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RADIOACTIVE MINERALS  
THE PROSPECTOR SHOULD KNOW

By

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(Revised Edition)



1954

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## FOREWORD

The interest in radioactive minerals among prospectors, mineral collectors, and people in general has increased by leaps and bounds in the past few years. This interest is, of course, due to the widespread publicity given the element uranium, because of its rather sudden emergence as a source of fabulous power and as a super-destructive war weapon. The publicity has brought home to all of us the great need of increasing our supplies of uranium for national security reasons, and has advertised, perhaps with overemphasis, the great financial reward to anyone who discovers uranium ores.

The Department laboratories are equipped to test for radioactivity, and the staff is prepared and glad to analyze samples for uranium and thorium minerals by any of several standard methods. Hardly a day goes by that the Department does not receive a sample or samples to test for radioactivity; also many inquiries come in concerning the properties of uranium minerals. Usually inquirers want to know how the principal minerals may be recognized and tested, and what geological associations are favorable for prospecting.

This pamphlet has been prepared to answer the principal questions which are continually being asked. It is hoped that the information contained herein will not only answer these questions but will point the way to discovery of commercial deposits of uranium ores in Oregon.

F. W. Libbey  
Director

May 10, 1949

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## FOREWORD

(revised edition)

Continuing demand for this pamphlet exhausted the first edition in 1952 and made necessary the issuing of a second edition. A few revisions in the text have been made by the author.

F. W. Libbey

December 30, 1952

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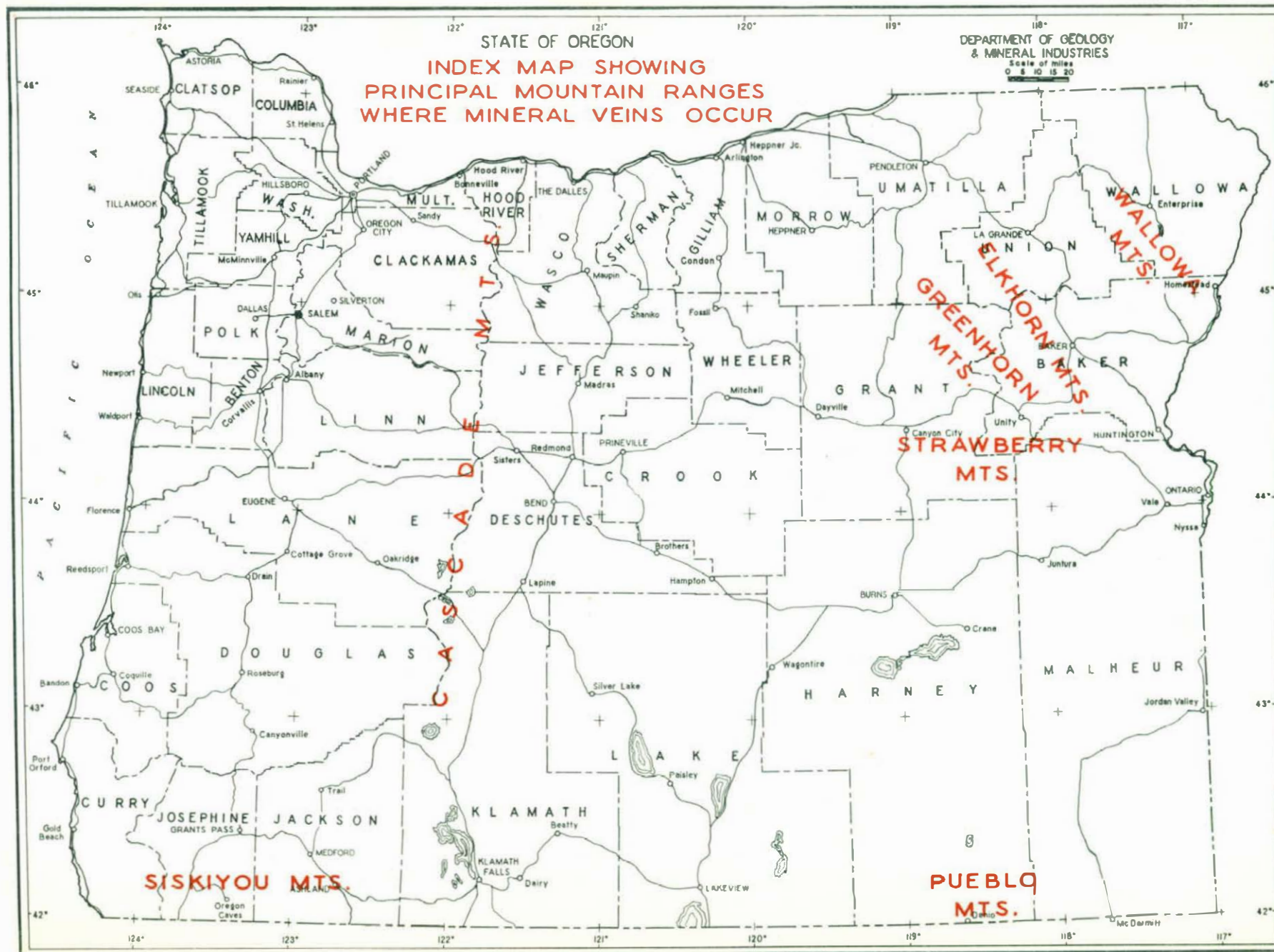
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## RADIOACTIVE MINERALS THE PROSPECTOR SHOULD KNOW

