# Radioactive Deposits in California



By G. W. Walker and T. G. Lovering





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## ABSTRACT

Reconnaissance examination by Government geologists of many areas, mine properties, and prospects in California during the period between 1948 and 1953 has confirmed the presence of radioactive materials in place at more than 40 localities. Abnormal radioactivity at these localities is due to concentrations of primary and secondary uranium minerals, to radon gas, radium (?), and to thorium minerals. Of the known occurrences only three were thought to contain uranium oxide (uraninite or pitchblende), 4 contained uranium-bearing columbate, tantalate, or titanate minerals, 12 contained secondary uranium minerals, such as autunite, carnotite, and torbernite, one contained radon gas, 7 contained thorium minerals, and, at the remaining 16 localities, the source of the anomalous radiation was not positively determined.

The occurrences in which uranium oxide has been tentatively identified include the Rathgeb mine (Calaveras County), the Yerih group of claims (San Bernardino County), and the Rainbow claim (Madera County). Occurrences of secondary uranium minerals are largely confined to the arid desert regions of southeastern California including deposits in San Bernardino, Kern, Inyo, and Imperial Counties. Uranium-bearing columbate, tantalate, or titanate minerals have been reported from pegmatite and granitic rock in southeastern and eastern California.

Thorium minerals have been found in vein deposits in eastern San Bernardino County and from pegmatites and granitic rocks in various parts of southeastern California; placer concentrations of thorium minerals are known from nearly all areas in the State that are underlain, in part, by plutonic crystalline rocks.

The primary uranium minerals occur principally as minute accessory crystals in pegmatite or granitic rock, or with base-metal sulfide minerals in veins. Thorium minerals also occur as accessory crystals in pegmatite or granitic rock, in placer deposits derived from such rock, and, at Mountain Pass, in veins containing rare earths. Secondary uranium minerals have been found as fracture coatings and as disseminations in various types of wall rock, although they are largely confined to areas of Tertiary volcanic rocks. Probably the uranium

in the uraniferous deposits in California is related genetically to felsic crystalline rocks and felsic volcanic rocks; the present distribution of the secondary uranium minerals has been controlled, in part, by circulating ground waters and probably, in part, by magmatic waters related to the Tertiary volcanic activity. The thorium minerals are genetically related to the intrusion of pegmatite and plutonic crystalline rocks.

None of the known deposits of radioactive minerals in California contain marketable reserves of uranium or thorium ore under economic conditions existing in 1952. With a favorable local market small lots of uranium ore may be available in the following places: the Rosamond prospect, the Rafferty and Chilson properties, the Lucky Star claim, and the Yerih group. The commercial production of thorium minerals will be possible, in the near future, only if these minerals can be recovered cheaply as a byproduct either from the mining of rare earths minerals at Mountain Pass or as a byproduct of placer mining for gold.

## INTRODUCTION

Radioactive minerals are widely distributed in California but, as yet, commercial concentrations of these minerals have not been found. Virtually all concentrations of uranium minerals, whether primary or secondary, have been found in place, whereas concentrations of thorium minerals commonly are associated with placer deposits. Rare, primary uranium minerals have been reported from pegmatite, granitic rock, and from quartz veins containing base-metal sulfides. The secondary uranium minerals, autunite, torbernite, and carnotite have been identified in a number of localities in the Mojave Desert region, principally in association with Tertiary volcanic or sedimentary rocks. Thorium-bearing minerals, including monazite, thorite, and allanite have been found in Pacific beach sands and in placer gravels along many of the rivers that head in the Sierra Nevada mountains; they also occur as accessory minerals in numerous exposures of crystalline rock. Monazite and cyrtolite (thorium-bearing zircon) are reported from pegmatites at various places in Riverside County, and allanite is a widely distributed accessory mineral in crystalline rocks exposed in San Bernardino County. Thorite has been identified in veins associated with bastnaesite (cerium-lanthanum fluocarbonate) on the Birthday Claims, San Bernardino County (fig. 1). Other radioactive minerals, including brannerite, ilmenite, euxenite, samarskite, and xenotime have been found in minute quantities in various geologic settings in California. None of the deposits constitutes an economic source of either uranium or thorium under present conditions.

## Purpose and scope

The primary purpose of this report is to present data pertaining to the occurrence, distribution, and geologic environment of deposits of radioactive minerals in California. A secondary purpose is to summarize the information available on occurrences in California and to present a brief description of each radioactive locality that was known prior to 1953.

This report is based largely on investigations of occurrences of radioactive material in California by the U. S. Geological Survey between 1948 and 1953. Part of the data contained in the report has been gathered by the U. S. Atomic Energy Commission and part is from published references.

Since 1948, a large number of mine properties, prospects, placer deposits, and claims have been examined for anomalous radioactivity by Government geologists. In addition, collections of ore and rock specimens from many other properties have been tested for radioactivity and many hundreds of miles of car traverses have been made, particularly in the Mojave Desert region. The tests of ore and rock specimens and the car traverses have been largely unsuccessful in finding new occurrences of radioactive material. Examination of mine properties, prospects, placer deposits, and claims has, on the other hand, confirmed the presence of radioactive minerals at more than 40 different localities in California.

For each individual deposit described in the following pages, the location, ownership, development, geology, mode of occurrence, and grade of ore is summarized, where this information is available. Much of the field work by Government geologists has been of a reconnaissance nature. Therefore, detailed information concerning some of the deposits is lacking. A few occurrences, because of their scientific or possible economic significance, have been studied in more detail.

## Acknowledgments

The field work leading to this report was done largely by various members of the U. S. Geological Survey and the U. S. Atomic Energy Commission. None of the reports mentioned below have been published; data from them have been included at appropriate places throughout this report and are duly acknowledged. References to published data are also included at appropriate places.

Some data on the Rathgeb mine (Calaveras County) and the Chilson (Vonsen) prospect (Kern County) were taken from a report by C. W. Chesterman and F. H. Main concerning reconnaissance for radioactivity of the western United States. Information on the Rosamond prospect (Kern County) was taken from two reports, one by F. M. Chace and one by G. W. Walker. R. U. King wrote the original report on the Josie Bishop claims (Kern County), and D. F. Hewett, W. N. Sharp, D. R. Shawe, and others have made extensive studies of the Mountain Pass area (San Bernardino County). D. G. Wyant is responsible for much of the early reconnaissance work for radioactivity in California; he wrote memorandum reports on the Live Oak Tank area (Riverside County) and the Kramer Hills area (San Bernardino County). The Hoerner-Ross pegmatite (San Bernardino County) was studied by D. F. Hewett of the U. S. Geological Survey, and C. C. Towle, Jr., of the U. S. Atomic Energy Commission, prepared a report on a reconnaissance for radioactivity of the Mother Lode gold belt. D. L. Everhart and C. C. Towle, Jr., wrote memorandum reports covering reconnaissance examinations of the Chilson, Rafferty, and Baxter properties, the Rademacher claim, and the Paymaster mine.

Most of the properties described in the report have been examined by George W. Walker who was assisted during many of the examinations by Luther H. Baumgardner. Most of the field work and the preparation of this interim report was done on behalf of the Division of Raw Materials of the Atomic Energy Commission.

## RADIOACTIVE DEPOSITS

Many small deposits of uranium- and thorium-bearing minerals are known in southern California but as yet no deposits of probable commercial importance of either have been reported; both thorium and uranium are scarce in northern California. Most of the uranium occurrences are widely scattered through the Mojave Desert region in the east-central and southeastern parts of the State; the individual deposits vary considerably in mineralogy and geology. Concentrations of thorium minerals, on the other hand, are largely restricted to beach and stream placer deposits and as disseminated accessory minerals in crystalline plutonic rocks.

Although more than twenty different radioactive minerals have been reported from California (table 2), only a few of these contain sufficient uranium or thorium to be classed as potential ore minerals. For purposes of this report, descriptions of the radioactive minerals have been segregated in the following pages on the basis of whether the minerals are principally uranium- or thorium-bearing.

Table 2.--List of radioactive minerals reported from California

| Name | Chemical Composition a/ | Uranium (percent) | Thorium (percent) | Megascopic appearance | Locality |
|---|---|---|---|---|---|
| Allanite | $(Ca, Ce, Th)_2(Al, Fe, Mg)_3Si_3O_{12}(OH)$ | 0.02 | < 3.2 | Prismatic, orange-brown to black crystals. | Rock Corral, Yosemite National Park and elsewhere. |
| Autunite | $Ca(UO_2)_2(PO_4)_2$ 10-12 $H_2O$ | 45-48 | ------ | Yellow-green, fluorescent, tabular crystals. | Jumpin claim, Rosamond prospect, Rafferty property, and elsewhere. |
| Betafite (?) | $(U, Ca)(Nb, Ta, Ti)_3O_9 \cdot nH_2O$ ? | 16.3-24.5 | 1.0-1.1 | Green-brown, brittle isometric crystals. | Hoerner-Ross property. |
| Brannerite | $(U, Ca, Fe, Y, Th)_3Ti_5O_{16}$ ? | 39.3 | 3.6 | Brownish-black prismatic crystals. | Mono County, near Coleville. |
| Carnotite | $K_2(UO_2)_2(VO_4)_2$ $3H_2O$ | 52.8-55.0 | ------ | Lemon yellow, locally micaceous, powdery | Vanuray and Lucky Star claims, Kramer Hills. |
| Cyrtolite | ZrS.04 - U, Y, Th, and R.E. | < 1.4 | ? | Transparent, reddish tetragonal crystals | Hoerner-Ross property. |
| Davidite (?) | Near $Fe^2(Fe^3, Ce)_2T._6O_{17}$ - R.E. and $UO_2$. | 4.4 | 0.12 | Black, opaque anhedral grains and hexagonal plates. | Sierra Nevada near Bishop |
| Euxenite | $(Y, Ca, Ce, U, Th)(Nb, Ta, Ti)_2O_6$ | 3-9 | < 4.3 | Black, prismatic crystals. | Rock Corral area. |
| "Gummite" (?) | Variable | 40-80 ? | ? | Red, waxey, brittle masses. | Jumpin claim, Rosamond prospect. |
| Monazite | $(Ce, La, Th)PO_4$ | --------- | < 26.4 ? | Yellow, red, brown, transparent crystals, commonly tabular. | Live Oak Tank area, Rock Corral area, various placers. |
| Pitchblende (?) | Betw. $UO_2$ and $U_3O_8$ | 55-83 | ------ | Black pitchy masses, powdery | Yerih group, Rainbow claim |

a/ Frondel and Fleischer (1952).

Table 2.--List of radioactive minerals reported from California--Continued

| Name | Chemical Composition a/ | Uranium (percent) | Thorium (percent) | Megascopic appearance | Locality |
|---|---|---|---|---|---|
| Samarskite | (Y, Ce, U, Ca, Fe, Pb, Th) $(Nb, Ta, Ti, Sn)_2O_6$ | 8.4-16.1 | < 3.7 | Black, dull, prismatic crystals. | Rock Corral area. |
| Thorite | ThSiO4 | < 9 | 25-63 | Black-brown glassy, isometric crystals-Uranoan variety round green grains. | Mountain Pass area, Sierra Nevada, various placers. |
| Torbernite | $Cu(UO_2)_2(PO4)_2$ $8H_2O$ | 47.1-50.8 | --------- | Green tabular crystals. | Chilson prospect, Lucky Star claim ? |
| Uraconite (?) (obsolete) | Uranium sulfate | ? | --------- | --------------------------- | Rathgeb mine |
| Uraninite (?) | $UO_2$ | < 88 | < 44 | Black, acicular crystals. | Rathgeb mine |
| Xenotime | $YPO_4$ | < 3.6 | < 2.2 | White, brown, red, resinous, tetragonal crystals. | Live Oak Tank area. |
| Yttrocrasite (?) | $(Y, Th, U, Ca)_2$ $Ti_4O_{11}$ ? | 2.3 | 7.7 | Black,tabular crystals. | Riverside Co. (see Murdoch and Webb, 1948, p. 318). |
| Zircon | Zr SiO4 | < 2.7 ? | < 13.1 ? | Translucent, colorless or yellowish, prismatic crystals. | Rock Corral area, various placers, and elsewhere. |

## Uranium deposits

### Distribution

Occurrences of uranium-bearing minerals are known from widely scattered localities throughout California, although most of them occur in the Mojave Desert geomorphic province. Characteristic of this arid desert region are near-surface concentrations of secondary uranium minerals in mid-Tertiary sedimentary or volcanic rocks, as for example those near Rosamond, Randsburg, Johannesburg, and Boron in Kern County, the Harvard Hills and Kramer Hills in San Bernardino County, and the Lucky Star claim in Imperial County. Probable secondary uranium minerals, as yet unidentified, have also been found in the Lippincott and Ubehebe mines, Inyo County, at the Wild Bill group of claims, Mono County, and at the Paymaster mine, San Bernardino County. In the Holcomb Valley district, near Big Bear Lake in the San Bernardino Mountains, and at the Rainbow claim, Madera County, small quantities of a primary uranium mineral--uraninite--is intimately associated with base-metal sulfide minerals. Uraninite has been reported (Rickard, 1895) at the abandoned Rathgeb gold mine in Calaveras County; other primary uranium minerals including samarskite, euxenite, davidite, and brannerite have been identified in crystalline rocks and in placer deposits in east-central and southeastern California.

### Size and shape

Most of the deposits containing secondary uranium minerals are small, not exceeding 100 feet in their greatest dimension. The deposits vary considerably in shape, but the majority are crudely tabular. Commonly, the secondary uranium minerals are erratically distributed on joint surfaces adjacent to mineralized faults; deposits of this type are essentially tabular in the plane of the fault and vary from a few inches to 10 feet in width and as much as 100 feet in length. Near surface, blanket-like deposits have been found locally where favorable sedimentary beds contain concentrations of secondary uranium minerals as disseminations and as coatings on joint surfaces. Deposits of this type rarely exceed 50 feet in their greatest dimension and commonly are only a few feet thick. In other deposits secondary uranium minerals occur in small disconnected patches which are not uniform in size or shape and which apparently have no systematic orientation.

It is difficult to make any generalizations about the size and shape of primary uranium deposits in California. Most of the primary minerals occur as disseminated accessory constituents in granitic rocks, as single crystals, or, locally, as small aggregates with other minerals in pegmatites, and as clots of crystals in base-metal-sulfide-bearing veins.

Localization

The known uranium deposits in California may be subdivided into four groups on the basis of their mode of occurrence. These are: (1) deposits in fissure veins, (2) deposits localized on fractures, bedding planes, and, locally, as disseminations in porous rock, (3) replacement deposits, and (4) occurrences of accessory minerals in granitic rocks or pegmatites. Only at the Rathgeb mine has a primary uranium mineral (uraninite ?) been found in association with a secondary uranium mineral (uraconite ?). Of the 29 uranium deposits described in the following pages, only 4 are thought to have been localized entirely by primary hydrothermal solutions. The remaining 25 deposits contain either secondary uranium minerals or unidentified uranium-bearing minerals associated with secondary base-metal minerals; the uranium in these deposits was probably introduced or, at least, redistributed by circulating ground water or by late hydrothermal solutions.

The occurrences in which uranium minerals are associated with quartz fissure veins were found to contain very little uranium. The uranium, which may be contained in either a primary or secondary mineral, is invariably associated with base-metal sulfides or their alteration products. Virtually all of the deposits of this type are found in granitic rocks. Uranium occurrences associated with quartz fissure veins include the Rathgeb mine, the Rademacher, Rainbow, and Red Devil claims, the Wild Bill group, and the Paymaster mine.

The largest group (group 2, above) includes those deposits in which secondary uranium base-metal minerals coat fractures and bedding planes. The country rock of such deposits varies; locally it may be bleached and partly altered to hydrothermal clay minerals; it may consist of Tertiary continental sedimentary rocks, in part tuffaceous, as for example at the Rosamond prospect, the Vanuray claim, the Harvard Hills and Kramer Hills; it may be Tertiary volcanic rocks, such as are found on the Jumpin, Goldenrod, and Lucky Star claims, and the Vonson and Chilson properties; or it may be older crystalline rocks as on the Josie Bishop claim and the Rafferty and Baxter properties.

