclase. . . . . Often it is necessary to identify it merely as feldspar.

Occurrence: orthoclase is usually found in the more siliceous rocks, such as granite, diorite, etc., but may also occur in a certain few basic rocks. The arkosic sandstones of western Oregon carry some orthoclase. Large masses of orthoclase are found in pegmatites, and in this form the mineral has an economic value in pottery and china clay operations. Feldspars alter to kaolin, which is a type of "pure" china clay. Slight alteration may cloud some cleavage surfaces. Complete alteration may leave clay (kaolin) in place of the feldspar, or it may be removed entirely and deposited elsewhere.

Similarities: plagioclase.

Uses: ceramics.

#### PHOSPHATE ROCK

Phosphate rock is composed largely of the amorphous (non-crystalline) mineral collophane, a calcium carbonate-phosphate. It is a difficult material to identify without blowpipe or chemical tests because of its indefinite character. Suspected phosphate rock should be sent to a laboratory for identification if means are not available for making the test in the field.

#### PITCHBLEND

Pitchblende is a complex compound of uranium and oxygen having no definite chemical composition. Radium is present in very small varying amounts.

Color: grey-green to black.

Luster: pitchy or greasy to dull.

Cleavage: none.

Fracture: conchoidal to uneven; brittle.

Form: massive.

Specific Gravity: 6.5 to 8.0.

Hardness:  $5\frac{1}{2}$

Streak: olive-green to black.

Distinguishing Features: its high specific gravity distinguishes it from black minerals of pitchy luster. If placed on an unexposed photographic plate it will fog the film.

Similarities: it is similar to pitchstone or obsidian, in color, fracture, and luster, but it is easily determined by its specific gravity.

Occurrence: in metalliferous veins with sulphides of lead, iron, copper, cobalt and zinc.

Uses: it is a source of uranium and radium.

PLAGIOCLASE  
(plaj'-ee-oh-klaze)  
(see also Feldspar and Orthoclase)

Plagioclase is one of the principal rock forming minerals. It belongs to the feldspar group, and is actually a group of minerals itself. (See Feldspar). The plagioclase minerals vary in composition from sodium (albite) to calcium (anorthite) aluminum silicate, and are also known as the soda-lime feldspars.

Color: white to grey, sometimes with a play of colors as in labradorite.

Luster: vitreous.

Cleavage: perfect in one direction and less perfect in another at nearly right angles to the first. Grooves or striations that are parallel to the long edge of the cleavages are a sure indication that the feldspar is a plagioclase.

Fracture: poorly developed.

Form: it seldom occurs in crystals which can be identified as such. As a rule, in basic rocks plagioclase has a lath-shape.

Specific Gravity: 2.6 - 2.7.

Hardness: 6.

Streak: white.

Distinguishing Features: similar to orthoclase.

Occurrence: Plagioclase is an essential feldspar in the more basic igneous rocks, particularly andesites and basalts. Some plagioclase (usually albite) occurs in the siliceous igneous rocks. If found in sedimentary rocks, it has resulted from the decomposition of an igneous rock containing plagioclase. Also it is contained in some metamorphic rocks. In fact, all rocks should be suspected of containing some feldspar until proven otherwise. Alteration: to saussurite, a greenish aggregate of zoisite minerals, also to clays, similar

Similarities: orthoclase. to orthoclase.

Uses: similar to orthoclase.

## PLATINUM

Platinum is a heavy, silvery white metal found in rounded grains, scales, irregular lumps and sometimes as nuggets. If iron is alloyed with platinum it may be slightly magnetic.

Color: silvery white.

Luster: bright metallic.

Cleavage: none.

Fracture: hackly; malleable.

Form: rounded grains, scales, irregular lumps and sometimes nuggets.

Specific Gravity: 14-19.

Hardness:  $4\frac{1}{2}$ .

Streak: light steel grey.

Distinguishing Features: high specific gravity and malleability.

Occurrence. found in placers and in basic (non-siliceous) rocks such as peridotites and dunites with chromite, olivine and serpentine.

Similarities: slightly-rusted to bright iron or steel shavings.

Uses: jewelry; scientific uses; catalyst.

PROUSTITE (Ruby Silver)  
(proos'-tite)

Proustite is one of the so-called "ruby silver" ores and is chemically classed as a silver-arsenic-sulfide ( $Ag_3AsS_3$ ). Pyrargyrite, a silver-antimony-sulfide ( $Ag_3SbS_3$ ) is the other "ruby silver". Color and streak may distinguish the two.

Color: scarlet-vermilion.

Luster: adamantine.

Cleavage: one direction, good.

Fracture: conchoidal to uneven.

Form: massive, and as distinct crystals.

Specific Gravity: 5.57 - 5.64.

Hardness: 2 - 2½.

Streak: Scarlet-vermilion.

Distinguishing Features: it has a lighter color and streak than pyrargyrite. Its similarity to cuprite and cinnabar requires blowpipe tests to distinguish between them.

Occurrence: as a vein mineral.

Similarities: pyrargyrite, cuprite, and cinnabar.

Uses: ore of silver.

PSILOMELANE (Black Hematite)  
(sil-om'-e-lane)

Psilomelane is an impure hydrous oxide of manganese.

Color: black to brown.

Luster: earthy, submetallic to dull, opaque.

Cleavage: none.

Fracture: conchoidal, if any.

Form: amorphous, no crystalline structure. It is a compact, massive to earthy mineral. Sometimes in botryoidal and stalactitic shapes.

Specific Gravity: 3.7 to 4.7, depending on its purity.

Hardness: 5-6, depending on its purity.

Streak: brownish black to brown.

Distinguishing Features: its hardness distinguishes it from pyrolusite and manganite, and its darker streak from limonite.

Occurrence: occurs in residual clays and in bog deposits. It may occur as an alteration product with other manganese minerals.

Similarities: pyrolusite, manganite, limonite.

Uses: ore of manganese.

PUMICE AND PUMICITE.

Pumice and pumicite are not minerals, but rocks, consisting of a fairly pure aggregate of a mineral compound. They are composed mainly of fine vesicular, fibrous glass. Their chemical analyses show the composition to be very similar to



the more siliceous lavas. Often pumice is porphyritic, containing crystals of feldspars, amphiboles and pyroxenes. Both result from the volcanic eruption of salic lavas.

Pumice is very porous and light of weight. It is found in fragments ranging in size from sand to large blocks. Because of the abundance of sealed glass cells some specimens will float indefinitely.

Pumicite is volcanic ash or dust which has resulted from the complete disruption of pumice during a volcanic explosion. The winds spread the dust outward from the source over the surrounding country, upon which it usually settles as a thin blanket. Sometimes thick deposits have been formed where the wind had drifted the ash into a protected canyon or by the streams having transported and deposited it in a lake.

Because pumice and pumicite are chemically and physically nearly the same they will be described as one.

Color light colored, mostly white and grey.

Luster vitreous to dull; separate grains are glassy appearing.

Form soft porous beds, which form powdery talus slopes.

Specific Gravity around 2.5 when all the air-cells are broken down.

Hardness: 5.5 to 6

Distinguishing Features: glassy appearance, porous texture and grittiness, when crushed between the teeth. Insoluble in acids.

Occurrences: in stratified layers interbedded with sedimentary and volcanic rocks. Usually abundant in a region of fairly recent volcanic activity.

Similarities diatomite, silty clay.

Uses: about 88 percent is used for cleansing and scouring compounds, and the rest for abrasives, cement admixtures, acoustic stucco and plaster.

PYRARGYRITE (Ruby Silver)  
(pie-rar'-gee-rite)

Pyrargyrite is one of the so-called "ruby silver" ores, the other being proustite. The principal differences between the two are color and streak. Pyrargyrite is a silver antimony sulfide ( $Ag_3SbS_3$ ) and proustite is silver-arsenic-sulfide ( $Ag_3AsS_3$ ).

Color: black to dark red; thin plates are deep red.

Luster: metallic-adamantine.

Cleavage: one direction good; one direction poor.

Fracture: conchoidal to uneven.

Form: massive. Crystals are prismatic.

Specific Gravity: 5.7 - 5.9.

Hardness:  $2\frac{1}{2}$ .

Streak: purplish red.

Distinguishing Features: red fragments and purplish red streak - proustite has a brighter color and streak.

Occurrence: a vein mineral formed by ascending solutions.

Similarities: proustite; cuprite, and cinnabar.

Uses: ore of silver.

PYRITE (Fool's Gold)  
(pie'-rite)

Pyrite is iron sulfide, a compound of iron and sulphur ( $\text{FeS}_2$ ).

Color: silvery to pale brass-yellow and may tarnish brown with a beautiful play of colors (iridescence).

Luster: metallic.

Cleavage: imperfect, cubic.

Fracture: conchoidal to uneven.

Form: pyrite crystallizes in the isometric system and is often found as cubes, pyritohedrons, octahedrons, and as massive and granular bodies. Pyritohedron faces have 5 edges. The crystal faces are often striated, or grooved.

Specific Gravity: 5.0.

Hardness: 6 to 6.5.

Streak: greenish to brownish black.

Distinguishing Features: the hardness and brittleness of pyrite distinguish it from gold. Chalcopyrite and pyrrhotite can be scratched with a knife, whereas pyrite can not. It is distinguished from marcasite with difficulty.

Occurrence: pyrite is the most common and widely distributed of the sulfides. It may occur in a rock as a result of the primary, or original deposition from a molten condition, or it may be secondary. Solutions containing iron are frequently reduced by carbon and we often find pyrite in coal and in carbonaceous sediments. Waters carrying soluble sulfides may also deposit pyrite from solution.

Alteration: pyrite tends to alter to limonite, the "iron-rust" mineral. Many times the alteration has proceeded in a manner whereby the limonite takes the crystal form of the pyrite (pseudomorphism) by replacement. Each atom of oxygen replaces an atom of sulphur and we say that the limonite is a pseudomorph after pyrite.

Similarities: marcasite, pyrrhotite, chalcopyrite, gold, and arsenopyrite.

Uses: pyrite is not classed as an iron ore, although the pure mineral contains 46.6% iron. It is used in the manufacture of sulfuric acid, but sulfur is replacing pyrite for that use. Gold is sometimes associated with pyrite, but its presence cannot be predicted by an "eye-ball assay".

PYROLUSITE (Black Oxide of Manganese)  
(pie'-row-lue'-site)

Pyrolusite is a hydrous manganese oxide,  $MnO_2(H_2O)_x$ .

Color: black.

Luster: metallic to dull; opaque.

Cleavage: none.

Fracture: splintery; often distinguishable.

Form: fibrous and columnar; massive.

Specific Gravity: 4.8.

Hardness: 2-2 $\frac{1}{2}$ ; soils the fingers very readily.

Streak: black.

Distinguishing Features: its softness distinguishes it from the other black manganese minerals.

Occurrence: usually an alteration product of manganite.

Similarities: manganite, psilomelane, limonite.

Uses: ore of manganese.

PYROXENE  
(pie'-rox-ene)

Pyroxene is a general name applied to a group of complex silicate minerals, of which the principal ones are:

augite	rhodonite (which see)
diopside	hedenbergite
hypersthene	diallage
aegirite (acmite)	spodumene
enstatite (and bronzite)	

It is very difficult to distinguish some of these minerals by megascopic (hand lens) methods, so they are discussed as a group.

Color: usually black, but may be grey, green, brown, and even white (diopside), and pink (rhodonite).

Luster: vitreous to pearly.

Cleavage: two well-developed cleavages, parallel to the length of the crystals; at nearly right angles to each other.

Fracture: uneven; brittle.

Form: the crystals are stubby as a rule, and have a cross section that is square, or nearly so. They sometimes occur in bladed and columnar masses.

Specific Gravity: 3.2 to 3.6.

Hardness: 5 to 6.

Streak: white to grey-green.




Distinguishing Feature: (see amphibole)

## Pyroxene

## Amphibole

## Epidote

## Tourmaline

Color	dark brown, green, black; may be red or white.	dark green, black; may be light green, white.	usually a distinctive pistachio-green	black; also pink, pale green.
Cleavage	two cleavages, with angle between planes $87^\circ$ & $93^\circ$ 	two cleavages, with angle between planes $56^\circ$ & $124^\circ$ 	one cleavage	poor cleavage
Form	short crystals	long crystals, sometimes fibrous	long crystals, with striations	long crystals, with striations
Cross-section of crystal	often same as cleavage, nearly square	six sided	six sided	triangular 
Hardness	5-6	5-6	6-7	7-7-5

Occurrence: pyroxenes are associated with igneous rocks, especially the basic ones. Pyroxenes are characteristic of basalts and gabbros, and do not commonly occur in rocks that contain quartz. They are readily decomposed on weathering and are not usually found in sedimentary rocks.