### Introduction

Radioactivity is the property of certain minerals or substances to disintegrate spontaneously with external emission of energy or radiation. Uranium and thorium are the most common radioactive elements. Uranium emits three types of radiation known as alpha, beta, and gamma rays. Alpha rays consist of positively charged particles; beta rays consist of negatively charged particles; and gamma rays are similar to light rays and X rays, but are of extremely shorter wave length. During the process of disintegration uranium breaks up into a number of elements, two of which are radium and lead. The mass of a quantity of uranium is decreased as a result of this process. The time required for a quantity of uranium to lose half of its mass is more than 4,000 million years. Investigations in recent years have led to the discovery that the nucleus of a uranium atom can be split into two portions and as a result enormous quantities of atomic energy are released.

Uranium and thorium occur in nature combined with other elements to form a large group of minerals. Only a few of these minerals are important ores of uranium; and one mineral, monazite, is the principal ore of thorium.

Uranium and thorium minerals occur in very small amounts in many rocks and waters of the crust of the earth. Mineral springs which have been in contact with radioactive rocks often are radioactive to some extent. Acidic or light-colored igneous rocks, such as granites, normally contain minute percentages of radioactive minerals; the dark or basic igneous rocks, such as basalt, have smaller percentages of these minerals than the acidic rocks. Some oil shales, other marine sediments, and phosphate beds are known to contain small quantities of uranium. Nearly all rock samples, when examined by the most sensitive methods, show extremely weak radioactivity. However, sufficient concentrations of radioactive minerals in rocks to constitute minable deposits are rare.

### Physical properties of minerals

It is essential that prospectors for uranium as well as other ores be familiar with the physical properties of minerals. The following physical properties are defined by Treasher (1940):\* color, luster, cleavage, fracture, form, specific gravity, hardness, and streak. Treasher's bulletin, or any textbook on mineralogy, will serve as a reference from which practical knowledge of these terms can be obtained.

Phosphorescence and fluorescence are physical properties of minerals which are also of some importance in prospecting for uranium ores. Phosphorescence is the emission of light by a substance after heating, rubbing, or exposure to electric radiation or to ultraviolet light. Fluorescence is the omission of light from a substance while it is being exposed to direct radiations, such as ultraviolet light. Only a few uranium minerals fluoresce, and they are discussed under individual mineral descriptions.

### General characteristics of uranium minerals

Minerals are classed as either primary or secondary in regard to their origin. Primary minerals are those originally formed in rocks by solidification from magma or deposition from related solutions, and retain their original form and composition. Secondary minerals are those formed by the alteration of primary minerals; for example, metal oxides, sulphates, and carbonates formed by the oxidation of original sulphides.

The most important primary uranium minerals are uraninite and pitchblende. Torbernite, autunite, carnotite, and gummite are the most common secondary uranium minerals.

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\*See list of publications in the back.

Uranium minerals may be black, brownish black, reddish brown, gray, orange, green, or yellow in color. Primary uranium minerals are dominantly black to reddish brown, extremely heavy, and have a metallic or submetallic luster or appearance. Secondary uranium minerals are characterized by brilliant yellow, orange, or green colors.

Most primary uranium minerals, except pitchblende, which is compact and massive with no evidence of crystal structure, occur as well-formed crystals or masses. Secondary uranium minerals commonly form as fine powders, grains, or as crusts on primary uranium minerals and on other minerals and rocks.

### Geology

The minerals which contain uranium occur as crystals, masses, or "pockets" in fissures, veins, and dikes similar to the occurrence of other metallic minerals, such as gold, silver, copper, lead, and zinc. Uraninite is more commonly found in acidic or light-colored igneous rocks, particularly granite pegmatites, than in other types of rocks. A pegmatite is a vein or dike of igneous rock characterized by extremely coarse texture due to the irregular concentration of large crystals of minerals. Crystals of uraninite occurring in granite pegmatites are usually scattered among large quartz and pink- to red-colored feldspar crystals. Metalliferous vein deposits containing pitchblende associated with cobalt and nickel minerals in addition to other minerals of base metals and precious metals have been, so far, the major source of uranium.

Secondary uranium minerals may occur in veins as crusts on the primary uranium minerals or as coatings on other vein minerals or country rock, but are generally found as fine powders or as aggregates of minute crystals or grains scattered through sedimentary rocks, such as sandstones. Occasionally secondary uranium minerals occur in massive, bedded deposits.