Commonly, the greatest concentration of secondary uranium minerals is in fault gouge or on joints or bedding planes immediately adjacent to faults (group 1, p. 12). Deposits in bedded sedimentary rocks may show a marked preference for individual beds; the reasons for selective deposition of uranium in these beds is not fully understood, although porosity, permeability, and $CaCO_3$ content play a significant part.

A third group (group 3, p. 12) includes deposits in which replacement, associated with fracture filling, has taken place in limestone. At the Yerih group of claims (Scotty Wilson property), San Bernardino County, uranium is intimately associated with base-metal sulfides occurring as irregular masses and thin seams erratically distributed in limestone. Uranium has also been found associated with wulfenite in oxidized ore bodies composed largely of primary and secondary lead and zinc minerals at the Lippincott and Ubehebe mines in Inyo County. At both properties, the base-metal sulfide ore bodies have, in part, replaced the limestone and have also filled fractures.

Uranium-bearing minerals in crystalline rock (group 4, p. 12) have been concentrated and localized to varying degrees; most of these minerals are erratically and sparsely distributed and constitute concentrations only in the sense that they are somewhat more prevalent than in the surrounding rocks. At the Hoerner-Ross deposit cyrtolite and betafite (?) are sparsely distributed in small pockets or clots in a thin zone in pegmatite and, at the Pomona Tile quarry, samarskite and euxenite occur sparingly in small iron-stained patches in pegmatite.

## Mineralogy

Uranium-bearing minerals reported from California can be divided into a group of primary minerals, including uraninite (or pitchblende ?), brannerite, samarskite, ilmenite, betafite, and euxenite, and a group of secondary minerals including autunite, torbernite, carnotite, and "gummite" (?). The primary minerals are those that are considered original constituents of quartz veins containing sulfide minerals and of plutonic crystalline rocks or pegmatites. The secondary uranium minerals are those derived from the alteration of the primary minerals; in most secondary deposits in California, it is believed that the secondary uranium minerals have been precipitated at some distance from the primary source of the uranium.

According to Rickard (1895, p. 329), uraninite (uranuous oxide) and uraconite (a name originally proposed for an ill-defined substance, supposedly uranium sulfate) occur at the Rathgeb mine in Calaveras County associated with gold in a quartz fissure vein. As described by Rickard, the uraninite consists of acicular black crystals which occur together with yellow uranium ochre (uraconite). On the Rainbow claim, Jackass district, Madera County, minute quantities of an unidentified uranium mineral occur in a smoky quartz vein associated with pyrite, chalcopyrite, tetrahedrite (?), bornite (?), and magnetite; probably the uranium mineral is uraninite. Uranium, probably as minute particles of an oxide, such as uraninite, is disseminated through galena and sphalerite on the Yerih group of claims, Holcomb Valley district, near Big Bear Lake in San Bernardino County.

Primary uranium-bearing rare earth columbates, tantalates, and titanates including such minerals as brannerite, samarskite, betafite, and euxenite have been identified from various geologic settings in California, although all of these minerals are extremely rare. Some have been found as accessory minerals in pegmatite and crystalline plutonic rocks, whereas others occur as a minor constituent of black sand concentrates. According to Pabst (in press), brannerite occurs as an accessory mineral in plutonic rocks exposed about 7 miles south of Coleville in Mono County. Betafite (?) and cyrtolite described herein have been reported by Hewett from pegmatites exposed on the Hoerner-Ross property, San Bernardino County, and samarskite and euxenite have been found in pegmatites exposed in the Pomona Tile quarry near Rock Corral (San Bernardino County). Other occurrences of some of these minerals have been described by Murdoch and Webb (1948).

Shawe (1953a) has reported uranium-bearing ilmenite, which may questionably be related to the mineral davidite, from granitic rocks and placer concentrates on the east slope of the Sierra Nevada in the vicinity of Bishop. The mineral occurs in black, anhedral grains and as hexagonal plates which have optical properties similar to ilmenite. Chemical tests indicate that the ilmenite contains iron, titanium, manganese, cerium group rare earths, vanadium, thorium, and uranium.

The secondary uranium minerals autunite, torbernite, "gummite" (?), and carnotite have been identified from a number of localities in the desert region of southeastern California. At some properties only one of these minerals is present, whereas other occurrences are characterized by associations of two or more secondary minerals.

Autunite, a hydrated phosphate of calcium and uranium, occurs characteristically as pale yellow-green or lemon yellow, square basal plates as much as a millimeter in size; all the autunite is more or less fluorescent in shades of yellow-green. Torbernite, a hydrated phosphate of copper and uranium, occurs as green, essentially non-fluorescent, square or rectangular basal plates which commonly are foliated. Most of the basal plates are extremely small, though a few are as much as a millimeter or more in size. Very small quantities of a brittle and waxey, dark reddish-brown to black mineral associated with autunite, hydrated iron oxides, chlorite (?), and an unidentified dark green waxey mineral are found on slickensided fault surfaces at the Rosamond prospect, Kern County. Small specimens containing this assemblage are more highly radioactive than normally would be expected from the small amount of autunite that is present. Possibly the red and green waxey minerals are gummite; however, according to accepted terminology "gummite" is a generic term applied to minerals occurring as alteration products of uraninite (Frondel and Fleischer, 1952, p. 5). The origin of the waxey minerals is unknown; primary uranium minerals were not observed on the property nor have any been identified from the surrounding area. Conceivably, the anomalous radioactivity of the material could be due to abundant submicroscopic particles of autunite sheared or disseminated through an unidentified mineral. In this report the waxey minerals are called gummite (?), as the physical properties are similar to those for gummite described in Dana's "System of Mineralogy" (Palache, Berman, and Frondel, 1952, p. 622-623). Carnotite, the hydrous potassium, uranium vanadate, occurs principally as a lemon yellow aggregate of cryptocrystalline material which, locally, consists of sparse micaceous plates up to a millimeter in size. A few occurrences of carnotite are characterized by a thin coating of yellow, dust-like particles on joint surfaces.

Autunite and "gummite" (?) are associated with iron and manganese oxides, chlorite (?), and opal at the Rosamond prospect (Kern County); at the Chilson property, autunite and torbernite occur as flakes and cryptocrystalline coatings on joint surfaces, and at the Lucky Star claim, Imperial County, carnotite and autunite or torbernite, associated with talc, hydrothermal clay minerals, manganese and iron oxides, gypsum, and calcite, are disseminated in hydrothermally altered and bleached wall rock. Other deposits, as for example the Vanuray claim, Kramer Hills, and other minor occurrences near Boron, contain carnotite associated with clay, opal, and oxides of iron and manganese in bedded Miocene clays and marls. At the Harvard Hills, east of Yermo, autunite has been found coating fractures in layered tuffaceous sedimentary rocks, black chert, marly sandstone, and limestone.

Autunite and other unidentified secondary uranium minerals are associated with quartz and clay minerals in altered granite at the Rafferty property (Los Angeles County). Secondary uranium minerals are also reported from the Paymaster mine in the Solo district. No data are available as to the mineralogy of this occurrence.

## Grade

All of the known uranium deposits in California are low in grade, and none were of economic interest in 1952. The richest sample analyzed, which contained 0.59 percent uranium, came from the Rosamond prospect. A specimen of highly radioactive lead ore from the Yerih group of claims was analyzed and found to contain 0.32 percent uranium. Selected specimens from the Birthday claims, the Rafferty, Stillwell, and Chilson properties, and the Lucky Star claim, contained 0.1-0.4 percent uranium, but the quantity of such material available was small in all of these deposits. None of the samples analyzed by the U. S. Geological Survey from other localities in the State contained as much as 0.1 percent uranium.

## Origin

The uranium in California's uranium deposits is thought to be genetically related to the intrusion of plutonic crystalline rock as well as to Tertiary volcanic activity. Studies have indicated that most of the uranium deposits in California occur in two important environments: (1) pre-Tertiary pegmatites, plutonic rocks, and related quartz veins in which primary uranium minerals have been found, and (2) Tertiary volcanic, near-surface intrusive, pyroclastic, and tuffaceous sedimentary rocks in which many of the deposits of secondary uranium minerals occur.

Uranium-bearing minerals in pegmatites, such as are found on the Hoerner-Ross property, at the Pomona Tile quarry, and elsewhere, are undoubtedly primary constituents of the pegmatite. Likewise, uranium-bearing accessory minerals in bodies of plutonic rock are primary constituents of the rock. The uranium-bearing minerals with the base-metal sulfide minerals found on the Yerih group of claims and on the Rainbow claim, probably came from the same hydrothermal solutions that deposited the sulfides.

The ultimate source of the uranium in the deposits containing secondary minerals is more difficult to ascertain; the mineralogy as well as the host rocks vary from one deposit to another, although the host rocks at many deposits are mid-Tertiary extrusive or intrusive volcanic rocks, or sedimentary beds containing pyroclastic material. The secondary uranium minerals, such as autunite, torbernite, carnotite, and "gummite" are rarely, if ever, formed directly from hot aqueous solutions emanating from a cooling magma. The uranium in these minerals has been derived from primary minerals that were leached and dissolved either by ground waters or by hydrothermal solutions. Deposition of uranium dissolved in these ground waters took place wherever a change of chemical environment caused a decrease in the solubility of the uranium. Secondary hydrous oxides of uranium, such as gummite, may form on the surface of primary pitchblende or may be deposited from solution at a considerable distance from their source. The phosphates, autunite and torbernite, have been found in close proximity to primary uranium deposits elsewhere, but in California they occur in areas remote from any of the known primary occurrences of uranium. Vanadates, such as carnotite, are not commonly formed close to primary uranium minerals although such associations have been reported from the Colorado Plateau area. Primary uranium minerals have not been found on properties containing secondary uranium minerals so that the relationship of these minerals is not known. However, many of the secondary deposits occur in rocks derived from Tertiary volcanic activity and, locally, some of the felsic flows and near-surface intrusives contain more uranium than other rocks exposed in the same area. It seems reasonable to infer that the uranium now present in the secondary minerals has been derived by the leaching and solution of primary constituents of the volcanic rock. Some of the uranium may be derived, however, through the leaching and solution of primary minerals in rocks other than the volcanics by late hydrothermal solutions that accompanied the volcanic activity. Evidence of hydrothermal activity that is either contemporaneous with, or later than the volcanic activity, is apparent at the Lucky Star, Vanuray and Jumpin claims, and elsewhere; at all of these properties, the wall rocks, which are in part either mid-Tertiary volcanic or tuffaceous sedimentary rock, are bleached and partly altered to hydrothermal clay minerals. In addition, some of the secondary uranium minerals found in areas of altered wall rock are intimately intermixed with hyalite opal.

## Thorium deposits

Thorium-bearing minerals, in variable amounts, have been reported from nearly all sections of California; they occur sparingly in most felsic plutonic crystalline rocks, in some metamorphic rocks, in some pegmatites, and in veins; numerous placer concentrations containing thorium minerals are also known throughout the State. Minerals that are classed as thorium-bearing for purposes of this report include: monazite, thorite, xenotime, and allanite. Thorium occurs as a major or minor constituent in these minerals, commonly in combination with uranium and the rare earths of the cerium group.

### Distribution

Although many occurrences of thorium minerals are known throughout the State, recent studies by Government geologists have been limited to occurrences at Mountain Pass, the Rock Corral area, Black Dog claim, and the Original and Pack Saddle claims in San Bernardino County, and the Live Oak Tank area and the Desert View claim in Riverside County. At Mountain Pass, in the northeastern Mojave Desert, thorite is associated with bastnaesite, a rare earth fluocarbonate, in vein deposits. In the same area, monazite crystals are locally disseminated in a mass of rock composed dominantly of calcite, barite, quartz, and bastnaesite. The Rock Corral area, on the northeast flank of the San Bernardino Mountains, is characterized by thorium-bearing allanite, monazite, and radioactive zircon disseminated in porphyritic quartz monzonite and in metasomatically altered inclusions. At the Black Dog claim, about 3 or 4 miles south of Rock Corral, a vein composed in part of thorium, monazite, and allanite is enclosed in crushed gneiss, and at the Original claim, small amounts of monazite (?) occur as an accessory mineral in crystalline rocks. The Live Oak Tank area contains monazite in black sands, and monazite and xenotime in pegmatite. At the Desert View claim, central Riverside County, small amounts of monazite occur in biotite gneiss. In addition, there are numerous published and unpublished references to thorium minerals in pegmatities in southern California, in granitic rocks in the Sierra Nevada Mountains, in black sand lenses along Pacific Ocean beaches, and in placer gravels along rivers flowing from the Sierra Nevada Mountains and the Klamath Mountains.

## Mineralogy

Thorium-bearing minerals reported from California include thorite, monazite, allanite and xenotime. As most of these minerals occur in small quantities as minute grains, megascopic identification is normally impossible. Identification of the thorium minerals from nearly all the widely scattered localities is based on microscopic examination, X-ray, spectrographic, or chemical analyses, or by other laboratory methods.

Thorite occurs in two main varieties and has been identified from the Mountain Pass area (Shawe, 1953b), from placer concentrates collected near Bishop (Shawe, 1953a), from coastal beach sands south of San Francisco (Hutton, 1952), and from placer concentrates collected along the west slope of the Sierra Nevada (George, 1951, p. 131). One variety, called uranoan thorite because of its uranium content, is green and has been found as rounded detrital grains which commonly show elongate prismatic habit. As far as is known, none of this material has been found in place. The other type of thorite, which has been found in place at Mountain Pass, the Rainbow group of claims, and elsewhere, is characterized by euhedral prismatic crystals and rounded grains which are yellow-orange to brown.

Monazite, the phosphate of cerium group rare earths, occurs most commonly as light to dark golden brown or reddish-brown grains which have a resinous luster. In some placer deposits, the monazite is in well-shaped prismatic crystals, whereas in other placers and in beach sands the monazite occurs in subhedral tablets.

Most of the allanite, which has been reported from California, has been found in granitic rocks and in pegmatities, although some placer occurrences are also known. Most of the allanite occurs in small prismatic crystals; locally, however, prismatic crystals as much as a few inches in length have been reported. The allanite is amber to dark brown or black in color and may show vitreous or resinous luster or, through alteration, a dull earthy luster.

Xenotime, occurring as colorless, rounded equidimensional grains in Pacific Ocean beach sands has been reported by Hutton (1952), and reported in pegmatite (Riverside County) as well-formed, yellowish brown tetragonal crystals up to a 1/4-inch in length by Melhase (1936).

## SUGGESTIONS FOR PROSPECTING FOR URANIUM AND THORIUM

The following generalizations may be of some assistance in prospecting for uranium in California: (1) the Mojave Desert province appears to be much more favorable for the discovery of uranium than the rest of the State; (2) uranium appears to have been deposited from solution in ground water or hydrothermal water and is concentrated in fractures and shear zones along which these waters circulate; (3) uranium is commonly associated with areas in which the wall rocks are bleached and altered to hydrothermal clay minerals; some deposits contain introduced silica in the form of hyalite opal as fracture coatings; (4) limonite, either as stains or massive gossans, is commonly radioactive in the vicinity of secondary uranium deposits.

Uranium has been found most commonly in California as small deposits of secondary minerals erratically distributed on fractures and bedding planes in various types of rock. The secondary deposits occur most abundantly, however, in mid-Tertiary volcanic, pyroclastic, and tuffaceous sedimentary rocks and in Tertiary continental sedimentary rocks. Some secondary deposits have been found in altered and unaltered granitic rocks and in altered base-metal sulfide bodies in limestone. In none of the secondary occurrences so far reported, has it been possible to conclusively demonstrate the source of the uranium, but much of it is thought to be related to mid-Tertiary volcanic activity. The uranium in most of the deposits is distributed along fractures and bedding planes which have been channel-ways for groundwaters or for hydrothermal solutions.

Minerals containing uranium and those containing thorium are only rarely associated in nature. Such association commonly is of complex refractory minerals, which are scattered erratically through pegmatite or as minute accessory crystals in plutonic rocks. Such deposits at present are of interest only to the mineral collector.

