Geology and Mineralogy

This document consists of 27 pages,
Series A

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

# URANIUM DEPOSITS OF THE NORTHERN PART OF THE BOULDER BATHOLITH, MONTANA*

By

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September 1955

Trace Elements Memorandum Report 944

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*This report concerns work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

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# URANIUM DEPOSITS OF THE NORTHERN PART OF THE BOULDER BATHOLITH, MONTANA

By George E. Becraft

## ABSTRACT

Uranium minerals and radioactivity anomalies occur in many silver-lead veins and chalcedony veins and vein zones in the Boulder batholith of southwestern Montana. Pitchblende has been identified in a few silver-lead veins. These veins occupy shear zones along which there is no evidence of large-scale lateral displacement. The wall rock adjacent to the veins is intensely silicified and sericitized quartz monzonite and granodiorite. 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 a gangue of light to dark gray quartz, altered rock, gouge, and subordinate chalcedony and carbonate minerals. No anomalous radioactivity nor uranium minerals have been found in similar veins in pre-batholithic rocks of the area.

Chalcedony veins and vein zones, 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 chalcedony vein zones consist of one or more discontinuous stringers or veins of chalcedony and microcrystalline 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 and vein zones.

All of the veins are early Tertiary in age, but the silver-lead veins probably are older than the chalcedony veins. Uranium is closely associated with chalcedony and microcrystalline quartz 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.

## INTRODUCTION

The Boulder batholith in western Montana extends from a few miles south of Helena to about 20 miles south of Butte. The "northern part of the batholith," as used in this report (fig. 1), includes most of the batholith north of the latitude of Boulder and a narrow strip near the east margin of the batholith south of Boulder. This area lies between the Elkhorn mountains on the east and the rather broad, high-level surface making up the Continental Divide on the west. Although the area is mountainous, the topography is not rugged and is characterized by smoothly rounded ridges commonly about 1,000 feet above the major valleys. Most of the higher valleys were occupied by glaciers in the Pleistocene epoch, but typical alpine cirques are rare.

Early in the spring of 1949 uranium minerals were discovered in the veins in the batholith near Boulder, Mont. This discovery led to additional discoveries near Clancy later that summer. Subsequently, more than 100 radioactivity anomalies have been detected by prospectors and by geologists of the U. S. Atomic Energy Commission and the U. S. Geological Survey.

Detailed geologic mapping of the northern part of the batholith was begun by the U. S. Geological Survey in 1950 on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission. The study of the