### Known deposits

Prior to World War II high-grade pitchblende deposits located on the eastern shore of Great Bear Lake in Canada, in the Katanga province of Belgian Congo, and in the Joachimsthal district in Bohemia produced most of the world's supply of uranium. The pitchblende in the Great Bear Lake deposits occurs in quartz-carbonate veins in metamorphosed Pre-Cambrian sediments, associated with a variety of metallic minerals, such as cobalt-nickel minerals, bismuth, native silver, chalcopyrite, argentite, galena, and pyrite. The cobalt-nickel mineralization is more extensive than the other types of mineralization. In the Belgian Congo deposits of pitchblende and other uranium minerals occur in the metamorphosed dolomites and shales of Pre-Cambrian age. Cobalt and copper are associated with the pitchblende in many of the veins. The mineralization in the mines of the Joachimsthal district in Bohemia consists dominantly of silver, cobalt and nickel, bismuth, and pitchblende in a gangue consisting largely of quartz, calcite, and dolomite. The host rocks are Pre-Cambrian schists and phyllites intruded by late Paleozoic granites.

Occurrences of uraninite and pitchblende are known in the New England states, Colorado, Texas, and in other states which contain areas of light-colored igneous rocks and metalliferous veins. A large number of minor occurrences of other uranium minerals have been found in the United States, but the carnotite deposits of the Colorado Plateau area (Colorado, Arizona, New Mexico, and Utah) are best known. The carnotite in these deposits occurs along the cracks or bedding planes and in pockets, mainly in sandstones and other sediments of Triassic and Jurassic age.

Silica deposits, chiefly opal, chalcedony, and agate, which are coated by minute particles of secondary uranium minerals have been found in a few localities in Oregon; for example, in the Pueblo Mountains near the town of Denio, Oregon; north of Jordan Valley in the area of Cow Creek, Malheur County; near Madras in Jefferson County; and in the Mutton Mountains near the Warm Springs Reservation in southern Wasco County, where they are associated with rhyolite, a fine-grained, acid, igneous rock. The rocks which are thus coated often exhibit the pale green to yellow fluorescence of certain uranium-bearing minerals. These deposits are not considered of commercial value as an ore of uranium.

Monazite, the principal thorium mineral, occurs in very small amounts in the black sands of some of the beaches along the coast of Oregon. According to Day and Richards (1905), samples of black sands from Astoria, Carnahan Station, Clatsop Spit, Clatsop Beach, Gearhart Beach, Fort Stevens, Hammond, and Warrenton in Clatsop County contained from a trace to as much as 6.5 percent monazite. Generally these samples contained about .02 percent of this thorium mineral.

A specimen consisting of pitchy, black masses of allanite in large brown-stained feldspar crystals was submitted to the Department in 1948, but the exact location from which the sample was taken has not yet been determined. Allanite usually contains a small percentage of thorium.

#### Where to prospect

When considering areas to prospect, it should be remembered that the known high-grade pitchblende deposits occur more commonly as replacement bodies in metalliferous veins than in pegmatite veins. The best chances of finding radioactive minerals would probably be in areas of known deposits or where geological conditions are similar to those of known deposits, and where other metals (especially copper, nickel, cobalt, silver, lead, zinc, and vanadium) occur. The search for uranium ores in the United States is in its infancy, and the discovery of new types of deposits is possible.

Generally, the most likely places in Oregon to prospect for uranium ores are believed to be: the northeastern part, in the Wallowa and Blue Mountain ranges; the southwestern part, in Jackson, Josephine, Curry, and Douglas counties, where old igneous and metamorphic rocks occur; and the southeastern part, in the Pueblo Mountains in Harney County (see index map opposite page 1). Other likely localities would be in other areas in which pegmatite and metalliferous veins are found.

The black sands of the Oregon beaches, which in a few places contain small amounts of monazite, should not be overlooked as a possible source of thorium. However, the black sands thus far investigated have not contained sufficient concentrations of thorium to be of value.

## PRINCIPAL RADIOACTIVE MINERALS

### Primary Uranium Minerals

#### Uraninite and pitchblende

**Form:** Uraninite belongs to the isometric crystal system. It occurs as well-formed crystals which are generally eight-sided, sometimes cubic, and rarely twelve-sided.

Pitchblende is the amorphous (no crystalline structure) variety of uraninite. It is usually massive and may occur with botryoidal or kidneylike surfaces. It may show a banded or layered structure.

**Properties:** Uraninite and pitchblende have an uneven to conchoidal fracture and are brittle with a hardness of 5 to 6. Both minerals are heavy, having a specific gravity varying from 6.5 in the amorphous forms to almost 10 in the crystalline varieties (common rock has a specific gravity of 2.5 - 2.8). The luster is submetallic to pitchlike or greasy, and sometimes dull. The color may be black, brownish black, gray, or dark green. The streak is brownish black, gray or greenish black. Uraninite, if pure, is the uranium dioxide,  $UO_2$ , but usually it is oxidized and contains some impurities. Pitchblende is the uranium oxide,  $U_3O_8$ . Lead, thorium, and other rare-earth metals are usually present in uraninite and pitchblende. Radium is found in uraninite and pitchblende in minute amounts. Both forms of the mineral readily alter to yellow, orange, red, or green secondary uranium compounds.

