Radioactive Deposits in New Mexico

GEOLOGICAL SURVEY BULLETIN 1009-L

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A CONTRIBUTION TO THE GEOLOGY OF URANIUM

RADIOACTIVE DEPOSITS OF NEW MEXICO

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ABSTRACT

Forty-five areas of radioactivity in New Mexico had been investigated by government geologists or reported in the geologic literature before 1952. Twenty-one areas contained visible uranium minerals and one contained thorium minerals. The occurrences were in the northwestern, north-central, central, southwestern, and southeastern parts of the State.

The deposits in northwestern New Mexico seem to be the most promising for the mining of uranium ore. In western San Juan County, on the eastern flanks of the Carrizo Mountains uplift, carnotite ore has been taken from several prospects in the Salt Wash sandstone member of the Morrison formation. On the southern rim of the San Juan Basin in Valencia and McKinley Counties, carnotite is widely disseminated in the Todilto limestone and the Morrison formation of Jurassic age and the Dakota formation of Cretaceous age. Farther south in the Zuni Mountains of Valencia County joint coatings in pre-Cambrian granites show abnormal radioactivity, but no uranium minerals have been found.

Many types of radioactive deposits have been found in north-central New Mexico. This region contains 4 radioactive copper deposits, in sandstones, 3 radioactive lignites or black shales, 2 radioactive spring deposits, and a uranium- and thorium-bearing pegmatite district.

In central New Mexico only two deposits, one in the San Acacia or San Lorenzo district in Socorro County and the other in the Scholle district in Torrance County, had been reported. The former deposit consists of autunite, torbernite, and uranophane sparsely disseminated in a breccia zone near the edge of a Tertiary andesite flow; the latter consists of carnotite associated with carbonized wood and secondary copper minerals in Permian sandstones.

The radioactive deposits of southwestern New Mexico include the White Signal and Black Hawk districts in Grant County and the Terry prospect in Sierra County. In the White Signal district autunite and torbernite are associated with veins and basic dikes cutting pre-Cambrian granite and diabase. In the Black Hawk district pitchblende is associated with nickel, cobalt, and silver minerals in quartz veins cutting pre-Cambrian granite. On the Terry prospect, near Monticello, uranophane occurs in a breccia zone cutting limestones of Mississippian age, which have been altered to jasperoid.

In many of the Lea County oilfields of southeastern New Mexico the brines, which are associated with oil from Permian strata, are radioactive; however, the uranium content of these brines is extremely low, and it seems unlikely that they will ever become a commercial source of uranium.

The only commercial deposits of uranium ore in New Mexico, known before 1952, are in the northwestern part of the State. A plant has been constructed near Grants, in Valencia County, to process this ore. The southwestern region also has several promising uranium deposits and additional exploration may prove they contain valuable reserves of uranium ore. The few tons of ore available on the Merry Widow claim in the White Signal district and the presence of pitchblende at Black Hawk suggest that further exploration here may discover important ore reserves. Information available on the rest of New Mexico does not indicate the presence of any important sources of uranium ore under market conditions prevailing at the end of 1951.

INTRODUCTION

SCOPE AND PLAN OF THE REPORT

The purpose of this report is to summarize the information available on uranium deposits and uranium mining activity in New Mexico before 1952.[1] The report has been divided into three main sections. First, a general discussion and comparison of the geology and mineralogy of the deposits as a whole is presented in the section entitled "Radioactive deposits." Second, in the body of the report, the radioactive localities are described by counties which are arranged alphabetically in the report. For each occurrence the location, general geology, mineralogy, and radioactivity are summarized and references are given to published reports covering the area. In the final section, "Conclusions" (p. 382), it is pointed out that, although the uranium deposits in New Mexico are diversified and widely distributed, only a few offer much hope of commercial development under economic conditions existing in 1952.

HISTORY OF URANIUM INVESTIGATIONS AND MINING

The earliest mention in geologic literature of a uranium mineral from New Mexico was in 1902, when a brief anonymous note mentioning the occurrence of uraninite in the President mine near Elizabethtown, Colfax County, appeared in the Mining and Scientific Press. No other references to this occurrence are known to the author. Lindgren, Graton, and Gordon (1910) noted the presence of carnotite in Peralta Canyon, Cochiti district, Sandoval County and of torbernite in the Jerome copper mine, San Lorenzo district, San Acacia, Socorro County. The first record of the samarskite-bearing pegmatites near Petaca appeared in Mineral Resources of New Mexico for 1915. In 1920 the discovery of autunite and torbernite in the White Signal district and pitchblende in the Black Hawk district in Grant County was recorded in the Engineering and Mining Journal (Leach, F. I., 1920). Wells (1924) reported carnotite in the Scholle district in Socorro County and

[1] While this report was in preparation more recent information on the Grants district, Coyote Creek, and La Ventana Mesa became available and has been included.

in the Carrizo Mountains in San Juan County. Northrop (1942) mentions cyrtolite, uraninite, and samarskite from pegmatites on Elk Mountain in San Miguel County. During World War II the deposits at White Signal, Black Hawk, San Lorenzo, and Petaca were reexamined for uranium, and a new radioactive microlite deposit was discovered in the Rociada district, Mora County.

Since World War II the carnotite-bearing limestone and sandstone deposits near Grants in Valencia and McKinley Counties, discovered in 1949 and examined by U. S. Geological Survey and U. S. Atomic Energy Commission geologists the following year, have attracted considerable interest. By the end of 1951 a mill was being set up near Grants to treat these ores and preparations were being made to mine them on a large scale. In 1950 a note in the Engineering and Mining Journal reported that secondary uranium minerals had been found in a mine in the Organ district, Dona Ana County.

Before 1952, 45 radioactive occurrences in New Mexico had been examined by U. S. Geological Survey and U. S. Atomic Energy Commission geologists or reported in the geologic literature. Deposits of carnotite in the Salt Wash sandstone member of the Morrison formation have been found on the eastern flanks of the Carrizo Mountains in San Juan County; although the deposits are small and scattered they are locally rich and a considerable amount of uranium ore has been shipped from them. In Grant County, southwestern New Mexico, autunite and torbernite are associated with pyritic quartz veins cutting pre-Cambrian(?) granitic rocks and younger intrusives in the White Signal district. There have been reports that pitchblende is present in argentiferous base-metal sulfide ore in fissure vein deposits of the nearby Black Hawk district. Although no uranium ore has been shipped from either the Black Hawk district or White Signal district recently, they both seem to be worthy of further exploration. None of the remaining radioactive occurrences known in New Mexico before 1952 contained known reserves of uranium ore under market conditions existing at that time.

During the last few years many new radioactive deposits have been investigated by geologists of the U. S. Geological Survey and the U. S. Atomic Energy Commission. Some of the new deposits are the radioactive copper deposits in Sandoval and Rio Arriba Counties, a uranophane prospect in Sierra County, radioactive coals and black shales in Sandoval and Mora Counties, and radioactive brine in oilfields of Lea County. As yet, however, no uranium ore of minable grade has been found in any of these localities, except possibly at La Ventana Mesa in Sandoval County.

Before 1952 the only uranium ore produced in New Mexico came from the Grants district and the Carrizo Mountains. The first shipment from the Grants district was made in the fall of 1950. Since

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that time extensive exploration has proved the existence of a large tonnage of ore distributed over a considerable area in this district. During the 1920's a few carloads of autunite and torbernite mixed with sericite were mined and shipped from the Merry Widow mine, in Grant County, to be used in "activated water" and face powder.

ACKNOWLEDGMENTS

This report was compiled largely from published and unpublished reports by members of the U. S. Geological Survey on work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission and from reconnaissance reports by members of the Atomic Energy Commission. The unpublished information has been combined with information published in the geologic literature before 1952. The length of each report section on a deposit is dependent on the amount of hitherto unpublished information available.

Unpublished memorandum reports are slightly condensed under the original title and the original author. The information in reconnaissance reports is summarized. Published reports by government geologists are abstracted with a reference to the published report. Other published reports are included in the bibliography and many of them are referred to in the section entitled, "Other reported occurrences."

The information on the deposits in the northwestern region has been taken mostly from an unpublished report (1950) by Fischer and Strobell. Rappaport (1952) has written about the Grants district, and unpublished reports by Sheridan (1950) and by Rosenzweig (1950) also supplied information about the district. Reports by Stokes (1951), Ellsworth (written communication, 1951), and Hatfield (written communication, 1951) were used for information on the deposits in the Carrizo Mountains district. Most of the descriptions of properties in the north-central region were taken from an unpublished report (1951) by Bachman and Read. The deposits in the central region were examined by Gott and Erickson (unpublished report, 1951). The information on the southwestern region was taken mostly from unpublished reports by Granger and Bauer (1950a, 1951a), by Granger (1950a, 1950b), and by Bauer (1950). One report by Granger and Bauer (1950) on the region has been published. McNeal wrote a report (unpublished, 1950a) on the Lea County oilfields in the southeastern region.

GENERAL DESCRIPTION OF NEW MEXICO

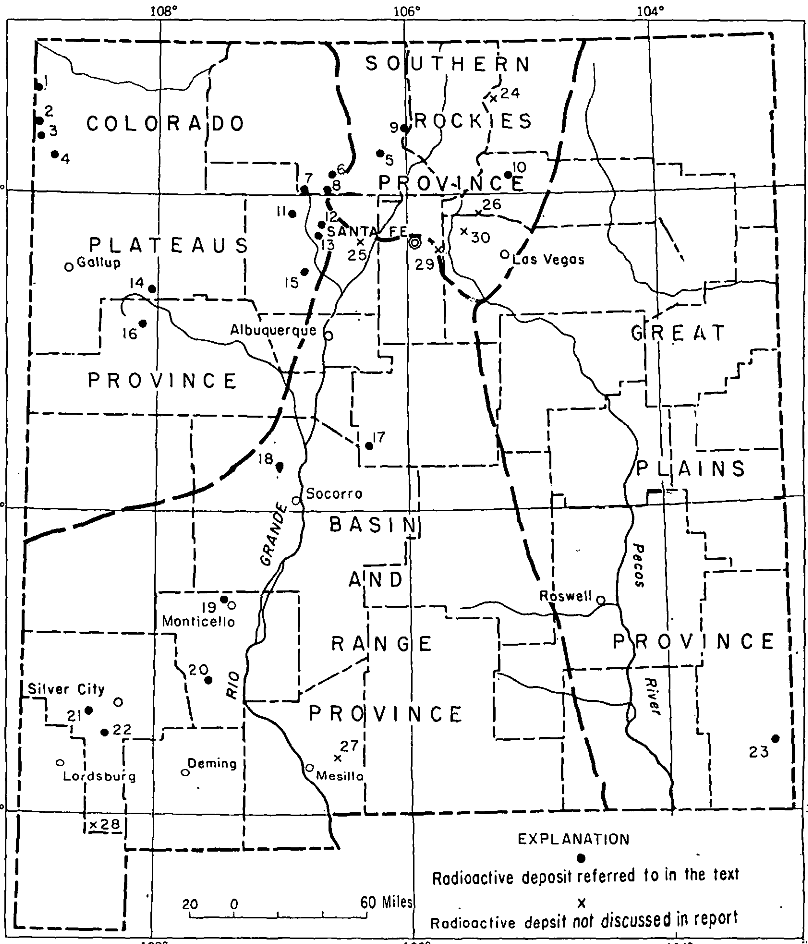
New Mexico includes parts of four physiographic provinces; these are (Fenneman, 1931) the Great Plains, the Southern Rocky Mountains, the Colorado Plateaus, and the Basin and Range. The provinces not only have contrasting topographic features but also have distinctive geologic features. The northwestern uranium region of New Mexico is in the Colorado Plateaus physiographic province; the deposits in the north-central region are partly in the Colorado Plateaus and partly in the Southern Rocky Mountains physiographic provinces; the deposits of central and southwestern New Mexico are in the Basin and Range physiographic province; and the single occurrence in the southeastern region is in the Great Plains physiographic province. (See fig. 49.)

The Great Plains occupy approximately the eastern third of the State. The southern and central parts of this physiographic province are characterized by gently rolling high plains of slight relief; but the northern part is characterized by buttes and mesas, many of which are capped with lava flows of Tertiary or younger age. The central, southern, and eastern parts of the province in New Mexico are underlain by sedimentary rocks of late Paleozoic, Triassic, Cretaceous, and Tertiary age.

In New Mexico the Southern Rocky Mountains physiographic province includes the lofty Sangre de Cristo and southern San Juan Mountains, which extend southward from Colorado along both sides of the Rio Grande Valley and terminate at about the latitude of Santa Fe. Both of these ranges, which separate the Great Plains from the Colorado Plateaus, have cores of pre-Cambrian crystalline and metamorphic rocks and are flanked by Paleozoic and Mesozoic sedimentary rocks and Tertiary volcanic rocks.

South of the southern Rockies, the Great Plains adjoin the Basin and Range physiographic province which occupies the southwestern part of New Mexico; it is characterized by isolated mountain ranges separated by broad graded desert plains. Many of the ranges are tilted fault blocks composed of paleozoic sedimentary rocks; but some are composed of pre-Cambrian granite and others of Tertiary volcanic rocks.

North of the Basin and Range province and west of the southern Rockies is the Colorado Plateaus physiographic province. The New Mexico part of the Colorado Plateaus consists of two nearly equal areas. The southern part, which Fenneman (1931) calls the Datil section, consists of a malpais of dissected volcanic flows and tuffs. This rugged and little known region occupies the area between the middle Rio Grande valley and the Arizona State line. The northern part of the Colorado Plateaus of New Mexico is a land of buttes, mesas, and wide plains. Structurally the area is a broad basin known as the San Juan Basin; belts of Triassic and Jurassic sedimentary rocks appear around its borders. The only commercial deposits of uranium ore known in the State before 1952, occur in these belts within the Colorado Plateaus.



EXPLANATION

1 Oak Springs deposit
2 Beautiful Mountain
3 Navajo Reservation (district 12)
4 Toadlena area
5 Cobre basin district
6 Coyote district
7 Copper City district
8 Jarosa district
9 Petaca district
10 Coyote Creek area
11 La Ventana Mesa
12 Jemez Springs
13 Spanish Queen group
14 Grants district
15 San Ysidro coalfield
16 Zuni Mountains
17 Scholle district
18 San Acacia district
19 Terry prospect
20 Virginia claim
21 Black Hawk district
22 White Signal district
23 Lea County oilfields
24 Elizabethtown district
25 Peralta Canyon
26 Rociada district
27 Organ district
28 Little Hatchet Mountains
29 Glorieta area
30 Elk Mountain area

FIGURE 49.—Index map of New Mexico showing radioactive deposits.

RADIOACTIVE DEPOSITS

The 45 radioactive occurrences, known in New Mexico before 1952, are mostly in the northwestern, north central, and southwestern parts of the State (fig. 49). At 21 of the localities uranium minerals are visible and at 1 of them thorium minerals are also present.

In northwestern New Mexico carnotite deposits are found in limestones and sandstones of Jurassic age. These deposits are scattered over large areas in the Grants and Carrizo Mountains districts.

The radioactive deposits of north-central New Mexico are somewhat more diversified, but the majority of them are of two types: uraniferous copper deposits associated with carbonized plant remains in arkoses, sandstones, and siltstones of Permian and Triassic age; and radioactive coals and black shales of Jurassic and Cretaceous age. In addition, 2 radioactive spring deposits and 1 pegmatite district containing uranium, thorium, and rare-earth minerals are within this region.

In southwestern New Mexico, 2 of the 3 radioactive deposits are associated with veins cutting pre-Cambrian granites and younger intrusives; the third is in a fracture zone in brecciated Mississippian(?) limestone, which has been altered to jasperiod.

At one locality in central New Mexico carnotite is associated with carbonized wood and copper in Permian sandstones; at another locality secondary copper and uranium minerals are disseminated in a breccia zone near the edge of a Tertiary andesite flow.

Only one radioactive occurrence had been reported from the Great Plains of eastern New Mexico before 1952. The deposit consists of a radioactive precipitate from brines associated with Permian rocks in the oilfields in the southeastern corner of the State.

TYPES OF DEPOSITS

The places where uranium deposits in New Mexico are found differ greatly in geology and topography, but deposits of a given type are often found in very similar areas though they may be far apart. The following outline shows the classification the writer has adopted:

- A. Disseminated deposits.
    1. Sandstones.
    2. Limestones and travertine.
    3. Coal and black shale.
- B. Oilfield brines.
- C. Fissure deposits.
    1. Veins.
    2. Breccia and shear zones.
- D. Pegmatites.

DISSEMINATED DEPOSITS

The disseminated deposits, especially those in sandstones and limestones, appear to be the most promising economically.

The disseminated deposits in sandstone include the carnotite deposits of the Grants district, in Valencia and McKinley Counties, the deposits of western San Juan County and many of the sandstone copper deposits of Mora, San Juan, and Rio Arriba Counties. In most of these deposits the uranium minerals are in permeable lenses of continental sandstones, closely associated with carbonized wood fragments and other fossil plant material.

The disseminated deposits in limestone are confined, so far as is now known, to the Todilto limestone in the Grants district of Valencia and McKinley Counties. Preliminary studies of this new district indicate that uranium minerals most commonly form a paint or stain along joints and bedding-plane fractures in the limestone, though small carnotite pods and lenses are also scattered through the limestone. The factors that control the distribution of these pods and lenses have not yet been discovered. Although the secondary uranium mineral carnotite is the chief economic mineral in the Grants district, some pitchblende has been identified from deposits in the Todilto limestone (Anonymous, 1951).

The radioactive travertine deposits of Jemez Springs and Caseman well represent a special type of radioactive calcareous sediments. At Jemez Springs maximum radioactivity is associated with black sooty layers and lenses in the white tufa. Most of these lenses are less than 4 feet long and 1 foot thick, but the largest are as much as 15 feet long and 2 feet thick. The distribution of radioactivity in the deposit at Caseman well was not determined.

Radioactive layers of coal and black shale are found at San Ysidro and La Ventana Mesa in Sandoval County and near Coyote in Rio Arriba County. The radioactivity is evenly distributed through layers that are commonly less than 1 foot thick and of unknown lateral extent.

OILFIELD BRINES

Abnormal radioactivity has been detected in oilfields of Lea County in southeastern New Mexico. The radioactivity emanates from a precipitate, deposited from brines, on the well casings.

FISSURE DEPOSITS

The fissure deposits include the quartz-silver base-metal veins of the Black Hawk district, the quartz-pyrite-chalcopyrite veins and the fracture zones of the White Signal district, the breccia zone in jasperoid on the Terry prospect, and the fracture zone in volcanic rocks near San Acacia.

The only vein deposits in the State containing primary uranium minerals that were known by 1952 are the quartz veins of the Black Hawk district. Uranium is associated with pods and lenses of base metal and silver sulfides scattered through the veins. All mine workings in the Black Hawk district are now inaccessible; therefore the dimensions and the distribution of these ore bodies could not be determined. Because of information in old reports, however, it seems probable that the veins are narrow and the ore shoots small and lenticular.

The deposits of the White Signal district, the Terry prospect, and the San Acacia district all contain secondary uranium minerals erratically distributed as coatings on fractures and linings of voids. In all three places the uranium minerals were deposited recently. Uranium minerals in the three areas, however, differ greatly in the environment of deposition. In the White Signal district the deposition of secondary uranium minerals occurred near oxidizing pyritic quartz veins and basic dikes cutting pre-Cambrian granites. The Terry prospect near Monticello exposes secondary uranium minerals coating vugs in veinlets that cut a breccia zone consisting of fragments of a jasperoid replacing Paleozoic limestone and a feldspar porphyry. At San Acacia a Tertiary andesite flow has been fractured near one edge. Secondary uranium minerals are widely distributed through this fractured zone as paint and fracture coatings.

PEGMATITES

The only radioactive pegmatites in the State that have been studied as a possible source of uranium are those near Petaca in eastern Rio Arriba County. Rare radioactive minerals are present in small pods replacing feldspar. A few crystals more than an inch in diameter have been taken from these replacement deposits but the individual pods are rarely more than a foot in diameter. The pods are widely and erratically distributed within the individual pegmatite dikes.

MINERALOGY

Both primary and secondary uranium minerals are known in New Mexico but those of secondary origin are by far the most common. Table 1 indicates the locations and characteristics of uranium minerals in New Mexico that had been identified before 1952. The radioactive silver ores of the Black Hawk district and the uraninite-bearing pegmatites near Petaca (Hess and Wells, 1930, p. 17–26) are primary; blebs of pitchblende have been reported from the Grants district (Rappaport, 1952), and small amounts of uraninite have been found in copper sulfide nodules at Coyote Creek, Mora County. All other occurrences of uranium minerals thus far reported are of a secondary origin. These include autunite and torbernite deposits of the White Signal district, uranophane near Monticello, and tyuyamunite and carnotite deposits in Valencia, McKinley, San Juan, and Mora Counties. No uranium minerals have yet been found in the radioactive carbonaceous matter in Rio Arriba and Sandoval Counties, in the radioactive spring deposits in the valley of the Jemez River, or in the radioactive brines in the Lea County oilfields. The primary

TABLE 1.—*Uranium minerals of New Mexico*

Name	Chemical composition[1]	Content U (percent)	Megascopic appearance	Locality
Autunite	$Ca(UO_2)_2(PO_4)_2.10\text{–}12H_2O$	45.4–48.2	Yellow-apple green small orthorhombic earthy crusts	White Signal, San Acacia.
Carnotite	$K_2(UO_2)_2(VO_4)_2.3H_2O$	52.8–55.0	Canary yellow, earthy masses and coatings, rarely orthorhombic crystals.	Scholle, Grants district, Carrizo Mountains area.
Fergusonite	$(Y,Er,Ce,Fe)(Nb,Ta,Ti)O_4$	.8–6.3	Black to dark-brown tetragonal crystals in pegmatites	Petaca.
Pitchblende	UO_2	56.9–82.9	Black, greenish, or brownish, pitchy luster, massive	Black Hawk district, Grants district.
Rutherfordine	UO_2CO_3(?)	72.1	Yellow dense masses of minute matted fibers	Grants district.
Samarskite	$(Y,Ce,U,Ca,Fe,Pb,Th)(Nb,Ta,Ti,Sn)_2O_6$.	8.4–16.1	Black, dark-brown, or reddish-brown massive coarse orthorhombic crystals radiating in pegmatites.	Petaca.
Sklodowskite	$Mg(UO_2)_2Si_2O_7.7H_2O$	58.4	Pale-lemon-yellow needlelike orthorhombic crystals	Grants district.
Torbernite	$Cu(UO_2)_2(PO_4)_2.8\text{–}12H_2O$	47.1–50.8	Emerald-green monoclinic micaceous crystalline crusts	White Signal, San Acacia.
Tyuyamunite	$Ca(UO_2)_2(VO_4)_2.nH_2O$	48.1–54.0	Greenish-yellow orthorhombic crystals and coatings	Grants district, Coyote Creek.
Uraninite	UO_2	88.2	Black, greenish, or brownish massive isometric crystals in pegmatites.	Petaca, Coyote Creek.
Uranophane	$Ca(UO_2)_2Si_2O_7.6H_2O$	56.6	Yellow needlelike orthorhombic crystals, sometimes massive.	Petaca, Terry prospect, San Acacia, Grants district.

