Selected Annotated Bibliography of the Geology of Uranium-Bearing Veins in the United States

GEOLOGICAL SURVEY BULLETIN 1059-G

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By BASIL G. DEAN

SELECTED BIBLIOGRAPHIES OF URANIUM GEOLOGY

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SELECTED ANNOTATED BIBLIOGRAPHY OF THE GEOLOGY OF URANIUM-BEARING VEINS IN THE UNITED STATES

By BASIL G. DEAN

ABSTRACT

This bibliography of 211 annotated references lists reports available as of June 1957. The annotations, arranged alphabetically by author, emphasize the geologic aspects of veins that contain uranium. An index map shows the location of vein deposits referred to in the annotations. Indexes are provided with entries listed according to author, geographic area, and subject.

INTRODUCTION

Uranium-bearing veins are common in the United States and have yielded a considerable tonnage of uranium ore, although this tonnage is not so large as that from disseminated deposits in sedimentary rocks (Everhart, 1956, p. 97; Stocking and Page, 1956, p. 5). Before World War II, uranium ore had been produced from only a few vein deposits in the United States. The most important were those in the Central City district, Colorado, from which about 300 tons of high-grade pitchblende concentrates were produced (Moore and Kithil, 1913). Smaller amounts of uranium ore were produced from uranium-bearing veins at the Silver Cliff mine, Wyoming; the Jesse D No. 1 and No. 2 claims, Utah; and the Merry Widow mine, New Mexico.

Since World War II large uranium-bearing vein deposits have been discovered in the Western United States. Some of the more important discoveries are the deposits at Marysvale, Utah; the Schwartzwalder (Ralston Creek) and Los Ochos mines, Colorado; the Early Day and Buckhorn claims, Nevada; the Midnite and Daybreak mines, Washington; the W. Wilson mine, Montana; the White King mine, Oregon; the deposits in the Pryor Mountains area, Montana and Wyoming, and the deposits in the Dripping Spring quartzite, Gila County, Ariz.

According to Nininger (1954, p. 43), as of 1954, uranium-bearing vein deposits outside the United States had yielded by far the largest part of the total world production of uranium. Most of this production was from the deposit at Shinkolobwe, Belgian Congo, and from the Eldorado mine, Great Bear Lake, Canada. The Shinkolobwe deposit since its initial development in 1921 and until 1954 probably had yielded more uranium than all other deposits together (Nininger, 1954, p. 43). Other important foreign uranium-bearing vein deposits, some of which have yielded large amounts of uranium ore, include those near Joachimsthal (Jachymov), Czechoslovakia, and adjacent areas in Saxony; the Beaverlodge district, Canada; the Cornwall district, England; the Guarda and adjacent districts in Portugal; and the deposits at Radium Hill, South Australia.

Many concepts regarding the geology of uranium-bearing veins are based on studies of the foreign deposits listed above, most of which have been known for many years. In contrast to these deposits, the important uranium-bearing veins in the United States—except for some in the Central City district, Colorado—were discovered since the mid–1940's. The study and development of deposits in the United States are in relatively early stages, and the literature on domestic deposits has not influenced geologic thinking as much as the literature on the previously known foreign deposits.

Because of the influence imparted by the literature describing the uranium-bearing veins at Joachimsthal, Shinkolobwe, and Great Bear Lake, and because many of the following annotations describing uranium-bearing veins in the United States refer to these deposits, the following selected references on these three important deposits are listed below.

SELECTED REFERENCES

DEPOSITS NEAR JOACHIMSTHAL, CZECHOSLOVAKIA

Hess, F. L., 1913, Uranium and vanadium: U. S. Geol. Survey Mineral Resources U. S., 1912, p. 1003–1037, see p. 1020–1023.

Kohl, E., 1942, Grossdeutschlands Vorkommen Naturlich-Radioktiver Stoffe und der Dedeutung für die Versorgung mit Radioaktiver Substanzen: Zeitschr. für das Berg-, Hütten- und Salinenwesen, v. 90, no. 8, p. 153–177.

Merritt, P. L., 1949, Pitchblende, the primary source of uranium: Michigan Coll. Mining and Technology, Conf. on Radioactive Ores, May 6, 1949, p. 9.

Step, J., and Becke, F., 1904, Das Vorkommen des Uranpecherzes zu St. Joachimsthal: Akad. Wiss. Wien, Math.-naturw. Kl., Sitzungsber., v. 118, p. 585–618.

Zuckert, R., 1926, Die Paragenesen von Gediegen Silber und Wismut mit Kobalt-Nickel-Kiesen und der Uranpechlende zu St. Joachimsthal: Preussiche Geol. Landesandst., Mitt. Abt. für Gesteins-, Erz-, Kohle-, und Salz-Untersuchungen, p. 69–132 [English abstract *in* Geol. Soc. America Bull. v. 46, 1935, p. 942–943.]

SHINKOLOBWE DEPOSIT, BELGIAN CONGO

Derriks, J. J., and Vaes, J. F., 1956, The Shinkolobwe uranium deposit, current status of our geological and metallogenic knowledge: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium, p. 94–128.

Merritt, P. L., 1949, Pitchblende, the primary source of uranium: Michigan Coll. Mining and Technology, Conf. on Radioactive Ores, May 6, 1949, p. 10–11.

Schuiling, H. J., 1930, The structure of the Kambove mine: Internat. Geol. Cong., 15th, South Africa 1929, Comptes rendus, v. 2, p. 446–453.

Thoreau, J., and Trieu de Terdonck, R. du, 1933, Le Gite d'uranium de Shinkolobwe-Kasolo (Katanga): Inst. Royal Colonial Belge, Mem., Colln. in quarto no. 2. [English abstracts *in* U. S. Bur. Mines, Minerals Yearbook, 1934, p. 499–502; Geol. Soc. America Bull., v. 46, p. 941–942.]

DEPOSITS AT GREAT BEAR LAKE, CANADA

Kidd, D. F., 1932, A pitchblende-silver deposit, Great Bear Lake, Canada: Econ. Geology, v. 27, p. 145–159.

——— 1942, The silver-pitchblende deposits near Great Bear Lake, Northwest Territories, *in* Newhouse, W. N., ed., Ore deposits as related to structural features: Princeton, N. J., Princeton Univ. Press, p. 238–239.

Kidd, D. F., and Haycock, M. H., 1935, Mineragraphy of the ores of Great Bear Lake: Geol. Soc. America Bull., v. 46, p. 879–960.

Merritt, P. L., 1949, Pitchblende, the primary source of uranium: Michigan Coll. Mining and Technology, Conf. on Radioactive Ores, May 6, 1949, p. 9–10.

Murphy, Richard, 1946, Geology and mineralogy at Eldorado mine: Canadian Mining Metall. Bull. 413; Canadian Inst. Mining Metallurgy Trans., v. 49, p. 426–435.

——— 1948, Eldorado mine [Northwest Territories], *in* Canadian Inst. Mining Metallurgy, Geol. Div., Structural geology of Canadian ore deposits, p. 259–268.

EXPLANATION OF ANNOTATED BIBLIOGRAPHY

This annotated bibliography of selected literature on the geology of uranium-bearing vein deposits in the United States lists reports available to the public as of June 1957. The literature includes published reports, open-file reports of the Geological Survey, and reports on file in depository libraries of the Atomic Energy Commission.

Reports pertaining primarily to the geochemistry of uranium and based largely on laboratory experiments have not been annotated, although the information presented may be applicable to the study of uranium-bearing veins. Similarly, reports pertaining primarily to isotopic age determinations have not been annotated.

The annotated reports have been selected to include those which discuss vein-type deposits containing abnormal concentrations of uranium or uranium minerals and which contribute to the geologic knowledge of such deposits. Many of the deposits described are of geologic interest only and have no apparent potential for production of uranium ore. References to areas or deposits for which several reports are available have been selected to present the most complete coverage of geologic information and the various conclusions reached by different authors. The stratigraphic nomenclature is that of the various authors and does not necessarily follow the usage of the U. S. Geological Survey.

Many reports included in the annotations discuss uranium deposits of several geologic types; however, the annotations for the most part refer only to that part of the report discussing deposits which may be considered as veins. The author has considered as veins, deposits having the characteristics that are outlined below. These characteristics are taken from an unpublished report by G. W. Walker and F. W. Osterwald.

Veins are masses of minerals occupying or filling a fracture or set of fractures in the enclosing rock. The veins were formed later than the fractures and enclosing rock by filling of open spaces and, in some places, with partial or complete replacement of the adjoining rocks. Veins are commonly, but are not universally, tabular in shape on either a large or small scale. The fractures or sets of fractures may be the result of compressive, tensile, or torsional stresses related to folding, faulting, and (or) intrusion of igneous masses. They may also be related to volcanic pipes, collapse breccias, and to near-surface postsedimentation slumping and release of stress. Only those deposits in which fractures dominated in localizing the introduced minerals are included in this bibliography. Many other types of uranium deposits localized dominantly by favorable wallrocks or by original cavities and structures in the rock may show some vein characteristics where fractures were partly instrumental in localizing the introduced minerals. Uranium veins include deposits that are localized primarily by fractures irrespective of the valence state of the uranium or the character of any associated metallic or nonmetallic minerals.

The annotations are arranged alphabetically by authors; if an author has written more than one report, the reports are listed chronologically. Coauthors are indexed alphabetically under

"Authors." The annotations are numbered consecutively for indexing. The indexes include an author index, a subject index, and a geographic index of localities mentioned in the annotations.

An index map (pl. 4) shows the location of vein deposits referred to in the annotations.

This compilation was done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

ANNOTATED BIBLIOGRAPHY

1 Adams, J. W., 1953, Beryllium deposits of the Mount Antero region, Chaffee County, Colorado: U. S. Geol. Survey Bull. 982-D, p. 95-119.

A beryl-bearing quartz vein, once mined for molybdenite, occurs in quartz monzonite at the California mine southwest of Mount Antero. Mineralogical study shows that some of the beryl was formed during the deposition of molybdenite. Brannerite, an oxide of titanium and uranium, was identified in material collected from the mine dump. The vein at the California mine is 1½ to 3 feet thick where exposed, is nearly vertical, strikes N. 72°-75° E., and is thought to extend for at least 1,000 feet along the strike to the northeast.

Beryl-bearing quartz veins similar to this vein are of world-wide distribution. They contain molybdenum, tin, tungsten, and bismuth and are believed to be transitional between pegmatites and hydrothermal veins.—*Excerpts from author's abstract*

2 Adams, J. W., Gude, A. J., 3d, and Beroni, E. P., 1953, Uranium occurrences in the Golden Gate Canyon and Ralston Creek areas, Jefferson County, Colorado: U. S. Geol. Survey Circ. 320, 16 p.

Pitchblende, associated with base-metal sulfides, has been found at nine localities in the northern part of Jefferson County, Colo., in shear zones that cut Precambrian metamorphic and igneous rocks, chiefly hornblende gneiss, biotite schist, and granite pegmatite. The known deposits are in the vicinity of Ralston Creek and Golden Gate Canyon, in the foothills of the Colorado Front Range and about 15 miles east of the pitchblende-producing area of the Central City district. Two of the pitchblende occurrences were found by a local prospector in 1949; the seven other deposits were found by Geological Survey personnel in 1951-52.

The pitchblende deposits, with one exception, are in major shear zones that contain veinlike bodies of carbonate-rich breccia that ranges from 1 to 5 feet in thickness. The breccias probably are related to the Laramide faults, or "breccia reefs" of similar trend, mapped by Lovering and Goddard. The breccias are composed of fragments of bleached and iron-stained wall rock, usually hornblende gneiss, that have been cut by veins and cemented by carbonate minerals, quartz, and orthoclase(?). Pitchblende and associated ore minerals, chiefly copper sulfides, occur in and along the margins of the breccias and apparently were introduced at a late stage of the carbonate deposition. At one deposit, the Buckman, the pitchblende is in narrow shear zones not closely related to any large breccia bodies.

Secondary uranium minerals are subordinate except at the Schwartzwalder mine, where torbernite and metatorbernite are common. Some alteration of pitchblende to nonopaque materials, believed to be hydrated oxides, has been noted in ore from two of the deposits.—*Authors' abstract*

This report describes the geology of each of the following deposits: In the Golden Gate Canyon area—Union Pacific prospect, Buckman property, and

Ladwig Nos. 1–3; in the Ralston Creek area—North Star mine, Schwartzwalder mine (Ralston Creek), and Nigger shaft (Hoffmeister prospect). Maps and cross sections of several of the properties and a table showing sample analyses from several properties are included.

3 Adams, J. W., and Stugard, Frederick, Jr., 1956, Wall-rock control of certain pitchblende deposits in Golden Gate Canyon, Jefferson County, Colorado: U. S. Geol. Survey Bull. 1030–G, p. 187–209; U. S. Geol. Survey Prof. Paper 300, p. 113-116; Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium, p. 279-282.

Carbonate veins cutting metamorphic rocks of Precambrian age in the Golden Gate Canyon area, Colorado, contain pitchblende and base-metal minerals. The veins occupy extensive faults considered to be of Laramide (earliest Tertiary) age, but normally contain pitchblende only where they cut hornblende gneiss. At the Union Pacific deposit, which was studied in detail, pitchblende, hematite, and some ankerite formed before the sulfide minerals, except possibly for minor earlier pyrite. Base-metal minerals and the bulk of the ankerite vein filling were deposited after the pitchblende. Chemical analyses show a high ferrous iron content in the hornblende gneiss in contrast to low ferrous iron in the adjacent biotite gneiss. It is thought that ferrous iron released by alteration of hornblende was partly oxidized to hematite by the ore-bearing solutions, and, contemporaneously, uranium was reduced and deposited as pitchblende.

In other veins that are not in hornblende gneiss, biotite or iron sulfide may have been similarly effective in precipitating pitchblende. Apparently both the ferrous ion and the sulfide ion can serve as reducing agents and control pitchblende deposition. Conditions that seem favorable for uranium deposition include those where uranium-bearing solutions had access to rocks rich in ferrous iron or preexisting sulfide minerals.—*Authors' abstract*

Geologic maps and sections of some deposits in Golden Gate Canyon are included.

4 Alsdorf, P. R., 1916, Occurrence, geology, and economic value of pitchblende deposits in Gilpin County, Colorado: Econ. Geology, v. 11, p. 266-275.

The pitchblende producing mines, or those in which pitchblende has been reported in the Quartz Hill area of Gilpin County, Colo., are in the vicinity of radioactive bostonite porphyry dikes of probable Tertiary age. Pitchblende, accompanied by some pyrite and galena, was deposited in fractures formed at about the time of the intrusion of the radioactive dikes, but before the main period of sulfide mineralization. The source of the pitchblende mineralization is believed to have been "deep-seated hot solutions, which are either genetically connected with the bostonite dikes or with their source." This mineralization involved both fracture filling and replacement of "the alkaline earths of the granites, so as to produce a type of vein in which, in the granites, there are no well-defined walls, but disseminated mineralization. The pitchblende veins are cut across, followed and obliterated by the subsequent faulting and vein filling of the period of the precious metal veins."

Although pitchblende has been found in both the veins and the porphyry dikes, commercial quantities were found only in veins that are enclosed by Precambrian wallrocks including the older altered granites, the younger intrusive granites, the granitic schists and gneiss, and, locally, the schists of the Idaho Springs formation, close to or in contact with the igneous rocks.

5 Anderson, E. C., 1955, Occurrences of uranium ores in New Mexico: New Mexico Bur. Mines and Mineral Resources Circ. 29, 32 p.

The known occurrences of uranium in New Mexico are briefly summarized by counties. Only the vein deposits are described in this annotation.

Uranium occurs in subore and ore grade at many places throughout the White Signal district, Grant County. The uranium is principally in autunite and torbernite in quartz pyrite veins that cut granite of Precambrian age. Pitchblende-bearing veins in the Black Hawk district, Grant County, contain nickel, cobalt, and silver minerals. At the Hines and Langford mines, Grant County, minor amounts of autunite and uranophane are associated with fluorite.

Autunite is reported in massive quartz veins that cut limestone and sandstone of Early Cretaceous age in southeastern Hidalgo County. Uranium and thorium are in shear zones cutting Dakota sandstone and shale in eastern Colfax County and in fractures and breccia zones cutting monzonite on Capitan Mountain, Lincoln County. Minor amounts of pitchblende occur along a thin shear zone in Precambrian schist near Truth and Consequences, Sierra County. At the Terry Bros.' property near Monticello, Sierra County, uranophane is associated with dark-purple fluorite in brecciated chert. Uranium is associated with thorium, fluorite, and galena in seams and fractures in highly altered granite near the southern end of the Caballo Mountains, Sierra County. In the Rocky Arroyo area, Eddy County, 40 miles northwest of Carlsbad, uranium in limestone is associated with a black vitreous asphalt-appearing material in fractures and as blebs and specks.

6 Argall, G. O., Jr., 1954, Why Anaconda's uranium mines are unique: Mining World, v. 16, no. 10, p. 54-59.

An airborne radiometric survey led to the discovery of an unusual uranium ore body about 6 miles north of Laguna, Valencia County, N. Mex. This deposit, known as the Woodrow mine, is in a "ring fault," or "breccia pipe," cutting shale, sandstone, and limy sandstone of the Morrison formation of Jurassic age. The breccia pipe is almost circular in plan with a diameter of 30 feet. The pipe is cone shaped, increasing in diameter with depth, and plunges about 75° SE. The center of the pipe has apparently dropped about 15 feet. The ore body contains oxide and silicate minerals, including uraninite and coffinite, intimately associated with asphaltic matter. Iron sulfides are also present.

The deposit may be of very recent age, because, in spite of intensive faulting and ground water circulation, secondary minerals extend only a few feet below the surface.

7 Armstrong, F. C., 1957, Eastern and central Montana as a possible source area of uranium: Econ. Geology, v. 52, p. 211–224.

Deposits of tyuyamunite in concentrations of ore grade occur along the crest and flanks of the Pryor Mountains in south-central Montana. The tyuyamunite fills and coats the walls of fractures and vugs in cherty and silicified breccia zones at or near the top of the Mission Canyon(?) limestone in the Madison group of Mississippian age. Tyuyamunite also fills and coats the walls of fractures and vugs in thin beds of silicified limestmne near the top of the Amsden formation (Mississippian and Pennsylvanian) which disconformably overlies the Madison group. The breccia zones in the Madison probably formed as the result of solution and collapse of the Mission Canyon at the time of the formation of the disconformity between the Madison and Amsden.

8 Armstrong, F. C., and Weis, P. L., 1955, The Garm-Lamoreaux mine, Lemhi County, Idaho: U. S. Geol. Survey open-file report, 14 p.

Uraninite and zippeite were found on the dump of the Garm-Lamoreaux mine, 11 miles northwest of North Fork, Idaho. The uranium minerals are believed to have come from a gold-sulfide-quartz vein on the now inaccessible No. 3 level. The vein is in quartzite of the Belt series of Precambrian age. The uranium content of samples collected from the dump ranges from 0.001 to 0.54 percent.

The report contains a surface sketch map and a composite underground geologic map of the Garm-Lamoreaux mine. A table summarizing information on samples obtained from the property is included.

9 Axelrod, J. M., Grimaldi, F. S., Milton, Charles, and Murata, K. J., 1951, The uranium minerals from the Hillside mine, Yavapai County, Arizona: Am. Mineralogist, v. 36, p. 1-22.

Several hitherto unknown secondary uranium minerals from the Hillside mine, about 3½ miles north of Bagdad, Yavapai County, Ariz., are described. This mine has yielded gold, silver, lead, and zinc from a vein several feet thick containing pyrite, arsenopyrite, galena, sphalerite chalcopyrite, tetrahedrite, and argentite. Minerals of the oxidation zone include silver, cerargyrite, cerussite, anglesite, smithsonite, and hemimorphite. The country rock is Precambrian mica schist intruded by Precambrian granite and related small aplite pegmatite dikes. The mineralization is probably of Cretaceous or early Tertiary age. Faulting has occurred both before and after mineralization.

Secondary uranium minerals coat gypsum on the walls of the drift in the oxidized zone on the 300-foot level of the mine. Three of the four uranium minerals were hitherto unknown, and are named andersonite, swartzite, and bayleyite. They are respectively, hydrous uranyl carbonates of sodium and calcium, of calcium and magnesium, and of magnesium. The fourth uranium mineral is schroeckingerite. The source of the uranium is unknown, but it may have come from primary uranium minerals in the sulfide vein or from the aplite pegmatite dikes in the country rock. A specimen of uranium-bearing ore from the 400-foot level of the mine contains a completely different group of uranium minerals including johannite, pitchblende, and a probably new zinc uranium sulfate.

10 Bain, G. W., 1950, Geology of the fissionable materials: Econ. Geology, v. 45, p. 273-323.

The uranium and thorium deposits of the world are discussed and classified as primary or hypogene deposits, sedimentary or bedded deposits, and oxidized deposits.

Primary deposits include pegmatites, high-temperature fissure veins, and mesothermal fissure veins. In 1950 mesothermal vein deposits were the principal source of uranium ore.

The principal primary uranium deposits are either in massifs or close to the margins of shields. The center of shields have no known or indicated concentrations of uranium mineralization. Economic vein deposits are unknown in uraniferous pegmatite provinces.

The uranium-bearing mesothermal fissure veins are grouped into a cobaltite-niccolite type and a fluorite type. The more important uranium-bearing veins of the world are of the cobaltite-niccolite type. The fluorite type do not seem to be significantly uraniferous.

Oxidized secondary deposits containing brightly colored secondary uranium minerals are generally in fracture zones where movement of ground water is concentrated. The uranium may have been leached by ground water from primary pegmatites and veins or from sedimentary secondary deposits. The uranium is removed from solution by phosphate or vanadate precipitants or by lime which lowers the acidity and reduces the solubility of phosphate and vanadate compounds.

The report summarizes the geology of the more important uranium-bearing veins of the world including those at Shinkolobwe, Belgian Congo; Eldorado mine, Canada; Erzgebirge region of Czechoslovakia; Cornwall, England; and the Urgerica mine and others in Portugal.

11 Barrett, D. C., and Magleby, D. N., 1954, Airborne radiometric survey, Kern and San Bernardino Counties, California, and Nye County, Nevada: U. S. Atomic Energy Comm. RME–2015, 17 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The results of an airborne radiometric survey of about 180 square miles in the western Mojave Desert are described. Rocks in the area range in age from Precambrian to Quaternary and are chiefly igneous. Six anomalies were discovered, one of which may indicate a uranium deposit of possible commercial value. The report includes a brief geologic description of the six anomalies and of other areas that have high background radioactivity. Uranium mineralization in the area may have been localized by faulting because the pattern of anomalies seems to follow the trend of the Garlock fault. Some anomalies are in or near small local faults.

The most promising anomaly revealed uranium at a contact between coarsely crystalline granite and porphyritic latite, in sec. 10, T. 9 N., R. 13 W. in Kern County, Calif. Meta-autunite and autunite were identified from a test pit. A selected sample from the test pit contained 0.41 percent U_3O_8 and 0.03 percent V_2O_5.

An anomaly about ½ mile southeast of the Rosamond uranium prospect in Kern County is caused by radioactivity in brecciated veins of black and brown to dark-red chalcedonic quartz within a zone of siliceous red-stained coarse-grained granite. No uranium minerals are visible. A grab sample from this deposit contained 0.08 percent U_3O_8 and 0.08 percent V_2O_5.

The report includes maps showing the areas surveyed, radioactivity anomalies, areas of high background radioactivity, and radioactive areas known before the survey.

12 Barton, P. B., Jr., and Behre, C. H., Jr., 1954, Interpretation and evaluation of the uranium occurrences near Goodsprings, Nevada, final report: U. S. Atomic Energy Comm. RME–3119, 108 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The uranium occurrences near Goodsprings in southwestern Clark County, Nev., are of two distinct types. One type consists of widespread minor occurrences of carnotite in thin coatings on fractures in sedimentary rocks of late Paleozoic age and in tuff and gravel of Tertiary and Quaternary age. The deposits are in otherwise unmineralized rocks east of the Goodsprings mining district. The uranium probably was derived from a tuff that formerly covered the region. The uranium was deposited probably by ground water along joints and minor faults.

The other type of uranium deposits are associated with ores in mines of the Goodsprings district which has yielded considerable amounts of zinc and lead and small amounts of copper, silver, gold, platinum, cobalt, vanadium, and uranium. Oxidized minerals form the bulk of the ores that are localized along faults in dolomitized limestone of late Paleozoic age. Although radioactive material has been found in many of the mines, the uranium metallization was very weak. No uranium ore has been shipped from the district except for a small experimental shipment from the Green Monster mine in 1951. No primary uranium minerals have been found. Secondary uranium minerals are at the Green Monster and Singer Tiffin mines and at the Desert Valley prospect. At most mines there are no visible uranium minerals, and radioactivity is concentrated in limonite, hydrozincite, or chrysocolla.

Uranium was probably absorbed from solution by these materials while they were in a fine-grained or colloidal state during their formation. Upon crystallization of the absorbent, the uranium was either returned to solution, or, if no solution was present, formed secondary uranium minerals. The source of the original uranium probably was pitchblende deposited with the base-metal sulfide ores.

The report contains stratigraphic columns, geologic maps, and tables. The important occurrences of uranium minerals or radioactivity are described in the text, and a table summarizes the radioactivity observed in the mines and prospects.

13 Bastin, E. S., 1915, Geology of the pitchblende ores of Colorado: U. S. Geol. Survey Prof. Paper 90–A, p. 1–5.

The author briefly reviews the sources and production of uranium ore in the United States between 1911 and 1913. Two hundred seventy-five pounds of pitchblende was produced from veins on Quartz Hill, near Central City, Colo. The geology of these pitchblende-bearing veins and of those in the Erzgebirge region of Saxony and Bohemia and in the Cornwall district of England are briefly summarized.

The Quartz Hill area is underlain by Precambrian crystalline rocks consisting of quartz-mica schist of the Idaho Springs formation intruded by Precambrian granites of at least two ages. The Precambrian rocks are intruded by Tertiary dikes and stocks of monzonite porphyry and bostonite porphyry. The pitchblende occurs in sulfide veins that are the result of combined fissure filling and replacement along a series of steeply dipping fractures which trend east to northeast and which cut both the Precambrian and Tertiary rocks. On the basis of their mineral composition, the sulfide veins may be divided into a pyritic type and a lead-zinc type. They have been worked principally for their precious metal content, though yielding also considerable amounts of copper and lead.

Minerals of the pyritic type are chiefly pyrite and quartz, commonly chalcopyrite and tetrahedrite, and less commonly enargite, fluorite, and rhodochrosite. Veins of the lead-zinc type commonly contain galena, sphalerite, pyrite, chalcopyrite, quartz, and calcite. Some parts of the district contain only one or the other of these types of mineralization, but many veins contain both. The lead-zinc type is later than, but closely followed, the pyritic mineralization. The two types probably represent successive epochs in one great vein-forming period. The ore-bearing solutions probably came from a common deep-seated source shortly after the monzonite intrusion.

The pitchblende ores are a local and unusual variation in the main sulfide mineralization, and were deposited during the earlier or pyritic mineralization. The pitchblende probably was deposited under conditions of moderate temperature and pressure. Unlike the European pitchblende, the pitchblende of Quartz Hill is not associated with nickel and cobalt minerals.

14 Bastin, E. S., 1916, Discussion—Occurrence, geology, and economic value of the pitchblende deposits of Gilpin County, Colorado: Econ. Geology, v. 11, p. 681–685.

This paper is a discussion of the paper by Alsdorf [annotation 4] on the pitchblende deposits in Gilpin County, Colo. Bastin and Alsdorf agree that the pitchblende-bearing solutions emanated "from the same source or sources as certain of the Tertiary intrusive rocks." However, they differ on "the precise sequence of events within the general period of Tertiary mineralization* * *."

Bastin does not believe Alsdorf's inference of a genetic relationship between two radioactive bostonite dikes on Quartz Hill and the pitchblende deposits is "supported by the broader geologic relations, which show that the bostonites are widespread outside the Quartz Hill pitchblende area, and also conversely that pitchblende occurs in the Jo Reynolds mine near Lawson not in known proximity to bostonite."

Bastin questions Alsdorf's suggestion that the pitchblende mineralization is earlier than the main sulfide mineralization which is believed to have occurred shortly after the intrusion of the monzonite. Alsdorf has based his opinion in part on the suggested genetic relationship between the pitchblende mineralization and the bostonite dikes which he believed were intruded before the monzonites. Bastin, however, points out that, in spite of careful search, no exposures have been found which show the mutual age relations of the monzonites and bostonites. According to Bastin, the main sulfide mineralization was later than at least some of the bostonites and monzonites and consisted of an early pyritic type which has been brecciated and "filled with ore containing principally galena and sphalerite with subordinate chalcopyrite and pyrite." Microscopic study of many specimens of rich pitchblende ore show much of the pitchblende intimately intergrown with pyrite and chalcopyrite, indicating nearly simultaneous crystallization of these minerals. "On the other hand, fractured or brecciated pitchblende has been cemented by galena, pyrite, and chalcopyrite * * *." Bastin states that, although the pyrite and chalcopyrite contemporaneously intergrown with the pitchblende may belong to an earlier period of mineralization than the pyritic chalcopyrite ores of the district, no specific evidence of this has been presented by Alsdorf.

Bastin concludes "that the pitchblende ores are a local variation of the widespread pyrite-chalcopyrite mineralization characteristic of this region, and are of the same order as other local variations observed in the same region, notably the presence of enargite in the pyritic veins of one locality, and of rhodochrosite in the galena-sphalerite veins of another locality."

15 Becraft, G. E., 1953, Preliminary report on the Comet area, Jefferson County, Montana: U. S. Geol. Survey Circ. 277, 8 p.

Several radioactive anomalies and a few specimens of sooty pitchblende and other uranium minerals have been found on the mine dumps of abandoned formerly productive base- and precious-metal mines along the Comet-Gray Eagle shear zone in the Comet area in southwestern Montana. The shear zone is from 50 to 200 feet wide and has been traced for at least 5½ miles. It trends N. 80° W. across the northern part of the area and cuts the quartz monzonitic rocks of the Boulder batholith and younger silicic intrusive rocks, as well as prebatholitic volcanic rocks, and is in turn cut by dacite and andesite dikes.

The youngest period of mineralization is represented by chalcedonic vein zones comprising one or more discontinuous stringers and veins of cryptocrystalline silica in silicified quartz monzonite and in alaskite that has not been appreciably silicified. In some places these zones contain no distinct chalcedonic veins but are represented only by silicified quartz monzonite. These zones locally contain uranium in association with very small amounts of pyrite, galena, ruby silver, argentite, native silver, molybdenite, chalcopyrite, arsenopyrite, and barite. At the Free Enterprise mine, uranium has been produced from a narrow chalcedonic vein that contains disseminated secondary uranium minerals and local small pods of pitchblende and also from disseminated secondary uranium minerals in the adjacent quartz monzonite.

Undiscovered deposits of uranium ore may occur spatially associated with the base- and precious-metal deposits along the Comet-Gray Eagle shear zone and with chalcedonic vein zones similar to the Free Enterprise.—*Author's abstract*

A geologic map of the Comet area showing radioactivity anomalies is included.

16 Becraft, G. E., 1956, Uranium deposits of the Boulder batholith, Montana: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium, p. 270–274; U. S. Geol. Survey Prof. Paper 300, p. 117–121.

Becraft, G. E., 1956, Uranium deposits of the northern part of the Boulder batholith, Montana: Econ. Geology, v. 51, p. 362–374.

Uranium minerals and radioactivity anomalies occur in silver-lead veins and chalcedony veins and vein zones in the Boulder batholith of southwestern Montana. Many silver-lead veins in the batholith contain radioactive material, and pitchblende has been identified in a few. These silver-lead veins occupy faults cutting quartz monzonite and granodiorite. Although the displacement along the faults is slight, the wall rock adjacent to most faults is intensely silicified and sericitized. The veins have yielded substantial quantities of lead, silver, zinc, and gold. The silver-lead veins consist principally of galena, sphalerite, tetrahedrite, chalcopyrite, and pyrite in the gangue of light- to dark-gray quartz, altered rock, gouge, and subordinate chalcedony and carbonate minerals. No anomalous radioactivity or uranium minerals have been found in similar veins in prebatholithic rocks of the area.

Chalcedony veins, some of which are uraniferous, are distinctly different from the silver-lead veins, and, with a single exception, are known only in the batholith. The veins consist of one or more discontinuous stringers or veins of chalcedony and slightly coarser grained quartz in silicified and sericitized quartz monzonite and granodiorite and in less strongly altered alaskite. Only small amounts of silver ore have been produced from these chalcedony veins.

All of the veins are early Tertiary in age, but the silver-lead veins are probably older than the chalcedony veins. Uranium is closely associated with chalcedony in both types of veins. This association suggests that all of the uranium in the area is of the same age. If so, some of the silver-lead veins must have been reopened during the period of chalcedony vein formation.—*Author's abstract*

The reports contain a generalized geologic map of the northern part of the Boulder batholith showing uranium deposits and radioactivity anomalies.

17 Bergin, M. J., 1955, Maybell-Lay area, Moffat County, Colorado, *in* Geologic investigations of radioactive deposits—Semiannual progress report, June 1 to Nov. 30, 1955: U. S. Geol. Survey TEI-590, p. 176–179, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Uranium deposits in the Maybell-Lay area in southeastern Moffat County, Colo., are in conglomerate and sandstone of the Browns Park formation of Miocene age. Uranium ore was mined from two deposits in the area. The uranium in these deposits occurs from the surface to depths as great as 200 feet. Drilling indicates the uranium ore bodies are circular to elongate bodies of irregular thickness. Some deposits in the area contain uranium in gouge zones along faults, coatings on fractures, and disseminated in soft sandstone. The uranium minerals include meta-autunite, uranophane, and zeunerite or torbernite. The deposits are on the steep flank of a syncline and along or close to normal faults of post-Miocene age, which suggests that the localization of uranium was controlled by these structures. Changes in permeability and porosity of the host rocks may also have been important factors in controlling the deposition of uranium.

The report includes a generalized geologic map showing configuration of the base of the Browns Park formation in the Maybell-Lay area.

18 Bergin, M. J., 1956, Maybell-Lay area, Moffat County, Colorado, *in* Geologic investigations of radioactive deposits—Semiannual progress report, June 1 to Nov. 30, 1956: U. S. Geol. Survey TEI-640, p. 141, issued by U. S. Atomic Energy Comm. Tech Inf. Service Ext., Oak Ridge, Tenn.

Approximately 100 tons of ore averaging at least 0.22 percent uranium have been mined from clayey sandstone gouge along a high-angle fault cutting the Browns Park formation in sec. 27, T. 7 N., R. 94 W. Meta-autunite occurs as disseminated material and as fracture coatings in the gouge zone which ranges from 2 to 6 feet thick. The fault strikes N. 20° E. and dips 78° W. but the amount and direction of displacement are not known.—*Excerpt from text*

19 Bethke, P. M., and Kerr, P. F., 1954, Uranium occurrences in the older sedimentary rocks of the Marysvale district, *in* Annual report, June 30, 1953, to Apr. 1, 1954: U. S. Atomic Energy Comm. RME–3096 (pt. 1), p. 60–74, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Uranium-bearing veins and replacement bodies containing base and precious metal minerals are in sedimentary rocks of probable Carboniferous to Middle Jurassic age along the eastern front of the Tushar Mountains south and west of Marysvale, Utah. At higher elevations on the Tushar range these rocks are unconformably overlain by the Bullion Canyon volcanics of Tertiary age. The sedimentary rocks are on the upthrown block of the Tushar fault, a major fault with a stratigraphic displacement of over 4,000 feet.

Significant concentrations of uranium in the sedimentary host rocks have been noted in the New Deer Trail, the Shamrock, and the Great Western mines. In all three deposits the uranium is associated with ore bodies containing galena, sphalerite, covellite, chalcopyrite, and pyrite.

At the New Deer Trail mine, autunite(?) is in an alteration zone on the border of a lead-zinc replacement ore body. Uranium ore-grade specimens containing minute grains of pitchblende disseminated in base-metal ore minerals have been obtained from a base metal-quartz vein at the Great Western mine. At the Shamrock mine, meta-autunite seems to be disseminated along fractures in the base metal-quartz vein.

Small vein and replacement deposits of alunite occur in the Bullion Canyon volcanics where they overlie the sedimentary rocks at higher elevations in the range. "The alunite is believed to represent deposition along hydrothermal alteration channels which may be synchronous with base and precious metal emplacement in the underlying sedimentary rocks. Small precious metal occurrences have been worked in the Bullion Canyon volcanics themselves."

20 Bird, A. G., and Stafford, H. S., 1955, Uranium deposits of the Colorado Front Range foothills region: Mines Mag. [Colorado] v. 45, no. 3, p. 81–82.