Alteration: pyroxenes readily alter to carbonates and oxides and are generally the first minerals in basic igneous rocks to be affected by weathering. Under intense metamorphism they may alter to amphibole.

Similarities: amphibole, epidote, tourmaline.

Uses: . . . . . Jadeite (included in the pyroxene group) is used as a semi-precious and ornamental stone, especially in China.

#### PYRRHOTITE (see p.98b)

QUARTZ  
(kwarts)

Quartz is one of the most common minerals. Many valuable minerals are associated with siliceous (acid) rocks of which quartz is an important component. Chemically it is composed of silicon dioxide,  $\text{SiO}_2$ , of which there are three main varieties:

1. Quartz
2. Chalcedony (see chalcedony)
3. Opal (see opal)

Color: colorless, white, rose, amethyst, etc.

Luster: vitreous.

Cleavage: none.

Fracture: conchoidal.

Form: crystals of hexagonal form with pointed pyramidal ends are common in places where they have had an opportunity to grow unhampered. More frequently quartz is quite massive, the crystalline structure not being apparent to the eye.

Specific Gravity: 2.6 - 2.7.

Hardness: 7.

Streak: none.

Distinguishing Features: the hardness and lack of cleavage are quite distinctive. Usually has a glassy appearance.

Occurrence: found in most acid igneous rocks; almost never found in basic rocks. Found as grains in sandstones; as massive and crystalline quartz in veins, formed by ascending or descending solutions.

Similarities: beryl, scheelite, white feldspars.

Uses: crystals of large size are used in the manufacture of optical lenses. Massive varieties are used as flux, refractory, abrasive, grits, etc. Nearly pure quartz sands and sandstones are used in the manufacture of glass.

REALGAR  
(ree-al'-gar)

Realgar is an arsenic sulfide, occurring as an incrustation or as disseminated grains.

Color: red, which changes to orange as it alters to orpiment.

Luster: adamantine to resinous.

Cleavage: generally not distinguishable.

Fracture: conchoidal.

Form: massive and granular crystals.

Specific Gravity: 3.5.

Hardness:  $1\frac{1}{2}$  to 2.

Streak: orange yellow.

Distinguishing Features: lower specific gravity and hardness than cinnabar.

Occurrence: vein mineral associated with stibnite, cinnabar, pyrite, etc.

Similarities: cinnabar.

Uses: minor source of arsenic.

RHODOCHROSITE  
(roe'-doe-crow'-site)

Rhodochrosite is manganese carbonate ( $MnCO_3$ ).

Color: pink to brownish red; also yellowish grey and tan.

Luster: vitreous to pearly.

Cleavage: in 3 directions at oblique angles - rhombohedral, - like calcite.

Fracture: uneven; brittle.

Form: in rhombohedral masses, and as crystals; occasionally colloform.

Specific Gravity: 3.5 - 3.6.

Hardness:  $3\frac{1}{2}$  -  $4\frac{1}{2}$ .

Streak: white.

Distinguishing Features: rhodochrosite is heavier than calcite or dolomite, and is softer than rhodonite; soluble with effervescence in warm hydrochloric acid.

Occurrence: in veins with silver and lead ores; also found with other manganese ores.

Similarities: calcite, dolomite, magnesite, and rhodonite.

Uses: an ore of manganese.

RHODONITE  
(row'-doo-nite)

Rhodonite is manganese silicate ( $MnSiO_3$ ) belonging to the pyroxene group, but easily distinguished by its color.

Color: pink to red, sometimes stained black by manganese oxides.

Luster: vitreous.

Cleavage: in two directions at nearly right angles ( $92\frac{1}{2}^\circ$ ).

Fracture: conchoidal to uneven.

Form: cleavable and compact masses. Crystals are triclinic.

Specific Gravity: 3.4 - 3.6.

Hardness:  $5\frac{1}{2}$  -  $6\frac{1}{2}$ ; tough.

Streak: white.

Distinguishing Features: its hardness is greater than rhodochrosite, and its cleavage is more rectangular than rhombohedral. It has higher specific gravity than orthoclase.

Occurrence: rhodonite occurs in veins and as accessory mineral in various deposits.

Similarities: rhodochrosite, magnesite, orthoclase.

Uses: rhodonite is used as an ornamental stone and as a gem material.

RUTILE  
(rue'-teel)

Rutile is a titanium oxide ( $TiO_2$ ).

Color: brownish red to black.

Luster: adamantine to <sup>sub-</sup>metallic.

Cleavage: unimportant. It is imperfect, at right angle.

Fracture: uneven; brittle.

Form: embedded grains or crystals. Long, thin, acicular crystals are found penetrating other crystals.

Specific Gravity: 4.2.

Hardness:  $6-6\frac{1}{2}$ .

Streak: pale brown.

Distinguishing Features: its specific gravity is lower than cassiterite; crystallization, color and adamantine luster are distinctive.

Occurrence: as accessory mineral in veins, and in pegmatites; commonly as crystals embedded in quartz or feldspar; as secondary mineral; and as constituent of auriferous sands.

Similarities: cassiterite, zircon.

Uses: coloring material for porcelain; manufacture of ferrotitanium; paints.

SCHEELITE  
(she'-lite)

Scheelite is calcium tungstate ( $CaWO_4$ ), one of the important ores of tungsten, and is important as a strategic war mineral.

The mineral is rather difficult to determine by ordinary field methods, but its high specific gravity allows it to be detected even when disseminated throughout the rock, by ordinary panning, in the same manner as gold. Its appearance is very similar to that of quartz, but it may be positively identified by the use of the ultra-violet lamp.

Color: white, grey, or pale colors.

Luster: sub-adamantine.

Cleavage: in one direction, interrupted.



Fracture: uneven, brittle.

Form: crystals are tetragonal, while massive forms show little crystal development.

Specific Gravity: 6.0.

Hardness:  $4\frac{1}{2}$  to 5.

Streak: white.

Distinguishing Features: its high specific gravity and luster; its pale-blue fluorescence in ultra-violet light is distinctive.

Occurrence: in veins in crystalline rocks, associated with cassiterite, topaz, apatite and wolframite in quartz. In Oregon found at contacts of granite and limestone, associated with garnet, epidote, molybdenite, etc.

Similarities: quartz.

Uses: ore of tungsten, which is used widely in manufacture of tool steels.

SERPENTINE  
(ser'-pen-tine)

Serpentine is considered to be a hydrated magnesium silicate, with formula  $H_4Mg_3Si_2O_9$  or  $3MgO \cdot 2SiO_2 \cdot 2H_2O$ . It usually contains a small amount of iron replacing magnesium.

Color: usually greenish; also brownish, reddish, and variegated.

Luster: sub-resinous to greasy.

Cleavage: not important.

Fracture: conchoidal to splintery.

Form: usually massive; sometimes fibrous.

Specific Gravity: 2.5 - 2.65.

Hardness: variable,  $2\frac{1}{2}$ -4.

Streak: white, slightly shining.

Distinguishing Features: softness, greasy luster, "feel", and absence of cleavage.

Occurrence: commonly as masses, often of great size, resulting from alteration of certain rocks, notably peridotite. The fibrous variety, chrysotile, is described under asbestos.

Similarities: talc, into which it may grade; chlorite.

Uses: ornamental stone (verde antique); mineral filler.

SIDERITE  
(sid'-er-ite)

Siderite is iron carbonate ( $\text{FeCO}_3$ ) and is a minor ore of iron.

Color: brown to grey.

Luster: highly vitreous to sub-adamantine

Cleavage: 3 directions at oblique angles (rhombohedral), like that of calcite, with curved crystal faces like dolomite.

Fracture uneven; brittle.

Form: siderite occurs in crystals much like those of calcite. Some of the crystal faces may be curved, like those on dolomite. It more usually is found in cleavable masses, crusts, concretions, and oolites.

Specific Gravity: 3.8.

Hardness: 3.5 to 4.

Streak: pale brown to grey.

Distinguishing Features: it is similar to calcite and dolomite, having the same cleavage, but it has a higher specific gravity. Its color and general appearance is like that of sphalerite, but its rhombohedral cleavage and high luster is distinctive.

Occurrence: Siderite is usually a gangue mineral in deposits that are formed by replacements. A variety known as sphaeroiderite occurs in cavities in basalt and was first recognized by amateur mineralogists at Spokane.

Similarities: calcite, dolomite, sphalerite.

Uses: it is a minor ore of iron.

SILVER

The more important silver minerals are:

*Native Silver (Ag)	Proustite $\text{Ag}_3\text{AsS}_3$
*Argentite $\text{Ag}_2\text{S}$	Stephanite $\text{Ag}_5\text{SbS}_4$
Sylvanite $\text{AuAgTe}_4$	Polybasite $(\text{Ag,Cu})_{16}\text{Sb}_2\text{S}$
Pyargyrite $\text{Ag}_3\text{SbS}_3$	*Cerargyrite $\text{AgCl}$

Those starred are described in this bulletin.

Native silver is found at a number of localities, sometimes in large masses. It may contain up to 10 percent gold, or small amounts of copper, platinum, antimony, bismuth, mercury.

Color: tin white to pale yellow - usually dull and tarnished.

Luster: metallic.

Cleavage: none

Fracture: hackly; ductile and malleable.

Form: wire, thin sheets, skeleton crystals, rarely as nuggets.

Specific Gravity: 10.1 - 11.1.

Hardness:  $2\frac{1}{2}$ -3.

Streak: silver-white, metallic.

Distinguishing Features: color of freshly cut surface, and malleability.

Occurrence: a vein mineral associated with cobalt, nickel, copper, and lead; and with other silver minerals from which it was derived. In the gossan, or "iron hat" of some ore deposits, it occurs as native silver. It is rarely found as nuggets, in placer deposits.

Similarities: galena, native antimony, and stibnite.

Uses: monetary; in the arts; and in manufacture of chemicals.

SMALTITE (Co,Ni) As<sub>2</sub>  
(small'-tite)

Smaltite is considered to be a diarsenide of cobalt, but nickel is usually present. The mineral has been found in the ores of certain Oregon mines.

Color: tin white to steel grey, sometimes iridescent (rainbow colors).

Luster: metallic.

Cleavage: absent.

Fracture: granular; brittle.

Form: massive, without cleavage, although cubic crystals may be found occasionally.

Specific Gravity: 5.5 - 6.8.

Hardness:  $5\frac{1}{2}$ -6.

Streak: greyish-black.

Distinguishing Features: color, specific gravity. Smaltite is very similar to arsenopyrite and to cobaltite but may be distinguished from them by chemical and microscopical tests.

Occurrence: it occurs with silver and copper ores and in veins with ores of nickel and copper. Oxidation of smaltite results in erythrite, a pink, earthy mineral, known as "cobalt bloom" which characterizes outcrops of some deposits of cobalt minerals.

Similarities: arsenopyrite; cobaltite; pyrite.

Uses: ore of cobalt.

SMITHSONITE (Dry-bone)  
(smith'-son-ite)

Smithsonite is zinc carbonate,  $ZnCO_3$ .

Color: white to varied; sometimes blue or green.

Luster: vitreous.

Cleavage: has 3 directions of cleavage at oblique angles (rhombohedral) with curved edge like dolomite, but they are not prominently developed.

Fracture: uneven; brittle.

Form: it occurs as nodular masses and rough (drusy) crusts. Rarely found in crystal form.

Specific Gravity: 4.3 - 4.5.

Hardness: 5.

Streak: colorless.

Distinguishing Features: harder than other carbonates that have rhombohedral cleavage. The green and blue varieties resemble chrysocolla but are heavier and harder.

Occurrence: smithsonite occurs in the oxidized zone as an alteration product of sphalerite.

Similarities: chrysocolla, calcite, dolomite.

Uses: minor ore of zinc.

SPHALERITE (Rosin Jack, Black Jack, Zinc Blende)  
(sfal'-er-ite)

Sphalerite is an important ore of zinc and its name means "treacherous" indicating that it is difficult to determine. The Germans call it blende, meaning deceptive. It is zinc sulfide ( $ZnS$ ).

Color: variable, pale yellow (rosin jack) to black (black jack) depending on amount of iron present. Rarely colorless. Some of it is triboluminescent (develops an interior glow with friction).