Thorium minerals have been reported from widely scattered parts of the State--Mountain Pass, Rock Corral, and elsewhere in San Bernardino County, the western part of Riverside County, granitic rocks of the Sierra Nevada batholith, stream gravels along most of the major rivers that drain westward from the Sierra Nevada Mountains, and beach sands along the Pacific Coast of Northern California.

This wide distribution suggests that the thorium minerals are probably present in small amounts in most of the granitic intrusive rocks in the State and that careful sampling of gravels along rivers draining areas where such rocks are exposed would probably add considerably to the list of thorium occurrences. Thorium minerals are present in such small quantities, however, that it is doubtful that such deposits could be worked profitably for thorium minerals alone under present conditions. They might, however, be recovered as a valuable byproduct from gold dredging operations.

## ECONOMIC EVALUATION

Studies of radioactive deposits in California have shown that although uranium- and thorium-bearing minerals are widely distributed and occur in various geologic environments throughout the State, significant concentrations of these minerals are rare. To date none of the deposits in California have been exploited on a commercial basis, and probably none of the uranium deposits studied so far constitute a potential source of uranium under present economic conditions.

A complete appraisal of the uranium-bearing properties is not possible, however, because exploration on nearly all of them has been limited to surface or near surface prospecting, and the character of uranium mineralization at depth is not known. A few properties, such as the Yerih group, the Rafferty, Stillwell, and Chilson properties, the Lucky Star claim, and the Rosamond prospect contain mineralized rock of sufficiently high grade to constitute ore under present conditions, but apparently none of these properties contain enough tonnage of this type of rock to sustain mining operations or beneficiation plants.

Thorium-bearing minerals might be economically concentrated from some gold placer gravels as a byproduct of gold dredging operations or from the bastnaesite deposits at Mountain Pass as a byproduct in the recovery of rare earths minerals. Of the known thorium deposits in California, none can be successfully exploited solely for thorium minerals under present economic conditions.

# DESCRIPTION OF THE RADIOACTIVE LOCALITIES

Although many localities containing concentrations of radioactive material are known throughout California, the following descriptions of individual properties are limited to (1) those occurrences that have been examined by Government geologists since 1947 and (2) to other known concentrations of radioactive minerals of particular scientific or possible economic interest. Brief reference is also made to a number of occurrences of radioactive minerals which, as yet, have not been studied by the U. S. Geological Survey or the U. S. Atomic Energy Commission. The occurrences are listed alphabetical by counties in table 1 and their location is shown on figure 1.

For purposes of description the occurrences are grouped by geomorphic provinces in the following pages because many of the occurrences are found in the same or similar geologic environment within a given province. The boundaries of the geomorphic provinces are essentially the same as those described by Jenkins (1941). A few occurrences, for example those near Searles Station (Kern County) and near Big Bear Lake (San Bernardino County), are only short distances outside the boundaries of the Mojave Desert Province. For convenience, these properties have been described with other properties in the Mojave Desert Province.

## Mojave Desert Province

The Mojave Desert Province, which covers parts of Kern, Los Angeles, San Bernardino, Riverside and Imperial counties, in the southeastern part of the State consists of an extensive interior region of mountain ranges separated by broad, alluvial-filled desert valleys. The Mojave Desert is separated from the Sierra Nevada Province and the Basin and Range Province on the north by the Garlock fault and from the Transverse Ranges Province on the southeast by the San Andreas fault. In this report the eastern limit of the Mojave Desert Province is considered as the eastern boundary of the State.

The dominant bedrock types in the region consist of crystalline, metamorphic rocks of Paleozoic age and older Paleozoic sedimentary rocks, some early Mesozoic sedimentary rocks, intrusive plutonic rocks and related pegmatities of pre-Tertiary age, and Tertiary continental sedimentary and volcanic rocks.

(Page 22 A follows.)

Table 1. Radioactive occurrences in California (by counties) a/

| Map No. b/ | | Location c/ Section | Township | Range | Type | Country rock | Radioactive minerals (s) | Other minerals | Sample data |
|---|---|---|---|---|---|---|---|---|---|
| | Calaveras County | | | | | | | | |
| 2 | Rathgeb mine | 34 | 4 N. | 12 E. | Vein | Slate, amphibolite | Uraninite, uraconite | Gold, quartz | --------------- |
| | Fresno County | | | | | | | | |
| | George Seeman property | 26, 35 | 12 S. | 19 E. | Placer | San Joaquin River gravels | Monazite, ? | ----------- | 0.46% $U_3O_8$ 1.38% $ThO_2$ |
| | Imperial County | | | | | | | | |
| 36 | Lucky Star claim | 36? | 12 S. | 19 E. | Dissemi- nated | Schist, quartzite, felsic intrusives | Autunite?, carnotite, torbernite | Clay, talc | 0.021% U / 0.12% U |
| | Inyo County | | | | | | | | |
| | Bonanza mine | 10 | 15 S. (proj.) d/ | 40 E. | Replace- ment ? | Paleozoic sedimentary rocks | --------- | Cu, Ag, Pb minerals, idocrase garnet | 0.016% eU, 0.008% U |

a/ List does not include the 85, or more, thorium- or uranium-bearing placer deposits examined by personnel of Union Mines Development Corporation, U. S. Bureau of Mines, U. S. Atomic Energy Commission, and U. S. Geological Survey or placer occurrences listed in Murdock and Webb (1948). List does not include occurrences examined by Moore and Stephens (1952).

b/ Map numbers correspond with those used on figure 1.

c/ All township and range locations are based either on the Mount Diablo meridian or the San Bernardino meridian.

d/ Proj. - projected

(Page 22 B follows.)

Table 1. Radioactive occurrences in California (by counties) a/ --Continued

| Map No. b/ | | Location c/ Section | Township | Range | Type | Country rock | Radioactive minerals (s) | Other minerals | Sample data |
|---|---|---|---|---|---|---|---|---|---|
| 9 | Joe McCulley property | 7 | 18 S. | 44 E. | Replacement | Paleozoic limestone, Jurassic granite | ---------- | Cu and Ag sulfides, tactite minerals | 3X background |
| 7 | Lippincott mine | 13 (proj) | 15 S. | 40 E. | Replacement and fissure filling | Paleozoic dolomite, quartz monzonite, minette | ---------- | Galena, sphalerite, secondary Pb and Zn minerals, iron oxides, wulfenite | 0.050% U |
| 6 | Ubehebe mine | 1, 2 (proj.) | 14 S. | 40 E. | Replacement and fissure filling | Paleozioc dolomite, quartz monzonite, minette | --------- | Galena, sphalerite, secondary Pb and Zn minerals, iron oxides, wulfenite | 0.050% U |
| 8 | Santa Rose mine | 26, 35 (proj.) | 17 S. | 39 E. | Replacement and fissure filling | Permian (?), limestone, andesite, basalt | -------- | Galena, sphalerite, secondary Pb, Zn, and Cu minerals | ------------- |
| | Wingate Pass area | 83 miles NW of Baker | | | Fracture coatings | Limestone, chert, rhyolite | Secondary uranium minerals | Quartz, Pb and Cu carbonates | ------------- |
| | Kern County | | | | | | | | |
| 12 | Chilson property | 36? | 28 S. | 40 E. | Fracture coatings, dissemi-nated | Tertiary dacite | Torbernite, autunite ? | --------------- | 0.121% eU |

(Page 22 C follows.)

Table 1. Radioactive occurrences in California (by counties) a/ --Continued

| Map No. b/ | | Section | Location c/ Township | Range | Type | Country rock | Radioactive minerals (s) | Other minerals | Sample data |
|---|---|---|---|---|---|---|---|---|---|
| 23 | Goldenrod claim | 4 | 9 N. | 13 W. | Fracture coatings | Tertiary dacite | ---------- | Iron oxides | 0.001% U-0.041% U |
| 10 | Josie Bishop group | 30 | 29 S. | 37 E. | Fracture coatings | Jurassic granite, alaskite dikes | --------- | Pyrite, iron oxides quartz | 0.003% U |
| 24 | Jumpin claim | 9, 10 | 9 N. | 13 W. | Fracture coatings | Tertiary rhyolite | Autunite, "gummite"?, | Iron oxides | 0.002% U-0.037% U |
| 11 | Rademacher claim | 2 | 28 S. | 40 E. | Vein | Jurassic ? granite | --------- | Gold, base-metal sulfides, quartz | 3X background |
| 21 | Rosamond prospect | 25 | 10 N. | 13 W. | Fracture coatings disseminated | Tertiary tuffs, breccia, sediments | Autunite, "gummite"? | Mn and Fe oxides | 0.002% U-0.590% U |
| 22 | Stillwell property | 35 | 10 N. | 13 W. | Fracture coatings disseminated | Tertiary lithic tuffs | Autunite | ---------------- | 0.012% U-0.14% U |
| 20 | Vanuray claim | 26 | 11 N. | 8 W. | Fracture coatings disseminated | Miocene sandy clay | Carnotite | Mn and Fe oxides, Opal | 0.056% U |
| 19 | Name unknown | 14 | 7 W. | 11 N. | Fracture coatings | Miocene sandy clay | Carnotite | --------------- | ---------------- |
| | Los Angeles County | | | | | | | | |
| 25 | Lookout Lode claim | 9 | 8 N. | 8 W. | Vein | Quartz monzonite, aplite dikes | --------- | Chalcopyrite, secondary Cu minerals, quartz | 0.02% $U_3O_8$ |

(Page 22D follows.)

Table 1. Radioactive occurrences in California (by counties) a/ --Continued

| Map No. b/ | | Section | Location c/ Township | Range | Type | Country rock | Radioactive minerals (s) | Other minerals | Sample data |
|---|---|---|---|---|---|---|---|---|---|
| | Los Angeles County--Continued | | | | | | | | |
| 27 | Rafferty property | 26 | 7 W. | 8 W. | Dissemi-nated | Granite, aplite dikes | Autunite | Hydrothermal clay, quartz | 0.2% $U_3O_8$ |
| | Madera County | | | | | | | | |
| 4 | Rainbow claim | ? | 4 S. | 24 E. | Vein | Jurassic (?) granodiorite | ---------- | Quartz, chalcopyrite, tetrahedrite, bornite, pyrite | 0.003% U |
| | Mono County | | | | | | | | |
| 5 | Wild Bill group | 18 | 3 S. | 31 E. | Vein | Quartz monzonite | --------- | Gold, tenorite, cerussite, chalcopyrite, iron oxides, clay, quartz | 0.37% $U_3O_8$ |
| | Plumas County | | | | | | | | |
| 1 | Stokes property | 24 | 25 N. | 8 E. | Dissemi-nated | Hot spring deposits in Mississippian metasedimentary rocks | --------- | Fe and Mn oxides | 0.66% eU, 0.001% U |
| 1 | Stowell property | 24 | 25 N. | 8 E. | Dissemi-nated | | | | |
| | Riverside County | | | | | | | | |
| 35 | Desert View claim | 31, 32 | 5 S. | 10 E. | Dissemi-nated | Pre-Cambrian (?) biotite gneiss | Monazite ? | --------------- | 0.01% U |
| 34 | Live Oak Tank area | ------ | 2 S. | 9 E. | Placer, pegmatite | Pre-Cambrian gneiss, Jurassic monzonite | Monazite, xenotime | Titanite, zircon, biotite | 0.035% eU, 0.005% U |

(Page 22 E follows.)

Table 1. Radioactive occurrences in California (by counties) a/ --Continued

| Map No. b/ | | Section | Location c/ Township | Range | Type | Country rock | Radioactive minerals (s) | Other minerals | Sample data |
|---|---|---|---|---|---|---|---|---|---|
| | San Bernardino County | | | | | | | | |
| 13 | Alpha, Beta, Gamma claims | ? | 28 S. | 41 E. | Fracture coatings ? | Felsic intrusive | ---------- | Pyrite, secondary Cu minerals, iron oxides, gypsum | 3X background |
| 26 | Baxter property | 18 | 8 N. | 7 W. | Fracture coatings? | Altered granite | ---------- | Clay, caliche | 3X background |
| 18 | Harvard Hills | | 10 N. | 3 E. | Fracture coatings | Miocene tuffaceous sandstone, marly sandstone, limestone, chert | Autunite, carnotite? | ---------------- | 0.025% U, 30% eU |
| 17 | Hoerner-Rose property | 15 | 9 N. | 6 E. | Pegmatite | Quartz monzonite | Cyrtolite, betafite | Orthoclase, biotite, magnetite, quartz | --------------- |
| 28 | Kramer Hills | 13, 14 | 9 N. | 6 W. | Fracture coatings | Miocene Tuff, marl beds, limestone | Carnotite | Clay | 0.003% U |
| 14 | Mountain Pass area including Birthday claim, Easter Sunday group, and other properties | | 16 N.<br>15 1/2 N. | 13 E.<br>14 E. | Vein dissemi-nated | Pre-Cambrian gneiss, shonkinite, barite-carbonate rock, andesite | Thorite, monazite | Calcite, barite ankerite, limonite, quartz, bastnaesite, parasite | 5.50 % $ThO_2$<br>0.32% U |

(Page 22 F follows.)

Table 1. Radioactive occurrences in California (by counties) a/ --Continued

| Map No. b/ | | Section | Location c/ Township | Range | Type | Country rock | Radioactive minerals(s) | Other minerals | Sample data |
|---|---|---|---|---|---|---|---|---|---|
| 32 | Original and Pack Saddle claims | ? | 6 N. | 13 E. | Dissemi-nated | Granitic rocks, meta-sedimentary rocks | Monazite? | ---------- | 0.005% U, 0.06% Th |
| 16 | Paymaster mine | 8 | 13 N. | 10 E. | Vein | Pre-Cambrian limestone | Secondary uranium minerals | Clay, quartz | 0.04% $U_3O_8$ |
| 15 | Rainbow group | ? | 13 N. | 10 E. | Pegmatite | Granitic rocks | Monazite, thorite, hyalite opal | Quartz, feldspar, magnetite, hemitite | 0.027% U |
| 33 | Red Devil claim | ? | 6 N. | 18 E. | Vein | Jurassic (?) granite | --------- | Quartz, stibnite, cinnabar, stibiconite | 0.084% U |
| 31 | Rock Corral area including Konky, Jenkins, Black Dog, Pomona Tile quarry, and other properties | ---<br>--- | 3 N.<br>2 N. | 4 E.<br>5 E. | Dissemi-nated placer | Jurassic (?) quartz monzonite, biotite-rich inclusions | Allanite, zircon, samarskite, monazite,, euxenite, | --------------- | 0.15% eU |
| 30 | Yerih group (Scotty Wilson property) | 3, 4 | 2 N. | 1 E. | Replace-ment | Paleozoic limestone | Pitchblende ? | Pyrite, pyrrhotite, chalcopyrite, galena, sphalerite | 0.37% eU |
| | Tuolumne County | | | | | | | | |
| 3 | Gen. U. S. Grant mine | ? | 3 N. | 15 E. | Radon gas | Paleozoic slate, schist | -------- | Gold, quartz, iron oxides | 5X background |
| 29 | Ventura County | | | | | | | | |
| | Grimes Canyon area | 7, 18 | 3 N. | 19 W. | Dissemi-nated ? | Tertiary sedimentary rocks, interstratified and intrusive (?) volcanic rocks | ----- | -------------------- | 3X background |

Concentrations of radioactive materials in the Mojave Desert are not confined to any one geologic environment; they are associated with foliated, pre-Cambrian (?) rocks, such as those at Mountain Pass and in the White Oak Tank area; they are found in pegmatites and plutonic crystalline rocks, for example, at Rock Corral, the Pomona Tile quarry, Lookout Lodi claim, and elsewhere, and also with Tertiary rocks at many localities. These Tertiary rocks, consisting largely of continental lake beds and volcanic flows, breccias, and tuffs, are the host rocks for most of the occurrences of secondary uranium minerals.

