URANIUM IN THE BLACK ROCK DISTRICT.

YAVAPAI COUNTY, ARIZONA

By D. V. Haines and R. B. Raup, Jr.
URANIUM IN THE BLACK ROCK DISTRICT
YAVAPAI COUNTY, ARIZONA*

By

D. V. Haines and R. B. Raup, Jr.

April 1954

Trace Elements Memorandum Report 564

This preliminary report is distributed without editorial and technical review for conformity with official standards and nomenclature. It is not for public inspection or quotation.

*This report concerns work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.
### Distribution (Series A)

<table>
<thead>
<tr>
<th>Organization</th>
<th>No. of copies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argonne National Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>Atomic Energy Commission, Washington</td>
<td>1</td>
</tr>
<tr>
<td>Division of Raw Materials, Albuquerque</td>
<td>1</td>
</tr>
<tr>
<td>Division of Raw Materials, Butte</td>
<td>1</td>
</tr>
<tr>
<td>Division of Raw Materials, Denver</td>
<td>1</td>
</tr>
<tr>
<td>Division of Raw Materials, Douglas</td>
<td>1</td>
</tr>
<tr>
<td>Division of Raw Materials, Hot Springs</td>
<td>1</td>
</tr>
<tr>
<td>Division of Raw Materials, Ishperming</td>
<td>1</td>
</tr>
<tr>
<td>Division of Raw Materials, Phoenix</td>
<td>1</td>
</tr>
<tr>
<td>Division of Raw Materials, Richfield</td>
<td>1</td>
</tr>
<tr>
<td>Division of Raw Materials, Salt Lake City</td>
<td>1</td>
</tr>
<tr>
<td>Division of Raw Materials, Washington</td>
<td>3</td>
</tr>
<tr>
<td>Exploration Division, Grand Junction Operations Office</td>
<td>1</td>
</tr>
<tr>
<td>Grand Junction Operations Office</td>
<td>1</td>
</tr>
<tr>
<td>Technical Information Service, Oak Ridge</td>
<td></td>
</tr>
<tr>
<td>Tennessee Valley Authority, Wilson Dam</td>
<td>1</td>
</tr>
<tr>
<td>U. S. Geological Survey:</td>
<td></td>
</tr>
<tr>
<td>Alaskan Geology Branch, Menlo Park</td>
<td>1</td>
</tr>
<tr>
<td>Fuels Branch, Washington</td>
<td>1</td>
</tr>
<tr>
<td>Geochemistry and Petrology Branch, Washington</td>
<td>1</td>
</tr>
<tr>
<td>Geophysics Branch, Washington</td>
<td>1</td>
</tr>
<tr>
<td>Mineral Deposits Branch, Washington</td>
<td>2</td>
</tr>
<tr>
<td>E. H. Bailey, Menlo Park</td>
<td>1</td>
</tr>
<tr>
<td>A. L. Brokaw, Grand Junction</td>
<td>1</td>
</tr>
<tr>
<td>K. L. Buck, Denver</td>
<td>1</td>
</tr>
<tr>
<td>J. R. Cooper, Denver</td>
<td>1</td>
</tr>
<tr>
<td>N. M. Denson, Denver</td>
<td>1</td>
</tr>
<tr>
<td>C. E. Dutton, Madison</td>
<td>1</td>
</tr>
<tr>
<td>W. L. Emerick, Plant City</td>
<td>1</td>
</tr>
<tr>
<td>L. S. Gardner, Albuquerque</td>
<td>1</td>
</tr>
<tr>
<td>M. R. Klepper, Washington</td>
<td>1</td>
</tr>
<tr>
<td>A. H. Koschmann, Denver</td>
<td>1</td>
</tr>
<tr>
<td>R. A. Laurence, Knoxville</td>
<td>1</td>
</tr>
<tr>
<td>D. M. Lemmon, Washington</td>
<td>1</td>
</tr>
<tr>
<td>J. D. Love, Laramie</td>
<td>1</td>
</tr>
<tr>
<td>V. E. Mckelvey, Menlo Park</td>
<td>1</td>
</tr>
<tr>
<td>Q. D. Singewald, Beltsville</td>
<td>1</td>
</tr>
<tr>
<td>J. F. Smith, Jr., Denver</td>
<td>1</td>
</tr>
<tr>
<td>A. O. Taylor, Salt Lake City</td>
<td>1</td>
</tr>
<tr>
<td>A. E. Weissenborn, Spokane</td>
<td>1</td>
</tr>
<tr>
<td>TEPCO, Denver</td>
<td>2</td>
</tr>
<tr>
<td>TEPCO, RPS, Washington, (Including master)</td>
<td>2</td>
</tr>
</tbody>
</table>
CONTENTS