Luster: resinous to adamantine.

Cleavage: is very prominent. Planes intersect at angles of  $60^{\circ}$ , a type known as dodecahedral.

Fracture: conchoidal; brittle.

Form: massive forms are most common; . . . . . isometric, (like a cube), or some of its modifications. Some of the faces may be striated (grooved).

Specific Gravity: 4.0.

Hardness: 3.5 - 4.

Streak: pale yellow to dark brown.

Distinguishing Features: sphalerite looks like a number of other minerals. Its perfect cleavage and resinous luster are distinguishing features. It is much softer than garnet.

Occurrence: associated with galena, chalcopyrite, pyrite, and other sulfides in metalliferous veins. Often found in limestones and in contact-metamorphic zones.

Similarities: garnet, siderite.

Uses: ore of zinc.

#### STIBNITE (stib'-nite)

Stibnite is antimony sulfide,  $Sb_2S_3$ , and, when pure, contains 71.4 percent antimony.

Color: lead grey.

Luster: brilliant metallic on fresh surfaces, but on exposed faces a lead-grey tarnish develops.

Cleavage: perfect in one direction; parting is sometimes evidenced by lines on the cleavage faces.

Fracture: uneven.

Form: prismatic or acicular crystals, bladed aggregates, or granular masses.

Specific Gravity: 4.5.

Hardness: 2, (it can be scratched with the finger nail).

Streak: lead grey.

Distinguishing Features: crystal form, hardness, low fusibility (it will soften in a match flame) and perfect cleavage are distinguishing features.

Occurrence: vein mineral in quartz with zinc, <sup>lead,</sup> and mercury sulphides; sometimes associated with metallic gold.

Similarities: galena; rutile.

Uses: important source of antimony, which is used in storage battery lead; in babbitt metal, in type metal, and in manufacture of chemicals and munitions.

### SULFUR (Brimstone)

Sulfur (S) is well known and generally easily determined.

Color: yellow to yellowish-orange and-red, occasionally grey.

Luster: resinous to adamantine.

Cleavage: absent.

Fracture: conchoidal, very brittle.

Form: crystals; crusts; masses.

Specific Gravity: 2.

Hardness:  $1\frac{1}{2}$ - $2\frac{1}{2}$ ; varying with amount of impurities.

Streak: colorless.

Distinguishing Features: yellow color, low hardness, brittleness, odor of sulfur dioxide when burned.

Occurrence: its association with gypsum as a result of volcanic activity is well known; results from decomposition of pyrite in coal beds, where it occurs in hot springs deposits, and in regions of active or extinct volcanoes. Combined with other elements, sulfur forms sulphides and sulphates, which occur widely distributed in mineral deposits.

Similarities: none.

Uses: in the manufacture of sulfuric acid; in paper making; in manufacture of gunpowder, fireworks, insecticides, fertilizers, etc.

## TALC (Steatite, Soapstone)

Talc is a secondary mineral formed as the result of rock alteration. It is commonly associated with serpentine, and with talcose or chloritic schist. Chemically it is hydrous magnesium silicate and may contain small quantities of iron and aluminum. It is very resistant to heat and may be used directly as refractory material.

Color: white, grey, or pale green.

Luster: pearly.

Cleavage: perfect in one direction ; compact varieties show no cleavage, as a rule.

Fracture: none. Flexible in thin laminae, but not elastic.

Form: compact, massive, in scales, foliated (like matted leaves), and fibrous masses.

Specific Gravity: 2.7.

Hardness: when pure, 1.

Streak: white.

Distinguishing Features: foliated masses may be mistaken for mica but the sheets are not elastic. Talc has a "soapy" feel.

Occurrence: widely distributed and results from metamorphism (alteration by heat or pressure) from basic rocks. In many cases metamorphic action produces a rock called schist and if sufficient talc is present, it may be classed as a talcose schist. Purity varies over a wide range.

Similarities: mica; chlorite.

Uses: talcum powder; refractories; glaze for paper stock; mineral filler.

TELLURIDES  
(tell'-your-ides)

Tellurides are compounds of tellurium with other metals, usually gold and silver. They are not common, and are difficult to determine in the field; blowpipe, chemical, or optical methods are usually necessary in order to determine them definitely.

Metallic tellurium (Te) is rare, but has been found in some Colorado and European mines, associated with tellurides. The best known tellurides are:

Sylvanite	(Au Ag)Te <sub>2</sub>
Calaverite	AuTe <sub>2</sub>
Hessite	Ag <sub>2</sub> Te
Petzite	(Ag Au) <sub>2</sub> Te

TETRAHEDRITE (Grey Copper)  
(tet'-rah-he'-drite)

Tetrahedrite, frequently called "grey copper", is a compound of copper, antimony and sulfur, with varying amounts of iron, zinc, and sometimes silver as impurities. The pure mineral contains 52% copper; the silver-bearing variety may contain up to 30% silver.

Color: dark iron grey.

Luster: metallic.

Cleavage: none.

Fracture: uneven; brittle.

Form: its name suggests that it occurs as tetrahedrons, a four-sided figure, with 3 edges on each side. . . . . The usual form, however, is massive.

Specific Gravity: 4.4 - 5.1.

Hardness: 3-4½.

Streak: dark iron grey.

Distinguishing Features: When crystallized into tetrahedrons, the crystal form and color are distinguishing characteristics. Massive tetrahedrite can be mistaken for chalcocite, but it is brittle and chalcocite is sectile.

Occurrence: It occurs as a vein mineral with chalcopyrite, galena, sphalerite, and siderite. The massive ore is not uncommon in copper and silver mines.

Similarities: chalcocite.

Uses: ore of copper, and occasionally silver.

TITANIUM MINERALS  
(tie-tane'-ee-um)

The most important titanium minerals are described under the names of ilmenite, rutile, and titanite.

TITANITE (Sphene)  
(tie'-tan-ite)

Titanite is calcium-titanium silicate,  $\text{CaTiSiO}_5$ .

Color: varying tints of yellow or brown.



Luster: adamantine to high vitreous.

Cleavage: indistinct; brittle.

Fracture: none.

Form: Flat, wedge-shaped crystals; massive; granular.

Specific Gravity: 3.4 - 3.5.

Hardness: 5-5½.

Streak: none, or white.

Distinguishing Features: crystal shape.

Occurrence: it occurs in granitoid rocks with magnetite and hornblende, as an accessory mineral. In metamorphic rocks, it probably occurs as a decomposition product of pyroxenes.

Similarities: magnetite, hornblende.

Uses: perfect crystals have been used as gem stones.

#### TOURMALINE (tour'-ma-lene)

Tourmaline is a complex silicate of boron and aluminum containing chemically combined water, and is found as an accessory mineral in many rocks. It occurs in a variety of colors, and is pyro-electric, that is, a crystal which has been heated will on cooling develop positive electricity at one end and negative electricity at the other.

Color: usually black, brownish black, bluish black; also blue, green, red, and sometimes crystals are red at one end and green, blue, or black at the other. Transparent to opaque.

Luster: vitreous to resinous.

Cleavage: none.

Fracture: sub-conchoidal to uneven.

Form: prismatic (long, slender) crystals ranging in size from slender, small needles to those that are 4 inches and more in diameter. Sides of crystals show striations.

Specific Gravity: 3 - 3.25.

Hardness: 7 - 7½.

Streak: uncolored.

Distinguishing Features: a crystal cross section is rounded triangular, and it has no cleavage, as does hornblende; crystals often deeply striated.

Occurrence: in pegmatites, granites, and gneisses, and certain other metamorphic rocks.

Similarities: hornblende, pyroxene (which see).

Uses: the transparent red and green varieties are used as semi-precious gem stones, known variously as rubellite, indicolite, Brazilian sapphire, Brazilian emerald, Peridot of Ceylon (peridot is gem quality olivine), achroite.

#### WOLFRAMITE (wolf'-ram-ite)

Wolframite is one of the principal tungsten minerals and is an iron, manganese, tungsten oxide  $(Fe,Mn)WO_4$ .

Color: dark brown to black.

Luster: sub-metallic to metallic.

Cleavage: perfect in one direction.

Fracture: uneven.

Form: occurs in crystals or aggregates of crystals, somewhat tabular in shape.

Specific Gravity: 7.2 - 7.5.

Hardness: 5 to  $5\frac{1}{2}$ .

Streak: black to dark reddish brown.

Distinctive Features: its high specific gravity, cleavage in one direction, and metallic luster.

Occurrence: wolframite is found in pegmatites and in veins associated with siliceous rocks.

Similarities: hubnerite ( $MnWO_4$ ) is very similar to wolframite; for general field purposes hubnerite may be considered as brown in color and having a brown streak, while wolframite is generally black in color and gives a black streak.

Uses: Ore of tungsten, which is used in tool steels and other steel alloys.

#### ZIRCON (zir'-con)

Zircon, zirconium silicate ( $ZrSiO_4$ ), is an accessory mineral in acid igneous and metamorphic rocks. It is concentrated in certain sands as it is resistant to abrasion (hardness of  $7\frac{1}{2}$ ) and to chemical action.

Color: reddish-brown or grey; sometimes yellow, red, or colorless, rarely blue or green.

Luster: adamantine; brilliant.

Cleavage: imperfect.

Fracture: conchoidal; brittle.

Form: usually found as small grains in river and beach sands, in box-like crystals with pyramidal ends.

Specific Gravity: averages about 4.7, which is rather high for transparent materials.

Hardness: 7.5, harder than quartz.

Streak: uncolored.

Distinguishing Features: Crystal shape and high specific gravity.

Occurrence: loose crystals in sands derived from areas containing granitic and syenitic rocks; crystalline rocks especially granular limestone, chloritic and other schists; gneiss.

Similarities: quartz, cassiterite, rutile, diamond.

Uses: it is used as a refractory in the form of zirconia bricks; in ferro-alloys, and, when pure, as a gem; zirconium compounds are used as welding rod coatings, and in ceramics; zirconium metal is used in radio tubes.

ZEOLITES  
(zee'-oh-lights)

The minerals of this family of hydrous aluminum, calcium and sodium silicates are very similar in composition, association, and mode of occurrence. Many of them fuse easily, and give off water, hence the name, which in Greek means "boiling stone". They are secondary after feldspars.

Color: Most commonly colorless to white. Also yellow, reddish, brown, grey.

Luster: Vitreous.

Cleavage: Usually perfect in one direction.

Fracture Uneven.

Form: Nearly always in twinned crystals, often in sheaf-like aggregates. Platy, cubes, etc

Specific Gravity: 2-2.4.

Hardness: 3.5 - 5.5.

Streak: Colorless.

Distinguishing Features: Are all softer than quartz, and do not have the cleavage nor effervescence in HCl of calcite. They usually have good crystal form, but sometimes are in sheafs or in radiating crystals. Usually light-colored or pinkish.

Occurrence: These minerals are commonly found lining the gas bubbles and cavities in dark colored lavas, as well as in veins in these rocks.

Similarities: Calcite, feldspar, fluorite, garnet, aragonite.

ADDENDA

CORUNDUM  
(kor-un'-dumb)

Corundum is aluminum oxide in its purest natural form,  $Al_2O_3$ . Sapphire, ruby, and emery are all varieties of this mineral, whose brilliant luster and extreme hardness make it ideal as a gem stone.

Color: Gray, brown, nearly white, blue (sapphire), red (ruby).

Luster: Adamantine to vitreous.

Cleavage: In one direction sometimes perfect.

Fracture: Uneven to conchoidal.

Form: Crystals usually rough and rounded, six-sided. Also massive.

Specific Gravity: 4.

Hardness: 9.

Streak: none.

Distinguishing Features: The extreme hardness, only exceeded in nature by the diamond, is the most important characteristic. Its adamantine luster and high specific gravity are also important.

Occurrence: In metamorphosed rocks and granite, occasionally in other igneous rocks, especially those lacking quartz. Burmese rubies are mined from placer deposits.

Similarities: Massive variety may resemble cleavable feldspar, but is harder and denser.

Uses: Clear varieties form valuable gem stone (above). Also formerly used as an abrasive.

PYRRHOTITE  
(peer'-ho-tite)

Pyrrhotite or "magnetic pyrites" is an iron sulphide with a variable composition, although there is always one more "S" than there is "Fe" in the formula. It often contains small amounts of nickel. It is the only sulphide that is magnetic.

Color: Between bronze-yellow and copper-red, but tarnishes easily.

Luster: Metallic.

Cleavage: Usually massive, sometimes cleaves in one direction.

