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The Earth's Uranium

It is fairly common, yet it occurs in few concentrations that can profitably be mined. A brief summary of the most important deposits, including some that have only recently been revealed

by Paul F. Kerr

THE most important sources of uranium in the world are the Shinkolobwe mine in the Belgian Congo, two mines in northwest Canada, the Erz Mountains on the boundary between Czechoslovakia and East Germany and the Colorado Plateau in the U. S. Two years ago the latter area was not considered in the same class with the first three. But intensive prospecting and new geological knowledge have greatly increased our known resources. Today the U. S. production of uranium is an important factor in the world supply.

Uranium is a fairly common element, present almost everywhere in the earth's crust. The problem is to find it in concentrations that make it worth while to try to mine it. It has been suggested that we could get 70 tons of uranium from every cubic mile of sea water. This sounds impressive until one makes a simple calculation and finds that a cubic mile of sea water weighs about four billion tons—70 tons of uranium in that bulk of "ore" amounts to about one part in 60 million. There are many rock masses in the earth with a uranium content of one part in 10,000, but even this concentration is considered much too thin for mining by present methods. To interest mining engineers a deposit must have a uranium content of at least one part in a few hundred; that is, at least several pounds of uranium per ton of ore.

There are more than 80 known minerals that contain substantial amounts of uranium, but less than a dozen are at all abundant in the earth. The richest mineral is uraninite, a combination of uranium dioxide (UO_2) and trioxide (UO_3). This exists in black powdery and solid crystalline forms. Pitchblende is a variety of uraninite. Usually uraninite occurs in relatively deep deposits. The other important uranium minerals ordinarily are found near the earth surface. They are carnotite, a canary-yellow powder in which uranium is combined with potassium and vanadium; torbernite, a green crystal phosphate of uranium and copper; autunite, a yellow crystal phosphate of uranium and calcium; tyuyamunite, a yellow powder containing uranium, calcium and vanadium; thucholite, a black organic material in which uranium is combined with a hydrocarbon, and kolm, another uranium-hydrocarbon combination.

Carnotite is the most common uranium mineral in the Colorado Plateau. Torbernite is found in large masses near the surface in the Belgian Congo, where the richest deposits of uraninite are located. Good deposits of autunite are found in Portugal. Tyuyamunite is named for a city in a region of the U.S.S.R. where it is particularly abundant.