**Occurrence:** Uraninite is found mainly in pegmatite dikes associated with quartz and feldspars. Pitchblende occurs predominantly in veins associated with cobalt and nickel minerals and other minerals of base metals. Also, pitchblende occurs in small spotty deposits in veins with lead, zinc, copper, gold, and silver minerals.

**Distinguishing characteristics:** Uraninite and pitchblende are heavy, black minerals with a submetallic luster. There are several nonradioactive minerals which may be confused with them.

Hematite, a gray, reddish-brown or black iron-oxide mineral, often occurs in a botryoidal or kidneylike form similar to pitchblende, but the streak of pitchblende is black to greenish black and that of hematite is red. Ilmenite, wolframite, magnetite, and cassiterite are heavy dark-colored minerals with occurrences similar to those of pitchblende; however, pitchblende may be distinguished by its characteristic weathering to yellow and orange-colored secondary minerals.

Hornblende, a black nonmetallic mineral which occurs in igneous rocks, and black tourmaline, which often is found in pegmatites, are two minerals that are often mistaken for the primary uranium minerals. Hornblende and tourmaline are lighter in weight than the uranium minerals.

### Secondary Uranium Minerals

Torbernite, autunite, carnotite, and guamite are the more common secondary uranium minerals with which prospectors should be familiar. More deposits of carnotite have been found than have deposits of any of the other secondary minerals. Carnotite has been mined in commercial quantities in southwestern Colorado and southeastern Utah for many years.

#### Torbernite

**Form:** Torbernite belongs to the orthorhombic crystal system and occurs usually in thin, tabular, platy crystals.

**Properties:** Torbernite is bright green with a pearly luster and is transparent to translucent; hardness is 2 to 3; and specific gravity is 3 to 4. The streak is a slightly paler green than the color of the mineral. It is a copper uranium phosphate and often loses some combined water to form metatorbernite.



**Fluorescence:** Torbernite is not fluorescent, but metatorbernite exhibits a yellow-green color under ultraviolet light.

**Occurrence:** Torbernite is commonly associated with deposits of primary uranium ores, especially in pegmatites or sulphide lodes. It may form coatings in cracks and openings in weathered outcrops or may be scattered through the country rocks some distance from the primary ore.

#### Autunite

**Form:** Autunite is similar in appearance and occurrence to torbernite. It belongs to the orthorhombic crystal system and usually occurs as scales or tabular crystals.

**Properties:** Autunite is a lemon- to sulfur-yellow color, and is similar to torbernite in hardness and specific gravity. It has a pearly luster and a yellowish streak. It is a uranium calcium phosphate.

**Fluorescence:** Autunite is fluorescent, giving a yellow-green color.

**Occurrence:** Autunite is commonly associated with deposits of uraninite and other uranium minerals. It usually occurs in joints and cracks in granites and other rocks, and occasionally with tin, silver, and iron ores.

#### Carnotite

**Form:** Carnotite belongs to the orthorhombic crystal system occurring as soft powdery or earthy aggregates of very minute crystals which are not usually visible to the naked eye. It also occurs as an amorphous powder.

**Properties:** Carnotite is canary yellow, but may have brown iron stains or a greenish tinge. Hardness is 2 to 3 and specific gravity is 4+; both of these properties vary widely due to impurities. It is a potassium uranium vanadate.

**Fluorescence:** Carnotite does not fluoresce.

**Occurrence:** Carnotite usually occurs as soft powder or grains which coat the cracks and partings and as a filling in the spaces between grains in sedimentary rocks. Also, it sometimes replaces wood and bitumin of sediments.

**Distinguishing characteristics:** The bright canary or lemon yellow of carnotite is characteristic and distinguishes it from the dull tan or yellow color of limonite, an iron-oxide mineral.

#### Gummite

**Form:** The mineral is massive and dense occurring as rounded or flattened masses and is rarely crystalline.

**Properties:** Gummite is brittle with a hardness of 2 to 5 and a conchoidal to uneven fracture. It has a greasy or waxy luster resembling gum. The color is yellow, orange, reddish yellow to orange red, reddish brown to brownish black, and black. The streak is yellow, brownish, or olive green. The specific gravity is 4 to 6. Gummite has a variable chemical composition, consisting essentially of oxides of uranium with lead and thorium. It is probably the final oxidation product of uraninite.

**Occurrence:** Gummite is an alteration product of uraninite or pitchblende, sometimes replacing crystals of uraninite, and thus it indicates the presence of uraninite.

The characteristic physical properties and usual occurrences of the principal uranium minerals are tabulated below:

Table 1.