The Ralston Creek uranium deposit 8 miles northwest of Golden, Jefferson County, Colo., was discovered by Fred Schwartzwalder in 1949. Exploration revealed several uranium-bearing veins, and the first ore was shipped in November 1953. The uranium occurs in three sets of faults that cut hornblende gneiss of the Idaho Springs formation of Precambrian age. The major faults in the mine area strike between 35° and 40° NW. and dip from 45° to 80° NE. They are parallel to the adjacent Rogers reef, a major northwest-trending shear. Individual faults in the set are comparatively short, and their mineralized portions probably are not more than a few hundred feet long. The faults are strongly brecciated. Mineralization extends from the breccia zone into the wallrock for as much as 2 or 3 feet along fractures and foliation planes. A second set of fractures strikes parallel to the first set but dips 35° S. The best pitchblende is in heavily mineralized breccia zones at the intersections of these fractures with other faults. A third set of fractures trend parallel to the foliation of the gneiss, which in the mine area strikes northeast and dips 73° W. Veins occupying the third set of fractures are narrow and tight and contain largely clay gouge with a minimum of breccia. The clay generally contains uranium of only marginal commercial importance.

In addition to pitchblende and sooty uraninite, the various sets of fractures may contain abundant pyrite, chalcopyrite, galena, quartz, carbonates, and lesser amounts of molybdenum and vanadium minerals. The veins were brecciated by postmineralization movement and recemented by silica and carbonate minerals. The near-surface oxidized portions of the veins contain secondary iron, copper, and uranium minerals including torbernite, autunite, and uranophane. Below this near-surface zone is a transitional zone containing both highly colored secondary uranium minerals and sooty uraninite. Unoxidized sulfides, sooty uraninite, and pitchblende are beneath the transition zone. This sequence of zones commonly may be observed within 100 feet of the surface. At depths of about 100 feet the veins may be secondarily enriched with pitchblende and uraninite.

The intense folding and crushing of the country rock in the mineralized zone greatly increased its permeability, which facilitated widespread rock alteration including silicification, kaolinization, or sericitization.

21 Boutwell, J. M., 1905, Vanadium and uranium in southeastern Utah: U. S. Geol. Survey Bull. 260, p. 200–210.

A uranium-vanadium deposit, the Jesse D No. 1 and No. 2 claims, 2 miles east of Richardson, Grand County, Utah, is along a steeply dipping northeast-trending fracture zone, 5 to 25 feet wide, that cuts sandstone and shale of probable Carboniferous, Triassic, or Jurassic age. Carnotite and calciovolborthite and other vanadium minerals coat fractures and seem to replace sandstone host rock along the fracture zone. Small shipments of ore were made from the property in 1903 and 1904.

22 Boyd, F. S., Jr., and Bromley, C. P., 1953, Reconnaissance of the Aspen area, including the Smuggler mine, Pitkin County, Colorado: U. S. Atomic Energy Comm. RME–4031, 23 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

A radiometric reconnaissance in the Aspen area revealed uranium in breccia veins at the Smuggler mine half a mile east of Aspen. The uraniferous breccia is along a bedding-plane fault along the contact between dolomite of the Leadville limestone of Mississippian age and the Weber quartzite of Pennsylvanian age. These beds strike north-northeast and dip 50°–60° NW. The breccia is composed of fragments of dolomitic limestone in a matrix of black carbonaceous shale. The uranium is associated with variable amounts of lead, zinc, and silver sulfides and sulfosalts in the matrix adjacent to the hanging wall. No uranium minerals have been identified; however, most of the uranium probably is in finely disseminated pitchblende. The uranium may have been deposited during the last of three stages of mineralization. Some of the uranium may be of secondary origin, as indicated by its association with barite, native silver, and goslarite. Selected samples from the mine contain as much as 1.27 percent U_3O_8.

The report includes a geologic map of the Aspen area and plan maps and cross sections of mine workings.

23 Burbank, W. S., and Pierson, C. T., 1953, Preliminary results of radiometric reconnaissance of parts of the northwestern San Juan Mountains, Colorado: U. S. Geol. Survey Circ. 236, 11 p.

A reconnaissance radiometric survey of parts of the northwestern San Juan Mountains has revealed uranium-bearing ores in several mining districts in Ouray and San Juan Counties and thorium-bearing veins in southwestern Gunnison County.

Four types of uranium-bearing base-metal and precious-metal sulfide deposits were discovered in the Uncompahgre and Red Mountain districts of Ouray and San Juan Counties. These include (1) Pyritic impregnations, possibly of early Tertiary or much older age, containing uranium in sheared and drag-folded zones of Precambrian slates; (2) seams and impregnations of pitchblende(?)-bearing ores of early Tertiary age in black bituminous shales of the Pony Express limestone member of the Wanakah formation of Jurassic age; (3) pitchblende in late Tertiary chimney deposits in volcanic rocks of Tertiary age, of the Red Mountain district, in association with high-grade copper-silver-lead ores and with pyritic ores; (4) sooty pitchblende also of late Tertiary age, in altered volcanic rocks in pyrite-chalcopyrite seams, small veins, and pyritized rock. The deposits in the Precambrian slates and those in the chimney deposits and minor veins of the volcanic rocks seem to be the most important. At least two ages of uranium mineralization are definitely established, and a third may be possible.—*Excerpts from authors' abstract*

The report includes several tables summarizing the location, type and age of deposit, wallrocks, mineralogy, radioactivity, and uranium content of the uranium-bearing deposits examined. Also included are a generalized geologic map showing principal structural areas in the San Juan region and a geologic map showing structure of the Silverton volcanic center and areas nearby.

24 Butler, A. P., Jr., and Schnabel, R. W., 1956, Distribution of uranium occurrences in the United States: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium, p. 224–230.

Butler, A. P., Jr., and Schnabel, R. W., 1956, Distribution and general features of uranium occurrences in the United States: U. S. Geol. Survey Prof. Paper 300, p. 27–40.

Uraniferous vein deposits in the Western States are mainly of Tertiary age. Most economic deposits are in crystalline rocks of Precambrian, Mesozoic, and Tertiary age. Occurrences in Eastern United States, mostly undated, are mainly in rocks of Precambrian age. Pitchblende, associated with base-metal sulfides or with fluorite, is the principal uranium mineral in vein deposits at depth. Supergene secondary uranium minerals occur in some deposits but are not generally abundant. Uranium is mined from veins in Colorado, Arizona, Montana, Nevada, and California, but principally from those near Marysvale, Utah—*Excerpt from authors' abstract*

The report includes an index map showing deposits and principal occurrences of uranium in the United States.

25 Campbell, R. H., 1955, Reconnaissance for radioactivity in the Gold Hill mining area, Boulder County, Colorado: U. S. Geol. Survey TEM–563A, 27 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Several radioactive deposits were found as a result of reconnaissance in the Gold Hill mining area, Boulder County, Colo. The ore deposits of the area have been worked chiefly for gold. All ore shipped has come from fissure veins, most of which are gold telluride veins. There are, however, some important sulfide veins which show a vague zonal distribution of pyritic gold ores and silver-lead ores. The results of this reconnaissance suggest a possible relationship of the radioactive deposits to this indistinct sulfide zoning; however, the zoning is so obscure that its practical application to prospecting for uranium is of doubtful value at the present time.

Pitchblende, torbernite, metatorbernite, and schroeckingerite have been identified in specimens from the area; however, no uranium minerals have yet been identified from most of the radioactive deposits, and the uraniferous material present is probably in disseminated small particles. Although selected samples from several localities assay 0.10 percent uranium or more, the known deposits are small and probably are not of immediate economic importance.—*Author's abstract*

The report includes geologic maps and sections and a table containing tabulated descriptions of the localities examined for radioactivity.

26 Christman, R. A., Brock, M. R., Pearson, R. C., and Singewald, Q. D., 1955, Wet Mountains, Colorado, thorium investigations, 1952-1954; U. S. Geol. Survey TEI-354, 52 p., see. p. 48 (open-file report).

This report presents the results of detailed geologic mapping of the McKinley Mountain area 10 miles northeast of Westcliffe on the west flank of the Wet Mountains in Custer and Fremont Counties, Colo. Radioactive deposits occur along northwest-trending fractures in Precambrian igneous and metamorphic rocks. Samples from the deposits contain as much as 4.03 percent ThO_2. All the thorium deposits within the mapped area are low in uranium, the highest analyses being only 0.01 percent uranium. However, nearly a ton of handpicked ore that contained 0.1 percent U_3O_8 and 45 percent carbonate was shipped from a prospect on the Watter's ranch 5 miles southeast of the mapped area. The uranium is in a dense purplish-red carbonate vein ½ to 1½ feet wide and about 100 feet long. "If the excess radioactivity indicated by the equivalent uranium value is assumed to be due to thorium, the ore may also contain 0.78 percent equivalent ThO_2."

The report includes a geologic map of the McKinley Mountain area, an index map showing localities of radioactive material, and a map of known thorium deposits in parts of Custer and Fremont Counties excluding the McKinley Mountain area. Several tables showing sample data are included.

27 Christman, R. A., Heyman, A. M., Dellwig, L. F., and Gott, G. B., 1953, Thorium investigations 1950–52, Wet Mountains, Colorado: U. S. Geol. Survey Circ. 290, p. 25.

Very small amounts of uranium have been found in the thorium-bearing veins of the Wet Mountains thorium district in Custer and Fremont Counties, Colo. The thorium minerals occur in northwest-trending shear zones in metamorphic and igneous rocks of Precambrian age. Thorite has been tentatively identified as the principal radioactive mineral and is associated with barite, quartz, galena, fluorite, limonite, pyrite, and rare-earth oxides. The deposits are probably of Tertiary age. Channel samples from the veins contain as much as 4.5 percent equivalent ThO_2. The uranium content is generally about 0.002 percent. The Griffen property, 1 mile north of the junction of State Routes 143 and 277, yielded a sample containing 0.058 percent uranium, the largest amount found in the district.

28 Cook, E. F., 1955, Prospecting for uranium, thorium, and tungsten in Idaho: Idaho Bur. of Mines and Geology Pamph. 102, 53 p.; see p. 13–15.

Uranium-bearing veins have been found in 5 mines of the Couer d'Alene district in northern Idaho since the original discovery of uraninite in the lower workings of the Sunshine mine in 1949. The uraniferous veins of the district are in quartzite of the St. Regis formation of Precambrian age. Most of the uranium is in veinlets in the wallrock of the silver ore bodies, which contain argentiferous tetrahedrite, pyrite, arsenopyrite, chalcopyrite, siderite, and quartz. The silver-bearing veins are along faults and shear zones that cut the uranium veinlets. The age of the uraninite is 750 million years, which dates it as Precambrian.

At the Garm-Lamoreaux mine, 11 miles north of North Fork, torbernite and autunite(?) are associated with quartz, chlorite, pyrite, hematite, galena, and gold in a northwest-trending fracture that cuts fine-grained quartzite of the Belt series. At the Moon Claim, 3 miles northwest of Gibbonsville, torbernite is in fractures cutting a gold quartz vein in quartzite and mica schist. A radioactive material (gummite?) coats fractures in granite east of Naples in Boundary County. Uranium of ore grade is in a property currently being developed in the Hailey gold belt, 12 miles southwest of Hailey, Blaine County. The uranium occurs as finely divided uraninite associated with quartz, pyrite, gold, galena, and sphalerite. The deposit is in fractured monzonite that has been intensely bleached and silicified.

Several vein-type uranium deposits close to the Idaho border in adjacent States are briefly described. These include the deposits on the Colville Indian Reservation northwest of Spokane, Wash., where uranium ore containing autunite and uranophane is principally in mica schist near a granite contact. Pitchblende is reported from a nearby molybdenum mine. Autunite in fractures in granite was discovered in 1955, 20 miles northeast of Spokane.

The report includes a map of Idaho and adjacent areas showing the location of the uranium deposits described in the report.

29 Cook, E. F., 1957, Radioactive minerals in Idaho: Idaho Bur. of Mines and Geology Mineral Resources Rept. 8, 5 p.

This report summarizes the radioactive minerals of Idaho and was taken largely from Pamphlet 102 of the Idaho Bur. of Mines and Geology [annotation 28]. Only additional information on uranium-bearing veins is included here.

"Uranium occurs in two mines in the Gibbonsville district of northern Lemhi County; both deposits are associated with quartz veins which cut quartzite and mica schist. At one of these deposits, 3 miles northwest of Gibbonsville, 100,000 tons of uranium ore averaging better than 0.1 percent U_3O_8 have been blocked out in a shattered quartz zone about 30 feet wide.

"In Stanley Basin late in the summer of 1955 uranium was discovered in a silicified fault zone cutting granitic rock. Little is yet known about the grade or extent of the deposit, but uranophane and autunite have been identified, and samples with high radioactivity apparently contain a finely divided black uranium mineral, possibly uraninite.

"A relatively new discovery of radioactivity associated with sedimentary rocks has been made along the North Fork of Big Lost River in Custer County. A narrow, but possibly extensive, zone of radioactive fault gouge and breccia in graphitic argillite and quartzite may contain uranium."—*Excerpts from author's text*

30 Cook, F. S., and Wylie, E. T., 1956, The geology of the Woodrow mine, New Mexico [abs.]: Econ. Geology, v. 51, p. 112–113.

Anaconda's Woodrow mine, on the Laguna Indian Reservation in Valencia County, N. Mex., has produced uranium ore from a nearly vertical pipelike structure in the Jurassic Morrison formation.

The inside of the pipe, from 20 to 30 feet in diameter, has been dropped from 25 to 40 feet in relation to the surrounding rocks. Uranium oxides, pyrite, and minor amounts of other minerals occur in or near the resulting gouge and brecciation. Mining has been in process to the 100-foot level. Drilling has revealed that mineralization occurs at greater depth. The origin of the deposit, though still in doubt, is believed by the writers to be hydrothermal.—*Authors' abstract*

31 Davis, D. L., and Hetland, D. L., 1956, Uranium in clastic rocks of the Basin and Range province: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium, p. 387–391; U. S. Geol. Survey Prof. Paper 300, p. 351–359.

Several uranium deposits in lacustrine sedimentary rocks and tuffs of the Basin and Range province are discussed. Only the deposits that show an affinity to vein-type deposits are described in the following annotation.

Anomalous radioactivity extends over an area about 1 mile wide and 8 miles long in lacustrine sedimentary rocks of Miocene age near Tonopah, Nev. Local concentrations of higher radioactivity and uranium are concentrated in areas of weak northward-trending shears. The deposits of the Silver Queen group are along an iron-stained northward-trending shear zone in tuffaceous beds of the Siebert tuff. No uranium minerals have been identified, though yellow radioactive coatings are found on collophanite and opal. Most of the uranium is in the collophanite. The uranium may be of hydrothermal origin or may have been leached from the tuff and reconcentrated in the present beds.

A uranium deposit is in water-laid tuff near the head of Dacie Creek in northwestern Lander County, Nev. The highest radioactivity in this deposit is confined to minor fractures in the tuffs, though no uranium minerals have been observed.

In the Garfield Hills about 10 miles southeast of Hawthorne, Nev., carnotite is in a series of closely spaced vertical fractures in tuffaceous sandstone of the Esmeralda formation of Tertiary age.

The report contains a geologic and isorad map of the Silver Queen group.

32 Davis, H. C., 1954, Summary report of reconnaissance and exploration for uranium deposits in northern Nevada: U. S. Atomic Energy Comm. RME–2013 (pt. 1, revised), 23 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

This report is a summary of reconnaissance for radioactive deposits in northern Nevada and an adjacent part of California. The report briefly describes the following vein-type deposits: Coaldale deposit, Lovelock and Nickel mines, East Walker River area deposits, Majuba Hills mine, Round Mountain area deposits, Stalin's Present prospect, Chalk Mountain mine, Currant claims, Early Day claims, Getchell mine, Long Lease mine, Moonlight group, Southam claims, and the Truckee Canyon group. Each of the deposits are described as to location, geology, and radioactivity. Very little exploration has been done at most of the deposits. A few of the veins contain pitchblende or uraninite. Most of the veins contain only secondary uranium minerals, and at a few deposits no uranium minerals were visible.

33 Derzay, R. C., 1953, Uranium occurrence at the Cherokee mine, Queen Mineral Ranch, Gilpin County, Colorado: U. S. Atomic Energy Comm. RME-4041, 8 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Pitchblende-bearing vein material was found on the dump of the Cherokee mine about 2 miles southeast of Central City, Gilpin County, Colo. Handpicked samples from the dump contain from 0.40 to 1.97 percent U_3O_8. The country rock is predominantly Precambrian quartz biotite schist and schistose gneiss with lenses of pegmatite. About 800 feet southeast of the Cherokee mine is a stock of quartz monzonite porphyry of Tertiary age from which dikes of the same composition radiate outward into the older rocks. Two of these dikes crop out in the vicinity of the mine. Two nearly vertical veins trend east-west in the immediate area of the mine, the American Girl-Cherokee and the Annie. The veins consist of chalcopyrite, galena, pyrite, and sphalerite, in a gangue of quartz and altered schist. The uranium is in pitchblende veinlets 1/32 inch to 2 inches wide. The report includes a plan and longitudinal section of the Cherokee mine.

34 Derzay, R. C., 1956, The Los Ochos uranium deposit: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium, p. 468–472.

Derzay, R. C., 1956, Geology of the Los Ochos uranium deposit, Saguache County, Colorado: U. S. Geol. Survey Prof. Paper 300, p. 137–141.

The Los Ochos mine is in the Cochetopa mining district in the northwest corner of Saguache County, Colo. Precambrian schist, granite, and gneiss overlain by the Morrison formation of Jurassic age and by the Dakota and Mancos formations of Cretaceous age crop out in the mine area. These rocks are cut by four sets of well-defined high-angle faults of Late Cretaceous or Tertiary age. A major east-west-trending high-angle reverse fault, the Los Ochos, is traceable for several miles. At the Los Ochos mine this fault intersects a steeply dipping northeast-trending pitchblende-bearing shear zone. The two faults form the sides of the Los Ochos ore body that is triangular in plan and mainly a steeply plunging pipe. "The ore body measures 82 feet along the northeast-trending shear, 85 feet in width, and 120 feet along the Los Ochos fault. It extends at least 60 feet above the drift and downward for an undetermined distance."

"The deposit consists predominantly of pitchblende that fills the interstices of brecciated sandstone of the Morrison formation and Precambrian granite and schist within the pipe. Sparse yellow to orange-yellow secondary uranium minerals are associated with the pitchblende * * *. The primary mineral assemblage, believed to be epithermal, includes marcasite, chalcedony, and minor ilsemannite. * * * Clear to very dark quartz masses, pods, and veinlets; chalcedony; and yellowish barite constitute the gangue minerals.

* * *. In the mine area intense hydrothermal alteration obscures much of the original nature of the rocks. Silicification and kaolinization of the vein zone and wall rocks, where exposed by mining operations, are predominant." The mineralization is believed to be of Tertiary age. This deposit and nearby prospects indicate that intersections of northeast-trending shear zones and east-west-trending faults are important ore controls.

A photogeologic map of the vicinity of the Los Ochos deposit and a geologic map and sections of the Los Ochos mine are included.

35 Dings, M. G., and Schafer, Max, 1953, Radiometric reconnaissance in the Garfield and Taylor Park quadrangles, Chaffee and Gunnison Counties, Colorado: U. S. Geol. Survey TEI–255 (pt. 1), 25 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

At the Madonna mine half a mile south of Monarch, anomalous radioactivity is associated with a small lead-zinc ore body in the Manitou dolomite of Ordovician age along a northwest-trending reverse fault that dips steeply southwest. No radioactive minerals have been identified, but radioactivity is greatest in the oxidized material bordering the primary sulfide minerals. Selected samples of radioactive material from the mine dump contain an average of 0.05 percent uranium. The primary sulfide ore is weakly radioactive, averaging only 0.004 percent equivalent uranium.

Specimens of Manitou dolomite from the dump of the Silent Friend mine in the Quartz Creek mining district contain carbonaceous shale seams that are anomalously radioactive. The mine workings were not accessible, but the mine is reported to have yielded silver and lead ore from a vein along a northwest-trending reverse fault in the Manitou dolomite. Two samples of the radioactive material contain 0.038 and 0.067 percent uranium. The radioactivity is confined almost entirely to the black carbonaceous shale. The uranium probably is secondary and was carried downward by surface waters along the fault zone and precipitated by the carbonaceous shale.

Brannerite associated with pyrite, molybdenite, beryl, and other minor constituents occurs in very minor quantities in the California vein in the Mount Antero region.

The report contains generalized geologic maps of the Taylor Park and Garfield quadrangles and tables showing equivalent uranium and chemical uranium content of samples from the Madonna and the Silent Friend mines.

36 Drake, A. A., Jr., 1957, Geology of the Wood and East Calhoun mines, Central City district, Gilpin County, Colorado: U. S. Geol. Survey Bull. 1032–C, p. 129–170.

The Wood-East Calhoun area is underlain by complexly folded Precambrian gneiss and pegmatite. The major fold is an anticline that trends about N. 60° E. The Precambrian rocks are intruded by bostonite porphyry dikes of Tertiary age. All the rocks are cut by eastward- to northeastward-trending faults that have been filled by precious-metal-sulfide veins which have been worked chiefly for gold. The Wood vein, which has produced much of the uranium of the Central City district, fills an east-trending fault; the Calhoun vein is in a northeast-trending fault.

The veins consist chiefly of quartz; pyrite is the predominant metallic mineral and chalcopyrite ranks next in abundance. Sphalerite, galena, tetrahedrite-tennantite, and pitchblende occur locally. Alteration-stage quartz and pyrite were deposited first, followed in order of deposition by pitchblende, light-yellow pyrite, massive quartz, yellow pyrite, sphalerite, comb quartz, chalcopyrite, tetrahedrite-tennantite, galena, chalcopyrite, pyrite, and gray to light-brown fine-grained quartz. The veins of the district are zoned; quartz-pyrite veins are near the center, and galena-sphalerite veins are on the periphery. The pitchblende bodies occur between these veins, but, paragenetically, the pitchblende is earlier than all other metallic minerals.

A trace-element study of the ore shows an association of bismuth, antimony, and arsenic with copper and of cadmium with zinc; high-grade uranium samples contain unusually large quantities of zirconium and molybdenum.

Pitchblende and other ore minerals are concentrated in ore shoots. These are in open spaces controlled by the competency of the wall rocks, the presence of a prevailing direction of weakness in the rocks, and changes in strike and dip of the vein. The pitchblende is believed to be a local constituent of the quartz-pyrite ores and was deposited by residual solutions from the quartz bostonite magma.—*Author's abstract*

A geologic map of the Wood-East Calhoun area, geologic maps and sections of the mines, and several tables showing production and assay data are included.

37 Duncan, D. C., 1953, A uranium-bearing rhyolitic tuff deposit near Coaldale, Esmeralda County, Nevada: U. S. Geol. Survey Circ. 291, 7 p.

A small deposit of uranium-bearing rhyolitic tuff is exposed at the northern end of the Silver Peak Mountains about 4 miles south of Coaldale in Esmeralda County, Nev. The deposit consists of weakly mineralized welded tuff containing veinlets and small irregular pods of higher grade uranium-bearing rock. The conspicuous ore minerals are autunite and phosphuranylite, which coat some fractures and partly fill some feldspar crystal cavities in the tuff. Uranium is also present in small amounts in siliceous material that occurs as scattered veinlets and as matrix of a breccia pipe. Numerous limonite-stained joint surfaces on the welded tuff also contain small amounts of uranium. No identifiable uranium minerals were found in the siliceous vein material or in the limonite-stained fracture coatings. Several samples collected from weathered outcrops contained from 0.002 to 1.86 percent uranium.—*Author's abstract*

A geologic sketch map of the deposit and a table summarizing data on samples obtained from the deposit are included.

38 Everhart, D. L., 1949, The geologic environment of primary vein deposits of uranium: Michigan Coll. Mining and Technology, Conf. on Radioactive Ores, May 6, 1949, p. 13–15.

Most primary uranium veins of the world, except the hypothermal uranium-bearing veins at Cornwall, England, probably formed in a mesothermal environment. In this environment minerals containing such elements as Au, Ag, Cu, Pb, Zn, Co, Ni, and U together with quartz and carbonate minerals may be deposited as vein fillings in open spaces along fissures and to a lesser extent may replace wall rock. The deposits are vertically zoned so that deeper parts of the vein are highly siliceous and pyritic and contain the most Au, Cu, and Zn. Higher in the vein away from the loci of the greatest heat, Pb and Ag minerals occur in greatest quantity. "Minerals reflecting the higher temperatures appear to have been deposited in the early stages of mineralization and those deposited under conditions of lower temperature in the later phases. Each phase may replace a preceding one, with sulfides commonly replacing gangue, but rarely vice versa. In this scheme of sequence and zoning, the primary uranium oxides, pitchblende and uraninite, in general occupy an intermediate to early position."

The source of the hydrothermal solutions for the primary uranium-bearing veins is probably magma, which in many places formed nearby sizable plutons of intrusive igneous rock. Although the source magma is generally believed to be of granitic or "acidic" composition, this has not been fully proved. The strongest evidence for this concept is the association of the pitchblende-bearing veins in the Joachimsthal district, Czechoslovakia, and in the Central City district, Colorado, with intrusive bodies of granite and quartz monzonite.

Age determinations of pitchblende from known deposits indicate a wide variation in their age, and no particular metallogenic epoch in geologic history is characterized by abundant uranium mineralization.

Geologic, mineralogic, and chemical guides which may be used in the search for primary vein deposits of uranium are listed and briefly discussed.

39 Everhart, D. L., 1950, Some features of the secondary redistribution of uranium in oxidation zones [abs.]: Geol. Soc. America Bull., v. 61, p. 1458.

The problem of finding uraninite-bearing primary veins involves a careful consideration of the redistribution of uranium in areas of intense oxidation.

Secondary uranium phosphates and sulfates can be formed in at least two ways—as the result of the reconstitution of uraninite in primary veins or by ground-water action on uranium-bearing accessory minerals in igneous rocks. Such uranium deposits commonly are found in or near fractures cutting intrusive rocks, and have been formed under semiarid or arid climatic conditions.

Suggested criteria for determining the presence of primary uraninite-bearing veins in association with deposits of these secondary minerals have been established for deposits in Portugal and the Marysvale district in southwestern Utah: (1) the presence of uranium-bearing minerals which include base metals in their lattice, (2) rigid structural control by normal and reverse faults, (3) the relationship of uranium minerals to zones of hydrothermal alteration, and (4) the association of typical mineral assemblages including limonite, quartz, hematitic jasper, clay minerals with distinctive base-exchange properties, sericite, and other secondary minerals. Deposits of secondary uranium minerals in parts of the Mojave Desert area, California, exhibit characteristics that differ markedly from those described above and are believed to have resulted from redistribution of uranium from accessory minerals of granites by ground-water action.

It is believed that the suggested criteria should be applied to known torbernite-autunite deposits in other semiarid or arid areas of the world.—*Author's abstract*

40 Everhart, D. L., 1951, Geology of uranium deposits—condensed version, with mineral tables by Muriel Mathez: U. S. Atomic Energy Comm. RMO–732, 33 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The general geologic features of the major types of uranium deposits, together with examples, are discussed. The use of field instruments for radiation detection, suggested sampling procedures, and the evaluation of uranium ore bodies are briefly described. A table showing data on the common uranium minerals is included.

The general features of the major hydrothermal uranium-bearing veins of the world are summarized as are those of vein deposits in the United States. The Shinkolobwe mine in the Belgian Congo, the largest and richest primary vein deposit known in 1951, is briefly described.

The uranium-bearing vein deposits of the United States, are typically mesothermal base-metal veins. The most favorable host rocks are felsic igneous rocks and siliceous metasediments. The characteristic uranium mineral in the veins is pitchblende, which may be associated with iron, copper, lead, silver, and zinc sulfides, and native silver and hematite. The major gangue minerals are quartz, opal, chalcedony, siderite, calcite, fluorite, and barite.

The pitchblende-bearing veins are open-space fillings of fractures or faults. Replacement of other vein minerals and the host rock by pitchblende has occurred only on a very small scale. The relative age of the pitchblende with respect to the other minerals is variable. In oxidized parts of pitchblende veins secondary uranium minerals generally have formed. These minerals are largely phosphates, sulfates, and hydrous silicates which may be associated with secondary metallic minerals that are derived from sulfides or oxides of base metals, and with gangue minerals that are typical of hydrothermal deposits. The wallrock of such deposits may have been altered in part to clays or affected by chloritization, sericitization, or silicification.

41 Everhart, D. L., 1956, Uranium-bearing vein deposits in the United States: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium, p. 257–264; U. S. Geol. Survey Prof. Paper 300, p. 97–103.

More than 100 vein deposits in the United States contain significant amounts of uranium minerals, though deposits of this type have not been as important commercially as disseminated deposits in sedimentary rocks. In the Western United States, the uranium-bearing vein deposits are distributed generally throughout the Rocky Mountain system and the Basin and Range province. In Michigan a few uraniferous veins are along the southern edge of the Canadian Shield.

The uranium-bearing veins of the United States may be divided into five mineralogic types as follows: (1) uranium and iron oxides, silica, and fluorite; (2) uranium oxides, copper, lead and molybdenum sulfides, silica, and fluorite; (3) uranium oxides, copper, cobalt, nickel, lead, zinc, and silver sulfides, and carbonates; (4) uranium oxides, silica, and gold-bearing pyrite; and (5) uraniferous hydrocarbon. The six types of host rocks most favorable for uranium-bearing veins are felsic intrusive rocks, rhyolitic extrusive rocks, schist and gneiss of sedimentary origin, quartzite, metavolcanic rocks, and arenaceous sedimentary rocks.

Structurally the veins, in nearly all places, show evidence of open-space filling in tension fractures. Different degrees and types of hydrothermal alteration are adjacent to most of the veins. Silicification is greatest in granitic host rocks. Argillization is common in igneous host rocks of nearly all types. Sericitization is prevalent where abundant potassium was available and chloritization occurs where iron and silica were abundant. Hematitization is especially evident in metasedimentary host rocks.

The uraniferous veins of the Western United States are of Tertiary age and are closely related in time to igneous activity of that period, but the uranium-bearing veins of the Sunshine mine, Idaho, may be of Precambrian age. The uranium-bearing veins in the southern part of the Canadian Shield in Michigan also appear to be of Precambrian age, as do all others in the Shield in Canada.

The uranium vein deposits in the United States, as in other parts of the world, seem to have been precipitated from uraniferous hydrothermal solutions, derived at the end of a granitic or syenitic magmatic cycle. Precipitation occurred under pressure and temperature zones ranging from hypothermal to epithermal. The gold-uranium and cobalt-nickel-silver type ores characterize the mesothermal zone. The simpler mineralogic types (types 1 and 2) seem to be deposited through a greater range of temperature and pressure.

The report contains a map of the United States showing the distribution of significant uranium-bearing vein deposits. Two tables are included. "In table 1 the mineral-assemblage types are recorded along with the favorable host-rock types, indicating the nature and incidence of selected type examples of vein deposits in the United States. In table 2, the principal and (or) geologically significant vein deposits of the country are tabulated, summarizing their major geologic characteristics, following the classification scheme shown on table 1."

42 Everhart, D. L., and Wright, R. J., 1951, The paragenesis of pitchblende-bearing veins: Denison Univ. Sci. Lab. Jour., v. 42, art. 7, p. 66–74.

The age relations of pitchblende in twelve vein deposits are described. On the whole, pitchblende occupies a variable paragenetic position; in some deposits it is one of the earliest minerals to form and in others it is one of the latest. It is noted that in the Precambrian deposits studied, pitchblende is early in the mineral sequence, in late Paleozoic-early Mesozoic deposits it is variable in position, in late Mesozoic-early Tertiary deposits it is commonly late in the sequence.

The variable paragenetic position of pitchblende is ascribed to its probable deposition from a colloidal solution. Because of its high valences, uranium is particularly susceptible to coagulation from a colloid.—*Author's abstract*

Most of the pitchblende-bearing veins described in this report are outside the United States. The pitchblende-bearing veins in the United States described are in the Coeur d' Alene, Colorado Front Range, and Marysvale districts. These deposits are of late Mesozoic and early Tertiary age and in all of them pitchblende is late in the mineral sequence.

43 Everhart, D. L., and Wright, R. J., 1953, The geologic character of typical pitchblende veins: Econ. Geology, v. 48, p. 77–96.

Information concerning geologic features of pitchblende veins throughout the world has been assembled. Thirteen of these deposits are described briefly and their features are summarized and classified.

Several of the deposits * * * [are of the] nickel-cobalt-native silver type and are dominantly in metamorphic host rocks. The remaining deposits have certain features in common, namely: simple mineralogy, pyrite and/or galena as the representative metallic minerals, silica or fluorite gangue, and granitic or monzonitic host rock. These deposits appear to constitute a second type of pitchblende-bearing deposits, which is described as the siliceous-pyrite-galena type.

Three uranium metallogenic epochs are recognized: those of Precambrian age in Africa and the Canadian Shield, late Paleozoic in Europe, and late Mesozoic-early Tertiary in the Cordillera of North and South America.

Other features common to many of the described deposits include the variable paragenetic position of pitchblende, the controlling influence of tensional fractures on pitchblende deposition, and the widespread association of pitchblende with hematitic alteration.—*Authors' abstract*

Pitchblende-bearing veins in the United States in the Coeur d' Alene, Colorado Front Range, and Marysvale districts are described. The following information is summarized in tabular form for each of the 13 deposits described: Host rocks, mineral association, paragenesis, structural relationships, hydrothermal alteration, geologic age, and source references.

44 Fischer, R. P., 1955, Vanadium and uranium in rocks and ore deposits [abs.]: Geol. Soc. America Bull., v. 66, p. 1558; Econ. Geology, v. 50, p. 775.

Vanadium apparently does not tend to concentrate in the normal hypogene environment, and specifically it does not appear to concentrate in most hypogene veins containing uranium ore. If this is true, unusual processes and conditions might be required to explain a hypogene source of vanadium and uranium in deposits containing commercial concentrations of both metals.—*Excerpt from author's abstract*

45 Gabelman, J. W., 1956, Uranium deposits in limestone: U. S. Geol. Survey Prof. Paper 300, p. 387–404.

The uranium deposits of the Grants district, New Mexico, contain pitchblende and secondary uranium minerals in the lacustrine Todilto limestone of Jurassic age. The deposits for the most part do not have the geologic characteristics of vein-type deposits. The primary ore bodies containing pitchblende are commonly elongated replacement bodies confined to minor anticlinal crests within larger shallow synclines. However, some ore bodies consist entirely of secondary uranium minerals in networks of fractures.

Several vein-type deposits containing secondary uranium minerals or anomalous radioactivity distributed along joints and fractures in lacustrine and marine limestones are briefly described. Deposits of this type are described from Arizona, New Mexico, Wyoming, Texas, and New Jersey.

The uraniferous fluorite pipes and veins in dolomitized marine limestone of Silurian age in the Thomas Range, Utah, also are briefly described.

46 Gale, H. S., 1908, Carnotite and associated minerals in western Routt County, Colorado: U. S. Geol. Survey Bull. 340–D, p. 257–262.

Carnotite is associated with copper, vanadium, selenium, manganese, chromium, and iron oxide minerals in a deposit near Skull Creek in western Routt, now Moffat, County, Colo. The deposit is in a massive, coarse-grained crossbedded sandstone of Jurassic age. "The deposit as a whole occupies a brecciated zone in the rock, the minerals being concentrated in or evidently distributed from the coarser joints or more porous layers. To a less extent some of the minerals are found impregnating the more massive sandstone."

47 Gillerman, Elliot, 1952, Fluorspar deposits of Burro Mountains and vicinity, New Mexico: U. S. Geol. Survey Bull. 973–F, p. 261–289; see p. 285.

Uranium minerals are associated with fluorite in two small fluorspar deposits in southwestern Grant County, N. Mex. The Langford fluorspar deposit, in sec. 25, T. 22 S., R. 16 W., is in a silicified breccia zone 5 feet wide in granitic rock. The deposit contains fine-grained dark-purple fluorite associated with quartz and calcite. A few crystals of autunite are near the fluorite, and a primary uranium-bearing mineral may occur within the fluorite.

The Hines fluorspar deposit, in sec. 34, T. 21 S., R. 14 W., is in a fracture zone in quartzite of the Bliss(?) sandstone of Cambrian(?) age. The dark-purple finely crystalline fluorite is in veins 1 inch to 1 foot wide. Autunite and possibly uranophane are along fractures in the quartzite near, but not in contact with, the fluorite. Tungsten and molybdenum are in a parallel vein 50 feet east of this deposit.

48 Gillerman, Elliott, and Whitebread, D. H., 1956, Uranium-bearing nickel-cobalt-native silver deposits, Black Hawk district, Grant County, New Mexico: U. S. Geol. Survey Bull. 1009–K, p. 283–313.

The Black Hawk (Bullard Peak) district, Grant County, N. Mex., is 21 miles by road west of Silver City. Since 1893, there has been no mining in the district except during a short period in 1917 when the Black Hawk mine was unwatered and reopened.