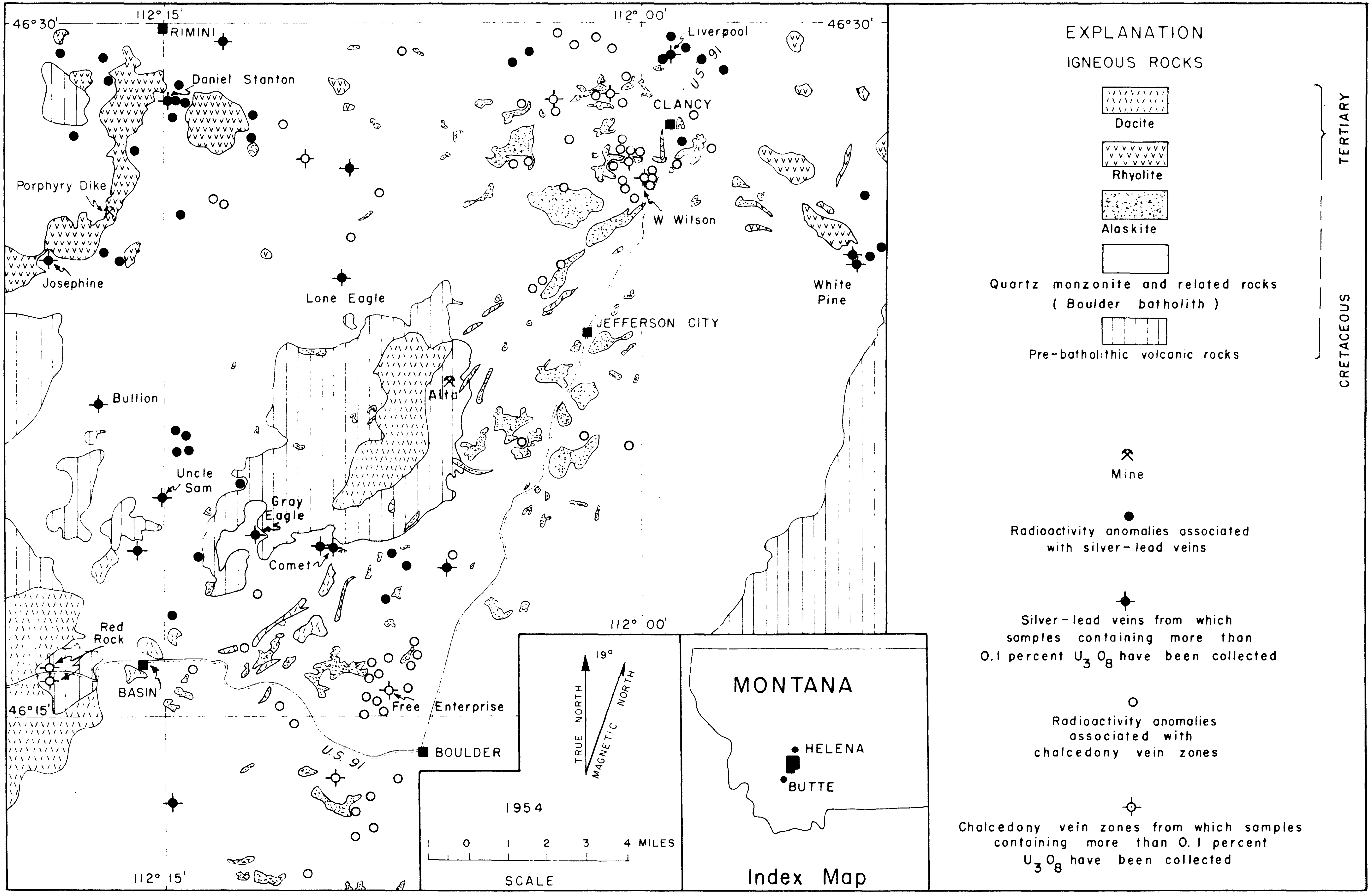



Fig I. Generalized geologic map of the northern part of the Boulder batholith, Montana, showing uranium deposits and radioactivity anomalies uranium deposits has been made an integral part of the U. S. Geological Survey's study of the geology and mineral deposits in the area south of Helena and north of Butte between the Townsend Valley about 30 miles east of Boulder and the Deer Lodge Valley about 30 miles west of Boulder.

The author is indebted to the geologists of the U. S. Geological Survey who have mapped in the area and have made their information available to him for this report, and particularly to Darrell M. Pinckney, Samuel Rosenblum, and Daniel Y. Meschter for their aid in the study of the uranium deposits. The writer also appreciates the kind cooperation of all the mine owners in the area.

## GENERAL GEOLOGY

### General statement

Previous geologic work in this area has been of a reconnaissance nature in connection with studies of the mineral deposits in and near the Boulder batholith. The most complete studies are by Knopf (1913), Billingsley and Grimes (1918), and Pardee and Schrader (1933). Only a brief summary of the geology is included here.

The principal rocks of the area are quartz monzonite and granodiorite of the Boulder batholith. These rocks, with a few notable exceptions, do not have a great range in mineralogic or chemical composition, but they have a considerable range in texture and fabric. In the detailed mapping the batholith was divided into 23 units based principally on the textural differences apparent in hand specimens.

The rocks of the batholith cut sedimentary rocks ranging from Pre-cambrian to Mesozoic in age near the northern margin of the batholith and Cretaceous volcanic rocks elsewhere. The volcanic rocks comprise fine- and coarse-grained fragmental rocks, mainly of the andesitic composition, tuff flows (Fenner, 1948) of quartz latitic composition, and subordinate lava flows. Associated with the volcanic rocks are numerous diorite porphyry intrusive bodies. The distribution of the pre-batholithic volcanic rocks suggests that only the upper part of the batholith has been uncovered within the area.

The batholitic rocks and locally the older volcanic rocks near the margin of the batholith have been intruded by silicic rocks--including aplite, alaskite, alaskite-porphyry, and pegmatite--all designated as alaskite on figure 1. The silicic rocks occur principally as dikes, but gently dipping sheets are common and a few large bodies of irregular shape have been recognized. Gradations between two or more of the above types are common in a single outcrop. Most of the alaskite is confined to a moderately well-defined, northeastward-trending zone that approximately parallels the eastern boundary of the batholith.