Abstract ................................................................. 4
Introduction .............................................................. 4
Abe Lincoln mine ....................................................... 6
  Location .............................................................. 6
  History, production, and ownership ................................. 7
  Mine workings ...................................................... 7
Geology ................................................................. 11
  Rock descriptions .................................................. 11
    Gneiss-schist complex ........................................... 11
    Tourmaline granite ............................................. 13
    Dike rocks ..................................................... 13
      Felsite ....................................................... 13
      Trachite porphyry ............................................ 14
      Basalt ....................................................... 15
  Structure .......................................................... 15
  Mineral deposits .................................................. 16
    Mineralogy ...................................................... 16
      Paragenesis .................................................. 17
    Radioactivity .................................................. 17
Other mines and localities .......................................... 19
  Bracken property .................................................. 19
  Monte Cristo mine and area ...................................... 21
  Other mines ...................................................... 22
Recommendations ..................................................... 22
Literature cited ..................................................... 23
Unpublished reports ................................................ 23

ILLUSTRATIONS

Figure 1. Location map of the mines in the Black Rock district, Yavapai County, Arizona ................................................. 5

2. Geologic map of the Abe Lincoln mine area, Yavapai County, Arizona ......................................................... In envelope

3. Plan of workings, Abe Lincoln mine ................................... 6

4. Geologic map of the 175-level (accessible part), Abe Lincoln mine ......................................................... 10

TABLE

Table 1. Radioactivity measurements in the vicinity of the Abe Lincoln mine, Yavapai County, Arizona ................. 20
URANIUM IN THE BLACK ROCK DISTRICT, YAVAPAI COUNTY, ARIZONA

By D. V. Haines and R. B. Raup, Jr.

ABSTRACT

A radioactivity survey of the Black Rock district in southern Yavapai County, Ariz, disclosed anomalous radioactivity in several localities, chiefly at the Abe Lincoln mine in sec. 11, T. 8 N., R. 3 W., about 14 road miles northeast of Wickenburg. The Abe Lincoln vein system occupies a fault zone which strikes N. 50° E., and dips from 78° to 87° NW. The country rock in the vicinity of the mine consists of Pre-Cambrian gneiss-schist complex, gneiss, and tourmaline granite, intruded by dikes of felsite, trachite porphyry, and basalt. Chalcopyrite is the chief ore mineral; azurite, chalcocite, and malachite are present in lesser amounts. The gangue minerals are principally pyrite, quartz, calcite, purple fluorite, and limonite. Some specimens of vein material found on the dumps contained a secondary yellow uranium mineral, which, in one specimen, was identified by X-ray methods as schoepite \( (UO_3 \cdot 2H_2O) \); pitchblende may be present. Inasmuch as most of the mine workings are caved and flooded, radioactive material in place could not be sampled.

Moderate radioactivity is present at the Bracken property and at several other localities in the Black Rock district.

The writers recommend re-opening the Abe Lincoln mine to permit a more extensive examination of the vein.

INTRODUCTION

During parts of July and December 1953, the writers conducted a preliminary reconnaissance for radioactive materials in the Black Rock district, Yavapai County, Ariz, (fig. 1). The reconnaissance, made on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission, included a scintillation-meter survey of dumps and accessible mine workings, and outcrops along the main traveled roads in the
FIGURE 1—LOCATION MAP OF MINES IN THE BLACK ROCK DISTRICT, YAVAPAI COUNTY, ARIZONA

MINES
1 Abe Lincoln
2 Bracken Property
3 Copper Cap No. 1
4 Franklin D.
5 Keystone
6 Monte Cristo
7 O'Brien
8 Swallow
district. Anomalous radioactivity was found at the Abe Lincoln mine, the Bracken property, and several other localities. Samples taken at these areas indicated that the material at the Abe Lincoln mine was the most radioactive and, accordingly, more detailed work, including surface and underground mapping, was done in December 1953.

Discussions of previous work done in the Black Rock district are limited to a report on the ore minerals at the Monte Cristo mine by Bastin (1923) and an unpublished report on the Abe Lincoln mine by Elsing and Faick (1952). In 1943, engineers for the Reconstruction Finance Corporation sampled the Abe Lincoln vein system to determine its copper content; the assay data are summarized in the report by Elsing and Faick who examined the property in connection with a request by the owners for a Defense Materials Procurement Agency loan.

Mining districts immediately east, northeast, and south of the Black Rock district are discussed by Jaggar and Palache (1905), Lindgren (1926), and Jahns (1952).

**ABE LINCOLN MINE**

**Location**

The Abe Lincoln mine is in the SW 1/4 sec. 11, T. 8 N., R. 3 W. (unsurveyed), and is 14 miles by road northeast of Wickenburg, Ariz. The general area of the mine, which is in Buckhorn Gulch, is shown in the extreme southeast corner of the Geological Survey’s Congress topographic quadrangle, scale 1:125,000. The mine is accessible by good graded roads from Wickenburg.