Precambrian quartz diorite gneiss * * * is the most widespread rock in the district. The quartz diorite gneiss is intruded by many Precambrian and younger rocks, including * * * monzonite porphyry, * * * probably of Late Cretaceous or early Tertiary age * * *.

The ore deposits are in fissure veins that contain silver, nickel, cobalt, and uranium minerals. The ore minerals, which include native silver, argentite, niccolite, millerite, skutterudite, nickel skutterudite, bismuthinite, pitchblende, and sphalerite, are in a carbonate gangue in narrow, persistent veins, most of which trend northeast. Pitchblende has been identified in the Black Hawk and the Alhambra deposits and unidentified radioactive minerals were found at five other localities. The deposits that contain the radioactive minerals constitute a belt 600 to 1,500 feet wide that trends about N. 45 E. and is approximately parallel to the southeastern boundary of the monzonite porphyry stock. All the major ore deposits are in the quartz diorite gneiss close to the monzonite porphyry.—*Excerpts from authors' abstract*

A geologic map of the Black Hawk mining district and geologic maps of the Black Hawk mine and vicinity and of the Alhambra mine and vicinity are included.

49 Goddard, E. N., 1946, Fluorspar deposits of the Jamestown district, Boulder County, Colorado: Colorado Sci. Soc. Proc., v. 14, no. 1, 47 p.; see p. 5, 19.

Minute grains of pitchblende are disseminated through several of the large fluorspar deposits of the Jamestown district in central Boulder County, Colo. The fluorspar deposits occupy veins and breccia zones in altered granite of Precambrian age and granodiorite of Tertiary age on the west and south sides of a sodic granite-quartz monzonite porphyry stock of Tertiary age. "In nearly all the deposits, early coarse-grained fluorite is strongly brecciated and cemented by fine-grained fluorite mixed with clay minerals, quartz, pyrite, and some carbonates. Fragments of sulfide minerals, chiefly galena and pyrite, are found in some deposits, and minute grains of pitchblende are sparingly present." The fluorite ranges in color from nearly white through purple to deep violet. The deep violet color appears to be related to the pitchblende. The equivalent uranium content of several samples of fluorite ore ranged from 0.00029 to 0.0515 percent.

50 Granger, H. C., 1955, Dripping Spring quartzite, *in* Geologic investigations of radioactive deposits—Semiannual progress report for June 1 to Nov. 30, 1955: U. S. Geol. Survey TEI-590, p. 187-191, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The most promising uranium deposits in the Dripping Spring quartzite of Precambrian age are within a few feet of discordant contacts between favorable siltstone host rocks and diabase intrusive bodies. In places heat and emanations from diabase have converted the siltstone to feldspathized siltstone. Deposits in and near feldspathized siltstone commonly follow the margins of narrow rheomorphic breccia zones and dikes and contain visible blebs and discontinuous veinlets of fine-grained uraninite associated with disseminated pyrrhotite and molybdenite. The deposits in unmetamorphosed siltstone contain the primary uranium mineral, in a form not yet identified, that is finely disseminated in the walls of tight joints. Much of the uranium may be absorbed on clay minerals. Pyrite is common in most of these deposits.

The author suggests that the uranium was derived from hydrothermal fluids resulting from the differentiation of diabase magma. None of the igneous facies produced by differentiation of the diabase magma contained any minerals with which the uranium could combine; therefore, much uranium was expelled in fluid emanations into the surrounding sedimentary rocks along joints, bedding planes, permeable beds, and the margins of rheomorphic dikes and breccias. Uraninite was deposited where the temperature and other conditions were favorable. "Further from the source the uranium was adsorbed by clay minerals and fine-grained carbon. An essential factor in deposition of uranium was a strongly reducing condition brought about by finely divided carbon and the original pyrite content in the rocks."

51 Granger, H. C., and Bauer, H. L., Jr., 1952, Uranium occurrences on the Merry Widow claim, White Signal district, Grant County, New Mexico: U. S. Geol. Survey Circ. 189, 16 p.

The Merry Widow claim is about 1 mile west of White Signal, Grant County, N. Mex. Uranium minerals were discovered in the White Signal district in the early 1920's; several mines in the district had been worked previously for gold, silver, and copper.

The Precambrian granite country rock is intruded by numerous dikes ranging in composition from basalt to pegmatite. The uranium minerals torbernite and autunite generally are in basalt or diabase near intensely oxidized quartz-pyrite veins that are common in the district. At some places, including the Merry Widow mine, the uranium minerals are in fractured granite or in latite adjacent to a quartz-pyrite vein. At a depth of 520 to 550 feet the persistent veins are completely oxidized; and, although secondary uranium minerals and radioactive fracture surfaces were visible in drill core, no primary uranium minerals were identified.

The spatial relationship between secondary uranium minerals and oxidized quartz-pyrite veins, suggests that the unoxidized parts of the veins may contain primary uranium minerals. "The generally high phosphate content of the basic intrusive rocks in the district may account for the localization of phosphate-bearing uranium minerals near the intersections of quartz-pyrite veins with diabase and other subsilicic rocks."

The report includes a geologic map of the Merry Widow claim and of the 40- and 60-foot levels of the Merry Widow mine. An assay plan map of trenches and two tables show the results of sampling on the claim and in the mine.

52 Granger, H. C., and Raup, R. B., Jr., 1954, Dripping Spring, Arizona, *in* Geologic investigations of radioactive deposits—Semiannual progress report, June 1 to Nov. 30, 1954: U. S. Geol. Survey TEI-490, p. 112-117, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Uranium deposits have been known in the Dripping Spring quartzite of Precambrian age since early 1950, and ore-grade material is now being mined from at least six different deposits in southeastern Arizona.

Most of the known uranium deposits are restricted to thinly laminated indurated siltstone in the middle unit of the upper member of the quartzite or to the gradational part of the lower unit just below. The deposits "are controlled by fractures that trend either N. 10°-30° E. or N. 65°-85° W., although some disseminated ore minerals are in the wall rocks adjacent to the fractures. In some deposits the fractures are filled with as much as 2 inches of gouge, gossan, sulfides, and locally vein quartz. In others the fractures are so tight that only disseminated minerals are visible. In unoxidized parts of the better developed deposits, pitchblende, pyrite, chalcopyrite, galena, and rarely sphalerite are present. In the oxidized parts of the deposits the uranium minerals are metatorbernite, autunite, uranophane, bassetite, and perhaps other minor minerals. These are associated with hydrous iron oxides, gypsum, and more rarely malachite, azurite, and fluorescent opal."

"Most deposits appear to extend through a stratigraphic interval of from 6 inches to 20 feet. The rock adjacent to the fractures may be abnormally radioactive for several hundred feet, but, unless the fractures are very closely spaced, the ore width is commonly less than 5 feet. The length over which a fracture may be mineralized varies from a few feet to over 150 feet." All the deposits are near diabase intrusions, and the largest deposits are near conspicuous structures that are contemporaneous with or predate the intrusions.

53 Gruner, J. W., Fetzer, W. G., and Rapaport, Irving, 1951, The uranium deposits near Marysvale, Piute County, Utah: Econ. Geology, v. 46, p. 243-251.

Uranium-bearing veins were discovered in 1949 about 3 miles north of Marysvale in south central Utah. The country rock consists of volcanic and intrusive rocks of Tertiary age. The older volcanic rocks, the Bullion Canyon series, were intruded by relatively small intrusives of latite porphyry, quartz monzonite, and granite or aplite. Younger volcanic rocks, the Mount

Belknap series, were deposited on the eroded surface of the intrusives and older volcanic rocks.

The uranium deposits are in nearly vertical veins or ore zones that strike northeast. The veins are chiefly in quartz monzonite, but some uranium mineralization extends into the overlying agglomerate. The ore zones consist of one or more narrow veins or veinlets containing quartz, fluorite, calcite, pyrite, and jordisite. Pitchblende occurs in very thin seams or as grains in and between the veins. The chief concentrations of pitchblende are confined to a maximum of a few inches in any one zone. The width of the ore zones is still unknown, but they appear to swell and pinch within short distances. Extensive oxidation to a depth of 200 feet produced secondary uranium minerals including schroeckingerite, autunite, torbernite, a uranophanelike silicate, and two unidentified minerals. Other secondary oxidation products include goethite and ilsemannite. Hydrothermal argillic alteration and weathering are closely associated. The deposits probably formed in the shallow epithermal zone late in Tertiary time.

The Prospector, Buddy, Bullion Monarch, and Freedom No. 2 mines are briefly described.

54 Gruner, J. W., and Gardiner, Lynn, 1950, Some observations on the ores of Hack Canyon 50 miles southwest of Fredonia, Arizona, *in* Third progress report for period Mar. 1 to July 1, 1950: U. S. Atomic Energy Comm. RMO-746, p. 8-8a. (Available for consultation in U. S. Atomic Energy Comm. Depository Libraries.)

The Hack Canyon uranium deposit, in sec. 26, T. 37 N., R. 5 W., 50 miles southwest of Fredonia, Ariz., is in a dropped block of Coconino sandstone of Permian age. The ore consists of malachite, torbernite, and azurite in fractures and bedding planes in the sandstone. Thin films of erythrite coat some fractures. In some places the mineralized rock grades from yellowish soft sandstone inward into hard sandstone cemented with a black material. X-ray examination indicates that the black cementing material probably contains covellite and uraninite.

55 Grutt, E. W., Jr., 1955, Geologic notes on some Wyoming uranium districts: Mines Mag. [Colorado], v. 45, no. 3, p. 106-108.

The geology of several uranium districts in Wyoming is briefly described. Only vein-type deposits are discussed in this annotation.

In the Esterbrook and Copper Mountain districts uraninite is present in steeply dipping veins of hydrothermal origin that cut rocks of Precambrian age. Although the deposits are near old copper prospects, the uraninite is not intimately associated with copper mineralization. In the Esterbrook district uraninite ore is present as much as 200 feet below surface outcrops that show only trace amounts of uranium.

An occurrence of uranium in the Pedro Mountains seems to represent high-temperature hydrothermal mineralization. The uranium is in tiny uraninite crystals that are embedded in or intergrown with grains of molybdenite and pyrite. The deposit is in sheared graphitic rocks and coarsely crystalline siliceous rock of Precambrian age.

Some uranium deposits in the Lance Creek district have been localized by well-defined vertical fracture zones in individual beds of the White River formation of Oligocene age. Locally, the fracture zones are silicified and filled with chalcedony or calcite.

At the north end of the Crooks Gap area in the Green Mountains, several uranium deposits containing principally autunite, associated with gypsum, hematite, and limonite occur near a large fault and appear to "resemble vein deposits more than disseminated deposits, but the origin of the uranium is unknown."

The most important deposits in the Maybell-Lay area of Moffat County, Colo., contain uranium as disseminations in fine- to medium-grained sandstone in the Browns Park formation. An unidentified yellow uranium mineral and small grains of asphaltic material occur in fracture and breccia zones along steeply dipping faults.

56 Gude, A. J., 3d, and McKeown, F. A., 1953, Results of exploration at the Old Leyden coal mine, Jefferson County, Colorado: U. S. Geol. Survey open-file report, 18 p.

At the Old Leyden coal mine in northern Jefferson County, Colo., uranium occurs in a brecciated, silicified coal bed and in an overlying silicified sandstone in steeply dipping beds of the Laramie formation of Late Cretaceous age. Six diamond-drill holes were drilled by the U. S. Bureau of Mines to explore the lateral and downward extent of the deposit. "Small lenticular bodies of uraniferous material * * * occur at intervals in the coal and silicified coal over a strike length of about 800 feet. These bodies contain 0.10 to 0.50 percent uranium. Data obtained from drilling indicate a discontinuous radioactive zone between these higher grade bodies; assays of samples from the cores range from 0.001 to 0.10 percent uranium. The uranium is localized where the zone of coal or carbonaceous clay that underlies the silicified sandstone unit is in or adjacent to the shear zones associated with the faulting. The only identified uranium mineral * * * is carnotite."

A geologic map of the mine area, geologic sections through the mine adit and selected diamond-drill holes, and logs of the six diamond-drill holes are included.

57 Hadfield, J. P., Jr., 1953, Reconnaissance in the western part of the Trans-Pecos region of Texas: U. S. Atomic Energy Comm. RME-4021, 15 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Reconnaissance, which was concentrated in and around the mining districts of the Trans-Pecos region of southwest Texas, revealed many areas of slightly abnormal radioactivity, but only a few deposits contain uranium minerals. At one of these, the Rossman prospect, 3 miles northeast of Allamore in Hudspeth County, tyuyamunite and an unidentified uranyl vanadate occur in a small area of veinlets in an irregular fracture zone that cuts silicified limestone of the Millican formation of Precambrian age. One selected chip sample taken across the veinlets contained 0.017 percent U_3O_8.

58 Harrison, J. E., and Leonard, B. F., 1952, Preliminary report on the Jo Reynolds area, Lawson-Dumont district, Clear Creek County, Colorado: U. S. Geol. Survey Circ. 213, 9 p.

Pitchblende occurs in the deposit of the Jo Reynolds area, which was primarily a lead-zinc-silver ore body. The reported production in 1919 of 8 tons of high-grade uranium ore, presumably from the lowest workings of the mine, is still unconfirmed but has a fair degree of credibility. The deposit consists of 3 (possibly 4) veins, but the ore was concentrated principally along the No. 2 vein. The No. 2 vein is localized along a fault, which is independent of the Precambrian structures in the bedrock. The age of the mineralization is inferred to be Tertiary.

The deposits of the Jo Reynolds area appear to contain an ore shoot, which has a trend of N. 17° E., a plunge of 60° NE., and a rake of 70° NE. Localization of the ore body in a shoot, or possibly shoots, is attributed either to intersection of the main shear with a transverse set of joints or the movement along a curved fault surface.—*Authors' abstract*

The report includes geologic maps of the Jo Reynolds area and part of the Jo Reynolds mine and a plan and section of the Jo Reynolds mine.

59 Harrison, J. E., and Wells, J. D., 1956, Geology and ore deposits of the Freeland-Lamartine district, Clear Creek County, Colorado: U. S. Geol. Survey Bull. 1032–B, p. 33–127.

The Freeland-Lamartine district is in Clear Creek County, Colo., about 3 miles west of Idaho Springs. The district is underlain by igneous and metasedimentary rocks of Precambrian age. These rocks have been intruded by dikes and plugs of Tertiary age. The ore deposits are in typical mesothermal veins. Two principal transitional types of ore, pyrite-gold and galena-sphalerite, have been mined in the district.

"Every accessible mine in the district was examined for radioactivity, and the dumps of inaccessible mines were traversed with a scintillation counter. Secondary uranium minerals—torbernite, autunite, and dumontite(?)—occur in vugs or fractures or in gouge, along several veins. Hydrous iron oxides from veins and from recent deposits on mine walls commonly show an unusual amount of radioactivity. In most of the radioactive material sampled, however, no discrete uranium minerals could be identified. It is tentatively concluded that large areas containing only pyrite-gold veins are poor in uranium and that areas of pyrite-gold or galena-sphalerite veins containing chalcopyrite are more favorable localities in which to look for uranium deposits."—*Authors' abstract, in part*

60 Hart, O. M., 1955, Uranium investigations in Mohave County, Arizona: U. S. Atomic Energy Comm. RME–2029, 18 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Radiometric examinations were made of virtually all mines in Mohave County, Ariz., south of the Colorado River and exclusive of the Hualapai Indian Reservation.

In the Cerbat Mountains uranium occurs in lead-zinc bearing quartz-sulfide veins in the Ithaca Peak granite of Mesozoic(?) age. The uranium appears to be associated with sphalerite portions of the veins and was probably deposited during the last stage of mineralization. Samples from the district contained from 0.008 to 0.50 percent U_3O_8.

At the Red Hills (Tate) property in sec. 7, T. 11 N., R. 13 W., in the Rawhide Mountains, uranium occurs in a vein consisting of fault or sedimentary breccia at the base of the Artillery formation. "The radioactive and associated minerals appear to be fracture coatings and not constituents of the chalcedonic quartz phase of mineralization. Chrysocolla is locally abundant with yellow and orange uranium minerals. A hematite-stained portion of the vein is particularly radioactive and contains accessory calcite, fluorite, hematite, and a little limonite." Channel samples at 5-foot intervals across the vein contained an average of 0.06 U_3O_8 for an average width of 10 feet. Individual samples from the property assayed from 0.01 to 0.314 percent U_3O_8.

In the Fools Peak area 3 miles west of Rawhide, uranium is along shear zones or in fracture fillings in kaolinized coarse-grained granite. The radioactivity is associated with hematite stains and slight silicification. Uranium minerals cannot be distinguished megascopically. Samples from prospects in the area contained from 0.01 to 0.28 percent U_3O_8.

61 Hart, O. M., and Hetland, D. L., 1953, Preliminary report on uranium-bearing deposits in Mohave County, Arizona: U. S. Atomic Energy Comm. RME–4026, 52 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Radiometric examinations were made of mines in the Wallapai district and selected properties in the Maynard and Greenwood districts, Mohave County, Ariz. Sulfide-bearing veins in the Wallapai district of probable mesothermal origin are in granite, gneiss, and schist of Precambrian age. The veins are near the Ithaca Peak granite stock of Mesozoic(?) age and may be genetically related to the granite. Uranium was found in a few veins in the district that contain predominantly sphalerite, and generally some galena, along with varying amounts of quartz, pyrite, arsenopyrite, and limonite. The uranium minerals in the veins were not specifically identified, but are probably finely divided primary uraninite and very minor amounts of autunite. The authors believe the uranium minerals were introduced during the last stages of mineralization following brecciation and shearing of the earlier precious metal and base-metal sulfide vein filling.

The uranium-bearing veins at the Democrat and State mines in the Maynard and Greenwood districts, respectively, are geologically similar to veins in the Wallapai district. Autunite, however, is the predominant uranium mineral in the State mine.

The Detroit group, De La Fontaine mine, Prosperity claim, Bobtail mine, and the Lower Summit mine in the Wallapai district, the State mine in the Greenwood district, and the Democrat mine in the Maynard district are described.

The report contains geologic maps of most of the properties described.

62 Hauptman, C. M., 1956, Uranium in the Pryor Mountain area of southern Montana and northern Wyoming: Uranium and Modern Mining, v. 3, no. 11, p. 14–21.

The uranium deposits of the Pryor Mountain district are in two adjacent areas; the northern area is in the Pryor Mountains in eastern Carbon County, Mont., and the southern, or Little Mountain area, is on the north end of the Bighorn Mountains in Big Horn County, Wyo. Ore has been shipped from properties in both areas.

The deposits in both areas of the district are in the upper part of the Madison limestone of Mississippian age and are believed to be cavern fillings in which the uranium was deposited either from descending ground water solutions or from ascending hydrothermal solutions. Tyuyamunite is the only uranium mineral definitely identified. It occurs as a finely crystalline bright-yellow powder filling vugs and fractures in brecciated cavern fill.

The deposits on Big Pryor Mountain are associated with highly silicified breccia zones and have a relatively low lime content (less than 4 percent). Ores from East Pryor Mountain and Little Mountain have a high lime content.

63 Hawley, C. C., and Moore, F. B., 1955, Control of uranium deposition by garnet-quartz rock in the Fall River area, Clear Creek County, Colorado [abs.]: Geol. Soc. America Bull., v. 66, p. 1675.

Tertiary vein deposits in the Fall River area, Clear Creek County, Colo., contain gold- and silver-bearing base-metal ores and locally uranium. The veins cut Precambrian metasedimentary and granitic wall rocks.

Uranium occurs in five veins, but only at the intersections of the veins with garnet-quartz rock layers. The uranium occurs as hard lustrous pitchblende that was deposited early in the paragenetic sequence and as soft sooty pitchblende (of probable supergene origin). Associated metallic minerals are pyrite, chalcopyrite, tennantite, galena, and sphalerite. Gangue minerals are quartz, carbonates, and barite.

The garnetiferous rock contains more than 50 percent garnet and quartz in approximately equal proportions. Biotite, magnetite, and amphibole are other constituents. This rock is interlayered with biotite gneiss and amphibolite and cut by biotite-muscovite granite and pegmatite. The garnet-quartz rock is pyritized adjacent to the vein; the other wall rocks are silicified and sericitized.

The cause of uranium deposition may have been physical or chemical or some combination of both. The garnetiferous rocks formed a more highly fractured vein zone than did the associated biotite gneiss and amphibolite. A chemical control is suggested by the fact that other competent rocks, such as granite and pegmatite, do not contain significant quantities of uranium at their intersections with the veins.—*Authors' abstract*

64 Hetland, D. L., 1955, Preliminary report on the Buckhorn claims, Washoe County, Nevada and Lassen County, California—Pt. 1: U. S. Atomic Energy Comm. RME-2039, 12 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The Buckhorn claims are about 29 miles north of Reno on the west slopes of the Antelope Range along the California-Nevada border. Secondary uranium minerals, including gummite, uranophane(?), and autunite(?), occur along narrow steeply dipping silicified fractures in Tertiary volcanic rocks of rhyolitic composition. The uranium minerals are in two zones separated stratigraphically by a thick bed of volcanic tuff. Several other uranium deposits have been discovered in the Tertiary volcanic rocks both north and south of the Buckhorn claims. All of these deposits contain uranium minerals and ore-grade material has been exposed at one.

A geologic map and section of the Buckhorn claims are included.

65 Hillier, R. L., 1954, Preliminary report on the uranium occurrence of the Jeep No. 2 claim, Clark Mountain mining district, San Bernardino County, California: U. S. Atomic Energy Comm. RME-2011, 11 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The Jeep No. 2 claim is about 30 miles northeast of Baker, in the Clark Mountain mining district, San Bernardino County, Calif. The mine was worked for copper in 1907. Carnotite coatings on brown jasper are associated with oxidized copper, zinc, lead, and manganese minerals in small replacement bodies and in well-defined veins in partially dolomitized limestone. Small amounts of radioactive material have been found in the underground workings and on the old dumps. The average uranium content of 5 samples from the mine is 0.073 percent uranium.

A geologic map and cross section of the claim, a geologic map of the underground workings, and a scintillometer and sample map of the underground workings are included. A table shows the assay data on samples taken from the claim.

66 Hillier, R. L., 1956, Preliminary report on uranium occurrence, Silver King claims, Tooele County, Utah: U. S. Atomic Energy Comm. RME-2035 (revised), 25 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Uranium was discovered on the Silver King claims in the fall of 1953. The claims are on the west flank of the Sheeprock Mountains in the eastern part of the Erickson mining district, Tooele County, Utah. Uraninite occurs in north- to northwest-trending copper-nickel-silver bearing fissure veins near the margin of a granitic stock of probable late Tertiary age. Sedimentary rocks in contact with the granite are chiefly dolomite and quartzite of Middle and Upper Ordovician age.—*Excerpt from author's abstract*

A geologic map and cross sections of the Silver King area, plans and geologic maps of the workings, and cross sections of diamond-drill holes are included. A table shows analyses of samples taken from the claims.

67 Hilpert, L. S., and Corey, A. F., 1955, Northwest New Mexico, *in* Geologic investigations of radioactive deposits—Semiannual progress report for June 1 to Nov. 30, 1955: U. S. Geol. Survey TEI-590, p. 104–118, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The geology of the uranium deposits of northwestern New Mexico is very briefly summarized. An index map shows the locations of the deposits which are labeled according to type and age of host rock. A table lists the deposits by name, location, and by host-rock formation. The deposits are of several geologic types and occur in metamorphic, igneous, and sedimentary rocks of various ages. Only vein-type deposits are referred to in this annotation.

Uranium occurs in a copper-quartz-fluorite vein cutting crystalline rocks of Precambrian age in the Zuni Mountains, Valencia County. Uranium deposits along the Rio Grande Valley in Socorro, Bernalillo, and Santa Fe Counties occur in shear zones that cut acidic and basic intrusive and extrusive rocks of Tertiary age. The deposits generally contain copper-bearing minerals. The Foutz No. 2 deposit in McKinley County is related to fractures in the Westwater Canyon member of the Morrison formation. The mineralogy is obscure and it is not known whether the fracturing preceded or followed the initial mineralization.

The Woodrow deposit north of Laguna occurs in a vertical breccia pipe in the Brushy Basin member of the Morrison formation of Jurassic age. The Charley No. 2 deposit in Socorro County consists of disseminated autunite and perhaps carnotite in fractured bentonitic mudstone in the Popotosa formation of Tertiary age. This deposit is close to a fault that separates the Tertiary rocks from Precambrian crystalline rocks.

68 Heinrichs, E. N., 1954, Moab-Inter-river area, Utah strip-mapping, *in* Geologic investigations of radioactive deposits—Semiannual progress report, June 1 to Nov. 30, 1954: U. S. Geol. Survey TEI–490, p. 35–36, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The uranium deposits in the Moab-Inter-river area south of Moab, Utah, may be classified into two groups based on the most obvious controls localizing the ore: (a) deposits along northwest-trending faults on anticlines or domes and (b) bedded channel deposits not apparently related to tectonic structures. Deposits of the first group are in fault gouge and in brecciated sandstone and arkose along and between northwest-trending high-angle faults, 10 to 50 feet apart, that cut the north flank of the Cane Creek anticline. The deposits are in the canyon of lower Cane Creek in the Rico, Cutler, and Chinle formations. Uranium minerals coat fractures and carbonaceous material. Minerals identified from field examination of hand specimens include andersonite or schroeckingerite, tyuyamunite, zippeite(?), chalcocite, malachite, and brochantite(?). The ratio of uranium to vanadium in the ore produced from the vein deposits is 1:2 in contrast to a 3:1 ratio in ore produced from bedded channel deposits.

69 Hubbard, C. R., 1955, A survey of the mineral resources of Idaho: Idaho Bur. of Mines and Geology Pamph. 105, p. 60–62.

The first reported shipment of uranium ore from Idaho was made in April 1955 from the McConnell-Sargent claims about 6 miles south of Salmon, Lemhi County. This deposit contains stringers of uranophane and autunite in rhyolite of the Challis volcanics of Tertiary age. A similar occurrence has been noted on Williams Creek in sec. 12, T. 20 N., R. 21 E.

Exploration work was done in 1954–55 on the Hailey Trust Co. deposit 12 miles southwest of Hailey in Blaine County. This deposit contains uraninite in quartz veins containing gold, galena, and sphalerite in monzonite host rock.

Exploration work was continued in 1954–55 at the Garm-Lamoreaux mine, 11 miles north of North Fork in Lemhi County. The geology of the Garm-Lamoreaux mine and of the uranium-bearing veins in the Coeur d'Alene district in Shoshone County also is very briefly described.

70 Huntting, M. T., 1957, Uranium in Washington: Washington Dept. Conserv. Devel., Div. Mines and Geology Inf. Circ. 26, 10 p.; extracted with minor changes from uranium section of Washington Div. Mines and Geology Bull. 37, Inventory of Washington Minerals, Part II, Metallic Minerals, p. 350–357.

Information on about 100 uranium deposits known within the State of Washington is summarized. The following information, where available, is given for each deposit: Location, owner, ore, gangue, type of deposit, development, assays, production, and references. Most of the occurrences are vein-type deposits.

"All the verified occurrences of uranium in Washington are either in granitic rock or in metamorphic rocks intruded by granite. Uraninite and secondary uranium minerals have been found in pegmatite dikes in this State but not in commercial quantities. The more promising uranium deposits in Washington have been found (1) in and near the contact of granite and rock the granite intrudes, (2) in shear zones cutting these rock types, and (3) as secondary minerals impregnating the fractured, decomposed, and disintegrated granitic and metamorphic rocks adjacent to contacts and shear zones."

As of February 1957, uranium ore had been shipped in quantities of more than one carload each from five properties in Washington, all in Stevens and Spokane Counties. These properties include the Midnite mine operated by the Dawn Mining Co., the Dahl, Lowley, and Huffman properties operated by Daybreak Uranium, Inc.; and the Lehmbecker property operated by North Star Uranium, Inc.

71 Hutton, C. O., 1957, Sengierite from Bisbee, Arizona: Am. Mineralogist, v. 42, p. 408–411.

The hydrated copper uranyl vanadate, sengierite, has been identified from specimens of copper ore from the Cole shaft, Bisbee, Ariz. The only other known occurrences of sengierite are in Morocco and in the Belgian Congo. The sengierite at Bisbee occurs as efflorescent patches on specimens of chalcocite obtained from a silver-bearing copper sulfide vein in the Escabrosa limestone of Mississippian age. In addition to the sengierite, small crystals of tyuyamunite line fractures in the limestone country rock adjacent to the massive chalcocite-covellite ore bodies.

72 Isachsen, Y. W., Mitcham, T. W., and Wood, H. B., 1955, Age and sedimentary environments of uranium host rocks, Colorado Plateau: Econ. Geology, v. 50, p. 127–134.

The Bald Eagle mine is one of several contiguous uranium-vanadium mines in the marine Hermosa limestone [Pennsylvanian] located on the northeast flank of the Gypsum Valley anticline, about 13 miles southwest of Naturita, Colorado * * *. Carnotite appears to be localized along closely spaced irregular fractures that give the rock a high permeability.

Yellow uranium minerals occur in a fluvial sandstone of the Rico formation [Pennsylvanian] in Cane Springs Canyon about 10 miles southwest of Moab, Utah. Bleaching of the red sandstone accompanies the uranium minerals which impregnate the sandstone along a fault.

Copper-uranium-vanadium ore is found in the Middle(?) Supai formation [Permian] at the Ridenour mine, about 30 miles north of Peach Springs, Ariz. The host rock is fluvial red sandstone and shale, bleached to light gray-green in the vicinity of the ore. The uranium occurs sporadically in the hanging wall of a copper vein.

Copper-uranium-lead ore, associated with abundant limonite and pyrite, is found in the Coconino sandstone [Permian] at the Orphan Lode mine, which is about 1,200 feet below the south rim in the Grand Canyon and about 1½ miles from Bright Angel Lodge. The host rock is an eolian sandstone. The ore occurs along fracture zones, and the uranium component appears to be intimately associated with fine-grained galena.

Uranium-vanadium mineral concentrations are found in the Wingate sandstone [Triassic] at Temple Mountain in the southeast corner of the San Rafael Swell, Emery County, Utah. Ore occurs within a collapse zone, and is scattered throughout the Wingate sandstone for a distance of 300 feet laterally from the fractured area.

Copper-uranium mineral concentrations are found in the Navajo formation

[Jurassic] about 2 miles west of Red Mesa Trading Post, Utah. The host rock is a massive light-red eolian sandstone. Mineralized pods occur along fractures that parallel a basic dike lying 500 feet to the southeast.

Several deposits containing yellow uranium minerals, concentrated along fractures in sandstone [Browns Park formation, Pliocene-Miocene age] occur ½ mile north of [Maybell-Lay area] Juniper Springs, Colo. Uraninite-uranophane ore is found in veinlets injected into a [Tertiary] monzonite porphyry plug in the Henry Mountains of Garfield County, south central Utah. Fluorite and fine-grained quartz intergrowths are associated with the uraninite stringers.—*Excerpts from authors' text*

73 Jarrard, L. D., 1957, Some occurrences of uranium and thorium in Montana, with sections on prospecting for radioactive minerals: Montana Bur. Mines and Geology Misc. Contr. 15, 90 p.

This report describes the geology of the uranium and thorium deposits of Montana and briefly describes vein-type deposits at Shinkolobwe, Belgian Congo; Great Bear Lake and Beaverlodge Lake, Canada; Marysvale, Utah; Sunshine mine, Idaho; and the Midnite and Daybreak mines in Washington. The general geology of uranium, uranium minerals, and the various geologic types of uranium deposits are briefly discussed.

Most of the uranium deposits in Montana are vein-type deposits. Uranium-bearing veins in the granitic rocks of the Boulder batholith in western Montana are of two types: (a) the siliceous reef or chalcedony type and (b) the base-metal sulfide type. The siliceous reef deposits appear to be the more important type and exploration and mining operations have been concentrated on these deposits, particularly those in the Clancey area. One of these properties, the W. Wilson claim, yielded about 700 tons of uranium ore averaging about 0.5 percent U_3O_8. The veins contain uraninite and secondary uranium minerals associated with base-metal sulfides in a gangue of cryptocrystalline quartz.

Autunite occurs as fracture coatings in a fault zone in the St. Regis quartzite of the Belt series near Saltese in western Montana.

"During the late summer of 1956 a comparatively high-grade showing of uranium ore was found adjacent to the West Fork of the Bitterroot River directly opposite the mouth of Deer Creek in southern Ravalli County." Uraninite, gummite, and uranophane occur as narrow veinlets and fracture coatings along near-vertical faults in a phyllite bed in quartzitic sedimentary rocks of the Ravalli(?) group of the Belt series of Precambrian age.

Small amounts of tyuyamunite are closely associated with tear and thrust faults along the east front of the Beartooth Mountains south of Red Lodge.

The most important uranium deposits in Montana are those discovered in the fall of 1955 in the Pryor Mountains, Carbon County. These deposits are along major faults and anticlines in the upper part of the Madison limestone of Mississippian age. "The ore bodies appear to be invariably associated with collapsed caverns in the limestone although the better grade of material has been found to lie below the collapse itself. The collapse areas have been brecciated and recemented by silicification, and uranium minerals [tyuyamunite] are contained within the collapse breccia." In some places fluorite is associated with tyuyamunite, thus suggesting a possible hydrothermal origin for the deposits, although the author believes that "the deposits occur as a result of deposition from meteoric or surface waters * * *." The deposits contain ore of relatively high grade (up to 6 percent U_3O_8), and the majority range in size from 100 to 1,500 tons. Geologically similar deposits are just south of the State line on Little Mountain, Wyo.

A map showing the National Forests of Montana with known uranium occurrences, a geologic map of the Boulder batholith and vicinity, and a geologic map of the Pryor Mountains are included.

74 Jarrard, L. D., and Mead, W. E., 1955, Exploration diamond drilling in the Boulder batholith, Jefferson and Silver Bow Counties, Montana: U. S. Atomic Energy Comm. RME–2031 (pt. 1), 13 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

In 1953 the Atomic Energy Commission conducted a diamond-drilling program in the Boulder batholith to explore the character and extent of uranium mineralization beneath surface outcrops and shallow workings.

Sixteen holes were drilled in base-metal-type deposits including the Gray Eagle-Comet shear zone, Lone Eagle mine, Nickelodeon claim, and the Uncle Sam mine. Very slight radioactivity was found in only five of the holes.

Forty-four holes were drilled in siliceous-reef-type deposits. Thirty-seven of these holes were drilled on the President group of claims. Most of these deposits are below ore grade. Drilling indicates that in most instances the small isolated zones of uranium minerals in the outcrops do not persist even to moderate depths.

Drilling at 3 other siliceous-reef-type deposits penetrated ore-grade material over a width of half a foot at the Mooney claim, 4 miles west of Butte. Anomalous radioactivity was found in holes drilled at the Redstone-Atomizer claims and at the Red Rock claim. The radioactive material in both deposits was not of ore grade.

The report contains a geologic map of the Boulder batholith showing the location of drilling areas.

75 Kaiser, E. P., 1951, Uraniferous quartzite, Red Bluff prospect, Gila County, Arizona: U. S. Geol. Survey Circ. 137, 10 p.

Abnormally radioactive zones occur in 2 favorable layers each about 20 feet thick in the upper silty part of the Dripping Spring quartzite of Precambrian age at the Red Bluff prospect, 12 miles northeast of Roosevelt Dam, Gila County, Ariz. The zones are spatially associated with a diabase dike and a diabase sill. The quartzite is nearly horizontal.

The uranium appears to be rather evenly disseminated through the rock in the abnormally radioactive zones which are estimated to contain an average of 0.026 percent uranium. An exception to this general rule are some northwest-trending fractures and black streaks that are highly radioactive only within the favorable zones. The principal uranium mineral in the radioactive zones has not been definitely identified, though small quantities of autunite and uranophane have been observed. The uranium may be contained in very small grains of pitchblende.

The deposits are localized by favorable structures and by favorable host rock. The report includes a geologic map and section of the central part of the Red Bluff prospect.

76 Kerr, P. F., 1956, Rock alteration criteria in the search for uranium: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium, p. 679–684; U. S. Geol. Survey Prof. Paper 300, p. 633–639.

The hydrothermal alteration of host rocks of many uranium-bearing veins may be used as a guide in the search for uranium. Although alteration effects are more easily detected in igneous and metamorphic rocks, they are also observed in sedimentary rocks. Types of hydrothermal alteration perhaps related to the deposition of uranium, particularly in the Western United States, include ferrugination, fluoritization, chloritization, argillization, alunitization, and dolomitization.

77 Kerr, P. F., 1956, The natural occurrence of uranium and thorium: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium, p. 5–59.