The youngest consolidated rocks in the area are rhyolite and dacite. The rhyolite in the western part of the area occurs almost exclusively as flows, remnants of which now cap mountains and ridge crests whereas most of the small rhyolite bodies shown in the northeastern part of figure 1 are plugs of dikes. The dacite occurs as tuff beds and dikes. Almost all of the dikes are in a northeastward-trending zone somewhat better defined than the zone of alaskite intrusions (fig. 1). The large area of dacite near the center of the map area consists mainly of tuff and other fragmental rocks and is cut by many small dacite dikes. Most of the dacite tuff in the area occurs as valley-fill or as remnants on valley walls. The surfaces on which the dacite tuffs and rhyolite flows rest indicate that extensive erosion took place between the intrusion of the batholith and the extrusion of the volcanic rocks.

There is no direct evidence of the relative ages of the dacite and rhyolite because the two rocks have not been observed in contact, but geomorphic evidence suggests that the rhyolite may be older than the dacite. In the map area the rhyolite, which appears to be more resistant to erosion than the rather poorly consolidated dacite tuff, caps ridge crests and appears to have been deposited on a surface of relatively low relief. The dacite tuff appears to have accumulated in the valleys at a somewhat later stage of erosion.

## Structural features

Detailed mapping in the batholith has shown strong northeast- and east-trending structures. Several gross features of the area, such as the long dimension of the batholith, the zone of alaskite intrusions, the belt of dacite dikes, and many of the larger stream valleys, are oriented N. 20° E. to N. 30° E. Numerous veins, shear zones[1], and faults fall into two dominant sets--a generally east-trending set, and a N. 60° E.-trending set, both of which dip steeply. Almost all of the shear zones, which locally contain silver-lead veins, are east-trending. These zones are as much as 200 feet wide, but there is no evidence of large-scale

[1] Shear zone is used in this report in a purely descriptive sense to mean a zone of closely spaced surfaces on which one wall has moved relative to the other producing slabs or slivers of rock.

lateral displacement. Many faults in the vicinity of Clancy and Boulder are occupied by chalcedony veins. These veins near Boulder and west of Clancy have a predominantly N. 60° E. trend; those east of Clancy have a predominantly east trend. A few north-trending structures can be observed on the aerial photographs and topographic maps of the area.

Numerous faults of diverse trends have been observed in mines in the area, but few can be traced on the surface because of lack of key rock units.

## Mineral deposits

The mineral deposits in the northern part of the batholith are probably of at least three different ages. The oldest deposits, which include all of the deposits that have yielded substantial amounts of metals, occur in the east-trending shear zones and are common in the batholith and in the pre-batholithic volcanic rocks. These are principally silver-lead deposits, but some contain important amounts of gold and zinc and minor amounts of copper. Typical examples of this type of deposit are the Alta and Comet mines. The most productive mine in the area, the Alta, reported to have produced about $32,000,000 in silver and lead, is a few miles west of Jefferson City (fig. 1) in a roof pendant of pre-batholithic volcanic rocks. The volcanic rocks have been intensely altered and sheared along a well-defined zone. The ore, in distinct veins and in replacement bodies, consists principally of galena, pyrite, tetrahedrite, and minor sphalerite. Above the water table, the ore bodies have been almost completely oxidized. Ore bodies of like type at the Comet mine, a few miles southwest of the Alta, occur on a similar structure that cuts quartz monzonite of the batholith. In this report, silver-bearing veins near Clancy are included with the older silver-lead deposits.

From the approximate latitude of Basin (fig. 1) to the northern margin of the batholith, veins similar to the Comet and Alta are common; south of Basin, however, veins of this type are relatively few and unimportant.

Dacite dikes cut several of the base metal veins and dacite tuffs and rhyolite flows rest on erosional surfaces developed after the formation of the veins.

A distinctly different and probably younger type of deposit are the chalcedony veins and vein zones that locally contain a little silver but no important concentrations of base metals. The vein zones consist of one or more discontinuous stringers and veins of chalcedony and microcrystalline quartz in altered quartz monzonite and granodiorite and in alaskites that have not been strongly altered. The zones have been repeatedly brecciated and silicified along predominantly northeast-trending, steeply dipping faults. Crosscutting relations of several chalcedony and microcrystalline quartz veinlets in a few vein zones indicate as many as four distinct periods of brecciation and silicification.

All of the chalcedony vein zones are younger than the alaskite and most of them are older than the dacite. Dacite dikes cutting the vein zones are relatively common, but in a few locations chalcedony vein zones cut dacite dikes. Crosscutting relations at one location suggest that a dacite dike was intruded during the formation of a chalcedony vein zone.