The mine is at an altitude of about 4,400 feet in a region of steeply rolling hills; maximum relief is more than 300 feet. Vegetation is sparse and consists chiefly of mesquite, saguaro, cats-claw, and prickly pear. The summers are very hot, and the winters are moderately warm. Rainfall is low throughout the year, with the heaviest showers in July and August.
History, production, and ownership

Data on previous history, production, and ownership of the mine have been taken from the unpublished report by Elsing and Faick (1952).

Development work at the mine was started prior to 1917 and a flotation mill was constructed in 1920. Operations were continued intermittently until 1924 when the property was shut down and abandoned. Recorded production during this period amounted to approximately 52 tons of crude copper ore and concentrates; ore grade was approximately 12 percent copper. After 1950, further development work was done and, in 1951, a shipment of 42 tons of crude ore was made that contained about 2 percent copper. Most of this ore apparently came from development work as there is only one small accessible stope and maps of the inaccessible workings show no stopes.

In 1952 the property was owned by a limited partnership known as "The Abe Lincoln Mines", the members of which have organized the "F. L. Robinson Mining Associates, Inc.", an Arizona corporation, and operated the mine. Officers of the corporation include F. L. Robinson, President, C. A. Johnson, Secretary, E. I. Mills, partner and consulting engineer, and E. I. Mills, Jr., superintendent. The mining agreement covers 8 unpatented claims. An application by the corporation in 1952 for a DMPA loan was denied on the basis of insufficient ore reserves and high cost of production.

Mine workings

The mine consists of two shafts, two adits, and 3,150 feet of drifts and crosscuts; two other adits explore the vein system for short distances but do not connect with the main workings. (See figs. 2 and 3.)

Shaft No. 1, a 660-ft vertical shaft, is reported to have given access to workings on the 660-, 350-, 175-, and 145-ft levels; it is now caved from the surface to the 175-level (Elsing and Faick, 1952). The 660-level has 1,150 feet of workings which trend northwest and northeast from Shaft No. 1; this level is now inaccessible because of flooding. On the 350-level, 730 feet of workings have been driven from Shaft No. 1.
Shaft No. 2
Adit portal
175-level
Adit portal
145-level
Partly caved
Adit
150-level
Caved
44-ft winze
Shaft No. 1
175-level
350-level
660-level
Open cut
Powder house adit level
Shaft going above and below level
145-level
150-level
Powder house adit
Bottom of shaft
Top of winze

FIGURE 3-PLAN OF WORKINGS, ABE LINCOLN MINE

Adjusted from map compiled by Elsing and Foick, 1952, from old records
of which 310 feet trend west-southwest and 420 feet trend northeast. In 1950 or 1951, Shaft No. 2 was sunk 175 feet vertically and a 70-foot crosscut was driven southeastward to connect with the 350-level. Although apparently in good condition, Shaft No. 2 was flooded to 60 feet below the collar at the time of the writers' examination; local ranchers were pumping the water for stock use. The headframe is standing and appears to be in good condition.

The 175-level is entered by an adit and follows the Abe Lincoln vein system for a reported distance of 490 feet southwestward, where it connects with Shaft No. 1. However, the 175-level is caved 350 feet from the portal and could not be examined beyond this point. This level is partly stoped and timbered (fig. 4). A short adit about 50 feet south of and 25 feet above the portal of the 175-level also explores the vein for about 60 feet in a southwesterly direction.

The 145-level is entered through an adit 230 feet almost due north of Shaft No. 1. The adit trends south-southeast for about 220 feet until it intersects the Abe Lincoln vein system, at which point short drifts explore the vein northeast and southwest. The southwest drift apparently connects with Shaft No. 1. The 145-level is partly caved at the portal and is completely caved 160 feet from the portal; the exposed segment is not timbered.

The powder-house adit southwest of Shaft No. 1 is reported to have been 100 feet long, but is now mostly caved to the surface. The resulting open cut on the vein system is shown in figure 2. A caved prospect pit or short adit is 35 feet below the powder house adit on the northwest.

A map of the mine workings was compiled by Elsing and Faick from old records and shows considerable differences in the position of various map features as located by the writers using a telescopic alidade and plane-table (fig. 2). The map compiled from the old records was adjusted (fig. 3) by the writers to correspond to figure 2.
FIGURE 4.—GEOLOGIC MAP OF THE 175-LEVEL (ACCESSIBLE PART), ABE LINCOLN MINE


**Geology**

The Abe Lincoln vein system is in a metamorphic rock complex, locally intruded by granite and by dikes of both felsic and mafic composition. The two predominant structural trends, N. 50° E. and N. 32-45° W., in the vicinity of the mine are reflected by the strikes of the dikes. Information on faulting is difficult to obtain because access to the mine workings is limited and because surface exposures are mostly obscured by talus, alluvium, and dump material. The Abe Lincoln vein system, which is on the hanging wall of a trachite porphyry dike, consists of veins on the hanging wall and footwall of a narrow basalt dike. The two narrow veins contain quartz, calcite, chalcopyrite, and pyrite. Radioactive minerals have not been found in any of the accessible mine workings but have been found in small quantities on the dumps of Shaft No. 1, the 145-level adit, and the 175-level adit. The secondary uranium mineral schoepite ($\text{UO}_3\cdot 2\text{H}_2\text{O}$) has been identified. Purple fluorite is found in the gangue of the radioactive material.