Fracture: Uneven to subconchoidal.

Form: Distinct crystals rare, usually granular massive.

Specific Gravity: 4.6.

Hardness: 3.5 - 4.5.

Streak: Dark greyish black.

Distinguishing Features: It is the only magnetic sulphide mineral; and the peculiar reddish-bronze color is characteristic.

Occurrence: In veins with other sulphides, in large masses in igneous rocks.

Similarities: Niccolite, pyrite, marcasite, chalcopyrite.

Uses: It is an important ore of nickel at Sudbury, Ontario.

FIGURE 14

MINERALS ARRANGED AS TO SPECIFIC GRAVITY

<u>1-2</u>		<u>3-4</u>		<u>5-6</u>	
1.1 - 1.7	Coal	2.2 - 3.2	Asbestos	4.4 - 5.1	Tetrahedrite
1.5 - 2.0	Nitrates	2.6 - 3.4	Chlorite	4.5 - 5	Ilmenite
1.7	Borax	2.7 - 3.1	Mica	5.0 - 5.3	Hematite
1.9 - 2.4	Diatomite	3.0	Magnesite	5.0	Pyrite
		3.0 - 3.2	Fluorite	5.0	Bornite
		3.0 - 3.25	Tourmaline	5.1	Magnetite
<u>2-3</u>		3.0 - 3.5	Amphibole	5.5	Cerargyrite
1.9 - 2.4	Diatomite	3.0 - 3.8	Siderite	5.5 - 5.8	Chalcocite
2.0	Sulfur	3.1 - 4.3	Garnet	5.5 - 6.8	Smaltite
2.0 - 2.3	Opal	3.2	Apatite	5.6	Proustite
2.0 - 2.2	Chrysocolla	3.2 - 3.5	Epidote	5.7 - 5.9	Pyrrargyrite
2.1 - 2.6	Halite	3.2 - 3.6	Pyroxene		
2.2	Graphite	3.3	Olivine		
2.2 - 3.2	Asbestos	3.4 - 3.5	Calamine	<u>6-7</u>	
2.3	Gypsum	3.4 - 3.5	Orpiment	5.5 - 6.8	Smaltite
2.5	Bauxite	3.4 - 3.5	Titanite	6.0	Arsenopyrite
2.5	Pumice	3.4 - 3.6	Rhodonite	6.0	Cuprite
2.5 - 2.6	Orthoclase	3.5	Diamond	6.0	Scheelite
2.5 - 2.7	Feldspar	3.5	Realgar	6.0 - 6.3	Cobaltite
2.5 - 2.7	Serpentine	3.4 - 3.6	Rhodochrosite	6.1 - 6.4	Anglesite
2.5 - 3.1	Mica	3.7 - 4.7	Psilomelane	6.5 - 6.6	Cerussite
2.6	Chert	3.7 - 3.9	Azurite	6.5 - 8.0	Pitchblende
2.6	Chalcedony	3.6 - 4.0	Limonite	6.8 - 7.0	Cassiterite
2.6	Clay	3.8 - 4.0	Malachite		
2.6	Quartz				
2.6 - 2.7	Plagioclase				
2.6 - 2.96	Chlorite	<u>4-5</u>		<u>7-8</u>	
2.7	Beryl	3.1 - 4.3	Garnet	6.8 - 7.0	Cassiterite
2.7	Calcite	3.7 - 4.7	Psilomelane	7.1 - 7.5	Wolframite
2.7	Talc	3.8 - 4.0	Malachite	7.3	Argentite
2.8 - 3.4	Chlorite	3.9 - 4.2	Sphalerite	7.3 - 7.8	Niccolite
2.8 - 3.0	Dolomite	4.1 - 4.3	Chalcopyrite	7.3 - 7.6	Galena
2.9	Anhydrite	4.2 - 4.3	Rutile	8.0 - 8.2	Cinnabar
		4.3	Manganite		
		4.1 - 4.5	Smithsonite		
		4.3 - 4.6	Chromite	<u>8 - over 8</u>	
		4.4 - 5.1	Tetrahedrite	8.0--8.2	Cinnabar
		4.5	Barite	10.1-11	Silver
		4.5	Stibnite	14 - 19	Platinum
		4.3 - 5.5	Ilmenite	15 - 19	Gold
		4.6	Covellite		
		4.7	Zircon		
		4.7 - 4.8	Molybdenite		
		4.7 - 5.3	Monazite		
		4.8	Pyrolusite		

FIGURE 15

MINERALS ARRANGED AS TO HARDNESS

Minerals are arranged alphabetically under each hardness range. Minor variations within each range are not noted. If a mineral has a hardness that extends through more than one range, it is listed in each range; for example, limonite has a hardness of 1-5½; it will be found listed under 1-2, 2-3, 3-4, 4-5, 5-6.

<u>Hardness of 1-2</u>	<u>Hardness of 3-4</u>	<u>Hardness of 5-6</u>	<u>Hardness of 7-8</u>
Bauxite	Anglesite	Amphibole	Beryl
Bentonite	Anhydrite	Apatite	Chalcedony
Cerargyrite	Azurite	Arsenopyrite	Chert
Chlorite	Asbestos (2½-5½)	Asbestos (2½-5½)	Garnet (6½-7½)
Clay (1½-2½)	Barite (2½-3½)	Chromite	Quartz
Coal (1-1½)	Bornite	Cobaltite	Tourmaline
Covellite	Calcite	Feldspar (5½-6½)	Zircon
Diatomite	Cerussite	Hematite (5½-6½)	
Graphite	Chalcopyrite	Ilmenite	
Gypsum	Chrysocolla (2-4)	Limonite (1-5½)	<u>Hardness of 8-9</u>
Limonite (1-5½)	Cuprite	Magnetite (5½-6½)	Topaz
Molybdenite	Dolomite	Monazite	Spinel
Nitrates	Limonite (1-5½)	Niccolite	
Orpiment	Magnesite (3½-4½)	Opal (5½-6½)	
Realgar	Malachite	Pitchblende	<u>Hardness of 9-10</u>
Sulfur (1½-2½)	Mica (2½-3½)	Psilomelane	Corundum (ruby, sapphire)
Talc (1-4)	Rhodochrosite (3½-4½)	Pumice	
	Serpentine (2½-4)	Pyroxene	
<u>Hardness of 2-3</u>	Siderite	Rhodonite (5½-6½)	
Argentite	Sphalerite	Smaltite	<u>Hardness of 10</u>
Asbestos (2½-5½)	Talc (1-4)	Smithsonite	Diamond
Barite (2½-3½)	Tetrahedrite (3-4½)	Titanite	
Biotite		Wolframite	
Borax			
Chalcocite			
Chlorite			
Chrysocolla (2-4)	<u>Hardness of 4-5</u>	<u>Hardness of 6-7</u>	
Cinnabar	Asbestos (2½-5½)	Cassiterite	
Clay (1½-2½)	Fluorite	Epidote	
Coal (1-2½)	Calamine	Feldspar (5½-6½)	
Galena	Limonite (1-5½)	Garnet (6-7½)	
Gold	Magnesite (3½-4½)	Hematite (5½-6½)	
Gypsum	Manganite	Magnetite (5½-6½)	
Halite	Platinum	Olivene	
Limonite (1-5½)	Rhodochrosite (3½-4½)	Opal (5½-6½)	
Mica (2½-3½)	Scheelite	Orthoclase	
Proustite	Tetrahedrite (3-4½)	Plagioclase	
Pyrrargyrite		Pyrite	
Pyrolusite		Rhodonite (5½-6½)	
Serpentine (2½-4)		Rutile	
Silver			
Stibnite			
Sulfur (1½-2½)			
Talc (1-4)			

FIGURE 16

MINERALS ARRANGED AS TO STREAKBlack:

Chalcocite  
Coal  
Graphite  
Ilmenite  
Magnetite  
Manganite  
Molybdenite (greenish)  
Niccolite (brownish)  
Pitchblende  
Pyrolusite  
Wolframite

Brown:

Cassiterite (pale brown)  
Chromite (dark)  
Coal  
Cuprite (brownish red)  
Hematite (brownish red)  
Ilmenite (brownish black)  
Limonite (yellowish brown)  
Manganite (reddish)  
Niccolite (pale brownish black)  
Psilomelane (brownish black)  
Rutile (pale brown)  
Siderite (pale)  
Sphalerite  
Wolframite (reddish brown)

Greenish-black:

Chalcopyrite  
Molybdenite  
Pyrite

Gray-black: (lead grey)

Argentite  
Arsenopyrite  
Bornite  
Chalcocite  
Cobaltite  
Covellite  
Galena  
Graphite  
Platinum (steel grey)  
Smaltite  
Stibnite  
Tetrahedrite

Blue:

Azurite

Red:

Cinnabar  
Cuprite  
Proustite  
Pyrargyrite  
Realgar (orange)

Yellow:

Epidote  
Gold  
Orpiment  
Realgar (orange)  
Sphalerite

Green:

Chlorite (grayish)  
Malachite (pale)  
Pitchblende (olive-green)

Metallic:

Silver

Colorless or white to pale colors:

Amphibole	Fluorite	Sulphur
Anglesite	Garnet	Talc
Anhydrite	Gypsum	Titanite
Apatite	Halite	Tourmaline
Asbestos	Magnesite	Zircon
Barite	Mica	
Bauxite	Monazite	
Bentonite	Nitrates	
Bleaching Clay	Olivene	
Calamine	Opal	
Calcite	Orthoclase	
Cerargyrite	Plagioclase	
Cerussite	Pumice	
Chalcedony	Pyroxene	
Chert	Quartz	
Chrysocolla	Rhodochrosite	
Diatomite	Rhodonite	
Dolomite	Scheelite	
Feldspar	Serpentine	
	Smithsonite	



Name	Color	Luster	Cleavage	Fracture	Form	Sp. Gr.
AMPHIBOLE Complex silicate	Grey to black; varied.	Vitreous to glassy	2 directions making angles between faces of 55° & 125°.	Jagged blades on cleavage edges	Slender crystals, columnar, fibrous, striations parallel to length.	3-3.5
ANGLESITE PbSO <sub>4</sub>	White to dark grey	Adamantine to dull	Imperfect and not important	Conchoidal; brittle	Crystals; banded masses	6.3
ANHYDRITE CaSO <sub>4</sub>	White; tinted red and blue.	Pearly to glassy; massive variety is dull.	3 directions at right angles	Uneven in massive varieties	Granular masses of sugar-like texture.	2.9
APATITE Ca <sub>10</sub> F <sub>2</sub> (PO <sub>4</sub> ) <sub>6</sub>	White; green; & reddish brown.	Vitreous to sub-resinous	Imperfect	Uneven; brittle	Hexagonal crystals & compact masses	3.2
ARGENTITE Ag <sub>2</sub> S	Dark lead grey to dull black.	Metallic	Unimportant; sometimes forming cubes.	Uneven to hackly.	Massive crusts & rough cube-like crystals.	7.3
ARSENOPYRITE FeAsS	Silvery white to steel grey	Metallic	Not important	Uneven	Twin crystals; granular compact masses; columnar forms.	6.
ASBESTOS Complex silicate	Grey brown & green; varied	Silky to dull	Some varieties perfect; acicular	Splintery	Slender, acicular crystals and in fibrous masses.	2.2-3.2
AZURITE Cu <sub>2</sub> (OH) <sub>2</sub> ·(CO <sub>3</sub> ) <sub>2</sub>	Azure-blue	Vitreous; velvety	Not important	Conchoidal	Acicular crystals; nodular groups of crystals; and as crystalline coatings.	3.8
BARITE BaSO <sub>4</sub>	White & various tints of brown, blue, green & yellow	Vitreous	Perfect in 2 directions; imperfect in the 3rd; 2 cleavages at right angles; 3rd oblique.	Uneven	Tabular and platy crystals; globular & granular masses.	4.5
BAUXITE Al <sub>2</sub> O <sub>3</sub> ·2H <sub>2</sub> O	Shades of brown, yellow and red.	Earthy	None	Earthy to conchoidal	In clay-like masses and small rounded concretions called pisolites	2.5