The dike appears to cut the early microcrystalline quartz and later dark-gray to black chalcedony and in turn is cut by a small light-gray chalcedony veinlet that may represent the final phase of silicification in the formation of the chalcedony vein zone. These relations suggest that the formation of the chalcedony veins and vein zones took place over a considerable period of time.

The chalcedony vein zones are localized in two distinct areas of several square miles each, one near Clancy and one near Boulder, and are relatively rare throughout the remainder of the northern part of the batholith.

The youngest mineral deposits in the northern part of the batholith are small deposits of gold in Tertiary rhyolite near Rimini. The rhyolite is intensely altered and cut by many small quartz veinlets. The gold is disseminated throughout the rhyolite and concentrated in limonite-filled fractures. The largest mine in deposits of this type is the Porphyry Dike mine, about 5 miles southwest of Rimini, which has been operated sporadically for many years, but is inacessible at present.

## URANIUM DEPOSITS

### General statement

Radioactivity anomalies have been detected at many places in the northern half of the batholith, but very few occurrences have been found elsewhere in or around the batholith. One significant exception is a small uranium deposit associated with a chalcedony vein zone a few miles west of Butte. In the Butte district only very slight radioactivity and traces of pitchblende have been detected at random throughout the extensive mine workings, although the production of other metals from the Butte district far exceeds the total production from all the other districts in the batholith.

All but two of the known radioactivity anomalies are in the rocks of the batholith. These two are in pre-batholithic volcanic rocks at the Red Rock mine, and at the Monarch mine about 9 miles southwest of Rimini (not shown on fig. 1). At the Monarch mine the uranium appears to be restricted to a very small area along a fault surface and its relation to the other mineral deposits in the mine is not known (L. D. Jarrard, oral communication, 1954).

Uranium minerals and anomalous radioactivity have been found in and adjacent to the silver-lead deposits and in the chalcedony veins and vein zones. No structural nor mineralogical differences were noted between the silver-lead deposits in the batholith and those in the pre-batholithic volcanic rocks except that uranium minerals have been found only in the deposits in the batholith.

## Uranium associated with silver-lead veins

Radioactivity anomalies associated with silver-lead deposits in the rocks of the batholith are common north of the approximate latitude of Basin and rare south of Basin (fig. 1). Most of the mines are inacessible at present, and with few exceptions the only information concerning the relations between uranium and the other metals is obtained from study of ore specimens from dumps.

## Comet mine

The Comet mine is in the Comet-Gray Eagle shear zone in quartz monzonite near the roof of the batholith. The shear zone, which dips steeply and trends about N. 80° W., has been traced for a distance of about 6 miles. Displacement along it apparently has been slight. The shear zone cuts intensely altered pre-batholithic volcanic rocks and quartz monzonite and slightly altered alaskitic rocks; several dacite dikes cut the zone and are not sheared nor altered. Several silver-lead mines, of which the Comet is the largest, are situated along the zone. Radioactivity has been detected on the dumps of five of these mines, but Geiger counter and scintillation counter traverses along the entire length of the zone failed to disclose any radioactivity anomalies along the trace of the outcrop. This may be the result of thick cover and thorough leaching of the uranium from the zone near the surface.

The total value of silver, lead, zinc, gold, and copper produced from the Comet mine is reported to have exceeded $20,000,000. The mine was last worked from 1934 to 1941; during this time the production was about $3,000,000 from ore that ranged in value from $7 to $10 per ton in combined silver, lead, zinc, gold, and copper (Becraft, 1953).

The Comet vein has been developed to a depth of 960 feet by a vertical shaft and for a strike length of 2,200 feet by eight principal levels. None of the workings were accessible at the time the field work was done on which this report is based. No ore was mined from below the 700 level, and most of the production came from above the 500 level. Three principal veins that follow the trend of the shear zone and dip steeply to the south, and several splits from these veins were explored.

Ore minerals identified in dump samples are galena, sphalerite, pyrite, tetrahedrite, chalcopyrite, and arsenopyrite. The gangue is chiefly altered wall rock and quartz; some of the quartz is a clear crystalline variety and some a dark bluish-gray, fine-grained variety. The wall rock is dominantly quartz monzonite and subordinately alaskite. Adjacent to the vein, the quartz monzonite has been strongly silicified, sericitized, and argillized.