The More Common Uranium Minerals

| <u>Name</u> | <u>Color</u>                              | <u>Luster</u>              | <u>Hardness</u> | <u>Specific gravity</u> | <u>Remarks and occurrences</u>  |
|-------------|---|----------------------------|-----------------|-------------------------|---|
| Uraninite   | Black, gray, greenish, brownish           | Submetallic to greasy      | 5-6             | 8-10                    | Primary; usually in pegmatite dikes and in veins similar to those in which pitchblende occurs; massive; rarely as eight-sided crystals or as cubes.                       |
| Pitchblende | Black to greenish black                   | Dull metallic to pitchlike | 5-6             | Varies but heavy (6-9)  | Primary; amorphous variety of uraninite, in veins associated with silver, cobalt, nickel, lead, and copper minerals; no crystal form; sometimes botryoidal or kidneylike. |
| Torbernite  | Bright grass green                        | Pearly                     | 2-3             | 3-4                     | Secondary; associated with primary uranium ores; in cracks and joints of granite and other rocks; thin platy crystals.  |
| Autunite    | Lemon to sulfur yellow                    | Pearly to sub-adamantine   | 2-3             | 3                       | Secondary; tabular, micaceous crystals similar in occurrence to torbernite; fluorescence - yellow to green.   |
| Carnotite   | Canary yellow                             | Dull                       | 2-3             | 4+                      | Secondary; usually as soft powder (either amorphous or finely crystalline) filling cracks and spaces in sedimentary rocks.  |
| Gummite     | Yellow, orange, orange red, reddish-brown | Greasy, waxy               | 2-5             | 4-6                     | Secondary; resembles gum; alteration product of pitchblende and other uranium minerals.   |

## Thorium Minerals

Many primary uranium minerals, especially those occurring in pegmatites, contain some thorium. The greatest quantity of thorium is obtained from the mineral, monazite. Allanite is another thorium mineral but is not, at the present, considered as a commercial source of thorium. The United States Atomic Energy Commission uses thorium for research only, at the present time.

Monazite is known to occur in veins as the uranium minerals do, but its most common occurrence is in river-placer and beach-sand deposits, where it usually is associated with ilmenite, chromite, zircon, and rutile. Beach-sand areas rich in heavy black minerals are worthy of sampling for a possible monazite content. As mentioned before, some of the black sands of the beaches along the coast of Oregon are known to contain a small amount of monazite.

Thorium minerals do not alter or precipitate from solution as readily as uranium minerals, hence secondary thorium minerals are practically unknown.

### Monazite

Form: Monazite occurs as flattened, tabular crystals and also in massive form. When massive it tends to yield angular fragments. In beach sands it often occurs as pale yellow prismatic crystals with rounded ends.

Properties: The color of the crystals varies from a pale yellow to reddish brown. The streak is white, luster is resinous, and fracture is conchoidal to uneven. Hardness is 5.3 and specific gravity is 4.9 to 5.3. Sometimes it is the heaviest mineral present in sands. Monazite consists mainly of cerium and other rare-earth elements, with as much as 18 percent thorium. Sometimes the thorium content is practically nil.

Occurrences: In pegmatite dikes, and as small grains in rocks intruded by granite or pegmatite. Most commonly the known commercial ores occur in river and beach deposits. In these deposits, the monazite and other heavy minerals have been concentrated by current and wave action.

### Allanite

Form: Allanite occurs in tabular crystals or is massive.

Properties: Color is black when fresh, but is brown on weathered surfaces; luster is submetallic, pitchy, or resinous; hardness is 5.5 to 6; specific gravity is 3.0 to 4.2. Allanite is a silicate of cerium, thorium, and other rare-earth elements, together with calcium, iron, and aluminum. It is usually altered and then has a brown, friable outer crust. It contains from 1 to 3 percent of thorium.

Occurrences: The mineral is primary in pegmatites and granites.

## EQUIPMENT AND METHODS USED IN TESTING FOR RADIOACTIVE MINERALS

Radioactivity is determined by the effect of its rays or wave motion upon different substances. For example, a photographic emulsion will be exposed when struck by radioactive radiations; a gas, normally an insulator, will readily conduct electricity when gamma rays, which are emitted by radioactive substances, come in contact with it.

Certain types of equipment or methods for testing radioactivity of minerals are described as follows:

1. Geiger-Müller Counter
2. Photographic
3. Electroscope
4. Fluorescence

### Geiger-Müller counter

The Geiger-Müller counter is the most practical instrument that has been devised for locating radioactive minerals. These counters are available in various types from large laboratory models to light field models at prices ranging from \$100 to \$400 or more.

A Geiger counter, as it is usually called, employs radionic principles to measure and record radioactive emissions. It consists of a source of electricity, an amplifier unit, a Geiger-Müller tube, and an attachment for noting the radiations, such as earphones or a meter. When the electrical source is switched to the tube, a high voltage is placed across the terminals of the Geiger tube, which contains a nonconductive gas. When a gamma ray from a radioactive mineral penetrates the tube, electricity is conducted momentarily. This electrical pulse is amplified and noted as a "click." (A small instrument which records gamma ray contact by a flash of light is on the market.) Cosmic rays and random gamma rays produce the same effect, and will cause "clicks" to be heard even when the tube is not near radioactive substances. This effect is called the "background count." When a radioactive substance is placed near the tube the clicks increase to a faster rate than the normal background rate. Various degrees of increase of the rate will be noted, but highly radioactive minerals will cause a rate which the prospector will usually be unable to count accurately.

The background count will vary according to rock types and topography encountered and to variations in atmospheric conditions. Operators should learn to recognize the causes of these variations and should carefully record any change in background count.