**Rock descriptions**

The country rock in the vicinity of the mine is gneiss-schist complex and tourmaline granite, both intruded by dikes of felsite, trachite porphyry, and basalt. Hydrothermal solutions and weathering have altered the rocks of the area.

**Gneiss-schist complex**

The predominant rock in the area adjacent to the Abe Lincoln mine is a metamorphic complex of gneiss and schist (fig. 2). Although the relationship of the schist to the gneiss is not clearly discernible because of poor exposures, the schist apparently occurs as folded and contorted bands within the gneiss. The larger part of the complex is gneiss. The contact between the gneiss-schist complex and the tourmaline

---

According to Frondel and Fleischer (1952, p. 8) schoepite has the formula $\text{UO}_3\cdot 2\text{H}_2\text{O}$, although Palache and others (1944, p. 627) show the formula as $4\text{UO}_3\cdot 9\text{H}_2\text{O}(?)$. 

---
granite is not everywhere well defined. Stringers and dikes of granite pegmatite commonly extend from the granite into the complex. Along the north wall of the 175-level adit at the portal, the stringers apparently were injected lit-par-lit to such an extent that the rock might be called a migmatite. Jaggar and Palache (1905) dated the nearby, similar-appearing Crooks complex as Pre-Cambrian.

Within the complex, weathered gneiss is brown and friable; unweathered gneiss is light gray and compact. The gneiss is commonly fine-grained and contains numerous, discontinuous layers of mica which are closely-spaced, narrow, and sub-parallel. The mica is predominantly biotite; lesser amounts of muscovite are present. Between the mica layers are wider layers of equidimensional quartz, microcline, and albite. Albite forms approximately 43 percent by volume of the rock, quartz 25 percent, microcline 20 percent, biotite 10 percent, and muscovite 2 percent. The feldspars, particularly in the vicinity of the Abe Lincoln vein system, are slightly sericitized.

The gneiss may represent, in part at least, development of gneissic structure along the borders of granite intrusive into schist. Such an origin of the gneissic structure in the Bradshaw Mountains quadrangle is postulated by Jaggar and Palache (1905).

The schist in the mapped area is not uniform in appearance and composition. Weathered schist is brown or greenish-brown; fresh schist is fine-grained black or medium-grained mottled white and black. The mineral constituents are quartz, hornblende, muscovite, and epidote. Foliation is not uniformly developed; in some outcrops the schist is highly foliated and in others the foliation is not conspicuous.

A medium-grained, equigranular rock was noted on the slope between Shaft No. 1 and the 145-level adit. The structural relationships of this rock could not be determined because of poor exposure, but it is either a dike which has intruded the complex or a hornblende-rich component of the complex. The rock is 75 percent hornblende, 15 percent andesine, and 10 percent seicite and orthoclase. Minor amounts of chlorite and clinozoisite occur in veinlets in this rock.
Tourmaline granite

Granite crops out in the area east and southeast of Shaft No. 1 (fig. 2) as white, rounded outcrops. The granite is fine- to coarse-grained with a xenomorphic-granular texture and consists of quartz, microcline, black tourmaline (schorl), and a small amount of albite and muscovite. The schorl is well-crystallized and crystals 1 to 2 inches in length are common. The granite contains approximately 53 percent quartz, 40 percent microcline, 5 percent schorl, and 2 percent muscovite. Albite forms less than 1 percent of the rock. Pegmatitic facies of the granite are prominent southeast of Shaft No. 1, particularly near the contact between granite and gneiss-schist complex.

The tourmaline granite at the Abe Lincoln mine can be correlated with a fair degree of certainty with the southern, more pegmatitic facies of the Bradshaw granite described by Jaggar and Palache (1905). The Bradshaw granite is probably of Pre-Cambrian age.

Dike rocks

Dikes of felsite, trachite porphyry, and basalt have intruded both the gneiss-schist complex and granite. As a rule, the dikes are more resistant to weathering than the gneiss-schist complex or the granite and tend to protrude above the host rocks. However, the dikes are not traceable continuously for more than about one hundred feet because of talus cover. The dikes are the youngest rocks in the area, but the age relations among the different dikes could not be determined.