Moderate to high radioactivity has been detected at several places on the dump, and samples containing as much as 0.52 percent uranium have been collected; but no uranium minerals have been identified from these samples. The amount of uranium in the samples is considered significant because the dump material has been exposed to weathering for at least 10 years and possibly 35 years or more, and much of the uranium may have been leached by surface waters.

## Gray Eagle mine

The Gray Eagle mine is on the Comet-Gray Eagle shear zone about 1½ miles west of the Comet mine. Knopf (1913, p. 121) and Pardee and Schrader (1933, p. 287-289) described the mine. It was last operated in 1937 and was inacessible at the time the field work was done on which this report is based. The value of silver, lead, zinc, gold, and copper produced is estimated to be about $1,000,000. The mineralogy of the vein and wall rock is similar to that at the Comet mine.

Radioactivity at the mine, first reported by geologists of the U. S. Atomic Energy Commission in June 1951, is largely confined to one part of the dump, part of which has been shipped to the East Helena smelter for the silver content. Several strongly radioactive samples have been collected from the dump. A sample of weathered vein material that contained quartz, pyrite, a sooty black mineral, and a soft yellow mineral assayed 2.2 percent uranium. The sooty mineral is probably pitchblende for an X-ray powder picture of the sooty black mineral showed a very poor, possibly cubic pattern, and after ignition an X-ray powder pattern of the same mineral matched the standard $U_3O_8$ pattern. Spectroscopic analysis of a sample of the material showed major iron and silicon, and minor uranium, calcium, magnesium, aluminum, and manganese, and a trace of zirconium. This material unquestionably contains secondary uranium minerals, but they could not be identified specifically. A sooty black mineral intimately intermixed with pyrite was separated from gray crystalline quartz and identified as uraninite. Wright and Bieler (1953, p. 22) state that uraninite has extensively replaced pyrite.

### Other silver-lead mines

Radioactivity has been detected and selected samples that contain more than 0.1 percent $U_3O_8$ have been collected from the dumps of many other silver-lead mines in the batholith rocks. Among these are the Josephine, Daniel Stanton, Liverpool, Bullion, Uncle Sam, White Pine, and several unnamed properties (fig. 1).

## Uranium deposits associated with chalcedony vein zones

Many radioactivity anomalies have been detected in and adjacent to chalcedony vein zones in the batholith. Uranium ore has been produced from two mines in these zones; the Free Enterprise mine has produced a few tons of high-grade ore and about 150 tons of low-grade ore (Pardee and Schrader, 1933, p. 147) and the W Wilson mine has produced several hundred tons of moderately high-grade ore.

In the two areas where chalcedony vein zones are common-near the Free Enterprise mine and in the vicinity of Clancy--the topography is characterized by rounded hills commonly only a few hundred feet above the valley bottom. The vein zones, ranging from less than 1 foot to more than 10 feet in thickness crop out conspicuously, and some can be traced for more than a thousand feet.

W Wilson mine

The W Wilson mine is about 1½ miles southwest of Clancy. Uranium minerals were first discovered along the outcrop of the vein zone in 1949, and the geology of a few square miles in the vicinity of the mine was mapped in 1950 by Roberts and Gude (1953). Subsequently, detailed studies of the mine were made by D. Y. Meschter and by Wright and others (1954). Most of the following information is summarized from the reports of these workers.

The W Wilson vein has been explored by more than 3,000 feet of drifts, crosscuts, and raises. Uranium ore has been mined from two ore bodies along the main vein and from one small ore body along a smaller vein parallel to the main vein.

The dominant rock type in the vicinity of the mine is quartz monzonite with an approximate composition of 45 percent plagioclase (An 30-35), 25 percent potash feldspar, 20 percent quartz, 7 percent biotite, and 3 percent hornblende. The quartz monzonite is cut by a few thin dikes of alaskite.

Adjacent to each chalcedony vein, the quartz monzonite is typically altered in poorly defined gradational zones of decreasing intensity outward from the vein. The innermost zone immediately adjacent to the vein is characterized by silicification; sericitization characterized an intermediate zone and beyond that lies a zone of kaolinization. This alteration is similar to that accompanying the silver-lead veins and non-uraniferous chalcedony veins, and no particular feature of the alteration was recognized as specifically diagnostic of or peculiar to the uranium mineralization.