[1] From Frondel and Fleischer, 1952.

deposits in the Black Hawk and Petaca districts differ considerably in their mineralogy, but they are similar in that both are in areas of pre-Cambrian rocks.

The fissure veins in the Black Hawk district consist principally of carbonates, silicified carbonates, barite, and jasperiod. Within this gangue are small irregular pockets of pitchblende, pyrite, galena, sphalerite, chalcopyrite, niccolite, rammelsbergite, cobalt skutterudite (smaltite), native silver, and argentite. Some of the rich silver ores are highly radioactive, but the source of their radioactivity is not yet known. These deposits are similar in mineralogy to some in northern Canada, where pitchblende is associated with silver ores.

Near Petaca, in eastern Rio Arriba County, a quartz-feldspar pegmatite in pre-Cambrian quartz-mica schist contains an unusual amount of radioactive minerals. Microcline feldspar has been cut by vein quartz, and both were later replaced by albite and mica. The radioactive minerals consist of crystals and irregular masses of monazite, fergusonite, uraninite, and samarskite that also replace the microcline.

The secondary uranium minerals show an even greater variation in mineralogic association, as might be expected because of their wider distribution within the State.

In the Todilto limestone deposits, carnotite is associated with black oxides of iron and manganese, and, in places, with pitchblende, the uranium carbonate rutherfordine, and the uranium silicates uranophane and sklodowskite. In the deposits in the Morrison and Dakota formations, on the other hand, the carnotite tends to be associated with carbonaceous material and secondary vanadium minerals rather than with iron and manganese oxides.

The radioactive copper deposits are associated also with carbonaceous material but are quite different from the carnotite deposits. In the radioactive copper deposits uranium minerals are rarely visible and radioactivity is commonly associated with deposits of secondary copper minerals, such as chalcocite, malachite, azurite, and chrysocolla. At Coyote Creek in Mora County uraninite has been identified from copper sulfide nodules in black shales, and tyuyamunite is sparsely disseminated in arkosic sandstones.

The association of radioactivity and carbonaceous material also characterizes the coal and carbonaceous shale beds of San Ysidoro and La Ventana Mesa in Sandoval County and the black shale beds near Coyote in Rio Arriba County where neither copper nor uranium minerals can be found.

In the oilfields of Lea County the abnormal radioactivity is associated with water rather than with petroleum. The hot spring waters that are depositing radioactive tufa near Jemez Springs and at

Caseman well in Sandoval County contain only negligible quantities of uranium. Their radioactivity is due to the presence of small amounts of radium.

Near Monticello, in Sierra County, a silicified breccia is cut by veinlets of quartz and fluorite. In the veinlets are vugs partly filled by white clay, hydrous iron oxide, uranophane, and fluorescent hyalite formed in that order.

URANIUM CONTENT OF DEPOSITS

The percent of uranium in the deposits listed in table 12 indicates the uranium content of the richest samples on which analyses were available before 1952. The samples range from small hand specimens to channel samples many feet in length. Consequently, the percent figure gives, at best, only a roughly qualitative idea of the value of the best material in the uranium deposit. The richest samples range from more than 12 percent uranium for a samarskite specimen from Petaca down to a few thousandths of a percent for some of the radioactive sandstone copper deposits. Deposits in 9 areas in the State had yielded, before 1952, reliable samples containing more than 0.1 percent uranium. These are the White Signal and Black Hawk districts in Grant County, the Carrizo Mountains area in San Juan County, the Grants district in Valencia and McKinley Counties, La Ventana Mesa in Sandoval County, the Petaca pegmatites in Rio Arriba County, Coyote Creek in Mora County, and the Terry prospect and Virginia claim in Sierra County. The occurrence on the Virginia claim can hardly be considered a deposit; it consists of one small specimen of uraniferous ilmenite float, the origin of which is unknown. All of the remaining deposits described in this report were too low in grade to be of economic interest. Their chief importance is that they outline large areas of uranium-bearing rocks for future exploration.

The terms eU for equivalent uranium (estimated from radioactivity) and U for uranium (chemically determined) are used frequently in assay data throughout this report. Equivalent uranium content of a sample is what the uranium content would be if all radioactivity were due to uranium in equilibrium with its daughter products. A significant difference between eU and U may be due to differential leaching or enrichment, insufficient age for equilibrium to be established, or the presence of radioactive potassium or thorium.

ORIGIN

The original sources of uranium, from which most of the radioactive deposits of New Mexico have been derived, are still largely unknown. Magmas, from which veins and pegmatites were derived, were probably the origin of the primary uranium-bearing minerals in the veins of the Black Hawk district and of the samarskite, uraninite, and monazite at Petaca.

Determining the primary sources of the secondary radioactive deposits so widely scattered through the State is a fascinating problem. Although most of the deposits appear to be of secondary origin the presence of pitchblende in some of the carnotite deposits throughout the State indicates that they were probably derived from oxidation of primary uranium minerals. The origin of the solutions which deposited the primary uranium-bearing minerals is not known.

In most parts of New Mexico where radioactive deposits are known large areas are covered by Tertiary volcanic rocks. Some of these volcanic rocks, especially those of the Jemez and Mount Taylor fields in northern New Mexico, contain traces of uranium. It is possible that deposits of uranium minerals in nearby sedimentary rocks are the result of leaching from the volcanic rocks and later precipitation in the underlying sedimentary rocks. On the other hand, all the regions where radioactive deposits are known, except the Lea County oilfields, are underlain at no great depth by ancient crystalline and metamorphic rocks that also contain uranium-bearing minerals in small amounts and offer an equally probable primary source. Indeed, the uranium minerals of the White Signal deposits are more probably derived from the pre-Cambrian granite than from the Tertiary volcanic rocks.

Still another possibility is that the secondary uranium minerals may have been derived from primary uranium minerals in hydrothermal vein deposits by leaching and reconcentration in ground water. The primary source of radioactivity in the oilfields of Lea County is still unknown. Much work remains to be done before the original source of any of the secondary-uranium-mineral deposits in New Mexico can be determined.

DESCRIPTION OF MINES AND PROSPECTS

GRANT COUNTY

The following information has been taken from an unpublished compilation report on the uranium deposits of Grant County by H. C. Granger, H. L. Bauer, Jr., T. G. Lovering, and Elliot Gillerman (1953).

The known uranium deposits of Grant County are principally in the White Signal and Black Hawk districts. Both districts are within a northwestward-trending belt of pre-Cambrian rocks composed chiefly of granite and included gneisses, schists, and quartzites. Younger dikes and stocks are present in the pre-Cambrian complex. The White Signal district is on the southeast flank of the Burro Mountains; the

Black Hawk district is about 18 miles northwest of the town of White Signal (fig. 50).

In the White Signal district the secondary uranium phosphates—autunite and torbernite—are found as fracture coatings and disseminations in oxidized parts of quartz-pyrite veins and in the adjacent mafic dikes and granite; uraniferous limonite is common locally. Most of the known uraniferous deposits are less than 50 feet in their greatest dimension.

The most promising deposits in the district are on the Merry Widow and Blue Jay claims. The richest sample taken from the Merry Widow mine contained more than 2 percent uranium and a sample

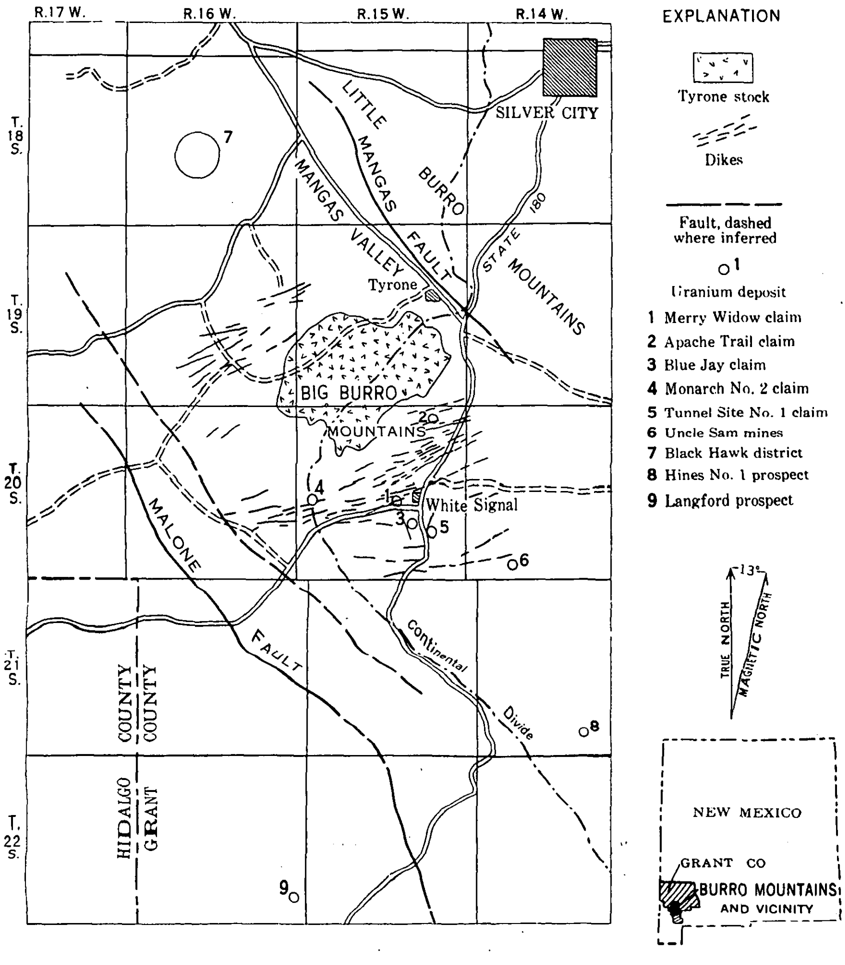


FIGURE 50.—Index map showing location of uranium deposits and major geologic features, Burro Mountains and vicinity, Grant County, N. Mex.

from the Blue Jay property contained as much as 0.11 percent; samples from the other properties were of lower grade.

In the Black Hawk district pitchblende is associated with nickel, silver, and cobalt minerals in fissure veins. The most promising properties in the Black Hawk district are the Black Hawk, Alhambra, and Rose mines. No uranium analyses of ore from this district were available in 1951.

There are no known minable reserves of uranium ore in either district, although there is some vein material at the Merry Widow mine of ore grade.

WHITE SIGNAL DISTRICT

By H. C. GRANGER and H. L. BAUER, JR.

Most of the mines and prospects in the White Signal mining district are in T. 20 S., R. 15 W., New Mexico principal meridian, and are within a few miles of the store and post office of White Signal.

Gold, silver, and copper minerals were found in the White Signal district in the late 1800's (Keith, written communication, 1945a), and mining activity was begun on the Merry Widow, Apache Trail, Tunnel Site, and Uncle Sam properties, and on many others not discussed in this report. In the early 1900's the rich near-surface ores were mined out, and since that time production has been small. About 1920 secondary uranium minerals were recognized on old dumps by A. A. Leach, and offers of as much as $50 per ton for high-grade uranium ore revived mining activity. The uranium minerals, autunite and torbernite, were embedded in plaster plaques to be used in "activitating" water for drinking, bathing, and watering plants. Two carloads of torbernite, clay, and sericite from the Merry Widow mine were produced for the manufacture of radioactive face powder. Neither of these enterprises was successful. The Union Mines Development Corporation made two examinations (Keith, written communications, 1944, 1945a) of the uranium deposits in the White Signal district. Postwar interest in uranium again revived prospecting activity. Granger and Bauer, of the U. S. Geological Survey, examined several of the known uranium-bearing deposits in the area during late 1949 and early 1950.

MERRY WIDOW CLAIM

The Merry Widow claim (fig. 50) is near the center of sec. 22, T. 20 S., R. 15 W., New Mexico principal meridian. It is 0.7 mile by dirt road northwesterly from the Silver City-Lordsburg highway at a point about 0.5 mile west of White Signal. The Merry Widow is one of a block of 6 claims, the Acme, Acme No. 1, Merry Widow, Merry

Widow No. 1, Ace in the Hole, and Deuce in the Hole, controlled in 1950 by A. G. Hill, of Dallas, Tex.

The Merry Widow mine was located in the 1880's as a gold property and was operated until exhaustion of the easily accessible ores in the early 1900's forced suspension of mining activity. After the discovery of uranium in the district, the mine was reopened during the 1920's and two carloads of ore containing a mixture of autunite, torbernite, sericite, and clay were shipped. The mine was again closed down and no further shipments are recorded.

The mine workings were examined and sampled for uranium by Keith (written communication, 1945). During February and March 1950 a geologic map on the scale of 1 inch equals 100 feet was made of the Merry Widow claim (pl. 17) by Granger and Bauer. Five exploration trenches and the 40- and 60-foot levels of the Merry Widow mine were mapped; 133 samples (table 2) were collected. The geologic map of only one of the trenches has been included in this report. (See pl. 18). During May 1950, diamond drilling was done on the Merry Widow claim by the owner and 650 feet of drill core was logged by Granger and Bauer.

Mine workings.—The Merry Widow mine consists of a 150-foot shaft, inclined from 65° to 72° SE., and about 450 feet of workings on 4 levels at 40, 60, 90, and 130 feet. In 1950 the mine was inaccessible below the 60-foot level. Both the 40- and 60-foot levels were mapped on a scale of 1 inch equals 10 feet (pl. 19).

In addition to the mine workings, 5 shallow trenches have been excavated on the claim (pl. 17).

Geology.—The Merry Widow claim is in an area underlain by a large pre-Cambrian granite mass that is cut by numerous dikes ranging in composition from basalt to rhyolite.

The granite near the Merry Widow claim (pl. 17) is typically medium grained but locally coarse grained to porphyritic. It is composed essentially of feldspar and quartz, with less than 5 percent biotite. The feldspar is partly argillized.

Two thick diabase dikes and several thin basalt dikes (pl. 17), probably of the same age, are exposed on the Merry Widow claim. The dikes strike northwest and dip northeast. The diabase dikes, which are as much as 35 feet thick, have narrow chilled borders, less than 3 feet thick, that are similar in texture to the basalt dikes. The centers of the diabase dikes have a coarse ophitic texture. A blanket of dark soil covers the diabase except near a vein where the diabase is commonly hardened by iron oxides and silica.

Several altered gray aphanitic dikes cut both the diabase and granite on the Merry Widow claim. These dikes, referred to as latite(?), are almost completely altered to clay minerals. The latite(?) dikes

TABLE 2.—*Analyses of samples from the Merry Widow claim, White Signal district, Grant County, N. Mex.*

Sample no.	Locality no.	Material	Type	Length of sample (feet)	eU (percent)	U (percent)	P_2O_5 (percent)
Trench 1							
HLB-1-1		Granite	Channel	2.7	0.004	0.002	0.13
2		do	do	2.9	.004	.001	.13
3		Quartz-pyrite vein, 1 in. thick	Grab		.007	.006	.54
4		Diabase	Channel	2.0	.002	.001	2.61
5		do	do	2.5	.002	.001	2.69
6		do	do	2.5	.002	.001	2.60
7		Latite	do	.5	.003	.001	.83
8		Granite, altered	do	2.5	.004	.001	.10
9		do	do	2.5	.004	.001	.20
10		do	do	1.5	.006	.003	.09
11	R-11	Latite and quartz-pyrite vein	do	.3	.023	.019	.53
12		Granite	do	1.5	.008	.004	.10
13		Granite, altered	do	1.5	.005	.003	.10
14		do	do	2.0	.009	.005	.14
15		Granite, iron-stained	do	2.0	.005	.003	.06
16		Quartz-pyrite vein, 3 in. thick	Grab		.005	.003	.17
17		Granite, iron-stained	Channel	2.0	.004	.002	.10
18		Granite	do	2.0	.007	.002	.07
19		Granite, iron-stained	do	2.5	.003	.002	.07
20		Quartz-pyrite vein, 20 in. thick	do	2.0	.009	.007	.23
21		Granite, altered	do	2.0	.004	.003	.09
22		do	do	2.5	.004	.003	.13
23		do	do	2.0	.009	.009	.14
24	R-9	Diabase, autunite	do	1.7	.100	.11	1.18
25		do	do	2.7	.029	.025	2.18
26		Diabase	do	3.0	.005	.004	1.79
27		do	do	2.0	.010	.009	1.65
28		Granite	do	3.0	.005	.004	.18
29		do	do	3.0	.006	.002	.12
Trench 2							
HLB-2-30		Granite, silicified	do	3.0	.011	.005	.08
31		do	do	4.1	.003	.002	.06
32		Granite, altered	do	3.0	.008	.005	.14
33		Diabase, altered	do	3.1	.006	.003	.56
34	R-10	Diabase, iron-stained	do	2.5	.013	.015	1.42
35		do	do	3.0	.004	.003	1.70
36		Diabase, altered	do	3.0	.006	.003	1.62
37		Granite, iron-stained	do	3.0	.005	.003	.35
38		Granite, altered	do	2.5	.005	.002	.04
39		Quartz-pyrite vein	do	2.5	.006	.005	.15
40		Granite	do	3.3	.006	.004	.11
41	R-7	Granite, torbernite	do	2.0	.011	.008	.04
42		Quartz-pyrite vein	do	3.0	.008	.005	.10
43		Granite	do	3.0	.006	.005	.07
44		do	do	3.8	.005	.003	.11
45		do	do	2.6	.004	.002	.09
46		do	do	3.0	.004	.002	.06
47		Granite, iron-stained	do	6.5	.006	.007	.15
HLB-6-48	R-8	Diabase, iron-stained	do	3.0	.016	.010	.97
HLB-7-49		Diabase, fault gouge	do	3.0	.020	.010	.46
Trench 5							
HLB-5-50		Diabase	do	3.0	.005	.004	1.72
51		do	do	2.0	.006	.004	.95
52		Granite, altered	do	3.0	.005	.002	.08
53		do	do	3.0	.020	.002	.08
54		Quartz-pyrite vein	do	1.3	.002	.002	.07
55		Granite, altered	do	2.0	.005	.002	.07
56		do	do	1.7	.008	.003	.06
57		do	do	2.0	.005	.002	.04
58		Granite	do	2.0	.004	.001	.08
59		do	do	1.6	.008	.006	.08
60		Quartz-pyrite vein	do	1.0	.014	.010	.13
61		Granite	do	2.0	.007	.002	.06
62		Granite, altered	do	2.0	.005	.002	.04
63		Granite	do	1.5	.005	.001	.07
Trench 3							
HLB-3-64		Granite	Chip	2.0	.004	.001	.13
65		Granite, altered	do	1.5	.005	.001	.07
66		do	Channel	2.5	.005	.004	.22
67		Latite	do	.5	.005	.004	.23
68		Diabase, iron-stained	do	2.5	.009	.007	1.48
69		Diabase	Chip	30.0	.006	.005	2.54
70		do	Channel	2.5	.008	.005	2.31
71		Granite, altered	do	2.5	.010	.007	.40
72		Quartz-pyrite vein, one-half inch thick	Grab		.008	.004	.32

TABLE 2.—*Analyses of samples from the Merry Widow claim, White Signal district, Grant County, N. Mex.*—Continued

Sample no.	Locality no.	Material	Type	Length of sample (feet)	eU (percent)	U (percent)	P_2O_5 (percent)
Trench 3—Con							
73		Granite, altered	Channel	2.5	0.004	0.002	0.06
74		do	Chip	17.0	.005	.002	.06
75		Granite, altered	do	7.0	.005	.002	.07
76		Latite	Channel	1.5	.006	.006	.15
77		Granite	do	3.0	.004	.002	.13
78		Quartz-pyrite vein, 24 in. thick	do	2.0	.003	.001	.15
HLB-3-79		Granite	do	2.5	.004	.001	.08
80		Granite, altered	Chip	13.0	.005	.002	.11
81		Granite	do	14.0	.003	.001	.08
HLB—82	R-4	Latite	Channel	1.5	.017	.020	.41
83		Diabase	do	1.7	.012	.015	.59
HLB-9-84	R-5	do	do	2.5	.76	.67	.42
HLB-10-85	R-3	Diabase, iron-stained	Chip	2.9	.010	.006	2.09
86		do	Grab		.021	.020	1.60
87	R-2	Fault gouge	Channel	2.5	.010	.006	.26
88		Diabase, altered	do	2.5	.017	.020	.66
89		Rhyolite fault breccia	do	3.0	.005	.003	.08
90		Quartz monzonite	Grab		.003	.001	.47
91		Granite	do		.005	.001	.05
92	R-1	Basalt	do		.092	.10	1.56
93		Quartz monzonite	do		.002	.001	.45
94		Granite	do		.005	.001	.02
HLB-10-95		Basalt	Grab		.007	.003	1.14
96		Rhyolite	do		.004	.001	.06
HLB-11-97		Granite	Channel	3.0	.005	.001	.08
98		do	Grab		.004	.001	.05
99		Quartz-pyrite vein	Channel	2.5	.004	.004	.58
100		Diabase	do	2.5	.005	.001	2.51
HLB-12-101	R-13	Diabase, torbernite	do	2.0	.87	.092	1.69
102		Diabase	do	2.0	.039	.034	2.11
103		Diabase, torbernite	do	2.0	.098	.077	1.77
104		Diabase	do	2.0	.018	.014	2.11
105		Granite, torbernite	Grab		.10	.070	.44
Trench 4							
HLB-4-106		Granite, altered	Chip	17.0	.004	.001	.14
107		Diabase, altered	Channel	3.0	.003	.001	.39
108		Granite and diabase	do	1.0	.002	.001	.27
109		Granite, altered	Chip	4.5	.004	.001	.10
110		Diabase, altered	do	26.0	.002	.001	.43
111		Granite	do	29.0	.005	.001	.08
112		Diabase	do	31.0	.002	.001	2.58
113		Granite	do	77.0	.006	.001	.04
114		Quartz monzonite	do	9.0	.003	.001	.43
115		Granite	do	26.0	.004	.001	.13
116		Diabase	do	26.0	.002	.001	2.02
117		Granite	do	33.0	.006	.001	.03
118		Quartz-pyrite vein	Channel	6.0	.003	.001	.10
119		Granite	Chip	18.0	.000	.001	.03
120		Quartz-pyrite vein and gouge	Channel	.5	.005	.002	.19
121		Granite	Chip	18.0	.005	.001	.06
122		Latite	Channel	2.0	.010	.008	.28
123		Granite	Chip	9.0	.005	.003	.03
124		Latite	Channel	4.0	.005	.004	.30
125		Granite	Chip	37.0	.004	.001	.07
126		Latite	Channel	6.0	.007	.007	.31
127		Granite	Chip	17.0	.001	.001	.08
128		Latite	Channel	5.0	.001	.001	.32
129		Granite	Chip	24.0	.001	.001	.05
130		Latite	Channel	4.0	.008	.008	.36
131		Granite and quartz-pyrite veins	Chip	40.0	.005	.001	.07
132		do	do	40.0	.004	.001	.04
ss-1		Granite, torbernite	Selected		.021	.014	.07

strike easterly in the southern half of the claim but strike northeasterly in the northern half; the dikes therefore, may be of different age. They are concealed by soil at the surface and can be seen only in mine workings and prospect pits.