This paper is a summary of geologic knowledge on the natural occurrence of uranium and thorium compiled largely from papers submitted to the first International Conference on the Peaceful Uses of Atomic Energy. The author considers the natural occurrence of uranium and thorium from three points of view: (a) original sources, (b) mechanisms of transport and deposition, and (c) types of deposits produced.

Individual uranium deposits and districts of the various geologic types of deposits are described. Uranium-bearing veins are discussed under an older group and under a younger group. Deposits of the older group are those of Precambrian and Paleozoic age and include those at Great Bear Lake and Lake Athabasca, Canada; Shinkolobwe, Belgian Congo; and Joachimsthal, Czechoslovakia. Deposits of the younger group are those of Tertiary age in the Western United States and include deposits in the Colorado Front Range; Marysvale district, Utah; Spokane Indian Reservation, Wash.; Thomas Range, Utah; and the Los Ochos mine, Colorado.

78 Kerr, P. F., Anderson, T. P., and Hamilton, P. K., 1951, Bellevue-Rochester mine, *in* Annual report for July 1, 1950, to June 30, 1951: U. S. Atomic Energy Comm. RMO–797, p. 45–57, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Soft black powder and friable black masses of uraninite are in two fissure veins in the Bellevue-Rochester mine, 1 mile west of Lawson, Clear Creek County, Colo. One vein is nearly vertical and ranges from a thin seam to several inches in width. The second vein dips about 60° N. and seems to strike parallel to the first and may intersect it above the tunnel level. The host rock of the veins is biotite schist of the Idaho Springs formation of Precambrian age. Each vein is enclosed by an alteration zone; the inner portion is argillic and the outer portion is chloritic. The uranium mineralization and the wallrock alteration are closely associated and are believed to be of hydrothermal origin.

The major part of this report is a discussion of the mineralogy of the wallrock alteration.

79 Kerr, P. F., Brophy, Gerald, Dahl, H. M., Green, Jack, and Woolard, L. E., 1952, A geologic guide to the Marysvale area, *in* Annual report for July 1, 1951, to June 30, 1952, Part 1: U. S. Atomic Energy Comm. RMO-924, 57 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The Marysvale area is in Piute County, Utah, about 200 miles south of Salt Lake City. The country rock includes two series of extrusive volcanic rocks, the older Bullion Canyon formation and the younger Mount Belknap formation. The Bullion Canyon formation is the most widely exposed rock in the area and consists of a great thickness of lavas and tuffs of post Oligocene age. This formation has been invaded by small bodies of intrusive rocks consisting mostly of quartz monzonite and lesser amounts of granite, monzonite porphyry, latite, and latite porphyry. These intrusive rocks and the Bullion Canyon formation were extensively eroded and unconformably overlain by flows and tuffs of the Mount Belknap formation.

The uranium mines are along the western border of a quartz monzonite intrusive near its contact with an overlying mass of Mount Belknap rhyolite. The uranium-bearing veins are along northwest- and northeast-trending fracture zones. The veins are almost entirely localized in altered host rocks that were originally quartz monzonite, granite, vitrophyre, or rhyolite. Most of the veins are in quartz monzonite and uranium is most abundant in places of prominent clay-mineral alteration and silicification. At depth the veins contain sooty black uraninite intimately mixed with fine-grained pyrite and fluorite. Other primary minerals include quartz, adularia, jordisite, hematite, and magnetite. Secondary uranium minerals are in the oxidized zone above the uraninite ore bodies and include autunite, torbernite, schroeckingerite, and uranophane(?). Other secondary minerals are limonite and ilsemannite.

The uranium in the deposits at Marysvale is believed to have come originally from a magmatic source, and it is probable that both liquids and gases were present in the veins when the uranium was originally deposited.

The report contains a topographic map showing the principal mines and prospects in the area, a reconnaissance geologic map of the area, and maps and sketches showing alteration zones in surface areas and in several mine workings.

80 Kerr, P. F., Rasor, C. A., and Hamilton, P. K., 1951, Uranium in Black King prospect, Placerville, Colorado, *in* Annual report for July 1, 1950, to June 30, 1951: U. S. Atomic Energy Comm. RMO-797, p. 25–43, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The Black King prospect is near Placerville, in San Miguel County, southwestern Colorado. The area is underlain by nearly horizontal sedimentary rocks of Permian to Cretaceous age, which have been intruded by igneous rocks of Tertiary age and cut by numerous faults. At the Black King prospect, tetrahedrite, chalcopyrite, sphalerite, and possibly skutterudite occur along faults of considerable displacement that cut sandstone and arkose beds of the Dolores formation. The faults show some postmineralization movement. "Masses and segregations of an uranium-bearing hydrocarbon corresponding in many respects to thucolite are found both in the sedimentary strata and along fissures. Minute specks of uraninite occur disseminated through the hydrocarbon. Earlier hydrocarbons appear to have been replaced by later generations, forming microtextures indicative of chemical replacement * * * it is believed that the mineralization is due to hydrothermal activity."

A plan map and sections of the Black King mine are included.

81 Kerr, P. F., and Robinson, R. F., 1953, Uranium mineralization in the Sunshine mine, Idaho: Mining Eng., v. 5, no. 5, p. 495–511.

Uranium was discovered in 1949 at the Sunshine mine, a well-known silver-lead producer, in the Coeur d'Alene district of northern Idaho. The uranium occurs in the footwall of the Sunshine vein from the 2,900- to the 3,700-foot levels. Several silver-bearing veins, including the Sunshine vein, cut the overturned north limb of the Big Creek anticline. The Sunshine vein dips about 60° S. approximately parallel to the axial plane of the anticline and cuts rocks of the Belt series of Precambrian age. The uranium-bearing part of the vein is in quartzite of the St. Regis formation.

The deposition of silver and uranium seem to belong to distinct epochs resulting from several periods of emplacement. Veinlets of the early uraninite contain pyrite and jasper and have been extensively divided and recemented into short segments. The later silver-bearing tetrahedrite-siderite veins are more massive and may extend without a break for hundreds of feet. The silver ores are in major fractures that are steeply inclined. The uraninite is not restricted to major vein fractures and above the 3,250-foot level is in shear zones related to fracture cleavage. On the 3,700-foot level, however, uraninite is largely restricted to a fissure vein. The uranium-bearing veins are characteristically associated with fine-grained silica stained red, brown, or pink, and commonly arsenopyrite.

The age of the uraninite, on the basis of isotopic analyses is 750 ± 50 million years, which agrees with geologic data, suggesting that phases of the Sunshine mineralization are of Precambrian age. It is not clear, however, whether the silver-bearing veins constitute a late phase of Precambrian mineralization or belong to a later period, possibly Tertiary.

Geologic maps of the 3,100-foot level and a section showing the general geologic structure of the Sunshine mine are included. Also included are photographs of polished surfaces of uraninite-bearing ore and several diagrams showing the structure and mineralized zones of various veins.

82 Kerr, P. F., Simpson, W. L., and Hamilton, P. K., 1953, Deer Trail area, Marysvale, Utah, *in* Annual report for June 30, 1952, to Apr. 1, 1953: U. S. Atomic Energy Comm. RME–3046, p. 52–57, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Uranium occurs in the Deer Trail mine about 6 miles southwest of Marysvale, Utah. The Deer Trail mine intermittently yielded ores of mercury, lead, silver, and gold and is presently yielding lead ore. The mine is located along the Tushar fault on the east slope of the Tushar Mountains. The ore deposits are in lens-shaped replacement bodies from 1 to 5 feet in thickness and are parallel to the bedding which dips 15° to 20° W. The host rock is limestone of Permian(?) age. No uranium mineral has been identified in the deposits, but chemical analyses indicate that small amounts of uranium occur along the upper and lower margins of a lead-zinc-silver replacement ore body.

This deposit is particularly interesting because it is the only uranium deposit in the Marysvale district not in volcanic and intrusive rocks of Tertiary age.

A geologic map of the main tunnel of the Deer Trail mine and a cross section of the uranium occurrence are included.

83 Keys, W. S., 1956, Deep drilling in the Temple Mountain collapse, San Rafael Swell, Utah: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium, p. 371–378.

Keys, W. S., and White, R. L., 1956, Investigation of the Temple Mountain collapse and associated features, San Rafael Swell, Emery County, Utah: U. S. Geol. Survey Prof. Paper 300, p. 285–298.

Temple Mountain is on the southeast flank of the San Rafael Swell about 44 miles southwest of Green River, Utah. The Temple Mountain collapse is a synclinal depression about 500 feet wide by 2,000 feet long, and has a maximum subsidence of 300 feet. The center is bleached and brecciated. The collapse was drilled to investigate "its structure and its relation to the uranium ores * * *."

A primary uranium mineral, probably pitchblende or uraninite, in hard, brittle asphaltite, is distributed along fractures and bedding planes in the sedimentary rocks of the collapse structure. The ore-bearing asphaltite also occurs as breccia cement and as disseminations in brecciated sandstone. In places the asphaltite has partly replaced quartz grains. Realgar and native arsenic are associated with, and seem to be genetically related to, the asphaltic uranium-ore. Secondary uranium-vanadium minerals, commonly hewettite and carnotite, occur as oxidation products of the asphaltic ore. No secondary uranium-vanadium minerals were found in the drilling, however, and the highest grade ore consists of uraniferous asphaltite. It is believed that the fractures which accompanied the subsidence provided a channel for the uranium-bearing solutions.

More than 95 percent of the uranium production of the Temple Mountain region has come from an area about 2,000 feet south of the Temple Mountain collapse. This area is known as the Temple Mountain mineral belt. Ore bodies within the mineral belt are similar in mineralogy to most of the ore in the collapse and are generally localized along bedding planes. Small bodies of uranium ore have been mined from a vertical fault zone at the Lopez mine, and localization of ore along faults has been reported from other mines.

A geologic map of the Temple Mountain mining area is included.

84 Killeen, P. L., and Ordway, R. J., 1955, Radioactivity investigations at Ear Mountain, Seward Peninsula, Alaska, 1945: U. S. Geol. Survey Bull. 1024–C, p. 59–94.

The Ear Mountain area is about 100 miles north-northwest of Nome on the north side of the Seward Peninsula. Radioactive material believed to be of replacement origin occurs along a tourmalinized mafic dike and an associated vein filling of quartz and tourmaline. The steeply dipping dike and vein are parallel and can be traced by float rocks for nearly a mile across the granite stock that constitutes the central part of Ear Mountain. Two trenches about 2,500 feet apart were dug across the vein and dike. An 8-foot channel sample along 1 trench contained 0.01 percent uranium. An 18-inch sample across a zone of red oxidized material in this trench contained 0.012

percent equivalent uranium. A light-green secondary uranium mineral, identified as intermediate between metazeunerite and metatorbernite, occurs in vugs in both the granite host rock and the tourmaline-quartz vein. The discovery of this deposit in 1945 was the first verified lode deposit of radioactive minerals in Alaska.

A topographic and geologic sketch map of Ear Mountain is included.

85 King, R. U., 1954, Colorado, *in* Geologic investigations of radioactive deposits–Semiannual progress report, Dec. 1, 1953, to May 31, 1954: U. S. Geol. Survey TEI–440, p. 174, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Secondary uranium minerals were discovered in an abandoned copper-fluorspar mine near Copperdale, about 3 miles northwest of the Ralston Creek area, Jefferson County, Colo. The uranium deposit is associated with a northeast-trending fault that crosses the Rogers "dike" breccia reef. "The reef * * * consists of massive brecciated white quartz with lenses of dark-purple fluorite and fragmented wall rocks with hematite and limonitic material. A pale-yellow uranium mineral (schroeckingerite?) occurs as aggregates of tiny micaceous flakes along fractures and joints. A sample of the uranium-bearing material contains 0.11 percent uranium."

86 King, R. U., and Granger, H. C., 1952, Torbernite occurrence at the Robineau claims, Clear Creek County, Colorado: U. S. Geol. Survey TEM–24A, 7 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The Robineau claims are about 1½ miles southwest of Lawson in Clear Creek County, Colorado. They include the George Peabody, MacGregor, and Little Mac claims.

"Fractured iron-stained granite pegmatite has been prospected by two shallow shafts on the George Peabody claim and several prospect pits on the other claims. As the mine workings were inaccessible at the time of examination, July 1949, radiometric traverses were made of the area covered by the claims, and the dump at one shaft was sampled. Torbernite and an unidentified radioactive mineral are associated with hydrous iron oxides on fracture surfaces in pre-Cambrian granite and pegmatite. A composite sample from the George Peabody dump contained 0.013 percent U_3O_8."—*Excerpt from authors' abstract*

87 King, R. U., Leonard, B. F., Moore, F. B., and Pierson, C. T., 1953, Uranium in the metal-mining districts of Colorado: U. S. Geol. Survey Circ. 215, 10 p.

The most favorable areas in Colorado for uranium ore deposits, exclusive of the Colorado Plateau, are the metal-mining districts of the central mineral belt. These districts have produced about 300 tons of high-grade uranium ore, most of which was mined between 1872 and 1919 from deposits on Quartz Hill in the Central City district. The uranium occurs in metalliferous pitchblende-bearing veins that occur chiefly in igneous and metamorphic rocks of Precambrian age. A few veins also occur in monzonite of post-Cretaceous age or in late Paleozoic and Mesozoic sedimentary rocks. The time of uranium deposition in the veins is thought to be Tertiary because of their association with Tertiary intrusive rocks. In Colorado, pitchblende has been found in six types of veins: (a) pyritic gold-quartz, (b) lead-zinc-silver,

(c) fluorite, (d) gold-telluride, (e) pyrite-siderite, and (f) polymineralic hydrocarbon veins.

The vein types listed above are briefly described, and geologic guides for prospecting for uranium deposits are discussed. The report contains a map showing the relation of pitchblende deposits to bostonite dikes in the Front Range mineral belt, a map showing the relation of pitchblende deposits to mineral zoning in the Central City district, and an index map showing the distribution of 51 uranium deposits in Colorado, generally exclusive of the Colorado Plateau. Also included is a table that lists each deposit, giving its geologic type, country rock, and radioactive minerals.

88 King, R. U., Moore, F. B., and Hinrichs, E. N., 1952, Pitchblende deposits in the United States, *in* Selected papers on uranium deposits in the United States: U. S. Geol. Survey Circ. 220, p. 8–12.

Pitchblende is found in the United States in (1) veins and breccia zones, (2) pyrometasomatic deposits, (3) pegmatites, and (4) sedimentary rocks.

Most of the vein deposits containing pitchblende are in the Front Range mineral belt of Colorado, but a few are in Arizona, Idaho, Montana, Nevada, and Utah. The pitchblende deposits in the Front Range mineral belt appear to be coextensive with alkali-rich Tertiary intrusive rocks, but a similar relation is not known elsewhere in the United States.

Pitchblende-bearing vein deposits can be classified on the basis of mineral association as (1) quartz-sulfide type, (2) quartz-sulfide-carbonate type, (3) quartz-sulfide-carbonate-hematite type and (4) fluorite-quartz type.

Pitchblende is finely disseminated in deposits of the fluorite-quartz type. In mesothermal veins, pitchblende occurs as pods and stringers distributed erratically over relatively narrow vertical limits. In many deposits, pitchblende occurs both as hard botryoidal masses and as powdery films and coatings.

The metallic minerals commonly associated with pitchblende in vein deposits include galena, sphalerite, chalcopyrite, pyrite, silver minerals, and gold. In contrast to well-known deposits in Canada and Africa, cobalt or nickel minerals have been found in only a few of the domestic pitchblende-bearing veins. In a few places, veins containing secondary uranium minerals near the surface contain pitchblende at depth.

The relationship of pitchblende-bearing veins to types of wall-rock alteration has not been clearly established.—*Authors' abstract*

A sketch map showing the relation of pitchblende deposits to bostonite dikes in the Front Range mineral belt, Colorado, and cross sections showing depth of pitchblende deposits in the Front Range are included.

89 King, R. U., and Theobald, P. K., 1955, Blackhawk district, Gilpin County, *in* Geologic investigations of radioactive deposits—Semiannual progress report for Dec. 1, 1954, to May 31, 1955: U. S. Geol. Survey TEI–540, p. 141–142, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Radioactivity is associated with quartz-hematite breccia in the northwest-trending Blackhawk fault zone at the Priscilla claim, 1½ miles southeast of Blackhawk. The discovery, made early in 1955, is 1¾ miles southeast of the Silver Hill uranium deposit. A sample of the breccia from the discovery cut contains 0.17 percent uranium, and dump material from a nearby abandoned shaft in the fault zone contains 0.017 percent uranium.

The Silver Hill deposit, a vein-type deposit that contains disseminated secondary uranium minerals in weathered schist, is being explored by drifting along the vein. Additional ore-grade material is being found as the drift is advanced. A sample from the vein contains 0.43 percent uranium.

These two deposits extend the favorable area of the Central City district eastward in the direction of the known uranium deposits of the Ralston Creek-Golden Gate area and suggest that further prospecting of breccia reefs and major faults may disclose additional uranium deposits—*Authors' complete text*

90 King, R. U., and Theobold, P. K., 1955, Colorado, *in* Geologic investigations of radioactive deposits—Semiannual progress report for Dec. 1, 1954, to May 31, 1955: U. S. Geol. Survey TEI–540, p. 208–209, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Radioactivity and minor uranium mineralization occur in a copper-bearing fault zone at the F.M.D. mine in Jefferson County, Colo. The average uranium content of 3 samples from the property was 0.018 percent uranium.

Uranium-bearing material of ore-grade was discovered in the radioactive breccia reef at Idledale, Jefferson County. "One core drill hole intersected the breccia-filled fault zone at a depth of about 200 feet, and an eigth-foot interval is reported to contain 0.58 percent uranium. In the drill core small masses of a black radioactive mineral tentatively identified as pitchblende are disseminated in a carbonate and feldspar matrix that contains angular fragments of altered wall rock and hematite-stained quartz."

91 Klemic, Harry, 1955, Northeast district, *in* Geologic investigations of radioactive deposits—Semiannual progress report for Dec. 1, 1954, to May 31, 1955: U. S. Geol. Survey TEI–540, p. 205, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

A ¼-inch veinlet of pitchblende containing small amounts of galena and pyrite was found at 1 locality in the Grandfather Mountain window area in Pisgah National Forest in western North Carolina. Several occurrences of torbernite and other secondary uranium minerals were found in the area. Most of the deposits are between Morgantown and Blowing Rock, near Highways 181 and 321.

92 Klepper, M. R., 1950, Forty-Niner, King Solomon Ridge, and West End claims near Clancy, Jefferson County, Montana: U. S. Geol. Survey TEM–31, 2 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The Forty-Niner, King Solomon Ridge, and West End claims are on the crest of an east-west-trending ridge on the north side of Clancy Creek about 1 to 1½ miles west of Clancy, Jefferson County, Mont.

The crest of the ridge is composed of a light-colored aplitic granite that appears to form a thick east-trending dike in quartz-monzonite. Radioactivity occurs in and adjacent to dark-gray siliceous slightly pyritic veins that cut the aplitic granite. One vein is 18 to 30 inches wide and contains a few crystals of secondary uranium minerals, possibly zeunerite and rutherfordine. A selected sample of the vein material contained 0.096 percent uranium.

Altered aplitic granite contains secondary uranium minerals, probably autunite and zeunerite, in thin crusts or fracture fillings. The material contains only 0.084 percent uranium.

93 Leonard, B. F., 1952, Relation of pitchblende deposits to hypogene zoning in the Front Range Mineral Belt, Colorado [abs.]: Econ. Geology, v. 47, p. 773; Geol. Soc. America Bull., v. 63, p. 1274–1275.

The distribution of pitchblende deposits in several Front Range mining districts shows a distinctive relation to the pattern of hypogene zoning. The deposits appear to be restricted to an intermediate or transitional zone between central areas of pyritic gold veins and peripheral areas of silver-lead-zinc veins. At present we do not know whether pitchblende is more common in the inner or the outer part of the intermediate zone. In at least one district (Central City) significant quantities of copper in the form of chalcopyrite have been produced from the intermediate zone. The position of uranium in an intermediate zone between gold and zinc was tentatively implied by W. H. Emmons (1926) in his generalized treatment of hypogene zoning.

At least seven local geologic factors must be considered in interpreting the zonal distribution of Front Range pitchblende deposits: Bostonite intrusives, fault patterns, multiple stages of uranium mineralization, differences between paragenetic sequence and position of minerals in successive zones, correlation of pitchblende with copper sulfides (and sulfosalts?), scale and complexity of zoning in plan and in section, and effective depth of mineralization. The significance of some of these factors can already be evaluated.

The concept of the position of pitchblende in hypogene zoning is developed to stimulate and guide the systematic search for pitchblende deposits. Though the zonal position of pitchblende deposits is best known for areas of complex base-metal mineralization dominantly of mesothermal (possibly xenothermal) character, knowledge of the zonal position of uranium deposits in widely different geologic environments might be similarly useful in a search for ore.—*Author's abstract*

94 Love, J. D., 1954, Pedro Mountains, *in* Geologic investigations of radioactive deposits—Semiannual progress report, June 1 to Nov. 30, 1954: U. S. Geol. Survey TEI–490, p. 229–230, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

A small shipment of uranium ore has been made from a deposit in the Pedro Mountains in sec. 14, T. 27 N., R. 84 W., Carbon County, Wyo. The uranium is associated with a graphite layer about 6 feet thick, underlain by thin quartzite(?), and intruded and surrounded by granite of Precambrian age. Within the weathered zone secondary uranium minerals are abundant along fractures and are disseminated in the granite adjacent to the graphite bed. A lesser amount of mineralization occurs in the quartzite(?), and the graphite contains a finely disseminated fluorescent mineral. Sulfides, chiefly pyrite, are concentrated below the weathered zone. A black mineral that appears to contain uranium is finely disseminated in the unweathered granite.

95 Love, J. D., 1954, Shirley Mountains, *in* Geologic investigations of radioactive deposits—Semiannual progress report, June 1 to Nov. 30, 1954: U. S. Geol. Survey TEI–490, p. 227–228, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Secondary uranium minerals occur in vertical calcite veins that cut the Tensleep sandstone of Pennsylvanian age in sec. 30 and 31, T. 25 N., R. 81 W., and in sec. 36, T. 25 N., R. 82 W., in the Shirley Mountains, Carbon County, Wyo. The veins are as much as 24 feet thick. Some are more than 1,000 feet long and extend vertically for more than 500 feet. The uranium content of samples from several shallow test pits ranges from 0.03 to 0.39 percent.

96 Lovering, T. G., 1954, Radioactive deposits of Nevada: U. S. Geol. Survey Bull. 1009–C, p. 63–106.

This report is a brief summary of the information available through 1951 on uranium deposits in Nevada. The location, ownership, development, geology, and grade of ore is summarized for each deposit. The only deposit that has produced ore is the Green Monster mine in Clark County from which 5 tons of 1.09 percent uranium ore was shipped in 1951. This mine was the source of a considerable tonnage of zinc and lead ore mined from a steeply dipping mineralized breccia zone in the Bullion dolomite member of the Monte Cristo limestone of Mississippian age. "Secondary uranium minerals occur in a zone 1 to 2 feet thick on the footwall side of the ore body. Kasolite and an unidentified uranium mineral are associated with malachite, azurite, cuprite, cerrusite, calamine, and limonite in a yellow earthy ore as replacement deposits in the upper stope * * *" where most of the uranium has been found and where selected samples assayed as high as 9 percent uranium.

The grade of the ore "decreases rapidly with depth; 0.057 percent uranium was the highest value obtained 80 feet below the upper stope." The uranium reserves of this deposit are small.

In the Washington district in Lyon County, uranium-bearing quartz fissure veins cut porphyritic granite of probable Jurassic age. The veins average a few inches in width and range in uranium content from 0.001 to 0.14 percent. Pitchblende, kasolite, and torbernite are associated with copper-silver-lead minerals chiefly chrysocolla, chalcocite, chalcopyrite, galena, and argentite.

At the Majuba Hill mine in Pershing County, a vein 3 feet wide containing copper, tin, and an average of almost 0.3 percent uranium cuts quartz porphyry and rhyolite of Tertiary age. Secondary uranium minerals including zeunerite, torbernite, metatorbernite, autunite, and gummite are associated with sooty chalcocite, pyrite, and arsenopyrite. Uranium also occurs in the country rock adjacent to the vein, in fault gouge, in tourmalinized intrusion breccia, and in the rock adjacent to the breccia.

At the Stalin's Present prospect in Pershing County, pitchblende occurs as scattered grains in a tabular body of diopside-rich rock and gummite coats fracture surfaces in the adjacent country rock. Samples taken across the diopside-rich rock contained from 0.042 to 0.18 percent uranium. The deposit has been interpreted as a foot-thick layer of uranium-bearing metamorphic rock composed of diopside, epidote, and chlorite enclosed by granitic country rock. The deposit also has been interpreted as narrow, discontinuous uranium-bearing replacement veins of diopside-rich rock which cut a dike or tongue of quartz porphyry. This body of quartz porphyry is about 75 feet wide and has intruded metasediments near the workings.

Several other uranium-bearing veins are described in this report. Samples obtained from these properties contain less than 0.1 percent uranium.

97 Lovering, T. G., 1956, Radioactive deposits in New Mexico: U. S. Geol. Survey Bull. 1009–L, p. 315–390.

This report summarizes information on the radioactive deposits of New Mexico. The deposits are discussed by counties, and for each deposit the location, general geology, mineralogy, and radioactivity are described. References are given to published reports that describe the areas. Vein-type deposits are described below.

In southwestern New Mexico uranium-bearing veins occur in the White Signal and Black Hawk districts in Grant County. In the White Signal district autunite and torbernite occur as fracture coatings and disseminations in oxidized pyritic quartz veins that cut granite of Precambrian age and diabase. Uraniferous limonite is common locally in the veins. The following deposits in the White Signal district are described: The Merry Widow, Apache Trail, Blue Jay, Monarch No. 2, and Tunnel Site No. 1 claims and the Uncle Sam silver mines. In the Black Hawk district at the Black Hawk and Alhambra mines pitchblende is associated with nickel, cobalt, and silver minerals in quartz veins cutting granite of Precambrian age. All mine workings in the district are inaccessible. There are no known minable reserves of uranium ore in either the White Signal or Black Hawk districts, though there is some vein material of ore grade at the Merry Widow mine.

Two other vein deposits in Grant County contain minor amounts of uranium minerals. At the Hines No. 1 prospect southeast of White Signal, fluorite and autunite(?) occur in a nearly vertical breccia zone in the Bliss(?) sandstone of Cambrian age. At the Langford prospect southwest of White Signal, radioactive dark-purple fluorite and autunite(?) are associated with pink calcite in a silicified breccia zone cutting granite of Precambrian age.

At the Terry prospect in Sierra County, 2 miles northeast of Monticello, uranophane is associated with fluorite in a silicified breccia zone. The nearly vertical breccia zone is in limestone of Mississippian age that has been altered to jasperoid. Samples from the deposit contain from 0.004 to 0.45 percent U_3O_8.

At a deposit near San Acacia, Socorro County, autunite, torbernite, uranophane, and carnotite are sparsely disseminated in a breccia zone cutting an andesitic flow rock of Tertiary age. The uranium minerals are associated with secondary copper minerals, calcite, and quartz. A selected sample of dump material contained 0.026 percent uranium.

Although the deposits in the Todilto limestone of Jurassic age in the Grants district, Valencia and McKinley Counties, are classified by the author as disseminated-type deposits, some of them are structurally controlled by concentration of carnotite and tyuyamunite along joint surfaces. In this respect where induced cavities have been partly instrumental in localizing the uranium minerals, the deposits show vein affinities.

Geologic maps and sections of several deposits are included. Tables show analyses of samples from various deposits, and the significant features of the radioactive deposits of New Mexico are summarized in tabular form.

98 Lovering, T. S., and Goddard, E. N., 1950, Geology and ore deposits of the Front Range, Colorado: U. S. Geol. Survey Prof. Paper 223, p. 175, 183, and 190.

Pitchblende associated with sulfides occurs in east-northeast-trending veins on the south slope of Quartz Hill in the Central City-Idaho Springs district of Colorado. The pitchblende-bearing veins are near two strongly radioactive north-northwest-trending bostonite dikes and it is suggested "that the uranium-bearing solutions are related to a deep bostonite magma apexing in a narrow northerly zone at depth and that these fluids first followed fissures or dikes transverse to the east-northeasterly veins in which the ore has been found." Pitchblende has been reported from the Alps, Belcher, Calhoun, German, Kirk, Leavenworth, Mitchell, Pewabik, Wood, and Wyandotte mines where it occurs as a minor component of the pyritic gold-silver ores for which the mines have been primarily worked.

At the German and Belcher mines low-grade uranium ore containing about 0.25 to 0.5 percent uranium oxide consisted of altered schist or pegmatite impregnated with pyrite, sphalerite, and pitchblende. High-grade uranium ore formed irregular masses in the low-grade disseminated ore. The pitchblende is generally cut by small veins of sulfides.

At the Jefferson-Calhoun mine pitchblende is cut by many later veinlets of pyrite, sphalerite, quartz, and galena. The ore contained as much as 29 percent U_3O_8.

99 McKay, E. J., and Hyden, H. J., 1956, Permian of north Texas and southern Oklahoma, *in* Geologic investigations of radioactive deposits–Semiannual progress report for June 1 to Nov. 30, 1956: U. S. Geol. Survey TEI–640, p. 208–216, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Uranium ore was mined from a vein-type deposit in the Rush Springs sandstone of Permian age at Cement in Caddo County, Okla. The deposit is localized along joints, parallel to the axis of the Cement anticline. "The deposit is about 150 feet long, 3 to 5 feet wide, and is worked to a depth of 3 to 6 feet. Ore minerals tyuyamunite and carnotite are disseminated in sandstone parallel to joints which dip about 80 degrees to the southwest. The uranium-vanadium ratio is 2:1 in ore; the average calcium carbonate is 9 percent. Concentrations of ore minerals appear to be in poorly defined pockets along the strike of the joints." Fractures along similar anticlines in the Andarko basin may contain other concentrations of uranium minerals.

100 McKelvey, V. E., 1955, Search for uranium in the United States: U. S. Geol. Survey Bull. 1030–A, 64 p.

This report briefly summarizes "the information on the common uranium minerals, the kinds of deposits in which uranium is found, the methods used in the search for uranium, the important deposits found in this country thus far, the outlook for future discoveries, and the recent literature on the geology of uranium deposits in the United States."

Only a few of the uranium-bearing veins and related deposits that have been found in recent years in the United States have yielded any production, and no vein deposit of major importance by world standards has been found. Most of the deposits are fracture fillings in igneous or metamorphic rocks, and a few are in breccia and fault zones in carbonate rocks. Most of the veins are metalliferous quartz-sulfide deposits, mainly of the simple type high in lead, copper, silver, or gold. A few are uraniferous fluorite deposits. Most of these veins contain pitchblende and, where oxidized, secondary uranium minerals such as autunite and torbernite. Secondary enrichment is uncommon, and most oxidized vein deposits are less uraniferous than the lodes from which they were derived.

The more important vein deposits at Marysvale, Utah, in the Colorado Front Range, and near Boulder, Mont., are briefly described. The report includes a map showing vein and replacement deposits of uranium in the United States. The names of the deposits and references to them are listed.

101 McKelvey, V. E., Everhart, D. L., and Garrels, R. M., 1955, Origin of uranium deposits, *in* Bateman, A. M., ed., Econ. Geology, 50th anniversary volume, 1905–1955, Pt. 1, p. 464–533.

This report briefly summarizes the geochemistry of uranium and discusses the occurrence and origin of uranium in igneous rocks, veins, sandstone-type deposits, coal and associated carboniferous shale, and in marine sedimentary rocks. The following annotation refers to the vein-type deposits.

The occurrence of uranium in certain granitic and syenitic igneous rocks suggests its tendency to concentrate in late-stage differentiates. The hydrothermal solutions formed at the end of such a magmatic series may move upward along open fractures to form uranium-bearing veins.

The authors classified the uranium-bearing vein deposits of the world into three major types designated as nickel-cobalt-native silver, silica-iron lead, and iron-titanium veins. The three types of deposits have definite characteristics in regard to their associated metallic and gangue minerals, host rock, structural habit, and geochemical history.

Uraninite, davidite, brannerite, and coffinite are the four major primary uranium minerals in vein deposits of all types. Secondary uranium minerals may form as alteration products of these primary minerals. In deeply oxidized zones secondary uranium minerals may constitute the major part of the ore down to the water table. In deposits of this type, grade does not change significantly between the secondary and primary ores.

The major metals in uraniferous veins in their general order of abundance are iron, copper, cobalt, lead, nickel, silver, and zinc. Other less common metals include molybdenum, bismuth, titanium, vanadium, and gold.

There are three major groups of nonmetallic gangue minerals in uraniferous veins—silica minerals, carbonate minerals, and fluorite. Crystalline quartz occurs in nearly every known uranium-bearing vein. Chalcedony and jasper are common and opaline silica is prominent in a few. Nearly all the common carbonate minerals have been reported; dolomite, ankerite, and siderite are the most common. Dark fluorite is common, particularly in veins of simple mineralogy.

Primary uranium minerals occupy a variable position in the paragenetic sequence. In deposits of Precambrian age pitchblende is early in the sequence. In deposits of late Paleozoic and Mesozoic age its position is variable, and in deposits of late Mesozoic and early Tertiary age it is commonly late in the sequence.

The distribution of pitchblende in a pattern of hypogene zoning has been suggested for relatively few deposits. In the Colorado Front Range pitchblende seems to be in a transitional zone between central areas of pyritic gold veins and peripheral areas of silver-lead-zinc veins. In the Cornwall deposits pitchblende apparently occurs in the copper-bearing zone. A similar relationship has been suggested for a few other districts characterized by complex base-metal mesothermal mineralization.

Field evidence suggests that uranium may be deposited in veins as an oxide at temperatures ranging from room temperature to several hundred degrees centigrade. In laboratory experiments pitchblende has been precipitated from solutions ranging from 25° to 233° C. Field evidence indicates that most uranium-bearing veins were formed at depths shallow enough and at pressures low enough to be deposited as open-space fillings. Replacement has occurred in only a few deposits, primarily in carbonate-rich host rocks. Precipitation of primary uranium minerals may be caused solely by decrease in temperature and (or) pressure, or may be the result of chemical interaction with the wall rock. Chemical reaction with wall rock would seem to be the more important process in most hydrothermal deposits. The structural control of primary uranium mineralization is characterized by open-space fissure filling within straight parts of the veins. Tight segments, such as may be found along bends in the veins, are generally barren of ore.

The report includes a table listing the three major types of uranium veins. For each type, typical host rocks and metallic and gangue minerals are listed. Well-known deposits are listed as examples of each type of deposit.

102 McKelvey, V. E., Everhart, D. L., and Garrels, R. M., 1956, Summary of hypotheses of genesis of uranium deposits: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium p. 551–561; U. S. Geol. Survey Prof. Paper 300, p. 41–53.

The distribution of uranium in igneous rocks and veins is explained by Larsen and Phair as a function of the size, valence, and abundance of the uranium ion and of equilibrium between oxidation and reduction. Because of the low concentration of uranium in basic magmas and the large size and tetravalence of the uranium ion, it neither precipitates as a separate mineral nor isomorphously substitutes in plagioclase and other rock-forming minerals. Hence, it concentrates in silicic magmas from which it may be deposited as a minor constituent of accessory minerals in which it can substitute isomorphously. More uranium is deposited as discrete minerals and less enters the accessory minerals as differentiation proceeds toward the highly hydrous pegmatite stage, probably because increase in the water content of the magma reduces the solubility of tetravelent uranium compounds. During very late magmatic stages the uranium is oxidized to the hexavalent state, which forms relatively soluble compounds in aqueous solutions and is carried off in hydrothermal solutions. Deposition of uranium in veins takes place when conditions once again become reducing, a conclusion in accord with the facts that the common vein mineral is pitchblende, the one richest in low-valent uranium, and that sulfides are a constant component of pitchblende veins.—*Excerpt from authors' abstract*

Three important types of uraniferous veins have been recognized:

nickel-cobalt-native silver veins, such as those at Shinkolobwe, Belgian Congo, and Great Bear Lake, Canada; silica-iron-lead veins, such as those at Urgerica, Portugal, and Marysvale, Utah; and iron-titanium veins, such as those at Radium Hill, Australia.

Little is known directly about the composition of uranium-bearing hydrothermal solutions. Studies indicate, however, that uranium is transported as the uranyl ion in sulfate or carbonate aqueous solutions that may be either acid or alkaline. Liquid CO_2 has also been suggested as the ore-transporting solution. "From the mineral assemblages and some experimental evidence the silica-iron-lead veins that contain pitchblende are classed as epithermal; the other silica-iron-lead veins and the cobalt-nickel-silver veins are believed to be mesothermal; and some uraninite, brannerite, and davidite veins, which somewhat resemble pegmatite deposits, are regarded as hypothermal."