The W Wilson vein zone consists of from 1 to 5 veins of chalcedony and microcrystalline quartz, locally as much as 3 feet thick but averaging only a few inches. The interlacing of individual veinlets of quartz and chalcedony along the strike and dip of the vein has resulted in a pattern that resembles crude netting. The chalcedony in the vein zone is characteristically dark gray to black, but locally chalcedony of lighter shades of gray is present. At least three, and possibly four, generations of silica and at least three periods of brecciation during formation of the vein zone are indicated.

Uranium minerals were first discovered at the W Wilson mine in two ore bodies that contained sparse nodules and veinlets of pitchblende and relatively abundant yellow and orange secondary uranium minerals: uranophane, phosphuranylite, uranocircite, meta-autunite, and a mixture of oxides referred to as gummite. A few secondary minerals, mainly metatorbernite, meta-autunite, and uranophane, are sparsely distributed along and adjacent to fractures outside of the ore bodies indicating the transportation and redeposition of some of the uranium by meteoric water.

The two very irregular, lenslike ore bodies ranged from less than 1 foot to 5 feet in thickness and were as much as 50 feet in length. The ore bodies plunged steeply to the northeast and were separated laterally by about 10 feet of altered quartz monzonite. One extended to a depth of about 30 feet and the other to a depth of about 70 feet.

D. Y. Meschter (personal communication, 1953) stated that at least three periods of silicification in the W Wilson mine can be recognized. The first period consists of clear microcrystalline quartz, the second of black and dark gray chalcedony, and the third of clear microcrystalline quartz. He concluded that pyrite, chalcopyrite, and pitchblende are essentially contemporaneous with the dark gray to black chalcedony.

Wright and others (1954, p. 5) state: "Autoradiographs have shown that the most recent of the several varieties of vein chalcedony is usually the most radioactive; this material is generally found in veinlets and in the cementing material enclosing breccia fragments. Almost all of the late, radioactive silica is dark gray or black. Semiquantitative spectroscopic analyses and radiometric counts of carefully micropicked fractions of the various chalcedony color varieties have shown a tendency for Ag, As, Co, Cu, Mn, Mo, Ni, Pb, and Sn to be concentrated in the dark gray and black colors, along with uranium. Cobalt, nickel, silver, and copper, common associates of uranium in vein deposits, generally vary with uranium."

Because galena and sphalerite have been found only in trace amounts in the W Wilson vein, the relations between these minerals and the uranium minerals are not known.

## Red Rock mine

One of the two known occurrences of uranium minerals in the pre-batholithic volcanic rocks is at the Red Rock mine about 1½ miles west of Basin. The batholith is exposed about 3,000 feet northeast of the mine but may underlie the volcanic rocks at the mine at a relatively shallow depth.

The Red Rock vein consists of light gray chalcedony in intensely silicified, sericitized, and brecciated volcanic rocks. The entire altered zone is about 300 feet wide and forms a conspicuous northeasterly trending ridge for several thousand feet on each side of U. S. Highway 91. A conspicuous outcrop along this zone on the north side of the highway is locally called Indian Head Rock. The Red Rock vein differs from the typical chalcedony vein zone of the batholith in that it is a single vein of chalcedony with gradational margins rather than a series of anastomosing veinlets with sharp boundaries.

The vein ranges from less than 1 foot to about 4 feet in thickness. It is exposed in two adits--one north of the highway and one south of the highway--along a well-defined fault surface that shows evidence of post-mineralization movement. The wall rock adjacent to the vein has been almost entirely replaced by chalcedony and fine-grained, disseminated pyrite. Within the vein, sharply angular fragments of the altered wall rock are cemented by a reddish-gray chalcedony that contains no pyrite. The final phase of silicification is represented by microcrystalline quartz in small veinlets and lining vugs.

Although no primary uranium minerals have been identified from the Red Rock vein, finely disseminated pitchblende is probably present in the reddish-gray chalcedony. Locally, meta-autunite has been deposited in fractures in the vein and adjacent wall rock from circulating meteoric water.

## Uranium associated with veins of mixed type

Uranium minerals and radioactive anomalies have been found in and adjacent to a few veins that have some characteristics of both the silver-lead veins and the chalcedony veins and vein zones. They contain abundant amounts of lead and silver minerals and small amounts of sphalerite in a gangue that is predominantly microcrystalline quartz and chalcedony. The mineral assemblage of these veins suggest that they were formed either during an intermediate period of mineralization or during both of the periods described above. The vein in the Lone Eagle mine is an example of a vein of mixed type.