Hardness	Streak	Distinguishing Features	Occurrence	Similarities	Uses
5-6	White	False hex. cross-section; striations; cleavage; and long-bladed prisms.	Salic igneous rocks; gneisses; mica schists.	Pyroxene; Tourmaline; Epidote.	Fibrous forms as asbestos.
3	White to grey	Does not effervesce in acid; heavier than barite; crystal structure.	Secondary mineral found in oxidized zone of lead deposits.	Cerussite; Barite	Minor ore of lead
3-3½	White	Harder and higher sp. gr. than gypsum; false cubic cleavage is distinct.	In bedded sedimentary deposits; in cave deposits; and as a metamorphic rock.	Gypsum	Fertilizer
5	Colorless	Softer than beryl; about same hardness as glass; and sub-resinous luster.	Salic igneous rocks; metamorphosed rocks; high temp. deposits	Beryl	Used in prep. of superphosphate for fertilizer.
2-2½ Sectile	Shining dark lead grey	Low hardness; high specific gravity & sectility; it is not malleable.	Vein mineral with other silver, lead, and copper sulfides.	Resembles tarnished silver and cuts like lead.	Ore of silver
5½-6; tough.	Greyish-black	Garlic odor when struck; distinguished from smaltite by blowpipe tests.	Widespread and associated with the common sulfides.	Pyrite Marcasite Smaltite	Principal source of white arsenic.
2½-5½; varied.	Colorless	Separation into fine, slender fibers that are somewhat flexible.	Alteration product from serpentines & amphiboles.	Zeolites	Manufacture of asbestos products.
3½-4	Light-blue.	Azure-blue color; crystalline occurrence; small water content; softer than its similarities.	Oxidized zone of copper deposits; commonly associated with malachite.	Sodalite Lazurite Lazulite	Ore of copper; gem material.
2½-3½	Colorless	Breaks into tabular forms; high sp. gr.; does not effervesce in acids.	In separate veins and as a gangue mineral with deposits of galena, sphalerite, etc.	Dolomite Calcite Celestite Strontianite	Paint pigments; in barium salts; & as a heavy medium in well muds.
1-2 Soft; red types harder	Non-metallic	Clayey odor and fracture; chemical analyses are necessary for exact identification.	A weathering product, probably from the desilication of clay.	Clay Laterite	Ore of aluminum; refractories.

Name	Color	Luster	Cleavage	Fracture	Form	Sp. Gr.
BENTONITE Complex silicate	Light colors; varied	Earthy	None	Earthy & conchoidal like clay	Similar to that of clay	2.5
BERYL BeAl silicate	Emerald green; blue & yellow	Vitreous	Imperfect and indistinct	Conchoidal to uneven; brittle	Hexagonal crystals with a flat base; rarely as columnar masses.	2.7
BIOTITE Complex silicate	Dark brown & greenish black	Shiny on cleavage surfaces	Perfect in 1 direction	Uneven; brittle.	Thin sheets; massive aggregates of cleavable scales or flakes.	2.9
BORAX Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> · 10H <sub>2</sub> O	White when pure; grey	Vitreous to dull	Imperfect	Uneven	Individual crystals; aggregates of crystals; and glassy masses.	1.7
BORNITE Cu <sub>5</sub> FeS <sub>4</sub>	Copper red with purple tarnish	Metallic	None	Uneven; conchoidal; brittle.	Compact masses and scattered specks	5.
CALAMINE Zn <sub>2</sub> (OH) <sub>2</sub> SiO <sub>3</sub>	Colorless; white; pale colors	Vitreous to pearly	1 direction, perfect	Uneven to sub-conchoidal; brittle.	Massive; colloform; rounded; tabular crystals.	3.4 to 3.5
CALCITE CaCO <sub>3</sub>	Colorless to any light color	Vitreous	Perfect in 3 directions, forming rhombs	Indistinct; brittle	Separate crystals of varied habits; crystalline masses	2.7
CASSITERITE SnO <sub>2</sub>	Brown or black; rarely varied	Submetallic to adamantine	Imperfect	Sub-conchoidal; brittle.	Crystals; stream-worn pebbles; & in mammillary nodules.	7.
CERARGYRITE AgCl	White; grey; green	Resinous to adamantine	None	Unimportant; sub-conchoidal	Massive; thin crusts or coatings	5.5
CERUSSITE PbCO <sub>3</sub>	Grey; brown; yellow	Adamantine to dull	Not prominent	Conchoidal; brittle.	Compact masses; fibrous; rarely in crystals	6.5
CHALCEDONY SiO <sub>2</sub>	White to varied	Waxy & brilliant to dull	None	Conchoidal; brittle	Massive and banded concretionary nodules.	2.6

Hardness	Streak	Distinguishing Features	Occurrence	Similarities	Uses
1-2; soft.	White	Dry surfaces adhere to the tongue; clayey odor. most varieties swell when placed in water.	A bedded clay deposit that is usually derived from the weathering of volcanic ash.	Other clay minerals & bauxite.	Filter; coagulant; molding ingredient in sands.
7 $\frac{1}{2}$ -8	None	Light colors; harder than apatite; softer than corundum; some crystals show vertical striations.	In granitic pegmatites, mica schists, & gneisses.	Quartz Apatite Corundum Chrysoberyl	Source of beryllium metal, gems
2 $\frac{1}{2}$ -3	White to light green	Easy cleavage dark even in thin flakes; flexible.	In igneous rocks, granites, pegmatites, sands, & metamorphic rocks.	Phlogopite Vermiculite Chlorite	Flake or powder used in asphalt roofing.
2-2 $\frac{1}{2}$	White	Soluble in water; feeble sweetish alkaline taste	Salt deposits of evaporated lakes, with other borates.	Borates Epsomite Alum	Source of boron; washing compound.
3	Grayish-black	Distinct purple tarnish; softer than other iron copper minerals.	Widespread in vein deposits & igneous magmas, associated with other sulfides.	Chalcocite Covellite Chalcopyrite	An important ore of copper.
4 $\frac{1}{2}$ -5	White	Cleavage, which smithsonite does not have.	Oxidized zone, with smithsonite; derived from sphalerite.	Smithsonite	Ore of zinc.
3	White	Cleavage rhombs; bubbling in cold, dilute muriatic acid (HCl).	Widespread as secondary mineral; primary in sedimentary deposits.	Aragonite Barite Dolomite Siderite	Optics; same uses as limestone.
6-7	Grey; rarely brown	High sp.gr.; hardness; infusibility; streak.	Primary in granitic pegmatites; placer deposits.	Rutile Wolframite Tourmaline Garnets	Ore of tin
1-1 $\frac{1}{2}$ highly sectile	White	Sectility; waxy and greasy appearance	Secondary mineral found in upper parts of silver deposits	Wavellite and some copper carbonates	Ore of silver
3-3 $\frac{1}{2}$	Uncolored	High sp.gr.; luster; bubbling in dilute nitric acid.	Secondary mineral in oxidized zones of lead deposits.	Anglesite Barite Witherite	Minor ore of lead
7	None	Hardness; conchoidal fracture; and fine grain	Cavity and vein fillings common in lava flows.	Quartz Chert Opal	Gem stone; abrasive

## FIELD IDENTIFICATION OF MINERALS

Name	Color	Luster	Cleavage	Fracture	Form	Sp. Gr.
CHALCOCITE Cu <sub>2</sub> S	Sooty-black and dull grey	Metallic	Indistinct	Granular; imperfect; conchoidal	Compact masses; sometimes granular.	5.7
CHALCOPYRITE CuFeS <sub>2</sub>	Brass-yellow	Metallic	None	Sub-conchoidal; brittle	Compact masses; separate crystals that look like tetrahedrons	4.2
CHERT SiO <sub>2</sub>	White; grey; red & black	Dull	None	Conchoidal; brittle	Rounded nodules; lenses; & stratified beds	2.6
CHLORITE Complex silicate	Dark-green	Vitreous to pearly	One direction; basal perfect but not as good as mica.	Splintery	Foliated and scaly masses.	2.6-2.96
CHROMITE FeO.Cr <sub>2</sub> O <sub>3</sub>	Brownish black	Metallic	None	Uneven	Commonly in compact masses and granular aggregates.	4.4
CHRYSOBERYL	Distinguished from beryl only by chemical and optical					
CHRYSOCOLLA CuSiC <sub>3</sub> 2H <sub>2</sub> O	Pale-blue to greenish-blue	Vitreous to dull	None	Conchoidal to earthy; brittle	Cryptocrystalline; enamel-like in texture	2.2
CINNABAR HgS	Orange; crimson; & brownish red	Adamantine to dull.	Rhombohedral Perfect in 3 directions; unimportant	Uneven	Small crystals; crystal aggregates; massive & earthy forms	8
CLAY Hydrous aluminum silicate	Varied, usually light colored	Dull to earthy	None	Uneven; conchoidal in flint clays	Massive & bedded	2.6
COAL Solid hydrocarbon	Black to brown	Dull to vitreous	None	Even and conchoidal	Jointed blocks & angular fragments	1.2-1.7
COBALTITE CoAsS	White to greyish black, reddish tinge	Metallic	3 directions, perfect, at right angles	Uneven	Massive; crystals like pyrite.	6 to 6.3
COVELLITE CuS	Indigo-blue or darker	Sub-metallic to resinous	Basal, perfect.	None	Usually thin hexagonal plates; massive.	4.6

Hardness	Streak	Distinguishing Features	Occurrence	Similarities	Uses
2½-3; sub-sectile	Black	Sub-sectility; softness; and sooty appearance	Enriched sulfide zones of copper veins; with other copper sulfides.	Argentite Bornite Tetrahedrite	High grade ore of copper
3½-4	Greenish black	Softer than pyrite; non-magnetic; purple and copper sheen.	Common as a primary mineral with other Cu-Fe sulfides.	Pyrite Pyrrhotite Bornite Gold	Most important ore of copper.
7	None	Hardness; typical conchoidal fracture; & very fine grained.	In sedimentary beds with chalk, limestone, and shale.	Quartz Chalcedony	None
1-2½	Greyish green	Scaly flakes with fair elasticity; green color; and greasy feel.	Alteration product of ferro-magnesium minerals	Mica Talc	None
5½	Greyish brown	Feebly magnetic; dark brown streak; association with serpentine and magnetite.	Basic igneous & metamorphic rocks, such as peridotite and greenstone.	Franklinite Magnetite Ilmenite Specularhematite	Ore of chromium
tests.					
2-4	White to light blue	Light-blue color; glassy; inferior hardness; and non-effervescence.	Secondary mineral in leached and oxidized zones.	Turquoise Malachite Azurite	Minor ore of copper; gem stone.
2-2½	Scarlet or a dark red.	Bright red color; scarlet streak; and high sp.gr.	Primary mineral deposited as veins & specks in various kinds of rocks.	Hematite Cuprite Realgar	Important ore of quicksilver.
1½-2½; soft	Uncommon; red varieties are yellowish.	Clayey odor; dry clay sticks to tongue; sticky and soapy when wet.	Alteration product from different rocks; usually residual deposits.	Bauxite Shale Siltstone Bentonite	Ceramic industry in making pottery, bricks, etc.
1-1½	Brown to black.	Black color & streak; brittleness; & combustibility.	Interbedded in sed. rocks and in pockets of sed. rocks.	Oil shale and other solid hydrocarbons	Fuel.
5½	Greyish-black	Cubic cleavage; white color as opposed to pyrite's yellow.	In veins with other cobalt & nickel minerals.	Arsenopyrite Smaltite Pyrite	Ore of cobalt.
1.5-2	Lead-grey to black	Often shows fine purple color when moistened with water.	Associated with other copper minerals; usually secondary.	None	Ore of copper.