"Precipitation of primary uranium minerals in veins may be caused solely by a reduction in the amounts of sulfate or carbonate in solution by whatever cause, by a decrease in temperature or pressure or both, or by chemical interaction with the host rock. Most of the pitchblende vein deposits show a marked structural control, a tendency to be deposited along straight parts of fractures rather than along crooked parts. In a few deposits pitchblende is found impregnated in wall rock, but most deposits away from throughgoing structures are along related tensional fractures. Replacement deposits are rare except in carbonate or carbonaceous host rocks and in some high temperature deposits."

The report also discusses the occurrence and origin of uranium in sandstone, coal and associated carbonaceous shale, black shale, and marine phosphorites.

103 MacKevett, E. M., 1956, Kern River area, California, *in* Geologic investigations of radioactive deposits—Semiannual progress report for Dec. 1, 1955, to May 31, 1956: U. S. Geol. Survey TEI-620, p. 227–229, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The uranium deposits in the Kern River area, California, consist chiefly of secondary uranium minerals localized discontinuously along regional fractures that cut the Isabella granodiorite. "The deposits are chiefly open-space fillings that coat fracture surfaces or form pods or veinlets. Minor disseminations of secondary minerals are found locally in gouge or altered wall rock." Most of the deposits are rich in autunite and contain minor flecks of an unidentified dark uranium(?) mineral, limonite, and opal. Fine-grained bluish-black ore, consisting of sooty pitchblende, secondary molybdenum minerals, carbonaceous(?) matter, limonite, and minor fluorite forms the core of some autunite-rich deposits mostly in the Kergon shear zone. All the deposits are generally accompanied by argillic alteration and iron staining and are characterized by a scarcity of common gangue minerals.

All samples of the Isabella granodiorite that were analyzed chemically contain abnormal amounts of uranium associated with accessory xenotime and zircon. This may indicate that the uranium deposited in the fractures was leached from the Isabella granodiorite.

104 Matthews, T. C., 1955, Oregon radioactive discoveries in 1954 and 1955: Oregon Dept. Geology and Mineral Industries, Ore.-Bin, v. 17, no. 12, p. 87–92.

This reference consists of two tables containing information on the known deposits of radioactive materials in Oregon. In table 1 the deposits are listed by counties, and the location, uranium minerals, host rock and associated minerals, equivalent U_3O_8, chemical analysis for U_3O_8, fluorescence, and presence or absence of mercury are given for each deposit where the information is available.

Table 2 gives the results of qualitative spectrographic analyses of many samples from the deposits. The report includes a map of Oregon showing the location of reported radioactive occurrences. Several of the occurrences listed in table 1 are vein-type deposits.

105 Matthews, T. C., 1956, Radioactive occurrences in Oregon, 1956: Oregon Dept. Geology and Mineral Industries, Ore.-Bin, v. 18, no. 12, p. 105–107.

Information on discoveries of radioactive minerals in Oregon during 1956 is presented in tabular form. The location, uranium minerals, host rock and associated minerals, equivalent U_3O_8, chemical analyses for U_3O_8, fluorescence, and presence or absence of mercury are given for each deposit where the information is available. Several of the deposits listed in the table are vein-type deposits. An index map shows the location of the deposits. Numbers on the map correspond to those listing the deposits in the table.

106 Miller, R. D., 1954, Copper-uranium deposit at the Ridenour mine, Hualapai Indian Reservation, Coconino County, Arizona, Part 1: U. S. Atomic Energy Comm. RME–2014, 18 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The Ridenour mine is in the northern part of the Hualapai Indian Reservation in sec. 6, T. 31 N., R. 8 W., about two miles southeast of the Colorado River. The mine is near the middle of the top sandy member of the Supai formation which is Permian in age. Total thickness of the Supai formation in this area is about 900 feet. The ore minerals occur in veins and brecciated zones which form a semicircular pattern in plan view. Carnotite mineralization forms an enclosing envelope around copper-bearing veins which contain major amounts of malachite, azurite, and chalcocite and minor amounts of chrysocolla, bornite, and chalcopyrite. Gangue minerals are chiefly pyrite and limonite. A grab sample of the carnotite zone in the hanging wall in one stope assayed 1.8 percent U_3O_8, and a select sample from a very thin veinlet in another stope assayed 2.5 percent U_3O_8. The dimensions of the uranium-vanadium bearing zone generally have not been exposed by the workings sufficiently to determine the production potential or uranium reserves of the property.—*Author's abstract*

The report includes geologic maps and sections of the mine, a table summarizing the stratigraphy in the mine area, and a table showing the results of chemical analyses of samples from the mine.

107 Moen, W. S., 1954, Uranium mineralization at the Mooney claim, Silver Bow County, Montana: U. S. Atomic Energy Comm. RME–2006, 15 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Uranium is in a nearly vertical east-west-trending vein at the Mooney claim about 10 miles west of Butte, Mont. The vein is of the silicified reef type in altered granitic rock of the Boulder batholith. The vein contains white vein quartz, black and brownish cherty quartz, banded chalcedonic quartz, and lesser amounts of stibnite, galena, and pyrite. Abnormal radioactivity occurs in the black cherty quartz and in small irregular concentrations of meta-autunite. Meta-autunite occurs along fracture surfaces in the vein and in wall rock, and also is disseminated in the wall rock.

"No primary uranium mineral has been identified, but it is probable that the black cherty quartz, some of which assays 0.64 percent equivalent uranium, may contain finely disseminated pitchblende or uraninite.

"Chemical assays of samples taken from the point of highest radioactivity on the outcrop of the Mooney vein showed 0.09 percent uranium oxide across 1 foot of quartz and 0.32 percent from 6 inches of adjacent wall rock. A section of diamond-drill core from 55 feet beneath the above samples assayed to 0.61 percent uranium oxide across 1 foot of vein material, while a 3-inch section of the core assayed as high as 2.4 percent uranium oxide."

It is believed that uranium was leached at and near the surface.

A geologic map and cross section of the Mooney vein are included.

108 Moore, F. B., and Butler, C. R., 1952, Pitchblende deposits at the Wood and Calhoun mines, Central City mining district, Gilpin County, Colorado: U. S. Geol. Survey Circ. 186, 8 p.

Pitchblende has been mined in commercial quantities from 4 gold-and silver-bearing pyrite-sphalerite-galena veins that occur in an area about ½ mile square on the south side of Quartz Hill, Central City district, Gilpin County, Colo. These veins are the Kirk, the German-Belcher, the Wood, and the Calhoun.

Two of these veins, the Wood and the Calhoun, were studied in an attempt to determine the geologic factors favorable for pitchblende deposition.

The pitchblende-bearing veins cut both pre-Cambrian granite gneiss and quartz-biotite schist; however, the gneiss was the more favorable host rock. Two bostonite porphyry dikes of Tertiary(?) age were crosscut by the Wood and Calhoun veins.

The pitchblende occurs in lenses erratically distributed along the veins and in stringers extending outward from the veins. In the lenses it forms hard masses, but elsewhere it is soft and powdery. The pitchblende is contemporaneous with the pyrite but earlier than the sphalerite and galena in the same vein. All the observed pitchblende was at depths of less than 400 feet. The veins probably cannot be mined profitably for the pitchblende alone under present conditions.—*Excerpts from authors' abstract*

A geologic map of part of the Central City district and geologic maps and sections of the Wood and Calhoun mines are included. Tables showing assay data and production of uranium ore from the Wood mine are also included.

109 Moore, F. B., and Cavender, W. S., 1952, Pitchblende deposit at the Caribou mine, Boulder County, Colorado [abs.]: Econ. Geology, v. 47, p. 775; Geol. Soc. America Bull., v. 63, p. 1281.

Pitchblende occurs at the Caribou mine in a mesothermal carbonate vein that contains silver, lead, and zinc minerals. Unlike most of the large well-known pitchblende deposits of the world, it does not contain nickel- and cobalt-bearing minerals. The deposit is believed to be unique in that the host rock is a Tertiary monzonite. The pitchblende is in a tension fracture (the Radium vein) of an interconnecting vein system, at vertical depths between 875 and 1075 feet. Two pitchblende ore shoots are known; the largest one has a vertical dimension of 200 feet and a horizontal dimension of 70 feet. Within the ore shoots, pitchblende forms a discontinuous seam as much as 6 inches thick along the side of sulfide veins. The sulfides and the pitchblende are not intergrown. There is no apparent difference in mineralogy, other than the presence of pitchblende, between the pitchblende-bearing vein and the other veins in the system. The pitchblende is predominantly a soft, sooty variety, but the larger masses also contain a hard, botryoidal variety. The soft pitchblende is believed to have been deposited later and at a lower temperature than the hard pitchblende.—*Authors' abstract*

110 Moore, G. W., and Levish, Murray, 1955, Uranium-bearing sandstone in the White River badlands, Pennington County, South Dakota: U. S. Geol. Survey Circ. 359, 7 p.

Carnotite occurs as efflorescent coatings on chalcedony veins in the Brule formation of Oligocene age at several localities about 3 miles southwest of Scenic, S. Dak. Chalcedony veins as much as 2 inches thick are common in the area and fill nearly vertical fractures cutting very fine grained sandstone and siltstone of the Brule formation. The veins rarely extend into the underlying bentonitic claystone of the Chadron formation. The source of the uranium and the silica (in the chalcedony) may have been volcanic ash in the Brule formation and the overlying rocks of Miocene age. Downward moving ground water may have leached the uranium and silica and deposited it in the rocks below.

111 Moore, R. B., and Kithil, K. L., 1913, A preliminary report on uranium, radium, and vanadium: U. S. Bur. Mines Bull. 70, p. 43–47, 52–53.

Five mines in the Quartz Hill area, about 2 miles from Central City, Gilpin County, Colo., have produced uranium from pitchblende-bearing veins. These mines—the Kirk, the German, the Belcher, the Wood, and the Calhoun—were originally worked for gold.

The Kirk mine is developed on a fissure vein 3 to 6 feet wide that trends east-west and dips 80° S. The vein cuts gneiss and mica schist and contains gold, silver, and copper in addition to pitchblende. The pitchblende ore shoot seems to pitch from east to west, and, except for one place, the ore was on the hanging wall. The richest ore was found between the 140- and 250-foot levels. The mine is reported to have produced about 20 tons of ore averaging 35 percent U_3O_8 and 100 tons averaging 3 to 4 percent U_3O_8. Most of this ore was produced in 1905–06. Production before that time could not be determined.

The German and Belcher mines are on a vein that dips steeply south and cuts gneiss, mica schist, intrusive andesite, and granite. In addition to pitchblende the vein contains gold and silver and sulfides of iron, copper, lead, and zinc. As at the Kirk mine, pitchblende and gold do not occur together. The pitchblende ore shoot plunges from west to east. The mines are reported to have produced about 8 tons of ore containing about 9.4 percent U_3O_8 in the 3 years before 1913.

The Wood and Calhoun mines have produced a small amount of pitchblende but in 1913 were worked only for gold. The Wood vein is 9 to 18 inches wide, and contains lead, zinc, copper, silver, and gold in addition to pitchblende. In general, the mines are similar as regards the character of the veins and quality of pitchblende. A porphyry dike, which may be related to the deposition of the pitchblende, crops out just west of the mines; the workings of the Calhoun mine extend into the dike.

A well-defined fissure vein 1 to 4 feet wide has been found about 9 miles from Russel Siding, Huerfano County, Colo. The vein, which was originally worked for copper, yielded assays ranging from 2.6 to 7.35 percent vanadium and assays are reported to show as much as 1.75 percent U_3O_8. "The ore is heavy, black, and banded and is probably gneiss impregnated with vanadium minerals."

112 Morehouse, G. E., 1951, Investigation of thucholite deposits near Placerville, Colorado: U. S. Atomic Energy Comm. RMO-910, 13 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Near Placerville, Colo., two somewhat unusual occurrences of uranium are found in an extensive fault zone which cuts the Dolores formation. The uranium mineral, which has been identified as uraninite, is intimately associated with asphaltic material. This combination of radioactive organic material has been considered to be thucholite.

At the Black King prospect, thucholite is found in the fault associated with primary sulphides of copper, lead, zinc, molybdenum, and antimony; it is also found in the adjacent hanging-wall beds which have been highly altered. At the White Spar prospect, 1½ miles southeast, the mineral assemblage and occurrence are similar to those of the Black King, but the exposed wall rock is less altered. A radiometric survey along the fault zone between the two deposits failed to indicate the presence of additional uranium-bearing material. Although no uranium ore has been shipped from either property, material of commercial grade exists.—*Author's abstract*

A generalized geologic map of the Placerville area and sketch maps of the Black King No. 5 and the White Spar prospects are included. Tables show the sedimentary formations near Placerville and the results of sample analyses from the two properties.

113 Nelson, H. E., and Hillier, R. L., 1954, Preliminary report on the uranium occurrence of the Silver Lady claim, Jaw Bone mining district, Cross Mountain quadrangle, Kern County, California: U. S. Atomic Energy Comm. RME-2012, 18 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

High radioactivity and metatorbernite are associated with a shear zone at the Silver Lady claims about 20 miles north of Mojave, Calif., in the southeastern extremity of the Sierra Nevada Mountains. The deposits are along the Silver Lady fault, a nearly vertical shear zone 50 feet wide and over 2,000 feet long that cuts intrusive granites of Jurassic(?) age and volcanic rocks of Pliocene(?) age. The radioactivity and metatorbernite occur at intervals for 1,500 feet along the north side of the Silver Lady fault and in west-northwest-trending spurs splitting off from the north side of the fault. The metatorbernite is associated with molybdenite, ferrimolybdite, pyrite, manganese oxide, sericite, and smoky quartz, and occurs disseminated in the hydrothermally altered granite breccia of the oxidized shear zone. There seems to be a zonal arrangement of metals with uranium, molybdenum, iron, and manganese predominating successively from west to east along the fault. A channel sample 4½ feet wide from the most radioactive fault breccia contains 0.071 percent U_3O_8.

A topographic and geologic map of the Silver Lady claim area and a topographic map of the Cross Mountain quadrangle showing major faults are included.

114 Nininger, R. D., 1954, Minerals for atomic energy: New York, D. Van Nostrand Co., Inc., p. 43–58, 80–83, 116–148.

Primary vein deposits of uranium although relatively few in number, have supplied most of the world's uranium to date. Most of this uranium came from the veins at Shinkolobwe in the Belgian Congo, at Joachimsthal in Czechoslovakia and adjacent areas in Saxony, and at Port Radium, Northwest Territories, Canada. These and other primary vein deposits of uranium in the following areas are briefly described: Beaverlodge area, Canada; Devon and Cornwall, England; Urgeirica mine and adjacent areas, Portugal; Massif Central, France; Radium Hill, South Australia; Tete district, Mozambique; Rum Jungle, Northern Territory, Australia; Marysvale district, Utah; Boulder area, Montana; and Front Range, Colo. In addition to primary vein deposits, deposits of secondary uranium minerals in fractures and fracture zones are briefly described. These deposits were formed in fractures in near-surface rocks by ground waters that have moved the uranium varying distances from its original, and often unknown, source. Some of these deposits may prove to be merely oxidation products in place of primary deposits. Deposits of this type that are described include those at Tyuya Muyun, U.S.S.R.; Kara-Tau, U.S.S.R.; Red Bluff deposit, Gila County, Ariz.; Silver Cliff mine, Wyoming; Bukhovo, Bulgaria; Cuneo-Turisia district, Italy; and Mount Painter, South Australia.

Major areas of the world which are described as being particularly favorable for primary vein deposits of uranium include shields, massifs, and principal mountain systems.

115 Norman, H. W., 1957, Uranium deposits of northeastern Washington: Mining Eng., v. 9, p. 662–666.

Vein-type uranium ore deposits in northeastern Washington occur in two distinct geologic environments: (a) in and near the contact of metamorphic rocks and granitic intrusives and (b) in sheared and faulted zones within granitic intrusives.

The deposits on the Spokane Indian Reservation are along mineralized contact zones. The Midnite mine, the best example of this type of deposit, is on the sheared contact of the Loon Lake granite of Late Cretaceous age and the Deer Trail argillite of probable Precambrian age. The argillite is altered to calc-silica hornfels and quartz-mica schist near the contact. The strike of the contact approximately parallels the strike of the bedding which averages N. 15° E. and dips from 55° to 65° E. The dip of the contact is irregular and ranges from horizontal to 70° E. Scattered concentrations of secondary uranium minerals are in individual bodies or pods along the sheared contact zone. Enriched zones occur where transverse gash fractures interesect the major shear zone. Although shears occur in both the metasedimentary and igneous rock, most of the uranium is in the metasedimentary rock. The uranium minerals in order of decreasing abundance are uranophane, autunite, and torbernite. Uraninite has been found in drill cores from the metasedimentary rock, but, as of 1957, mining operations were in the oxidized surface zone. The uranium minerals are associated with pyrite and with minerals tentatively identified as pyrrhotite and molybdenite. Calcite and quartz are the most abundant nonmetallic minerals. The uranium mineralization is not believed to be the direct result of contact metamorphism because no significant replacement of the host rock by uranium minerals is evident. Exploration drilling along the contact zone has indicated a large tonnage of ore reserves.

A deposit on a similar sheared contact is on the Lowley lease, 7 miles south of the Midnite mine. The zone of oxidation is shallow and virtually all production has been from ore containing uraninite and coffinite commonly associated with pyrite and pyrrhotite. Minor amounts of uranophane and autunite were near the surface but did not persist at depth.

The Mount Spokane uranium district occupies an area of about 100 square miles along the east margin of the Loon Lake granite batholith. Uranium deposits in the district are in faults and fractures. The Daybreak mine is the most extensively developed deposit and is on an east-west shear zone that dips 8 °to 10° N. and is intersected by a series of northwest gash fractures and by less well-developed northeast tension faults. Uranium minerals are throughout the shear zone and in many of the transverse fractures, but the largest and richest ore bodies are at the intersection of the main shear zone and the northwest fractures. The geologic characteristics of the Daybreak mine are typical of many nearby deposits. The Mount Spokane deposits are unique in that uranium occurs in only one mineral, meta-autunite, which may be a primary mineral.

116 Olson, J. C., Shawe, D. R., Pray, L. C., and Sharp, W. N., 1954, Rare-earth mineral deposits of the Mountain Pass district, San Bernardino County, California: U. S. Geol. Survey Prof. Paper 261, 75 p.

Small amounts of thorium and traces of uranium are in the rare-earth mineral deposits of the Mountain Pass district, San Bernardino County, Calif. These deposits are veinlike bodies of rare-earth-bearing carbonate rocks that cut metamorphic rocks of Precambrian age. The veins are spatially and genetically related to potash-rich igneous rocks of probable Precambrian age that intrude the metamorphic rocks. Most of the veins are less than 6 feet thick; however, one mass of carbonate rock is 700 feet in maximum width and 2,400 feet long. Carbonate minerals make up about 60 percent of the veins and of the large carbonate body, and are chiefly calcite, dolomite, ankerite, and siderite. The other constituents are barite, bastnaesite, parisite, quartz, and variable small quantities of sulfides, oxides, silicates, phosphates, and fluorite and wulfenite. Radioactive minerals are in mineralized shear zones containing abundant hematite and goethite and in the carbonate rocks. The principal source of radioactivity is thorium in thorite and monazite. The uranium content of the deposits is low; the highest sample contained only 0.02 percent uranium. The ThO_2 content is more than 2 percent in some samples. Radioactive age determinations on monazite from one of the carbonate bodies indicates a Precambrian age for the deposits.

117 Osterwald, F. W., 1956, Relation of tectonic elements in Precambrian rocks to uranium deposits in the Cordilleran foreland of the Western United States: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium, p. 293–298; U. S. Geol. Survey Prof. Paper 300, p. 329–335.

The Cordilleran foreland is a large area immediately east of the main folded and thrusted belts of the Middle Rocky Mountains. Within the foreland a series of simple folded mountains alternates with broad asymmetric basins. Most of the structures are caused by vertical movements of blocks in the Precambrian basement rocks that are expressed at the surface by flexures and high-angle normal and reverse faults.

Many of the tectonic elements of the region were active at various times during geologic history. The tectonic pattern of the region is related to structures in the Precambrian rocks which have influenced the later movements, and it is likely that the pattern is the result of a set of large structures which were established during the Precambrian.

Most uranium deposits in the Cordilleran foreland, irrespective of the type of deposit, are related to the tectonic pattern on both a small and a large scale. They are clustered where large northwestward-trending structures, such as major basins and mountain ranges, are intersected by later more subdued northeastward-trending structures; where large northwestward-trending structures are intersected at acute angles by in-echelon faults or folds; or near the axial parts of major basins. Structure-contour maps, showing the configuration of the Precambrian basement rocks, may be used to point out areas of structures favorable to the deposition of uranium, even though only flat-lying Tertiary sedimentary rocks crop out at the surface.

The observed relation is thought to be caused by one or more of the following: (1) Repeated deformation along old structures has influenced sedimentation, resulting in rock types favorable for concentration of uranium in restricted positions with respect to the various tectonic features; (2) intersections of major tectonic elements may be places in which the energy levels are changed, allowing small amounts of uranium to be released from rock minerals and to be concentrated in places of favorable lithologic character and structure; (3) margins of major tectonic elements may be places in which the energy levels are changed, allowing uranium to be released and concentrated in smaller, oblique folds and faults; (4) repeated deformation of old structures causes even relatively young Tertiary rocks to be slightly deformed and jointed, thereby providing a favorable structural environment for uranium deposition. The areas of high energy change also provided foci for volcanic activity during Tertiary time.—*Author's abstract*

The report contains a map showing structural trends of the Cordilleran foreland and a structure-contour map of the top of Precambrian rocks in the southern Powder River Basin, Wyo., showing localities of uranium or high radioactivity.

118 Page, L. R., 1956, Geologic prospecting for uranium and thorium: U. S. Geol. Survey Prof. Paper 300, p. 627–631; Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium, p. 688–691.

The search for uranium and thorium in the United States has emphasized the value of geologic guides in prospecting. Prospecting for new districts is based on very general geologic criteria; prospecting for individual ore deposits in new or old districts requires specific guides that in part are of only local significance.

New districts of high-grade epigenetic deposits are sought in (1) broad areas in the vicinity of small potassic or sodic intrusives, exposed or buried, and associated pyroclastic materials, (2) areas of terrestrial sedimentary rocks in depositional and structural basins, and (3) areas of deeply eroded batholithic rocks. Such areas are commonly characterized by relatively recent crustal instability.

Structure is a primary guide to vein deposits because veins occur in faults, shear zones, and other tectonic features in otherwise impermeable rocks; secondary guides are zonal distribution of metals, mineral associations, alteration, and type of wall rocks.

Pitchblende or uraninite ore is closely associated with (1) dark-colored fluorite and quartz; (2) mixed lead, zinc, copper, and silver or cobalt, nickel, and silver minerals; (3) ferrous iron- and carbonate-rich parts of wall rocks; and (4) hematitic and argillic alteration with or without silicification. Scattered yellow and green oxidized minerals are guides to pitchblende and uraninite in depth. Molybdenite in radioactive veins commonly indicates the presence of brannerite.—*Excerpts from author's abstract*

119 Pearce, Richard, 1895, Some notes on the occurrence of uraninite in Colorado: Colorado Sci. Soc. Proc., v. 5, p. 156–158; 1916, Mining and Sci. Press, v. 113, p. 44.

Pitchblende coated with a canary-yellow secondary uranium mineral was discovered on the dump of the Wood mine near Central City, Colo., by Richard Pearce in 1871. This is believed to be the first discovery of pitchblende in Colorado. The original shaft was sunk through the center of a vertical vein of pitchblende, and, consequently, most of the pitchblende was lost. The remaining pitchblende was extracted in 1871 and yielded 3 tons of ore containing about 60 percent pitchblende, which was shipped to London and sold for about $7,500. The mine was reopened in 1894 and another lenticular deposit of pitchblende was found at greater depth.

120 Phair, George, 1952, Radioactive Tertiary porphyries in the Central City district, Colorado, and their bearing upon pitchblende deposition: U. S. Geol. Survey TEI–247, 53 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

In the Central City district of Colorado pitchblende occurs in veins as "fissure fillings in gneiss of Precambrian age associated with early auriferous pyrite and chalcopyrite and is itself one of the earliest minerals to be deposited. Subsequently more or less sphalerite, galena, and late chalcopyrite were introduced." Of the 17 mines in the district known to contain pitchblende, 16, including the 6 known commercial sources of pitchblende production, are within 500 feet of highly radioactive (0.008–0.010 percent equivalent uranium) bostonite porphyry dikes. The pitchblende deposits were formed shortly after the intrusion of these dikes, which are the third and youngest of a series of genetically related radioactive intrusives of Tertiary age. The two earlier rocks of this series include (1) slightly to moderately radioactive ($eU<0.007$ percent) monzonite stocks and dikes and (2) excessively radioactive ($eU>0.014$ percent) nonporphyritic quartz bostonite dikes. The quartz bostonite dikes contain as much as 25 times more equivalent uranium than the best available average for granitic rocks. Individual samples contain as much as 0.01 percent uranium and 0.05 percent thorium. Most of the uranium and at least part of the thorium in the quartz bostonites is believed to occur in cyrtolite or naegite, which have crystallized as primary constituents of the rock.

"The implication of the field and chemical evidence is that uranium-rich solutions given off by a cooling quartz bostonite mass at depth became further enriched by leaching uranium from the quartz bostonite channelways while enroute to higher levels. Zircon, the probable host for much of the uranium and part of the thorium in the rocks, separated in reduced amounts from the youngest quartz bostonite liquids—a change which, in effect, tended to throw uranium into the residual liquid. Possible mechanisms by which uranium became concentrated with respect to thorium in the derived aqueous solutions are considered. In this connection the late magmatic introduction of fluorite and of ferric oxides may be of special significance."

The report contains a map showing the distribution of radio elements in Tertiary porphyry intrusives near Central City, Colo.

121 Phair, George, and Shimamoto, K. O., 1951, Hydrothermal uranothorite in fluorite breccias from the Blue Jay mine, Jamestown, Boulder County, Colorado: U. S. Geol. Survey TEI–144, 16 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.; 1952, Am. Mineralogist, v. 37, p. 659–666.

Uranothorite was identified from samples of fluorite breccia ore from the Blue Jay mine, one of the larger fluorite producers in the Jamestown district, Boulder County, Colo. The Jamestown fluorite deposits are at the northern end of the Front Range mineral belt and probably are of epithermal or mesothermal origin. The uranothorite associated with the fluorite ores is clearly of hydrothermal origin in contrast to all thorites and uranothorites previously described in the literature, which, except for a single microscopic crystal or thorite(?) from the high-temperature tin veins at Llallagua, Bolivia, occur either as residual concentrates in places or in place in granitic rocks, especially pegmatites.

122 Pierson, C. T., Burbank, W. S., and Singewald, Q. D., 1952, Some uranium occurrences in the central and southwestern parts of the Colorado Mineral Belt [abs.]: Geol. Soc. America Bull., v. 63, p. 1368.

Uranium minerals are associated with base- and precious-metal veins in the Alma, St. Kevin, and Lower Uncompahgre districts; and with pyritic veins and copper-lead-silver volcanic breccia pipe deposits in the Red Mountain district. They occur as coatings on fracture surfaces and as disseminations in country rocks in the Leadville, St. Kevin, and Upper Uncompahgre district.

Pitchblende has been found in the Alma, Leadville, Upper and Lower Uncompahgre, and Red Mountain districts. Torbernite and pitchblende(?) occur in the St. Kevin district.

In the Lower Uncompahgre district, a genetic relationship between the uranium deposits and the zoning of metalliferous deposits related to the eruptive center of the Lower Uncompahgre district is suggested by the occurrence of uranium close to the boundary between a pyrite-gold-base-metal core and an outer silver-lead-zinc zone. No clearly defined zonal relationships were noted in the other districts.

The pitchblende(?) in the veins of the Red Mountain district, and in the Alma, St. Kevin, Leadville, and Upper and Lower Uncompahgre districts was probably deposited by hypogene processes. In the St. Kevin district, torbernite and sooty pitchblende(?) are alteration products of primary pitchblende(?).—*Excerpt from authors' abstract*

123 Pierson, C. T., and Singewald, Q. D., 1953, Results of reconnaissance for radioactive minerals in parts of the Alma district, Park County, Colorado: U. S. Geol. Survey Circ. 294, 9 p.

Pitchblende in the Alma district is associated with Tertiary veins of three different geologic environments: (1) veins in Precambrian rocks, (2) the London vein system in the footwall block of the London fault, and (3) veins in a mineralized area east of the Cooper Gulch fault. Pitchblende is probably not associated with silver-lead replacement deposits in dolomite.

Secondary uranium minerals, as yet undetermined, are associated with pitchblende on two London vein system mine dumps and occur in oxidized vein material from dumps of mines in the other environments.—*Excerpts from authors' abstract*

The report contains a generalized geologic map of the Alma district showing areas tested for radioactivity, a geologic sketch map of part of the Orphan Boy mine, and a table listing the localities tested for radioactivity with a brief description of each.

124 Pierson, C. T., and Singewald, Q. D., 1954, Occurrences of uranium-bearing minerals in the St. Kevin district, Lake County, Colorado: U. S. Geol. Survey Circ. 321, 17 p.

The St. Kevin district is on the east flank of the Sawatch range about 5 miles northwest of Leadville, Lake County, Colo. The ore deposits are in composite veins along fissure zones. The district yielded principally silver and subordinate amounts of gold, zinc, and lead. Turquoise occurs in a few prospects.

"Uranium minerals in the St. Kevin district and vicinity are found in metalliferous veins of Tertiary age and as disseminations and fracture coatings in Precambrian igneous and metamorphic rocks that were hydrothermally altered in advance of vein formation.

"Anomalously radioactive vein material was found in the St. Kevin district at 11 mine dumps * * * and, also, at several places within the few underground workings now accessible * * *. The radioactive vein material consists of gouge and intensely sericitized and silicified granite transected by veinlets of vuggy quartz containing minor amounts of sulfide minerals. Samples of the vein material contain as much as 0.013 percent uranium, but the radioactive mineral, which probably is secondary, has not been identified.

Although no primary uranium minerals have been found, it is probable that the uranium minerals in the vein material * * * formed as a result of supergene alteration of primary pitchblende."

The report contains a generalized geologic map of the Sugar Loaf and St. Kevin district, showing vein pattern; maps of selected localities; maps showing localities tested for radioactivity; and a table listing the radioactivity anomalies with a brief description of each.

125 Powers, J. F., 1954, Nevada-Utah district, *in* Geologic investigations of radioactive deposits—Semiannual progress report, June 1 to Nov. 30, 1954: U. S. Geol. Survey TEI-490, p. 231-232, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Uranium ore was shipped from the Moonlight mine in northern Humboldt County, Nev., where uranium minerals occur along an eastward-dipping fault that displaces volcanic rocks of Tertiary age.

Uranium deposits occur in breccia pipes in the Kaibab limestone of Permian age along the Hurricane fault in southern Iron County and Washington County, Utah. "The pipes are at the intersection of a smaller set of faults with the main Hurricane fault. Sampling indicates that in four places along the fault there is a fair amount of ore-grade material. Twenty-eight tons of ore recently were shipped from one of the properties."

126 Quigley, J. E., 1950, Primary uranium ore now being mined in Utah: Eng. Mining Jour., v. 151, no. 8, p. 90-93.

About 150 tons of uranium ore is being produced per day from 3 mines in the newly discovered uranium district 4 miles northeast of Marysvale, Utah. The deposits are in the old Durkee mining district which has produced gold, silver, iron, and alunite. The uranium ores consist primarily of autunite. Pitchblende has been produced from the lower level of the Prospector mine.

The rocks exposed in the area are of Tertiary age and consist of an older series of volcanic rocks intruded by a coarse-grained monzonite and a finer grained monzonite which grades into granitic phases. These rocks are unconformably overlain by siliceous rhyolite. The uranium ore being mined occurs in veins cutting the coarse grained monzonite. Autunite is in the older volcanic rocks, the younger rhyolite, and in the fine-grained monzonite intrusives.

The ore is in fracture zones extending outward from the contact of the rhyolite and the coarse-grained monzonite or in fracture zones parallel to the contact. The fractures are iron stained and contain, in addition to autunite, lesser amounts of other secondary uranium minerals including torbernite, schroeckingerite, and uranophane. The veins also contain fluorite and quartz. The wallrock of the veins containing secondary uranium minerals has been altered to iron-stained clay minerals. The black sooty pitchblende found at a vertical depth of 70 feet in the Prospector mine occurs with fresh pyrite and small amounts of autunite. The wallrock shows very little alteration. The author suggests the alteration which accompanies the overlying secondary uranium ores is the result of the action of sulfuric acid produced by the weathering of pyrite in the near surface parts of the veins.

The report contains brief descriptions of the Farmer John, and Prospector mines, and the Freedom and Buddy claims. The history of the discovery and development of the uranium deposits is briefly reviewed.

127 Raup, R. B., 1953, Southwest district, *in* Geologic investigations of radioactive deposits—Semiannual progress report, June 1 to Nov. 30, 1953: U. S. Geol. Survey TEI–390, p. 209–212, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Uranium minerals occur along fractures and are disseminated in the Dripping Spring quartzite of Precambrian age in two areas north of Globe, Ariz. A significant amount of uranium ore has been produced from one of the areas.

A narrow torbernite(?)-bearing zone extends 30 feet along the footwall of a gold quartz vein in granite in the Weaver Mountains, Yavapai County, Ariz. The uranium content is inferred to be 0.05 percent or less.

Exploration for copper in the Tyrone district, Grant County, N. Mex., revealed abnormal radioactivity in several holes drilled in granite and quartz monzonite. At the surface, abnormal radioactivity was detected in fracture zones and in remnants of discarded drill sludge. The uranium content of the deposits is below ore grade and no uranium minerals were identified.

128 Raup, R. B., 1954, Southwest district, *in* Geologic investigations of radioactive deposits—Semiannual progress report, Dec. 1, 1953, to May 31, 1954: U. S. Geol. Survey TEI–440, p. 180–182, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Flecks of uranophane or autunite occur in a narrow carbonate vein at Fluorine Hill, 2½ miles east of Pearce, Cochise County, Ariz. The vein contains a small amount of dark-purple fluorite and is enclosed in a host rock of rhyolite porphyry. A grab sample of vein material contained 0.11 percent uranium.

Samples of vein material from dumps of the Abe Lincoln mine in the Black Rock district, Yavapai County, Ariz., contain a secondary uranium mineral identified as schoepite. Pitchblende also may be present. The uranium content of the samples ranged from 0.074 to 0.46 percent. Samples of radioactive material in place could not be obtained as most of the mine workings are inaccessible. The Abe Lincoln vein system occupies a northeast-trending fault zone in a gneiss-schist complex of Precambrian(?) age. Ore minerals are copper sulfides and carbonates in a gangue of pyrite, quartz, calcite, fluorite, and limonite.

129 Reyner, M. L., 1950, Reconnaissance of Basin-Boulder-Clancey area, Jefferson County, Montana: U. S. Atomic Energy Comm. RMO–674, 13 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

This report summarizes the geology and radioactivity of 15 of the more radioactive deposits of a total of about 30 quartz-sulfide vein deposits examined in the Boulder batholith, Montana. Secondary uranium minerals are reported from some deposits, and samples of ore grade (0.1 percent U_3O_8) or better have been reported from the Comstock claims and the Josephine and Lone Eagle mines.

An index map showing mines and prospects examined for radioactivity is included.

130 Rickard, Forbes, 1913, Pitchblende from Quartz Hill, Gilpin County, Colorado: Mining and Sci. Press [San Francisco, Calif.], v. 106, no. 23, p. 851–856.

Several mines near the west end of Quartz Hill, 1½ miles west of Central City, Colo., have produced small quantities of high-grade pitchblende. This report describes the pitchblende deposits at the German and Belcher mines, which are connected and worked as one mine. The country rock of the district consists of gneisses and schists of Precambrian age that are intruded by granite dikes and porphyrytic andesite dikes. The pitchblende-bearing veins of the district are without exception associated with fine-grained aplitic granite dikes. The veins trend northeast and contain ores of two types. One is characterized by pitchblende, accessory pyrite, and sphalerite and galena in subordinate quantities. The other type of ore consists of pyrite, chalcopyrite, sphalerite, and galena, and gold and silver in varying amounts.

The pitchblende vein at the German and Belcher mines is associated with a granite dike 5 to 9 feet wide. The vein ranges from 4 to 20 inches in width, and at places occupies a position in the center of the dike. Pitchblende streaks or lenses in the vein are seldom more than 3 to 4 inches wide. The grade of ore ranges from 2½ to 4 percent U_3O_8. Gangue minerals of the pitchblende vein are of pegmatitic character. Quartz which is abundant in the gold-silver vein is not seen in association with pitchblende. The gold-silver vein was formed after the pitchblende vein, and, for the most part, follows the trend and occupies the footwall side of the preexisting pitchblende vein. The author suggests that the pitchblende may have crystallized directly from magma.