### Lone Eagle mine

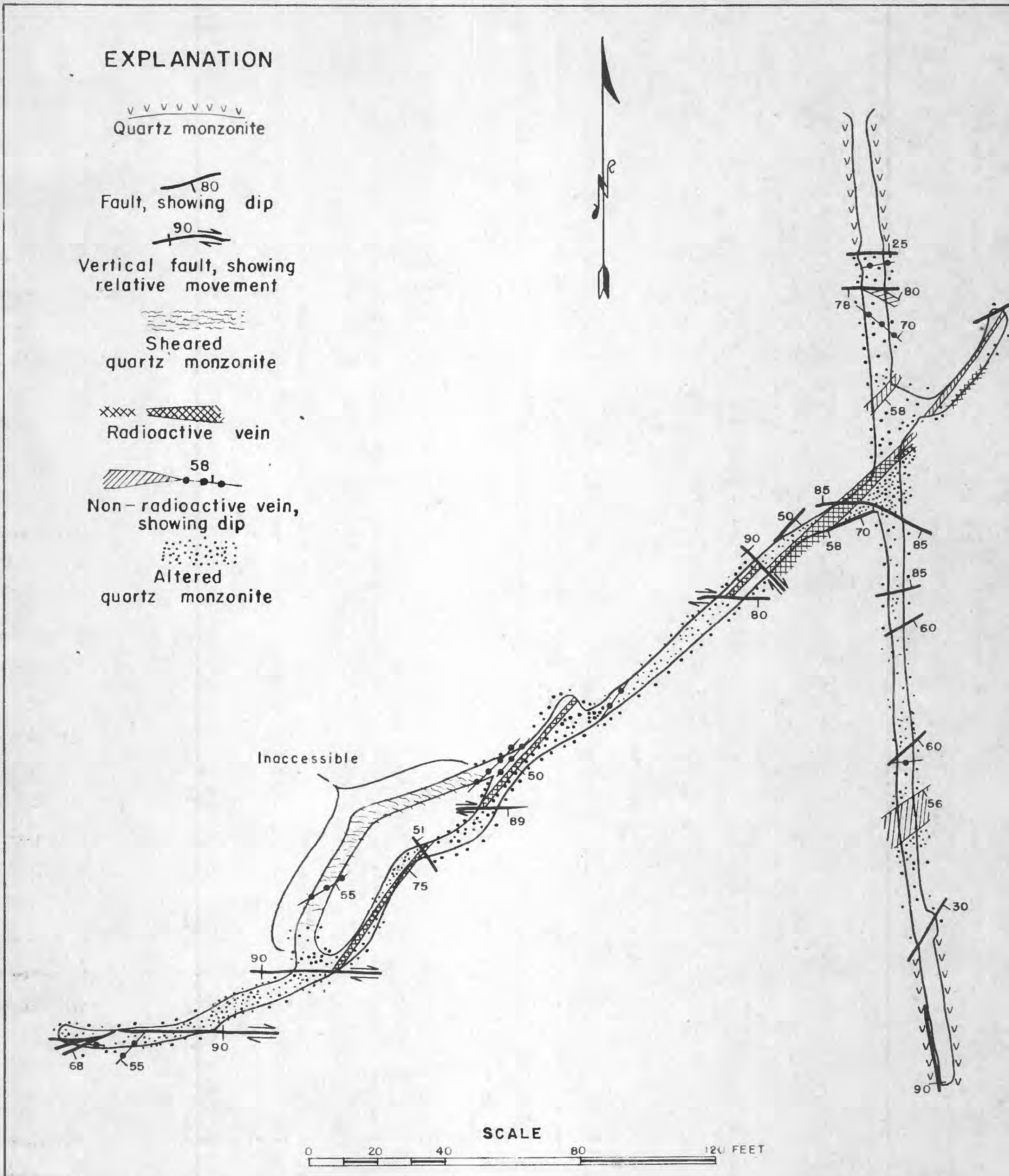
The Lone Eagle mine is on the South Fork of Quartz Creek about 9 miles southwest of Clancy (fig. 1). The area, although mountainous, is of moderate relief, and altitudes range from 5,000 to 7,500 feet. The vein crops out at only one point, and because the hill above the mine is covered by a thick mantle of soil and a heavy growth of conifers, it cannot be traced on the surface.