Thick northeastward-trending dikes of quartz monzonite porphyry (pl. 17) cut the granite in the northern part of the Merry Widow claim. The porphyry has quartz phenocrysts up to 8 mm across in a finer groundmass.

Three small exposures of a dark fine-grained rock, tentatively identified as diorite(?), were mapped (pl. 17). The exposures are irregular and discontinuous and no relation to other rocks is apparent.

A series of aphanitic greenish rhyolite dikes, exposed in an eastward-trending zone (pl. 17), are believed to be the most recent intrusive rocks on the Merry Widow claim. Other rhyolite dikes in the district commonly strike slightly north of east, but the individual dikes on the Merry Widow claim strike northwesterly.

Structure.—The rocks on the Merry Widow claim have been complexly faulted and fractured, but displacement can be determined only where the larger faults offset dikes, as much as 60 feet in some places. In the southern half of the claim most of the faults have easterly trends, but in the northern half most of them strike northerly or northwesterly. The significance of this change in the fault pattern is not known. Most of the faults have steep dips, ranging from 60° to vertical.

Faults on the Merry Widow claim are commonly filled by quartz and limonite vein material or by other intrusive rocks. Many of them are characterized by limonite filling or wide altered zones rather than by breccia, slickensides, or other direct evidence of faulting. Many small faults are so well cemented by quartz and limonite that they are very inconspicuous.

Joints on the Merry Widow claim show no persistent trend; locally joints may have a uniform strike, but another conflicting set may appear a few feet away. The persistent joint sets commonly have the same attitude as nearby faults or dikes, suggesting that they may be minor fractures in shear zones.

Uranium deposits.—Most of the uranium on the Merry Widow claim is in the eastward-striking Merry Widow vein zone, although small patches of uranium-bearing rock are widely scattered throughout the area. The highest uranium assays in the Merry Widow vein zone were obtained within 100 feet of the Merry Widow shaft.

Veins of three distinct types are found on the Merry Widow claim: barren quartz veins; quartz-hematite (specularite) veins which apparently contain no metallic element other than iron; and quartz-pyrite veins, the most common type. Uranium is associated with the quartz-pyrite veins. Pyrite in the quartz-pyrite veins near the surface is thoroughly oxidized to limonite. Quartz is commonly dense and erratically distributed. It occurs as pods, lenses, and veinlets but rarely as a prominent continuous fissure filling. Granite wall rock bordering the veins is stained by hydrous iron oxides and, in most places, either silicified or altered to clay minerals and sericite.

Fracture zones are filled with massive vitreous limonite or cellular limonite containing scattered masses and blebs of vein quartz.

Where the diabase dikes are cut by the veins they are commonly impregnated with hydrous iron oxide and with silica which makes them relatively resistant to weathering.

Hydrous iron oxides are abundant in the near-surface parts of the veins on the Merry Widow claim. Limonite, either massive with conchoidal fracture or cellular, fills many of the veins. The pulverulent form of limonite is also common, and in places it invades the altered rhyolite. Limonite in and near the vein was produced by oxidation of pyrite, and perhaps of chalcopyrite. Pyrite may be found near the surface where shielded from alteration, as within the masses of vein quartz.

Bismite (bismuth trioxide), associated with small pockets of high-grade gold ore, has been reported from the Merry Widow mine but none was recognized by Granger and Bauer.

Some green minerals, exposed on the walls of the Merry Widow mine, are believed to be copper sulfates. They are similar in appearance to torbernite and may easily be confused with it.

Secondary uranium minerals are found at several localities on and near the Merry Widow claim. In the field, the flaky yellow fluorescent uranium minerals were called autunite and the flaky or tabular green weakly fluorescent and nonfluorescent uranium minerals were called torbernite. No distinction was made between torbernite and metatorbernite.

Autunite and torbernite usually are found in and near the intersections of diabase or basalt dikes with quartz-pyrite veins. Both minerals coat fracture surfaces and project into small cavities in the fracture blocks. The fractures and cavities are also commonly iron stained. Locally, as in trench 2 (locality R–7, pl. 17) and at shaft 2, torbernite crystals are disseminated in the granite and coat altered grains of feldspar. Although autunite locally is most abundant near the surface, torbernite is predominant a few feet below the surface.

In 1950 the only uranium-bearing rock of economic importance known on this claim was within the area developed by the Merry Widow mine (table 3). The measured uranium-bearing rock in the mine is defined vertically by the surface of the ground and the 130-foot level; horizontally it is defined by the eastern limits of the 40-, 60-, and 130-foot levels and the western limits of the 40- and 130-foot levels. The highest grade ore is within 20 feet of the shaft between the 60-foot level and the surface.

The size and grade of uranium deposits on and near the Merry Widow claim, exclusive of the mine, are indicated in table 4. The

TABLE 3.—*Analyses of samples from the Merry Widow mine, White Signal district, Grant County, N. Mex.*

[Modified from S. B. Keith (written communication, 1945). Keith collected 15 samples from the 130-foot level. The samples ranged from 0.03 to 0.08 percent uranium del.]

Sample no.	Distance from shaft (feet)	Length of sample (feet)	Location and description	U_3O_8 [1] (percent)
			40-foot level, west	
6557	0	2.1	Back; diabase [2] and altered granite, torbernite	0.67
6558		2.0	Back; gouge and iron oxide	.04
6559	5	3.1	Back; from 5-in. contact zone, torbernite	.39
6560		2.8	Back; gouge, diabase, granite, iron oxide, breccia, torbenite	.34
6561		4.0	Back; diabase, iron oxide, bismite, hyalite	.04
6562		2.0	Back; diabase, bismite, hyalite	.08
6563	10	3.5	Back; blocky diabase	.03
6564		3.0	Back; gouge, altered granite, iron oxide, torbernite	.38
6565		3.8	Back; altered diabase, bismite, torbernite	.15
6566	15	4.2	High back; altered granite, iron oxide, gouge	.05
6567	20	3.7	Back; altered diabase, iron oxide	.05
6568		5.0	High back; gouge, iron oxide, altered granite, torbernite	.42
6569	25	2.7	High back; gouge, altered diabase, iron oxide	.06
6570	30	3.5	High back; gouge, altered diabase, iron oxide, torbernite	.11
6571	35	2.9	High back; altered diabase, gouge, iron oxide	.07
6572	40	3.3	High back; gouge, altered diabase, iron oxide	.06
6573	45	1.9	Back; altered diabase, disseminated torbernite	.08
6574		2.0	Back; much iron oxide, gouge, altered diabase	.06
7500	50	.8	Back; altered granite	.03
7501		1.5	Back; gouge, altered diabase	.14
7502		1.7	Back; diabase, iron oxide	.03
7503	55	1.6	Back; altered granite, iron oxide	.05
7504		1.0	Back; gouge, iron oxide, altered diabase	.03
7505	60	1.7	Back; altered granite, iron oxide	.03
7506		.8	Back; gouge, iron oxide	.04
7507		2.2	North wall; perpendicular to diabase-granite contact, torbernite	.48
			40-foot level, east	
7508	5	2.0	Back; altered granite, iron oxide, torbernite	0.43
7509		2.1	Back; gouge, iron oxide	.33
7510	10	1.2	Back; altered granite	.03
7511		1.3	Back; altered granite, disseminated torbernite	.31
7512		.9	Back; gouge, altered diabase, concentration of torbernite	1.76
7513		2.2	Back; altered diabase, gouge, torbernite	.63
7514	15	.7	Back; gouge, altered diabase	.05
7515		2.2	Back; altered granite, iron oxide, torbernite	.32
7516		1.0	Back; diabase	.21
7517		.4	Back; altered diabase, gouge, concentration of torbernite	1.90
7518		1.4	Back; altered diabase, iron oxide	.06
7519	20	.2	Back; gouge	.02
7520		2.4	Back; altered granite, iron oxide	.04
7521		1.5	Back; altered granite, iron oxide, disseminated torbernite	.34
7522		2.2	Back; altered diabase	.05
7523		2.3	Back; altered diabase, iron oxide	.04
7529	25	2.2	Back; altered granite, iron oxide stringers	.01
7524	25	3.4	Back; granite, iron oxide stringers	.04
7525		.9	Back; altered diabase	.03
7531	25	1.2	North wall; altered granite, torbernite	.24
7532		.7	North wall; altered diabase, torbernite	.36
7530	30	3.3	Back; altered granite, gouge, iron oxide stringers	.02
7526	37	3.5	East wall; altered granite, iron oxide stringers	.03
7527		3.3	do	.03
7528		3.1	East wall; altered granite, iron oxide, gouge vein	.16
			60-foot level, west	
6250	0	1.3	Back; altered diabase, torbernite	0.12
6251		2.7	Back; gouge, iron oxide	.03
6252		1.4	Back; gouge, iron oxide, sparse torbernite	.05
6253	5	1.7	Back; brecciated diabase, gouge, torbernite	.40
6254		1.8	Back; gouge, iron oxide, torbernite	.52
6255	10	3.7	do	.83
6256	15	1.5	do	.92
6257		2.5	Back; iron oxide, gouge, bismite, torbernite	.51
6258	20	5.0	Back, south crosscut; altered granite, iron oxide	.03
6259		2.8	Back; gouge, iron oxide	.05
6260		3.5	Back; iron oxide, gouge, torbernite.	
6261		4.8	East wall of north crosscut; diabase, pyrite, iron oxide, bismite stringers.	
6262		4.8	do	

TABLE 3.—*Analyses of samples from the Merry Widow mine, White Signal district, Grant County, N. Mex.*—Continued

Sample no.	Distance from shaft (feet)	Length of sample (feet)	Location and description	U_3O_8 [1] (percent)
			60-foot level, west—Continued	
6263	25	0.3	Back; granite, iron oxide	0.04
6264		1.1	Back; gouge, torbernite, hyalite	.12
6265		.5	Back; iron oxide, gouge, torbernite, hyalite	.11
6266		.5	Back; diabase, torbernite	.49
6267	30	1.7	Back; granite, iron oxide	.05
6268		1.3	Back; gouge, iron oxide	.04
6269		.5	Back; diabase	.06
6270	35	2.7	East side raise, 12.5 ft above rail; gouge, iron oxide, torbernite	.13
6271	40	1.7	West side raise, 12.6 ft above rail; gouge, iron oxide	.08
6272	45	.8	Back; gouge, torbernite	.26
6273		1.1	Back; diabase	.12
6274		2.6	Back; altered granite	.02
6275	50	.9	Back; altered granite, iron oxide	.06
6276		1.6	Back; gouge, iron oxide, brecciated diabase	.03
6277		2.6	Back; altered granite	.01
6278	55	2.2	Back; gouge, iron oxide	.02
6279		1.7	Back; granite	.01
6280	60	3.3	Back; gouge, iron oxide	.02
6281	65	2.5	Back; brecciated granite, iron oxide, gouge	.02
6282		1.8	Back; gouge, altered granite	.02
6283	70	1.7	High back; gouge, iron oxide	.04
6284	75	1.3	High back; gouge, diabase, granite	.03
6285	80	1.7	Back; granite, iron oxide	.02
6286		1.7	Back; altered diabase, gouge, iron oxide	.07
6287	85	2.2	Back; granite	.04
6288		1.6	Back; altered diabase, gouge, torbernite	.20
6289	90	3.1	Back; granite, hyalite	.04
6290		.7	Back; gouge, altered diabase, iron oxide, torbernite	.26
6291	95	2.2	Back; granite	.02
6292		1.1	Back; altered diabase, gouge	.11
6293	100	1.0	Back; granite, iron oxide	.02
6294		1.0	Back; altered diabase	.10
6295		1.2	Back; iron oxide, gouge	.07
6296	105	2.5	Back; granite, iron oxide	.03
6297		1.8	do	.03
6298	110	.9	do	.03
6299		.7	Back; altered diabase, gouge	.03
6300		2.6	Back; granite, iron oxide	.03
6301		.6	Back; altered diabase, gouge	.22
6302	115	.9	Back; altered granite, iron oxide	.03
6303		.4	Back; altered diabase, torbernite	.32
6304		2.5	Back; altered granite, iron oxide	.03
6305		.5	Back; gouge, altered diabase, iron oxide	.30
6306	120	.6	Back; altered diabase, gouge, torbernite	.29
6307		2.7	Back; granite, iron oxide	.03
6308	125	.7	Back; altered diabase, gouge	.15
6309		1.1	Back; granite, iron oxide, gouge	.03
6310	130	.8	Back; diabase, gouge, torbernite	.13
6311		1.9	Back; granite, iron oxide	.02
6312	135	.6	Back; gouge, diabase, iron oxide, torbernite	.11
6313		2.0	Back; granite, iron oxide	.02
6314	140	.6	Back; gouge, iron oxide	.04
6315		1.0	Back; iron oxide	.04
6316		2.3	Back; granite, iron oxide	.01
6317	10	1.6	Back; diabase	.08
6318		2.0	Back; gouge, altered diabase, iron oxide	.05
6319		1.5	Back; diabase	.06
6320	15	1.8	West side raise, 10.5 ft above rail; gouge, altered diabase, torbernite	.36
6321		1.2	West side raise, 10.5 ft above rail; diabase	.10
6322	15	3.7	West wall of crosscut; diabase, pyrite, bismite	.04
6323		4.3	do	.03
6324		1.7	do	.03
6550	20	4.7	East wall crosscut; gouge, brecciated diabase, torbernite	.24
6551		3.2	East wall crosscut; granite, iron oxide	.02
6552		2.1	East wall crosscut; granite, iron oxide, diabase	.03
6553	25	4.2	Back; diabase, pyrite, iron oxide	.05
6554	30	1.7	North wall of raise; granite, diabase, torbernite	.21
6555	35	1.7	North wall of raise; torbernite, granite, diabase	.40
6556	40	2.0	North wall of drift; torbernite, granite, diabase	.12

[1] Average of analysis of duplicate samples; made at Rifle, Colo., and Tonawanda, N. Y.
[2] Keith did not recognize latite in the mine. Part of the diabase and much of the gouge in the table are probably altered latite.

TABLE 4.—*Summary of analyses of samples from the Merry Widow claim, exclusive of the Merry Widow mine, White Signal district*

Locality no. on pl. 17	Dimensions (feet)		Analyses (percent)			Description
	Length	Width	Uranium	Equivalent uranium	P_2O_5	
R 1	5	1	0.05 –0.10	0.092	1.56	Radioactive basalt dike, torbernite crystals coat fractures near surface. Rock has been impregnated with iron oxides and silica.
R 2	10	2.5	.01 – .02	.010–0.017	.26–0.66	Altered diabase along a fault, scattered autunite crystals along fractures.
R 3	25	2	.01 – .02	.010– .021	1.60–2.09	Two exposures of iron-stained diabase 25 ft apart along fault. Fracture surfaces are radioactive, no uranium minerals visible.
R 4	30	2	.01 – .02	.017	.41	Radioactive latite dike 2 ft wide. Radioactive zone 30 ft long, no uranium minerals are visible.
R 5	25	3	.05 – .10	.076	.42	Fault block of radioactive diabase 3 ft wide, less than 30 ft long. Fracture surfaces coated with radioactive hyalite, no uranium minerals visible.
R 6	--------	--------	------------	.01(?)	----------	Iron-stained fracture along fault zone in granite; no samples analyzed.
R 7	6	2	.008	.011	.04	Torbernite coating fractures in granite near Merry Widow vein zone.
R 8	30	3	.01 – .02	.016– .020	.46– .97	Iron-stained silicified diabase adjacent to a fault and radioactive gouge from this fault.
R 9	20	4	.05 – .10	.029– .100	1.18–2.18	Fracture zone in a diabase dike between two fault veins. Fractures contain autunite, most abundantly near granite contact.
R 10	--------	2.5	.015	.013	1.42	Fractured iron-stained diabase dike. No uranium minerals are visible.
R 11	--------	.3	.019	.023	.53	A 2½-in. quartz-pyrite vein and an adjacent latite dike. Vein is only locally uraniferous. No uranium minerals were observed.
R 12	--------	--------	.000–2.06	------------	----------	Merry Widow mine. See table 2 for sample analyses. Torbernite is largely concentrated along fractures in granite, diabase, and latite near the shaft on the 40- and 60-ft levels.
R 13	15	4	.015– .092	.018– .87	.44–2.11	Fracture zone in granite and diabase. Torbernite coats fractures most abundantly near the contact on the diabase side.
R 14	--------	--------	.002– .01	.007– .014	.04– .13	A 2-in. quartz-pyrite vein and adjacent argillized granite wall rock. No uranium minerals were observed.
R 15	--------	--------	------------	.01(?)	----------	Narrow quartz vein and associated fracture zone in diabase dike. No samples were analyzed.

table summarizes the sample data for the 15 localities from which samples containing over 0.01 percent uranium were obtained.

Although only secondary uranium minerals have been found in the White Signal district, observations made during this examination suggest that some of the quartz-pyrite veins may contain primary uranium minerals below the zone of oxidation.

The relatively unaltered rocks on the Merry Widow claim commonly have a lower uranium content than the material in quartz-pyrite veins. The large quartz-pyrite vein near the west end of trench 1 (pl. 18) contains 0.007 percent uranium, whereas the wall rocks on either side contain 0.003 and 0.002 percent. A narrow quartz-pyrite vein along the contact between granite and diabase in the east end of trench 1 contains 0.006 percent uranium, the adjacent granite and diabase contain only 0.001 percent. Similar examples in the other trenches suggest that the quartz-pyrite veins have played an important part in the distribution of secondary uranium minerals.

During exploration of the Merry Widow vein by means of diamond drilling it was found that the vein material in the larger veins had been thoroughly oxidized by circulating meteoric waters to a depth of at least 550 feet. Pitchblende or other primary uranium minerals would probably be unstable in the highly acid waters produced by the oxidation of pyrite; therefore the lack of recognizable primary uranium minerals in the drill core merely suggests that if these minerals were once present they have since been removed. It is believed that the unoxidized parts of some of the veins may contain primary uranium minerals and that the distribution of secondary uranium minerals in altered rocks has resulted from precipitation of uranium from solution in meteoric waters along fractures in the more favorable host rocks.

There is a possible relationship between the latite(?) dikes and the uranium deposits. Locally, in the Merry Widow mine, the uranium minerals coat fractures in the latite(?) away from the diabase dikes. At localities R–4 and R–11 (pl. 17) the uranium is closely associated with the latite(?). The arrangement of the veins and dikes suggests that the veins were emplaced after the intrusion of the latite(?) and before the intrusion of the rhyolite. Perhaps the mineral-bearing solutions followed soon after the intrusion of the latite(?); the primary ore-bearing solutions may have been derived from the magma that consolidated to form latite(?).

Apparently the intermediate and basic rocks have been more favorable hosts for the deposition of secondary uranium minerals than have the acid rocks. The reason for this is not entirely clear but may be due in part to the phosphate content. Certainly, it would seem that a high phosphate content in the host rock is more conducive to precipitation of phosphate-bearing uranium minerals than a low phosphate content. Of 19 samples that contained over 0.01 percent uranium, all but 2 contained over 0.30 percent P_2O_5. The average P_2O_5 content of these samples was 1.07 percent.

Results of exploration.—Five prospect trenches on the Merry Widow claim were carefully sampled (pls. 18 and 20). The samples were analyzed for both uranium and phosphate (table 2) in order to determine the relative distribution of these elements in the different types of rocks and veins.

The uranium content of 133 samples ranged from 0.001 to 0.11 percent (table 2). Of these, 19 samples from 12 different localities contained more than 0.01 percent uranium. Results of the sampling suggest that the average uranium content of all rocks on the Merry Widow claim, where relatively unaffected by alteration other than weathering, was 0.003 percent or less. The phosphate content varies widely in the different types of rock. The average P_2O_5 content of rocks on the Merry Widow claim is diabase 1.60 percent, basalt 1.35 percent, latite 0.37 percent, quartz monzonite porphyry 0.45 percent, granite 0.10 percent, rhyolite 0.06 percent. Of the 19 samples that contained over 0.01 percent uranium, only 2 contained less than 0.30 percent P_2O_5. These were also the only samples taken more than 2 feet from diabase, basalt, or latite.

In May 1950 the owner of the Merry Widow claim explored the vein by means of a diamond-drill hole which collared 380 feet south of the Merry Widow shaft and cut the vein at a depth of about 520 feet. The core from this hole was logged geologically at the drill site and also scanned for radioactivity with a Geiger counter in the field and a radiometric core scanner in the laboratory (fig. 51). The hole was drilled with an AX bit on a bearing of N. 60° E. at an angle of 72° and was intended to intersect the vein at a depth of about 575 feet. The hole cut the vein between 520 and 550 feet and was bottomed at 650 feet. The overall core recovery was 79.6 percent. Most of the core is medium-grained granite composed of quartz (30 percent), potash feldspar (60 percent), and biotite and other mafic minerals (10 percent). Feldspars are moderately kaolinized to a depth of 200 feet. From 200 to 550 feet the feldspars are weakly kaolinized and some of the grains are soft and greenish. Near the veins the feldspars are moderately sericitized. The granite from 550 to 650 feet is unaltered.

The core from 72 to 97 feet consists of diabase from a dike which is fine grained near the contacts and medium to coarse grained in the center. The diabase is much fractured, and plagioclase has been altered to clay. Mafic minerals give the rock a characteristic dull greenish-gray color.