131 Ridland, G. C., 1950, Radioactivity at the Caribou silver mine, Boulder County, Colorado: Mining Eng., v. 187, no. 1, p. 98–101; Am. Inst. Mining Metall. Engineers Trans., v. 187.

Exploration for radioactive deposits conducted in 1945 in the Colorado Front Range resulted in the discovery of pitchblende in the historic silver deposits of Caribou Hill, 35 miles northwest of Denver. The silver veins at Caribou Hill occupy shear zones that cut a quartz monzonite stock of probable Tertiary age. The stock is on the axis of a major anticline in biotite schist of the Idaho Springs formation of Precambrian age.

Pitchblende was found on the dump of the old Caribou mine. Subsequent examination of the accessible workings revealed a pitchblende-bearing vein on the 1,040-level of the mine. The pitchblende is in a silver ore body in a siliceous-carbonate gangue. The ore body is in a northeast-trending fracture, and branches off to the east along a subsidiary east-west fracture. The pitchblende is in a continuous black seam 1 to 16 inches wide, which extends from a point 45 feet southwest of the junction of the 2 fractures to a point 110 feet east of the junction. The seam is on the footwall of the ore body, along the northeast-trending fracture, and is in the center of the east-west trending fracture.

The black seam is composed of veinlets of black vitreous colloform pitchblende associated with galena, sphalerite, ruby silver, colloform pyrite, proustite, and chalcopyrite. These minerals are in a gray colloform groundmass believed to be an intimate mixture of pitchblende and proustite.

132 Roberts, W. A., and Gude, A. J., 3d, 1953, Geology of the area adjacent to the Free Enterprise mine, Jefferson County, Montana: U. S. Geol. Survey Bull. 988–G, p. 143–155.

This report describes the geology of the Free Enterprise mine, 2 miles west of Boulder, Mont., and of an adjacent area of about 2 square miles extending northeastward from the mine.

The uranium minerals are in an epithermal silver-bearing cryptocrystalline silica vein in quartz monzonite and alaskite of the Boulder batholith. The Free Enterprise vein is one of many silicified reeflike veins in this area, most of which trend about N. 60° E. and dip steeply to the northwest. Many of the veins are slightly to moderately radioactive, but the Free Enterprise vein is the only one known to contain uranium minerals. The veins commonly are in groups within lenticular silicified zones that range in width from a few inches to several tens of feet and are composed of stringers and veins of silica arranged in a subparallel to an echelon pattern. Many of the zones "are brecciated, and gouge or microbreccia is found at the margins or within some of them." Where quartz monzonite is the wallrock, the veins are bordered by an altered zone, but no alteration is present where alaskite is the wall rock. The quartz monzonite seems to be a more favorable host rock for the veins and associated uranium minerals than is alaskite.

"At the Free Enterprise mine small amounts of pyrite, galena, ruby silver, argentite, native silver, molybdenite, chalcopyrite, arsenopyrite, and barite have been found in the vein. The uranium minerals present are uraninite, gummite-type hydrous oxides, autunite, metatorbernite, and some zeunerite and uranophane and an unidentified dark brown primary uranium mineral resembling samarskite. The primary [uranium] minerals occur as pods in the vein, and the secondary [uranium] minerals occur as fracture linings and as scattered crystals in and adjacent to the vein. Leaching by downward percolating waters has removed most of the uranium from the near-surface part of the vein and probably has slightly enriched parts of it and the adjacent wall rock from the bottom of the leached zone to the ground water level. The nature of the Free Enterprise deposit, the abundance of silicified veins, and the weak to moderate surficial radioactivity of some of these veins suggest that many small deposits of uranium and silver minerals may occur in this area in significant concentrations at relatively shallow depth. Cost of exploring and mining, however, might be prohibitive."

133 Roberts, W. A., and Gude, A. J., 3d, 1953, Uranium-bearing deposits west of Clancey, Jefferson County, Montana: U. S. Geol. Survey Bull. 988–F, p. 123–141.

The geology of the Clancey district, Jefferson County, Mont., and nine uranium deposits in an area west of Clancey are discussed. These deposits include the following claims: W. Wilson, Harry S., A. Lincoln, G. Washington, Forty-niner, and other unnamed prospects.

Most of the mineral production in the district has come from vein and placer deposits of silver, gold, lead, and copper; none of these is abnormally radioactive. Uranium occurs only in and adjacent to silicified breccia fracture zones in quartz monzonite and related rocks of the Boulder batholith. The uranium minerals are in short discontinuous silica stringers, along fractures, and in pore spaces in the adjacent wallrocks of either altered quartz monzonite or alaskite. The uranium minerals seem to be concentrated in pockets along the silicified zones. These pockets range from 6 inches to 18 feet in their greatest dimension and contain as much as 3 percent uranium. Dark-gray cryptocrystalline silica in some of the deposits is radioactive, probably due to sparsely disseminated pitchblende.

One or more secondary uranium minerals including torbernite-zeunerite, autunite or uranocircite, rutherfordine, voglite, and uranophane were found at each of the properties examined. These minerals occur as fracture linings and in pore spaces in and adjacent to the silicified zones. At the W. Wilson deposit they enclose and seem to replace pitchblende.

A geologic map of the area west of Clancey and geologic maps of several of the deposits are included.

134 Robinson, R. F., 1950, Discussion—Uraninite in the Coeur d'Alene District, Idaho: Econ. Geology, v. 45, p. 818–819.

The author comments on several statements made by Thurlow and Wright in their paper on "Uraninite in the Coeur d'Alene district, Idaho," [annotation 173].

According to Thurlow and Wright, the uraninite-bearing veins appear to intersect the Sunshine vein system. Robinson points out the reverse interpretation is most likely correct and states that "uraninite-bearing zones * * * are definitely observed to be intersected by later major siderite-tetrahedrite veins. These veins contain no more than a trace of radioactivity * * *. This indicates to us that much of the uraninite is an early phase of the Sunshine mineralization epoch." Robinson also points out that the uraninite occurs with an early generation of pyrite, not recognized by Thurlow and Wright, and suggests that many of the other sulfides and oxides are of multiple generations and that present research will bring out a much more complex paragenesis than that set forth by Thurlow and Wright.

135 Schafer, Max, 1955, Preliminary report on the Lakeview uranium occurrences, Lake County, Oregon: Oregon Dept Geology and Mineral Industries, Ore.-Bin, v. 17, no. 12, p. 93–94.

The first uranium ore produced in Oregon was shipped in 1955 from the White King and Lucky Lass mines, both about 14 miles northwest of Lakeview. The region is underlain by a thick sequence of volcanic and tuffaceous rock of Tertiary age. The White King deposit is in an area of numerous faults; it is believed that some of these faults were the main control for mineralization. At the White King mine, secondary uranium minerals, chiefly of the novacekite-saléeite group, coat fractures in opalized tuff and are disseminated through the overlying unconsolidated clayey tuff. Cinnabar, pyrite, stibnite, orpiment, and realgar are associated with the uranium minerals. The deposit probably was formed at relatively low temperature and pressure.

The Lucky Lass deposit is in volcanic rocks stratigraphically above the mineralized tuffs of the White King mine. The deposit is cut by many steeply dipping faults resulting in blocks of ore having sharp boundaries with unmineralized rock. The uranium minerals are similar to those at the

White King deposit and occur as fracture coatings, vesicle fillings, and disseminations in clayey gouge. The only associated metal determined was a trace of mercury.

136 Schafer, Max, 1956, Uranium prospecting in Oregon, 1956: Oregon Dept. Geology and Mineral Industries, Ore.-Bin, v. 18, no. 12, p. 101–104.

Uranium ore is in tuffaceous agglomerate or breccia of Tertiary age at the White King property in Lake County, Oreg. The ore solutions may have been hydrothermal and may have been channeled by the many small vertical faults in the area. The richer ore is in layers of porous tuff overlain by nonporous clayey tuff which acted as a caprock to contain the solutions. The sulfide minerals associated with the uranium mineralization are typical of a hydrothermal deposit of low-temperature and low-pressure origin.

In the Pike Creek area in Harney County, uranium occurs in the Pike Creek volcanic series of Pliocene age. The deposit is along the contact of a rhyolitic intrusive breccia and a bedded acid tuff. Autunite(?) occurs along bedding and joint surfaces in the tuff and at the contact.

In the Bear Creek area near Bend, Crook County, uranium occurs along a small shear zone in silicified and porous tuff of the Clarno formation of Eocene age. Two narrow, vertical zones contain secondary uranium minerals and high radioactivity extends for several feet on each side of the visible mineralization. Samples from the deposit contain traces of mercury in addition to the uranium.

137 Schnabel, R. W., 1955, compiler, The uranium deposits of the United States: U. S. Geol. Survey Mineral Inv. Resource Map MR-2 (with text).

This map shows the location of important uranium deposits in the United States and distinguishes deposits in veins, igneous rocks, pegmatites, clastic terrestrial sedimentary rocks, limestone, coal, shale, phosphorite, and placers. The geology of each type is briefly summarized in the text. The deposits are listed by name and are further distinguished as (a) deposits actively or formerly mined for uranium or potentially minable under June 1955 market conditions, (b) deposits too low in grade to be mined for uranium alone, or (c) deposits of possible importance but unevaluated because of insufficient data.

138 Sharp, B. J., 1955, Uranium occurrence at the Moonlight mine, Humboldt County, Nevada: U. S. Atomic Energy Comm. RME-2032 (pt. 1), 15 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The Moonlight mine is in the Kings River Valley, Humboldt County, Nev., about 15 miles south of the Oregon border. Uranium minerals are along a normal fault that dips 60° E. At the surface the fault displaces volcanic rocks of probable Miocene age. Granodiorite of probable Jurassic age crops out north of the mine and is also exposed in the lower workings.

About 170 feet below the collar of the shaft granodiorite is in fault contact with the rhyolite and is on the footwall of the fault. The uranium minerals, including autunite, torbernite, meta-autunite, metatorbernite, and possibly gummite and uraninite, are disseminated in gouge and broken material in the fault and in small tension and shear fractures in the wall rock. Gangue minerals include iron oxides (in the oxidized zone), pyrite, smoky quartz, fluorite, and clay minerals. The deposit has yielded several carloads of uranium ore of marginal grade. Anomalous radioactivity was detected north of the mine along the Moonlight fault for a distance of about 2 miles. However, no anomalous radioactivity has been detected along other faults parallel to the Moonlight fault.

139 Sharp, B. J., 1956, Preliminary report on a uranium occurrence and regional geology in the Cherry Creek area, Gila County, Arizona: U. S. Atomic Energy Comm. RME–2036 (revised), 16 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The Black Brush uranium claims in the Cherry Creek area, Gila County, Ariz., are approximately 36 miles north of Globe, Ariz. The area is underlain by essentiallly flat-lying sedimentary rocks of the Precambrian Apache group which have been block faulted and intruded by diabase of possible Tertiary age. Uranium occurs in the upper member of the Dripping Spring quartzite and is associated with sets of fractures (joints) which trend N. 20° E. and N. 70° W. The mineralized zone is one to one-and-a-half feet thick and extends an unknown (probably several feet) distance away from the fractures.

The mineral assemblage at the Black Brush workings is similar to other deposits in the Dripping Spring quartzite. Uraninite is the main uranium-bearing mineral at the property and it occurs in paper-thin lenses and local disseminations in the quartzite. Secondary uranium minerals are not abundant, but torbernite * * * has been recognized and bassetite * * * tentatively identified. Gangue minerals include pyrite, pyrrhotite, chalcopyrite, bornite, marcasite, and galena which occur along fractures and as local disseminations.

Selected samples have assayed as high as 1.75 percent U_3O_8 and several mining width samples assayed above 0.20 percent. One sample from the ore pile indicated that it contains several hundred tons of ore-grade material. —*Excerpts from author's abstract and text*

140 Sharp, B. J., 1956, Uranium deposits in volcanic rocks of the Basin and Range province: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium, p. 252–256; U. S. Geol. Survey Prof. Paper 300, p. 79–83.

Volcanic rocks have been generally considered unfavorable hosts for uranium ore deposits. The discovery of uranium minerals in rhyolite at Marysvale, Utah, was the first of several in the Basin and Range province. In addition to the Marysvale occurrence, uranium has been found in veins in rhyolite breccia in the Kings River area, Humboldt County, Nev. Other localities in this region that are known to contain uranium minerals in volcanic rocks include areas in Lassen and Kern Counties, Calif., and in Esmeralda, Lincoln, and Washoe Counties, Nev.

Vein-type uraninite deposits in granitic rocks in the Marysvale district are closely associated with volcanic rocks. Uranium minerals occur in red rhyolite agglomerate and in felsitic to glassy dikes. Uraninite has been identified in the rhyolite agglomerate in close association with fluorite.

Other uranium minerals identified are autunite, meta-autunite, torbernite, and uranophane.

In the Kings River area, uranium occurs along a northward-trending fault which displaces Miocene volcanic rocks. The volcanic sequence was extruded upon an old erosion surface of granodiorite of Jurassic(?) age which crops out north of the ore deposit and is also exposed in mine workings. Uranium minerals include autunite, torbernite, and possibly gummite and uraninite. Gangue minerals are pyrite, quartz, fluorite, and clays. The structure is mineralized throughout its exposed depth of 270 feet.—*Excerpts from author's abstract*

Other deposits in volcanic rocks in the Basin and Range province are briefly described and include those in the Antelope Range, Nev., and California; the Atlanta and Coaldale areas, Nevada; Beaver, Utah; and Rosamond, Calif. These deposits seem to be localized by small fractures, faults, and shear zones in volcanic rocks varying from rhyolitic tuff and agglomerate to dacite. Most of the deposits contain only secondary uranium minerals. Uraninite was tentatively identified from the Atlanta district, Nevada.

The report contains a geologic map and cross sections of underground workings in the rhyolite agglomerate in the Marysvale area, Utah, and a geologic map of the Kings River area, Nevada.

141 Sharp, B. J., and Hetland, D. L., 1954, Preliminary report on uranium occurrence in the Austin area, Lander County, Nevada: U. S. Atomic Energy Comm. RME-2010, 16 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Uranium was discovered in 1953 in mineralized fracture zones in the southern part of the Reese River silver mining district, Lander County, Nev. The deposits are 3 miles south of Austin in and near the southern margin of a body of quartz monzonite of Jurassic(?) age that intrudes metamorphosed sedimentary rocks, dominantly quartzites and phyllites, of Cambrian(?) and Silurian(?) age. Metatorbernite and autunite(?) associated with quartz, pyrite, limonite, and hematite occur in east-west-, west-northwest-, and northeast-trending fracture zones that cut the intrusive quartz monzonite and the metamorphosed sedimentary rocks. The mineralized fracture zones contain silica and fine-grained dike material and form reeflike ridges where they cut the intrusive rocks. They do not form reefs where they cut the metamorphosed sedimentary rocks. The mineralized fractures are generally more radioactive in the metamorphosed sedimentary rocks than in the intrusive quartz monzonite. Silver mines in the central and northern parts of the Reese River district were developed along veins similar to those in which uranium occurs; however, no abnormal radioactivity was detected on the dumps of the silver mines examined. The authors suggest that the metals in the district may be zoned outward from the central Austin area.

Development work has been done at the Early Day and Eldorado claims.

The report includes a table showing the results of radiometric and chemical assays on samples from the Early Day and Eldorado claims and a geologic map of the area south of Austin.

142 Sharp, B. J., and Myerson, B. L., 1956, Preliminary report on a uranium occurrence in the Atlanta area, Lincoln County, Nevada: U. S. Atomic Energy Comm. RME–2048 (revised), 18 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Uranium occurs at the Blue Bird claims, in the Atlanta area, Lincoln County, Nev., about 35 miles north of Pioche. The country rock is limestone, quartzite, and dolomite of Ordovician age unconformably overlain by Tertiary volcanic rocks. The Ordovician rocks are moderately folded and are cut by bedding-plane faults and numerous block faults. The overlying Tertiary volcanic rocks are cut by some of the faults. Silicified breccia pipes occur in the Ely Springs dolomite, the youngest of the Ordovician rocks. The pipes are parallel to or along major fault systems and are believed to be of intrusive origin, though no igneous rock is present in the breccia. Some of the pipes are mineralized with gold, silver, and uranium minerals.

The uranium ore in the Blue Bird mine is in highly silicified pods within the brecca pipe. Uraninite, the major ore mineral, is in black cryptocrystalline silica that cements limestone and quartzite breccia. Fine-grained pyrite is abundant in the ore pods. Near the surface secondary uranium minerals line vugs and coat joints and small fractures. The ore averaged slightly more than 0.3 percent U_3O_8.

Anomalous radioactivity and uranium was detected in similar silicified breccia pipes and zones, including the Atlanta mine and several abandoned gold and silver workings.

Geologic maps and cross sections of the Atlanta area and the Blue Bird mine are included.

143 Sheridan, D. M., 1956, Ralston Buttes, Colorado, *in* Geologic investigations of radioactive deposits—Semiannual progress report for June 1 to Nov. 30, 1956: U. S. Geol. Survey TEI–640, p. 125–137, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The uranium deposits in the Ralston Buttes district, Jefferson County, Colo., are grouped in two main areas, the Golden Gate Canyon and the Ralston Creek. The uranium deposits are hydrothermal veins in metamorphosed crystalline rocks of Precambrian age and are located where major northwest-trending Laramide breccia reefs split into a complex network of faults and fractures. In the northwestern part of the district the breccia reefs are commonly cemented by quartz, fluorite, and hematite, and in the remainder of the district by ankerite and potash feldspar. The uranium deposits seem to be localized where the fracture zones cut metamorphic rocks rich in hornblende and biotite, or garnet and biotite. Pitchblende is the principal uranium mineral in the deposits and is associated with minor amounts of base-metal sulfides in a gangue of carbonate minerals, potash feldspar, and quartz. Secondary uranium minerals at the deposits are torbernite, metatorbernite, uranophane, autunite, uranopilite, and meta-autunite. Some veins contain as much as 0.14 percent vanadium oxide in an unknown mineral. Native bismuth has been recognized from one deposit and uraniferous asphaltite from another. Paragenetic studies indicate pitchblende preceded the deposition of sulfide minerals. Postmineralization movement is common in some of the deposits.

"The uranium deposits range in thickness from thin mineralized veinlets less than an inch thick to major ore shoots as much as 6 to 8 feet thick. Commonly the uraniferous material occurs in lenses or shoots that are discontinuous along strike. Individual ore bodies range in size from small pods or lenses containing 50 tons or less to large shoots containing over 1,000 tons of ore."

A brief description is given of the Schwartzwalder mine, the largest mine in the Ralston Buttes district.

Geologic maps of the Ralston Buttes district and of the Schwartzwalder mine are included.

144 Shoemaker, E. M., 1956, Structural features of the central Colorado Plateau and their relation to uranium deposits: U. S. Geol. Survey Prof. Paper 300, p. 155–170.

Most uranium deposits in the central Colorado Plateau do not appear to be directly related to faults and joints, though the relation of some deposits to such structures has been subject to different interpretations. A few deposits "are known where the field evidence has been interpreted by nearly all observers as indicating a genetic relation between uranium deposits and faults."

The report briefly describes some vein deposits that are along faults and fractures, many of which are related to salt anticlines. The deposits contain secondary uranium minerals which in many deposits are associated with copper minerals. Deposits of the type outlined above include the Red Head claims, Utah; Rajah mine, Colorado; Hidden Treasure mine, Colorado; deposits north of the Ute Mountains, Colo.; deposits near Hanksville, Utah; and a deposit between the Henry and Abajo Mountains, Utah. Deposits in the collapse structure at Temple Mountain also are briefly described.

145 Sims, P. K., 1954, Colorado Front Range, *in* Geologic investigations of radioactive deposits—Semiannual progress report, June 1 to Nov. 30, 1954: U. S. Geol. Survey TEI–490, p. 135–137, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Although uranium is widespread in Tertiary vein deposits in the Central City-Georgetown area of the Colorado Front Range, known individual deposits are small. At least 10 mines were being explored for uranium in 1954, and uranium was produced from the Carroll and Cherokee mines. The uranium within Tertiary veins in the area is nearly as widespread as other metals but not so abundant. Field studies largely substantitate the conclusion that the uranium was derived from the widespread radioactive bostonite intrusives of Tertiary age.

Uranium was discovered in 1954 on Silver Hill (sec. 7, T. 3 S., R. 72 W.) in the northeast part of the Central City district, in an area not known previously to contain uranium. Two veins are radioactive along a linear distance of 800 feet. The uranium occurs in secondary uranium minerals which in part replace altered schist wall rocks. The grade of the deposits is estimated to be between 0.1 and 0.2 percent uranium.

146 Sims, P. K., 1956, Colorado Front Range, *in* Geologic investigations of radioactive deposits—Semiannual progress report for Dec. 1, 1955, to May 31, 1956: U. S. Geol. Survey TEI-620, p. 217-221, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

"Studies of the Tertiary intrusive rocks in the central part of the Front Range mineral belt, Colorado, show that these rocks probably consolidated from two magma series and that both uranium and thorium were concentrated during differentiation of each series. The maximum enrichment in the radioactive elements took place in the youngest members of the series. Uranium, which was deposited in faults as pitchblende, was given off by late-stage, aqueous fluids of quartz bostonite and possibly also biotite-quartz latite magmas."

147 Sims, P. K., 1956, Paragenesis and structure of pitchblende-bearing veins Central City district, Gilpin County, Colorado: Econ. Geology, v. 51, p. 739-756.

Pitchblende occurs locally along early Tertiary gold-, silver-, and sulfide-bearing quartz veins in the Central City district, Colorado, within the mineral belt of the Front Range. The veins cut a complex mass of Precambrian metamorphic and igneous rocks and early Tertiary intrusive porphyritic rocks.

The veins are fissure fillings that formed at intermediate temperatures and pressures. They consist mainly of pyrite, sphalerite, and galena in a quartz gangue, but also contain tennantite, chalcopyrite, enargite, and pitchblende. The veins differ in quantitative mineralogy, and they can be classified as pyrite-type and galena-sphalerite-type veins.

Vein filling took place during three stages of mineralization, from oldest to youngest: a uranium stage, a pyrite stage, and a base-metal stage. Major periods of fracturing and vein reopening took place between the vein-forming stages.

The pyrite and base-metal stages of mineralization were of broad areal extent and produced a concentric zonal arrangement of the ores in the district. In contrast, the uranium stage of mineralization was local in extent and resulted in scattered clusters of uranium deposits, which show no definite spatial relation to the district-wide zoning pattern.

Pitchblende is present in only a few veins. The ore bodies are localized in structurally controlled open spaces along faults. They occur locally along four of the six vein sets of the district, in the form of ore shoots or small lenses and pods that are separated by vein material essentially devoid of uranium. The shoots are small and measure at most a few tens of feet in height and length, and average less than a foot in width; few contain more than 50 tons of ore. Some of the shoots are systematically arranged within the veins but others are erratically distributed.—*Author's abstract*

The report includes a map of the Central City district showing relation of significant uranium deposits to zoning of mineral deposits, a vertical longitudinal projection of the Carroll mine, a detailed geologic map showing details of pitchblende-bearing ore along part of the Carroll vein, and a sketch showing the character of pitchblende-bearing veinlets between footwall and hanging-wall seams in the Carroll mine.

148 Sims, P. K., 1956, Uranium deposits in the Front Range, Colorado: Mines Mag. [Colorado], v. 46, no. 3, p. 77–79.

Most of the known uranium deposits in the Front Range are in the northern part of the "Front Range mineral belt" near Central City and in the "Foothills belt" in Jefferson County. The deposits are vein fillings in faults that were formed during the Laramide orogeny.

At Central City uranium is in veins containing gold, silver, and base-metal sulfides. The principal uranium mineral is pitchblende, which is altered to torbernite or kasolite in the oxidized parts of some veins. Only a small percentage of the veins in the district contain uranium, and, where present, it is in discrete ore shoots, pods, and lenses. Most of the uranium ore is high grade, but individual shoots seldom contain more than 100 tons of uranium ore.

The uranium deposits of the "Foothills belt" are in or near faults of the breccia-reef type that are largely filled with breccia fragments of country rock cemented by carbonate and hydrous iron oxide. The deposits are in areas of complex faulting where the faults change from a general northwesterly trend to a westerly trend. The major deposits of the "Foothills belt," those of the Ralston Creek area, are within a belt of hornblende garnet rocks which, when fractured, yielded the maximum amount of open space for filling by the uranium minerals. In Golden Gate canyon, 2 miles south of the Ralston Creek area, the deposition of uranium seems to have been controlled by the chemical character of the rocks rather than by their physical character. "The uranium in the deposits within the 'Foothills belt' is largely in pitchblende. A small quantity of uranium-bearing asphaltite was found at 2 localities. Base-metal sulfides, gold, and silver are sparse, and are not valuable constituents of the veins. Surface exposures commonly show some green secondary copper minerals and sparse green to yellow secondary uranium minerals. Individual ore shoots in the Ralston Creek area appear to contain several hundred tons of uranium ore."

149 Sims, P. K., Drake, A. A., and Moench, R. H., 1954, Preliminary geologic and vein maps of part of the Central city district, Gilpin and Clear Creek Counties, Colorado: U. S. Geol. Survey open-file report, 8 p.

This reference consists of three maps. Figure 1 is an index map showing the location of the mapped area. Figure 2 is a geologic map of part of the Central City district, Gilpin and Clear Creek Counties, Colo. Figure 3 is a preliminary map of the same area showing veins and principal mines. The scale of the maps in figures 2 and 3 is 1 inch = 500 feet. A table listing 459 shafts and adits identified by number on figure 3 is included. The name of the mine or claim is given where known. The table also indicates at which properties pitchblende has been produced or observed underground, where it occurs on the dump, or where it has been reported but unconfirmed.

150 Sims, P. K., Osterwald, F. W., and Tooker, E. W., 1955, Uranium deposits in the Eureka Gulch area, Central City district, Gilpin County, Colorado: U. S. Geol. Survey Bull. 1032–A, 31 p.

The Eureka Gulch area of the Central City district, Gilpin County, Colo., was mined for ores of gold, silver, copper, lead, and zinc, but there has been little mining activity in the area since World War I. Between 1951 and 1953 nine radioactive mine dumps were discovered in the area by the U. S. Geological Survey and by prospectors. The importance of the discoveries has not been determined as most of the mines are inaccessible, but the distribution, quantity, and grade of the radioactive materials found on the mine dumps indicate that the area is worthy of additional exploration as a possible source of uranium ore.

The uranium and other metals are in or adjacent to steeply dipping mesothermal veins of Laramide age that cut Precambrian metasedimentary rocks, granite gneiss, pegmatite, and Laramide intrusive rocks. Pitchblende is present in at least four veins, and metatorbernite, which is associated at places with kasolite, is found along two veins for a linear distance of about 700 feet. The pitchblende- and metatorbernite-bearing ores appear to be mutually exclusive and seem to occur in different veins. Colloform grains of pitchblende were deposited in the veins essentially contemporaneously with pyrite. The pitchblende is earlier in the sequence of deposition than galena and sphalerite. The metatorbernite replaces altered biotite-quartz-plagioclase gneiss and altered amphibolite, and to a lesser extent forms coatings on fractures in these rocks adjacent to the veins; the kasolite fills vugs in highly altered vein material and in altered wall rocks. Much of the pitchblende found on the dumps has been partly leached and is out of equilibrium. Selected samples of metatorbernite-bearing rock from one mine dump contain as much as 6.11 percent uranium.

The pitchblende is a primary vein mineral deposited from uranium-bearing hydrothermal solutions. The metatorbernite probably formed by oxidation, solution, and transportation of uranium from primary pitchblende, but it may be a primary mineral deposited directly from fluids of different composition from those that deposited pitchblende.—*Authors' abstract*

The report contains geologic maps of the Eureka Gulch area and the north slope of Nigger Hill and a geologic map and section of McKay shaft, R.H.D. claim.

151 Sims, P. K., and Phair, George, 1952, Geology of the Copper King mine area, Prairie Divide, Larimer County, Colorado: U. S. Geol. Survey TEI–311 (Pt. 1), 44 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The Copper King mine, in Larimer County, Colo., in the northern part of the Front Range of Colorado, was operated for a short time prior to World War II for copper and zinc, but since 1949, when pitchblende was discovered on the mine dump, it has been worked for uranium.

The bedrock in the mine area consists predominantly of Precambrian (Silver Plume) granite with minor migmatite and metasediments—biotite-quartz-plagioclase gneiss, biotite schist, quartzite, amphibolite, amphibole skarn and biotite skõls. The metasediments occur as inclusions that trend northeast in the granite. This trend is essentially parallel to the prevailing foliation in the granite. At places the metasediments are crosscut sharply by the granite to form angular, partly discordant, steep-walled bodies in the granite. Faults, confined to a narrow zone that extends through the mine, cut both the Precambrian rocks and the contained sulfide deposits. The Copper King fault, a breccia zone, contains a deposit of pitchblende; the other faults are believed to be later than the ore.

The two types of mineral deposits—massive sulfide and pitchblende deposits—in the mine area, are of widely different mineralogy, age, and origin.

The massive sulfide deposits are small and consist of pyrite, sphalerite, chalcopyrite, pyrrhotite, and in places magnetite in amphibole skarn, mica sköls, and quartzite. The deposit at the Copper King mine has yielded small quantities of high-grade sphalerite ore. The massive sulfides are pyrometasomatic deposits of Precambrian age.

The pitchblende at the Copper King mine is principally in the Copper King vein, a tight, hard breccia zone that cuts through both granite and the massive sulfide deposit. A small part of the pitchblende is in small fractures near the vein and in boxwork pyrite adjacent to the vein; the postore faults, close to their intersection with the Copper King vein, contain some radioactive material, but elsewhere, so far as is known, they are barren. The pitchblende in the deposit forms a steeply plunging ore shoot that has a horizontal length of more than 50 feet and a vertical height of about 85 feet. The thickness of the ore shoot averages about 2 feet, but it ranges from a featheredge to about 4 feet. The hard pitchblende is intimately intergrown with siderite; other gangue minerals include pyrite, quartz, and finely comminuted fragments of the wall rocks. The vein was repeatedly reopened during mineral deposition as shown by several stages of brecciation and recementation by the vein matter. The pitchblende deposit probably formed at intermediate temperatures and depths and, according to the Pb/U ratio, is about 60 million years old—an early Tertiary age.—*Authors' abstract*

An outcrop map of the Copper King mine area and geologic maps and sections of the mine are included.

152 Sims, P. K., and Tooker, E. W., 1956, Pitchblende deposits in the Central City district and adjoining areas, Gilpin and Clear Creek Counties, Colorado: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva, 1955, Proc., v. 6, Geology of uranium and thorium, p. 265–269; U. S. Geol. Survey Prof. Paper 300, p. 105–111.

The Central City district and adjoining areas, in Gilpin and Clear Creek Counties, Colo., are in the mineral belt of the Colorado Front Range, an area of coextensive Laramide intrusions and mineral-producing districts. The Central City district is characterized by gold-, silver-, and sulfide-bearing quartz veins. Small quantities of high-grade pitchblende ore have been shipped intermittently from the district since 1872, largely as a by-product of gold mining. The total production exceeds 100,000 pounds of U_3O_8.

The country rock consists of a wide variety of folded and highly metamorphosed gneisses and granitic rocks of Precambrian age, which are intruded by many small dikes and stocks of porphyritic igneous rocks, principally monzonite and bostonite of early Tertiary age.

The vein deposits occur in faults of Laramide age that trend eastward, northeastward, and northwestward. They are largely fissure fillings that formed at intermediate temperatures and pressures. In the Central City district, a pattern of hypogene mineral zoning is well developed. A core area containing pyritic veins is surrounded by an area containing galena-sphalerite veins; an intermediate zone contains veins of composite type composed of minerals characteristic of veins in both the core and fringe areas. Pitchblende, a local constituent of the ores, is associated with veins of all types, but it is most abundant in composite and galena-sphalerite veins.

Pitchblende, characteristically showing colloform texture, was the first ore mineral to form; it was deposited contemporaneously with quartz and was followed closely by pyrite, chalcopyrite, sphalerite, tennantite, and galena. Carbonate minerals locally form a part of the gangue.

The pitchblende occurs in shoots, small pods, or lenses that are systematically arranged in some veins and erratically distributed in others. The shoots are small, the largest being about 40 feet high, 20 feet long, and a maximum of a foot thick. Most of the ore is selectively mined and hand sorted, and the material shipped ranges from less than 1 percent to as much as 65 percent U_3O_8.

The pitchblende was leached and altered by acid meteoric waters in the oxide portions of the veins. In veins of the galena-sphalerite type, however, where the supergene solutions were only slightly acid, some of the uranium was reprecipitated as torbernite and other secondary minerals in the lower part of the zone of oxidation. The torbernite was preferentially deposited in biotite-quartz-plagioclase gneiss and amphibolite wall rocks that had been altered largely to montmorillonite. Locally the torbernite replaced these rocks.—*Authors' abstract*

153 Smith, L. E., and Baker, K. E., 1951, Uranium in Fall River area, Clear Creek County, Colorado: U. S. Atomic Energy Comm. RMO–913, 12 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Pitchblende occurs in veins at the Golconda and Almaden mines in the Fall River area 4 miles northwest of Idaho Springs, Clear Creek County, Colo. The predominant country rock in the area is quartz-biotite schist of the Idaho Springs formation of Precambrian age. A stock of quartz-monzonite porphyry of Tertiary(?) age crops out northeast of the Golconda mine. Veins in the area are of three mineralogic types: quartz-pyrite, galena-sphalerite, and a combination of the two. Pitchblende occurs in both the quartz-pyrite and the combination type.

At the Golconda mine uranium occurs in two veins which strike northwest and dip to the northeast. The Virginia vein contains only a minor amount of uranium. The No. 4 vein contains pitchblende, quartz, crushed schist and pyrite, some chalcopyrite and galena, and a small amount of carbonate gangue. The pitchblende is in black streaks 0.2 to 5 inches wide and is closely associated with fine-grained pyrite and crushed schist fragments. The vein contains 2 narrow pitchblende shoots 45 and 65 feet long, averaging 10 inches in width and 0.183 percent in U_3O_8. Unidentified yellow and green secondary uranium minerals were noted on the walls of the tunnel.

At the Almaden mine pitchblende occurs in the nearly vertical east-west-trending Blazing Star vein. This vein has yielded small but high-grade shipments of gold, silver, and lead ore from narrow scattered lenses. The vein zone is barren except for small veinlets containing quartz, calcite, pyrite, galena, and some sphalerite and chalcopyrite. The pitchblende is in a small veinlet 1 inch wide and is associated with proustite and yellow and green secondary uranium minerals. A sample from the veinlet contained 0.90 percent U_3O_8 and a selected sample from the dump contained 2.4 percent U_3O_8.

No other significant occurrences of radioactivity were noted in the Fall River area.

The report includes an index map of the Fall River district showing properties examined for radioactivity; a plan for the Golconda tunnel, and assay and geologic maps of the No. 4 vein, Golconda mine; and a vertical section through the Blazing Star vein, Almaden mine.

154 Smith, W. C., and Gianella, V. P., 1942, Tin deposit at Majuba Hill, Pershing County, Nevada: U. S. Geol. Survey Bull. 931–C, p. 39–55.

Tin and copper deposits occur at Majuba Hill, Pershing County, Nev., about 35 miles north of Lovelock. The country rock is an intrusive rhyolitic porphyry of Tertiary age nearly all of which has been silicified and sericitized. Torbernite is associated with secondary copper minerals and copper sulfides along the Majuba Hill fault. This fault displaces a small deposit of cassiterite which occurs as a replacement of altered rhyolite breccia. The copper minerals were deposited later than the tin as lenses in the fault about 300 feet from the tin deposit. The dominant minerals in each deposit are different and the two deposits "appear to be products either of two separate mineralizations or of two distinct phases of a protracted mineralization * * *."

Geologic maps and sections of Majuba Hill and the Majuba Hill mine are included.

155 Staatz, M. H., and Bauer, H. L., Jr., 1950, Preliminary examination of the uranium prospect at the Spider No. 1 claim, Honeycomb Hills, Juab County, Utah: U. S. Geol. Survey TEM–165, 7 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The Spider No. 1 claim is in the Fish Springs mining district, 20 miles southeast of Callao, Juab County, Utah. Uranophane(?) and autunite(?) occur chiefly as coatings along steeply dipping minor fractures in tuff. In a few places the uranium minerals are disseminated unevenly through the tuff. Samples of the deposit taken by the U. S. Geological Survey range in grade from 0.009 to 0.053 percent equivalent uranium. Samples obtained by one of the claim holders are reported to range in grade from 0.02 to 0.19 percent uranium.

156 Staatz, M. H., and Bauer, H. L., Jr., 1953, Uranium in the East Walker River area, Lyon County, Nevada: U. S. Geol. Survey Bull. 988–C, p. 29–43.

Uraniferous quartz veins and uraniferous deposits of other types occur in an area at least 6 miles long and 3 miles wide, along the East Walker River in Lyon County, Nev. Most of the deposits are on the west side of the river.