Name	Color	Luster	Cleavage	Fracture	Form	Sp. Gr.
CUPRITE Cu <sub>2</sub> O	Dark red & brownish red	Adamantine to submetallic.	Imperfect	Uneven	Crystals; crystalline aggregates; and fine-grained masses.	6.0
DIAMOND C	Colorless to black	Adamantine to greasy	Perfect in 4 directions forming octahedrons	Conchoidal	Loose, single, & twinned crystals, with curved faces and edges.	3.5
DIATOMITE Hydrous silica	White & grey, colored by impurities	Dull to earthy	None	Uneven	Massive bedded deposits with a powdery, chalk-like appearance.	1.9-2.35
DOLOMITE CaMg(CO <sub>3</sub> ) <sub>2</sub>	White & light grey	Pearly to Vitreous	3 directions at oblique angles; rhomb faces curved.	Unimportant	Crystal coatings & aggregates; vein fillings; massive in beds.	2.8-3.0
EPIDOTE Complex Ca, Al, & Fe silicate	Pistachio green; yellowish green.	Vitreous	1 direction, basal perfect.	Uneven; brittle.	Crystals, columnar aggregates; and granular masses.	3.2-3.5
FELDSPAR (K Na, or Ca) Al silicate	White to grey to pink; green; & blue.	Vitreous & pearly	2 directions almost at right angles, sometimes only 1 cleavage distinct.	Uneven across cleavage planes	Crystals, loose & embedded in rock masses; intergrown cleavable aggregates.	2.5-2.7
FLUORITE CaF <sub>2</sub>	Transparent; light colored tints.	Vitreous	4 directions, forming perfect octahedrons.	Sub-conchoidal; compact kinds are splintery; brittle.	Cubic crystals; sometimes octahedrons; granular masses.	3.0-3.2
GALENA PbS	Lead-grey; greyish black.	Metallic	Perfect in 3 directions; small cubes break from large cubes.	Undeveloped.	Common in cubes; rare in octahedrons; in ore bodies Heavy as cleavable masses.	7.5;
GARNET Complex silicate	Varied; red to black.	Vitreous to resinous	Usually absent but fracture parting is common.	Uneven to sub-conchoidal	Distinct 12-sided crystals; granular masses; rounded grains in sand.	3.1-4.3
GOLD Au	Pale yellow; silvery tinge.	Metallic	None	Hackly; placer gold rounded; malleable & ductile.	Finely disseminated thru the rock; flakes; wire stringers; rounded nuggets	15-19

Hardness	Streak	Distinguishing Features	Occurrence	Similarities	Uses
$3\frac{1}{2}$ -4	Brick red and cochineal.	Absence of perfect cleavage; bright red streak; & hardness	Oxidized zone of copper deposits; with native copper.	Cinnabar Hematite	Minor ore of copper.
10	None	Extreme hardness; brilliant light dispersion; greasy appearance of rough stone.	Stream gravels; and kimberlite (altered peridotite).	Quartz Topaz Zircon Corundum	Precious gem; abrasives; and in machine tools.
1-1 $\frac{1}{2}$ ; soft	None	Light weight; soft chalky & clayey feel when rubbed or crushed between the fingers.	Bedded basin-shaped deposits associated with sediments and volcanic lavas.	Pumicite Chalk Tripoli Clay	Filter aid; insulant; admixture in concrete.
$3\frac{1}{2}$ -4	None	Curved cleavage faces; weak effervescence in cold dilute hydrochloric acid.	Similar to calcite (limestone) in sed. beds; vein and cavity fillings	Calcite Magnesite Siderite Rhodochrosite	Building & ornamental stone; refractory.
6-7	Grey to pale yellow	Distinct pistachio green color; deep striations; reticulated masses.	All kinds of high lime-bearing metamorphic rocks.	Amphiboles Pyroxenes Tourmaline Feldspar	None
5 $\frac{1}{2}$ -6 $\frac{1}{2}$	White or absent.	Crystalline structure; good cleavage; twin intergrowths; twinning lines or striations on the plagioclase feldspars.	All classes of rocks; abundant in acid igneous rocks, granites & pegmatites.	Apatite Epidote Rhodonite	Ceramics; scouring soaps; glass industry.
4	White	Good octohedral cleavage; harder than barite, celestite, & calcite; softer than apatite.	Gangue mineral in lead and zinc sulfide deposits; vein mineral in limestone.	Calcite Barite Celestite Strontianite Apatite	Flux in electric furnaces; glass & chemical industries.
2 $\frac{1}{2}$	Lead-grey	High sp. gr.; perfect cubic cleavage; lead-grey color.	In vein, contact metamorphic & replacement deposits, with other sulfides.	Stibnite Argentite	Most important ore of lead.
6-7 $\frac{1}{2}$ ; crystals tough	White	Hardness; absence of cleavage; 12-sided crystal habit.	Common accessory mineral in metamorphic rocks, limestones and sands.	Zircon Spinel Epidote Corundum Staurolite	Important as an abrasive; gem stone.
2 $\frac{1}{2}$ -3	Pale yellow; similar to color.	Uniform non-flickering yellow color; high sp. gr.; malleability & ductility	Widely distributed in quartz veins; in stream & beach placers.	Pyrite Chalcopyrite Golden mica	Monetary; in the arts.



Name	Color	Luster	Cleavage	Fracture	Form	Sp. Gr.
GRAPHITE C	Steel-grey to black.	Metallic to dull.	Basal, which is perfect in 1 direction.	Unimportant	Foliated or granular masses; minute disseminated scales.	2.2
GYP SUM CaSO <sub>4</sub> . 2H <sub>2</sub> O	White & grey; tinted shades.	Pearly & silky; sometimes dull.	Perfect in 1 direction; imperfect and fibrous in the others.	Fibrous & sub-conchoidal.	Single platy crystals; foliated, fibrous, columnar, & granular masses.	2.3
HALITE NaCl	Transparent or white; tinted.	Vitreous	Cubic perfect, and easily developed.	Conchoidal; brittle.	Cubic crystals & cubic fragments; granular & compact masses.	2.1- 2.6
HEMATITE Fe <sub>2</sub> O <sub>3</sub>	Steel-grey; red; & black.	Metallic	None	Hackly; sometimes conchoidal.	Massive; mammillary; fibrous; columnar; oolitic; and foliated masses.	5.0
ILMENITE FeTiC <sub>3</sub>	Iron-black	Metallic	None	Conchoidal brittle	Tabular crystals; flat plates; compact and granular masses; sand.	4.5- 5.0
LIMONITE 2Fe <sub>2</sub> O <sub>3</sub> . 3H <sub>2</sub> O	Brown to yellowish brown.	Dull to submetallic.	None	Uneven; conchoidal.	Compact; botryoidal; nodular; and pisolitic masses.	3.8
MAGNESITE MgCO <sub>3</sub>	Snow-white to grey	Vitreous to dull.	Unimportant; rhombic in crystalline varieties.	Conchoidal in fine-grained varieties.	Common in compact porcelain-like masses; sometimes coarsely crystalline and granular.	3.0
MAGNETITE Fe <sub>3</sub> O <sub>4</sub>	Black	Metallic; sometimes dull.	Not distinct; occasional octahedral parting.	Sub-conchoidal; brittle.	Small crystalline or non-crystalline grains; granular masses; sand.	5.1
MALACHITE Cu <sub>2</sub> (OH) <sub>2</sub> CO <sub>3</sub>	Emerald green	Vitreous to dull; velvety.	Unimportant.	Uneven to sub-conchoidal; brittle.	Massive or incrustations with botryoidal or fibrous or stalactitic surfaces; acicular crystals.	3.9- 4
MANGANITE Mn <sub>2</sub> O <sub>3</sub> .H <sub>2</sub> O	Black or dark grey.	Submetallic.	1 or 2 directions parallel to length of crystal.	Uneven	Prismatic crystals vertically striated; columnar and fibrous masses.	4.3
MICA	(see Biotite and Muscovite)					

Hardness	Streak	Distinguishing Features	Occurrence	Similarities	Uses
1-2 soft greasy feel	Black or dark, steel-grey	Softness; greasy feel; black streak; rubbing forms black marks on the fingers.	Widespread in nearly all kinds of metamorphic rocks.	Molybdenite. Specularite.	Mfg. of pencils, crucibles, lubricants.
1½-2	White	Softness; 1 perfect cleavage and the others imperfect or fibrous; non-effervescent in acid.	Bedded deposits associated with sedimentary rocks.	Anhydrite Calcite Zeolites Mica Talc	Calcined gypsum; soil stabilizer; flux.
2½	White	Perfect cubic cleavage; softness; and saline or salty taste.	As solid salt in beds & salt domes; in briny solutions.	Sylvite Carnallite Fluorite	Table salt; chemical & glass industry.
5½-6½	Brownish red or dark red.	Brownish-red streak; high sp.gr.; contains no water or very little water.	Widespread and associated with basic igneous rocks & metamorphic rocks.	Limonite Magnetite Chromite Ilmenite Franklinite	Most important ore of iron.
5-6	Brownish-black.	Brownish-black streak; weakly magnetic or non-magnetic.	In basic coarse grained igneous rocks and in black sands.	Magnetite Hematite Chromite Wolframite	Ore of titanium Paint filler
1-5½	Yellowish brown.	Yellowish-brown streak; high water content; compact structure.	Alteration product of various iron minerals; widespread.	Magnetite Hematite Chromite	Minor ore of iron; yellow pigment.
3½-4½; sometimes harder.	White	Fairly high sp.gr. & hardness; toughness; fine-grained texture; mild effervescence.	As lenses in sediments & as small deposits in metamorphic rocks.	Calcite Dolomite Rhodochrosite.	Caustic and dead-burned magnesite; refractory.
5½-6½	Black	Strong magnetism; black streak; brilliant black color.	Widely distributed in basic igneous rocks & metamorphic rocks.	Ilmenite Franklinite Hematite Chromite	Ore of iron
3½-4	Pale-green	Uniform green color; fibrous or acicular crystal structure; effervescence in HCl.	Characteristic in oxidized zone of copper deposits; widespread.	Chrysocolla Turquoise Smithsonite	Minor ore of copper; gem stone.
4	Reddish brown to black.	Crystalline structure; softer than psilomelane; harder than pyrolusite.	Secondary mineral in veins & cavities; residual in clays.	Psilomelane Pyrolusite Limonite Hematite	Ore of manganese.

Name	Color	Luster	Cleavage	Fracture	Form	Sp. Gr.
MOLYBDENITE MoS	Bluish lead grey	Metallic bright	Almost mica- ceous	None	In foliated masses	4.7 to 4.8
MONAZITE (Ce, La, Nd, Pr) PO <sub>4</sub>	Yellow; brown; reddish	Resin- ous	Parting in 1 direction	Conchoid- al to uneven.	Grains in various sands.	4.7 to 5.3
MUSCOVITE complex silicate.	White, green & yellow	Vitreous to pearly	Perfect in 1 direction, splitting into thin sheets	Hackly on cleavage edges.	Foliated flakes & scaly masses; large sheets and "books"; tabular structure.	2.76 to 3.0
NICCO- LITE NiAs	Pale copper- red	Metallic	None	Uneven	Nearly always in massive form.	7.3 to 7.7
NITRATINE (Nitrates)	White or color- less.	Earthy	Rhombohedral (3 directions at oblique angles).	Not ap- parent.	Rhombohedral crys- tals, usually massive.	1.5 to 2.
OLIVINE (Mg, Fe) <sub>2</sub> SiO <sub>4</sub>	Yellow- green	Vitreous	Indistinct	Conchoid- al; brittle	Granular masses.	3.3
OPAL SiO <sub>2</sub> -H <sub>2</sub> O	Varied	Greasy to pearly	None	Conchoid- al.	Nodular masses.	2. to 2.3
ORPIMENT As <sub>2</sub> S <sub>3</sub>	Lemon- yellow	Dull	Not distinct	None	Foliated masses or powdery incrustations.	3.4 to 3.5
ORTHOCLASE (K, Na)AlSi <sub>3</sub> O <sub>8</sub>	White, green, pink	Vitreous to pearly	2 directions at right angles with parting at an oblique angle.	Uneven	In cleavable crys- tals and masses embedded in rock.	2.5 to 2.6
PITCHBLENDE	Grey- green to black	Pitchy or greasy to dull	None	Conchoid- al to un- even	Massive	6.5 to 8.0
PLAGIO- CLASE (Na, Ca) AlSi <sub>3</sub> O <sub>8</sub>	White to grey	Vitreous	1 direction perfect, 1 direction less perfect.	Uneven	In cleavable crys- tals and masses embedded in rock.	2.6 to 2.7
PLATINUM Pt	Silvery white	Bright metallic	None	Hackly	Rounded grains and nuggets; irregular lumps	14 to 19

Hardness	Streak	Distinguishing Features	Occurrence	Similarities	Uses
1-1½	Green to blue-black; bluish grey on paper	Streak is more greenish than graphite and luster brighter	In pegmatites, contact metamorphic zones. High temp. quartz veins.	Graphite	Ore of molybdenum.
5	None	Cleavage, if grains are large enough to show cleavage.	In certain sand deposits derived from salic igneous rocks.	Titanite Zircon	In some cases, a source of thorium.
2-2½	Colorless	Highly flexible & elastic; splits into very thin sheets;	Pegmatites; most light colored igneous rocks; metamorphic rocks.	Gold flakes Chlorite Gypsum	Electrical insulation non-conductor.
5-5½	Pale brownish-black.	Its copper sheen; otherwise chemical tests are necessary.	Occurs with nickel & cobalt minerals.	Cobaltite Pyrite	Ore of nickel
1½-2	White	Cool, saline taste.	Arid regions by evaporation of water.	None	Fertilizer; manufacture of potassium nitrate
6½-7	Colorless	Greenish color and absence of cleavage	Basic or femic igneous rocks; such as peridotite & basalt.	No common ones	Refractory; gem
5½-6½	Colorless	Softness and low specific gravity; greasy luster	Deposited from siliceous solutions as secondary minerals.	Chalcedony	Certain varieties as gem material
1½-2	Pale lemon-yellow	Yellow color.	Vein mineral often associated with realgar	None	Synthetic orpiment as a paint pigment
6-6½	Non-metallic	Cleavage, carlsbad twinning	In salic igneous rocks & pegmatites; as grains in some sandstones	Plagioclase	Ceramics
5½	Olive-green to black	High specific gravity	Metalliferous veins with metallic-sulfide minerals.	Obsidian Pitchstone	Source of uranium and radium.
6	Colorless	Cleavage and polysynthetic twinning.	In more basic (femic) rocks and as grains in sandstone.	Orthoclase	Ceramics
4½; malleable.	Light steel grey	High specific gravity; malleability	Assoc. with peridotite or in placers derived from them.	Similar to bright iron or steel shavings	Jewelry; scientific uses; catalyst.