Felsite.—Felsite dikes are the most common type in the vicinity of the Abe Lincoln mine. All of the felsite dikes mapped trend from north to N. 55° W., with the exception of one in the most southerly part of the mapped area (fig. 2); the average trend is N. 45° W. Although it is difficult to accurately measure the dip of the felsite dikes, most dip steeply to the northeast or are vertical. A notable exception is the 38° W. dip measured on the northward trending felsite dike in the southern part of the mapped area. The dikes range from 2 to 6 feet in thickness.
The felsite is severely weathered in outcrops and is characteristically dark greenish-brown or maroon in outcrops; fresh felsite is greenish-gray or gray. Amygdules and vesicles ranging in size from microscopic to half an inch in diameter are common in rounded, elliptical, or irregular shapes. Amygdules contain quartz, epidote, and specularite; specularite also occurs in thread-like veinlets. Amygdules filled only by calcite are found in one felsite dike.

Under the microscope, the felsite shows a sub-feltty, fine-grained texture with abundant magnetite which occurs as disseminated fine specks. Phenocrysts, as much as 2 mm in size, are present in some specimens. Alteration has produced chlorite and epidote to such an extent that the original mineral constituents of the groundmass and phenocrysts could not be identified, but within the amygdules fresh, unaltered grains of quartz, epidote, and specularite are present.

**Trachite porphyry**. — A dike of trachite porphyry crops out in the open cut west-southwest of Shaft No. 1, on the ridge southwest of the open cut, and on the slope northeast of Shaft No. 1 (fig. 2). The dike ranges in width from 5 to 8 feet, strikes approximately N. 50° E., and dips 78°-89° NW. It occurs on the footwall of the Abe Lincoln vein system. A smaller dike of trachite porphyry crops out 200 feet northwest of Shaft No. 2.

The trachite porphyry has a light- to dark-gray fine-grained groundmass in which are small dark lath-shaped phenocrysts averaging 2 mm in length. The phenocrysts, forming about 15 percent of the rock, have been bleached in some specimens. Veinlets of chlorite, quartz, quartz-pyrite, and pyrite cut the rock; some pyrite is disseminated throughout the rock.

Microscopically, the phenocrysts consist of lath-shaped and pseudo-hexagonal grains of chlorite. Muscovite, epidote, and clinozoisite are found along the cleavages in the chlorite. The pseudo-hexagonal forms of chlorite contain numerous inclusions of a very fine acicular mineral of high birefringence, possibly rutile. The groundmass consists predominantly of cloudy orthoclase, fine-grained muscovite, and chlorite shreds. Minor amounts of quartz and plagioclase are present.
**Basalt**. — "Basalt" is used as a field term by the writers for the mafic dike rock which is between the veins of the Abe Lincoln vein system. Inasmuch as the basalt is less resistant to weathering than the other dikes or the gneiss, it is not well exposed. In the 175-level adit, however, the basalt is a dense black fine-grained rock. The dike ranges from 2 to 4 feet in thickness. Small grains of pyrite are disseminated through the rock. Calcite blebs averaging a quarter of an inch in diameter are present in the groundmass and many calcite veinlets, as much as a quarter of an inch wide, crosscut the rock. Elsing and Faick (1952) report calcite veins up to 6 inches in width cutting the basalt on the 350-level. The basalt is also cut by veinlets of quartz and of quartz, epidote, and pyrite.

The dike is so altered that the original mineral constituents of the fine-grained groundmass could not be identified under the microscope. A considerable part of the groundmass contains opaque matter which in reflected light is white and resembles leucoxene. A few grains of olivine are present. Calcite, as fillings of vesicles and fractures, forms approximately 10 percent of the rock.

**Structure**

Two structural trends are apparent in the vicinity of the Abe Lincoln mine. One trend, averaging N. 45° W., is based on the strikes of the felsite dikes. The other trend, averaging N. 50° E., is based on the strikes of the trachite porphyry dike, the basalt dike, and the vein material. Small iron-stained, quartz-filled fractures, striking N. 59° E. to N. 10° W. and dipping 38° W. to vertical, occur in both the granite and gneiss-schist complex.

The Abe Lincoln vein system, the trachite porphyry dike, and the basalt dike occupy a fault zone which strikes approximately N. 50° E. and dips 78-89° NW. The trachite porphyry dike is on the footwall of the fault zone and the basalt dike is on the hanging-wall side of the trachite porphyry dike; both dikes are pre-pre. Two veins comprise the Abe Lincoln vein system; they are adjacent to the walls of the basalt dike. The footwall vein ranges in width from a few inches to 5 feet; the hanging-wall vein is narrower. The walls of both veins are irregular and the veins are therefore lenticular or pockety. Slickensided gouge, from 1 to 18 inches thick, is common between the basalt dike and the footwall vein.
Evidence for other faults in the area is inconclusive. The southwest end of the vein system is reported to be offset by a nearly vertical, northwest-trending fault. This reported fault could not be substantiated, however, because the southwest part of the mine is inaccessible and the surface is largely covered with talus and dump material. Another fault may offset the northeast end of the vein system. A fault, hidden beneath the alluvium in Buckhorn Wash, would explain the absence of the vein system north of the wash.