### Rosamond prospect (21) _/

Small quantities of autunite and gummite (?) occur in tuffaceous sedimentary rocks at the Rosamond prospect in the SW 1/4 sec. 25, T. 10N., R. 13 W. San Bernardino base and meridian. The property is about 10 miles south of the town of Mojave, Kern County. In 1950, when the property was examined by F. M. Chace of the U. S. Geological Survey, it was owned by the Southern Pacific Railroad, and in 1952, when examined by George W. Walker and Luther H. Baumgardner, was under lease to Mr. Clifford Gillespie of Hollywood. In 1952, working on the property, made exclusively in prospecting for uranium, consisted of a short adit, a 20-foot shaft and numerous shallow pits.

Rocks exposed in the vicinity of the Rosamond prospect have been mapped by Simpson (1934) as part of the Rosamond formation of Miocene age. The basal stratum of the Rosamond formation, as exposed near the prospect, is a dark, highly brecciated amygdaloidal flow rock of andesitic or basaltic composition. Stratigraphically above and apparently conformable with the amygdaloidal flow is a sequence of layered tuffaceous sedimentary rocks that grade upward into poorly sorted, coarse, lithic tuffs and breccias of rhyolitic and dacitic composition. The beds of tuffaceous rocks strike northwest and dip at low angles to the southwest. A few, small, local flexures are present adjacent to numerous northwest- and west-trending faults. The faults dip at steep angles, some to the north and some to the south; some faults have displaced the tuff beds and the contact beneath them only a few inches, whereas others show a displacement of as much as 10 feet.

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_/ Numbers in parentheses refer to figure 1 and table 1.

Autunite occurs principally as coatings on fracture and joint surfaces, and to a less extent, as disseminations in the tuffaceous rocks adjacent to faults. Locally, on slickensided fault surfaces, there are very small quantities of a brittle and waxey, dark reddish-brown to black, radioactive mineral tentatively identified as gummite. The uranium minerals are erratically and sparsely distributed over an area of about 15 acres. Assays of twelve samples indicate a uranium content ranging from 0.002 to 0.59 percent and an average content of slightly less than 0.08 percent uranium.

## Stillwell property (22)

Autunite has been identified at the Stillwell property in sec. 35, T. 10 N., R. 13 W. about 5 miles (direct line) northwest of the town of Rosamond, Kern County. In 1952, the property was owned by Mr. L. J. Stillwell, 10442 Kling Street, North Hollywood, Calif. Development consists of three trenches, approximately 2 feet wide and 15 feet long.

Fine- to coarse-grained tuffaceous rocks, which were mapped by Simpson (1934) as part of the Rosamond formation of Miocene age are exposed in the area. Bedding in the tuffs strike N. 40° W. and dips approximately 15° to the SW. Small faults, which strike N. 70° E. and are nearly vertical, cut and offset the bedding. Autunite is erratically distributed as joint and fracture coatings and as disseminations in the tuffaceous rocks in and immediately adjacent to the faults. An assay of select chips collected from a mineralized fault indicates a uranium content of 0.14 percent, whereas assays of a 2-foot continuous channel sample across the fault indicate a uranium content of 0.090 percent.

## Goldenrod claim (23)

The Goldenrod claim is in sec. 4, T. 9 N., R. 13 W. about 7 miles west-northwest of Rosamond, Kern County. The property had not been developed when examined in April 1952.

Tests for radioactivity of the property indicate that an undetermined radioactive mineral is sparsely disseminated in dacite of the Rosamond formation. Locally, the dacite is flow banded, autobrecciated, and strongly jointed. Slight concentrations of the unidentified radioactive mineral occur associated with hydrated iron oxides on a fracture or fault of minor displacement.

A sample of the average dacite country rock contained 0.006 percent equivalent uranium and 0.001 percent uranium; a sample of the iron-stain material contained 0.063 percent equivalent uranium and 0.041 percent uranium.

### Jumpin claim (24)

The Jumpin claim, in secs. 9 and 10, T. 9 N., R. 13 W., San Bernardino meridian, is 5.5 miles west-northwest of Rosamond, Kern County. In November 1951, the property was owned by Sam Cytron, 177 North Swall Drive, Berverly Hills, Calif. Development consisted of a 25-foot trench, a 10-foot pit, and a shallow bulldozer cut.

The country rock is an altered rhyolite which intrudes quartz monzonite of Cretaceous (?) age. Autunite, gummite (?), and iron oxide stains coat fractures in the rhyolite. Assays of chip samples from this locality range from 0.002 to 0.037 percent uranium and indicate an average uranium content of about 0.02 percent.

### Vanuray claim (20)

The Vanuray claim is about 2 1/2 miles northwest of the town of Boron in sec. 26, T. 11 N., R. 8 W., Kern County. In November 1951, it was owned by Mr. C. J. Roycroft, P. O. Box 511, Boron, Calif. Prior to the discovery of uranium on the property, an 18-foot pit about 100 feet in diameter was excavated, presumably to exploit clay deposits that occur on the property.

The uranium is in a sandy clay which probably is a part of either the Ricardo formation or the Rosamond formation (Gale, 1946) of late Tertiary age. Bedding in the sandy clay strikes N. 30° E. and dips approximately 40° NW. A few, indistinct, minor, shear zones as much as 1.5 feet in width, which strike about N. 70° W. and have steep dips, cut the sandy clay. Carnotite, associated with opal and minor amounts of iron and manganese oxides, occurs as fracture coatings in the shear zones and as sparse disseminations in the sandy clay in and adjacent to the shear zones.

A selected grab sample, taken where the radioactivity is highest, assayed 0.056 percent uranium. A 12-foot continuous chip sample, which included 1.5 feet of weakly mineralized shear zone, and a grab sample of wall rock assayed 0.018 and 0.005 percent uranium, respectively.

## Chilson property (12)

A small body of medium-grained dacite, associated with Red Mountain andesite, occurs in the Summit Range 6 miles (direct line) north of Randsburg, Kern County, in sec. 36 (?), T. 28 S., R. 40 E., Mt. Diablo meridian. Torbernite and autunite occur as small green and yellow foliated crystals on joint surfaces and in small cavities in the dacite. The uranium-bearing minerals have been concentrated by ground water circulating along a sharp flexure in the upper 2 or 3 feet of the dacite. The deposit had been prospected by two open cuts, and a shaft 30 feet deep (fig. 2), when examined by C. W. Chesterman and F. H. Main in 1946. The Chilson property, known also, at various times, as the Vonsen property, Summit Diggins, Uranous claim, or Barnes' property, was under lease to Mr. Philip J. Barnes of Los Angeles in December 1951.

A chip sample from the face of one open cut in the mineralized zone assayed 0.121 percent equivalent uranium. Geiger counter readings on outcrops of the unmineralized dacite, however, indicate no more than 0.002 percent equivalent uranium.

## Rademacher claim (11) _/

The Rademacher claim is in sec. 2, T. 28 S., R. 40 E., Mt. Diablo meridian, 12 1/2 miles north of the town of Johannesburg in the Johannesburg mining district. It is owned by Mr. Joseph Forse of Johannesburg. The property, which was located for gold in 1896, has been developed by a 200-foot vertical shaft with several hundred feet of inter-connected workings. The mine has yielded over $120,000 in gold.

Quartz fissure veins and shear zones containing base-metal sulfides, secondary base-metal minerals, and free gold, occur in granitic rock of probable Jurassic age. A radioactivity examination of the surface exposures and of the dump material failed to show radioactivity of more than two to three time the background for the area, and no uranium minerals were observed.

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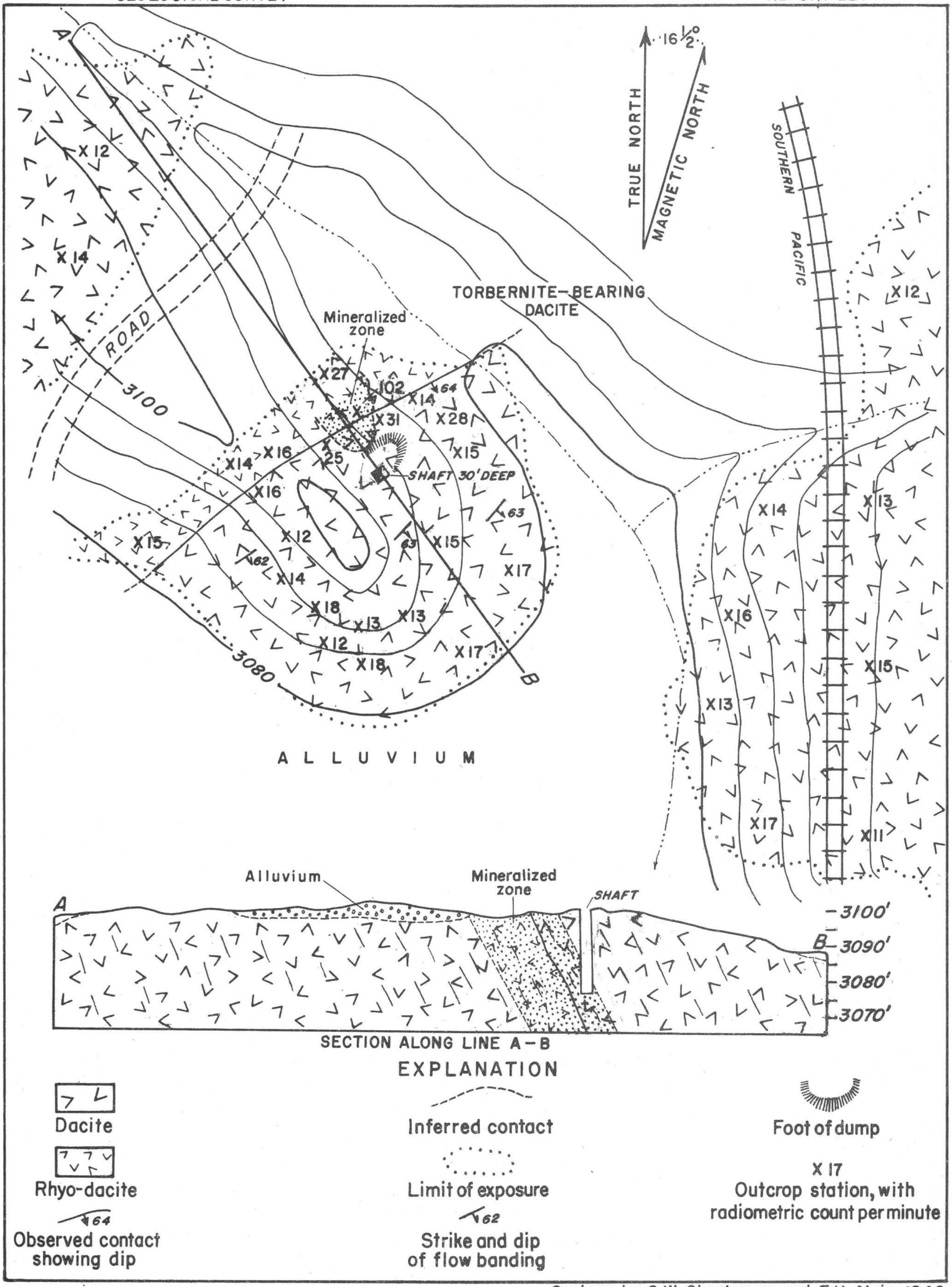
_/ Information obtained from Everhart and Towle (1950, b).




Geology by C.W. Chesterman and F.H. Main, 1946.

FIGURE 2.-CHILSON PROSPECT, KERN COUNTY, CALIFORNIA

40 20 0 40Feet

Contour interval 5 feet

*Datum is assumed*

56510

## Josie Bishop group (10)

The Josie Bishop claims are in sec. 30, T. 29 S., R. 37 E., Mt. Diablo meridian, just east of the abandoned San Antonio mine, Kern County. The claims are 4 miles west of Ricardo and approximately 25 miles north of Mojave. They are accessible by 8 miles of narrow dirt road from Ricardo on U. S. Highway 6. The group consists of 12 contiguous unpatented lode claims named Beryl Nos. 1 to 11 and the Beryl Extension. The property is at an elevation of approximately 3,600 feet above sea level.

Mining activity in the area dates back to about 1900 when the San Antonio mine was worked for precious and base metals. This mine and all claims in the area, with the exception of the Josie Bishop property, are now abandoned.

In 1948, when examined by R. U. King, of the U. S. Geological Survey, development on the claims consisted of discovery shafts and open cuts. The most extensive working is the 80-foot Badger discovery shaft on the Beryl no. 6 claim; 4 drifts totalling 60 feet in length have been driven from it.

Weathering has produced a residual soil over most of the area covered by the Josie Bishop claims; however, exposures, consisting largely of medium-grained pink granite cut by alaskite dikes, occur in the vicinity of the claims. The granite, which is part of the Sierra Nevada batholith of Jurassic age, locally contains inclusions of greenish gray, fine-grained rock. Faults were not found in the immediate vicinity, but indefinite fracture zones occur near the southeastern and northwestern corners of the Bishop group of claims. Rusty, iron-stained outcrops of fractured and weathered granite near the southeastern corner of the group are known locally as "the iron dike".

Mineralization of the granite is limited to the scattered quartz lenses in iron-stained fracture zones. Several of these quartz lenses have been prospected for precious metals. Small amounts of pyrite occur as impregnations in fractured and weathered granite; this relationship was determined from granite blocks on the dump of the discovery shaft on the Beryl no. 6 claim. No ore minerals were seen on the property. Weak radioactivity was detected with a Geiger counter in several places and is apparently related to the iron-stained fracture zones.

Assays of five samples, collected where radioactivity was strongest, indicate a uranium content of less than 0.003 percent (table 3).

Table 3.--Sampling data, Bishop claims, Kern County, California

| Sample no. | Description and Locality | eU (percent) | U (percent) |
|---|---|---|---|
| RUK-1-48 | 5-ft chip sample across fracture zone. Discovery shaft (Badger) of Beryl no. 6 claim | 0.004 | 0.003 |
| RUK-2-48 | 26-ft chip sample around discovery shaft on Beryl no. 4 claim | .005 | .003 |
| RUK-3-48 | 6-ft chip sample around face and walls of open cut at discovery end of Beryl no. 11 claim | .002 | .001 |
| RUK-4-48 | 6-ft chip sample around face and wall of open cut | .005 | .003 |
| RUK-5-48 | Grab sample of unmineralized granite from Bishop claims | .004 | .002 |

## Kramer Hills (28) _/

In 1947, D. F. Hewett, U. S. Geological Survey, discovered yellow stains in prospects in the Kramer Hills in secs. 12 and 14, T. 9 N., R. 6 W., San Bernardino meridian, which he tentatively identified as carnotite. Following positive identification of the yellow stain as carnotite, the prospects were examined in January 1949 by D. G. Wyant in company with D. F. Hewett. Claims covering the property, which are owned by O. H. Ball, 2024 W. 62d Avenue, Los Angeles, probably were located to prospect for borax which is common in this part of the Mojave Desert. At the time of the 1949 field examination, workings on the claims consisted of a trench approximately 100 feet long, two shallow shafts, and several prospect pits.

The Kramer Hills area consists of a pre-Cambrian basement complex overlain by marine Paleozoic sedimentary rocks, which are intricately folded, faulted, and intruded by granitic rocks of Jurassic (?) age. The older rocks are overlain by a thick sequence of non-marine Cenozoic sedimentary and interbedded

_/ Information obtained from Wyant (1949 b).

volcanic rocks. The uranium deposits occur in the Barstow formation of Miocene age which consists, in this area, of a sequence of pale green volcanic ash beds and inter-bedded white or buff clay and marly clay beds that are, in part, dolomitic. A basalt flow rests unconformably on the ash and clay beds. Locally, on joints and bedding surfaces exposed in the prospect pits, the marly clay beds are stained red, greenish yellow, and canary yellow; some of the yellow stain is composed of minute particles of carnotite and some of the greenish yellow stain has been identified as hydro-muscovite.

Readings taken at thirteen localities with a Geiger counter, indicate anomalous radioactivity only slightly above background readings. Analyses of four samples collected in the area are tabulated in table 4.