The vein is in intensely altered quartz monzonite in which biotite is altered to chlorite and the feldspars are altered to a light gray to greenish-gray mixture of clay and sericite. Silicified zones of quartz monzonite adjacent to the quartz veins and veinlets range in thickness from less than an inch adjacent to the small quartz veinlets to several feet adjacent to the large radioactive vein about 110 feet from the mine portal (fig. 2). Faulting and shearing are common throughout most of the mine.

The radioactive vein strikes about N. 45° E., dips from about 50° to 75° SE., and ranges from 1 to 5 feet in thickness. It is cut by several east-trending, steeply dipping faults, and in each case the vein on the south side of the fault is offset to the west.

The Lone Eagle vein consists principally of light gray to black microcrystalline quartz and chalcedony. Pyrite is common in the vein and in the altered wall rock adjacent to the vein. Veinlets of fine-grained pyrite cutting pyrite cubes indicate that at least two generations of pyrite are present in the vein. Sphalerite and galena are present locally along the vein. Uranium is present in two forms: as small irregular blebs of pitchblende in the vein and as a sooty black material coating irregular fractures in the vein and in the altered wall rock adjacent to the vein.

Wright and others (1954, p. 67) state that pitchblende has extensively replaced pyrite and in some places has replaced chalcedony and sphalerite that filled fractures in pyrite. They also observed a second generation of sphalerite and pyrite in veinlets cutting the pitchblende and conclude that the paragenetic "...sequence appears to have been as follows:




Geology by G. E. Becraft

Fig. 2. Geologic map of the Lone Eagle mine, Jefferson County, Montana

(1) Microcrystalline quartz which continued throughout the deposition.

(2) Well formed pyrite.

(3) Sphalerite with chalcopyrite, galena, and finely crystallized pyrite.

(4) Pitchblende and cryptocrystalline chalcedony with minor pyrite.

(5) Sphalerite and galena with cryptocrystalline chalcedony and minor pyrite.

(6) Argentite (?)"

## Age of the uranium deposits

All of the known uranium deposits are post-alaskite and pre-dacite. Data obtained by measuring the lead-alpha activity ratio in zircon suggest an age of about 60,000,000 years for the alaskite (Chapman and others, 1955) --Late Cretaceous or early Paleocene. Weed (1912) reports that dacite tuffs at the south end of the Deer Lodge Valley are contemporaneous with Miocene lake beds, but in the Townsend Valley quart-bearing tuffs in a similar setting are early Oligocene in age (Pardee, 1925, p. 27). These two observations indicate that the dacite may be either Miocene or Oligocene in age.

In the chalcedony vein zones the uranium was deposited with the dark gray to black chalcedony, which was deposited late in the formation of the vein zones but prior to the intrusion of the dacite. In the silver-lead veins also, the uranium appears to be intimately associated with dark gray to black chalcedony or microcrystalline quartz. In several of the silver-lead veins, the chalcedony cuts quartz veins containing galena and sphalerite and therefore is interpreted to be later than the sulfide mineralization. In the Lone Eagle mine, Wright and others (1954, p. 67) state that sphalerite and pyrite were observed in veins cutting the pitchblende.

The intimate association of uranium with dark gray to black chalcedony or microcrystalline quartz in the chalcedony vein zones and in the silver-lead deposits suggests that most of the uranium mineralization may be of the same age and that many of the silver-lead veins were reopened during the period of uranium mineralization.

Actual age determination using a uranium-lead method had not been possible because pitchblende collected from the chalcedony vein zones is intimately mixed with secondary minerals, and a sample clean enough for age determination has not been obtained. The pitchblende associated with silver-lead deposits has not been found in sufficient amounts for age determination.

## SUMMARY AND CONCLUSIONS

Uranium minerals and radioactivity anomalies are common in chalcedony veins and vein zones and in silver-lead veins in the northern part of the Boulder batholith. Only two anomalies have been detected in the pre-batholithic volcanic rocks although the structure and mineralogy, uranium minerals excepted, of the silver-lead veins appear to be similar in the batholith and the pre-batholith rocks.

Because of the intimate relation between the uranium minerals and dark gray to black chalcedony and microcrystalline quartz, all of the uranium deposits are thought to be closely related in origin and age. The uranium is believed to have been deposited from hydrothermal solutions in early Tertiary time, but its exact age is not known.

Known deposits in chalcedony veins and vein zones are small though a few are moderately high grade. The chance of finding large tonnages of ore in veins of this type is considered slight. Because of the large size and continuity of the structures along which the silver-lead veins have been formed, large minable uranium ore bodies may occur in some of these veins.

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