Mineral deposits

The Abe Lincoln mine is known primarily as a copper deposit. Although no significant radioactivity anomalies were detected in vein material in place, some dump material was found to be abnormally radioactive. The secondary uranium mineral schoepite (UO$_3$·2H$_2$O) was identified from one of the anomalous areas; pitchblende may be present as well. Calcite, purple fluorite, and quartz constitute the gangue of much of the radioactive material.

Mineralogy

The Abe Lincoln vein consists chiefly of chalcopyrite and lesser amounts of azurite, chalcocite, and malachite in a gangue of pyrite, quartz, calcite, and limonite. Gypsum is present along the walls of the 175-level adit, and purple fluorite associated with calcite is locally present on the dump of Shaft No. 1. Shipments of ore have contained small amounts of gold and silver, but no gold or silver minerals were observed (Elsing and Faick, 1952).

Bandung of quartz and calcite, quartz cut by calcite veinlets, and breccia cemented by calcite are all common in the veins. Some of the breccia contains a black gouge-like material as small, irregularly shaped pods or in thin, wavy bands. The gouge-like material, which is weakly radioactive, is a fine-grained aggregate of chlorite, sericite, altered feldspar, quartz, apatite, and leucoxene(?). Chalcopyrite and pyrite are disseminated in the gouge-like material, but no uranium minerals were identified in polished section.
Small amounts of a yellow radioactive mineral were found on the dumps of Shaft No. 1, Shaft No. 2, and the 145-level adit. One specimen from the dump of Shaft No. 1 was identified as schoepite (UO$_3$·2H$_2$O) by X-ray diffraction methods in the Denver laboratory of the Geological Survey. The schoepite coats a specimen containing quartz, rusty pyrite, malachite, and the gouge-like material previously described. Schoepite is reported to be an alteration product of uraninite in the Belgian Congo (Palache, Berman, and Frondel, 1944, p. 628) and at Beryl Mountain, New Hampshire (Rabbitt, 1953); uraninite or pitchblende may therefore be present with the schoepite at the Abe Lincoln mine.

**Paragenesis.** Textural relations in hand specimens and thin-sections of vein material suggest the following order of deposition of the hypogene vein minerals:

- Quartz
- Pyrite
- Chalcopyrite
- Calcite
- Fluorite

The veins are younger than all the rocks except possibly the felsite dikes. There is no direct evidence to indicate the age of the veins, but a comparison with mineral deposits in other districts nearby (Lindgren, 1926) indicates that the Abe Lincoln vein system is probably either Pre-Cambrian or Tertiary in age.

**Radioactivity**

A radioactivity survey of the dumps adjoining the 145-level adit, Shaft No. 1, and Shaft No. 2 disclosed anomalous radioactivity in some specimens of vein material on the dumps. Anomalous radioactivity was also detected in crushed rock, probably vein material, on an abandoned mill site located on the north slope of the hill below Shaft No. 1.

_/ Dashed line indicates relative interval of deposition._
A large specimen of banded vein material showing a maximum meter reading of 1.0 milliroentgens per hour was uncovered near the top edge of the 145-level adit dump. The specimen consisted of banded quartz, black gouge-like material, sanidine(?), pyrite, chalcopyrite, and schoepite. The schoepite occurred as rims around pyrite grains. This specimen assayed 0.35 percent equivalent uranium and 0.46 percent uranium. Smaller specimens of similar radioactive vein material were found in the vicinity. Other specimens, consisting almost entirely of limonite, showed radioactivity between 0.25 and 0.5 mr/hr, but this material was not sampled.

The 145-level adit intersects the Abe Lincoln vein system about 300 feet from the portal but is completely caved at 160 feet. Radioactivity in the accessible part of the adit ranged from 0.04 mr/hr to a maximum of 0.06 mr/hr.

The dump adjoining Shaft No. 1 showed no anomalous radioactivity except in an area about 8 by 5 feet on a side northeast of the shaft. In this area radioactivity reached a maximum of 1 mr/hr. Specimens found in this part of the dump included trachite porphyry containing pyrite and thin fracture coatings of malachite, iron-stain, and schoepite; slightly radioactive fractured basalt with calcite, specularite, and malachite and limonite stains; moderately to highly radioactive vein material consisting of chalcopyrite, pyrite, malachite, schoepite, quartz, sanidine (?), black gougy matter, and light to dark purple fluorite in calcite. Specimens in the area of highest radioactivity were sampled and found to contain 0.12 percent equivalent uranium and 0.11 percent uranium.

The gangue of this dump consists dominantly of calcite and fluorite and differs markedly from the quartz-pyrite gangue found on the other dumps. This may indicate a change in the gangue within the Abe Lincoln vein or it may indicate that another vein is present which parallels or crossects the Abe Lincoln vein system.