Table 4.--Sampling data, Kramer Hills, San Bernardino County, California

| Sample no. | Description and Locality | eU (percent) | U (percent) |
|---|---|---|---|
| DW-83: 260 | 12 feet clay, dolomite, including zone sampled by No. 261; from trench in Barstow formation | 0.002 | 0.002 |
| 261 | 3 feet clay, dolomite, marl, yellow stained; from trench in Barstow formation | .004 | .003 |
| 262 | Grab, greenish-yellow-stained, thick bedded, dolomitic marl, from portal trench in Barstow formation | .000 | .001 |
| 263 | Grab, marly clay, stained greenish-yellow; from shaft about 700 feet northwest of trench | .001 | .001 |

## Harvard Hills (18)

Secondary uranium minerals have been found in a number of places in and around the Harvard Hills in T. 10 N., R. 3 E., San Bernardino meridian, about 9 miles east of Yermo. Anomalous radioactivity has been detected both north and south of U. S. Highway 91 which, in this area, parallels the Union Pacific railroad. Lode mining claims, including the North Star Nos. 1 to 5, the Moonbeam, Martha E., and Jolly Boy, cover most of the mineralized areas. In 1952, many of the claims were owned by the Harvard Land

and Development Co., P. O. Box 7315, Los Angeles; some of the claims, however, were apparently owned by others. Several pits as much as 12 feet deep have explored areas of highest uranium concentration.

The Harvard Hills, which are in the center of a broad alluvium-filled valley, are composed of thin-layered lake beds consisting of tuffaceous sandstone, marly sandstone, limestone, clay, and chert of the Barstow formation of Miocene age. Autunite and carnotite (?) occur principally as coatings on fractures and on bedding planes, particularly in parts of the section containing chert and limestone. The uranium present in the area may have been introduced by the lake waters or it may have been a primary constituent of the tuffaceous debris in the sandstone which was redistributed by circulating groundwater.

A series of radioactivity traverses across the Harvard Hills indicate that the uranium minerals are concentrated principally on the north and northwest slopes of the hills. Anomalous radioactivity was detected, however, only where the shallow pits have exposed mineralized zones. One sample, collected by the Geological Survey, assayed 0.025 percent uranium, and two samples, submitted to the U. S. Atomic Energy Commission by Mr. J. A. Vandergrift, assayed 0.008 percent and 0.30 percent equivalent uranium.

## Lookout Lode claim (25)

Anomalous radioactivity is present at the Lookout Lode claim in the northeast corner of sec. 9, T. 8 N., R. 8 W., San Bernardino meridian, about 25 miles northeast of Lancaster, Los Angeles County. In March 1952, the property was owned by S. J. Curtis and Earl Hollingsworth, Rt. 1, Box 188, Lancaster. At that time, development consisted of 2 small pits located about 100 yards south of an abandoned gold mine.

The pits expose about 6 feet (strike-length) of a mineralized shear zone in quartz monzonite, aplite, and pegmatite of Cretaceous (?) age. The shear zone, which has a maximum width of 1.5 feet, strikes N. 40° E. and is essentially vertical. Abundant quartz, lesser amounts of chalcopyrite, pyrite, tenorite, azurite, hydrated iron oxides, manganese stain, and minute quantities of an unidentified black uranium mineral are present in the shear zone.

Samples of mineralized rock taken from the shear zone by Mr. S. J. Curtis and analyzed by the U. S. Atomic Energy Commission contained slightly less than 0.02 percent equivalent uranium. Testing of the dump for radioactivity at the abandoned gold mine indicates gamma ray activity the same as, or only slightly above, the background count.

## Rafferty property (27)

The Rafferty property is in the Willsona mining district in sec. 26, T. 7 N., R. 8 W., San Bernardino meridian, about 25 miles east of Lancaster, Los Angeles County. In 1950 the deposit was owned by John and Mike Rafferty of Adelanto, Calif. The property has been developed sporadically by hand labor since its discovery in 1948.

Exposures at the deposit consist of deeply weathered granite, cut by aplite dikes, and quartz veinlets which are accompanied by zones of hydrothermal alteration. Autunite and other secondary uranium minerals in association with clay minerals occur as late fracture coatings in hydrothermal zones. Chip samples taken from the zones contained as much as 0.2 percent $U_3O_8$.

## Baxter property (26)

Abnormal radioactivity is found on the Baxter property in the Silver Mountain district a few miles southwest of the Kramer Hills. The deposit, which in 1950 was owned by Mr. N. Baxter of Hemet, Calif., is in sec. 18, T. 8 N., R. 7 W., San Bernardino meridian. He explored the deposit by a bulldozer trench 50 yards long. The country rock is altered granite which is cut by a network of veins containing clay and caliche. Some of the vein material has an anomalous radioactivity of about 3-times the background count, although no uranium minerals are visible.

## Paymaster mine (16)

The Paymaster mine, in the Solo district, is 10 miles S. 80° E. of the town of Baker, in sec. 8, T. 13 N., R. 10 E., San Bernardino meridian. In 1950 the mine was owned by Mr. Joseph Ostringer of Baker. Development on the property consists of two shafts and an adit with several hundred feet of workings. The country rock is Archean limestone that is brecciated and cut by many fractures and faults; many of the fractures and faults are filled with vein quartz and gouge. Near the surface, yellow, secondary uranium minerals occur in the brecciated limestone as fracture coatings and as impregnations in the gouge along veins. At depth, radioactive zones in the limestone are associated with the quartz veins. Assays of grab and channel samples of the radioactive material range from about 0.003 to 0.04 percent uranium.

## Rainbow group (15)

Abnormal radioactivity has been found on the Rainbow claims, Solo district, about 12 miles S. 69° E. of Baker, San Bernardino County. The property was owned by Glenn and Blanche Alexander, in 1952. At that time, exploration consisted of a 15-foot shaft on the Rainbow No. 2 claim.

The country rock consists of foliated granitic material, presumably of pre-Cambrian age, that has been intruded by a pegmatite dike. The dike strikes N. 55° W., dips vertically, and is exposed along the strike for nearly 50 feet; throughout this distance it ranges in width from 6 inches to 3 feet. Dominant minerals in the pegmatite are feldspar and quartz. Erratically distributed in the pegmatite are irregular, dark gray to black, metallic masses of hematite that are as much as 10 inches in greatest dimension. The hematite is slightly magnetic and contains small amounts of magnetite. Disseminated in the hematite are anhedral crystals of slightly altered and iron-stained monazite, euhedral and anhedral crystals of thorite, and minor amounts of unidentified minerals of undetermined crystal form. Joint surfaces in the hematite and, locally, in the pegmatite are coated with hyalite opal that fluoresces a brilliant green under a blacklight. The opal may be uranium-bearing as suggested by the fluorescent green color; it is believed that some other unidentified uranium mineral is also present.

A select sample, collected by the U. S. Geological Survey, that contained hematite, quartz, and less amounts of monazite, thorite, and hyalite opal, assayed 0.027 percent equivalent uranium and 0.027 percent uranium. A sample submitted by the owners to the U. S. Geological Survey laboratories assayed 0.02 percent uranium.

## Mountain Pass Area (14)

Radioactive materials in association with major concentrations of rare earths minerals occur in the Mountain Pass Area in the northeast part of San Bernardino County about 58 miles southwest of Las Vegas, Nevada, via U. S. Highway 91. Deposits in the area, which are of particular interest because of the high content of non-radioactive bastnaesite (cerium-lanthanum fluocarbonate) and parisite (cerium-lanthanum-calcium fluocarbonate), were first discovered in 1948 by the presence of radioactive thorium-bearing minerals associated with the rare earths minerals. Since 1949, extensive studies have been made of the rare earths deposits and the associated thorium occurrences by J. C. Olson, D. F. Hewitt, D. R. Shawe, W. N. Sharp, and others of the U. S. Geological Survey. As the final results of their detailed studies soon are to be published, only a brief reference to the occurrence of thorium minerals will be presented here.

The rare earths and thorium deposits of the Mountain Pass Area are confined to a block of pre-Cambrian rocks, nearly 7 miles long and more than 2 miles wide, that is bounded on the north and west by faults and on the east and south by the alluvium of Ivanpah Valley. Dominant rock types within the block are hornblende and mica gneisses, biotite granite gneiss, augen gneiss, and minor amounts of dike rocks of mafic to intermediate composition. Intruded into the pre-Cambrian rocks are masses of biotite shonkinite, syenite, and granite; they, in turn, are cut by andesite dikes. Also present in the pre-Cambrian block are masses and veins of carbonate rock composed of many minerals, principally calcite, dolomite, barite, quartz, bastnaesite, and parisite. The carbonate rocks cut the potash-rich intrusives as well as the pre-Cambrian rocks.

Abnormal radioactivity, largely owing to thorium in thorite and monazite, has been found in many places in the Mountain Pass Area. Most of the anomalous activity occurs in or immediately adjacent to areas underlain by carbonate rock, although locally the shonkinite is abnormally radioactive. The distribution of the rare earths minerals, bastnaesite and parisite, which locally amount to more than 50 percent of the carbonate rock, apparently have little or no effect on the distribution of anomalous radioactivity, whereas the distribution of limonite and other oxides of iron are commonly closely related to areas of high gamma-ray activity. Most of the radioactive monazite has been found as crystals scattered in the largest mass of carbonate rock. Thorite, on the other hand, is the dominant radioactive mineral in areas containing oxides of iron.

More than 120 samples have been collected from the Mountain Pass Area by the U. S. Geological Survey for analysis of uranium and thorium content. Samples have been collected from all the claims lying between the Birthday Claims on the northwest and areas south of the Windy group of claims on the southeast. Analyses indicate an erratic distribution of uranium and thorium in the Mountain Pass Area; uranium values range from 0.001 to 0.030 percent and thorium values from 0.02 to 6 percent.

## Hoerner-Ross pegmatite (17) _/

The Hoerner-Ross pegmatite, in central San Bernardino County, is on the east side of the crest of a nearly conical peak south of the main ridge of the Cady Mountains; the Cady Mountains are an isolated mountain unit approximately 5 miles wide in a northerly direction and 9 miles long in an easterly direction. The peak is 7 miles N. 56° E. of Hector station on the Santa Fe Railroad. Hector station is 30 miles east of Barstow. The pegmatite is accessible by a desert road 3 miles east from Hector, north under a railroad bridge, then 6 miles northeast up a wash to the east side of the peak. It also may be reached by travelling another desert road north from Hector for about 2 miles, then east 4 miles to a wash, and then up the wash to its end, which is another 4 miles from the east-west road. From the end of the wash, a steep trail, rising 700 feet vertically over a horizontal distance of about 2,500 feet, leads up the bare ridge to the deposit. No record of studies or mapping exists for that part of the Cady Mountains containing the Hoerner-Ross pegmatite. In 1945, however, the eastern and southern parts of the Cady Mountains were mapped by Cordell Durrell (1953), in connection with a study of the celestite deposits along the southern slope.

Durrell's geologic map shows that the southeastern part of the Cady Mountains is made up of Tertiary volcanic rocks; basalt flows occur at the base of the section and are overlain successively by andesite flows and rhyolite tuffs, and playa deposits containing beds of celestite. His map also shows a small area of granite in the saddle separating the Cady Mountain mass from the hills lying to the southeast. This granite was later classified by Hewett as quartz monzonite and will be considered as such in this paper. The quartz monzonite, which is pale reddish brown, where fresh, and is coarsely crystalline, appears to form the higher part of the Cady Mountains in which the pegmatite occurs. Crystals of feldspar in the quartz monzonite range in size from 1/8 to 3/8 of an inch in diameter; grains of quartz and biotite are smaller. Thin sections show that the rock is composed of: orthoclase and microcline, 35 percent; quartz, 30 percent; plagioclase (andesine), 25 percent; micro-perthite, 5 percent; and biotite, 3 percent. The monzonite shows several systems of joints, but lacks the layering or foliation common in the Archean rocks of this region. Numerous dikes of a rock

_/ Information obtained from Hewett (1950).

similar in composition to the quartz monzonite, though of a finer grain size, occur in the vicinity of the pegmatite. A thin section of the dike rock shows quartz 35 percent; orthoclase and microcline, 30 percent, plagioclase (andesine) and micro-perthite, 25 percent; magnetite, 5 percent; biotite, 3 percent, and sphene, 2 percent. The dikes trend northwest roughly parallel to the Hoerner-Ross pegmatite. The pegmatite body, striking about N. 10° W. and dipping 65° W., is about 100 feet long and 25 feet wide at the widest part and is roughly elliptical in shape. The contact between the pegmatite and the enclosing monzonite is definite and sharp. The owners report two other small bodies of similar pegmatite nearby.

The pegmatite, as exposed in an open cut 40 feet long and 10 feet deep, is roughly separable into two layers. The lower (eastern) layer is about 12 feet thick, faintly layered, and is made up largely of feldspar, with minor amounts of magnetite, quartz, green mica, and other minerals. The predominant mineral, flesh-colored coarsely crystalline feldspar, in places has cleavage faces several inches in diameter. Locally it has been replaced by feathery white albite. Magnetite occurs in the flesh-colored feldspar as small isolated masses as much as 2 inches long. Quartz, in the lower layer, occurs as small pipe-like bodies several inches in diameter and 6 to 15 inches long. The longer axes of these bodies are normal to the foot-wall of the pegmatite. Within the lower layer, there are several rounded, pale yellow to green, masses of an incoherent material. One of these is several inches in diameter and 10 inches long. The rounded masses are composed largely of coarse fragments of feldspar and lesser amounts of green mica, small quartz crystals, and minute tetragonal crystals of strueverite. This mineral assemblage is slightly radioactive. Rosettes of biotite plates as much as 20 inches in diameter were found in the lower layer. Thin plates of biotite, 5 to 8 inches long, radiate outward from centers. The rosettes contain sparse crystals of highly radioactive crytolite, some of which are clearly tetragonal, while others appear hexagonal in cross section.

The upper layer of the pegmatite also is about 12 feet thick. It contains large masses of white quartz which have apparently replaced parts of the original feldspar. A lens, about 36 inches long and about 20 inches thick, composed of biotite, feldspar, magnetite, and cyrtolite is exposed in the residual feldspar of the upper layer. The lens contains plates of biotite 1/16 to 1/8 of an inch thick and as much as 6 inches in diameter, which separate flat plates of feldspar and magnetite. Small crystals of cyrtolite are found in the biotite and along the contact of the biotite and the feldspar. Small octahedrons and grains of a uranium mineral, tentatively identified as betafite, occur in the feldspar plates and in the magnetite. Laboratory test show that the betafite (?) contains uranium, titanium, and columbium. The outer shells of the octahedrons and grains are pale yellowish-green and fine-grained; the interiors are dark green and glassy. Approximately 5 to 10 grams of the uranium mineral can be extracted from about 25 pounds of the feldspar-magnetite-biotite rock that makes up the lens.

Unless many other lenses are present in the downward extension of the pegmatite the amount of uraniferous material present is negligible.

## Rock Corral area (31)

In 1949, prospectors discovered a number of small masses of rock containing thorium-bearing minerals in an area about 2 miles wide and 5 miles long in the vicinity of Rock Corral, about 53 miles east-northeast of San Bernardino. In 1952, an examination of the known occurrences and intervening areas by D. F. Hewett, G. W. Walker, R. M. Moxham, and L. H. Baumgardner of the U. S. Geological Survey indicated that some exposures of pegmatite, vein material, masses of biotite-rich rock in plutonic crystalline rocks, and, locally, the plutonic rocks themselves, contained concentrations of radioactive minerals. Several properties, including the Jinkins, Conkey, and Black Dog claims, and the Pomona Tile quarry, cover some of the areas with highest radioactivity. At the time of the examination, excavations consisted of several pits, or shallow shafts, in the most radioactive parts of the area.