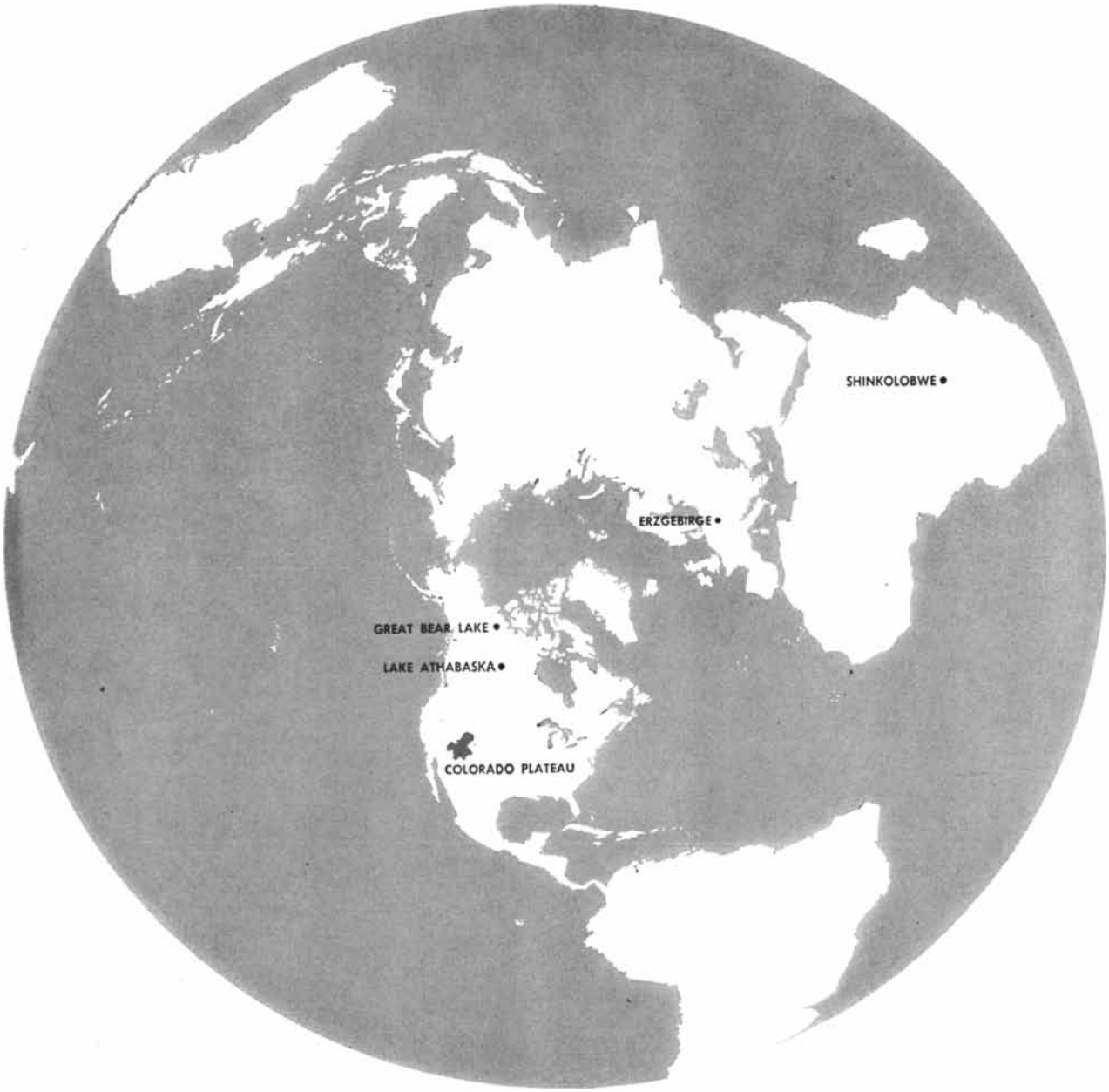
In looking around the world for likely sources of uranium minerals the geologist has certain general principles to guide him. He will look, of course, to faults, fissures and pockets in the earth's crust, where minerals in general are concentrated, and he will search for chemical and physical conditions that particularly favor the precipitation of uranium. He knows that concentrations of uranium often occur in veins cutting the granitic igneous rocks. Uranium (with its companion radium) tends to be associated in veins with certain other minerals, notably cobalt, nickel, bismuth and a few others, including small amounts of silver and gold. During the recent worldwide hunt for uranium another apparently significant fact has emerged: many of the uranium deposits have been found in ancient Pre-Cambrian rocks. It is believed to be more than a coincidence that the chief uranium locations in the Belgian Congo, the Erz Mountains, Canada, eastern Colorado and at several other places are all in Pre-Cambrian formations.

We can see the uranium picture most conveniently by reviewing briefly the history of each of the principal locations.

THE town of Joachimsthal in the Erz Mountains has been a mining center since the 15th century. For centuries the only metal mined was silver. The American word "dollar" is derived from the name of silver coins struck there, first called *Joachimsthaler* and later abbreviated to *thaler*. In the middle of the 19th century the element uranium was discovered in the Joachimsthal ores, but the only use then found for it was as a pigment for porcelain and glass. When in 1898 the Curies isolated radium, a product of the radioactive decay of uranium, from the uranium residues of Joachimsthal, the mines rose in importance; for many years they were the world's sole source of radium. Up to

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THE FOUR MOST IMPORTANT uranium regions are in northwestern Canada, the western U. S., the southern Belgian Congo and the Erz Mountains, or Erzgebirge, of Czechoslovakia and the Russian zone of Germany.

World War II they had yielded a total of 100 grams of radium.

The uranium-bearing formations of the Erz Mountains lie along two mountain belts which intersect at Joachimsthal. The mountains, once the boundary between Saxony and Bohemia, now are on the border between the Russian zone of Germany and Czechoslovakia. The principal uranium mineral in these deposits is uraninite. It lies in veins ranging from less than an inch to several feet in thickness. The veins also contain minerals of silver, cobalt, nickel and bismuth. They represent old fissures in the earth's crust that were partly filled by the precipitation of metallic minerals from ascending solutions. The wall rock consists of recrystallized sediments of Pre-Cambrian age.

Uranium is reported as U_3O_8. The total amount of U_3O_8 mined in the Erzgebirge region up to 1940 is estimated at 690 tons. We can only guess at how much the Russians may have obtained from their intensive mining of the area since the end of the war. In all likelihood the amount is at least several hundred tons.