A scintillation-meter survey of the dumps adjoining the No. 2 shaft and the 175-level disclosed only two very small specimens of a yellow radioactive mineral, presumably schoepite.
Radioactivity in the 175-level adit ranges from 0.03-0.04 mr/hr in the first 230 feet to 0.08-0.10 mr/hr in the last 90 feet. The remainder of the level is inaccessible.

On the north slope of the hill at the remains of an abandoned mill below the No. 1 shaft the radioactivity of some crushed vein(?) material ranged from 0.25 to 0.60 mr/hr. A sample of the most radioactive material contained 0.097 percent equivalent uranium and 0.074 percent uranium.

Results obtained from the entire scintillation-meter survey of outcrops, accessible mine workings, vein material, and dumps shown on the map (fig. 2) are summarized in table 1. The survey extended well beyond the limits of the mapped area, but no other significant radioactivity was detected.

OTHER MINES AND LOCALITIES

Examinations for radioactivity were made with a scintillation-survey meter at several other mines in the Black Rock district and at outcrops along roads in the district. Abnormal radioactivity was detected at two localities: (1) on the Bracken property and (2) near the Monte Cristo mine.

Bracken property

The Bracken property, approximately 1 mile west of the Abe Lincoln mine, can be reached by a graded dirt road from Wickenburg. At the time of the writers' visit in July 1953 Miller, Christofferson, and Dore who had leased the property from F. Bracken, owner, were developing the mine and shipping some ore material. At a later visit in December 1953, the shaft was flooded and no further work was being done. The workings include a 65-ft, steeply-inclined shaft with a 15-ft drift at the bottom of the shaft.

The vein is in granite, strikes N. 40° W., and dips steeply northeast. The vein material consists of pyrite, chalcopyrite, bornite, and iron oxides; some gold is reported by Miller. Radioactivity at the outcrop of the vein near the shaft is 0.22 mr/hr as measured by a scintillation-survey meter. The maximum radioactivity in the drift at the bottom of the shaft is 0.34 mr/hr. A sample of the vein outcrop contained
Table 1.--Radioactivity measurements in the vicinity of the Abe Lincoln mine, Yavapai County, Arizona

All measurements of radioactivity were made with a scintillation-survey meter held normal to and within one inch of the material to be tested.

<table>
<thead>
<tr>
<th>Material tested and location</th>
<th>Radioactivity (mr/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background radioactivity, Abe Lincoln mine vicinity</td>
<td>0.012</td>
</tr>
<tr>
<td>Gneiss-schist complex, exposures throughout the map area</td>
<td>0.013-0.024</td>
</tr>
<tr>
<td>Gneiss-schist complex, underground in the 145-level adit</td>
<td>0.040-0.060 (mass effect)</td>
</tr>
<tr>
<td>Tourmaline granite, exposures east of Shaft No. 1</td>
<td>0.016-0.018</td>
</tr>
<tr>
<td>Pegmatitic facies of the granite, 300 ft S. 40° E. from Shaft No. 1</td>
<td>0.022</td>
</tr>
<tr>
<td>Felsite dikes, exposures throughout the map area</td>
<td>0.018-0.021</td>
</tr>
<tr>
<td>Trachite porphyry dike, 235 ft N, 30° W, from Shaft No. 2</td>
<td>0.020</td>
</tr>
<tr>
<td>Narrow fractures which are quartz-filled and iron-stained, exposures throughout the map area</td>
<td>0.017-0.020</td>
</tr>
<tr>
<td>Vein material, surface exposures of Abe Lincoln vein system</td>
<td>0.019-0.040</td>
</tr>
<tr>
<td>Vein material, in 60-ft adit 25 ft above the 175-level portal</td>
<td>0.070 (mass effect)</td>
</tr>
<tr>
<td>Vein material, first 230 ft of the 175-level adit</td>
<td>0.030-0.040 (mass effect)</td>
</tr>
<tr>
<td>Vein material, remaining 90 ft of accessible drift on the 175-level</td>
<td>0.080-0.100 (partly mass effect)</td>
</tr>
<tr>
<td>Dump material, Shaft No. 1, average</td>
<td>0.012-0.024</td>
</tr>
<tr>
<td>Dump material, Shaft No. 1, &quot;hot spot&quot;</td>
<td>1.000 (maximum)</td>
</tr>
<tr>
<td>Dump material, Shaft No. 2, average</td>
<td>0.018-0.024</td>
</tr>
<tr>
<td>Dump material, 145-level adit, average</td>
<td>0.025</td>
</tr>
<tr>
<td>Dump material, 145-level adit, &quot;hot spots&quot;</td>
<td>0.100-1.000</td>
</tr>
<tr>
<td>Dump material, 175-level adit</td>
<td>0.024-0.025</td>
</tr>
<tr>
<td>Dump material, powder house adit</td>
<td>0.022</td>
</tr>
<tr>
<td>Dump material, adit or prospect pit 35 ft below the powder house adit</td>
<td>0.013-0.018</td>
</tr>
<tr>
<td>Crushed dump material, mill site</td>
<td>0.250-0.600 (maximum)</td>
</tr>
</tbody>
</table>
0.015 percent equivalent uranium and 0.012 percent uranium; vein material from the drift contained
0.009 percent equivalent uranium and 0.006 percent uranium. No uranium minerals were observed.