Dominant rock types exposed in the Rock Corral area are pre-Cambrian biotite gneiss, siliceous metasedimentary rock, dark interlayers of metavolcanic (?) rock, and intrusive quartz-monzonite of Mesozoic age. Locally, the metamorphic rocks are metasomatically altered and the intrusive rocks are contaminated with partly assimilated blocks of wall rock. Thorium-bearing allanite, as well as radioactive zircon and monazite, are conspicuous accessory minerals in biotite-rich inclusions (or small roof pendants) in the plutonic rocks and, locally, also in the plutonic rocks; some alluvial deposits derived from these rock types are also proportionately high in allanite, zircon, and monazite. Petrographic analysis of selected rock specimens collected in the area indicate that parts of the biotite-rich inclusions contain more than 7.0 percent of allanite and more than 1.0 percent of zircon. In addition, specimens of the plutonic rocks contain as much as 4.5 percent of allanite and 1.5 percent of zircon. Quartz-feldspar pegmatite at the Pomona Tile quarry contains minute amounts of samarskite, euxenite, allanite, and monazite associated with biotite, either magnetite or ilmenite, and other unidentified minerals. Remnants of an allanite- and monazite-bearing vein, about 15 feet long and as much as 5 or 6 inches wide, are exposed in biotite gneiss on the Black Dog claim.

A selected specimen from the Black Dog claim, submitted by Mr. B. Bauer to the U. S. Geological Survey laboratories, contained 1.87 percent equivalent uranium, 0.25 percent uranium, and 0.61 percent thoria. Selected specimens of the biotite-rich material assayed as much as 0.15 percent thorium; however, the quantity of material of this grade is small. Several analyses of the plutonic rock indicate that in some areas it averages about 0.008 percent equivalent uranium; many millions of tons of material of this grade are present in the Rock Corral area.

### Yerih group (30) _/

The Yerih group of claims, which is also known as the Scotty Wilson mine, in the Holcomb Valley district, is in the San Bernardino Mountains near Big Bear Lake in secs. 3 and 4, T. 2 N., R. 1 E., San Bernardino meridian. The property is owned by D. F. Gleber, 1036 Ferris Avenue, Los Angeles, Calif., and, in 1951, was under lease to Mr. P. J. Barnes, 248 South Olive Street, Los Angeles. The Yerih group was originally located in 1939 and, since that time, has yielded several tons of silver-lead-zinc ore. Exploration for lead-silver-zinc mineralization consisted of sinking a 30-foot vertical shaft and a nearby south-trending adit. In 1951, Mr. Barnes (lessee) sunk a 50-foot vertical shaft about 20 feet east of the original shaft and crosscut southward on the 25-foot and 50-foot levels for distances of 20 feet and 50 feet, respectively. In the spring of 1952, all of the workings were caved and inaccessible.

_/ Part of this information obtained from Wright, L. A., et al., (1953).

The mine workings are mainly in a poorly exposed, crushed and broken zone in massive limestone of the Furnace formation of Mississippian (?) age. Elsewhere on the property are exposures of quartzite, black, fine-grained, foliated metasedimentary rocks, calc-hornfels, and intrusive granitic rocks. Hydrothermal sulfides including pyrite, pyrrhotite, chalcopyrite, sphalerite, galena, and argentite occur locally as irregular masses and thin seams in the limestone. A uranium mineral, probably uraninite, is found erratically distributed in masses of the sulfide minerals.

Radioactivity traverses in the vicinity of the shaft collar and tests of the mine dumps indicate only slightly anomalous gamma-ray activity. Select specimens, however, have a count as high as 50 times background as measured with a portable Geiger counter. Samples submitted by Mr. Barnes to the U. S. Atomic Energy Commission contained as much as 0.37 percent equivalent uranium and 0.32 percent uranium, but the quantity of this material is small.

### Live Oak Tank area (34) _/

The Live Oak Tank area, Riverside County, is in the Joshua Tree National Monument, about 12 miles south of Twentynine Palms. The area, which can be reached over paved and gravel roads, was examined on December 13, 1948, by D. G. Wyant of the U. S. Geological Survey.

Bedrock exposed in the area, as mapped by Miller (1938), consists dominantly of crystalline metamorphic and plutonic rocks of pre-Cambrian age, and intrusive quartz monzonite of Jurassic (?) age. The pre-Cambrian rocks have been classified by Miller as metasedimentary rocks, Gold Park gabbro-diorite, Palms granite, Pinto gneiss, and monzonite porphyry; the Pinto gneiss is a metamorphic-igneous complex made up dominantly of metamorphic facies of the Gold Park gabbro-diorite, Palms granite, and some metasedimentary rocks. The quartz monzonite of Jurassic (?) age, named the White Tanks monzonite by Miller, is medium- to coarse-grained, massive, and homogeneous; a few lines of foliation, some variations in grain-size, and a few basic inclusions occur near the margins of the monzonite masses. Thin sections

_/ Information obtained from Wyant (1949).

show the bulk of the rock to be composed of quartz, microcline, microperthite, and oligoclase. The accessory minerals sericite, allanite, apatite, and titanite constitute 1 percent by volume of the rock. Zircon and allanite were also observed, by Miller, in thin sections from all the formations except the Gold Park gabbro-diorite.

Black sand in the dry wash at Live Oak Tank is of Recent age and reportedly contains monazite. The sand occurs on the surface of the dry wash in small, thin, discontinuous patches, and ranges from a few inches to several feet in length and from 1 mm to 1/2 inch in thickness. Patches of black sand also appear in the wash from 50 to 100 yards down stream from outcrops of the White Tank monzonite and some pockets of black sand were observed in natural riffles on the monzonite. Unquestionably, most of the dark concentrates were derived from exposures of the monzonite and probably were deposited on the surface of the dry wash in the closing stages of the last flash flood.

Tests of samples of the black sands from five localities and of outcrops of White Tanks monzonite at thirteen localities indicate gamma-ray activity only slightly above background. Tests of the Palms granite, including a porphyritic phase, and the porphyritic monzonite (of Miller) indicate that these rocks are essentially non-radioactive. Radioactivity testing of the Pinto gneiss was confined to an area underlain dominantly by a mixed complex composed of fine-grained metamorphic rocks and dikelets of quartz biotite granite which locally are pegmatitic. Most of the Pinto gneiss is only weakly radioactive, but in one small area, counter readings of as much as 20-times background were recorded. The more radioactive areas of the Pinto gneiss are characterized by a higher proportion of injected granitic rock and associated pegmatite.

A total of six samples, including samples of black sand, White Tanks monzonite, and Pinto gneiss were collected for analysis. The analyses indicate an equivalent uranium content ranging from 0.002 to 0.035 percent and a uranium content ranging from 0.000 to 0.005 percent (table 5). Most of the anomalous radioactivity of the Live Oak Tank area is attributable largely to thorium in monazite and xenotime, and to a less extent to radioactive titanite, zircon, and biotite.

Table 5.--Sampling data, Live Oak Tank area, Riverside County, California

| Sample no. | Analyses | | | Description |
|---|---|---|---|---|
| | Field | Laboratory | | |
| | * | eU (percent) | U (percent) | |
| DW-79: 246 | 4. | 0.008 | 0.003 | 3' chip, hornbl.-biot. inclusion (Pinto gneiss) in White Tanks monzonite. |
| 247 | 5. | .005 | .001 | placer, Recent gravel, incl. black sand; average material. |
| 248 | 3.5 | .002 | .000 | 10' chip, schist inclusion (Pinto gneiss) in White Tanks monzonite. |
| 249 | 2.5 | .004 | .000 | grab, chips of White Tanks monzonite from area 50' square. |
| 250 | 5. | .011 | .001 | placer, black sand skimmed from surface dry wash. |
| 251 | 2. | .004 | .003 | grab, chips of White Tanks monzonite from area 50' square. |
| DW-80: 252 | 60. app. | .035 | .005 | grab, biotite-feldspar porphyritic sill or dike in Pinto gneiss. |

* Average reading at the outcrop, sensitivity scale 0.2, Beckman Model MX-5. Background included. Average background was 2.5.

## Desert View claim (35)

The Desert View claim is in secs. 31 and 32, T. 5 S., R. 10 E., San Bernardino meridian, about 2 miles N. 25°W. of Cactus City, Riverside County. In 1952, the property was owned by Mr. Willis Murphy and Mr. E. H. Kreuger of Yucaipa Valley, California. Exploration on the property consists of 5 small pits, a 35-foot trench, and several bulldozer cuts.

Bedrock exposed on the claim consists essentially of banded, pre-Cambrian biotite gneiss that has been intruded by several 4-foot dikes of aplite, which is locally pegmatitic. A radioactive, rare-earths-bearing mineral, probably monazite, is erratically and sparsely distributed in the biotite gneiss; no abnormal radioactivity was found in the dikes.

Assays of two selected specimens collected in pits adjacent to the discovery monument indicate an equivalent uranium content of 0.13 and 0.15 percent, and a uranium content of 0.01 and 0.005 percent, respectively.

## Red Devil claim (33)

Weak anomalous radioactivity has been found on the Red Devil claim, Danby district, in the NW 1/4, T. 6 N., R. 18 E. (projected), about 12 miles southeast of Essex in San Bernardino County. When examined, in 1952, the property was owned by L. M. Donnell of Fenner and was under lease to R. A. Mesick, P. O. Box 481, Cathedral City; exploration consisted of 2 shallow pits in a mineralized shear zone.

Bedrock in the immediate vicinity of the pits consists of granite of Jurassic (?) age, although elsewhere on the claim metamorphic rocks of possible pre-Cambrian age are exposed. A shear zone which strikes N. 30°W., dips 80°W., and is visible only in the granitic rocks, contains discontinuous patches of vein material composed dominantly of silica, lesser amounts of stibnite, cinnabar, stibiconite (?), iron oxides, and small amounts of an unidentified uranium mineral. Locally, along the shear zone, the wall rock is hydrothermally altered and bleached.

Only small quantities of radioactive material were found when the property was tested for gamma-ray activity; all of the anomalous radioactivity is confined to the mineralized shear zone. A select specimen, which contained abundant stibnite, cinnabar, and stibiconite (?), assayed 0.076 percent equivalent uranium and 0.084 percent uranium.

### Lucky Star claim (36)

The Lucky Star claim, which is probably the same property previously known as the McKnight Clay deposit, is in sec. 36 (?), T. 12 S., R. 19 E., San Bernardino meridian, about 10 miles northeast of Glamis, Imperial County. Glamis, which is on the Southern Pacific Co. right-of-way, is the nearest railroad shipping point. Excavations at the property, in April 1952, consisted of a pit 20 feet wide and 50 feet long and five small prospect pits. The property is held by location by Mr. S. C. Wright, 233 North E St., Porterville, Calif.

Bedrock on the claim consists of pre-Cambrian (?) quartzite and quartz mica schist which have been folded, faulted, and subsequently intruded by felsic dikes, sills, and small volcanic necks or plugs of Tertiary age. The metamorphic rocks, as well as the felsic intrusive rocks, are locally bleached and hydrothermally altered. The areas of hydrothermal alteration contain, in addition to unidentified clay minerals and quartz, notable quantities of talc, gypsum, calcite, and less amounts of torbernite or autunite, carnotite, psilomelane, and hydrated iron oxides. Most of the carnotite occurs in the altered felsic intrusives, and most of the torbernite (?), and all of the talc, in the altered metamorphic rocks.

Assays of three channel samples collected in one small pit on the property indicate an equivalent uranium content of 0.028, 0.077, and 0.097 percent and a uranium content of 0.021, 0.076, and 0.12 percent, respectively. The quantity of material of this grade is small. Traverses for radioactivity elsewhere on the claim gave Geiger counter readings the same as, or only slightly above, the background count.

## Sierra Nevada Province

In a general way, the Sierra Nevada Province may be described as a single fault block of great magnitude, which represents the dominant mountain range of California. The Province is bounded on the east by the Basin and Range Province, on the west by the Great Valley of California, and on the south by the

Garlock fault. On the north, the Province is terminated where the Cenozoic volcanic rocks of the Cascade Range and the Modoc Plateau overlap the rocks characteristic of the Sierra Nevada.

The oldest rocks in the Province consist of a sequence of Paleozoic sedimentary rocks, most of which have been dynamically metamorphosed to phyllite, quartzite, recrystallized limestone, amphibolite and amphibolite schist, quartz-mica schist, and graphite schist. Stratigraphically above the Paleozoic rocks is a thick sequence of Mesozoic slate or phyllite and various types of metavolcanic rocks. The Paleozoic and Mesozoic rocks, exposed predominately in the west and northwest parts of the Province, have been invaded by great masses of plutonic rock composed largely of granodiorite and quartz-monzonite but including other plutonic rock types and locally, small masses of pegmatite. Quartz veins, many of which contain base-metal sulfides and gold, were introduced into the Paleozoic and Mesozoic rocks during the waning stages of plutonic invasion.

Although radioactive minerals are widely distributed throughout the Province, significant concentrations are rare. Hutton, (1951), Pabst, (in press), Shawe, (1953a), George, (1951), and others have identified various minerals including allanite, thorite, monazite, brannerite, and uranium-bearing ilmenite as sparsely disseminated accessory minerals in the plutonic rocks and as detrital grains in placer concentrates. Uraninite and uraconite have been reported by Rickard (1895) from the Rathgeb mine (Calaveras County), and radon gas, a radioactive product derived from the disintegration of uranium-bearing materials, has been reported from the General U. S. Grant mine (Tuolumne County). Uraninite may possibly be present at the Rainbow claim (Madera County) associated with sulfides in smoky quartz. Anomalous radioactivity associated with Hot Springs deposits has also been reported from the Stokes and Stowell properties in Plumas County. Examination for radioactivity of a number of other mine properties in the province by the U. S. Atomic Energy Commission and the U. S. Geological Survey, including gold properties in the Mother Lode belt and a few contact-metamorphic tungsten deposits, has failed to uncover any significant gamma-ray activity.

## Rathgeb mine (2) _/

According to Rickard (1895) acicular black crystals of pitchblende (uraninite) and a yellow uranium ochre (uraconite) are associated with spongy gold and clay minerals at the Rathgeb mine in the NW 1/4 sec. 34, T. 4 N., R. 12 E., Mt. Diablo meridian, a few miles south of San Andreas, Calaveras County.

The mine workings consist principally of a 220-foot shaft which, at the time of the field examination in 1947, was caved and inaccessible. A radioactivity reconnaissance of the dump and tests of a quartz vein exposed just below the shaft collar indicates only low gamma-ray activity and failed to confirm the presence of a uraniferous mineral.

## Rainbow claim (4)

The Rainbow claim, Jackass district, Madera County, in T. 4 S., R. 24 E., is approximately 16 miles (direct line) southeast of Camp Curry, Yosemite National Park. The property is accessible by mountain trail from Jackass Meadows (Madera County). In July 1952, workings on the property consisted of a 6-foot pit and a 2-foot discovery pit.

Minute quantities of a radioactive mineral, possibly uraninite, are associated with pyrite, chalcopyrite, tetrahedrite (?), bornite (?), magnetite, iron oxides, and smoky quartz in pegmatite intrusive into Jurassic (?) granodiorite. A sample of the most radioactive material, which contained appreciable quantities of quartz and base-metal sulfides, assayed 0.003 percent uranium.

## General U. S. Grant mine (3)

Radon gas has been identified in abandoned workings at the General U. S. Grant (or Sunnyside) mine in sec. 27, T. 3 N., R. 15 E., Mt. Diablo meridian. The mine, which was worked for gold presumably associated with base-metal sulfides in quartz, is in crumpled and iron-stained mica schist of Mississippian (?) age. Examination of the property failed to determine the source of the radon gas.

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_/ Part of this information obtained from Chesterman and Main (1947).

### Stokes and Stowell properties (1)

The Stokes and Stowell properties, which are adjoining, are in sec. 24, T. 25 N., R. 8 E., Mt. Diablo meridian, about 8.5 miles (direct line) northwest of Quincy, Plumas County. Several occurrences of radioactive material on the properties are within a few hundred feet of the Feather River highway (State Highway 24).

Bedrock in the area consists of steeply dipping, marine, metasedimentary rocks including slate, foliated and shaley limestone, fine-grained phyllitic tuffs (?), and quartzite which are probably part of the Calaveras formation of Mississippian age. Numerous northwest-trending faults, that parallel the major structures of the region, are exposed in road cuts along the Feather River highway. Locally, on some faults, hot springs are present; elsewhere, deposits of limonitic and manganiferous sinter indicate the position of hot springs which are no longer active.