Different types of rocks will cause a variation. For example, limestone is usually not radioactive, but igneous rocks may show very small amounts of radioactivity.

A decrease in the normal counting rate will sometimes be noticed when entering a surface depression with steep sides. This is due to the counter being somewhat shielded from the cosmic rays of space by the steep walls of the depression.

The amount and type of overburden of a radioactive deposit must be considered. Usually only a few feet of overburden will prevent a Geiger counter from readily detecting radioactivity. Size of deposit and concentration of radioactive minerals are all-important. Intense radioactivity was detected by a counter at the Great Bear Lake high-grade pitchblende deposits where the ore in one place was covered by 60 feet of overburden. Best results are obtained when the bedrock or veins are exposed.

A thunderstorm will greatly affect the counter, and it should not be used during a stormy period. The counter should be kept as dry as possible as excessive moisture often will cause a short circuit.

In testing samples of minerals or rocks which appear to be highly radioactive, first record the background count observed for a period of one minute. This should be repeated until an average is obtained. Then place the sample to be tested under the tube and record the number of counts per minute caused by the radioactivity of the specimen. The number of clicks obtained with the sample under the tube minus the background count gives a relative measurement of the radioactivity of the mineral or rock. For accurate measurements, the specimen should be compared with samples of known radioactive content.

The use of the Geiger counter in the field for a systematic survey of an area should be carefully planned. The limitations and characteristics of the counter to be used should be studied thoroughly and be well understood before beginning the survey. A topographic and geological survey of the area in question should, if possible, precede the counter survey, in order to facilitate planning and reduce the number of observations necessary.

Systematic observations should be made frequently, and the distance between observations should depend on previous knowledge of the area. For a detailed study of an area which has been geologically mapped and is known to contain radioactive minerals, the observation stations will probably be close together, from 20 to 50 feet or more apart. For general reconnaissance these stations may be placed from 20 to 50 yards apart, or more, according to accuracy of information desired.

The Geiger tube should be placed on the ground at each station and the average number of clicks per minute obtained from a 1- to 10-minute or longer period of observation. A record of the count is made, after subtracting the average background count obtained during an equal period of observation. The counter stations should be accurately placed on a map along with values obtained at each station. When enough stations are recorded on the map, a contour map of the radioactivity values can be prepared. In this way the areas of intense radioactivity may be plotted.

#### Photographic method

Only basic knowledge of photography is needed in the use of this method. It is probably the simplest means by which radioactivity of minerals can be detected.

Lay the specimen on an ordinary piece of film in a light-tight box for at least 36 hours. Place a coin, key, or other metallic object between the specimen and film. It is best to use a sheet of black paper between the metallic object and film to minimize possibility of light reaching the film. Develop the film, and if the sample is radioactive, an image of the coin will be obtained. The clearness of the image is a measure of the radioactivity of the mineral.

#### Electroscope

The use of the electroscope in detecting radioactivity depends on the principle that air is an insulator, but becomes a conductor in the presence of radioactive substances. An electroscope is usually a delicate instrument and should not be used in the field as the Geiger counter is. Samples should be brought from the field to the laboratory or any convenient place where the electroscope is kept.

A recent publication\* describes a method of constructing an electroscope as follows:

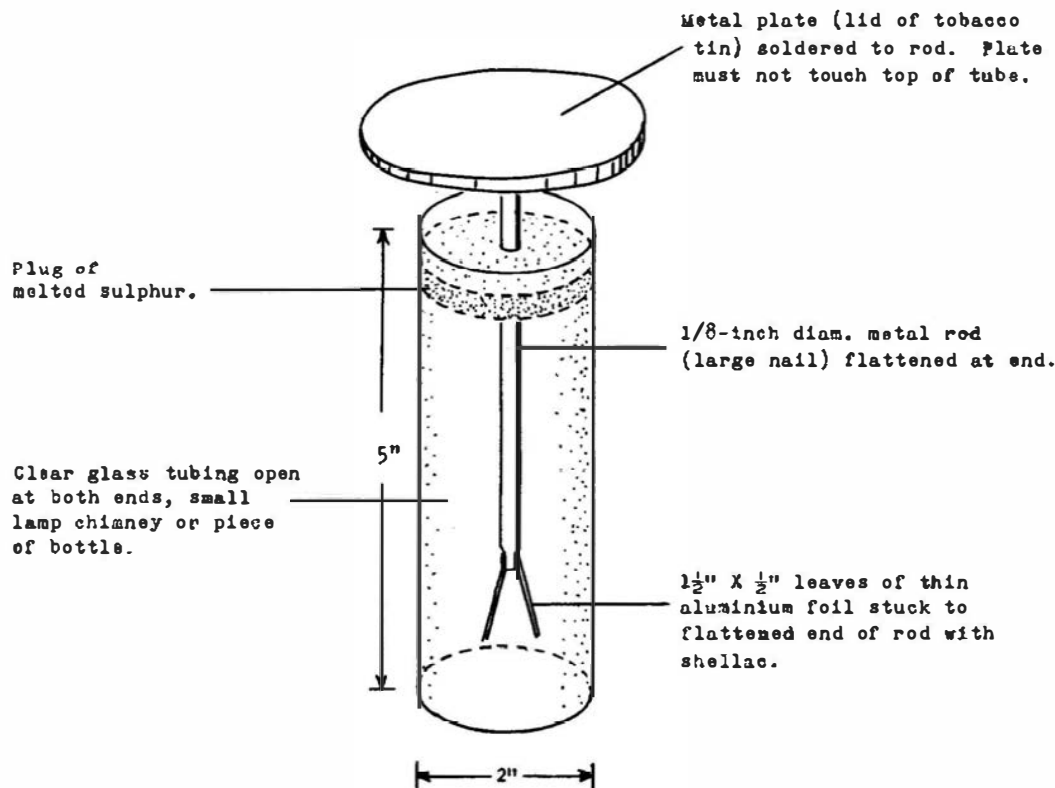
"The materials required are a piece of glass tubing 2 inches in diameter, 5 inches in length and open at both ends, a piece of metal, e.g. copper, 1/8 inch diameter and 3 3/4 inches long, 1/4 pound of sulphur, the lid of a tobacco tin and 2 to 3 square inches of gold or aluminium foil. These foils are widely used in commercial art and can usually be procured from art supply stores and from stationers. It should be sufficiently thin to allow objects to be distinguished