The core contains many quartz-pyrite veins, most of which are less than one-half inch thick, although a few are between ½ and 2 inches thick. The veins are abundant but show no persistent orientation. They are completely oxidized to a depth of 80 feet and partly oxidized to a depth of 150 feet. Below 150 feet pyrite is oxidized only in the wider vein zones. In the Merry Widow vein zone, between depths of 520 and 550 feet, the pyrite in the veins is oxidized to limonite and the wall rock is intensely altered and stained. A 2-inch vein of massive limonite at a depth of 528 feet and two 1-inch quartz veins at 540 feet are the largest individual veins that were found in this zone. The latite(?) dike, locally parallel with the vein in the Merry Widow mine, was not recognized in the core. Many quartz-

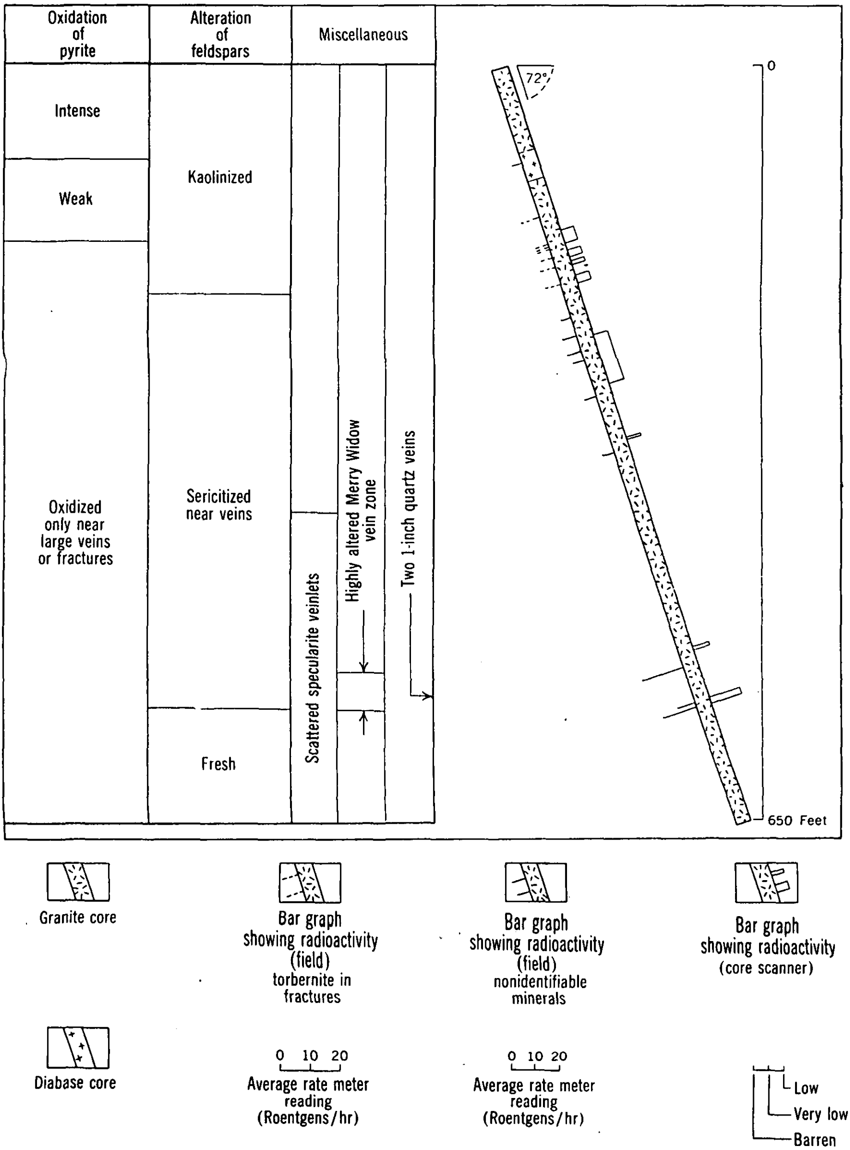


FIGURE 51.—Generalized log of diamond-drill core, Merry Widow claim, White Signal, N. Mex.

specularite veinlets are present between depths of 380 and 650 feet. The wall rock along the borders of these veins is only slightly iron stained.

Abnormally radioactive zones in the core were restricted commonly to narrow fractures less than one-eighth inch thick. Crystals of torbernite were noted in some of the fractures at depths of 127, 151, 154, 156, 161, and 184 feet (fig. 51). Other radioactive fracture surfaces showing no torbernite, at depths of 80, 170, 214, 229, 239, 246, 278, 324, 510, 540, and 542 feet, were commonly coated with fine-grained dark-green and white minerals, possibly a mixture of talc and serpentine or clay.

In the Merry Widow vein zone at a depth of 540 feet two weakly radioactive quartz veins 1 inch thick gave readings of twice the background count. Two feet below these veins, a fracture filled with amorphous dark-green and black minerals gave readings of twice to four times the background count. Similar black radioactive material was noted at depths of 278 feet and 510 feet, but no uranium minerals have been identified at these places. Specimens of these black fracture fillings from depths of 278, 510, and 542 feet were analyzed radiometrically and found to contain 0.2 to 0.3 percent equivalent uranium. The granite adjacent to the fractures had an equivalent uranium content of 0.01 to 0.02 percent.

The results of the core scanning in the laboratory cannot be converted to equivalent uranium content because the scanning machine is calibrated to measure radioactivity of sedimentary rocks. The assumption was made, however, that the normal or background radioactivity for the rock is 380 counts per minute. On this basis, most of the core is barren. Seven narrow zones have radioactivity less than 150 counts per minute above the background and are designated as very low grade. One zone from depths of 540 to 546 feet gave 158 to 384 counts per minute above the background and was called low grade. This zone is in the Merry Widow vein (fig. 51) and includes two 1-inch quartz veins and a dark-colored fracture filling.

Suggestions for prospecting.—Secondary uranium minerals on the Merry Widow claim have been found most commonly within the large eastward-trending Merry Widow vein zone where this zone cuts mafic or intermediate dikes high in phosphate. Prospecting should, therefore, be concentrated on the intersections of quartz-pyrite veins, such as the Merry Widow vein, with these dikes. Any search for primary uranium minerals should be guided by the same principles of ore control that govern the localization of the primary base-metal sulfides in the area.

Reserves.—The only uranium-bearing rock known on the property that has sufficient quantity and grade to constitute an ore reserve, under market conditions existing in 1952, lies close to the Merry Widow shaft within the Merry Widow vein zone between the 60-foot level and the surface.

APACHE TRAIL CLAIM

The Apache Trail uranium prospect is an unpatented claim in sec. 2, T. 20 S., R. 15 W., a school section. In 1951 it was leased from the State by Mr. Charles N. Russell, Box 8, Tyrone, N. Mex., and Mrs.

Elsie R. Wiley, 1451 South Oakhurst Drive, Los Angeles 35, Calif. The claim is accessible by vehicle by the following route: go 2.4 miles north from White Signal, N. Mex.; turn left (west) at gate onto an ungraded road: follow road for 2 miles to the Apache Trail prospect.

The claim was originally located for copper about 1890. Five cars of copper carbonate ore, averaging 5 percent copper and 5 ounces of silver per ton, were shipped between 1915 and 1920.

The original claim was abandoned and the present claim was located for gold in 1927. Bismuth, a common associate of gold in the district, was recognized at pit 5 (pl. 21) in a hematite-quartz vein, and 50 tons of ore, averaging 1½ ounces of gold per ton and 4 percent bismuth, were shipped. Bismuth in the ore is said to hinder concentration and smelting of other metals.

A 200-foot vertical shaft was sunk and 265 feet of drifts and cross-cuts on the 100-foot level were driven in 1932. The bismuth gold vein was never found in these workings. The shaft is inaccessible below the 100-foot level. Prospect pits have been dug at several places along the hematite vein.

H. L. Bauer, Jr., mapped the ground surface (pl. 21) and the 100-foot level (pl. 22) during part of 3 days in May 1950. At the same time he collected samples and examined the surface and workings for radio-activity.

Geology.—The country rock in the vicinity of the Apache Trail claim is a medium-grained biotite granite of pre-Cambrian age. On the claim the granite is cut by a fine-grained diabase dike, 1 to 2 feet thick, and a quartz-hematite vein 8 feet thick. The diabase dike is believed to be older than the vein because hematite appears to replace parts of the dike.

A greenish porphyritic dike, possibly andesite porphyry, is exposed at the eastern end of the claim. The relation of this dike to the hematite vein and the diabase is not known. A well-defined fault zone is exposed in the east drift and in the easternmost 40 feet of the west drift on the 100-foot level. Fragments of hematite in the fault zone indicate that this fault zone is younger than the vein. Fault gouge and slickensides are present on the hanging wall of the diabase dike on the 100-foot level; other faults are also present in the old copper stope (pit 10) and near pits 5 and 6.

The granite is fresh except at the old copper stope (pit 10) and near the quartz-hematite vein where it is altered to a soft fine-grained material as far as 5 feet from the vein. Farther from the vein the rock is less intensely altered and the original texture of the granite can be recognized. The diabase dike is altered and soft on the 100-foot level and in some pits on the surface.

Radioactive deposits.—Two types of radioactive deposits are present on the Apache Trail claim. The larger deposit is the quartz-hematite vein which does not contain visible uranium minerals; the other deposit is the diabase dike that locally contains visible torbernite.

The quartz-hematite vein is composed of specularite, magnetite, quartz, and a massive dull variety of hematite. Gold, copper carbonate, limonite pseudomorphs after pyrite, lead, and bismuth minerals are found in or adjacent to the quartz-hematite vein locally. The vein is up to 8 feet thick but pinches out in places; the average thickness is about 3½ feet. It is resistant to weathering and can be traced for several thousand feet east and west of the Apache Trail claim. No uranium minerals were seen in the quartz-hematite vein although at all places where sulfide minerals were originally present, and locally elsewhere, the rocks were radioactive. Radioactivity readings taken along the vein at the surface and underground range from 2 divisions on the 0.2 scale to 5 divisions on the 2.0 scale of a Geiger-Mueller counter with a 6-inch probe held 1 inch from the outcrop. Background readings on granite range from 1 to 5 divisions on the 0.2 scale. Radioactivity readings in pit 1 range from 15 on the 0.2 scale to 5 on the 2.0 scale. A 3½-foot channel sample cut across the quartz-hematite vein contains 0.012 percent uranium.

Radioactivity readings along the hematite vein on the 100-foot level range from 15 to 20 on the 0.2 scale. A 3-foot sample cut across the vein contains 0.011 percent uranium (table 5).

The diabase dike is highly radioactive only at the western end of the 100-foot level where clusters of tabular green crystals of torbernite coat fractures (pl. 22). Two samples across the diabase dike at this locality contain 0.041 and 0.038 percent uranium, respectively. Two samples from diabase and altered granite in this vicinity contain 0.008 and 0.012 percent uranium, respectively (table 5).

The small fault along the footwall of the diabase dike has been mineralized locally and torbernite crystals are concentrated next to this fault.

Suggestions for prospecting.—The distribution of radioactive deposits on this claim suggests that concentrations of torbernite are apt to

TABLE 5.—*Analyses (in percent) of samples from the Apache Trail claim*

Sample no.	Location	Material	Equivalent uranium	Uranium	Insoluble residue	Iron	Copper
BJ-4-4	100-ft level, western face	Diabase, 3 ft thick	0.033	0.041			
4-5	do	do	.017	.038			
4-6	100-ft level, western part	Diabase and altered granite.	.011	.012			
4-7	do	do	.010	.008			
4-8	do	Hematite-quartz vein, 3 ft thick.	.013	.011	12.44	58.67	1.36
5-9	Pit 1, east end of claim	do	.021	.012	21.73	42.93	.82

occur within the diabase dike where it is fractured or where it has been cut by faults and veins. Radioactivity of gossans along the quartz vein may indicate the presence of primary uranium minerals in the vein below the zone of oxidation.

BLUE JAY CLAIM

The Blue Jay claim is about 400 feet west of a dirt road which joins New Mexico Highway 180 at White Signal. The claim is about three-fourths of a mile south of White Signal (fig. 50). The quarter-section corner of the boundary between secs. 23 and 26, T. 20 S., R. 15 W. lies within the claim boundaries. The claim was located in 1949 by Otto and Fred Prevost, of White Signal and Silver City, respectively, and was leased to E. B. Killion of Silver City, N. Mex., in 1950. Granger and Bauer examined the radioactive deposits on the Blue Jay claim in March 1950 and mapped the area containing radioactive deposits (pl. 23) by planetable using a scale of 1 inch equals 30 feet. Forty-four samples were taken; both radioactive and barren rocks were sampled and assayed for P_2O_5 as well as uranium. The White Signal district had been examined previously by the Union Mines Development Corporation (Keith, unpublished reports, 1944, 1945a), but this examination did not include the Blue Jay claim.

Before the examination by Granger and Bauer, Mr. Killion had removed the overburden from four localities on the claim by bulldozer. These localities were selected by him on the basis of abnormal radioactivity detected with a portable Geiger counter. No ore had been produced.

Geology.—The Blue Jay claim is underlain by a large mass of pre-Cambrian granite cut by a variety of dikes.

The granite that forms the country rock in the vicinity of the Blue Jay claim is typically a leucocratic biotite-poor medium-grained rock in which the feldspars are partly argillized.

A diabase dike, cut by other intrusive rocks and faulted, trends northwest across the Blue Jay claim. Rock mapped as diabase in the northwestern bulldozer cut is intensely altered, friable, and locally bleached or iron stained. The diabase surrounding a 10-foot pit near the western margin of the area is bleached nearly white and is cut by paper-thin veinlets containing specularite and siderite(?).

A dark-gray fine-grained dike, about 7 feet wide, which is believed to be basalt, strikes northwest nearly parallel to the diabase.

Two bodies of altered intrusive rock are tentatively identified as latite because they are similar in habit and general appearance to unaltered latite outside the mapped area. These bodies have an easterly trend and are separated by rhyolite dikes. They may have originally been part of a more extensive dike or plug.

A thoroughly fractured friable aphanitic dike about 3½ feet wide is exposed in the northernmost bulldozer trench. It strikes about N. 80° E. and dips vertically. A 1- to 6-inch dike of similar material is exposed in a shallow pit 40 feet west of this trench. The minerals and the texture of the original rock have been destroyed by intense alteration.

A large white-to-gray rhyolite dike trends eastward across the area mapped and dips about 70° S. In the eastern part of the area (pl. 23) this dike contains four small inclusions of granite.

Most of the faults on the Blue Jay claim are occupied by dikes or veins. Where the faults are unmineralized they are obscure and display little brecciation or marginal fracturing. Two types of veins occupy the faults: specularite veins and quartz-pyrite veins. A persistent specularite vein, ½ to 2 inches wide and about 260 feet long, trends about N. 70° E. and dips steeply northward. Other specularite veins are short and very narrow.

Most of the veins are filled with limonite and sparse quartz and are bordered by argillized and, less commonly, by sericitized wall rock. These are believed to be oxidized quartz-pyrite veins.

Uranium deposits.—The uranium deposits on the Blue Jay claim are most commonly found in intermediate or basic dikes near oxidized quartz-pyrite veins. Two secondary uranium minerals have been found in the deposits. One is a tabular green nonfluorescent mineral, probably torbernite; the other, which was not identified, is a yellow powdery mineral with weak yellow fluorescence. Torbernite coats fracture surfaces in the rock at sample localities HLB–15–137, –159, –163, –170, and –176 (pl. 23). At sample locality HLB–15–177 the torbernite coats fracture surfaces in granite and the contact between a quartz vein and argillized feldspar. The yellow secondary uranium mineral, as a dull amorphous powder, coats innumerable fracture surfaces in the larger aphanitic dikes. The prevalence of this mineral in the dikes makes these rocks the richest sampled, containing up to 0.11 percent uranium (table 6).

Although no uranium minerals were seen in several of the samples containing an abnormal amount of uranium, the radioactive samples, rock and vein material, are very iron stained in most places, suggesting that the uranium may be associated with hydrous iron oxide.

Nearly all the samples that contain more than 0.01 percent uranium were taken from altered mafic rock near quartz-pyrite veins. The samples that are exceptions to this generalization were taken from material in the quartz-pyrite veins, which are very iron stained in places, or in fractures near granite. The intense iron stain, which is

TABLE 6.—*Analyses of samples from the Blue Jay claim, White Signal district, Grant County, N. Mex.*

[Readings in divisions on 2.0 scale of the beta-gamma rate meter are in italics; others are readings on the 0.2 scale]

Sample no. on pl. 23	Material	Field meter readings	Equivalent uranium (percent)	Uranium (percent)	P_2O_5 (percent)
	Fresh rock				
HLB-15-151	Granite		0.004	0.001	0.36
153	do		.001	.001	.43
179	do	2 to 7	.004	.002	.65
180	do	0 to 5	.004	.001	.60
152	Diabase		.007	.005	2.86
154	do		.003	.001	2.95
155	do		.003	.002	2.93
141	Basalt	4 to 8	.004	.003	2.58
150	Rhyolite		.003	.001	.48
157	do		.002	.001	.50
143	Granite and vein material	13 to 16	.020	.013	.35
145	do		.050	.035	.39
148	do		.020	.010	.43
	Altered rock				
138	Granite, altered	12 to 20	0.014	0.009	0.37
139	do	11 to 18	.011	.006	.54
140	do	2 to 6	.004	.003	.41
142	do	4 to 9	.008	.006	.43
144	do	5 to 9	.008	.009	.54
147	do		.017	.010	.35
158	do		.004	.001	.30
178	do	*3 to 5*	.023	.020	.37
156	Diabase, leached		.003	.002	2.93
160	Diabase, altered	*2*	.010	.008	.49
161	do	*3 to 6*	.028	.020	.56
162	do	*2 to 4*	.024	.028	.69
164	do	*3 to 5*	.039	.037	.62
165	do	*2 to 5*	.036	.031	.91
166	do	10 to 14	.010	.005	.53
167	do	*3 to 5*	.036	.035	.60
168	Latite, altered		.010	.006	.70
169	do	*2 to 5*	.019	.018	.95
171	do	*4 to 7*	.040	.031	1.03
172	do	*2 to 5*	.017	.009	.53
174	do	10 to 20	.018	.016	.79
175	do		.016	.009	.76
146	Aphanitic dike, altered	*15 to 17*	.17	.11	.49
149	do	*6 to 8*	.060	.041	.85
173	Rhyolite, altered	10 to 15	.012	.006	.36
	Rock showing visible torbernite				
177	Granite, visible torbernite	*5 to 20*	0.079	0.076	1.29
159	Diabase, visible torbernite	*5 to 7*	.037	.041	1.00
163	do	*3 to 5*	.035	.042	.80
137	Basalt, visible torbernite	9 to 17	.018	.017	2.58
176	do	*5 to 20*	.079	.085	1.65
170	Latite, visible torbernite	*3 to 8*	.051	.064	.90

believed to be indicative of oxidized pyrite in the near-surface parts of the veins, affects the argillized and sericitized wall rock and granite as far as 3 feet from the vein.

Radioactivity on the Blue Jay claim was recorded with a beta-gamma counter. The radioactivity of each rock was tested by recording the minimum and maximum fluctuations of the rate-meter needle for approximately 30 seconds; the probe was held 4 to 5 inches from the rock surface. The average reading for most of the relatively unaltered rocks was about 1 to 7 divisions on the 0.2 scale. This corresponds to about 0.001 to 0.003 percent uranium in samples taken nearby.

Forty-four samples were collected during the examination. Channel samples were cut in most areas of abnormal radioactivity; several grab samples were taken in relatively unaltered rock of minimum radioactivity. Minimum and maximum rate-meter readings were recorded for many of the samples (table 6) with the probe held about 1 inch from the rock.

On the Blue Jay claim both granite and rhyolite normally contain 0.001 to 0.002 percent uranium. Within a few inches of fractures and veins the granite may contain several times this amount. A sample of weathered granite with torbernite was submitted by the owner and found to contain 0.083 percent uranium. Basalt and diabase contain about 0.001 to 0.005 percent uranium except within or near fractures and veins where they may contain as much as 0.085 percent. The intensely altered latite contains from 0.006 to 0.064 percent uranium. All aphanitic dikes are altered and contain as much as 0.11 percent uranium. The total area of uranium-bearing rocks on the Blue Jay claim is small. The aphanitic dike that is 3½ feet thick is about 90 feet long, as determined by abnormal radioactivity in the soil along the indicated strike. Uranium content of the diabase in the bulldozer cut located in the northwestern part of the area (pl. 23) is abnormally high. The highest uranium concentration in this diabase is in an area about 25 feet square where the diabase is cut by an iron-stained vein or fracture.

Although the latite apparently has a high uranium content everywhere, the richest uranium concentrations in this rock are along an iron-stained fracture zone in the southwestern bulldozer cut.

Suggestions for prospecting.—The results of sampling indicate that no large deposits of uranium ore are available. If prospecting is done, it should be concentrated along the intersections of intermediate and basic dikes with quartz-pyrite fissure veins and along the radioactive aphanitic dike exposed in the northwestern bulldozer cut.

Reserves.—Results of sampling suggest that at 6 localities the uranium-bearing rock on the property contains between 0.01 and 0.05 percent uranium. The largest deposit is in and along the aphanitic dike in the northern bulldozer cut (pl. 23).

MONARCH NO. 2 CLAIM

The Monarch No. 2 claim is in sec. 19, T. 20 S., R. 15 W., about 4 miles west of the settlement of White Signal, and was owned by C. E. Russell, White Signal, N. Mex., in 1950 (fig. 50). A brief examination of the claim was made by H. L. Bauer, Jr., on May 22, 1950.

A milk-white rhyolite dike, which strikes N. 45° E., cuts granitic country rock on this claim. A massive quartz vein parallels the dike, which locally has been silicified and is cut by quartz stringers. Fracture surfaces in the dike are stained by limonite.

A prospect pit, 15 feet long and 2 feet deep, has been excavated in the rhyolite dike. A few autunite crystals were observed in the rhyolite, but none could be seen on the fracture surfaces. The radioactivity of the rhyolite caused a deflection of 5 to 15 divisions on the 0.2 scale of a counter. The quartz vein was not radioactive. A grab sample, BJ–7–14, was taken from the dump and found to contain 0.011 percent uranium.

The Money Maker and Wild Irishman claims are southwest of the Monarch No. 2 claim; they include the same rhyolite dike and associated massive quartz vein but show no abnormal radioactivity.

TUNNEL SITE NO. 1 CLAIM

The Tunnel Site No. 1 claim (fig. 50) is in the SE¼NE¼ sec. 26, T. 20 S., R. 15 W. and is reached by about 1½ miles of graded dirt road that turns south from State Highway 180 at White Signal, N. Mex.

The claim was owned by E. B. Killion of Silver City, N. Mex., when it was examined briefly by H. C. Granger and H. L. Bauer, Jr., on April 1, 1950. Development work consisted of a discovery shaft 10 feet deep and a 250-foot adit approximately 75 feet west of the shaft. Two winzes, 20 and 40 feet deep, were sunk about 90 feet and 110 feet, respectively, from the portal of the adit. Short crosscuts branch from the adit near the face.

The rocks on the claim are medium-grained gray pre-Cambrian granite cut by greenish-gray rhyolite dikes. The discovery shaft was sunk in bleached argillized granite near a rhyolite dike. Clay veins, 1 to 4 inches thick, that have no preferred orientation cut both the granite and rhyolite in and near the shaft. The clay appears to be of the kaolin type and contains no metallic minerals. Limonite-stained cavities in the veins may indicate the former presence of disseminated pyrite.

The adit, which was driven N. 30° E., along a granite-rhyolite contact, cuts several faults and vein zones. The veins cut by the adit are about 1 to 2 inches thick and are slightly iron stained; they appear to be oxidized quartz-pyrite veins.

The shaft and adit were traversed with a field counter. All measurements were made with the probe beta shield open. The radioactivity on the surface averaged about 5 divisions on the 0.2 scale in the shaft and throughout the adit. An area 2 feet high and 3 feet long on the west wall, about 45 feet from the portal of the adit, was abnormally radioactive. When the probe was placed on the wall, a maximum deflection of 7 was noted on the 2.0 scale. A channel sample the length of the radioactive zone assayed 0.018 percent equivalent uranium and 0.001 percent uranium. The reason for this apparent disequilibrium is not known.