Although radioactivity tests of the thermal waters at four active springs gave counts the same as, or only slightly above, background, similar tests of the limonitic sinter at four inactive springs gave counts of as much as sixteen times background. A selected sample of some of the most radioactive limonitic sinter assayed 0.66 percent equivalent uranium and 0.001 percent uranium; probably most of the abnormal radioactivity is caused by radium.

## Basin and Range Province

The Basin and Range Province of California, which covers most of Mono and Inyo Counties and parts of San Bernardino and Kern Counties, is characterized by roughly parallel ranges and intervening valleys or basins, which are controlled by faults. The Province lies east of the Sierra Nevada Mountains, north of the Garlock fault, and is contiguous with the great Basin and Range Province of Nevada.

The mountain ranges of the Province, including the Inyo, the Argus, and the Panamint Ranges, are underlain predominantly by Paleozoic sedimentary rocks and intrusive masses of granitic rock. The Paleozoic rocks are made up largely of limestone, dolomite, quartzite, and subordinate sandstone and shale. Exposures of pre-Cambrian and Triassic sedimentary rocks are found in the Inyo Range, and pre-Cambrian rocks are extensively exposed in the ranges east of Death Valley. The basins are filled with an appreciable thickness of continental sedimentary deposits of Tertiary to Recent age. Various types of Tertiary volcanic material, ranging in composition from rhyolite to basalt, are extensively exposed both in the valleys and in the mountain ranges.

Only five occurrences of radioactive materials in the Basin and Range Province (of California) have been examined by Government geologists, although other occurrences are known to exist. At the Wild Dog group of claims, small quantities of an unidentified uranium mineral associated with hydrated iron oxides and copper minerals occur adjacent to a quartz fissure vein which cuts quartz monzonite. An unidentified uranium mineral associated with wulfenite occurs in Paleozoic limestone and dolomite which have been intruded by quartz monzonite at the Ubehebe and Lippincott mines. The wulfenite and the uranium mineral occur in oxidized parts of irregular, sulfide replacement deposit in limestone. At the Joe McCulley property, base-metal and silver sulfides are found in the tactite zone between Mississippian limestones and an intrusive tongue of granite. Although anomalous radioactivity has been detected on the property, no uranium minerals have been identified. Concentrations of secondary uranium minerals also have been reported in felsic volcanic or tuffaceous rocks exposed in various parts of the province; as yet, none of these occurrences have been examined by Government geologists.

### Ubehebe (6) and Lippincott (7) mines

The Ubehebe mine in sec. 1 and 2, T. 14 S., R. 40 E. (projected) and the Lippincott mine in sec. 13, T. 15 S., R. 40 E. (projected), Inyo County, are about 20 miles northeast of Owens Lake at an elevation of approximately 4,000 feet. Workings at the Ubehebe mine total more than 2,300 feet, principally in adits and stopes and, at the Lippincott mine, total about 2,000 feet in adits and inclines. Prior to 1951, the Ubehebe mine had yielded over 2,000,000 pounds of lead, more than 100,000 pounds of zinc, nearly 35,000 ounces of silver, and some copper. Production records for the Lippincott mine are incomplete; apparently some lead, silver, and minor amounts of gold have been produced.

The deposits consist essentially of irregular replacement bodies and fracture fillings in Paleozoic dolomite, which has been intruded by quartz monzonite, locally by syenite, and by minette dikes. The ore bodies, which are largely altered to supergene minerals, consist chiefly of cerussite, hemimorphite, hydrated iron oxides, wulfenite, anglesite, silver-bearing galena, and sphalerite.

Anomalous radioactivity is caused by an undetermined uranium mineral associated with concentrations of wulfenite in the ore zones. Analysis of samples indicates a uranium content of from 0.001 to 0.050 percent.

## Joe McCulley property (9)

The Joe McCulley property is in sec. 7 (?), T. 18 S., R. 44 W., near the north end of the Argus Range. In 1950, when examined by Everhart and Towle (AEC Recon. Report, unpubl.), the property was owned by Joe McCulley, Box 53, Darwin, Calif. During the past 20 years the deposit has been worked periodically through 2 small adits for lead, zinc, copper, and silver.

The deposit is in a tactite zone along the west side of a tongue of granite that projects northward, from a small stock, into Mississippian limestone beds. Lead, zinc, copper, and silver sulfides and skarn minerals occur in a belt as much as 50 feet in width between limestone and granite. The sulfide minerals are largely oxidized near the surface.

Traverses for radioactivity of the contact zone and scanning of specimens taken from outcrops and dumps failed to reveal any radioactivity more than three times background count. No uranium minerals were found on the property.

## Wild Bill (Banner or Dog) group (5)

The Wild Bill group of claims is in sec. 18, T. 3 S., R. 31 E., about 8 miles south of Benton, Mono County. The group was owned, in 1951, by the Natural Resources Development Company, 354 Village Lane, Los Gatos, Calif. Development on the property consists of three adits; the total length of the workings is approximately 1,000 feet.

The Wild Bill group is in a quartz monzonite intrusive which shows, by the presence of numerous inclusions, that it has been contaminated by partly assimilated pieces of wall rock. Within the quartz monzonite, several 6-inch to 2-foot mineralized quartz veins strike northwest and dip at low angles to the southwest. Faults, which strike approximately N. 25° W. and dip steeply both east and west, cut and displace the mineralized veins; displacement on the faults is commonly less than 5 feet.

The quartz veins contain pyrite, chalcopyrite, galena, tenorite, sphalerite, gold (native ?), and alteration products of some of these minerals. Limonite, some cerussite, and unidentified brown and green, waxey clay minerals are found in crushed rock along faults and in a 3-inch band, which is exposed for 5 feet, directly beneath a quartz vein. Abnormal radioactivity is found in areas where limonite and cerussite are concentrated and the entire 3-inch band is appreciably radioactive. No uranium minerals have been identified, but, because of the association with hydrated iron oxides it is assumed that the uranium is probably contained in supergene minerals.

Chip samples, collected by the U. S. Geological Survey, contained as much as 0.1 percent uranium and samples collected by the owners and assayed by the laboratories of the U. S. Atomic Energy Commission contained as much as 0.31 percent uranium.

### Santa Rosa mine (8) _/

The Santa Rosa mine is in secs. 26 and 35 (projected), T. 17 S., R. 39 E., Mt. Diablo meridian, in the extreme southern part of the Inyo Mountains, Inyo County. The mine has yielded more than 11,000,000 pounds of lead, more than 450,000 pounds of copper, over 400,000 fine ounces of silver, some zinc and gold; the ore has been extracted from workings totalling about 4,012 feet and from several large stopes.

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_/ Information obtained from MacKevett (1953).

The mine is in an inlier of Permian (?) silicated limestone _/ bounded by Tertiary (?) volcanic rocks including andesite, basalt, and pyroclastic material. The silicated limestone is cut by three syenodiorite porphyry dikes which range from 2 to 3 feet in thickness. Several north-trending veins composed of oxidized lead, zinc, and copper minerals, with minor amounts of sulfides in an iron-rich siliceous gangue occur in faults in the silicated limestone. The veins range in length from less than 100 feet to about 700 feet and average between 3 and 4 feet in thickness.

A Geiger counter survey of the Santa Rosa mine indicates slight anomalous radioactivity in oxidized parts of the veins; the identity of the radioactive material is not known.

## Other reported occurrences of uranium and thorium minerals

Occurrences of thorium and uranium minerals have been reported from a number of other localities in California, a few of which already have been studied briefly by the U. S. Geological Survey or the U. S. Atomic Energy Commission. In these occurrences the uranium- or thorium-bearing minerals are present in such small amounts that none of them, under present conditions, could be considered a potential source of either uranium or thorium. The occurrences are indicated below.

Monazite has been reported in black sand concentrates from river gravels: from Placerville and the Indian Diggings in El Dorado County, from Trinidad in Humboldt County, from Michigan Bluff in Placer County, from the Brownsville district in Yuba County, and from unspecified localities in Butte, Nevada, and Plumas Counties, (Murdoch, Joseph, Webb, R. W., 1948), (Chesterman, C. W., 1950). Skidmore (1944) reports monazite in placer concentrates from the Ogilby district, Cargo Muchacho Mountains, from the San Joaquin River near Friant, and from the Tuolumne River near La Grange. Monazite has also been reported from Pacific Beach sands near Crescent City in Del Norte County, (Murdoch and Webb, 1948), and from the backshore zone of beaches in San Mateo County (Hutton, 1951). Monazite occurs in pegmatites from the following places in Riverside County: Mesa Grande, 2 miles north of Winchester, near the Vonsen limestone quarry, and the Southern Pacific quarry near Nuevo, (Chesterman, 1950). Weak gamma-ray activity, probably caused by thorium in monazite, has been

_/ An impure limestone that contains at least 20 percent lime silicate minerals.

found on the Original and Pack Saddle claims about 4 miles east-northeast of Amboy in San Bernardino County. The monazite (?) is an accessory constituent of granitic rocks. Other localities, in which minute amounts of torbernite, cyrtolite, samarskite (?), and xenotime have been reported, also are listed by Murdoch and Webb (1948).

Thorite has been found in placer gravels along the Feather, Yuba, American, Mokelumne, Tuolumne, and Merced Rivers (George, 1951). Allanite, which may or may not be radioactive, has been reported from the Ford mine, Calaveras County, from the Eagle Mountain iron deposits, Riverside County, from the Gassenberger Ranch, Tulare County, and elsewhere (Murdoch and Webb, 1948)

In 1952, G. W. Moore and J. G. Stephens of the U. S. Geological Survey, conducted a reconnaissance in California in search of new deposits of uranium-bearing carbonaceous rock. During the investigation, 50 localities were examined, including 46 that contain coal or carbonaceous shale and 4 that contain petroliferous material. A total of 63 samples of carbonaceous rocks were taken for analysis from 38 of the localities. The uranium content of the samples ranges from less than 0.001 percent to a maximum of 0.020 percent. The most significant concentrations of uranium in carbonaceous rocks in California are: Newhall prospect, Los Angeles County, 0.020 percent uranium; Fireflex mine, San Benito County, 0.005 percent uranium; American lignite mine, Amador County, 0.004 percent uranium; and Tesla prospect, Alameda County, 0.003 percent uranium.

Carper (1945) reports positive fluorescent bead tests for uranium from base metal-quartz veins cutting rhyolites in the Wingate Pass area in Inyo County; the area is about 83 miles northwest of the town of Baker, near Death Valley. Carper reports, however, that Geiger counter readings in the area averaged only 7 counts per minute above background and that the uranium content was too low-grade to be of further interest.

Weak anomalous radioactivity occurs erratically in mineralized shear zones on the Alpha, Beta, and Gamma claims in San Bernardino County about 10 miles northwest of Johannesburg. The shear zones contain minor amounts of pyrite, secondary copper minerals, hydrated iron oxides, gypsum, and an unidentified radioactive mineral.

Radioactivity reconnaissance of the Grimes Canyon area, Ventura County, indicates the presence of minor amounts of an unidentified radioactive material associated with mid-Tertiary volcanic rocks. The volcanic rocks are interstratified with mid-Tertiary sedimentary rocks and, locally, may possibly intrude the sedimentary rocks. Throughout most of the area, Geiger counter readings are the same as, or only slightly above, background count; however, locally, readings as much as 3-times background have been recorded.

On October 6, 1949 the Mariposa Gazette published an article on the discovery of uranium in the Mother Lode district by Dr. F. E. Tiffany of Mid Pine, Calif. Dr. Tiffany was contacted by geologists of the U. S. Atomic Energy Commission (Towle, C. C., 1950); he stated that the deposit was in Yosemite National Park about 28 miles from Mid Pine but was inaccessible at the time. He further stated that the deposit consisted of calciocarnotite (tyuyamunite), specimens of which contained as much as 4.0 percent $U_3O_8$. This material was reported to occur in a clay seam 4 to 8 inches wide and approximately 400 feet long, between granite and slate.

A number of samples from California submitted to the U. S. Geological Survey laboratories for analysis, are listed in table 6.

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(Page 52A follows.)

Table 6. Radioactive samples from California submitted to the U. S. Geological Survey laboratories for assay.

| Locality | Submitted by | Sample number | Type | Uranium minerals | Grade (percent) |
|---|---|---|---|---|---|
| Imperial County | | | | | |
| Lucky Star claim | S. C. Wright | W 657 | Kaolin | Carnotite, torbernite | 0.24 eU. |
| Unknown | A. I. Obermiller | A 10-2 | Pegmatite | ----------------- | 1.00 eU. |
| Kern County | | | | | |
| Near Mojave | R. W. Roundtree | 61709 | Altered breccia | ----------------- | 0.024 eU, 0.022U. |
| 5 mi. W. of Rosamond (Jumpin?) | C. G. Burton | CR 789 | Rhyolite. | Autunite | 0.03 U. |
| Near Boron (Vanuray). | C. J. Roycroft | W. 2923 | Limestone | Carnotite | 0.08 U. |
| Los Angeles County | | | | | |
| Near Palmdale | Mrs. E. Conn | W 116 | Sandstone, Limestone | Carnotite, Nb-Ta mineral | 1.30 eU. |
| Plumas County | | | | | |
| Feather River Hot Springs, T. 25 N., R. 8 E. | F. L. Stowell | W 618 | Limonite | ---------------------- | 0.29 eU. |
| Riverside County | | | | | |
| Cottonwood Mountains district (Desert View claim?) | W. J. Murphy | 59331 | Biotite gneiss | -------------------- | 0.13 eU, 0.01 U. |
| Unknown | A. I. Obermiller | A 10-1 | Pegmatite (?) | -------------------- | 0.36 eU. |
| San Bernardino County | | | | | |
| Summit Diggings | J. M. B. Parry | D 67007 | Gray porphyry | Radioactive opal, meta-torbernite. | 0.12 eU, 0.11 U. |
| Rainbow group | G. Alexander | RW 3500 | Magnetite, hematite | | 0.02 U. |
| 25 mi. E. of Barstow (Harvard Hills) | J. W. Vandergrift | W 2584 | Limestone | Secondary uranium minerals. | 0.30 eU. |
| Black Dog claim | B. Bauer | 31979 | | Allanite, monazite. | 1.87 eU. 0.25 U, 0.61 $ThO_2$, 29.63 rare earth oxides. |
| Lucky Star claim, Silver Mountain | Miss M. A. Boughey | W 2969 | Limestone | ---------------- | 0.019 U. |

(Page 52B follows.)

Table 6. Radioactive samples from California submitted to the U. S. Geological Survey laboratories for assay--Continued

| Locality | Submitted by | Sample number | Type | Uranium minerals | Grade (percent) |
|---|---|---|---|---|---|
| Tuolumne County | | | | | |
| Gen. U. S. Grant (Sunnyside) mine | J. C. Powell | RW 3724 | | Radon | |
| Ventura County | | | | | |
| Unknown | J. C. Stevenson, Jr. | W 2982 | Biotite gneiss | ------------------ | 0.032 U. |
| Unknown | | | | | |
| ------------------------ | H. J. Barrett | W 2989 | Sandstone, limestone | Autunite | 0.05 U. |
| ------------------------ | S. C. Bedell | W 806 | Silicified wood | ------------------ | 0.120 eU. |
| ------------------------ | K. C. Daulton | RW 3437 | Conglomerate | ------------------ | 0.005 U. |
| ------------------------ | K. C. Daulton | RW 3523 | Quartz, pyrite, tourmaline | ------------------ | 0.006 U. |
| ------------------------ | W. T. Duggs | W 1919 | Altered vein material | Minerals of uraninite group | 50.0 U. |
| ------------------------ | J. E. Gibson | W 2578 | Granite gneiss | ------------------ | 0.008 eU |
| ------------------------ | A. M. Jensen | RW 2332 | Sandstone, granite, calcite quartz | ------------------ | 0.007 eU |
| ------------------------ | A. C. Keenan | W 1947 | Breccia | ------------------ | 0.063 eU. |
| ------------------------ | J. F. Mack | W 2910 | Weathered granite | ------------------ | 0.02 U. |
| ------------------------ | J. F. Mack | W 1986 | Rhyolite | Secondary uranium minerals | 0.015 eU. |
| ------------------------ | C. O. Miller | W 2666 | Brecciated limestone | ------------------ | 0.05 U. |
| ------------------------ | J. E. Moreland | W 2657 | Lime-silicate rock | ------------------ | 0.008 eU. |
| ------------------------ | E. Tucker | RW 2076 | Gneiss | ------------------ | 0.008 eU. |
| ------------------------ | H. M. Valencia | W 1968 | Coal, arkose | ------------------ | <0.01 eU. |
| ------------------------ | W. H. Wolcott | W 2905-1 | Quartz, chalcopyrite, limonite. | ------------------ | 0.03 eU. |

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PART II

CONTENTS



TABLES



APPENDIX

## ABSTRACT

Inferred uranium reserves in California totalled about 3,000 tons of uranium-bearing rock at the end of 1952. Additional tonnages of very low-grade uraniferous rock are known to be present on some properties in southeastern California, but quantitative estimates are not available. Less than 15 percent of the total reserves, or about 400 tons, contains as much as 0.1 percent uranium. Virtually all of the uraniferous rock is found on properties in the Mojave Desert region, and it consists largely of secondary uranium minerals in Tertiary volcanic and tuffaceous sedimentary rocks.