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\*"Radioactive mineral deposits": Australia Bur. Min. Resources, Geology, and Geophysics, Dept. Supply and Dev., Pamph. 3, August 1948.

on looking through it. The leaf is cut into strips 1 inch long by  $\frac{1}{4}$  inch wide by placing it between sheets of paper and cutting it with a sharp razor blade. One end of the metal rod is flattened and then moistened with thinned-out shellac and a strip of foil is attached to either side of the flattened portion of the rod.

"The next step is to suspend the metal rod and the foil in the glass tube through an insulating plug of sulphur or other material with similar properties. This is done by pushing the free end of the rod through a piece of paper which is then pressed into one end of the glass tube and moulded into the shape of a stopper. The sulphur is melted and poured around the metal rod, the paper serving to prevent it from running through the tube. The lid of the tobacco tin is then soldered to the top of the metal rod, making sure that it does not touch the top of the glass tube."



Note: Gold or aluminium leaf may be used in place of aluminium foil, but is difficult to handle and too fragile for use in a portable electroscope.

Fig. 1. Sketch of electroscope showing materials used in construction.\*

\*"Radioactive mineral deposits": Australia Bur. Min. Resources, Geology, and Geophysics, Dept. Supply and Dev., Pamph. 3, August 1948.

An electrically charged object, such as a piece of glass rubbed with silk, is held close to the metal lid of the electroscope and the lid is touched with a finger. Then the finger is removed from the lid of the electroscope followed by the removal of the electrically charged object. This places like charges on the leaves of the electroscope with the result that they repel each other and therefore separate.

The leaves will remain charged and separated for several hours under normal conditions. The distance apart of the leaves is measured and the electroscope is placed over a sample. Radiations from a radioactive substance will cause the leaves to collapse in a few minutes.

The bottom of the glass tube should be smooth and the sample should rest on a piece of felt in order to prevent air currents from entering the tube and disturbing the leaves.

### Fluorescent methods

Fluorescence has been defined previously (page 1) and the uranium minerals which exhibit this property have been noted under individual mineral descriptions. The short-wave-length ultraviolet lamp is the type commonly used in testing the fluorescence of uranium minerals. Portable lamps are available.

The primary uranium minerals are nonfluorescent and only a few secondary ones fluoresce. Hence, the use of this method is restricted.

The fluorescent color of autunite is yellow green or greenish yellow. That of metatorbernite is yellow blue; gummite fluoresces a dull purplish red; and carnotite does not fluoresce.

Uranium in a substance may be detected by fusing a small quantity of the substance with sodium fluoride or borax on a small loop of platinum wire to form a bead. The bead is formed by dipping the hot loop into the powdered mineral and reheating for a minute or two. It is cooled, and then tested for fluorescence. Uranium will cause the bead to fluoresce a bright lemon-yellow color. The long-wave-length ultraviolet lamp gives the best reaction to the sodium fluoride bead.

When using borax instead of sodium fluoride for the bead, uranium minerals will cause the bead to fluoresce from a pale-green, yellowish-green, or greenish-yellow to pale-yellow color. Either a short-wave-length or a long-wave-length ultraviolet lamp is satisfactory with the borax bead.

### Scintilliscopes

A scintilliscopes is a tubular instrument consisting of an eyepiece with a magnifying lens and a screen coated with zinc sulphide powder. When an extremely radioactive mineral is placed near the screen, the rays emanating from the radioactive material produce bright flashes of light as they strike the zinc sulphide screen. These bright flashes of light, which can be seen through the eyepiece, are called scintillations. The scintilliscopes should be used in a dark place, and only after the observer's eyes are adjusted to the darkness. It is useful in detecting only strongly radioactive material.