To estimate the total extent of the uranium resources available to the U.S.S.R. we must extrapolate from what was known about them before 1944, for little information has been revealed from behind the Iron Curtain since that time. The principal uranium deposits in the U.S.S.R. before 1944 were considered to lie in the black shales and slates of the desert area of Asiatic Russia between Lake Balkhash and the Afghanistan border. This is the region where the mineral known as tyuyamunite is found. The Alai Range in the same general area also is reported to possess large amounts of black shales or slates containing on the order of a pound of uranium per ton of rock, but the labor required to work these deposits would be great indeed. Near-surface deposits of a uranium mineral are known to exist in Bulgaria. In addition the U.S.S.R. was known to

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possess scattered deposits of uranium minerals such as occur in other parts of the world; probably these are numerous enough to yield significant quantities of fissionable material.

According to press accounts some 3,000 geologists are exploring for uranium in the U.S.S.R. It must be assumed that they have made considerable progress. Whether the state-operated Soviet effort will ultimately produce more and cheaper uranium than will the cooperative efforts of government and private industry in the U. S., time alone will tell. But if any credence may be placed in the newspaper reports that hundreds of thousands of Russian workers are engaged in mining and hunting uranium, with digging and prospecting going on in 230 locations in eastern Germany alone, we may well conclude that the present uranium production available to the U.S.S.R. is seriously large.

OUR first source of supply is the Shinkolobwe mine in the Belgian Congo. Shinkolobwe is in the heart of Africa, about midway between the continent's east and west coasts and near the southern margin of the Congo Basin about 11 degrees south of the Equator. It lies in the center of a great mineral province long famous for its production of copper, cobalt, tin and diamonds; the province produces most of the world's industrial diamonds and leads the world in the production of cobalt.

In 1915 a Major Sharp, prospecting for minerals as an employee of the Tanganyika Concession, noticed some unusual bright yellow fragments of rock in the soil at Shinkolobwe. Analysis showed that they were rich in uranium. The concessionaires dug trenches and soon exposed veins of black uraninite. Later explorations disclosed masses of rock containing the highest percentages of uranium found anywhere. Near the surface above these veins lie brightly colored uranium minerals—yellow, orange or green—some of which have been found nowhere else in the world.

The Shinkolobwe area is one in which Pre-Cambrian rocks of varying ages are exposed at the surface. Curiously, in some places an older Pre-Cambrian rock lies on top of a younger; the layers apparently were overturned by faulting and deformation of the crust. It is in the older rock that the most important uranium deposits have been found. How the uraninite was deposited in this rock is a matter of conjecture. Originally the uranium came from deep in the earth crust. It rose in heated solutions and was deposited in spaces in the shattered rock of the old Pre-Cambrian strata as uraninite. The deformation that thrust the old layer upward then raised the veins of uraninite close to the surface. Some such explanation seems necessary to ac-



URANIUM PROSPECTORS' ROADS make a distant network in the hills near Marysvale, Utah. Veins of uraninite have been found in this region.



"HAPPY JACK" URANIUM PROSPECT is in the rugged country of southeastern Utah. In this region the uraninite is found not in veins but in strata.

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count for the emergence of so rich a concentration of uranium at Shinkolobwe—unmatched, as far as we know, anywhere else on the surface of the earth.

THE uranium deposits of Canada are in another great area of exposed Pre-Cambrian rocks, but in this case the ancient rocks have been laid bare by erosion of the younger rocks that covered them. Anyone who flies over the Canadian Shield can hardly fail to be impressed by the great number of scattered lakes, seemingly always extending to the horizon. The land areas between the lakes have been so swept by the great ice sheet which once covered the entire area that when viewed from the air they appear to have been planed. The surface is furrowed, however, with a network of fault lines that show up in the topography as long narrow depressions filled with trees, bushes and muskeg. It is along such fault lines or other fractures parallel to them that the Canadian uranium deposits were found and much of the uranium prospecting in the northland has been carried on of late.

The original Eldorado deposit was discovered in 1930 by the Canadian prospector Gilbert LaBine. On the east shore of Great Bear Lake, in a wilderness only a short distance south of the Arctic Circle, he spotted from the air a vein which proved to contain uraninite. It was later traced for several thousand feet and found to belong to a group of five neighboring veins. The original vein, named "No. 1," in places is as much as 30 feet thick.