Large, but low-grade, thorium deposits are available in the placer gravels along many of the rivers that drain westward from the Sierra Nevada mountains and in lode deposits in crystalline rocks in the Rock Corral area in San Bernardino County. The reserves of thorium-bearing rock in the Mountain Pass area are estimated to be about 9,000,000 tons that averages about 0.025 percent $ThO_2$ and 40,000 tons that averages about 0.215 percent $ThO_2$.

## RESERVES

Prior to 1952, tonnage and grade reserve estimates were available on only 12 uranium localities and three thorium localities in California. Estimates of the reserves of uranium and thorium are given in tables 7 and 8.

Table 7. --Uranium reserves of California

| Locality | Average grade (percent uranium) | Tons of ore (inferred) | Tons of uranium |
|---|---|---|---|
| Imperial County | | | |
| Lucky Star claim | 0.120 | < 50 | <.060 |
| | .050 | 100 | .050 |
| Kern County | | | |
| Golden Rod claim | .040 | 200 | .080 |
| Jumpin claim | .020 | < 50 | <.010 |
| Rosamond prospect | .02 | 1000 | .200 |
| | .005 | < 1000 | <.050 |
| Stillwell | .100 | < 30 | <.030 |
| Vanuray | .050 | 10 | .005 |
| Chilson (Vonsen) property | .100 | 300 | .300 |
| Madera County | | | |
| Rainbow claim | .003 | 5 | ---- |
| Mono County | | | |
| Wild Bill group | .04 | < 10 | <.004 |
| San Bernardino County | | | |
| Harvard Hills | .015 | < 200 | <.030 |
| Rainbow group | .020 | < 1 | ---- |
| Red Devil claim | .084 | < 1 | ---- |
| Total (figures rounded) | ------ | 3000 | .819 |

Note:
< = less than

Table 8.--Thorium reserves of California

| Locality | Average grade (percent $ThO_2$) | Tons of ore (inferred and potential) | Tons of thorium oxide |
|---|---|---|---|
| Calaveras County | | | |
| Calaveras River | 0.006 | 75,000,000 | 4,500 |
| San Bernardino County | | | |
| Mountain Pass area | .026 | 9,000,000 | 2,366 |
| | .217 | 40,000 | 87 |
| Stanislaus County | | | |
| Stanislaus River | .02 | 650,000 | 120 |
| Total (figures rounded) | ------ | 84,500,000 | 7,000 |

## METHODS OF CALCULATING RESERVES

The tonnage and grade estimates in these tables are all inferred or potential. The reserve figures were obtained from such a variety of sources as to preclude any uniformity of sampling technique and methods of estimations of reserves. Nearly all estimates were based largely on geologic inference from a relatively small number of samples; consequently, the resulting reserve calculations represent only an order of magnitude.

The reserve figures for the thorium gravels of the Calaveras River were originally stated in cubic yards; a conversion factor of 1.5 tons per cubic yard was used to obtain the tonnage estimate given in the table.

The remaining radioactive deposits in the State were considered to be either too small or too low in grade to warrant reserve estimates. On a few of the properties covered by older reports, reserves have been calculated in terms of equivalent uranium with no chemical analyses on which to base uranium and thorium reserve calculations; the equivalent uranium statistics are omitted from this report.

None of the properties examined were considered to have sufficient reserves of uranium-bearing material to be minable under market conditions existing in 1952. The same statement applies also to the thorium deposits, although if a process for successfully working the low-grade placer deposits can be devised, potential thorium reserves from this source are large. A favorable market for thorium might encourage its recovery as a byproduct from the exploitation of the rare earth deposits in the Mountain Pass area.

## RECOMMENDATIONS

Under present economic conditions none of the uranium-bearing properties in California examined prior to 1953 exhibit a sufficient tonnage of uranium ore to encourage exploitation or exploration either by Government agencies or by private capital. In addition, prospectors and citizens of California are apparently losing interest in prospecting for new occurrences of uranium, probably due to (1) the apparent small size and low-grade of known occurrences, (2) the lack of knowledge concerning the occurrence and economics of uranium, and (3) the lack of a local market should small tonnages of minable grade material be found. Limited development and exploration on some properties and more intense prospecting of potentially mineralized areas by private citizens might be encouraged if a local market were available. The known reserves of uraniferous rock in California, however, do not justify the expense necessary in establishing such a market. On the other hand, should a local market be established, exploration by private capital would undoubtedly be encouraged.

Limited exploration of the Rosamond prospect which exhibits essentially no minable ore, may be justified on the basis of (1) the extensive, but erratic, distribution of small amounts of secondary uranium minerals and (2) the lack of specific information on the character of the uranium-bearing material at depth. A limited amount of diamond-drilling by the claim owners is recommended to try to extend the known occurrence of uranium-bearing material.

The large, low-grade thorium deposits of the California placers and the smaller, higher-grade thorium-bearing veins in the Mountain Pass area constitute a valuable potential reserve of this element. In view of the difficulty of concentrating and processing thorium minerals, and the limited market, it is felt that no Government exploration or development of California thorium resources is warranted until the demand for thorium becomes much greater than in 1952.

Appendix 1.--Properties examined with negative results (by counties). 1/

| Name | Product | Section | Location Township | Range |
|---|---|---|---|---|
| Calaveras County | | | | |
| Marble Spring mine | Au ? | 3 | 2 N. | 13 E. |
| Mary Louise claim | $WO_3$ | 7 | 7 N. | 16 E. |
| Unknown (on Tiscornic Ranch) | Au | 16 | 3 N. | 12 E. |
| Unknown | Au ? | SE 1/4 9 | 3 N. | 12 E. |
| Unknown | Au | NE 1/4, NE 1/4 16 | 3 N. | 12 E. |
| Fresno County | | | | |
| Mud Lake No. 7 | $WO_3$ | 25 | 9 S. | 26 E. |
| Humboldt County | | | | |
| Copper Bluff mine | Cu | --- About 4 1/2 mi. N. of Hoopa (On U. S. Hwy. 96) | | |
| Imperial County | | | | |
| King mine | Au | 1 | 15 S. | 20 E. |
| Golden Queen mine | Au | 35 | 14 S. | 20 E. |
| Sovereign East | Au | 1 | 15 S. | 20 E. |
| Sovereign West | Au | 12 | 15 S. | 20 E. |

1/ List does not include properties and placer deposits tested by Union Mines Dev. Co., those listed in U. S. Geological Survey TEI-24 by Chesterman and Main, or those tested with negative results by the U. S. Atomic Energy Commission. In addition, list does not include properties tested by U. S. Geological Survey personnel involved in standard areal mapping projects, including properties in the Ubehebe Peak and Darwin quadrangles, Inyo County, and in the west and east Shasta copper district, Shasta County.

Appendix 1.--Properties examined with negative results (by counties).--Continued

| Name | Product | Location Section | Township | Range |
|---|---|---|---|---|
| Imperial County--con. | | | | |
| Talc ? quarry | | 2 | 15 S. | 20 E. |
| Golden Crown | Au | 1 | 15 S. | 20 E. |
| American Girl | Au | 17 | 15 S. | 21 E. |
| Vitrefax mine | Kyanite | 19 ? | 15 S. | 21 E. |
| Western Non-Metallics Co. | Sericite | 18 | 15 S. | 21 E. |
| Blossom mine | Au | 19 | 15 S. | 21 E. |
| Padre mine | Au | 19 | 15 S. | 21 E. |
| Madre mine | Au | 19 | 15 S. | 21 E. |
| Cargo Muchacho | Au | 29 | 15 S. | 21 E. |
| Little Bear | Au | 30 | 15 S. | 21 E. |
| Picacho mine | Au | 3, 4, 7, 10 (?) | 14 S. | 22 E. |
| Senator -- placer | Au ? | 5 and 8 (?) | 15 S. | 24 E. |
| Volunteer group | Cu | 26 | 12 S. | 20 E. |
| Cave Mans group | Cu | 26 | 12 S. | 20 E. |
| Paymaster | Pb, Ag | 24-25 / 19-30 | 11 S. | 19 E. / 20 |

Appendix 1. --Properties examined with negative results (by counties). --Continued

| Name | Product | | Location Section | Township | Range |
|---|---|---|---|---|---|
| Imperial County--con. | | | | | |
| Homestake | Pb, Ag | | 19 ? | 11 S. | 20 E. |
| Big Chief group | Pb ?, Ag ? | | 30 | 11 S. | 20 E. |
| Black Hill mine | Mn | | 8, 19 | 11 S. | 21 E. |
| Hodges mine | Mn | | 16 | 11 S. | 21 E. |
| Silver King mine | Au, Pb, Cu | | 23 | 12 S. | 19 E. |
| Perlite deposit | | | 3 ? | 9 S. | 18 E. |
| Perlite deposit | | | 10 ? | 9 S. | 18 E. |
| Pumice Buttes | | | 22 | 11 S. | 13 E. |
| Obsidian Buttes | | | 32 | 11 S. | 13 E. |
| Inyo County | | | | | |
| Evelyn's Delight prospect | Mn | | ? | 21 N. | 2 E. |
| Lee mine | Pb, Zn | | 14 (proj.) | 17 S. | 40 E. |
| Silver Dollar | Pb | | 29 (proj.) | 18 S. | 30 E. |
| Kern County | | | | | |
| Locarno mine | $WO_3$ | SE 1/4 | 21 | 29 S. | 34 E. |
| Lily Lode | $WO_3$ | --- Approximately 6 mi. southwest of Randsburg | | | |





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Appendix 1. --Properties examined with negative results (by counties). --Continued

| Name | Product | Section | Location Township | Range |
| --- | --- | --- | --- | --- |
| Kern County--con. | | | | |
| Duran bentonite deposite | | 21 ? | 28 S. | 40 E. |
| Churchill | Pb | 20 | 28 S. | 40 E. |
| Yellow Aster mine and adjacent properties | Au | 2, 3 | 29 S. | 40 E. |
| | | 34, 35 | 30 S. | 40 E. |
| Rosamond feldspar | Feldspar - Silica | 6 | 9 N. | 12 W. |
| Yellow Dog and adjacent properties | Au | 29, 32, 33 | 11 N. | 12 W. |
| Golden Queen and adjacent properties | Au | 6, 7 | 10 N. | 12 W. |
| Cactus Queen and adjacent properties | Au | 16, 17 | 10 N. | 13 W. |
| Bob Tail mine and adjacent properties | Au | 6 | 10 N. | 12 W. |
| Tip Top mine and adjacent properties | Au | 7 | 10 N. | 12 W. |
| Tropico mine and adjacent properties | Au | 11, 14 | 9 N. | 13 W. |
| Los Angeles County | | | | |
| Elma Conn | ------- | 11, 12 | 5 N. | 12 W. |

Appendix 1.--Properties examined with negative results (by counties).--Continued

| Name | Product | Section | Location<br>Township | Range |
|---|---|---|---|---|
| Mono County | | | | |
| Casa Diablo | Au | 21 | 4 S. | 31 E. |
| Sierra Vista | Au | 32 | 3 S. | 31 E. |
| Gold Crown | Au | 8 | 3 S. | 31 E. |
| Carbonate claims | Pb, Cu | 2 | 4 S. | 31 E. |
| Valley View group | Pb, Cu | 2 | 4 S. | 31 E. |
| Orange County | | | | |
| Wesley R. Collins property --- 1756 Pomona Avenue, Costa Mesa | | | | |
| Plumas County | | | | |
| Highgrade claims Nos. 1 and 2 | Mn | 29 | 26 N. | 11 E. |
| Iron dyke | Mn | 27 | 26 N. | 9 E. |
| Riverside County | | | | |
| Cajalco Tin mine and surrounding area | | | 4 S. | 5, 6 W. |
| Mueller-Kelley prospect | Cu --- 2 1/2 mi. S. 16° W. of Midland | | | |
| Marshall Ranch | ----- | 24 | 2 S. | 1 W. |
| Unknown | Pb | ? | 7 S. | 17 E. |



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Appendix 1. --Properties examined with negative results (by counties). --Continued

| Name | Product | Section | Location<br>Township | Range |
|---|---|---|---|---|
| San Benito County | | | | |
| Alpine mine | Hg | 13 | 18 S. | 11 E. |
| Anita (Esperanza) mine | Hg | 17 | 18 S. | 13 E. |
| Breen mine | Hg | 31 | 18 S. | 12 E. |
| Gem mine | ? | 25 | 18 S. | 12 E. |
| Juniper mine | Hg | 11 | 16 S. | 10 E. |
| North Star mine | Hg | 2 | 18 S. | 11 E. |
| Wonder mine | Hg | 31 | 17 S. | 12 E. |
| San Bernardino County | | | | |
| Barium Queen | Ba | 22, 27 | 10 N. | 1 W. |
| Van Duzen Canyon | Pb ?, limestone | 3 | 2 N. | 1 E. |
| Rose mine | Au | 19, 20 | 2 N. | 3 E. |
| Duncan Tungsten prospect | $WO_3$ | 31 | 2 N. | 3 E. |
| Tungsten Prospecting Assoc. claims | $WO_3$ | 13 | 2 N. | 2 E. |
| Giant Ledge, Hard Cash claims | Cu, Pb, $WO_3$ | ? | 14 N. | 16 E. |
| Sagamore mine | Pb, Zn, $WO_3$ | 32, 33 | 14 N. | 16 E. |

Appendix 1. -- Properties examined with negative results (by counties). --Continued

| Name | Product | Section | Location<br>Township | Range |
|---|---|---|---|---|
| San Bernardino County--con. | | | | |
| Blew Jordon Zinc prospect | Zn | 30 | 2 N. | 6 W. |
| Blue Nugget Copper claims | Cu | 31 | 9 N. | 3 W. |
| Lead Mountain mine | Ba, Pb | 36 | 10 N. | 1 W. |
| White Cloud | Silica | 35 | 29 S. | 44 E. |
| U. S. Bentonite | | 32 | 28 S. | 41 E. |
| Granite Wells prospect ? | Cu | ? | 29 S. | 44 E. |
| Atolia mine and adjacent properties | $WO_3$ | 19, 20 | 30 S. | 41 E. |
| Atolia-Rand placers | $WO_3$ | 19, 30 | 30 S. | 41 E. |
| San Diego County | | | | |
| Schmitt-Mitt property | ? | ? | 18 S. | 1 E. |
| Siskiyou County | | | | |
| Keystone Asbestos property | Chrysotile, Cr | 34 | 40 N. | 9 W. |
| Siskon mine | Au, Cu ? | ? | SW 1/4 14 N. | 8 W. |
| Tamarack Lake area | asbestos | 33 | 38 N. | 5 W. |
| Wangoodlord tungsten claims | $WO_3$ | 19, 30 | 39 N. | 12 W. |