## THE UNITED STATES ATOMIC ENERGY COMMISSION

Prior to 1942 the demand for uranium was restricted to its use as a coloring agent and as a source of radium. During World War II the search for uranium as a source of atomic energy was conducted with secrecy by the Army's Manhattan Project. Since then the use of uranium in atomic weapons, for isotope production, and the possible use for generation of power has made it necessary to intensify the search for uranium deposits.

On August 1, 1946, the Atomic Energy Act was passed by the 79th Congress, and the Atomic Energy Commission was established. In April, 1946, the Commission announced a program to stimulate the discovery and production of domestic uranium by private enterprise. The major elements of this program are:

1. Government-guaranteed 10-year minimum prices of \$3.50 per pound of contained  $U_3O_8$  for small lots of domestic refined uranium, and of \$3.50 per pound of recoverable  $U_3O_8$  less refining costs for small lots of ore or mechanical concentrates assaying at least 10 percent  $U_3O_8$ , both prices f.o.b. shipping point.
2. A bonus of \$10,000 for the discovery of a new deposit and production therefrom of the first 20 tons of uranium ore or mechanically produced concentrates assaying 20 percent or more  $U_3O_8$ .
3. Government-guaranteed 3-year minimum prices for the low-grade carnotite and roscoelite-type uranium-vanadium ores of the Colorado Plateau area and Government operation of two vanadium-uranium plants in that area.

Some laws and rules of the Atomic Energy Commission are:

1. Uranium deposits on the public lands, and other lands owned by the United States, are now reserved by the United States, subject to mineral rights established on or before August 1, 1946. Valid locations of deposits of uranium ores on public domain may be staked if the uranium occurs in a deposit which is valuable because of other minerals. In the unlikely event of the discovery of a deposit of uranium-bearing ore which does not contain some other valuable mineral, the Commission, upon notice, will take steps to protect the prospector's equity. Uranium in deposits on lands in private ownership to which title was granted prior to August 1, 1946, belongs to the owner of the land. Such uranium, as well as that on public lands, is subject to licensing procedures discussed below.
2. Licenses are required for all transfer of source material after its separation from its place of deposit in nature. The term "source material" means any material, except fissionable material, containing 0.05 percent or more either of uranium or thorium. This means that a license must be obtained from the Commission in order to buy or sell uranium or thorium after it has been mined. A license can be obtained from the United States Atomic Energy Commission, Post Office Box 30, Ansonia Station, New York 23, New York.
3. Samples of material which are suspected of containing uranium may be sent to the New York office of the Division of Raw Materials of the U.S. Atomic Energy Commission for free examination and analysis, or they may be sent to any U.S. Bureau of Mines or U.S. Geological Survey laboratory.
4. Anyone with uranium for sale to the Government should get in touch with the Division of Raw Materials, United States Atomic Energy Commission, in Washington, D.C., and discuss a contract. First, samples of the ore should be sent to the New York office for analysis.
5. Certain information pertaining to uranium ore is considered as secret. The Commission preserves secrecy concerning the actual production and reserves of uranium available to the United States. Also, some formal procedures must be followed in handling "classified" letters, reports, and the like.



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## Appendix

### Some Manufacturers and Distributors of Geiger Counters

Smith's Fluorescents  
220 S.W. Alder Street  
Portland 4, Oregon

The Mineralogist  
329 S.E. 32nd Avenue  
Portland 15, Oregon

White's Electronics  
1218 "M" Street  
Sweet Home, Oregon

Fisher Research Laboratory  
1961 University Avenue  
Palo Alto, California

National Technical Laboratories  
820 South Mission Street  
South Pasadena, California

Ultra-Violet Products, Inc.  
5205 Santa Monica Blvd.  
Los Angeles, California

Fatten Engineering Company  
1732 Blake Street  
Denver, Colorado

Alec Manufacturing Company  
4011 Cuming Street  
Omaha 3, Nebraska

Omaha Scientific Supply Corporation  
3623 Lake Street  
Omaha 4, Nebraska

Radiation Counter Laboratories  
1844 W. 21st Street  
Chicago 8, Illinois

The Victoreen Instrument Company  
5806 Hough Avenue  
Cleveland 3, Ohio

Herbach and Rademan, Inc.  
1204 Arch Street  
Philadelphia 7, Pennsylvania

The Radio Company  
489 Fifth Avenue  
New York 17, New York

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1069 State Office Building, Portland 1, Oregon

|   |  | Prices<br>(subject to change) |
|---|--|-------------------------------|
| <b>BULLETINS**</b>  |  |                               |
| 1. Mining laws of Oregon, 4th revision, 1954, contains Federal placer mining regulations . . . . .  |  | \$ 0.50                       |
| 3. Geology of part of the Wallowa Mountains, 1938: C. P. Ross . . . . .   |  | 0.50                          |
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| (2d vol.) Two papers on foraminifera from the Tertiary of Western Oregon and Western Washington,<br>1949: Cushman, Stewart, and Stewart; and one paper on mollusca and microfauna of<br>Wildcat coast section, Humboldt County, California, 1949: Stewart and Stewart . . . . . |  | 1.25                          |
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\*A complete list of publications will be mailed upon request. Please include remittance with order. Postage free.

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12/8/54