UNCLE SAM SILVER MINES

The Uncle Sam silver mines are in sec. 32, T. 20 S., R. 14 W. (fig. 50). They were visited in March 1950 by H. L. Bauer, Jr. The ownership of the properties is not known.

The mines are a series of abandoned shafts, adits, stopes, and prospect pits extending for about half a mile along a shear zone in pre-Cambrian granite. The shear zone ranges from 1 to 6 feet in width, trends N. 40°–45°W., and dips 70°–85° SW.

Quartz and sulfide minerals fill fractures in the shear zone which is marked by 2 to 6 feet of iron-stained granite.

Abnormal radioactivity was noted in some specimens of sulfide-bearing vein material from a dump. These specimens gave readings of 8 to 12 divisions on the 0.2 scale of a survey meter when the probe was placed in contact with the vein material. The background was 5 divisions on the 0.2 scale. At the portal of an adit 500 feet southeast of the main shaft a silicified fracture 1 foot wide registered 10 to 12 divisions on the 0.2 scale. A 2-inch limonite vein, in a small pit about 1,500 feet northwest of the main shaft, registered from 2 to 5 divisions on the 2.0 scale. No samples were taken at the abnormally radioactive areas because of their small size and relatively low radioactivity.

BLACK HAWK DISTRICT

By H. C. Granger and H. L. Bauer, Jr.

The Black Hawk district is in secs. 20, 21, 28, and 29, T. 18 S., R. 16 W., New Mexico principal meridian, and is about 20 miles by road from Silver City, N. Mex. (fig. 50). The district is reached by a dirt road that extends south from U. S. Highway 260 about 13 miles northwest of Silver City.

On March 19, 1950, the authors made radioactivity traverses of the Black Hawk mine dump and dumps from other mines on the same vein. Rocks along Black Hawk Canyon were tested as far south as 2 miles from the Black Hawk mine.

Additional information was compiled from the files of the U. S. Bureau of Mines in Silver City, N. Mex.

The silver deposits of the Black Hawk district were discovered in 1881 and $1.5 million worth of silver was produced in 7 years. About half of this amount came from the Black Hawk mine; the remainder came from the Alhambra, Rose, and Hobson mines, all within a mile of the Black Hawk mine. Mining ceased in 1893 and

TABLE 7.—*Samples from the Black Hawk district, collected and assayed by the U. S. Bureau of Mines*

Locality	Ni (percent)	Co (percent)	Ag (oz/ton)	Au (oz/ton)
Rose mine dump	0.07	0.08	10.55	0.06
Alhambra mine dump	.18	.10	34.70	.02

the mines remained idle until 1917 when the Black Hawk mine was reopened for exploration. Reports do not show that any ore was mined at this time. After 1918 there was little activity in the district, although Leach (1920, p. 989) mentions pitchblende from the Black Hawk district.

In 1948 the U. S. Bureau of Mines became interested through Albert A. Leach, owner of the Alhambra mine, who submitted old reports on the mines and also several specimens that contained silver, nickel, cobalt, and uranium (pitchblende). The Bureau made a brief examination of the district on July 24, 1948, and collected two samples (table 7) which were not assayed for uranium.

Geology.—According to an unpublished report (1918) on the Black Hawk mine by Weed, the oldest rock near the mine is a coarsely porphyritic gneiss of probable pre-Cambrian age. This rock contains large feldspar crystals in a groundmass of biotite and, locally, quartz. The gneiss is cut by aplitic dikes that grade into feldspar pegmatites. Dikes related to a large intrusion of monzonite porphyry are present near the Black Hawk mine.

According to Weed (unpublished report, 1918), pink granite, dark quartz diorite, and a rhyolite dike are found near the Black Hawk mine. He further states that monzonite porphyry and gneiss were found in the mine and that both rocks are cut by carbonate veins; but only in the gneiss are the veins ore bearing.

Ore deposits.—The veins in the Black Hawk district are well defined at fresh exposures but are rather inconspicuous in exposures at the surface. They cut the rocks within an area of nearly 4 square miles.

According to an unpublished report by A. A. Leach (1917), the gangue in the vein is composed of partly silicified carbonates. The silicified gangue is commonly a fine-grained jasperoid. Pyrite, galena, sphalerite, and chalcopyrite are associated in the vein with niccolite, nickel skutterudite, smaltite (cobalt skutterudite), native silver, and argentite.

Pitchblende has been reported in the Black Hawk and Alhambra mines, and the Black Hawk dump was carefully examined for vein material, but a few specimens of carbonate gangue containing small amounts of metallic sulfides were all that could be found.[2]

[2] Pitchblende has been definitely identified in specimens from dumps in the Black Hawk district as a result of more recent work by Elliot Gillerman and D. H. Whitebread, of the Geological Survey.

The presence of cobalt-, nickel-, and silver-bearing minerals in a gangue of carbonates and silicified carbonates indicates a similarity between the mineral assemblage in the Black Hawk district and that in many deposits known to contain pitchblende.

Radioactivity.—In July 1949 the engineers of the U. S. Bureau of Mines examined the dump of the Alhambra mine with a Geiger counter. They found that one small pile of ore was slightly radioactive. The Bureau also tested several specimens of cobalt-nickel ore from the Alhambra mine which had been submitted by Albert A. Leach. One specimen was found to be very radioactive, probably because of the presence of pitchblende.

Granger and Bauer tested a specimen of native silver from the Black Hawk mine, owned by Ira Wright, Silver City, N. Mex. The specimen, about 60 to 80 percent native silver, registers 15 divisions on the 2.0 scale of a field counter. The average background was about 4 divisions on the 0.2 scale.

No radioactivity over twice normal background was observed on the Black Hawk or nearby dumps along the Black Hawk vein. One small dump about a mile south of the Black Hawk mine, on the west wall of the canyon, registered 10 divisions on the 0.2 scale. The country rock showed no abnormal radioactivity.

BLACK HAWK MINE

The Black Hawk property consists of 14 claims, 8 of them patented. In 1950 it was owned by the Black Hawk Consolidated Mines Co., Milwaukee, Wis. Ira Wright, of Silver City, N. Mex., was general manager.

The mine includes 4 vertical shafts and 1 inclined shaft, all caved and inaccessible. According to old reports, the main shaft extends from the surface to the eighth level, 450 feet below the surface, and a winze on the eighth level extends 150 feet deeper; the total depth is 600 feet.

The vein is exposed on the second level for 434 feet to the east and 80 feet to the west of the shaft.

The Black Hawk mine is reported to have produced $650,000 in silver between 1881 and 1889.

ALHAMBRA MINE

The Alhambra mine is on a group of 5 patented and 3 unpatented claims owned, in 1950, by Albert A. and Frances I. Leach, Lordsburg, N. Mex. The main shaft is reported to be 400 feet deep, and the mine contains several hundred feet of horizontal workings.

Records show that the Alhambra mine produced $400,000 in silver before 1893.

ROSE MINE

The Rose mine is on a patented claim owned, in 1950, by Mrs. Elizabeth J. McCabe, Pasadena, Calif.

It is reported that the main shaft is 200 feet deep and that there are levels at 50, 100, 150, and 200 feet. At present, these workings are caved and inaccessible.

Past production is reported to be $140,000 in silver.

OTHER DEPOSITS

HINES NO. 1 PROSPECT

The Hines No. 1 prospect is in the NE¼ sec. 34, T. 21 S., R. 14 W., about 13 miles by road southeast of White Signal (fig. 50). The deposit was discovered by Joe Frost and Charles Russell, of Tyrone, in March 1950. The property may be reached from White Signal by traveling 1.5 miles east along the White Signal-Whitewater road and then turning south to the Royall Ranch. Beyond the ranch the road is indefinite and inquiry should be made for directions to the property.

Development consists of two pits. The deposit was examined by Harry C. Granger, Herman L. Bauer, Jr., and Elliot Gillerman in April 1950; it was re-examined and mapped by Elliot Gillerman in June 1950 (unpublished report).

The Hines deposit is in Bliss(?) sandstone of Cambrian age. The exposure is 250 to 300 feet wide and is surrounded by alluvium on all but the northwest side where it is in fault contact with pre-Cambrian granite. This fault strikes N. 30° E. and seems to dip steeply northwest.

The Bliss(?) sandstone in this vicinity consists of medium-grained well-cemented silicified white quartzite, grayish-green ferruginous quartzite, gray quartzite, sandstone, and a bed of brown medium-grained limestone 10 feet thick, which contains gastropod fragments. These rocks strike northwest and dip steeply to the northeast near the two pits. A small northwestward-trending fault cuts the sedimentary rocks a short distance north of the pits (fig. 52).

Fluorite and autunite(?) are present in quartzite breccia along a nearly vertical shatter zone that strikes N. 85° E. A subsidiary breccia zone, which strikes N. 50° W., branches southeastward from the main zone. Scheelite occurs in a similar breccia zone that strikes about N. 75° E. It is close to, but not contiguous with, the fluorite-autunite zone. The fluorite is white, violet, or dark purple; it is found as fissure fillings and matrix in the breccia in pit 2. Rare small crystals of a yellow fluorescent material, tentatively identified as autunite, coat fracture surfaces on the quartzite in pit 2, but they are generally not closely associated with the fluorite. No radioactive material was found in pit 1.

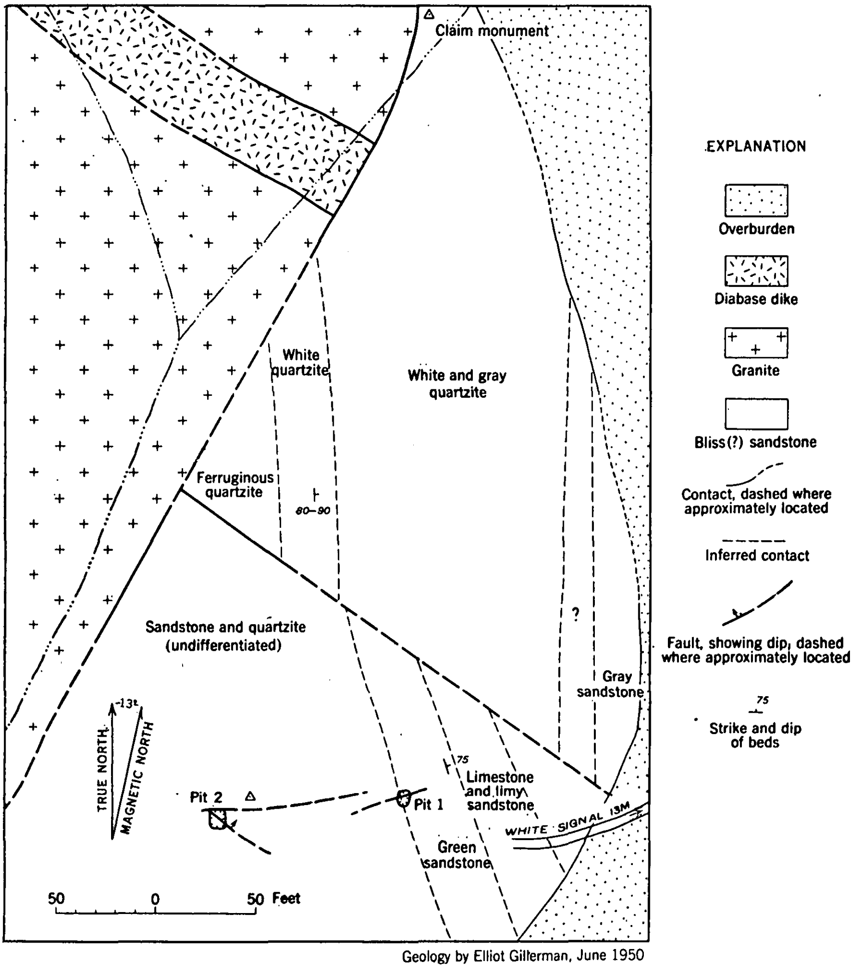


FIGURE 52.—Geologic sketch map of the Hines No. 1 prospect, Grant County, N. Mex.

The time when mineralization occurred is unknown; the paragenetic relation of the fluorite and the autunite(?) are inconclusive, but the autunite(?) appears to be later.

Radioactive breccia exposed in pit 2 gave a maximum reading of 5 divisions on the 2.0 scale of a beta-gamma counter. Two channel samples across the breccia zone, one in the east end and one in the west end of pit 2, both contained 0.004 percent uranium (table 8). A grab sample, submitted by the owner, assayed 0.027 percent equivalent uranium.

LANGFORD PROSPECT

The Langford prospect is in the S½ sec. 25, T. 22 S., R. 16 W., about 23 miles by road south of White Signal; it can be reached by driving 19.5 miles south from White Signal on the Separ road and then turning

TABLE 8.—*Analyses of samples from the Hines No. 1 prospect, Grant County, N. Mex.*

Sample no.	Locality	Description	Equivalent uranium (percent)	Uranium (percent)
HLB-14-134	Pit 2	Quartzite breccia and fluorite. Channel sample 1.5 ft long.	0.005	0.004
135	do	Quartzite breccia and fluorite. Channel sample 3 ft long.	.006	.004
136	Pit 1	Quartzite breccia	.001	.001

west for 3.5 miles on a dirt road to the prospect (fig. 50). This deposit was discovered by Charles Russell, of Tyrone, and was undeveloped in 1950. It was examined and mapped by Elliot Gillerman in April and June 1950 (unpublished report).

The deposit is in a silicified breccia zone cutting fine-grained grayish-pink pre-Cambrian granite. Many pegmatite dikes, 2 inches to 2 feet wide, are found in the granite; south and southeast of the deposit rhyolite and diabase dikes cut the granite also.

Two ore minerals are present; a dark-purple fluorite and a yellow uranium mineral, possibly autunite, associated with pink calcite in the silicified breccia zone. The breccia is exposed in a fault for about 150 feet along the north bank of a small creek. The fault strikes N. 35° W. and dips 65° SE. The fluorite and autunite(?) are limited to the middle 50 feet of the exposure, but pink calcite is found along the entire exposed length of the fault. The vein minerals are present throughout the 2½- to 3½-foot zone of breccia but are most concentrated on the footwall side of the fault. Fluorite is found as tiny violet to dark-purple crystals in veinlets less than half an inch wide. The bright-yellow autunite(?) lines cavities in the breccia less than 5 mm in diameter. The dark-purple fluorite was found to be radioactive.

The radioactive breccia zone gave a maximum reading of 5 divisions on the 2.0 scale of a beta-gamma counter.

REPORTED OCCURRENCES

The following reported uranium occurrences in Grant County have not yet been studied by the U. S. Geological Survey and are not included in this report: many small deposits in the White Signal district, some of which are included in the unpublished report by Keith (1945a); torbernite from the Chino disseminated copper pit near Santa Rita; autunite in the Eureka district, in the Little Hatchet Mountains; and radioactive xenoliths in Tertiary lavas in Little Gallinas Canyon in the Black Range. Two samples of cherty material from Little Gallinas Canyon were submitted by C. H. Rogers to the U. S. Geological Survey for analysis. They contained 0.068 and 0.016 percent uranium, respectively.

LITERATURE

The ore deposits of the White Signal and Black Hawk districts are described briefly in U. S. Geological Survey Professional Paper 68 (Lindgren, Graton, and Gordon, 1910, p. 321–324), but the discussion is limited to the gold, silver, and base-metal deposits. The general geology and mineral deposits (exclusive of uranium) of the White Signal district have also been discussed by Sidney Paige in U. S. Geological Survey Geologic Atlas, folio 199 (1916).

The first published reports dealing with uranium in these districts are by F. I. Leach (1920) and Granger and Bauer (1952). Each of these reports describes in detail a small area, usually a single property.

LEA COUNTY

The following information was abstracted from an unpublished report by R. P. McNeal (1950a).

Abnormal radioactivity has been detected in several of the oilfields of Lea County in southeastern New Mexico (fig. 49, deposit 23). These fields, including the Hobbs, Monument, Cooper, and Jal, are along the western edge of the central basin platform bordering the Delaware basin.

Production in these fields comes from the San Andres, Big lime (of drillers), and Seven Rivers formations, all of Permian age. The depth of producing strata ranges from 3,300 to 4,100 feet.

The positions of the radioactivity anomalies, as represented on some gamma ray logs by extremely high deflections, correspond closely to the positions of the producing strata. A precipitate which lines the tubing in some wells is strongly radioactive. Radioactivity anomalies have been noted only in those wells that produce water with the oil. All available evidence indicates that the radioactive elements were transported by water.

Localization of the radioactive fields along the west edge of the central basin platform and the fact that the oil production of the radioactive wells is from Permian formations suggest a possible relationship of radioactivity to the Permian evaporites in the Delaware basin to the west.

MORA COUNTY, COYOTE CREEK

The following information has been taken from an unpublished report by G. B. Gott and R. L. Erickson (1951) and from U. S. Geological Survey Circ. 334 by H. D. Zeller and E. H. Baltz (1954).

Copper-uranium-bearing black shale and sandstone of the Permian Sangre de Cristo formation are exposed 2 to 3 miles south of Guadalupita on Coyote Creek (fig. 49, deposit 10). The abnormal radioactivity of the shale was first discovered in 1951 by Charles B. Read and George O. Bachman, of the U. S. Geological Survey. The shale is about 5 feet thick, dips nearly vertically, is nonmarine, and is overlain and underlain by arkosic sandstones. The deposits are in lenticular carbonaceous zones in both shales and sandstones. Chalcocite, pyrite, and malachite are abundant. Uraninite from copper sulfide nodules in the black shales has been identified, and tyuyamunite is disseminated in some of the arkosic sandstones. Zeller and Baltz (1954) conclude that copper and uranium were syngenetically deposited with the sediments and concentrated in the carbonaceous zones during lithification. They report that samples from some of the zones contain as much as 0.67 percent uranium and average 3 percent copper.

RIO ARRIBA COUNTY

Uranium minerals are present in many different places in Rio Arriba County. In the mountains, along the eastern border of the county, near the town of Petaca, samarskite is found in pegmatites cutting pre-Cambrian schist. A few miles south of Coyote, black shales of Jurassic age show abnormal radioactivity. Two copper districts at Jarosa and at Cobre basin, in the western part of the county, contain radioactive plant remains associated with copper minerals in sandstones of Permian and Triassic age.

PETACA PEGMATITE

Hess and Wells (1930) reported a samarskite-bearing pegmatite 2½ miles southwest of the town of Petaca (fig. 49, deposit 9). At the time of their examination this land belonged to Charles Springer, of Cimmaron, N. Mex. The claim was located for mica and included one of a group of pegmatites that extends about 14 miles north and south. These pegmatites strike northwest and dip southwest roughly parallel to the schistosity of the pre-Cambrian quartz-mica schist which they intrude.

Within the pegmatite large masses of pink microcline as much as 10 feet in diameter are associated with vein quartz, white microcline, and muscovite in books up to 18 inches thick. The radioactive minerals replace the microcline. The minerals consist of masses of samarskite, ranging in size from microscopic grains up to pieces an inch thick, and of imperfect crystals and larger masses of a dull-reddish monazite.

COYOTE OCCURRENCE

The information on this and the following three deposits has been abstracted from an unpublished report (1951) by G. O. Bachman and C. B. Read.

A radioactive carbonaceous shale member of the Jurassic Todilto limestone crops out on a high mesa 4 miles south of the town of Coyote (fig. 49, deposit 6). The equivalent uranium content of this shale is estimated at 0.005 percent.

COPPER CITY GROUP

The Copper City group of prospects is in a coarse sandstone member of the Triassic Chinle formation in the southern part of the county, approximately 7 miles east of Cuba (fig. 49, deposit 7). Copper carbonates and sulfides associated with carbonized plant remains have been mined on this property. This organic matter contains an estimated 0.006 percent equivalent uranium. The copper content averages 1½ percent.

JAROSA DISTRICT

Twenty-five miles east of Cuba, in the Jarosa district on the eastern flank of San Pedro Mountain (fig. 49, deposit 8), copper minerals have been found at several places in the Cutler formation of Permian age. The prospects are in a radioactive zone about 4 feet thick and contain carbonaceous material. This zone is estimated to contain about 1 percent copper and 0.006 percent equivalent uranium.

COBRE BASIN GROUP

Cobre basin is in the southeastern part of the county 7 miles northeast of Abiquiu (fig. 49, deposit 5). Radioactive low-grade copper-ore bodies are found in a coarse sandstone of the Triassic Chinle formation. The radioactive material is localized by carbonized plant remains. The equivalent uranium content of these deposits is estimated at 0.005 percent and the copper content at 0.8 percent.

LITERATURE

The first published report on uranium-bearing material from Rio Arriba County was issued in 1930 by Hess and Wells (1930, p. 17–26) on the pegmatites near Petaca. This report is primarily about mineralogy and about the laboratory methods employed by the authors to ascertain the age of the pegmatite by determining lead-uranium ratios on the samarskite. An article by L. R. Page (1950) in Economic Geology also discusses these deposits. A reconnaissance report by Bachman and Read (unpublished, 1951) briefly describes radioactive spring deposits, coal and black shale, and sandstone copper deposits in Rio Arriba and Sandoval Counties.

SANDOVAL COUNTY

Sandoval County, in north-central New Mexico, just south of Rio Arriba County, contains many different radioactive deposits, all of secondary origin. Radioactive coal and black shale are found near San Ysidoro and on La Ventana Mesa. Hot spring waters are depositing radioactive tufa at Jemez Springs and Caseman well. A short distance from Jemez Springs a sedimentary copper deposit, known as the Spanish Queen group, is associated with uranium-bearing carbonized plant remains. The Perry Robb spring deposits near Jemez Springs were studied in detail by Granger (unpublished report). Many of his conclusions about them may have wider applications; hence these deposits are discussed in some detail. The available information on the other deposits in the county is much more limited, and they can only be described briefly in this report.

RADIOACTIVE SPRING DEPOSITS, PERRY ROBB PROPERTY, JEMEZ SPRINGS

By H. C. Granger

A radioactive thermal spring deposit near Jemez Springs, Sandoval County, N. Mex., was brought to the attention of the U. S. Geological Survey by Mr. Perry Robb in January 1950. The deposit is along the Jemez River in sec. 14, T. 18 N., R. 2 E., New Mexico principal meridian (fig. 49, deposit 12). It may be reached by going north 1.7 miles from Jemez Springs on a graded dirt road, State Highway 4.

The thermal spring deposits are in the valley of the Jemez River. The valley is a sharply incised canyon 1,700 feet deep; the valley floor is less than 1,000 feet wide and the canyon rims are about 2 miles apart. One of the springs has formed an elongated deposit (fig. 53) of calcareous tufa across the valley that has partly dammed the Jemez River. This deposit is a local scenic attraction and is called the Soda Dam. The Soda Dam and surrounding deposits were examined by the author in April 1950. A sketch map on a scale of 1 inch equals 100 feet was made (fig. 53); 5 samples of calcareous tufa, 4 of thermal spring waters and 1 sample of river water were collected.