Intensive mining began during the war, when the need for uranium for the Manhattan Project developed. Since the Eldorado mine is 1,380 miles by boat and 800 miles by air from the nearest railhead in the province of Alberta, transportation is a problem. The uranium oxide is shipped to the railhead over a circuitous route by way of several lakes and rivers. The Eldorado Mining and Refining Company, Ltd., operator of the mine, also runs its own airline from Eldorado to Edmonton. The company is controlled by the Canadian Government.

Since the end of the war the great Canadian Shield has been extensively prospected. Uranium has been found at various places in a zone which extends from Great Bear Lake southward through Great Slave Lake and Lake Athabaska and finally eastward along the northern shore of Lake Superior. Near the eastern arm of Lake Athabaska the Eldorado Company has recently found a group of veins along what is known as the St. Louis fault. On the basis of extensive drilling and tunneling into the shattered rock the engineers have concluded that this deposit will yield an amount of uranium comparable to that from the Eldorado site. It is expected to begin producing before the end of this year.

IN the U. S. the main center of prospecting has been the Colorado Plateau, which covers parts of the four states of Colorado, Utah, Arizona and New Mexico. The ore here, as we have noted, is carnotite, a vanadate of potassium and uranium. It occurs in old sandstones formed in what seems once to have been a shallow fresh-water sea. The sandstone contains a great many fossil logs and other plant remains. In some of the logs carnotite has replaced part of the original material. One such log, four feet thick and 100 feet long, yielded 105 tons of uranium-vanadium-radium ore. The market value of this log at the time it was mined is reported to have been about $230,000.

The logs and other vegetable matter appear to have been important factors in the accumulation of the concentrations of uranium and vanadium. Presumably the organic matter played a part in the chemical reduction and precipitation from solutions of dissolved salts containing uranium.

Deposits of carnotite underlie large areas in Colorado, Utah, Arizona and New Mexico. The U. S. sources of uranium are not restricted to carnotite. Near Marysvale, Utah, significant veins of uraninite have been found. Another encouraging discovery of uranium ore has recently been made at the old Sunshine silver mine in the Coeur d'Alene district of Idaho. There are also promising veins bearing uranium in the granitic rocks of western Montana. The Pre-Cambrian formations of the northern Michigan Peninsula have shown possibilities, but no workable deposits as yet.

Throughout much of the western U. S. an army of prospectors is searching for uranium with an enthusiasm that must be witnessed to be appreciated. The "uranium rush" is producing new types of prospectors. Radio technicians, businessmen and people of many other occupations who have never had any interest in mining have equipped themselves with Geiger counters and assailed the hills in search of radioactive rocks. They have reported many usable prospects, and some of these are already being mined. One interesting deposit was discovered accidentally by a plumber on a picnic. He was amusing himself with a portable Geiger counter and happened on some loose rocks that showed unusual radioactivity. He then traced the rocks to the uranium deposit. An attractive feature of uranium-hunting is that it can be carried on with little more equipment than a Geiger counter; anyone can be a prospector, even if he does not know much about rocks. And a search of the terrain with a Geiger counter is a fascinating experience.

It appears that it may also become possible to explore for uranium from the air. The U. S. Geological Survey, working with the Atomic Energy Commission, has made tests of this possibility with low-flying planes carrying specially built counters. Some planes fly slowly over the terrain at an altitude of about 500 feet. They have been able to locate rock deposits of unusual radioactivity within about a quarter of a mile. Such a survey is very crude, of course, and it must be followed up with a more intensive exploration on the ground, which may eventually come to naught. But the survey can cover a great deal of terrain in a relatively short time.