Six properties or areas were mapped, sampled, and tested radiomentrically. These properties are: the Far West Willys group, Northwest Willys group, West Willys group, Silver Pick property, Grant View hot spring, and the Boerlin ranch radioactive area.

The East Walker River area is underlain by coarse-grained porphyritic granite. Cutting the granite are numerous aplite dikes and a few perthite-quartz pegmatites. Faults were seen in a few places.

Radioactive material was found in the East Walker River area in deposits of four types: (1) quartz veins carrying small amounts of copper, lead and silver minerals; (2) partly altered granite adjacent to quartz veins; (3) gouge zones; and (4) hot springs. The quartz vein deposits are the most abundant. The uranium minerals pitchblende and kasolite occur in the quartz veins, in aggregates and streaks associated with copper and silver minerals, galena, and barite. In many quartz veins abnormal radioactivity is absent or only locally present. Samples collected from quartz veins contain from 0.001 to 0.14 percent uranium; only 5 of 46 samples contain more than 0.025 percent uranium.

Partly altered granite adjacent to the quartz veins in the West Willys No. 7 property contains scattered torbernite, but the highest uranium content in deposits of this type is 0.006 percent.

The third type of deposit is represented on the Silver Pick property, where a gouge zone of differing thickness contains scattered flakes of torbernite. Five samples from this deposit contain from 0.005 to 0.013 percent uranium.

The uraniferous material found to date in the area is of too low grade and small size to be of value at present.—*Excerpt from authors' abstract*

Geologic maps and sections of the areas examined are included.

157 Staatz, M. H., and Osterwald, F. W., 1956, Uranium in the fluorspar deposits of the Thomas Range, Utah: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium p. 275–278; U. S. Geol. Survey Prof. Paper 300, p. 131–136.

Uranium-bearing fluorspar deposits on Spors Mountain in the western part of the Thomas Range, Juab County, Utah, constitute the largest known reserve of uraniferous fluorspar in the United States.

Spors Mountain is made up largely of a thick sequence of conformable Ordovician to Devonian sedimentary rocks, most of which are limestone and dolomite; the fluorspar deposits are in dolomite of Middle Silurian age. Many small volcanic plugs and dikes intrude the sedimentary rocks. The rocks of the district are cut by close-spaced and complex faults.

The uraniferous fluorspar deposits have three structural habits: (1) oval to irregular pipes, (2) veins, and (3) disseminated deposits. The fluorspar occurs chiefly in the pipes. These differ considerably in size and are for the most part adjacent to faults or adjacent to intrusive breccia bodies. The ore, containing 65–94 percent fluorite, closely resembles brown, white, or purple clay, and forms either soft pulverulent masses or boxworks. The pipelike ore bodies commonly become smaller and lower in grade with depth.

Uranum contents of 155 fluorite samples range from 0.003 to 0.33 percent. The uranium content of some individual deposits varies systematically vertically and nonsystematically horizontally. Other deposits show no systematic vertical variation. At most deposits uranium is enriched near the surface, presumably as a result of leaching of uranium from the upper part of the deposit and redeposition by adsorption in the dry underlying fluorite a few inches to as much as 30 feet below the position from which it was removed.

The fluorspar is believed to have been formed from fluorine-rich fluids carrying minor amounts of uranium, which rose along faults and shattered zones in the dolomite. These fluids probably were derived from the same source that formed abundant topaz in rhyolites that make up most of the eastern half of the Thomas Range. The uranium was originally dispersed throughout the fluorite, probably within the crystal structures.—*Authors' abstract*

The report includes a geologic map of the east pit of the Fluorine Queen mine and block diagrams showing the shape of the Lucky Louie pipe and the large pipe on the Bell Hill property.

158 Steinhauser, S. R., 1956, Uranium in the Gulf Coastal Plain of Texas: Mines Mag. [Colorado], v. 46, no. 3, p. 73–76.

At Tordilla Hill in western Karnes County uranium occurs in soft friable sandstone and intensely silicified sandstone and tuff along a probable fault or shear zone in the Fayette sandstone of late Eocene age. "Some of the silicified sandstone is black and practically quartzitic. Some samples of this material are quite uraniferous yet contain no identified uranium minerals. Pyrite, marcasite, and ilsemannite have been identified in it. Opal and minor chalcedony are the cementing materials. This deposit undoubtedly is genetically related to faulting; but whether the uranium was introduced by ground water, hydrothermal waters, or a combination of the two is not certain."

159 Stephens, J. G., 1955, Crooks Gap area, Fremont County, Wyoming, *in* Geologic investigations of radioactive deposits—Semiannual progress report for June 1 to Nov. 30, 1955: U. S. Geol. Survey TEI–590, p. 181, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The ore mined at the Hazel mine in sec. 9, T. 28 N., R. 92 W., in the Crooks Gap area of southeastern Fremont County, Wyo., occurred along the plane of a high-angle reverse fault, which places the Chugwater formation of Triassic age on the Cody shale of Cretaceous age. The other uranium deposits in the area all occur in conglomeratic arkose in the Wasatch(?) formation of Eocene age.

160 Stewart, R. H., 1951, Radiometric reconnaissance examination in southeastern Pennsylvania and western New Jersey: U. S. Geol. Survey TEM–255, p. 6–8, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The Stockton torbernite locality is in a sandstone quarry half a mile northwest of Stockton, Hunterdon County, N. J. Quarrying operations in sandstones and shales of the Stockton formation of Triassic age have revealed a tabular mineralized zone 10 feet wide trending N. 35° W. Joint surfaces within the mineralized zone are coated with manganese stains, hematite, limonite, and, in places, with torbernite, metatorbernite, and muscovite. The rock within the mineralized zone contains an approximate average of 0.009 percent uranium. A few small spots contain up to 1.24 percent uranium. "The mineralogy suggests a possible hydrothermal origin, and primary uranium minerals may exist below the zone of oxidation * * *." All other occurrences of copper mineralization examined in the area contained less than 0.001 percent equivalent uranium.

161 Stocking, H. E., and Page, L. R., 1956, Natural occurrence of uranium in the United States—a summary: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva, 1955, Proc., v. 6, Geology of uranium and thorium, p. 211–216; U. S. Geol. Survey Prof. Paper 300, p. 5–12.

This report summarizes data on uranium in the United States from papers submitted to the International Conference on the Peaceful Uses of Atomic Energy held in Geneva in 1955. Uranium in igneous rocks, veins, terrestrial sedimentary rocks, chemical precipitates, coals, marine sedimentary rocks, and in petroleum and asphaltites is discussed. The following excerpt from the authors' abstract pertains to uranium-bearing veins.

Pitchblende-bearing veins of Tertiary age are mined at Marysvale, Utah; Ralston Buttes, Gunnison, and Central City, Colo.; and Boulder, Mont. In the Couer d'Alene district, Idaho, uranium-bearing veins of Precambrian age are known. Numerous other uraniferous veins are found in crystalline rocks of the United States. The pitchblende may be associated with copper, lead, silver, zinc, and gold minerals; with sulfides and fluorite; or with carbonate and silica gangue minerals and only minor amounts of sulfides. In the Thomas Range, Utah, are uraniferous fluorite veins and pipes of ore grade. Secondary uranium minerals occur in the upper parts of many of the veins.

162 Stow, M. H., 1953, Report of geological reconnaissance in south-central Montana and northwestern Wyoming: U. S. Atomic Energy Comm. RME–3069, 34 p., issued by U. S. Atomic Energy Comm. Tech. inf. Service Ext., Oak Ridge, Tenn.

Geological reconnaissance in south-central Montana and northwestern Wyoming revealed high radioactivity and secondary uranium minerals along fractures in the Flathead quartzite of Cambrian age near its contact with Precambrian crystalline rocks. The most radioactive deposits examined are the Weaver prospect, 3 miles west of Red Lodge, and the Royse claim, about 7 miles south of Red Lodge. The Weaver prospect is on or very near the Willow Creek fault; the Royse claim is near small faults transverse to the Beartooth thrust fault.

Generalized geologic maps of the east front of the Beartooth Mountains showing the location of the radioactive deposits examined are included.

163 Stow, M. H., 1955, Report of radiometric reconnaissance in Virginia, North Carolina, eastern Tennessee, and parts of South Carolina, Georgia, and Alabama: U. S. Atomic Energy Comm. RME–3107, p. 15–18, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Reconnaissance for radioactivity in several Southeastern States during the summer of 1954 revealed uranium minerals in the Hampton-Morgantown area in northeastern Tennessee and the adjacent part of North Carolina. The deposits are in the Cranberry granite of Precambrian age and are along fracture and schistose zones close to prominent faults. The uranium content of samples from these deposits ranges from 0.021 to 0.50 percent. The most significant deposit is on North Harper Creek in Avery County, N. C. At this deposit uraninite is in veins and schistose zones in the Cranberry granite. One uraninite vein is one-half inch wide, and extends across the streambed for about 15 feet.

164 Stugard, Frederick, Jr., Wyant, D. G., and Gude, A. J., 3d, 1952, Secondary uranium deposits in the United States, *in* Selected papers on uranium deposits in the United States, p. 19–25: U. S. Geol. Survey Circ. 220.

Secondary uranium minerals occur in small quantities in many metallic vein deposits. In a few places, notably in the veins at Marysvale, Utah, secondary uranium minerals are abundant enough to constitute ore. In most deposits their main value is as an indicator of possible primary ore.

The weathering and alteration of primary uranium oxides in a vein may result in the formation of different secondary uranium minerals in different zones. The minerals will vary with the composition of the vein, of country rock, and of the solutions formed by weathering. A diagram in this report shows the hypothetical vertical zonation of secondary uranium minerals in weathered veins. Near the surface the veins may contain efflorescent uranium sulfates and carbonates. This zone may grade downward into a zone containing uranium silicates, phosphates, arsenates, and vanadates. These minerals may grade downward into a zone of secondary uranium oxides, accompanied by relict primary uranium oxides. Below this zone are unaltered primary oxides. The weathering of the pitchblende-bearing veins at Marysvale, Utah, produced a zonation of secondary uranium minerals similar to that outlined.

165 Taylor, A. O., Anderson, T. P., O'Toole, W. L., and others, 1951, Geology and uranium deposits of Marysvale, Utah, interim report on the producing area: U. S. Atomic Energy Comm. RMO–896, 30 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Rocks within the currently known area of uranium ore deposits at Marysvale, herein designated as the "central" area, are exclusively of igneous origin. In order of first appearance, they include: (a) quartz-monzonite porphyry; (b) porphyritic quartz-monzonite; (c) quartz-monzonite; (d) granite. These, all intrusives, are overlain by (e) the late Tertiary extrusive Mt. Belknap rhyolite. All of the intrusives invaded the early Tertiary Bullion Canyon volcanic series, but all except a few traces of this older group was eroded before the rhyolitic effusion.

Faulting and fissuring later than the rhyolite flow gave rise to extensive alteration of the fractured rocks and mineralization by uranium, though it is not yet proved that the two effects were simultaneous. Shear zones with a northeasterly trend have thus far been the most productive of uranium ores, but fractures in other directions show increasing possibilities.

The primary uranium mineral is pitchblende, most commonly soft and pulverulent, occasionally the hard, botryoidal variety. It is associated with calcedonic silica, adularia, pyrite, calcite, jordisite, purple to black fluorite, hematite, magnetite, and tentatively identified siderite and marcasite. Deposition is believed to have been epithermal, possibly solfataric or fumarolic. Some of the sooty pitchblende found at depths less than 60 feet may be secondary, but much of it is associated with minerals which show no evidence of oxidation except near the boundary between primary and secondary uranium mineralizations.

Alteration of primary oxides has yielded a considerable variety of secondary uranium minerals, including autunite, torbernite, schroeckingerite, uranophane, and a few others not yet identified. Uranophane is most abundant near outcrop, but the others, apparently more susceptible to atmospheric decomposition, occur 5 to 10 feet deeper.

A red, hematitic zone, resulting from rock alteration, is almost invariably associated with uranium minerals in the primary zone, sometimes persisting up into the zone of supergene alteration. Its usefulness as a guide to ore, however, is somewhat diminished by reason of its small and inconspicuous size in proportion to the mass of mineralized material.—*Authors' abstract*

The report includes a map of the uranium-producing area and contains descriptions of the following properties: The Prospector, Freedom No. 2 and No. 1 (Seegmiller), Bullion Monarch, and Buddy mines and the Yellow Canary prospect.

166 Taylor, A. O., and Powers, J. F., 1955, Uranium occurrences at the Moonlight mine and Granite Point claims, Humboldt County, Nevada: U. S. Geol. Survey TEM-874-A, 16 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The Moonlight mine and Granite Point claims are on the west flank of the Double H Mountains between the Kings River and Quinn River valleys in northern Humboldt County, Nev.

At the Moonlight mine uranium minerals occur along a north-trending eastward-dipping fault that displaces intensely altered volcanic rocks of Tertiary age. Near the surface the principal uranium mineral is autunite, but at depth torbernite, "gummite(?)," and pitchblende(?) are the ore minerals. The uranium minerals are associated with fluorite, pyrite, and smoky quartz and are erratically distributed along the fault. Some ore-grade material is in the brecciated zone that forms the hanging wall of the fault. The deposit probably formed under epithermal conditions after brecciation and silicification of the rock.

The Granite Point claims are 2 miles north of the Moonlight mine at the base of a rhyolite cliff. The rhyolite is abnormally radioactive; 1 sample contained 0.02 percent U_3O_8, but no uranium minerals were found.

A geologic map and cross section of the Moonlight mine are included.

167 Theobald, P. K., and Guilinger, R. R., 1955, A radioactive copper-bearing shear zone in the vicinity of the F.M.D. mine, Jefferson County, Colorado, *in* Geologic investigations of radioactive deposits—Semiannual progress report for June 1 to Nov. 30, 1955: U. S. Geol. Survey TEI-590, p. 202-212, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Uranium occurs in a copper-bearing northwest-trending shear zone cutting hornblende gneiss of Precambrian age at the F.M.D. mine, 4½ miles west of Morrison, Jefferson County, Colo. The shear zone is slightly silicified and contains copper sulfides, pyrite, and limonite. The wallrock of the shear zone is altered to chlorite, biotite, sericite, and clay minerals. Uranium occurs in limonite-rich zones, but is spotty and low in grade. The highest grade of 3 samples contained only 0.028 percent uranium.

168 Theobald, P. K., and King, R. U., 1954, Colorado-Wyoming district, *in* Geologic investigations of radioactive deposits—Semiannual progress report, June 1 to Nov. 30, 1954: U. S. Geol. Survey TEI-490, p. 223-225, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Eight abnormally radioactive deposits in Boulder, Jefferson, and Gilpin Counties in the Colorado Front Range are briefly described. The deposits are in shear zones and veins cutting crystalline rocks of Precambrian age.

Secondary uranium minerals occur in the deposit near Diamond Lake, Boulder County, and in the deposit on Silver Hill, Gilpin County. Samples from the Diamond Lake deposit contained 0.035 and 0.21 percent uranium. Although no uranium minerals have been identified, ore-grade material is reported from a deposit in brecciated and bleached hornblende gneiss along the South Platte River in southern Jefferson County.

Pitchblende(?) has been found in a vein in Trail Creek, 6 miles north of Esterbrook, Wyo., in the Laramie Range. Moderate radioactivity occurs in a northeast-trending breccia reef a quarter of a mile south of the Trail Creek deposit.

169 Thurlow, E. E., 1956, Uranium deposits at the contact of metamorphosed sedimentary rocks and granitic intrusive rocks in Western United States: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium, p. 288–292; U. S. Geol. Survey Prof. Paper 300, p. 85–89.

On the Spokane Indian Reservation in northeastern Washington uranium minerals occur in the sheared contact zone of the Loon Lake granite of Cretaceous(?) age and the Deer Trail argillite of late Paleozoic(?) age. Secondary uranium minerals also occur along shear zones parallel to and near the contact within the metamorphosed sedimentary rocks. Autunite and uranophane are the principal uranium minerals in the oxidized zone, and uraninite and pyrite have been found in drill cores from a depth of 150 feet. Gangue minerals other than pyrite are very rare, and the host rock shows very little replacement.

Near Austin in Lander County, Nev., autunite and metatorbernite occur in fractures in quartz monzonite of Jurassic(?) age and in metamorphosed sedimentary rocks of possible Cambrian or Silurian age. The uranium minerals are in mineralized fractures containing finely divided sericite and quartz. The veins are in both igneous and metamorphic rocks near the contact zone. The richest concentrations of uranium minerals are in fractures in the metamorphic rocks.

Geologic maps of parts of the Spokane Indian Reservation and the Austin area are included.

170 Thurlow, E. E., and Jarrard, L. D., 1954, Boulder batholith—potential Montana uranium province: Mining Eng., v. 6, no. 7, p. 697–698.

Uranium occurs in veins in the quartz monzonite of the Boulder batholith of early Tertiary age in western Montana. Uranium ore has been produced from three widely separated small deposits in the batholith. The veins are grouped into a younger silicious reef type and an older base-metal vein type. Base-metal sulfide ores are not common in the younger type, which has been valuable mainly for precious metals. Silver-lead and gold-silver ores are in both types. Uraninite is in both types, thus suggesting that uranium, along with cryptocrystalline quartz, was introduced into both types of veins simultaneously.

The silicious reefs are steeply dipping brecciated tabular shear zones cemented by cryptocrystalline quartz which causes them to stand out in prominent outcrops. Pyrite is the only common sulfide mineral. Small amounts of chalcopyrite, molybdenite, galena, and ruby silver are present. Secondary uranium minerals, principally autunite and metatorbernite, are generally associated with the anomalous radioactivity that is found at closely spaced intervals along the reefs. In deposits of higher grade, gummite is commonly associated with remnants of pitchblende. The uranium in the reefs seems to be concentrated principally in pods measuring tens of feet along both strike and dip.

Small amounts of uranium are in the base-metal veins of the Butte district and in many other parts of the batholith. A small shipment of uranium ore was produced from a base-metal vein at the Long Eagle mine west of Clancey. The uranium is primarily in pitchblende in thin seams and coatings on fracture surfaces and is intimately associated with dark-gray to black chalcedonic quartz. The pitchblende occurs with vein material that is not of ore grade for its base-metal content. Pitchblende in the Butte district is associated with reddish siliceous vein material containing much pyrite, but at present the occurrences are of academic interest only.

171 Thurlow, E. E., and Reyner, M. L., 1950, Free Enterprise uranium prospect, Jefferson County, Montana: U. S. Atomic Energy Comm. RMO–678, 12 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The Free Enterprise property is located in the Boulder mining district, Jefferson County, Mont. Secondary uranium minerals occur here in small irregular concentrations in and adjacent to a narrow silicified fracture zone in quartz monzonite. The zone has been prospected to a depth of 150 feet. Small amounts of a black to brownish uranium mineral, presumably pitchblende, have been observed, and the secondary minerals are characteristic of the alteration of pitchblende and uraninite. Indications are that a primary uranium mineral which was introduced with quartz and sulphides has been reconstituted by the action of surface and near-surface waters, reprecipitating uranium in secondary minerals. Below the present water level, where the vein is relatively unaltered and unenriched, only small amounts of uranium are present.—*Authors' abstract*

A geologic map and section of the Free Enterprise mine are included.

172 Thurlow, E. E., and Reyner, M. L., 1952, Preliminary report on uranium-bearing deposits of the northern Boulder batholith region, Jefferson County, Montana: U. S. Atomic Energy Comm. RMO–800, 62 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Uranium-bearing veins were discovered in the northern part of the Boulder batholith in western Montana in 1949. The batholith crops out for a length of 60 miles and averages about 18 miles in width. It intrudes sedimentary rocks of Precambrian to Cretaceous age, and is composed predominantly of quartz monzonite with dikes and irregular masses of aplite, alaskite, and other granitic rocks. Uranium has been found in two types of veins, a younger siliceous reef type and an older base-metal type.

The younger siliceous reef veins contain the most uranium, and a minor amount of precious metals has been produced from a few deposits of this type. The veins contain chiefly cryptocrystalline quartz and varying amounts of pyrite, galena, ruby silver, native silver, and uranium minerals. The uranium is chiefly in secondary minerals, such as autunite, metatorbernite, and gummite. Uraninite occurs at two deposits. Zeunerite, phosphuranylite, and uranophane have been tentatively identified. The secondary uranium minerals occur along fractures within the veins and as disseminations in the wallrock. In general, the veins are highly brecciated, and all are nearly vertical and trend predominantly northeast. They occur mainly in quartz monzonite that is deficient in hornblende. Argillic alteration of the wallrock is pronounced.

Uraninite and secondary uranium minerals including autunite and metatorbernite also occur in some of the base-metal sulfide veins in the batholith. These veins are probably older than the siliceous reef veins, and have yielded gold, silver, lead, zinc, and copper. The veins typically contain quartz, pyrite, arsenopyrite, galena, sphalerite, chalcopyrite, and tetrahedrite. Following the deposition of these minerals, the veins seem to have been brecciated and reopened with the introduction of uraninite, cryptocrystalline silica, ankerite, and pyrite and possibly arsenopyrite and chalcopyrite. The uraninite fills fractures within and adjacent to vein material. The uraninite fillings are generally thin, but botryoidal coatings of pitchblende occur. There are many variations in the mineralogy and general character of the veins.

About 50 mines and prospects were examined, and 14 of these containing more than a trace of uranium are described. One property, the Free Enterprise mine, has shipped uranium ore. The report contains geologic maps and sections of several of the properties described.

173 Thurlow, E. E., and Wright, R. J., 1950, Uraninite in the Coeur d'Alene district, Idaho: Econ. Geology, v. 45, p. 395–404.

Uraninite occurs in the lower levels of the Coeur d'Alene and Sunshine mines, two silver-base-metal producers, in the Silver Belt area of the Coeur d'Alene district, Idaho.

The Coeur d'Alene district is underlain by quartzite, argillite, and limestone of the Belt series of Precambrian age. These rocks are complexly folded and faulted, and intruded by monzonitic stocks presumably related to the Idaho batholith. Most of the ore deposits of the Silver Belt and the uraninite-bearing veins are in quartzite of the St. Regis formation on the north limb of the overturned Big Creek anticline.

In the Sunshine mine the uraninite-bearing veins are primarily in the footwall of the Sunshine shear (vein) system. In general, the veins are parallel to the strike of the bedding and are mainly controlled by fracture cleavage. The veins appear to be independent of the Sunshine vein which "is localized primarily along a shear zone with little regard for bedding or cleavage." In places the uranium-bearing veins appear to intersect the Sunshine vein. The width of the uranium-bearing veins rarely exceeds 18 inches, and in places radioactivity is found along paper-thin seams. Locally, the veins are numerous and closely spaced, forming broad mineralized zones.

The mineralogy of the uranium-bearing veins is similar to that of the copper-silver ores and consists of pyrite, tetrahedrite, arsenopyrite, and chalcopyrite in gangue of siderite and quartz. Small spherulites of uraninite replace vein quartz, quartzite wall rock, and, to a lesser extent, tetrahedrite. Minor amounts of secondary uranium minerals have formed presumably since mine development. All veins with significant radioactivity are bordered by a brownish-red alteration zone in the quartzite wallrock. These zones range from a fraction of an inch up to a foot in width and are believed due to finely disseminated hematite. The red-colored alteration is uniquely associated with the uranium mineralization and is not known elsewhere in the mine.

The authors suggest that the uraninite may have been introduced during a separate epoch of mineralization or, more probably, that it was deposited in the late stages of the deposition of the main silver-base metal ores.

The report contains several photographs and photomicrographs of polished surfaces of uraninite-bearing ore. Two maps show the general geology and structure of the west end of the Silver Belt, and one map shows the location of the uranium-bearing veins in part of the Sunshine mine.

174 Thurston, W. R., Staatz, M. H., Cox, D. C., and others, 1954, Fluorspar deposits of Utah: U. S. Geol. Survey Bull. 1005, 53 p.; see p. 5, 17, 28, 30, 34, 38, 40.

The fluorspar deposits of the Thomas Range district in Juab County, Utah, are abnormally radioactive, but generally no uranium minerals can be seen. The fluorspar deposits are epithermal pipelike bodies and veins in dolomite of Silurian age and in rhyolite porphyry of Tertiary age. Fluorite constitutes 65 to 95 percent of each deposit. Other visible minerals include dolomite, calcite, quartz, opal, and clay minerals. Carnotite has been found in a few deposits. Assays of 45 fluorspar samples from the district ranged from 0.005 to 0.33 percent uranium. Samples from the Bell Hill, Harrisite, and Eagle Rock properties contained more than 0.1 percent uranium.

The Monarch, or Staats, fluorspar deposit in T. 29 S., R. 16 W., in west-central Beaver County, contains autunite and uranophane as local coatings on the fluorite. The fluorspar deposit is along a faulted contact separating rhyolite porphyry of Tertiary age and limestone of Cambrian age.

175 Trites, A. F., Jr., and Tooker, E. W., 1953, Uranium and thorium deposits in east-central Idaho and southwestern Montana: U. S. Geol. Survey Bull. 988–H, p. 157–209.

This report describes the results of examinations conducted in 1950 by the Geological Survey to determine the grade, reserves, and mode of occurrence of uranium and thorium in 39 mines and prospects in 7 districts in east-central Idaho and southwestern Montana. Only 6 of the 39 properties examined seemed to contain significant amounts of uranium. These deposits are the Garm-Lamareaux mine and the Moon claim in the North Fork-Shoup district, Idaho; the Carnotite, R. and M., and Uranium claims in the Melrose district, Montana; and the Iola prospect in the Deer Creek district, Montana.

Uranium is in gold, lead, copper, and quartz-hematite veins that cut quartzite and phyllite of the Belt series of Precambrian age and Paleozoic limestone and shale. The cobalt-copper and lead-silver veins examined do not seem to contain significant amounts of uranium. The uranium deposits are near upper Mesozoic granitic intrusive rocks of the Idaho and Boulder batholiths or near post-Paleozoic granite that probably is related to the Boulder batholith. The uranium minerals are torbernite and autunite, associated with pyrite, galena, copper, gold, hydrous iron oxides, malachite, azurite, manganese minerals, quartz, chlorite, and clay minerals. "The uranium minerals commonly occur in small lenses and stringers in fracture zones. They form coatings on fractures outward from the vein fillings or on small crosscutting fractures in the vein. Rarely the uranium deposits are as much as 150 feet long and 5 feet wide." The grade and reserves of the known uranium deposits are poorly known because the deposits have not been extensively developed, but the reserves probably are small. Samples from the deposits indicate a range from 0.02 to 0.1 percent uranium.

176 Vickers, R. C., 1953, An occurrence of autunite, Lawrence County, South Dakota: U. S. Geol. Survey Circ. 286, 5 p.

In July 1952 an occurrence of autunite was found in the northern part of the Black Hills, S. Dak., during a reconnaissance for radioactive deposits. [The deposit is 5 miles west of Lead in the Bald Mountain mining district and is known as the Annie Creek autunite prospect.]

The autunite occurs as fracture coatings and disseminations in siltstone of the Deadwood formation of Cambrian age and is concentrated mainly in the lower 2 feet of the siltstone at the contact with an intrusive rhyolite porphyry; the radioactive zone is exposed in two old workings, which are 90 feet apart. An 18-inch vertical channel sample of the autunite-bearing siltstone contained 0.048 percent uranium. The gangue minerals are fluorite and limonite.

The uranium is believed to have been introduced into the siltstone by solutions of magmatic origin that migrated along the lower contact of the siltstone after or during emplacement of the porphyry.—*Author's abstract*

The report includes a geologic map and cross section of the deposit and a table showing semiquantitative spectrographic analyses for several elements and chemical analyses for uranium.

177 Vickers, R. C., 1953, North-Central district, *in* Search for and geology of radioactive deposits—Semiannual progress report for Dec. 1, 1952, to May 31, 1953: U. S. Geol. Survey TEI–330, p. 204–206, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Pitchblende and secondary uranium minerals occur in small stringers and pods in quartz and calcite veinlets in a low-angle shear zone along the East Branch of the Huron River in sec. 1, T. 51 N., R. 30 W., Baraga County, Mich. The shear zone is 10 to 30 feet thick and cuts black slates of the Michigamme slate of Precambrian age. A study of polished surfaces from the deposit indicates two hypogene stages and one supergene stage of mineralization. Quartz and minor hematite were introduced into the sheared slate during the first stage. The second stage was initiated by fracturing of the quartz and deposition of calcite, pyrite, pitchblende, native copper, and tennantite, followed by bornite and chalcopyrite. Secondary copper minerals and secondary uranium minerals including secondary(?) pitchblende were formed during the supergene stage.

178 Vickers, R. C., 1954, Occurrences of radioactive minerals in the Bald Mountain gold-mining area, northern Black Hills, South Dakota: U. S. Geol. Survey Circ. 351, 8 p.

Six radioactive occurrences were found in July 1953 during a reconnaissance of the Bald Mountain gold-mining area, Lawrence County, S. Dak.

The rocks in the area consist mainly of the flat-lying Deadwood formation of Cambrian age intruded by many sills, laccoliths, and dikes of Tertiary age. Associated with the intrusive rocks are gold-silver deposits which have been interpreted as being localized by solutions migrating up fractures and replacing favorable beds, mainly in the Deadwood formation. The radioactive occurrences are in fractured and altered siltstone of the Deadwood formation and the overlying Whitewood limestone and in altered intrusive rocks. Samples contain as much as 0.19 percent equivalent uranium and also contain thorium and the rare earths. All the occurrences are in the weathered zone, and differential leaching has probably disturbed the original thorium/uranium ratio. The increase in rare-earth content toward the center of the gold-producing area and the occurrence of uranium minerals (autunite and torbernite) on the fringe of the productive area are probably related to a zonal pattern.

Although none of the occurrences are large enough to constitute ore, uranium-bearing hydrothermal solutions were probably present during Tertiary mineralization in the Bald Mountain area and may have given rise to the carnotite-type deposits in the sediments surrounding the Black Hills.—*Author's abstract*

The report contains a geologic map of the Annie Creek autunite occurrence and tables showing analyses of uranium-bearing samples from properties in the Bald Mountain area.

179 Walker, G. W., 1953, Rosamond uranium prospect, Kern County, California: California Div. Mines Spec. Rept. 37, 8 p.

Small quantities of autunite, hydrous uranium and calcium phosphate, and another radioactive mineral not yet identified occur in tuffaceous sedimentary rocks of the Rosamond formation of Miocene age at the Rosamond prospect, which is about 10 miles south of Mojave, Kern County, Calif., in the western Mojave Desert.

The results of examination of the property in January, 1952, by George W. Walker and Luther H. Baumgardner, of the U. S. Geological Survey, indicated that the autunite occurs principally as coatings on fracture and joint surfaces and, to a lesser extent, as disseminations in the tuffaceous rocks adjacent to faults. A waxy reddish-brown to black radioactive mineral is found in small quantities on slickensided fault surfaces associated with iron oxides and chlorite(?). The uranium minerals are erratically distributed over an area of about 15 acres. Assays of 12 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.—*Author's abstract*

A geologic map and section of the prospect and a table showing the results of sample analyses are included.

180 Walker, G. W., 1956, Relationship between uranium-bearing veins and their host rocks, *in* Geologic investigations of radioactive deposits—Semiannual progress report for Dec. 1, 1955, to May 31, 1956: U. S. Geol. Survey TEI–620, p. 359–360, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Study of the relationship between uranium-bearing veins and their host rocks shows that veins are in all varieties of rocks but are most abundant in holocrystalline igneous and metamorphic rocks characterized by moderate to high silica contents; these host rocks have widely variable chemical composition but have similar physical characteristics in that they tend to rupture under stress rather than to undergo plastic deformation.

Conceivably this tendency to rupture and the detailed characteristics of the resultant fractures, shears, faults, and fragmentation, affecting the adsorptive properties of the host rocks, may have an important bearing on the apparent preferential deposition of uranium * * *.

Locally, the chemical and (or) mineralogic composition of the host rocks appears to aid in the deposition and localization of uranium in individual veins * * *. For most vein deposits, however, no such chemical relationship can be established, possibly owing to (1) lack of adequate data, (2) inert chemical properties of ore solutions with respect to the host rocks, or (3) marked differences in chemical interaction between ore solutions and host rocks from one deposit to another.—*Excerpt from author's text*

181 Walker, G. W., and Adams, J. W., 1956, Mineralogy of uranium-bearing veins, *in* Geologic investigations of radioactive deposits, Semiannual progress report for June 1 to Nov. 30, 1956: U. S. Geol. Survey TEI–640, p. 220–221, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

A study of the mineralogy of uranium-bearing vein deposits in the United States, based largely on published data but supplemented by the examination of polished and thin sections of ore specimens from a number of widely separated vein deposits, suggests new and significant relationships, namely: (1) the primary textures of uraninite (pitchblende) in veins are almost universally colloform—textures considered by many geologists to result from colloidal deposition, (2) idiomorphic crystals of uraninite are extremely rare, having been reported in only two vein deposits, and (3) in general, uraninite (pitchblende) is early in the paragenetic sequence and commonly was followed by brecciation before other metallic vein minerals were introduced.—*Authors' complete text*

182 Walker, G. W., Lovering, T. G., and Stephens, H. G., 1956, Radioactive deposits in California: California Div. Mines Spec. Rept. 49, 38 p.

This report describes deposits of radioactive minerals in California. For each deposit, where the information is available, the location, ownership, development, geology, and grade of samples, is given. Many of the deposits are veins or veinlike and may be divided into three groups: (a) deposits in quartz fissure veins, (b) deposits on minor fractures, and (c) replacement deposits along fractures.

Uranium-bearing quartz fissure vein deposits are at the Rathgeb mine, Red Devil claim, Wild Bill group, Paymaster mine, and the Perry Jones claims. The uranium in these veins is generally of limited and erratic distribution. The primary or secondary uranium minerals are commonly mixed with base-metal sulfides or their oxidation products. The only primary uranium mineral identified from this type of vein is uraninite from the Rathgeb mine. Nearly all the veins of this type occur in granitic rocks.

Most of the vein deposits in California belong to the second group in which secondary uranium minerals coat fracture surfaces. Commonly the minerals are in fault gouge or are erratically distributed on joint surfaces adjacent to mineralized faults. Many different varieties and ages of host rocks have been noted for these deposits. The Miracle mine and others in the Kern River Canyon area, Kern County, are developed on vein deposits belonging to this second group.

The third group of vein deposits are base-metal sulfide bodies containing uranium, which in part, replace limestone along fractures. An example is the deposit on the Yerih group of claims in San Bernardino County.

The report includes geologic maps of selected deposits in Kern County, a map of California showing the location of 92 radioactive deposits, and a table summarizing information on each of the deposits.

183 Walker, G. W., and Osterwald, F. W., 1956, Relation of secondary uranium minerals to pitchblende-bearing veins at Marysvale, Piute County, Utah: Internat. Conf. on Peaceful Uses of Atomic Energy, Geneva 1955, Proc., v. 6, Geology of uranium and thorium, p. 283–287; U. S. Geol. Survey Prof. Paper 300, p. 123–129.

Secondary uranium minerals in vein-type deposits are more abundant at Marysvale than elsewhere in the United States and are the near-surface expression of pitchblende- and fluorite-bearing veins at depth. The primary veins and their secondary counterparts yield ore of about the same grade. The gradational boundary between the zone of primary and secondary uranium minerals is extremely irregular, ranging from a few tens of feet to as much as 400 feet in depth beneath the ground surface.

Primary vein minerals include vein quartz, chalcedony, adularia, pyrite, marcasite, calcite, siderite, jordisite, fluorite, hematite, magnetite, and pitchblende. Most commercial deposits of uranium are restricted to quartz-pyrite-adularia-fluorite-pitchblende veins. Some of the pitchblende-bearing veins contain molybdenum minerals. The assemblage of secondary minerals reported at Marysvale contains iron and manganese oxides, ilsemannite, autunite, torbernite, metatorbernite, schroeckingerite, uranophane, phosphuranylite, β–uranotil, tyuyamunite, rauvite, umohoite, zippeite, johannite, uranopilite, and sooty pitchblende.

Host rocks for the veins include extrusive and pyroclastic rocks of post-Oligocene age, quartz monzonite and other rocks that intrude the extrusive and pyroclastic rocks, and flows and tuffs of late Tertiary age that unconformably overlap the older rocks. Most of the ore mined has been from veins in quartz monzonite.

The host rocks are cut by three sets of vertical to moderately steep faults that trend northeast, northwest, and north. Pitchblende and secondary uranium minerals are most common in northeast-trending faults, less common in northwest-trending faults, and rare or absent in north-trending faults. The uranium-bearing veins pinch and swell, and the ore is commonly localized in shoots in both the primary and secondary zones.

The assemblage of secondary uranium minerals varies, in part, with respect to the type and degree of alteration of wall rock, to the primary mineralogy of the veins, and to the depth beneath the ground surface. The secondary uranium minerals occur as disseminations in altered wall rock and as fracture coatings and are most abundant within 10 feet of the originating vein.