A scintillation-meter survey of the area around the Bracken shaft disclosed that the radioactivity
away from the vein outcrop decreases rapidly from 0.22 mr/hr to 0.02 mr/hr. Radioactivity of the vein
itself remains at about 0.22 mr/hr for 75 feet along the outcrop and then decreases rapidly to 0.02 mr/hr.
The vein is traceable for about 200 feet on the surface.

A small area of anomalous radioactivity was found in a road cut half a mile northeast of the
Bracken property shaft. The radioactive zone is only a few inches wide and can be traced for about 20 feet
along the road-cut. A 1.6-foot channel sample contained 0.038 percent equivalent uranium and 0.012
percent uranium; the maximum radioactivity was 0.50 mr/hr. A smaller concentration of radioactive
material in altered gneiss-schist was found in a road-cut 100 yards north of the cut mentioned above. Radio-
activity here ranges from 0.16 to 0.18 mr/hr. Similar anomalies were found in iron-stained fractures on the
hillside west of the road-cut. Traverses were continued on both sides of the road between the Bracken
property and the Abe Lincoln mine, but no significant radioactivity was found.

**Monte Cristo mine and area**

The Monte Cristo mine, an inactive mine about 12 road miles northeast of Wickenburg, was
described in 1923 by Bastin. The mine drifts follow two parallel veins which strike slightly west of north.
The main deposit is located in the west vein which dips 45-55° W.; the east vein has a steeper dip, so that
the two veins diverge downward. Near the surface the veins are along the foot- and hanging walls of a 4-
foot diabase dike, but the veins diverge so that on the seventh level they are 60 feet apart. Chalcopyrite
is the principal ore mineral, but cobalt-nickel minerals and native silver are common. The gangue includes
quartz, calcite, siderite, and barite; the host rock is granite gneiss (Bastin, 1923).
A scintillation-meter survey for radioactivity was made of the dumps, main shaft, and south
drifts on the 100-, 200-, and 300-levels; no significant radioactivity was found. Radioactivity on the dumps
ranges from 0.018 to 0.030 mr/hr. In the south drifts on the first three levels, the radioactivity is between
0.019 and 0.024 mr/hr. The main shaft extends to the 1200-level but is flooded below the 300-level.

Along a road cut 0.8 mile east of the Monte Cristo mine the radioactivity increases slightly to
an average of 0.06 mr/hr over a few square feet of weathered rock. The dumps adjoining two small shafts
nearby were checked; no anomalously high radioactivity was found. However, a small piece of moderately
radioactive material was found in a wash adjacent to one of the shafts. Anomalous radioactivity was found
one-eighth of a mile upstream from the shaft in an iron-stained quartz vein about 4 feet wide. The radio-
activity emanated from small patches within the vein and could not be traced for more than a few feet.
Maximum radioactivity recorded on this material with a scintillation counter was 0.17 mr/hr.

Other mines

The dumps of the following mines and areas were checked with a scintillation-survey meter:
Swallow mine, Franklin D. mine, O’Brien mine, Copper Cap No. 1 mine, and the Keystone area. No
significant radioactivity was detected.

Recommendations

Although no radioactive material can be seen in place in the accessible parts of the Abe Lincoln
mine, assays of material from the dumps indicate that ore-grade material may be present in the mine and
re-opening the mine to determine the source of the uranium-bearing material might be desirable.

Inasmuch as the radioactivity detected on the dumps of Shaft No. 1 and the 145-level was higher
than that on the dumps of Shaft No. 2 and the 175-level, it would seem most probable that any radioactive
material present in the mine would be exposed on the 145-level or the 660-level.
If the amount of uranium in the Abe Lincoln mine is found to be significant, the underground workings at other mines in the district, which are now inaccessible or unsafe, should be examined. These mines include the Monte Cristo, Swallow, Franklin D., O'Brien, Copper Cap No. 1, and Keystone.

LITERATURE CITED


UNPUBLISHED REPORTS


FIGURE 2.—GEOLOGIC MAP OF THE ABE LINCOLN MINE AREA, YAVAPAI COUNTY, ARIZONA

0 100 200 300 Feet

Contour interval: 25 feet
Datum is assumed

EXPLANATION

Talus, alluvium, or dump material
No exposures of bedrock

Abe Lincoln vein system
Two veins separated by a basalt dike

Trachite porphyry

Tourmaline granite
Poor to good exposures

Gneiss-schist complex
Poor to good exposures

Contact, showing dip
Dashed where approximately located

Strike and dip of foliation

Iron-stained quartz-filled fracture, showing dip
Dashed where approximately located

Vertical shaft

Portal of adit

Open cut

Rock dump