General Geology.—The oldest rock in the area, a medium-grained pre-Cambrian granite with red feldspar, is exposed along the floor of the Jemez River valley. This granite underlies 700 feet of Paleozoic limestone, sandstone, and shale of the Pennsylvanian Magdalena group and Permian Abo sandstone. The rocks are exposed as apparently flat-lying beds along both walls of the Jemez River valley. They are capped by volcanic rocks ranging in composition from rhyolite to andesite of Cretaceous to Quaternary age. The most recent rocks are thermal spring deposits of calcareous tufa. Springs emit water ranging from 10° to 70° C.

Radioactivity.—Most of the deposits left by the thermal springs are of white radioactive porous calcareous tufa, but some contain massive travertine and rarely pisolitic calcite. Near the canyon walls tufa commonly contains fragments of talus which fell while the deposit was being formed. Locally the white tufa contains a black sooty radioactive material. These black areas are commonly less

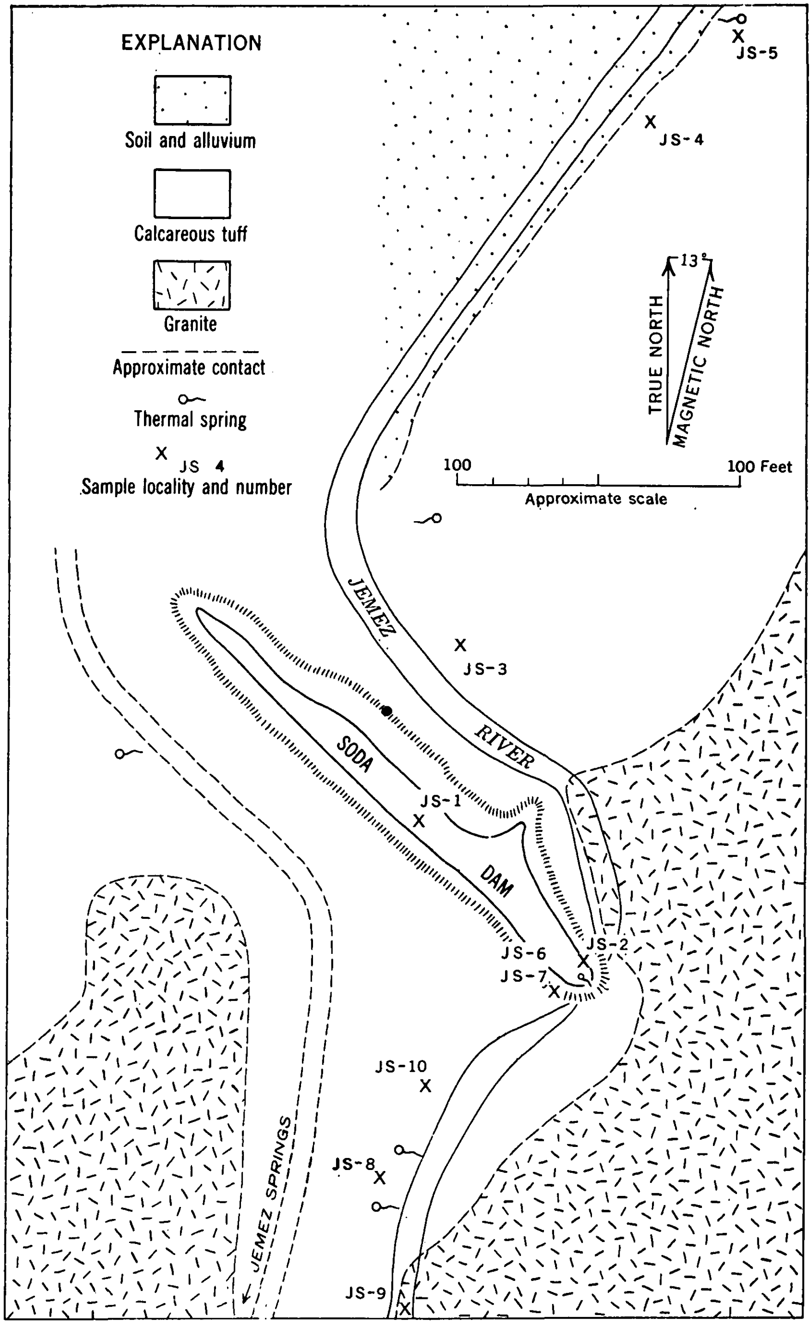


FIGURE 53.—Sketch map showing geology and sample locations, Perry Robb deposit, Sandoval County, N. Mex.

than 4 feet long and 1 foot thick, but they may be as much as 15 feet long and 2 feet thick. The black material appears to follow the layering of tufa.

The thickness of the tufa deposits above the nearby granitic rock is not known but is assumed to average at least 6 feet. All the porous calcareous tufa is weakly radioactive. An average normal background reading is about 4 divisions on the 0.2 scale of a beta-gamma counter; the average radioactivity of the more recently deposited tufa ranges between 7 and 12 divisions. The tufa and travertine that is obviously older has much lower radioactivity, commonly less than twice the normal background. The most radioactive part of the deposit is the black sooty material parallel to the tufa layers. The radioactivity of this material ranges from 4 to 10 divisions on the 2.0 scale.

Sampling and grade.—Both the spring water and the calcareous tufa deposits were sampled. Water from 3 thermal springs (JS–2, 5, 8) and the river (JS–9) contained 0.040 ppm uranium; 1 thermal spring (JS–7) contained 0.036 ppm uranium. Analyses of grab samples (table 9) cut in the white tufa contained from 0.002 to 0.0006 percent equivalent uranium compared to 0.023 to 0.20 percent equivalent uranium in tufa that contained the black sooty material. Radium has been tentatively identified as the major radioactive element.

TABLE 9.—*Analyses (in percent) of samples from the Perry Robb deposit, Sandoval County N. Mex.*

Field no.	Material	eU	U	ThO_2	Ba	Sr
JS-1	Calcareous tufa	0.006	0.002	0.02	0.1	0.01
3	Black material	.20	.001	.002	1.0	.01
4	do	.023	.000	.02	.1	.01
6	Calcareous tufa	.006	.000	.01	.1	.01
10	do	.002	.000	.02	.01	.01

Origin of radioactive material.—According to Doerner and Hoskins (1925): "In the presence of a large excess of barium over radium, sulphate ions will precipitate radium even though the solubility product of radium is not exceeded." Inasmuch as the radioactivity from one gram of uranium is equivalent to the radioactivity from 5.3×10^{-7} grams of radium it is evident that the samples contained a large excess of barium over radium. For example, sample JS–3 excluding the quantity of uranium and thorium, contains 1.06×10^{-7} percent radium and 1.0 percent barium, or a ratio of radium to barium of roughly 1 to 10,000,000.

Assuming from the field and laboratory evidence that the method of coprecipitation described by Doerner and Hoskins was instrumental in precipitating the radium in these spring deposits, the calcareous tufa, mainly calcite, and the radioactive material, radium, have been precipitated from solution in thermal spring waters that have cooled and partly evaporated at the surface. The abnormal temperature of the water may be caused by igneous activity, by heat developed along a fault plane, or by exothermic chemical reactions. Probably the path of the water passes near or through a body of uncooled igneous instrusive rock. The calcite in the tufa could be derived from lime-rich beds in the overlying Magdalena group and Abo sandstone, alteration of calcic feldspar and other minerals in the igneous rocks, or calcium-rich primary magmatic solutions. The lime-rich beds in the overlying formations are believed to be the most probable source.

The radium coprecipitated with barium sulfate must have come from uranium somewhere along the path of the spring waters. It is not known whether the uranium, from which the radium was derived, is an epigenetic deposit in the form of a vein or dissemination or a syngenetic deposit of uranium minerals in the rocks traversed by the spring waters. Also, it is not known whether the uranium has been dissolved and washed away by the spring waters or whether the deposit is, for the most part, still in place.

CASEMAN WELL

Slight radioactivity was found by Bachman and Read (unpublished report, 1951) in travertine around Caseman well, 10.6 miles north of San Ysidro.

SAN YSIDRO COALFIELD

Radioactive coal has been found (Bachman, G. O., and Read, C. B., unpublished report, 1951) in the San Ysidro coalfield in sec. 31, T. 15 N., R. 1 E., New Mexico principal meridian (fig. 49, deposit 15). This coal is in the Upper Cretaceous Dakota sandstone in beds about 1 foot thick which grade laterally into carbonaceous shales. The coal is estimated to contain 0.002 percent equivalent uranium.

LA VENTANA MESA

The information on La Ventana Mesa, as well as that on the San Ysidro coalfield and the Spanish Queen group, has been taken from unpublished reports by Bachman and Read (1951) and by Vine, Bachman, Read, and Moore (1953).

La Ventana Mesa is about 1½ miles east of La Ventana, N. Mex. (fig. 49, deposit 11). Radioactive coal and shale are present in the upper part of the Cretaceous Mesaverde formation near the top of the mesa, and the La Ventana sandstone member of the Mesaverde formation that caps the mesa contains carnotite. Uranium is also present in carbonaceous lenses in the basal member of the Mesaverde formation and in the Dakota sandstone east of La Ventana Mesa; however, the only deposits of possible economic importance, so far as could be determined, are those on La Ventana Mesa. These deposits are largely concentrated in coal seams immediately beneath the La Ventana sandstone and appear to have been localized by tent-shaped structures in the beds immediately beneath the coal seams, minor synclines within the coal seams, joints in the overlying La Ventana sandstone, carbonaceous material, and porous sandstone beds. The zone of greatest radioactivity does not exceed 0.6 of a foot in thickness at most places observed. However, this zone is known to grade laterally into thick coal beds and a radioactive zone of greater thickness may be present. Figures 54 and 55 show the geologic relations of the radioactive material on La Ventana Mesa and nearby places. Sample analyses are given in table 10.

TABLE 10.—*Analyses (in percent) of samples from La Ventana Mesa, Sandoval County, N. Mex.*

[Preliminary analyses (unpublished report, 1951) for uranium, ash, and uranium in ash by G. O. Bachman and C. B. Read]

Sample no.	Equivalent uranium	Uranium	Ash	Uranium in ash
BNM-48	0.032	0.02	80	0.03
51	.010	.01	70	.01
52	.003			
53	.122	.2	45	.5
54	.003			
56	.005			

West of the Rio Puerco the coal beds are much less radioactive than on La Ventana Mesa. This may be due partly to the presence of a marine shale which becomes prominent westward in the La Ventana sandstone. The marine shale has lowered the permeability of the La Ventana sandstone and may have deterred the passage of solutions bearing radioactive elements. In the opinion of Vine, Bachman, Read, and Moore (unpublished report, 1953), the deposits are diagenetic; uranium was introduced by ground water and may originally have been derived from the slightly uraniferous Bandolier tuff of Pliocene age which now covers a large area east of the Nacimiento Mountains.

Coal samples collected by Vine, Bachman, Read, and Moore (unpublished report, 1953) contain as much as 0.62 percent U, and 1.34 percent U in the ash.

SPANISH QUEEN GROUP

By G. O. BACHMAN and C. B. READ

The Spanish Queen group of copper mines and prospects, about 50 miles northwest of Albuquerque, is in the Permian Abo formation that crops out in the canyonwalls of the Jemez River (fig. 49, deposit 13).

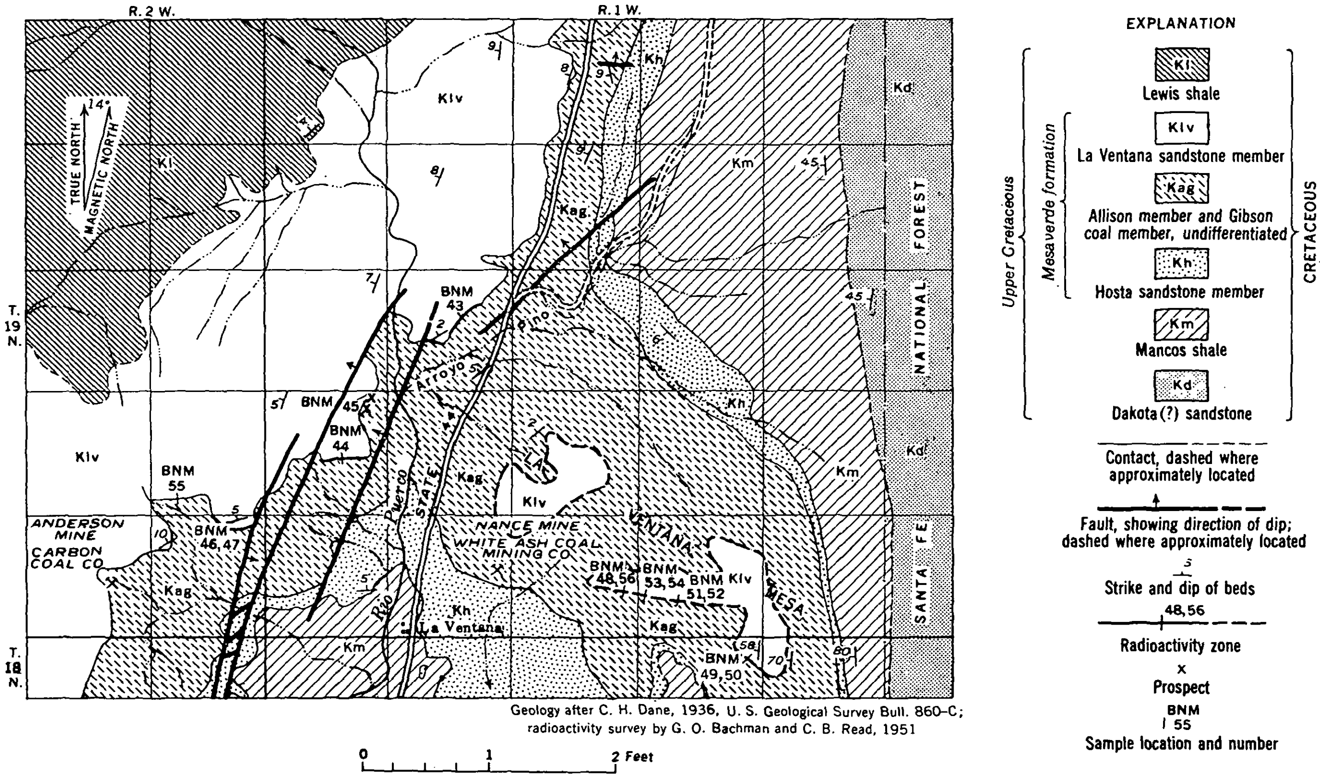


FIGURE 54.—Geologic map of La Ventana Mesa and vicinity, Sandoval County, N. Mex.

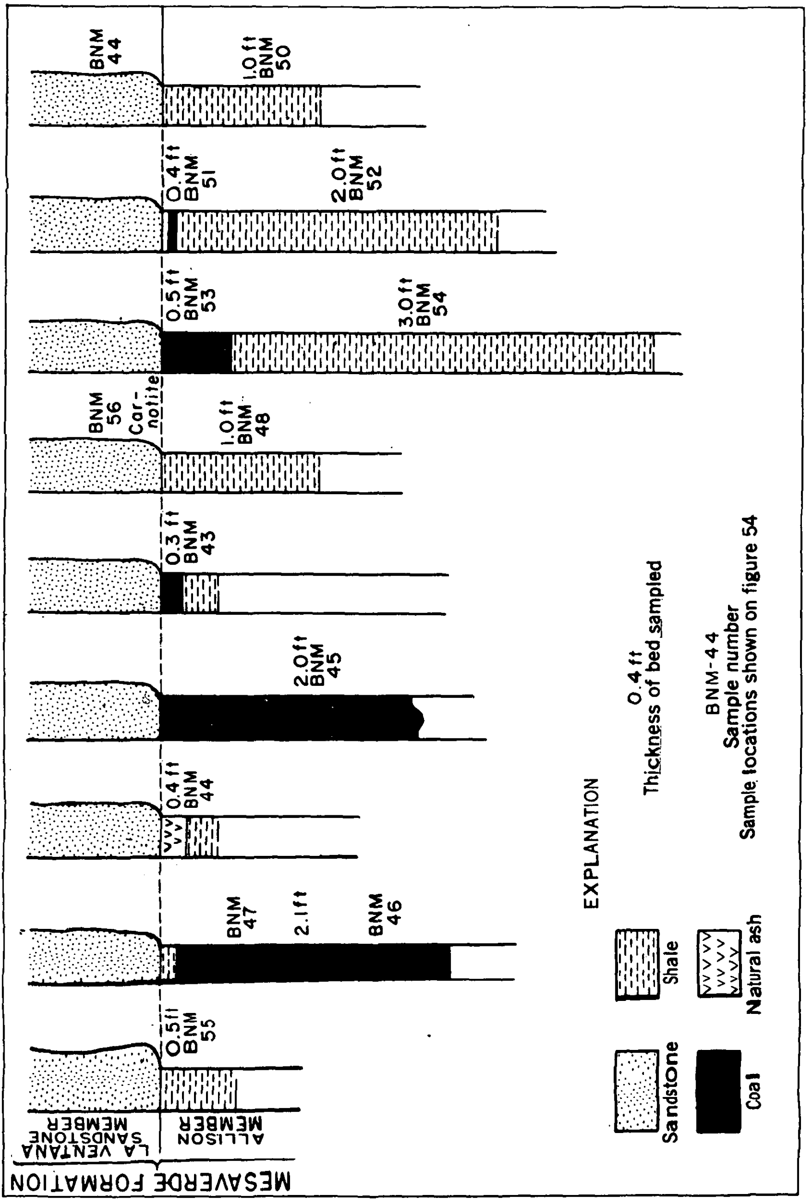
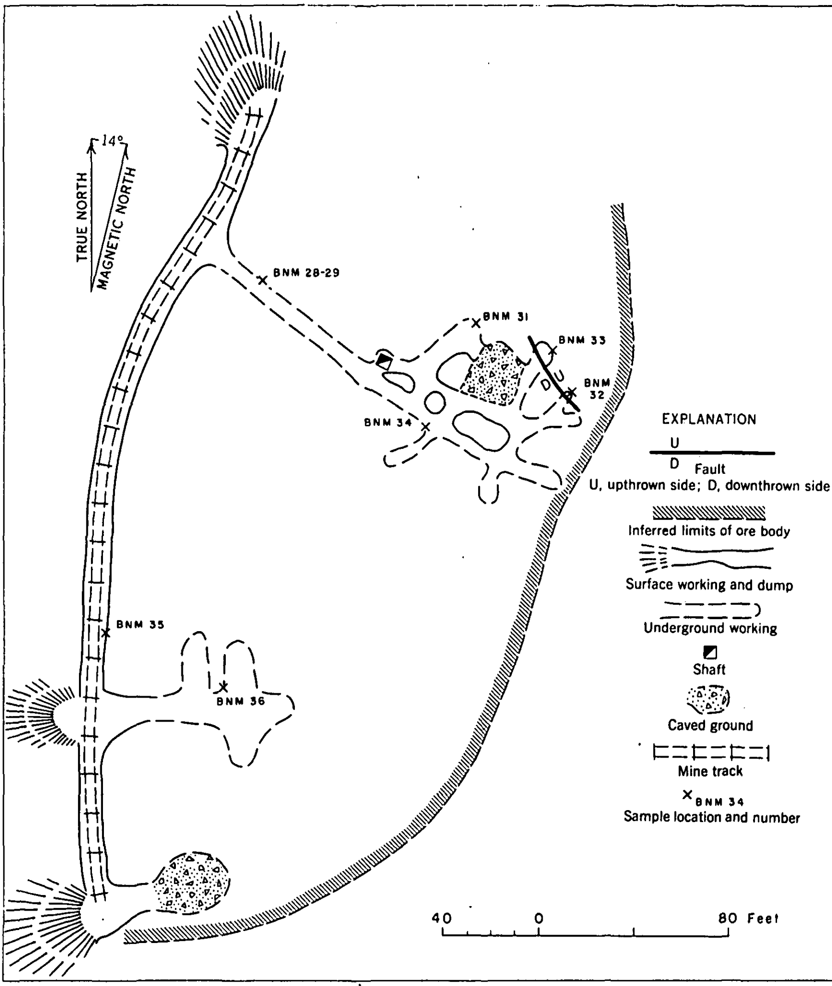


FIGURE 55.—Graphic sections of coal beds and associated strata, La Ventana Mesa, Sandoval County, N. Mex.

Intermittent operations over a considerable period of time have resulted in the development of two small mines and several prospects, none of which was active in 1951. One of these small mines is the East Spanish Queen mine (fig. 56).



Mapped by G. O. Bachman and C. B. Read, August 1951

FIGURE 56.—Sketch map of the East Spanish Queen mine, Jemez Canyon, Sandoval County, N. Mex.

The series of prospects on the east side of the Jemez River was examined and found to be variably radioactive through a vertical zone up to 6 feet thick. Radioactivity seems to be stronger in and near carbonaceous material which is also the place of concentration of the copper sulfides chalcocite and bornite. Estimated average equivalent uranium in the copper ore body is 0.01 percent, but selected samples contain as much as 0.1 percent equivalent uranium. No identifiable uranium minerals were observed. The copper content of the deposit is believed to average about 3 percent and the inferred magnitude of the ore body is 20,000 tons.

One small mine has been developed in the west wall of Jemez canyon. Sparse copper ore is present in 6 feet of sandstone and siltstone; the estimated grade of the ore is not in excess of 1 percent. Radioactivity is apparent throughout the workings, partly due to radon gas contamination in the stagnant air. Equivalent uranium is estimated at 0.01 percent, but selected samples may contain 0.1 percent. The inferred size of the sandstone ore body is about 10,000 tons.

LITERATURE

The first report on radioactive occurrences in the county was by Granger (unpublished report, 1951) who made a thorough investigation of the Perry Robb hot springs near Jemez Springs. This report was soon followed by a reconnaissance report by Bachman and Read (unpublished report, 1951) that describes the radioactivity at Caseman well, Jemez Springs, San Ysidro coalfield, La Ventana Mesa, and the Spanish Queen copper deposits. The Spanish Queen prospects were later visited and briefly summarized by Gott and Erickson (unpublished report, 1951). Read (unpublished report, 1952) and Vine, Bachman, Read, and Moore (unpublished report, 1953) re-examined the deposits in the La Ventana Mesa area.

SAN JUAN COUNTY

The uranium deposits of San Juan County in northwestern New Mexico are confined to carnotite disseminated in the Morrison formation. The stratigraphy and lithology of the carnotite ore strata have been discussed in a paper by L. C. Craig and V. L. Freeman (unpublished report, 1951). The uranium has been found only in the basal or Salt Wash sandstone member of the Morrison formation. The Salt Wash sandstone is a continental stream deposit composed dominantly of fine- to medium-grained sandstones with some interbedded sandy siltstones. Ore does not occur where there is little sandstone or where the sandstone units are thin, platy, and lenticular. The descriptions of the carnotite deposits of the Oak Springs and Navajo Reservation districts follow. No reports on the deposits at Beautiful Mountain or Toadlena (fig. 49, deposits 2, 4) were available before 1952.

Some gas wells in the Rattlesnake field in the west-central part of the county were tested (McNeal, R. P., 1950a unpublished report), but the uranium content was negligible. Three helium-bearing gas wells in the northwestern part of the county were checked for radioactivity, and water samples were analyzed in the Denver laboratories of the Survey. No unusual radioactivity could be detected with a Geiger counter, and the highest uranium content in any of the water samples was only 0.04 parts per million of uranium.