## FIELD IDENTIFICATION OF MINERALS

Name	Color	Luster	Cleavage	Fracture	Form	Sp. Gr.
PROUSTITE $\text{Ag}_3\text{AsS}_3$	Scarlet-vermilion	Adamantine	1 direction good	Conchoidal to uneven	Massive crystals	5.57 to 5.64
PSILOMELANE $4\text{MnO}_2$ (Ba, K <sub>2</sub> ) $\text{O}(\text{H}_2\text{O})_x$	Black to brown	Sub-metallic to dull	None	Conchoidal; brittle.	Compact earthy material that is amorphous.	3.7 to 4.7
PYRRARGYRITE $\text{Ag}_3\text{SbS}_3$	Black to dark red	Metallic; adamantine	1 direction good	Conchoidal to uneven	Massive; prismatic crystals	5.7 to 5.8
PYRITE $\text{FeS}_2$	Silvery to pale brass yellow	Metallic	Imperfect cubic	Uneven to conchoidal	Massive and granular forms; in cubes and pyritohedrons	5
PYROLUSITE $\text{MnO}_2(\text{H}_2\text{O})_x$	Black	Metallic to dull	None	Splintery, not often distinguishable	Fibrous and columnar forms; in crusts and masses.	4.8
PYROXENE Complex silicate	Black to green to white; usually darker colors	Vitreous to pearly.	Imperfect in 2 directions at nearly right angles; parting in 1 direction at an oblique angle.	Uneven; brittle	Embedded crystals, usually stubby; bladed and columnar masses.	3.2 to 3.6
QUARTZ $\text{SiO}_2$	White to varied	Vitreous	Unimportant	Conchoidal	Massive (bull quartz; hex. crystals with pointed ends.	2.6 to 2.7
REALGAR $\text{As}_2\text{S}_2$	Red to orange-red.	Adamantine to resinous.	Not prominent.	Conchoidal	Massive; granular; crystals.	3.5
RHODOCHROSITE $\text{MnCO}_3$	Pink to brownish red	Vitreous to pearly	3 directions at oblique angles like calcite	Uneven; brittle	Crystals and fine to coarse grained cleavable masses.	3.5 to 3.6
RHODONITE $\text{MnSiO}_3$	Pink to red	Vitreous	2 directions at nearly right angles.	Conchoidal to uneven	Cleavable and compact masses	3.4 to 3.6

Hardness	Streak	Distinguishing Features	Occurrence	Similarities	Uses
2-2½	Scarlet-vermillion	Lighter color and streak than pyrrargyrite.	Vein mineral formed by ascending solutions	Pyrrargyrite Cuprite Cinnabar	Ore of silver
5-6; tough.	Brownish black to brown.	Absence of crystalline structure & streak.	In residual clays and bog deposits.	Pyrolusite Manganite Limonite	Ore of manganese.
2½	Purplish red	Darker color and streak than proustite.	Vein mineral formed by ascending solutions.	Proustite Cuprite Cinnabar	Ore of silver
6-6½	Greenish to brownish black	Harder than pyrrhotite and chalcopyrite; a low temp. form called marcassite is very similar.	Assoc. with all sulfides & in all rocks; often in tiny cubic crystals	Pyrrhotite Chalcopyrite Gold Marcasite Arsenopyrite	Mfg. sulfuric acid
2-2½	Black	Inferior hardness and low moisture content.	Similar to other manganese oxides, probably derived from manganite.	Psilomelane Manganite Limonite	Ore of manganese
5-6	Colorless	Contrasted with amphibole-cleavage at 90° instead of 60°; square instead of hexagonal cross section; stubby instead of elongated.	In femic (basic) igneous rocks; do not commonly occur in rocks containing quartz.	Amphibole Epidote Tourmaline	None important.
7	None	Its high hardness and lack of cleavage.	Salic igneous rocks; veins; grains in sandstone & some metamorphics.	Calcite Scheelite Feldspars	Abrasive; glass making; gems; flux.
1½-2; sectile	Orange-yellow	Lower specific gravity and hardness than cinnabar.	Vein mineral associated with stibnite, cinnabar, pyrite, etc.	Cinnabar	Source of arsenic.
3½-4½	Colorless	Heavier than calcite and dolomite and softer than rhodonite.	Vein mineral with silver ores and with some Mn ores.	Calcite Dolomite Magnesite Rhodonite	Ore of manganese
5½-6½; tough	Colorless	Heavier than orthoclase & harder than rhodochrosite; cleavage differs from pink carbonates.	In high temp. veins, and in crystalline limestones	Rhodochrosite Calcite etc.	Ornamental stone and gem material.

Name	Color	Luster	Cleavage	Fracture	Form	Sp. Gr.
RUTILE TiO <sub>2</sub>	Brownish red to black.	Adamantine; metallic	Not important.	Uneven; brittle	Embedded grains or crystals	4.2
SCHEELITE CaWO <sub>4</sub>	White, grey and pale	Sub-adamantine	Distinct in 1 direction with step-like interruptions.	Uneven; brittle	As crystals and in massive form.	6
SERPENTINE Complex silicate	Greenish, brownish, reddish, variegated	Resinous to greasy	Not important.	Conchoidal to splintery	Massive	2.5 to 2.65
SIDERITE FeCO <sub>3</sub>	Various shades brown & grey	Sub-adamantine to high vitreous	3 directions at oblique angles; (rhombohedral) like calcite	Uneven; brittle.	Small crystals; cleavable masses; crusts; concretions; and oolites	3.8
SILVER Ag	Tin white to pale yellow	Metallic	None	None	Wire; thin sheets; skeleton crystals; rarely as nuggets.	10.1 to 11.1
SMALTITE (Co, Ni) As <sub>2</sub>	White to grey; iridescent	Metallic	None	Granular	Massive; cubic crystals	5.5 to 6.8
SMITHSONITE ZnCO <sub>3</sub>	White to varied; sometimes blue or green.	Vitreous	3 directions at oblique angles (rhombs), but not prominent.	Uneven; brittle.	Nodular masses and crusts.	4.3 to 4.5
SPHALERITE ZnS	Pale yellow to black, dependent on iron content.	Resinous to vitreous	Dodecahedral, 12 sided figure derived from cube.	Conchoidal; brittle	Massive; crystals	4.0
STIBNITE Sb <sub>2</sub> S <sub>3</sub>	Dark lead-grey	Metallic to dull on fresh surface	Perfect in 1 direction with cross lines on cleavage surfaces.	Uneven	Granular masses; slender crystals in radiating groups.	4.5

Hardness	Streak	Distinguishing Features	Occurrence	Similarities	Uses
6-6½	Pale brown	Lower sp.gr.than cassiterite; red color and adamantine luster.	High temp. veins or pegmatites; in metamorphics.	Cassiterite	Coloring matter for porcelain & production of ferrotitanium.
4½-5	White	High sp.gr.and sub-adamantine luster with disseminated masses; ultra-violet lamp is helpful.	In veins formed at high temperature.	Quartz	Ore of tungsten.
2½-4	White, slightly shining	Softness, greasy luster & "feel"; absence of cleavage.	Alteration product of femic rocks and of amphibolites.	Talc Chlorite	Ornamental stone
3½-4	Pale brown or grey	Higher sp.gr. than calcite; rhomb.cleavage and high luster from sphalerite	Vein mineral; replacement of limestone concretions; small crystals in cavities.	Calcite Dolomite Sphalerite	Minor ore of iron
2½-3 Malleable	Metallic, silver-white	Bright color of freshly cut surface and malleability	Vein min.with cobalt & nickel & other silver minerals; in the "iron hat" or gossans, rarely in placers	Resembles some fresh surfaces of native metals [as lead & tin.]	Silver; jewelry; monetary uses.
5½-6	Greyish-black	Lack of cleavage; otherwise chemical tests are necessary.	With silver and copper ores; in veins with ores of cobalt, nickel & copper.	Arsenopyrite Cobaltite Pyrite	Ore of cobalt and nickel.
5	Colorless	Harder than other carbonates; harder and heavier than chrysocolla.	In oxidized zone and formed from alteration of sphalerite.	Other carbonates. Chrysocolla	Minor ore of zinc.
3½-4	Pale yellow to dark brown	Perfect cleavage and high luster; softer than garnet.	Vein mineral with other sulfides; replacement mineral in sed.rocks; a contact metamorphic mineral.	Garnet Siderite	Ore of zinc.
2	Dark lead grey to black.	Perfect cleavage; softness; low fusibility.	Associated with other sulfides.	Galena	Principal source of antimony.



Name	Color	Luster	Cleavage	Fracture	Form	Sp. Gr.
SULFUR S	Yellow to yellowish red.	Resinous to adamantine.	Absent	Brittle	Crystals; crusts; masses.	2.
TALC Complex silicate	White to grey to pale green	Pearly	Perfect in 1 direction into foliated masses.	None	Scales; foliated; fibrous; and compact masses.	2.7
TETRAHEDRITE Copper-antimony sulfide.	Dark iron grey	Metallic	Absent	Uneven, brittle	Usually massive; tetrahedral crystals	4.4 to 5.1
TITANITE or SPHENE CaTiSiO <sub>5</sub>	Varying tints of yellow or brown.	Adamantine to high vitreous	Indistinct	None; brittle	Flat, wedge shaped crystals; massive; granular.	3.4 to 3.5
TOURMALINE Complex silicate.	Black; brownish; bluish; green; red.	Vitreous to resinous	None	Sub-conchoidal to uneven.	Prismatic crystals	3 to 3.25
WOLFRA-MITE (Fe, Mn) WO <sub>4</sub>	Black or dark brown.	Metallic to sub-metallic	One direction perfect.	Uneven; brittle	Heavy black masses; tabular crystals.	7.2 to 7.5
ZIRCON ZrSiO <sub>4</sub>	Reddish-brown to light variegated.	Adamantine	Imperfect	Conchoidal	Usually found as loose grains in some "black sands"	4.7

Hardness	Streak	Distinguishing Features	Occurrence	Similarities	Uses
1½-2½	Colorless	Yellow color; low hardness; brittleness; odor of sulfur when burned.	Decomposition of many sulfides; product of vulcanism.	None	Manufacture of sulfur products.
1-1½; may range to 4 with impurities	White Non-metallic	Soapy feeling & low hardness.	Results from alteration of amphiboles, and serpentine.	Mica Chlorite	Talcum powder; paper glaze; refractory.
3-4½	Dark grey	Chalcocite is sectile while tetrahedrite is brittle.	Vein mineral with other sulfides.	Chalcocite	Ore of copper
5-5½	White	Crystal shape.	Common in granitic rocks with magnetite & hornblende; in metamorphic rocks.	Magnetite Hornblende	None important.
7-7½	Colorless	Triangular crystal cross-section and lack of cleavage.	In salic igneous rocks and in certain metamorphic rocks.	Amphibole Pyroxene Epidote	Transparent varieties as gems.
5-5½	Black to dark reddish brown.	High sp.gr. and cleavage in only direction.	In granular salic rocks & pegmatites; assoc. with cassiterite & scheelite.	Hubnerite	Ore of tungsten
7½	Colorless	Difficult without optical tests.	Loose crystals in sands derived from salic rocks.	Diamond	Refractory; ferro-alloys; gems.