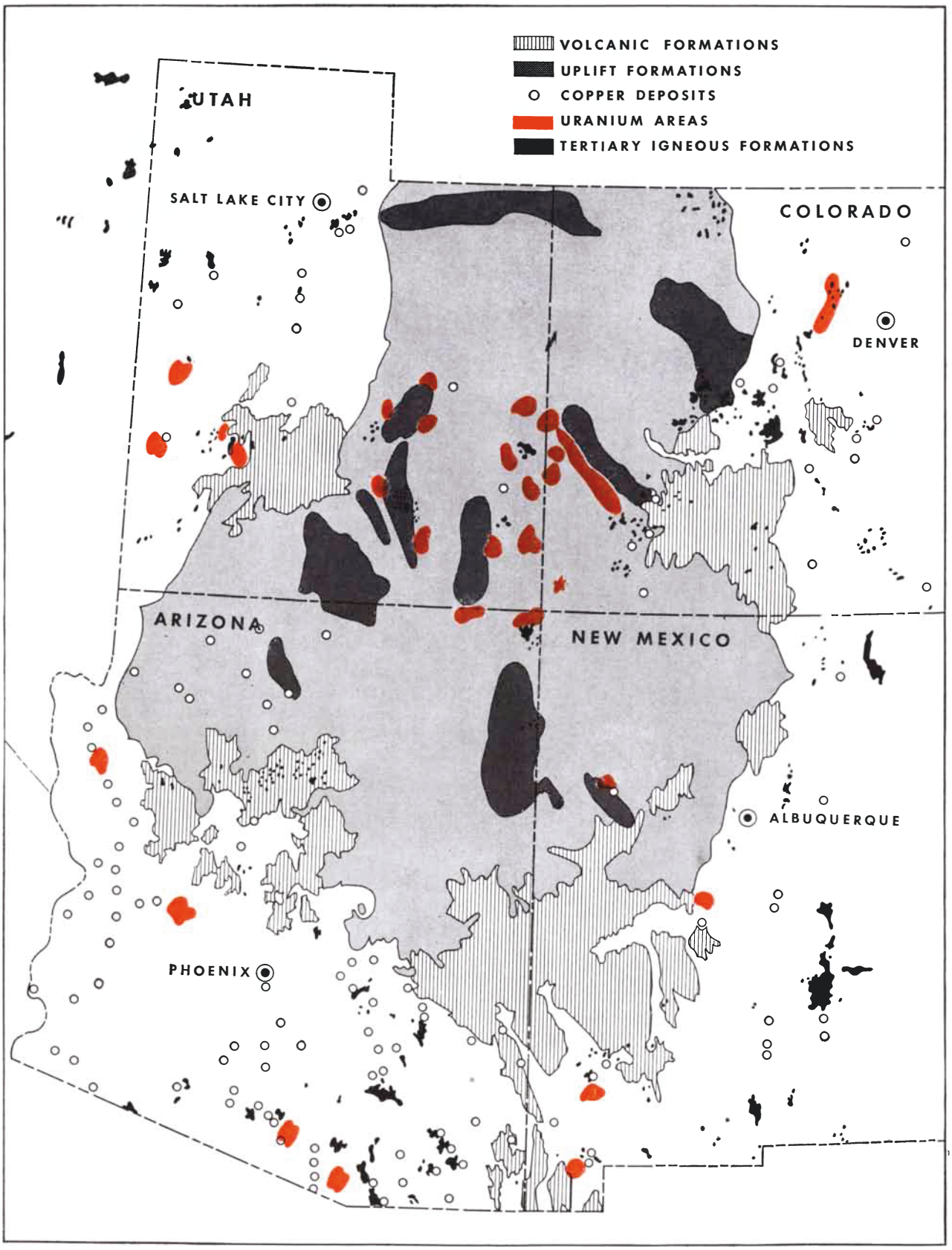
FROM the finds of the prospectors and from geological studies we are steadily enlarging our knowledge of the occurrence of uranium in the earth. The deposits found are being scrutinized by geologists; the minerals taken from them are being studied in the laboratory. These analyses provide further clues as to the types of formations where uranium is likely to exist. The studies are not restricted to high-grade sources of the metal. Recently attention has been directed to the fact, previously overlooked, that the gold ores of the Witwatersrand in South Africa contain some uranium. The average uranium content of these rocks is small, but with 60 million tons of gold ore passing through the Witwatersrand mills each year, the salvage of even a small amount of uranium from each ton may well be worth while. In our own country there are known to be large deposits of uranium-bearing phosphate rock in Florida, Idaho and western Wyoming, black shale in Tennessee and pegmatites scattered through many parts of the nation. These ores are of very low grade—one pound of uranium in several tons of rock—but in the aggregate they constitute an enormous potential reserve.

As our information accumulates, it appears more and more evident that uranium is deposited in the earth in much the same way and by much the same processes as other metals, such as copper, lead, silver, cobalt and nickel. In fact, uranium is often associated with those metals, as we have seen. Hence we should increasingly be able to apply our long-established knowledge of the older minerals to the newer problem of uranium prospecting. Given unrestricted peacetime publication of geological information, and the incentive of industrial demand, man should learn a great deal more about the earth's uranium resources.

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COLORADO PLATEAU covers a large part of four western states. In the uranium areas near the center of the plateau the uranium minerals tend to occur in strata; in the areas around the edge of the plateau, they tend to occur in veins. The distribution of copper deposits is roughly similar to that of the uranium veins.

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