OAK SPRINGS DISTRICT, CANYON NO. 2 CLAIM

Canyon No. 2 claim in the Oak Springs district (fig. 49, deposit 1) is located about 10 miles north of Redrock, Ariz., and about 1 mile east of the Canyon claim which is on the New Mexico-Arizona border. The claim was held and had been operated by Cato Sells before 1952. A road leads to a rim 20 feet above the mine workings.

Five small exposures have been worked, and a few tons of carnotite ore have been shipped.

The ore is in the Salt Wash sandstone member of the Morrison formation. The position of the contact between the Salt Wash sandstone and the Bluff sandstone is unknown. The ore is concentrated in a body 20 feet west of a basaltic dike and in bodies adjacent to the dike. The dike, which strikes N. 20 W. and dips vertically, is about 3 feet thick. Another dike of similar attitude, but only 1 foot thick, cuts the claim about 300 feet farther west. No alteration of the sandstone near the dike is evident; nor is there any noticeable displacement of the bed, which has a regional dip of 3° to the east. The ore extends 200 feet west of the dike; it extends only 12 feet to the east but reappears again in a small area 425 feet away from the dike. The sandstone enclosing the ore is light gray, fine grained, and shows crossbedding. Above and below the sandstone are blue-green clays containing a few fossil branches and other carbonaceous material. Above the upper clay seam is a massive buff sandstone. A second mineralized seam, not over 3 inches thick, is 15 feet above the main zone.

The environment and existing exposures point favorably to the possibility of finding more ore on the claim.

NAVAJO RESERVATION (DISTRICT 12), JOHNSON CLAIM

The Johnson claim is approximately 3 miles east of the Arizona State line (fig. 49, deposit 3). A measurement from an aerial-photograph mosaic showed the location to be about latitude 36°24′ N., longitude 109°0′ W. A wagon road runs to the claim, but the last 1½ miles are impassable by automobile.

In 1951 the claim was held jointly by Innes Johnson, Sr., and Innes Johnson, Jr., of Sanastee, N. Mex.

The area examined was on the southern and southwestern cliffs of a large mesa. The dip of about 15° toward the northeast causes the high cliffs to the south and west; to the east and northeast the mesa grades into the flats. The carnotite deposits are in the Salt Wash sandstone member of the Morrison formation about 100 feet above the base. Three areas of rather strong uranium mineralization are spaced at about 1 mile intervals around the mesa. Between these areas most of the surface is covered with unconsolidated sand. Vanadium minerals are abundant on these sand slopes, but uranium minerals are sparse.

Although adequate information as to the extent of mineralization between the widely separated exposures will not be available without further exploratory work, it is felt that the few mineralized areas now visible do not warrant further field work on this particular claim.

LITERATURE

The first radioactivity survey in the county was made by McNeal (unpublished report, 1950), who investigated several gas wells in and around the Rattlesnake field in 1950 but found no unusual radioactivity. In the spring of the following year Ellsworth (written communication, 1951) and Hatfield (written communication, 1951) visited two carnotite prospects on the Navajo Reservation in western San Juan County. At about the same time an unpublished report (1951) on the distribution, stratigraphy, and lithology of the ore strata was prepared by Craig and Freeman. Stokes (1951) reported on the carnotite deposits of the Carrizo Mountains area in New Mexico and Arizona. The deposits at Beautiful Mountain and Toadlena are shown on Craig and Freeman's map but are not discussed individually in their report.

SIERRA COUNTY

The only locality in Sierra County on which uraniferous material had been developed before 1952 is the Terry uranophane prospect, about 2 miles northeast of the town of Monticello. A piece of radioactive ilmenite "float" was picked up in the Hillsboro district and there are rumors of pitchblende "ledges" in the Black Range; however, a Geiger counter survey of the area failed to locate any radioactive deposits.

TERRY URANOPHANE PROSPECT, MONTICELLO

By H. C. Granger

Uranophane is associated with fluorite in jasperoid breccia on the Terry prospect, 2 miles northeast of Monticello (fig. 49, deposit 19). The Terry prospect, consisting of the Pitchblende Strikes Nos. 1, 2, 3, and 4 claims, is just south of the San Mateo Mountains in sec. 26, T. 10 S., R. 6W., New Mexico principal meridian. In 1951 the claims were owned jointly by Ray Terry, Earl Terry, W. H. Terry, and W. H. Terry, Jr., of Hot Springs, N. Mex. The only development work on the claim consisted of 2 prospect pits in the uranophane-fluorite deposit and 2 small pits dug in the Quaternary gravels (fig. 57).

The prospects may be reached by driving northerly from Monticello for 1.5 miles on the Red Rocks ranger station road and then going southeasterly for 0.7 mile on a poor ranch road. From this point an obscure track leads northeasterly for 0.5 mile to the prospect pits.

The deposit was examined on April 27, 1950, by H. C. Granger and Herman L. Bauer of the Geological Survey, accompanied by Ray Terry, of Hot Springs, N. Mex. A pace and compass map of the deposit was made on a scale of 1 inch equals 10 feet, and 7 samples were collected.

General geology.—A bed of gray and red jasperoid which strikes about N. 50° W. and dips 40° NE. is the oldest rock on the Terry uranophane prospect. Its thickness is unknown. The jasperoid is tentatively identified as part of the Kelly limestone of Mississippian

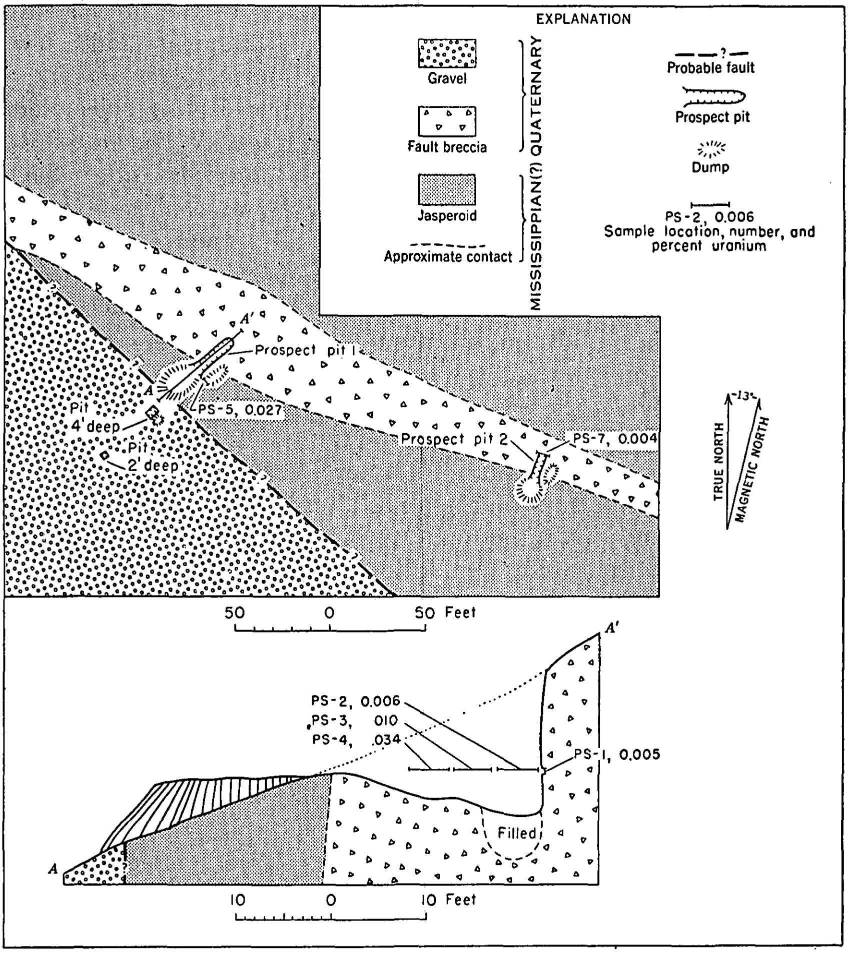


FIGURE 57.—Geologic sketch map and section, Terry prospect, Sierra County, N. Mex.

age because of its lithologic similarity to rock described by Loughlin and Koschmann (1943, p. 53) in the nearby Magdalena district.

Beds of partly silicified limestone and sandstone, probably belonging to the Magdalena group of Pennsylvanian age, overlie the jasperoid. These beds strike N. 10° to 20° W. and dip 40° to 45° NE. A sill of feldspar porphyry at least 600 feet long and 200 feet wide cuts the jasperoid about 300 feet north of the uranophane deposits. The feldspar porphyry is light gray and contains feldspar phenocrysts about 3 mm in diameter in a felsitic groundmass. Quaternary gravels, composed predominantly of cobbles and pebbles of igneous rocks, are in fault(?) contact with jasperoid in the southwest part of the map area (fig. 57).

The uraniferous deposits at the Terry prospect are in a fault breccia that strikes N. 68° W. across the jasperoid. The dip is not known but is assumed to be nearly vertical. The contacts of the breccia are indistinct. The breccia, composed of jasperoid fragments and a few fragments of igneous rocks (porphyry) and limestone, grades into fractured jasperoid. The matrix of the breccia consists of silica and fluorite. Vugs in the fluorite are filled with white clay, and fractures in the fluorite and jasperoid contain uranophane and iron oxide. The sequence of mineral deposition is (1) quartz and chalcedony, (2) colorless crystals of fluorite in quartz, (3) green fluorite, (4) white clay, (5) hydrous iron oxide, and (6) uranophane and fluorescent hyalite. Silica occurs in the matrix as small quartz crystals, chalcedony, and jasper. The colorless and purple fluorite is commonly intergrown with quartz that was deposited contemporaneously with the fluorite. Vugs in the breccia are coated with fluorite crystals as large as 10 mm in diameter. Quartz veins cut the fluorite, and fluorescent hyalite coats fractures in jasperoid. Green fluorite is rare in the deposit and in places appears to be later than the purple variety. A white pulverulent hydrothermal clay mineral wholly or partly fills cracks in the fluorite or fractures in the breccia.

Hydrous iron oxides on fractures in the breccia suggest that pyrite probably is associated with the fluorite in the unaltered parts of the deposit. Uranophane has been deposited on fractures in fluorite; small flat radiating groups of acicular crystals less than 8 mm in diameter commonly coat fluorite or jasperoid. Uranophane is reported to be more abundant in the lower 4 feet of prospect pit 1 than in present exposures. Vugs in this part of the pit are lined with radiating crystals of uranophane as long as one-half inch.

Radioactivity.—Four channel samples and a grab sample from the dump were taken at prospect pit 1, and a chip sample 4 feet long was cut at prospect pit 2 (table 11). A grab sample of the feldspar

TABLE 11.—*Analyses of samples from the Terry prospect, Monticello, Sierra County, N. Mex.*

[Radioactivity of samples PS-1 to PS-5 is given in the number of divisions on the 2.0 scale of a Geiger counter; radioactivity of samples PS-6 and PS-7 is given in divisions on the 0.2 scale]

Sample no.	Description	Radioactivity	eU (percent)	U (percent)
PS-1	Jasperoid breccia, <5 percent fluorite	3	0.006	0.005
2	Jasperoid breccia, 20 percent fluorite	3	.008	.006
3	Jasperoid breccia, 40 percent fluorite	3	.012	.010
4	Jasperoid breccia, 20 percent fluorite	3	.037	.034
5	Jasperoid breccia, 30 percent fluorite	6	.028	.027
6	Feldspar porphyry	4	.002	.001
7	Jasperoid breccia, 5 percent fluorite	8	.005	.004

porphyry was taken so that its uranium content might be compared with that of the breccia.

The uranium content of samples taken in this deposit ranged from 0.004 to 0.034 percent (fig. 57) in contrast to one dump sample taken by J. H. Soule (written communication, 1949), of the U. S. Bureau of Mines, which assayed 0.45 percent uranium oxide.

A sample of the feldspar porphyry intrusive rock contained 0.001 percent uranium. The dump sample taken by the U. S. Bureau of Mines probably represents material from the bottom of prospect pit 1, but this part of the deposit is now concealed. The presence of material of this grade, however, suggests that further exploration of the deposit, laterally or in depth, may result in finding similar grade ore. Other fluorite-bearing breccia zones in the jasperoid, if present, also should be prospected. In the southern part of the Magdalena district Loughlin and Koschmann (1943, p. 14–16, 53–54) described extensive areas of silicified Kelly limestone that might be worth prospecting for deposits similar to those on the Terry prospect.

RADIOACTIVE ILMENITE ON THE VIRGINIA CLAIM, HILLSBORO DISTRICT

The following data have been abstracted from an unpublished report (1950b) by H. L. Bauer, Jr.

A specimen of radioactive ilmenite from the Virginia claim, Hillsboro district, Sierra County (fig. 49, deposit 20) was submitted to the Survey by the owner, Mr. B. O. Bishop, of Silver City, N. Mex.

According to Mr. Bishop, development on the Virginia claim consists of a 52-foot vertical shaft, a 70- to 80-foot inclined shaft, and stopes. The openings are driven on the contact of an igneous rock and limestone. Vanadinite, wulfenite, galena, sphalerite, and cerussite are reported to occur at the claim. The ilmenite specimen was a piece of float found 1,500 feet north of the vertical shaft and just below a limestone-monzonite contact. Dimensions of the specimen were approximately 2 inches by 1 inch by half an inch. Calcite and epidote were noted on one corner of the specimen. The ilmenite specimen contained 1.4 percent equivalent uranium. Results of chemical analyses for uranium were not available when this report was written. Employees of the Bureau of Mines in Silver City examined the Virginia claim with a Geiger counter and found no radioactivity higher than background.

REPORTED OCCURRENCE OF PITCHBLENDE, BLACK RANGE

This information was taken from an unpublished report (1950c) by H. C. Granger and H. L. Bauer, Jr.

On March 8, 1950, Mr. J. G. McPherson, Silver City, N. Mex., reported a possible occurrence of pitchblende in the Black Range, N. Mex., in or near secs. 2, 11, or 14, T. 14 S., R. 10 W., New Mexico principal meridian. This area was examined by Granger and Bauer in April 1950, but their investigation did not reveal any areas of abnormal radioactivity or evidence of uranium minerals.

SOCORRO COUNTY, SAN ACACIA DISTRICT

A deposit near San Acacia (fig. 49, deposit 18) in shear zones in an andesitic flow contains small quantities of dolomite(?) and carnotite associated with secondary copper minerals, calcite, and quartz. One sample selected from dump material contained 0.026 percent uranium.

TORRANCE COUNTY, SCHOLLE DISTRICT

G. B. Gott and R. L. Erickson (unpublished report, 1951) mention the occurrence of calcite, malachite, and azurite with carbonized wood, lignite, and pellets of hydrocarbon in a sandstone belonging to the Abo formation of Permian age from the Scholle district, T. 2 N., R. 5 E. (fig. 49, deposit 17). In addition, an article in the Grand Junction Daily Sentinel dated June 23, 1949, reports a uranium discovery made on June 4 of that year by William McIllhaney, of Albuquerque, 3 miles north of Scholle. The article reports a large area of low-grade radioactive sandstone and siltstone cut by a small seam containing carnotite. A 2-pound sample from an unknown locality in the Scholle district was submitted to the U. S. Atomic Energy Commission in Grand Junction in the spring of 1949. This sample was reported to contain 6.65 percent U_3O_8, 5.35 percent V_2O_5, and 15.55 percent Cu.

VALENCIA AND McKINLEY COUNTIES

GRANTS DISTRICT

The following general information on the Grants district has been taken from an unpublished report (1950) by R. P. Fischer and J. D. Strobell and from a more recent report by Irving Rappaport (1952).

The town of Grants, from which the district takes its name, is 80 miles west of Albuquerque and 60 miles east of Gallup on Route 66 and the main line of the Santa Fe railroad. Uranium ore appears to be largely confined to sedimentary rocks of Jurassic age which are exposed in a belt extending northeastward from near Grants almost to Gallup. Another broad belt, about 25 miles east of Grants, trends northward. Uranium is concentrated in two stratigraphic zones. The lower zone is in the Todilto limestone and overlying basal Summerville formation; the upper zone is in the Westwater Canyon sandstone and Brushy Basin shale members of the upper Jurassic Morrison formation, and overlying Dakota sandstone of Cretaceous age. These two zones are separated by 500 to 800 feet of barren rock.

General geology.—The rocks in the Grants district, including the uranium-bearing formations, dip about 10° NE. from the broad Zuni Mountains uplift whose crystalline core is exposed about 25 miles to the southwest. The sedimentary rocks flanking the uplift range in age from Permian to Cretaceous. To the east they are buried by the Upper Cretaceous, Tertiary, and Quaternary volcanic rocks of the Mount Taylor field, but reappear east of these volcanic rocks. Northward the sedimentary rocks extend into the San Juan Basin.

A broad bench as wide as 2,000 feet in places has been developed on the Todilto limestone. Part of the bench is covered by a thin veneer of soil and by the basal beds of the overlying Summerville formation.

The Summerville formation consists of red-brown and white banded silty sandstone from 150 to 200 feet thick. The Summerville is overlain by the 150-foot thick Bluff sandstone, which is a massive white sandstone with local red and brown staining. The Bluff sandstone forms a cliff, but it is less extensive or prominent than the cliff formed by the Entrada sandstone that underlies the Todilto.

The Entrada, Todilto, Summerville, and Bluff formations together form the San Rafael group in this area.

The San Rafael group is overlain by 600 or 700 feet of Morrison rocks, predominantly sandstone, consisting of the Recapture shale, Westwater Canyon sandstone and Brushy Basin shale members; the Salt Wash sandstone member was not recognized in this region. The Morrison formation forms a steep slope interrupted by vertical cliffs, that rises to the Cretaceous Dakota sandstone escarpment.

The Todilto limestone is a thin-bedded dense gray crystalline limestone that weathers to tan, light gray, or white. Its thickness varies regionally from 5 to several tens of feet; where visible on the Rim Rock claim, the Todilto is estimated to be 12 to 15 feet thick. Eastward in New Mexico the formation is much thicker, contains gypsum, and the limestone is very fetid and bituminous. A fish fauna from the eastern (gypsiferous) facies of the Todilto limestone and the correlative Pony Express limestone member of Colorado is said to be possibly marine, but no evidence of marine origin of this western facies of the Todilto limestone is now known.

The uranium deposits in Todilto limestone show a general tendency to concentrate along minor folds; the deposits also appear to have been lithologically controlled and are more abundant in the pure limestone than in the impure silty or gypsiferous facies.

Carnotite and tyuyamunite, the chief minerals, are found in thin isolated patches and discontinuous coatings on the joint and bedding surfaces. In some places they form a barely visible paint or stain, no more than a faint yellow coloration. In others, they are thick enough to form a brilliant yellow film.

In addition to carnotite and tyuyamunite, uranophane, sklodowskite (uranium silicates), rutherfordine (uranium carbonate), and pitchblende have been reported from the Todilto limestone.

Carnotite and abundant reddish-brown to black oxides of iron and manganese(?) cover the limestone and coat joint and bedding surfaces. The presence of the hydrous calcium vanadates hewettite or metahewettite is suspected.

Minor amounts of carnotite appear to be sparsely scattered through the limestone in a very patchy distribution; local concentrations are separated laterally by barren areas.

The Morrison formation consists of mudstone interbedded with sandstone and conglomerate. The Dakota formation consists largely of sandstone and subordinate mudstone interbedded with thin lenses of carbonaceous material. Uranium in the Morrison and Dakota formations is distributed throughout a stratigraphic range of 300 feet.

The most important uranium-bearing mineral in the Morrison and Dakota deposits is carnotite which "occurs as canary-yellow material interstitial between sand grains, as coating on mudstone galls, and as rich laminae which follow bedding planes for short distances and then transect these original planes at small angles" (Rappaport,1952). Some schroeckingerite has tentatively been identified as impregnating sandstone and coating joints and bedding planes.

Description of deposits.—The following are descriptions of a few of the deposits in the Grants area. They are modified from unpublished reports by M. J. Sheridan (1950) and A. Rosenzweig (1950) and from a published report by Rappaport (1952).

GLOVER CLAIMS

The Glover claims, in sec. 20, T. 14 N., R. 11 W., New Mexico principal meridian, were owned by Fred Glover, of Pruitt, N. Mex., in 1950. M. J. Sheridan used a Geiger counter to examine the claims on November 21, 1950. The Glover No. 2 claim covers minor occurrences 2 to 3 feet below the top of the Todilto. Carnotite with manganese oxide and abundant calcite reaches a maximum thickness of 1 foot and is traceable for 15 feet along the outcrop. Three other claims with reportedly less significant showings were not examined.

T. NOS. 1 TO 4 CLAIMS

The T. Nos. 1 to 4 claims in sec. 28, T. 14 N., R. 11 W., New Mexico principal meridian, belonged at the time of examination to Henry Andrews, of Blue Water, N. Mex. The claims were recorded in September 1950 and examined on November 21, 1950. Four claims cover widespread occurrences along the east rim and at the head of a north-draining canyon. Only the most southerly, Claim No. 1, was examined, but ore minerals can be traced almost continuously for at least 400 feet around the rim at the head of the canyon. Radioactivity, which is generally weak, seems to be confined to a 0.5- to 1.0-foot layer at, or near, the top of the Todilto. Minor radioactivity in float was noted 100 to 200 feet back from the rim. A sample chipped from several points on the outcrop represents only the high-grade material and contained 0.21 percent equivalent uranium.

ANDREWS PROPERTY

An unnamed carnotite deposit to which W. C. Andrews, of Pruitt, N. Mex. had mineral rights in 1950 lies in sec. 19, T. 14 N., R. 11 W. In a U-shaped indentation in the rim of the Todilto two outcrops show a zone of easily traceable ore minerals 1 to 3 feet below the top of the formation. One exposure on the north flank of the U is continuous for about 100 feet and shows carnotite(?) in fractures on bedding planes throughout a 1- to 3-foot zone. About 100 feet east of this exposure another 75-foot zone is continuously but weakly mineralized through thicknesses ranging from a few inches to 2 feet. Radioactivity traversing of part of the area back from the rim disclosed spotty concentrations of ore minerals. A random chip sample contained 0.20 percent equivalent uranium.

BOTTOMS CLAIMS

Two claims, in sec. 18, T. 14 N., R. 11 W., New Mexico principal meridian, were owned by Lloyd Bottoms, of Pruitt, N. Mex., when they were traversed with a Geiger counter on November 21, 1950. The claims cover weakly mineralized outcrops in a south-facing rim of Todilto limestone. The best ore is in a 0.2- to 0.5-foot zone traceable radiometrically for about 25 feet. A sample taken where the zone is 0.4-foot thick contains 0.07 percent equivalent uranium. About 400 feet to the west and 100 feet to the east small mineralized areas were detected by the counter.