GLOSSARY

The definitions given herein are taken principally from "A Glossary of the Mining and Mineral Industry". by Albert H. Fay, published by the U.S. Bureau of Mines as Bulletin 95, and from Webster's New International Dictionary, 2d Edition.

Aberration: A lens condition that permits light rays to be focussed at different points not all on the same plane or field of observation. It is impossible to bring the entire "field" in focus if a lens is not properly corrected.

Spherical Aberration: is the inability of the marginal rays of a lens to focus in the same plane with those passing through the center of the lens. As a result, the center of the "field" may be in focus but the margins are out of focus.

Chromatic Aberration: is caused by the inability of the lens to focus different colors of light in the same plane. The "field" is surrounded by rings of color.

Acicular: needle shaped; slender, like a needle or bristle, as some leaves or crystals.

Acidic Rocks: a descriptive term applied to those igneous rocks that contain more than 65 percent silica ( $\text{SiO}_2$ ) as contrasted with intermediate or basic rocks. The term "Salic rocks" is preferable to "Acidic rocks".

Adamantine: a term used to describe the luster of a mineral; luster like that of a diamond.

Adsorb: to condense and hold a gas on the surface of a solid, particularly metals. Also to hold a mineral particle within a liquid interface. During the World War (1914-1918) carbon made from peach stones was capable of holding gas to the surface of the carbon particles. No gas was absorbed, however.

Alumina: oxide of aluminum,  $\text{Al}_2\text{O}_3$ .

Amorphous; a term applied to rocks and minerals having no definite molecular structure.

Amygdules: a small globular cavity in an eruptive rock such as lava, caused by expanding steam or vapor at the time the rock cooled; they generally are lined or filled with secondary minerals.

Argentiferous: containing silver.

Basalt: the basalt or basaltic group of rocks is used to include all the dark, femic, fine-grained volcanic rocks, such as the true basalts and others.

Basic: this term as applied to rocks is a general one for those igneous rocks that are comparatively low in silica. About 45 or 50 percent of silica is the upper limit. The term "femic rocks" is preferred to "basic rocks".

Bladed: decidedly elongated and flattened, like a knife blade. The term is used to describe the structure of certain minerals.

"Books": a term used to describe mica crystals from which individual sheets can be stripped. The similarity of these mica sheets to the leaves of a book explains the term.

Botryoidal: having the form of a bunch of grapes. A mineral has botryoidal form if the surface is a series of bumps, each one about the size of a grape.

Carlsbad Twinning: a type of twinned crystal occurring in the monoclinic crystal system with the vertical axis as the twinning axis.

"Colors": refers to particles of metallic gold.

Conchoidal: shell shaped. The more compact rocks such as flint, argillite, felsite, etc., break with conchoidal fracture. The curved, or conch-like breaks on the surface of a broken chunk of glass are examples of conchoidal fracture.

Contact Metamorphism: a general term applied to the change that takes place along an intrusive contact (of an intruded igneous rock and the enclosing rocks into which it has been thrust), such as the recrystallization of limestone with the development of typical silicate minerals.

Country Rock: the general mass of adjacent rock as distinguished from that of a dike, vein, or lode.

Cryptocrystalline: formed of crystals of microscopic fineness, but not glassy.

Diameters: a unit of magnification of microscopic and telescopic observation equal to the number of times the linear dimension of an object is increased; as, a magnification of eight diameters means the dimensions are increased in the ratio of 8 to 1.

Disseminated: to be scattered or diffused through. A disseminated mineral is one which is scattered through the rock rather than being concentrated in masses or veins.

Dodecahedron: an isometric (cubic) form composed of 12 faces, each parallel to one axis and intersecting the other two axes at equal distances.

Effervescent: to bubble and hiss, as limestone or any carbonate on which acid is poured.

Femic: a coined word, portions of ferromagnesium, that describes those rocks or minerals that have a predominance of ferromagnesian minerals. Synonymous with "basic" when basic is applied to rocks.

Field Magnification: a sphere or range of activity or observation, ...the area, usually circular, visible through the lens system of an optical instrument, as a microscope or telescope.

Fluorescence: the emission of light from within a substance while it is being exposed to direction radiation, or in certain cases, to an electrical discharge,

(as from an ultra-violet lamp). A fluorescent substance gives off light when excited with ultra-violet rays.

Flux: material that will assist fusion by forming more fusible compounds.

Foliated: leaf-like. The meaning is similar to that of laminated, but the latter generally indicates a finer division of layers.

Gangue: the waste or non-valuable minerals in the ore. In a copper ore, quartz is gangue. The word is pronounced as if spelled "gang".

Geodes: a hollow nodule or concretion, the cavity of which is later lined with crystals. The geode may ultimately become filled with the later minerals.

Gneiss: a banded crystalline rock with more or less well-developed cleavage but without the fissility (separation into thin sheets) of schist.

Gossan: a mass of iron oxide (limonite) that may cover a mineral deposit. The original rock has been weathered, many of the soluble minerals have been removed, and the weathered residue remains. Also called "iron hat".

Granite: a granular igneous rock composed essentially of quartz, feldspar, and mica. Commonly a part of the feldspar is plagioclase. The mica may be muscovite or biotite or both. Hornblende is a common, and augite an uncommon, component. Commercially almost all compact igneous rocks are called granite as distinguished from slate, sandstone, and marble. As used here, it applies to a particular rock as defined.

Granitoid: the suffix "oid" means "like". A granitoid rock therefore is one that is like a granite. It may be a granodiorite, diorite, or a similar rock. The term is useful as a generality.

Homogeneous: of the same kind or nature; consisting of similar parts, or of elements of a like nature; opposed to heterogeneous.

Hydrous: containing water chemically combined, as in hydrates and hydroxides.

Igneous: formed by crystallization from a molten state; said of the rocks of one of the great classes into which all rocks are divided, and contrasted with sedimentary and metamorphic rocks.

Iridescence: the exhibition of prismatic (rainbow) colors in the interior, or on the surface of a mineral. An oil film on water exhibits a play of colors and illustrates iridescence.

Iron Hat: see Gossan.

Magmatic Segregation: the process by which different types of igneous rocks are derived from a single parent magma (molten mass within the earth) or by which different parts of a single molten mass assume different compositions and textures as it solidifies. Also called Magmatic Differentiation.

Malleable: capable of being extended or shaped by beating with a hammer, as gold, silver, etc.

Matrix: the rock or earthy material containing a mineral or metallic ore. Sometimes called Groundmass.

Megascopic: large enough to be distinguished with the naked eye; the opposite of Microscopic.

Metamorphism: any change in the texture or composition of a rock, often its induration or solidification, especially by deformation and by a rise of temperature.

Micaceous: composed of thin scales, like a mass of tiny mica flakes.

Mineralogist: one who is versed in the science of minerals, or one who treats or discourses of the properties of mineral bodies.

Mohs Scale: an arbitrary scale, beginning with 1 and ending with 10, to designate varying degrees of hardness. There is no relationship of the numbers; 4 is not necessarily twice as hard as 2.

Molecule: the smallest part of a substance that can exist separately and still retain its composition and characteristic properties; the smallest combination of atoms that will form a given chemical compound.

Nodular: having the shape of nodules (see Nodule).

Nodule: a small, roundish lump of mineral of irregular shape.

Nomenclature: the system of names used in a particular branch of knowledge or art, or by any school or individual (Webster).

Nucleus: a kernel; a central mass or point about which other matter is gathered, or to which an accretion is made.

Octahedral Form: in the isometric (cubic) system, a closed form of eight faces, each having equal intercepts on all three axes.

Oolite: a variety of limestone consisting of round grains like the roe of a fish; the name is derived from two Greek words which mean "egg-stone". Also applies to any other material having a similar texture.

Oolitic: characteristic of, pertaining to, of the nature or texture of, or composed of, oolite. (See oolite).

Oxidized zone: that portion of an ore deposit which has been subjected to the action of surface waters carrying oxygen, carbon dioxide, etc. That zone in which sulfides have been removed or altered to oxides and carbonates.

Pervious: admitting passage; capable of being penetrated (Webster).

Pisolitic: consisting of rounded grains like peas or beans.

Polysynthetic Twinning: repeated twinning in which the crystal is made of thin lamellae alternately in reversed position. Plagioclase feldspar frequently has this twinning.

Primary Ores: those minerals and ores that retain their original form and composition, as original sulfides.

Pseudomorph: a crystal, or apparent crystal, of some mineral, having the outward form characteristic of another mineral, which has been replaced by substitution or by chemical alteration (see Replacement). Limonite is very frequently found in cubes, pseudomorphic after the original cubes of the pyrite from which it was derived.

Pyribole: a word that has been coined to describe a mineral that may be an amphibole or may be a pyroxene, and definite decision cannot be made with the resources at hand.

Quadrangle: the tract of country represented by one of the atlas sheets published by the United States Geological Survey. In densely populated areas each quadrangle measures 15' in latitude and 15' in longitude and is mapped on the scale of 1/62,500 (approximately 1 inch = 1 mile). Elsewhere the size is 30' x 30' and the scale of mapping is 1/125,000 (approximately 1 inch = 2 miles) except in a few sparsely settled regions when the size is 1° x 1° and the scale is 1/250,000 (approximately 1 inch = 4 miles). (Webster).

Quadrant: the quarter of a circle; an arc of 90°.

Replacements: the process by which one mineral or chemical substance takes the place of some earlier different substance, often preserving its structure or crystalline form. If the structure of the original mineral is preserved, the replacement is said to be a pseudomorph (see Pseudomorph).

Rhombohedral: a six-sided form whose faces are parallelograms. The resultant shape is that of a box which has been pushed out of shape by applying pressure at one corner.

Salic: a coined word, derived from silica-alumina, and pertains to rocks and minerals predominately composed of silica and alumina. Synonymous with "acidic", but salic is preferential. (See Acidic).

Schist: a crystalline rock that can be readily split or cleaved because of having a foliated or parallel structure, generally secondary and developed by shearing and recrystallization under pressure.

Secondary Mineral: a mineral resulting from the alteration of a primary mineral. Thus, original sulfides, by oxidation change to sulfates, carbonates, and oxides, and these by hydration become hydrous forms.

Sectile: capable of being severed by the knife with a smooth cut, but yet pulverizable. Distinguished from brittle and malleable.

Silica: an oxide of silicon, chemically known as silicon dioxide and having a chemical formula of SiO<sub>2</sub>.

Silicate: of, or pertaining to, silica; containing silica, or partaking of its nature. Containing abundant quartz. Any mineral that contains silica is known as a silicate.

Stalactite: descending, columnar deposits, generally of calcite, formed on the roof of a cavern by the drip of mineral solutions. In the Oregon Caves, the "rock icicles" hanging from the roof are stalactites. (See Stalagmite).

Stalagmite: uprising, columnar deposits, generally of calcite, formed on the floor of a cavern by the drip of mineral solutions from the roof. Solutions dripping from the end of stalactites may form stalagmites beneath them. (See Stalactite).

Striations: very fine, parallel lines marking the surfaces or cleavage faces of minerals. Also, the channels or scratches made in rock scouring.

Tabular: having a shape like a table; flattened; laminated.

Tetrahedrons: a crystal form, in the isometric (cubic) system, enclosed by four faces having equal intercepts on all three axes. Each face is a triangle. A tetrahedron has four faces, - an octahedron has eight faces, while the faces of each are still triangular.

Twin Crystals: crystals, in which one or more parts, regularly arranged, are in reverse position with reference to the other part or parts. They often appear externally to consist of two or more crystals symmetrically united, and sometimes have the form of a cross or star. They also exhibit the composition in the reversed arrangement of part of the crystal faces, in the striae of the surface, and in reentrant angles; in certain cases the compound structure can only be surely detected by microscopic examination in polarized light. (See Carlsbad and Polysynthetic Twinning).

Vitreous: having the luster of broken glass, quartz, or calcite. The word is derived from vitreol, an old name for sulfuric acid. This acid has a vitreous luster.

Vug: a cavity in the rock, usually lined with a crystalline incrustation. It differs from an amygdule in that the amygdule was formed in a lava rock by expanding vapor (see Amygdule). A geode is usually somewhat spherical in shape, while a vug is more elongated. (See Geode).

Weathering: the group of processes whereby rocks on exposure to weathering change in character, decay, and finally crumble to soil. Weathering processes include: chemical action of air and rain water; plants and bacteria; mechanical action resulting from temperature changes.



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