As pitchblende- and fluorite-bearing veins show no marked tendency to be richer in uranium than their overlying secondary counterparts, it is probable that the solution of primary uranium minerals and redeposition as secondary ones occurred essentially in place. Some of the secondary uranium minerals may have been deposited by warm solutions, either juvenile water or heated phreatic water.

The assemblage of secondary minerals is somewhat similar to that of deposits at Wolsendorf, Germany, and in the Boulder batholith, Montana. These deposits, however, contain at least small amounts of base-metal sulfide minerals which are absent at Marysvale. Primary mineralogy of the veins, therefore, seems to have little influence on the assemblage of secondary uranium minerals developed in the oxidized zone.—*Authors' abstract*

184 Walker, G. W., and Osterwald, F. W., 1956, Uraniferous magnetite-hematite deposit at the Prince mine, Lincoln County, New Mexico: Econ. Geology, v. 51, p. 213–222.

A pyrometasomatic magnetite-hematite deposit in sedimentary rocks of Permian age near the margin of the Lone Mountain stock in Lincoln County, N. Mex., contains between 0.015 percent and 0.031 percent uranium. The deposit is composed mainly of magnetite with lesser amounts of hematite, hydrated iron oxides, pyrite, leuchtenbergite(?), gypsum, chalcopyrite, metatorbernite, torbernite(?), covellite, sphalerite(?), quartz, marcasite, and an unidentified uranium-bearing mineral; it is surrounded by an aureole of recrystallized limestone, gypsum, epidote, and actinolite with lesser amounts of specularite, phlogopite, fluorite, pyrite, and chalcopyrite. Autoradiographs and polished-section studies suggest that most of the uranium is dispersed in the iron oxide minerals. The association of iron and uranium may be related to the melting points of the elements. The deposit probably formed at a rather low temperature by self-oxidation of a ferrous hydroxide hydrosol contained in a mildly alkaline solution—*Authors' abstract*

185 Wallace, S. R., 1955, Zonal relations of uranium deposits in metalliferous districts, *in* Geologic investigations of radioactive deposits—Semiannual progress report for Dec. 1, 1954, to May 31, 1955: U. S. Geol. Survey TEI–540, p. 149–150, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The six-weeks study during 1954 of radioactivity in the Bisbee district was a preliminary reconnaissance to determine the district's suitabilty for a study of the relation between uranium and zoning. The Bisbee district was selected for three reasons: (1) significant concentrations of uranium had been reported from the district, (2) the geographic position of different types of ore within the district suggested a zonal distribution of the ores, and (3) the total amount of metal deposited within the district was known to be large, suggesting that the quantity of uranium might be appreciable.

The results of the preliminary investigation suggest that most of the uranium in the district is associated with massive sulfide replacement ore bodies in limestone; apparently there is little difference in uranium content of lead-zinc ores and copper ores. The low-grade disseminated copper ore of the Sacramento Hill porphyry stock exhibits no abnormal radioactivity. Most of the high values previously reported are the result of secondary salts deposited on the walls of mine workings in and near the ore bodies. A few, very small, high-grade pods containing primary uranium minerals were discovered, but no minable concentrations of uranium ore are known in the district.

Some of the acid mine waters from Bisbee and other mining districts in the southwest are exceptionally rich in uranium, and suggest that there may be localities where concentration and flow are sufficient to encourage attempts to extract uranium from solution.—*Author's complete text*

186 Wallace, S. R., and Laub, D. C., 1954, Zonal relations of uranium deposits in metalliferous districts, *in* Geologic investigations of radioactive deposits—Semiannual progress report, June 1 to Nov. 30, 1954: U. S. Geol. Survey TEI–490, p. 146–147, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

In the Gold Hill district, Boulder County, Colo., gold telluride veins apparently bear no direct genetic relation to the relatively few pyritic gold veins or to the lead-zinc-silver veins believed to be both earlier and later than the telluride veins. District zoning of uranium deposits [annotation 25] cannot be demonstrated because parts of many veins of all types are anomalously radioactive. The radioactivity of most deposits is generally of low intensity and probably no economic concentrations of uranium exist in the district.

187 Weathers, Gerald, 1954, Uranium occurrence at the King No. 1 claim, Gila County, Arizona: U. S. Atomic Energy Comm. RME–2016 (pt. 1), 14 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The King No. 1 claim is about 4 miles south of Miami, Gila County, Ariz. The claim is on a northwest-trending fissure vein in the Solitude granite of Precambrian age. The vein averages 1½ feet in width and contains chiefly quartz and lesser amounts of pyrite, chalcopyrite, malachite, manganese oxides, iron oxides, and metatorbernite. The wallrock is kaolinized and sercitized muscovite granite. The metatorbernite occurs as aggregates of crystals along minute fractures within the quartz and altered muscovite granite. Present exposures of ore-grade material are confined to near the surface. Similar veins are exposed at the south end of the claim. Projections of these veins suggest an intersecting or echelon vein system.

The report includes a geologic map of the claim, a geologic map of part of the Globe Copper district, and a map of the original mine workings showing the vein and radiometric readings.

188 Webb, B. P., and Coryell, K. C., 1954, Preliminary regional mapping in the Ruby Quadrangle, Arizona: U. S. Atomic Energy Comm. RME–2009, 12 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Reconnaissance mapping in the Ruby Quadrangle, Ariz., indicates the existence of a complex assemblage of volcanic rocks and associated sediments, divisible into a younger and older series. The young series consists of flat-lying tuffs, lavas, and tuffaceous conglomerates of late Cenozoic(?) age. The older series consists of (acidic and intermediate) lavas, tuffs, conglomerates, and associated sediments of Mesozoic(?) age, locally folded and extensively intruded by a dioritic magma—*Excerpt from authors' abstract*

Uranium deposits seem to be confined to acidic lavas of the older rock series. At the Annie Laurie prospect, 2 miles south of Ruby, minor amounts of galena, sphalerite, chalcopyrite, and pitchblende occur in minor shear zones cutting acidic lava associated with the Oro Blanco conglomerate.

The White Oak mine on the northern flank of the Pajarito Mountains has yielded a few tons of uranium ore from a northwest-trending shear at the intersection with a main northeast-trending shear. The host rock is a porphyritic rhyolite member of the Pajarito lavas. Anomalous radioactivity occurs at the Little Doe prospect and the Iris and Natalia claims near the northwest corner of the quadrangle. The host rocks are acidic lavas which are considered to be correlatable with the Pajarito lavas.

The report contains a reconnaissance geologic map of the Ruby quadrangle.

189 Wedow, Helmuth, Jr., White, M. G., and Moxham, R. M., 1952, Interim report on an appraisal of the uranium possibilities of Alaska: U. S. Geol. Survey, open-file report, 123 p.

The authors have divided the Territory of Alaska into nine major regions and for each of these regions they have summarized the geology and mineral deposits and appraised the uranium possibilities. The appraisals are based on known occurrences of radioactive materials and geologic criteria that suggest the presence of uranium. Vein-type deposits from which uranium has been identified are briefly described below.

The York tin district of the western Seward Peninsula contains mineral deposits in veins and replacement deposits along and in the vicinity of the contact between granite of probable Mesozoic age and limestone and shale of Paleozoic age. The mineralogy of these deposits is similar to the uranium-tin mineralization at Cornwall and the Erzgebirge. Prospects in the Lost River and Brooks Mountain areas contain minor amounts of uranium closely associated with hematite, limonite, wolframite, molybdenite, pyrite, tetrahedrite, fluorite, and hydrous copper carbonates. The maximum uranium content of a few samples from the Lost River area was 0.049 percent uranium.

Metatorbernite and uraniferous hematite have been reported from a vein-type replacement deposit near Ear Mountain on the Seward Peninsula.

Uranium has been found associated with iron oxides and sulfides in veinlets on the Mountain View property in the Hyder district on the east edge of the Coast Range batholith in southeastern Alaska. Mineral deposits of the Hyder district occur in hydrothermal veins of intermediate-temperature range containing such typical minerals as argentiferous galena and tetrahedrite.

In the lower Yukon-Kuskokwim region of southwestern Alaska, zeunerite occurs with chalcopyrite, arsenopyrite, and pyrite in quartz veins cutting granitic rock on Mission Creek [Konechney prospect].

190 Wells, J. D., and Harrison, J. E., 1954, Radioactivity reconnaissance of part of north-central Clear Creek County, Colorado: U. S. Geol. Survey Circ. 345, 9 p.

A radioactivity reconnaissance of 334 vein deposits in north-central Clear Creek County, Colo., made during the field seasons of 1951 and 1952 disclosed 7 deposits containing uranium of ore grade.

"Within the area studied, * * * [veins] containing chalcopyrite have the highest grade and highest percent of occcurrences of significant abnormal radioactivity. Zones of galena-sphalerite veins have approximately the same rate of occurrence of significant abnormal radioactivity as zones of galena-sphalerite with chalcopyrite. Any locality or zone containing pyritic-type veins without chalcopyrite is considered unlikely to contain a uranium deposit."—*Excerpt from authors' abstract, in part*

The report contains a map showing radioactivity of localities examined and a table showing radioactivity and mineralogic data for localities of high, moderate, and low abnormal radioactivity.

191 Wells, R. L., and Rambosek, A. J., 1954, Uranium occurrences in Wilson Creek area, Gila County, Arizona: U. S. Atomic Energy Comm. RME–2005 (Revised), 17 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The Walnut No. 2, York No. 1, Shepp No. 2, and May No. 2 claims are in the Wilson Creek area 10 miles southeast of Young, Gila County, Ariz. Uranium minerals and radioactivity occur in zones up to several feet in thickness in the upper member of the Dripping Spring quartzite of Precambrian age. Metatorbernite, the only uranium mineral identified, occurs in minute aggregates of crystals in tiny vugs scattered through the quartzite and is intergrown with iron oxide coating fracture surfaces. At the Shepp No. 2 claim uranium is localized in a steeply dipping northeast-trending fracture. The uranium has penetrated the host rock to a maximum of 2 feet on each side of the fracture. The metatorbernite is associated with a minor amount of malachite.

The report includes columnar sections of the Dripping Spring quartzite, a map showing the location of the uranium claims, and geologic sections through the radioactive zones.

192 West, W. S., 1952, Reconnaissance for radioactive deposits in the lower Yukon-Kuskokwim region, Alaska, 1952: U. S. Geol. Survey Circ. 328, 10 p.

Trace amounts of metazeunerite have been identified in vein material from the Konechney prospect in the Russian Mountains. The prospect is on a mineralized zone about 200 feet wide that consists of quartz veins and thin layers of breccia and gouge. The deposit, which is reported to contain copper, gold, and silver, is in a quartz monzonite stock of Tertiary age and in nearly vertical basalt dikes that strike parallel to the trend of the mineralized zone.

A geologic map of the Russian Mountains and several tables showing equivalent uranium analyses of samples from the region are included.

193 West, W. S., and Benson, P. D., 1955, Investigations for radioactive deposits in southeastern Alaska: U. S. Geol. Survey Bull. 1024–B, p. 25–57.

Above-normal radioactivity was detected on the Mountain View property in the Hyder district, southeastern Alaska. The Mountain View property is on the contact between rocks of the Hazelton group, which are chiefly volcanic rocks of probable Jurassic age, and the Texas Creek granodiorite, a batholithic intrusive of probable Jurassic or Cretaceous age. Quartz-sulfide veins cut both the granodiorite and rocks of the Hazelton group. The most radioactive vein sample contained 0.049 percent equivalent uranium. The radioactive material seems to be chiefly uranium in an unidentified highly radioactive opaque mineral and in trace amounts in the sulfides of the vein deposits. Some radioactive material is disseminated in the igneous rocks, and some secondary uranium minerals occur as thin coatings on fracture surfaces in veins and rocks.

194 West, W. S., and White, M. G., 1952, The occurrence of zeunerite at Brooks Mountain, Seward Peninsula, Alaska: U. S. Geol. Survey Circ. 214, 7 p.

Zeunerite occurs near the surface of a granite stock on the southwest flank of Brooks Mountain, Alaska. The largest deposit is at the Foggy Day prospect. Zeunerite is disseminated in hematite which partially or totally fills openings and vugs in a highly oxidized lens-shaped body of pegmatitic granite and, to a minor extent, in openings and cracks in the weathered granite enclosing the lens. Although a few specimens from the pegmatitic lens contain as high as [2.2 percent uranium], the average content of the lens rock is between 0.1 and 0.2 percent equivalent uranium and that of both the lens material and the surrounding zeunerite-bearing granite is about 0.07 percent equivalent uranium. A smaller concentration of zeunerite occurs as surface coatings on a few of the quartz-tourmaline veins that occupy joint fractures in granite on Tourmaline No. 2 claim. The vein material here contains about 0.05 percent equivalent uranium. Zeunerite, in trace amounts, was identified in a sample from a site near Tourmaline No. 2 claim and in two samples from other sites near the Foggy Day prospect. The zeunerite at these three localities is probably related in source to the Tourmaline No. 2 claim and Foggy Day prospect deposits.—*Excerpts from authors' abstract*

A geologic map of the Brooks Mountain area and a table showing the results of analyses of selected samples from the Brooks Mountain area are included.

195 Wilmarth, V. R., 1953, Garo, Colorado, *in* Search for and geology of radioactive deposits—Semiannual progress report for Dec. 1, 1952, to May 31, 1953: U. S. Geol. Survey TEI–330, p. 109–110, issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The uranium-vanadium deposit at the Shirley May mine near Garo, Park County, Colo., is in the Maroon formation of Permian age on the northeast flank of the Garo anticline. Tyuyamunite and carnotite, the principal uranium minerals, are associated with vanadium and copper minerals and occur as disseminations, cementing material, and fracture fillings in three separate medium- to coarse-grained sandstone beds. The gangue minerals are calcite, manganite, and hematite. The average grade of ore produced is 0.16 percent uranium and 0.72 percent V_2O_5. "The localization of ore at the Garo deposit is controlled principally by faulting and the porosity of the sandstones adjacent to the faults."

196 Wilmarth, V. R., 1953, Yellow Canary uranium deposits, Daggett County, Utah: U. S. Geol. Survey Circ. 312, 8 p.

The Yellow Canary uranium deposit is on the west side of Red Creek Canyon in the northern part of the Uinta Mountains, Daggett County, Utah. Two claims have been developed by means of an adit, three opencuts, and several hundred feet of bulldozer trenches. No uranium ore has been produced from this deposit.

The deposit is in the (pre-Cambrian) Red Creek quartzite. This formation is composed of intercalated beds of quartzite, hornblende, garnet schist, staurolite schist, and quartz-mica schist and is intruded by dioritic dikes. A thick unit of highly fractured white quartzite near the top of the formation contains tyuyamunite as coatings on fracture surfaces. The tyuyamunite is associated with carnotite, volborthite, iron oxides, azurite, malachite, brochantite, and hyalite. The uranium and vanadium minerals are probably alteration products of primary minerals.

The uranium content of 15 samples from this property ranged from 0.000 to 0.57 percent.—*Author's abstract*

The report contains a generalized geologic map of the north flank of the Uinta Mountains showing the location of the Yellow Canary No. 1 and No. 2 claims and a geologic map and section of part of the claims.

197 Wilmarth, V. R., Bauer, H. L., Jr., Staatz, M. H., and Wyant, D. G., 1952, Uranium in fluorite deposits, *in* Selected papers on uranium deposits in the United States: U. S. Geol. Survey Circ. 220, p. 13–18.

The association of small quantities of fluorite with uranium minerals in veins has been reported for many localities. Recent studies in Colorado, Utah, Wyoming, and New Mexico further indicate that uranium is a common constituent of many fluorite deposits.

Fluorite deposits known to contain uranium occur in breccia zones, veins, pipes, and bedded replacement deposits. These deposits can be grouped on the basis of essential minerals as (1) fluorite, (2) fluorite-quartz-sulfide, and (3) fluorite-sulfide deposits. The deposits contain pitchblende or other primary uranium minerals, together with such secondary uranium minerals as schroeckingerite, torbernite, autunite, uranophane, carnotite, and sklodowskite.

In some deposits the uranium occurs as fine-grained primary minerals disseminated through the fluorite ore body; in others the uranium is in the fluorite itself in a form not yet identified. Secondary uranium minerals coat fracture surfaces and vugs in both the ore bodies and adjacent wall rocks.

Purple fluorite is commonly associated with radioactive deposits, but because of the many exceptions to this rule it is of limited value.—*Authors' abstract*

Geologic maps of the Fluorine Queen property, Juab County, Utah, the Burlington mine, Jamestown, Colo., and the Thursday property, Juab County, Utah, are included.

198 Wilmarth, V. R., and Johnson, D. H., 1954, Uranophane at Silver Cliff mine near Lusk, Wyoming: U. S. Geol. Survey Bull. 1009–A, p. 1–12.

The uranium deposit at the Silver Cliff mine near Lusk, Wyo., consists primarily of uranophane which occurs as fracture fillings and small replacement pockets in faulted and fractured calcareous sandstone of Cambrian(?) age. The country rock in the vicinity of the mine is schist of pre-Cambrian age intruded by pegmatite dikes and is unconformably overlain by almost horizontal sandstone of Cambrian(?) age.

The mine is on the southern end of the Lusk Dome, a local structure probably related to the Hartville uplift. In the immediate vicinity of the mine, the dome is cut by the Silver Cliff fault, a north-trending high-angle reverse fault about 1,200 feet in length with a stratigraphic throw of 70 feet. Uranophane, metatorbernite, pitchblende, calcite, native silver, native copper, chalcocite, azurite, malachite, chrysocolla, and cuprite have been deposited in fractured sandstone.

The fault was probably mineralized throughout its length, but, because of erosion, the mineralized zone is discontinuous. The principal ore body is about 800 feet long. The width and depth of the mineralized zone are not accurately known but are at least 20 feet and 60 feet, respectively.

The uranium content of material sampled in the mine ranges from 0.001 to 0.23 percent uranium, whereas dump samples range from 0.076 to 3.39 percent uranium.—*Authors' abstract*

Geologic maps and sections of the Silver Cliff mine are included.

199 Wilmarth, V. R., and Vickers, R. C., 1953, The Robinson and Weatherly uraniferous pyrobitumen deposits near Placerville, San Miguel County, Colorado: U. S. Geol. Survey open-file report, 47 p.

Uranium deposits that contain uraniferous pyrobitumen of possible hydrothermal origin occur at the Weatherly and Robinson properties near Placerville, San Miguel County, Colo. These deposits were mined for copper, silver, and gold more than 50 years ago and were developed for uranium in 1950.

The Robinson property, half a mile east of Placerville, consists of the White Spar, New Discovery Lode, and Barbara Jo claims. The rocks in this area are nearly horizontal sandstones, shales, limestones, and conglomerates of the Cutler formation of Permian age and the Dolores formation of Triassic and Jurassic(?) age. These rocks have been faulted extensively and intruded by a Tertiary(?) andesite porphyry dike. Uranium-bearing pyrobitumen associated with tennanite, tetrahedrite, galena, sphalerite, chalcopyrite, bornite, azurite, malachite, calcite, barite, and quartz occurs in a lenticular body as much as 40 feet long and 6 feet wide along a northwest-trending steeply dipping normal fault. The uranium content of eleven samples from the uranium deposit ranges from 0.001 to 0.045 percent uranium and averages about 0.02 percent uranium.

The Weatherly property, about a mile northwest of Placerville, consists of the Black King claims Nos. 1, 4, and 5. The rocks in this area include the complexly faulted Cutler formation of Permian age and the Dolores formation of Triassic and Jurassic(?) age. Uranium-bearing pyrobitumen and uranophane occur along a northwest-trending steeply dipping normal fault and in the sedimentary rocks on the hanging wall of the fault. Lens-shaped deposits in the fault zone are as much as 6 feet long and 2 feet wide and contain as much as 9 percent uranium; whereas channel samples across the fault zone contain from 0.001 to 0.014 percent uranium. Tetrahedrite, chalcopyrite, galena, sphalerite, fuchsite, malachite, azurite, erythrite, bornite, and molybdite in a gangue of pyrite, calcite, barite, and quartz are associated with the uraniferous material. In the sedimentary rocks on the hanging wall, uranium-bearing pyrobitumen occurs in replacement lenses as much as 8 inches wide and 6 feet long and in nodules as much as 6 inches in diameter for approximately 100 feet away from the fault. Pyrite and calcite are closely associated with the uraniferous material in the sedimentary rocks. Samples from the replacement bodies contain from 0.007 to 1.4 percent uranium.—*Authors' abstract*

The report contains geologic maps and sections of the deposits, tables showing stratigraphic sections, and tables showing analyses of samples from the properties.

200 Winterhalder, E. C., 1954, Geologic and radiometric reconnaissance of North Park, Jackson County, Colorado: U. S. Atomic Energy Comm. RME-1008, p. 7-8. (Available for consultation at U. S. Atomic Energy Comm. Depository Libraries.)

Uranium is in a mineralized breccia zone of Tertiary age cutting Precambrian granite at the Pedad prospect in sec. 27, T. 9 N., R. 82 W., on the east side of the Park Range, Jackson County, Colo. The deposit was originally prospected for fluorite. The uranium is associated with black chert, fine-grained pyrite, and dark-purple fluorite. Chip samples from the prospect pit contained 0.14 and 0.34 percent U_3O_8. Anomalous radioactivity has been traced for 600 feet along the breccia zone, and radioactive outcrops were found on parallel breccia zones.

201 Wolfe, H. D., 1953, Preliminary examination of the Hanosh Mines property, Monticello, New Mexico, and reconnaissance of other fluorite properties in Grant, Lincoln, Sierra, and Socorro Counties, New Mexico: U. S. Atomic Energy Comm. RME-1020, 13 p. (Available for consultation in U. S. Atomic Energy Comm. Depository Libraries.)

The Hanosh Mines uranium-bearing fluorite deposit (Terry prospect) is about 2 miles northeast of Monticello, in Sierra County, N. Mex. The mineralization is in brecciated chert that, in part, seems to replace limestone of Paleozoic age. The brecciated chert occurs as a lenticular xenolith in andesitic intrusive rock of Tertiary age. Dark-purple uranium-bearing fluorite and minor amounts of uranophane and gummite are found in the chert breccia in small veins and as interstitial cementing material. The chert-fluorite zone is about 12 feet wide and averages about 0.035 percent U_3O_8 at its greatest width. The zone is at least 50 feet long and tends to narrow and lens out in both directions along the strike. Select samples from the more radioactive parts of the zone contain as much as 0.48 percent U_3O_8.

"Reconnaissance of 29 other fluorite properties in Grant, Lincoln, Sierra, and Socorro Counties disclosed only one additional property with any appreciable radioactivity * * *." This property is the Purple Rock mine in sec. 22, T. 18 S., R. 18 W., near Red Rock, Grant County. The radioactivity is caused by dark-purple fluorite in brecciated veins or lenses cutting granite of Precambrian age. Three samples from the property contained an average of 0.0037 percent U_3O_8.

Uranium-bearing fluorite also has been reported in breccia veins at the Langford and Hines fluorspar deposits in Grant County. These deposits do not contain uranium in commercial quantities.

202 Wright, H. D., 1954, Mineralogy of a uraninite deposit at Caribou, Colorado: Econ. Geology, v. 49, p. 129-174.

At the Caribou mine, near Nederland, Colo., a vein of uraninite-bearing sulfide ore in monzonite is enveloped by an alteration halo up to 4 feet thick. Alteration began with the development of chlorite, calcite, epidote, and pyrite in pyroxene and biotite followed by an argillic phase of montmorillonite and kaolinite formation chiefly in plagioclase and orthoclase, and finally a sericitic and silicic phase strongly developed adjacent to the vein. The zonal arrangement is complicated by a sericitized zone lying outside the argillized zone. The alteration was reflected chemically by strong leaching of lime and soda, increases in potash and silica adjacent to the vein, and little change in magnesia and alumina.

Deposition of vein minerals took place in 2 stages separated by a period of brecciation. In Stage A, quartz, calcite, and siderite were followed successively by pyrite, chalcopyrite, sphalerite, and galena. Uraninite was deposited early in Stage B, following gersdorffite and chalcedony. Sphalerite, chalcopyrite, pyrite, argentite, proustite, and native silver completed the sequence. Uranium leakage from the vein extended to the outer limit of altered wall rock, beyond lead and zinc dissemination. The metals appear to have been transported by ionic diffusion through porous wall rock, and penetration was controlled by the amount of porous rock formed by hydrothermal alteration, rather than by abundance and spacing of fractures.

Uraninite at Caribou has characteristic colloform texture, and a colloidal origin appears probable. Sulfides showing similar forms are believed not to have had a colloidal origin. Measurement of the three best X-ray powder patterns of uraninite gave lattice constant values of 5.368 Å, 5.385 Å, and 5.398 Å. The variation may be due to differences in U^6/ total U ratio in the 3 different specimens—*Author's abstract*

The report includes several diagrams showing variations in density and chemical composition of the different alteration zones along the Radium vein.

203 Wright, H. D., and Emerson, D. O., 1957, Distribution of secondary uranium minerals in the W. Wilson deposit, Boulder batholith, Montana: Econ. Geology, v. 52, p. 36–59.

Weathering of pitchblende in the "siliceous reef" deposit at the W. Wilson mine, near Clancey, Mont., has produced an assemblage of secondary uranium minerals, including meta-autunite, meta-uranocircite, metatorbernite, metazeunerite, uranophane, beta-uranophane, phosphuranylite, gummite, and an unidentified mineral, possibly a complex uranium silicate. The secondary minerals show a distinct zonation about primary uranium concentrations. Variation in composition of the ground-water solutions with depth, together with the differences in solubility of the secondary minerals, may be responsible for the zonation. Vitreous orange and yellow gummite replaced pitchblende directly, and a fine-grained yellow mixture of oxides, silicates, and phosphates of uranium (called gummite in the field) was deposited in the vein and wall rock breccias around the pitchblende. Meta-autunite and some meta-uranocircite were deposited farther out from pitchblende in the intergranular pore spaces of the wall rock. Metatorbernite and metazeunerite tend to be concentrated along fractures at considerable depths below the surface, due, it is thought, to the probable higher concentration of copper in the solutions with increasing depth.

The apparent deposition of the bulk of the uranium secondaries within a short distance from the primary source, pitchblende, appears to indicate that supergene enrichment in the oxidation zone is not important. The sparse distribution of sulfides in the siliceous veins and the apparent lack of other strongly reducing conditions below the water table would seem to render unlikely the possibility of a pitchblende enrichment by reduction of the U^{6+} ion in meteoroic water moving downward below the water table. —*Authors' abstract*

204 Wright, H. D., and Shulhof, W. P., 1957, An investigation of the amount and distribution of uranium in sulfide minerals in vein ore deposits—Annual report for July 1, 1955, to Mar. 31, 1956: U. S. Atomic Energy Comm. RME–3142, 29 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

Material collected from 40 deposits in Idaho, Utah, Arizona, New Mexico, and Colorado was studied to determine uranium content and distribution in galena, sphalerite, pyrite, and chalcopyrite associated with pitchblende in vein deposits.

Uranium determinations were made of 91 sulfide samples from 19 deposits. The uranium content generally ranges from 1 ppm to several hundred parts per million; some samples contain more than 1,000 ppm. Sulfides concentrated from ore in barren parts of uranium-bearing mines generally contain less than 10 ppm uranium. Thus far, the data obtained show a rough correlation between uranium content of the sulfides and radioactivity of the ore at the sampling site. Not enough data are available to compare the level of uranium content in different sulfides occurring together or in a given sulfide from different deposits and districts.

205 Wright, H. D., and Shulhof, W. P., 1957, Mineralogy of the Lone Eagle uranium-bearing mine in the Boulder batholith, Montana: Econ. Geology, v. 52, p. 115–131.

The Long Eagle mine is the only producing uranium deposit among the "base metal" veins in the Boulder batholith, Montana. Steeply dipping fracture fillings in quartz monzonite contain sparsely distributed pitchblende, together with pyrite, sphalerite, galena, and minor chalcopyrite and argentite in a gangue of quartz, calcite and siderite. Deposition of coarsely crystallized quartz and the sulfides was followed by extensive brecciation prior to the introduction of microcrystalline quartz, pitchblende, and minor fine-grained sulfides. The latter assemblage strongly resembles the "siliceous reef" uranium deposits in the batholith. Of the three varieties of pitchblende recognized, only one appears to represent primary introduction of uranium. Detailed data were obtained on the pitchblende varieties and an unusual, fine-grained galena associated with pitchblende.

Study of the wall rock provided detailed information on the nature and composition of the feldspars, the percentage mineral composition and texture of the rock, and its chemical composition. The rock may be classified petrographically as a peraluminous granodiorite (Shand) or an adamellite (Johannsen).

The alteration halo, extending as much as 30 feet from the vein, has a mineral assemblage—sericite, kaolinite, montmorillonite, chlorite, quartz, calcite, siderite, and pyrite—similar to that associated with the "siliceous reefs" and to the Butte alteration decsribed by Sales and Meyer. Of the plutonic minerals, only quartz, apatite, and zircon are found adjacent to the vein. Study of the alteration zoning was inhibited by the lack of adequate samples more than a few feet from the vein.—*Authors' abstract*

206 Wright, R. J., 1950, Current status of atomic raw materials, Part 2: Earth Science Digest, v. 5, no. 1, p. 3–8.

This paper briefly summarizes the similar features in the geologic environment of the few major vein deposits of the world from which pitchblende-bearing ore has been produced. These features are—

(1) A large proportion of the deposits are in Precambrian sedimentary rocks or their metamorphic equivalents.

(2) Ores are generally complex mineralogically, and cobalt, nickel, and silver minerals are commonly associated with the pitchblende.

(3) Gangue minerals of the veins are primarily carbonates and quartz.

(4) Mineralization appears to have occurred in the medium- to high-temperature range.

(5) The veins commonly form in tension fractures.

(6) Associated igneous rocks are primarily granitic.

(7) Hematitic alteration of the wallrock and (or) the gangue minerals is common.

The use of some of these geologic features to guide prospecting has resulted in the discovery of pitchblende-bearing veins at several mines in the Western United States, including the Caribou mine in Colorado and the Couer d'Alene and Sunshine mines in the Couer d'Alene district, Idaho.

207 Wright, R. J., 1950, Reconnaissance of certain uranium deposits in Arizona: U. S. Atomic Energy Comm. RMO–679, 19 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

This report presents the results of investigation of 17 uranium-bearing mineral deposits in Arizona. The deposits are grouped and discussed under four types: (a) vein deposits with associated base and precious metals; (b) vein deposits in granite which contain only minor metallic minerals; (c) deposits in sedimentary rocks near intrusive contacts; (d) deposits in broad shear zones in volcanic rocks.

Deposits in type (a) include the Hillside, Papago Chief, Jim Kane, and Iris Mines and the St. Joe and "Spelbrink" claims. These deposits are mesothermal veins containing mixed sulfide ores of copper, lead, and rarely zinc, and commonly containing trace amounts of gold and silver. The host rocks of 5 of the 7 deposits in this group are volcanic rocks. The other 2 deposits are in schist and gneiss of Precambrian age. The examination of most of these deposits was limited to near-surface outcrops which contained only secondary uranium minerals. Pitchblende was identified in samples from the Hillside and Jim Kane mines. In general, the uranium seems to be most closely associated with copper minerals.

Deposits of type (*b*) include the Big Ledge, Glen, Lena, and the "R. F. Howard" claims. The radioactivity in some of these deposits seems to be associated with iron oxides and red jasper.

Deposits of type (*c*) include the Red Bluff claims in Gila County. At this deposit, uranophane, metatorbernite, and other secondary uranium minerals coat fractures in, and are intimately distributed through, siltstone of the Dripping Spring quartzite of Precambrian age. Radioactivity in the siltstone seems to decrease away from a steeply dipping diabase dike, which has been emplaced along a fault. Two other deposits of this type, the Black Dike prospect and the Valley View claim, are briefly described.

Deposits of type (*d*) include the Annie Laurie deposit and the Golondrina claim. The Annie Laurie deposit contains pitchblende in sheared and strongly silicified rhyolite. At the Golondrina claim uranium-bearing pyromorphite is associated with secondary lead and copper minerals on fracture surfaces in a sheared zone in volcanic flow rock.

The report includes a geologic map of Santa Cruz County and southern Pima County and tables listing the location and analyses of samples for deposits examined as well as other deposits reported to the author.

208 Wright, R. J., 1951, Annie Laurie prospect, Santa Cruz County, Arizona: U. S. Atomic Energy Comm. RMO–677, 8 p., issued by U. S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

The Annie Laurie uranium prospect is 3 miles south of Ruby, in the Oro Blanco district of southern Arizona. The uranium is in lens-shaped zones of pitchblende several inches long and less than 1 inch thick. The deposits are in a strongly silicified porphyritic andesite flow rock that overlies limestone, shale, and conglomerate. The rocks are nearly horizontal and all probably are of Tertiary age. The pitchblende zones are dark gray and are bordered by red zones of hematite alteration. Several bright-yellow secondary uranium minerals including metatorbernite and uranophane are within a few feet of the surface. The near-surface occurrence of pitchblende, within 6 feet of the surface at one place, may be related to the intense silicification of the rock which has made it resistant to weathering. The silicified host rock is brecciated and recemented by veinlets up to several inches wide containing minor fluorite, pyrite, sphalerite, galena, and chalcopyrite in a gangue of carbonate minerals. Pitchblende was not seen in these veinlets. The results of sampling and a radiometric survey of the area suggest the extent of the pitchblende-bearing rock is narrowly limited. Selected grab samples have contained as much as 0.79 percent U_3O_8.

The report includes an isorad map of the prospect and the immediate vicinity outlining the areas of abnormal radioactivity.

209 Wyant, D. G., 1954, The East Slope No. 2 uranium prospect, Piute County, Utah: U. S. Geol. Survey Circ. 322, 6 p.

The secondary uranium minerals autunite, metatorbernite, uranophane(?), and schroeckingerite occur in altered hornfels at the East Slope No. 2 uranium prospect. The deposit, in sec. 6, T. 27 S., R. 3 W., Piute County, Utah, is about 1 mile west of the Bullion Monarch mine which is in the central producing area of the Marysvale uranium district.

Hornfels, formed by contact metamorphism of rocks of the Bullion Canyon volcanics bordering the margin of a quartz monzonite stock, is in fault contact with the later Mount Belknap rhyolite. The hornfels was intensely altered by hydrothermal solutions in pre-Mount Belknap time. Hematite-alunite-quartz-kaolinite rock, the most completely altered hornfels, is surrounded by orange to white argillized hornfels containing beidellite-montmorillonite clay, and secondary uranium minerals. The secondary uranium minerals probably have been derived from pitchblende, the primary ore mineral in other deposits of the Marysvale area.

The two uranium-rich zones, 4 feet and 5 feet thick, have been traced on the surface for 60 feet and 110 feet, respectively. Channel samples from these zones contained as much as 0.047 percent uranium.

The deposit is significant because of its position outside the central producing area and because of the association of uranium minerals with alunitic rock in hydrothermally altered hornfels of volcanic rocks of early Tertiary age.—*Author's abstract*

Geologic maps and cross sections are included. Tables show the results of radiometric and chemical analyses of samples from the prospect and spectrographic analyses of samples from alteration zones in the deposit.

210 Wyant, D. G., and Stugard, Frederick, Jr., 1951, Indian Creek uranium prospects, Beaver County, Utah: U. S. Geol. Survey open-file report, 7 p.

Metatorbernite(?) and autunite(?) are sparsely disseminated in an argillized and silicified zone in the Bullion Canyon latite of Tertiary age at Indian Creek, 20 miles west of Marysvale, in Beaver County, Utah. The deposits are on the Sniffer and Mystery groups of claims about one-quarter mile east of a large stock of quartz monzonite of Tertiary age. The deposits are in a landslide area where exposures are scarce and the trend of the alteration and accompanying uranium minerals cannot be definitely established. The altered zone appears to trend approximately east-west and is at least 1,000 feet long and 300 feet wide. The altered zone is cut by many veinlets and irregular blebs of purple fluorite. The geologic setting of the deposits is similar to some in the Marysvale district.

The report contains a geologic map and section of the deposits.

211 Anonymous, 1957, Eastern uranium mine prepares to ship product: Eng. Mining Jour., v. 158, no. 6, p. 81.

The Ramapo Uranium Corp. is mining uranium and iron ore from magnetite veins in some old iron mines near Warwick, N. Y. The original uranium discovery was made at the Miles Standish mine. The magnetite veins, in granitic rock, contain uraninite associated with pyrite on the footwall side of the veins. Three nearly parallel radioactive zones are in an area 2½ miles long by 1 mile wide. The uranium-bearing magnetite reportedly contains from 0.05 to 0.15 percent U_3O_8; 25,000 tons of ore has been proven. Pockets of ore are reported to contain as much as 1 percent U_3O_8.

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