LAWRENCE ELKINS CLAIM

This claim is in sec. 24, T. 14 N., R. 12 W., and belonged to Lawrence Elkins, of Pruitt, N. Mex. in 1950. It is on an isolated mesa that is inaccessible by road. The mesa is entirely capped by Todilto limestone and the rim had, as of 1950, been only lightly prospected. Radioactive float, which is probably near its source, is distributed for about 40 feet along a shallow gully traversing the mesa. Calcite and manganese oxides are common. A sample chipped from various boulders of radioactive float contained 0.39 percent equivalent uranium.

HARD WORK, RED POINT, AND OTHER CLAIMS

A group of claims that belonged in 1950 to Jim Hutton and Glen Williams, of Grants, N. Mex., are in the N½ sec. 16, T. 13 N., R. 10 W., New Mexico principal meridian. These claims were located in October 1950 and were examined in November 1950 with a Geiger counter. Reportedly, there are 15 claims along the rim of Todilto in this open area. The only mineralized area noted was in the discovery cut at the top of the rim on one of the claims (probably the "Hard Work"). The cut, approximately 12 feet by 5 feet and 3 feet deep, exposed ore minerals in the upper 2 feet of the Todilto limestone, which in this locality is 7 to 8 feet thick. About 30 feet back from the rim ore minerals were noted in one boulder that was probably in place. A sample of the highest grade material in the discovery cut contained 1.18 percent equivalent uranium. The outcrop was checked at various places for several hundred feet in both directions from the discovery cut, but no other mineralized areas were seen.

RED BLUFF CLAIM GROUP

The Red Bluff No. 1 claim belonged in 1950 to O. A. Jones et al., Grants, N. Mex., and is in sec. 36, T. 13 N., R. 10 W., New Mexico principal meridian. It was examined with a Geiger counter in November 1950. Two mineralized areas are exposed in the western part of a northward-trending finger of a Todilto-capped bench. The southern area exhibits, for about 75 feet along the outcrop, a weakly mineralized zone in thin-bedded limestone near the base of the formation. The maximum thickness of mineralized rock noted was about 3 feet; a sample contained 0.14 percent equivalent uranium. About 150 feet to the north the outcrop is continuously mineralized near the base of the formation for 150 feet; the deposit is less than a foot thick except in one zone where fractures and bedding planes throughout the 8 to 9 feet of Todilto contain carnotite. A sample of the most radioactive rock contained 0.37 percent equivalent uranium.

The Red Bluff Nos. 2 to 7 claims are in sec. 4, T. 12 N., R. 9 W. and belonged to the owners of the Red Bluff No. 1 when they were examined in November 1950 with a Geiger counter. Five claims that cover about 3,000 feet of the rim of Todilto include several widely distributed radioactive exposures in the upper part of the Todilto limestone. A location cut on the Red Bluff No. 2 claim, at one of the more promising places, exposes rock with weak radioactivity in the joints and seams of the upper 2 to 3 feet of limestone. Radioactivity was not traceable along the outcrop away from the cut. A sample, selected from the highest grade material exposed in the cut, had an equivalent uranium content of 0.08 percent. A further examination of the outcrop showed very local areas, 5 to 10 feet long, of weakly mineralized rock.

The Red Bluff Nos. 7 and 8 claims are in sec. 4, T. 12 N., R. 9 W., New Mexico principal meridian. They belonged in 1950 to the owners of the other Red Bluff claims. In one test pit of the Red Bluff No. 7 claim carnotite coats bedding-plane and joint surfaces in the Todilto limestone. One sample from this pit contained 0.11 percent equivalent uranium. The Red Bluff No. 8 claim is mineralized for 50 feet along the rim. A sample from the richest portion of the rim, where excavation has begun, contained 0.63 percent U_3O_8, and 0.53 percent V_2O_5.

GRAY EAGLE, BLACKHAWK, AND BONNEY CLAIMS

O. A. Jones and J. C. Dorsett, of Grants, N. Mex., owned these claims, in sec. 4, T. 12 N., R. 9 W., New Mexico principal meridian when the claims were examined with a Geiger counter on November 19, 1950. These claims extend about 3,000 feet along a Todilto limestone outcrop that is weakly and discontinuously mineralized near the top. The extent of individual radioactive exposures along the outcrop is commonly only a few feet, although one exposure was about 75 feet long. Locally, parts of the Todilto are strongly radioactive, and at these places shallow test pits were being sunk to fulfill claim location requirements.

A sample taken from a 3-foot thickness at an outcrop where abnormal radioactivity is traceable for 15 feet, showed an equivalent uranium content of 0.20 percent. Another sample from a 4-ton discovery-cut stockpile nearby had an equivalent uranium content of 0.17 percent. Only the most radioactive material was sampled. A sample was taken from an ore bed 10 to 12 inches thick which could be traced a few feet only; the ore was exposed in the bottom of a gully 100 feet back from the rim of the outcrop. It had an equivalent uranium content of 0.71 percent, which was the highest of any samples taken. A sample from the Blackhawk discovery cut, on the rim of Todilto where carnotite was erratically distributed through a bed 2 to 3 feet thick and traceable only a few feet beyond the cut, had an equivalent uranium content of 0.27 percent.

MARK ELKINS CLAIM

On an unnamed claim in the N½ sec. 19, T. 12 N., R. 9 W., New Mexico principal meridian, carnotite is present at the top of the Todilto and can be traced 150 to 170 feet along the outcrop. The claim belonged in 1950 to Mark Elkins, a rancher of Grants, N. Mex. The ore ranges from a few inches to 2 feet in apparent thickness. Discontinuous ore was noted 4 to 5 feet below the top zone also. Soil cover obscures the limestone back from the rim and the extent of the ore zone in this direction could not be determined. No exploratory work of any sort had been undertaken before 1950 on this deposit. Samples chipped at several places along the outcrop, although representative of only the more highly mineralized rock, give some indication of the probable grade. These chip samples contained an average of 0.25 percent equivalent uranium.

RAILROAD SECTIONS

Four railroad sections in the Grants district were examined and the results of these investigations (Anonymous, 1951) are summarized below.

Uranium minerals were seen on land belonging to the Santa Fe railroad, sec. 13, T. 13 N., R. 11 W., New Mexico principal meridian. The deposit was examined with a Geiger counter on November 20, 1950. Carnotite is present in a V-shaped indentation in the rim of Todilto limestone. The mineralized zone ranges in thickness from a few inches to 4 feet and is continuous for approximately 900 feet along the outcrop. The mineral-bearing stratum is from 1 to 4 feet below the top of the formation and exhibits fracture- and bedding-plane fillings typical of other deposits in this area. The intensity of radioactivity is variable. A sample taken from a 2-foot zone at the best point on the outcrop shows an equivalent uranium content of 0.58 percent. Another sample chipped from an average-looking 4-foot face contained 0.10 percent equivalent uranium.

A railroad section claim, belonging to the Santa Fe, in the N½ sec. 19, T. 13 N., R. 10 W., New Mexico principal meridian was examined with a Geiger counter on November 18, 1950. The Todilto outcrop is mineralized for about 1,500 feet at or near the top of the formation. The heaviest concentration of radioactive material is exposed in a 2-foot zone that is comparatively well mineralized for about 35 feet along the outcrop. The extent of the mineralized ground behind the rim has not been determined, though rapid radiometric traverses indicate gradual reduction to a normal count at 50 feet. The deposits were estimated to be contained in a block 35 feet by 35 feet by 2 feet.

A grab sample from a 10- to 15-ton stockpile had an equivalent uranium content of 0.68 percent. Stripping exposed two other areas to the west with abnormal radioactivity. They measured 10 to 12 feet along the outcrop and were as much as 1 foot thick.

Another section, sec. 25, T. 13 N., R. 10 W., belongs to the Santa Fe railroad. The Todilto crops out in the northwest corner of the section several hundred feet north of the rim. Carnotite with hematite and limonite is present through 1 to 5 feet of limestone continuously for more than 100 feet along the outcrop. Traces of ore minerals were found in the underlying limestone. The restriction of mineralization to fractures and seams has made estimates of ore potential difficult. Samples taken from various points along the outcrop, indicative of the better material, had an equivalent uranium content of 0.26 percent.

Still another section belonging to the Santa Fe railroad, in sec. 19, T. 13 N., R 9 W., contains uranium deposits in the Westwater Canyon sandstone member of the Morrison formation. The Dakota sandstone and Morrison formation crop out along a prominent cliff in the northern part of the section. Uranium is present in several stratigraphic zones in the Westwater Canyon member, both in the cliff and in isolated erosion remnants south of it. The ore deposits are similar in most respects to typical deposits in the Salt Wash sandstone farther north on the Colorado Plateaus. They are concentrated along channels and in sandstone rolls; carnotite is closely associated with carbonized wood fragments and limonite; clay and mudstone surrounding ore-bearing lenses are commonly altered from red to green. These deposits differ from those in the Salt Wash in having a low vanadium content. Several tons of ore averaging 0.67 percent U_3O_8 had been shipped from this property before 1953.

INDIAN ALLOTMENTS

A reconnaissance investigation was made of two radioactive occurrences on Indian allotments. The data on these deposits are summarized below.

An Indian allotment held in 1950 by the Desedillo family of Pruitt, N. Mex., is in sec. 26, T. 13 N., R. 10 W., New Mexico principal meridian. Here the Todilto limestone forms a south-facing cliff, and is mineralized for a distance of at least 70 feet, 30 feet of which contains variable amounts of carnotite in a 2-foot zone near the base of the formation. At one point where the ore was thickest, the entire 12 feet of limestone was mineralized for some 10 feet along the outcrop. Slight local folding may have helped to localize the ore. The remaining 40 feet of mineralized outcrop to the east has carnotite distributed along the joints; but the carnotite is confined mostly to the same 2-foot zone mentioned above. Away from the rim the soil cover obscures most of the limestone; but scattered outcrops 15 feet away from the rim contain ore showings and a trace can be noted at 45 feet. Back of the rim along the banks of a stream the Todilto is exposed in the NE¼ of the same section for several hundred feet. Two small radioactive areas containing mineralized float were found. Traces of ore minerals were noted in the underlying sandstone. A chip sample representing the higher grade material in the NW¼ section contained 1.70 percent equivalent uranium.

An Indian allotment, in the SW¼ of sec. 18, T. 13 N., R. 10 W., New Mexico principal meridain, was examined with the aid of a Geiger counter. It was under tentative lease in 1950 to Jim Hutton and Glen Williams, of Pruitt, N. Mex. Here the Todilto limestone is exposed in the bottom of a minor gully an estimated 1,500 feet north of the rim outcrop. Between 1 and 2 feet of overlying soil and barren limestone havé been stripped away and an area 15 by 40 feet showing carnotite-mineralized joints and bedding planes has been uncovered. The thickness of the ore zone, indicated in a small test pit, is about one foot. Chip samples from the pit contained 0.08 percent equivalent uranium. A radioactivity check of surrounding soil-covered areas indicated a limited extent only for the stripped deposit but revealed other areas of abnormal radioactivity 200 feet west and 100 feet south.

JONES CLAIM

An unnamed claim, belong in 1951 to A. O. Jones, of Grants, N. Mex., is in sec. 33, T. 12 N., R. 9 W., New Mexico principal meridian. It was examined with a Geiger counter on January 7, 1951. The deposit is at the intersection of two steep gullies at the base of a lava-capped mesa. About 12 feet of limestone are exposed. The upper 4 to 6 feet are thick bedded; radioactivity ranges from strong to weak; the lower portion of the limestone is thin bedded and weakly to moderately mineralized. A selected sample of thick-bedded limestone contained 0.98 percent U_3O_8 and 0.54 percent V_2O_5; a sample of the thin-bedded lower limestone contained only 0.21 percent equivalent uranium.

ZUNI MOUNTAINS AREA

Gott and Erickson (unpublished report, 1951) mention radioactivity associated with malachite, azurite, chrysocolla, fluorite, and calcite in joints and fractures in arkosic sandstones and conglomerates of Permian age and altered pre-Cambrian granite from the Zuni Mountains, T. 11 N., R. 12 W. (fig. 49, deposit 16). Selected samples of the radioactive material contained 0.009 percent uranium, 4.5 percent copper, and 0.02 percent V_2O_5.

LITERATURE

The first discussion of uranium in the Grants district was in an unpublished report (1950) by Fischer and Strobell. This memorandum covers, in a general way, the location, history, geology, and mineralogy of the entire district but gives little specific information on the individual properties. Later in the same year most of the known properties were visited by Sheridan (unpublished report, 1950) and a few by Rosenzweig (unpublished report, 1950) who summarized their findings in a preliminary reconnaissance report for each property. A preliminary report on the uranium deposits of the Grants district was also prepared by M. L. Reyner and M. J. Sheridan (unpublished report, 1950) for the U. S. Atomic Energy Commission. The minerals found in the district were the subjects of careful laboratory analyses by Gruener and Gardiner (written communication, 1951) who presented their results in a progress report to the Atomic Energy Commission. A more detailed report on the Grants district was prepared by Irving Rappaport (1952) for the Atomic Energy Commission.

OTHER REPORTED OCCURRENCES

In addition to the deposits discussed in the preceding pages, seven reported radioactive occurrences from the State had not recently been investigated by geologists of the U. S. Geological Survey or the U. S. Atomic Energy Commission before 1952 and, therefore, are not described here. These are Elizabethtown, Peralta Canyon, Rociada, the Organ Mountains, Elk Mountain, the Little Hatchet Mountains, and the Glorieta deposits.

In 1902 an anonymous note in the Mining and Scientific Press mentioned the occurrence of uraninite in the President mine near Elizabethtown in Colfax County (fig. 49, deposit 24). No details are given and no further references in the literature could be found. In 1910 the U. S. Geological Survey report by Lindgren, Graton, and Gordon on ore deposits of New Mexico (Prof. Paper 68) briefly mentions carnotite from Peralta Canyon, Cochiti district, in Sandoval County (fig. 49, deposit 25); but again no details are given. J. M. Hill mentions the presence of small noncommercial radioactive microlite-bearing pegmatites cutting pre-Cambrian granite near Rociada (fig. 49, deposit 26), in an unpublished report in 1945. S. B. Keith examined the Swanson-Lauer property in the Organ district (fig. 49, deposit 27) for uranium in 1944; but the results were negative. However, in 1950 a brief note appeared in the Engineering and Mining Journal saying that secondary uranium minerals had been reported from the Memphis King mine in the same district. The University of New Mexico Bulletin, Minerals of New Mexico, by Stuart Northrop (1942) lists the occurrence of uraninite, samarskite, and cyrtolite from pegmatites on Elk Mountain in San Miguel County (fig. 49, deposit 30). The same reference also lists a questionable occurrence of autunite in the Eureka district, Little Hatchet Mountains, Grant County (fig. 49, deposit 28). O. B. Muench reported in the American Chemical Society Journal in 1938 (Muench, 1938a) a detailed chemical and mineralogical study of a specimen of monazite from a pegmatite dike near Glorieta (fig. 49, deposit 29). In an abstract appearing in the Pan-American Geologist (Muench, 1938b) for the same year, the locality was stated to be somewhere near Taos.

CONCLUSIONS

Of the New Mexico uranium deposits that were known in 1952, only those in the Grants district of Valencia and McKinley Counties had large proved reserves of uranium ore. Table 12 shows the significant features of uranium deposits in New Mexico known before 1952. The carnotite deposits of the Carrizo Mountains area, San Juan County, are mostly small and widely scattered, but many of them contain pockets of good ore and it is probable that small quantities of uranium ore will continue to be produced from this area for some time. If autunite and torbernite become commercially important sources of uranium, the deposits of these minerals in the White Signal district might constitute a valuable reserve. If continued exploration were to reveal the presence of substantial amounts of uranium oxides at Black Hawk or in depth at White Signal, these districts might become ore producers. The same may be said for the uranophane deposits at Monticello. Not enough exploration and development has been done at any of these places to indicate conclusively that there is or is not sufficient uraniferous material to constitute ore.

The pegmatites near Petaca do not contain sufficient quantities of uranium and thorium minerals to be minable for these elements alone; however, it might be economically possible to recover them as byproducts from the production of beryl.

The low-grade uranium-bearing copper deposits in Mora, Rio Arriba, and Sandoval Counties might become of economic interest if the copper could be mined and the uranium could be recovered as a byproduct. With the possible exception of La Ventana Mesa the radioactive coal, black shale, and hot spring deposits in these counties now seem only of scientific interest, as is the radioactivity associated with the oilfields of Lea County.

The relatively wide distribution of known uranium occurrences in New Mexico should encourage exploration.

TABLE 12.—*Significant features of radioactive deposits in New Mexico*

Deposit	Location				Type of deposit	Country rock	Minerals	Development	Percent U	Percent eU	Production
	Township	Range	Section	Deposit no. on fig. 49							
Grant County:											
White Signal district:				22							
Merry Widow	20 S.	15 W.	22		Fracture coating	Granite and dikes	Autunite, torbernite, pyrite, limonite, quartz.	2 shafts, 450 ft of workings.	<2.06		Au, U.
Apache Trail	20 S.	15 W.	2		Vein and dike	Granite and diabase dike.	Torbernite (Pb, Bi, Cu) sulfides, limonite, quartz.	200-ft shaft, 265 ft of workings.	<.041		Au and Bi only.
Blue Jay	20 S.	15 W.	26		Fracture coating	Granite and dikes	Torbernite, pyrite, specularite, clay minerals, quartz.	Bulldozer trenches	<.11		(1).
Monarch No. 2.	20 S.	15 W.	19		do	Rhyolite dike	Autunite	15-ft prospect pit	<.011		(1).
Tunnel Site No. 1.	20 S.	15 W.	26		Disseminated	Granite, rhyolite dikes.	Limonite, clay minerals, quartz.	250-ft adit		<0.018	(1).
Uncle Sam silver mines	20 S.	14 W.	32		Shear zone	Granite	Quartz, sulfide minerals.	Shafts, adits, stopes		(2)	Ag only.
Hines No. 1	21 S.	14 W.	34		Breccia zone	Quartzite	Autunite, fluorite, limonite, hyalite.	2 prospect pits		<.027	(1).
Black Hawk district.	18 S.	16 W.		21	Veins	Granite, gneiss and dikes.	Pitchblende, pyrite, galena, sphalerite, sulfides, carbonates, quartz.	Shafts and several thousand ft of workings.		(3)	Ag only.
Lea County:				23							
Hobbs field	18 S.	37 E.			Water in oil wells	Sedimentary rocks (Permian).		Oil wells, 3,000 to 4,500 ft deep.			Oil only.
Monument field	19 S.	36 E.			do	do		do			Do.
Cooper field	24 S.	36 E.			do	do		do			Do.
Jal field	25 S.	37 E.			do	do		do			Do.
Mora County:											
Coyote Creek	3 miles south of Guadalupita.			10	Disseminated	Black shale (Permian).	Uraninite, metatyuyamunite, chalcocite, malachite.		.67		
Rio Arriba County:											
Petaca	26 N.	8 E.		9	Pegmatite	Pre-Cambrian schist.	Uraninite, samarskite, monazite, mica.		(4)		
Coyote	22 N.	3 E.		6	Disseminated	Shale of Todilto limestone (Jurassic).	Carbonaceous material.			<.005	
Copper city	21 N.	1 E.		7	do	Sandstone of Chinle fm (Triassic).	Carbonized wood, copper carbonates, and sulfides.	Adits and pits		<.006	

See footnotes at end of table.

TABLE 12.—*Significant features of radioactive deposits in New Mexico*—Continued

Deposit	Location: Township	Location: Range	Location: Section	Location: Deposit no. on fig. 49	Type of deposit	Country rock	Minerals	Development	Percent U	Percent eU	Production
Rio Arriba County—Continued											
Jarosa	21N.	3 E.		8	Disseminated	Cutler (Permian)	Carbonized wood, secondary copper minerals.			<0.006	
Cobre basin	24N.	6 E.		5	do	Sandstone of Chinle fm (Triassic).	Carbonized wood, secondary copper minerals.			<.005	
San Juan County:											
Rattlesnake field	29N.	19 W.			Water in gas wells	Limestone (Mississippian).		Gas wells, 7,000 ft deep.	(5)		Natural gas and helium only.
Oak Springs district:				1							
Canyon No. 2 claim.					Disseminated	Salt wash member of Morrison fm.	Carnotite, Carbonaceous material.	Prospect pits	<0.5		U.
Navajo Reservation district 12:				3							
Johnson claim.					do	do	Carnotite	do	<.5		
Beautiful Mountain.	9N.	5 W.		2	do	do	Carnotite, Carbonaceous material.	do			
Toadlena	6N.	4 W.		4	do		do	do			
Sandoval County:											
Jemez Springs	18N.	2 E.	14	12	Hot springs	Tufa and travertine	Sooty radioactive material, calcite.			<.20	(1).
San Ysidro coal-field	15N.	1 E.	31	15	Disseminated	Coal and black shale. Dakota ss. (Cretaceous).	Carbonaceous material			<.002	
La Ventana Mesa	14N.	1 W.		11	do	Coal and black shale (Mesaverde group).	do		<.62		
Spanish Queen mine.	4 miles south of Jemez Springs.			13	do	Abo formation (Permian?).	Carbonized wood, chalcocite, malachite.		<.01		
Sierra County:											
Monticello district, Terry prospect.	10S.	6 W.	26	19	Breccia zone	Jasperoid (Mississippian).	Uranophane, fluorite, hyalite, clay, quartz.	2 prospect pits	(6)		
Hillsboro district, Virginia claim.				20		Limestone (Mississippian?).	Ilmenite (float), calcite, epidote.			<1.5	

Socorro County: San Acacia (San Lorenzo) dist.	1 S.	2 W.		18	Breccia zone	Andesite flow (Tertiary).	Carnotite, torbernite, uranophane, secondary copper minerals.		<.026		
Torrance County: Scholle district	2 N.	5 E.		17	Disseminated	Abo formation (Permian?).	Carbonized woody hydrocarbon.		<.014		
Valencia and McKinley Counties: Grants district:				14			Carnotite, tyuyamunite, pitchblende, Uranium silicates, and carbonates.				
Glover claims	14 N.	11 W.	20		do	Todilto limestone (Jurassic).	Carnotite, manganese oxide, calcite.				
T. Nos. 1 to 4 claims	14 N.	11 W.	28		do	do	Carnotite			<.21	
[1]	14 N.	11 W.	19		do	do	do			<.20	
Bottoms claims.	14 N.	11 W.	18		do	do	do			<.07	
Mark Elkins claims.	14 N.	12 W.	24		do	do	do			<.039	
Railroad sections.	13 N.	9 W.	19		do	Westwater Canyon sandstone member of Morrison formation (Jurassic).	Carnotite, carbonized wood, limonite.		<.67		U.
Zuni Mountains	11 N.	12 W.		16	Fracture coating	Abo formation (Permian?) and pre-Cambrian granite.	Malachite, azurite, fluorite, calcite.		<.007		

[1] No data.
[2] <5 on 2.0 scale of Geiger counter.
[3] <15 on 2.0 scale of Geiger counter.
[4] <12 percent U_3O_8.
[5] Water <0.04 ppm of U.
[6] <0.45 percent U_3O_8.

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