# Geology of the Shinarump No. 1 Uranium Mine, Seven Mile Canyon Area, Grand County, Utah

By W. I. Finch





*Trace Elements Investigations Report 287*



UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Geology and Mineralogy

This document consists of 36 pages,
plus 3 figures.
Series A

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

# GEOLOGY OF THE SHINARUMP NO. 1 URANIUM MINE, SEVEN MILE CANYON AREA, GRAND COUNTY, UTAH*

By

W. I. Finch

October 1953

Trace Elements Investigations Report 287

Open Filed 1/11/54.
GS-C-336.

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.

USGS - TEI-287

GEOLOGY AND MINERALOGY

| Distribution (Series A) | No. of copies |
|---|---|
| American Cyanamid Company, Winchester | 1 |
| Argonne National Laboratory | 1 |
| Atomic Energy Commission, Washington | 2 |
| Battelle Memorial Institute, Columbus | 1 |
| Carbide and Carbon Chemicals Company, Y-12 Area | 1 |
| Division of Raw Materials, Albuquerque | 1 |
| Division of Raw Materials, Butte | 1 |
| Division of Raw Materials, Denver | 1 |
| Division of Raw Materials, Douglas | 1 |
| Division of Raw Materials, Grants | 1 |
| Division of Raw Materials, Hot Springs | 1 |
| Division of Raw Materials, Ishpeming | 1 |
| Division of Raw Materials, New York | 6 |
| Division of Raw Materials, Phoenix | 1 |
| Division of Raw Materials, Richfield | 1 |
| Division of Raw Materials, Salt Lake City | 1 |
| Division of Raw Materials, Washington | 3 |
| Dow Chemical Company, Pittsburg | 1 |
| Exploration Division, Grand Junction Operations Office | 10 |
| Grand Junction Operations Office | 1 |
| Technical Information Service, Oak Ridge | 6 |
| Tennessee Valley Authority, Wilson Dam | 1 |
| U. S. Geological Survey: | |
| Alaskan Geology Branch, Washington | 1 |
| Fuels Branch, Washington | 1 |
| Geochemistry and Petrology Branch, Washington | 1 |
| Geophysics Branch, Washington | 1 |
| Mineral Deposits Branch, Washington | 12 |
| E. H. Bailey, San Francisco | 1 |
| K. L. Buck, Denver | 2 |
| J. R. Cooper, Denver | 1 |
| N. M. Denson, Denver | 1 |
| C. E. Dutton, Madison | 1 |
| W. I. Finch, Denver | 1 |
| R. P. Fischer, Grand Junction | 5 |
| L. S. Gardner, Albuquerque | 1 |
| M. R. Klepper, Washington | 1 |
| A. H. Koschmann, Denver | 1 |
| R. A. Laurence, Knoxville | 1 |
| D. M. Lemmon, Washington | 1 |
| J. D. Love, Laramie | 1 |
| R. G. Petersen, Plant City | 1 |
| R. J. Roberts, Salt Lake City | 1 |
| Q. D. Singewald, Beltsville | 1 |
| J. F. Smith, Jr., Denver | 1 |
| R. W. Swanson, Spokane | 1 |
| A. E. Weissenborn, Spokane | 1 |
| W. P. Williams, Joplin | 1 |
| TEPCO, Denver | 2 |
| TEPCO, RPS, Washington (Including master) | 4 |
| | 91 |

CONTENTS



ILLUSTRATIONS

ILLUSTRATIONS--Continued



TABLES

# GEOLOGY OF THE SHINARUMP NO. 1 URANIUM MINE, SEVEN MILE CANYON AREA, GRAND COUNTY, UTAH

By W. I. Finch

## ABSTRACT

The Shinarump No. 1 uranium mine is located about 12 miles northwest of Moab, Utah, in the Seven Mile Canyon area, Grand County, Utah. A study was made of the geology of the Shinarump No. 1 mine in order to determine the habits, ore controls, and possible origin of the deposit.

Rocks of Permian, Triassic, and Jurassic age crop out in the area mapped. Uranium deposits are found in three zones in the lower 25 feet of the Upper Triassic Chinle formation. The Shinarump No. 1 mine, which is in the lowermost zone, is located on the west flank of the Moab anticline near the Moab fault.

The Shinarump No. 1 uranium deposit consists of discontinuous lenticular layers of mineralized rock, irregular in outline, that, in general, follow the bedding. Ore minerals, mainly uraninite, impregnate the rock. High-grade seams of uraninite and chalcocite occur along bedding planes. Formation of uraninite is later than or simultaneous with most sulfides. Chalcocite may be of two ages, with some being later than uraninite. Uraninite and chalcocite are concentrated in the poorer sorted parts of siltstones. Guides to ore in the Seven Mile Canyon area inferred from the study of the Shinarump No. 1 deposit are the presence of bleached siltstone, copper sulfides, and carbonaceous matter. Results of spectrographic analysis indicate that the mineralizing solutions contained important amounts of barium, vanadium, uranium, and copper as well as lesser amounts of strontium, chromium, boron, yttrium, lead, and zinc.

The origin of the Shinarump No. 1 deposit is thought to be hydrothermal,

## INTRODUCTION

The Shinarump No. 1 uranium mine is located about 12 miles northwest of Moab, Utah, in the Seven Mile Canyon area, Grand County, Utah (fig. 1). A road about a quarter of a mile long connects the mine area with U. S. Highway 160. The mineralized horizons crop out along a northwest-trending escarpment paralleling Highway 160. Vegetation in the area is sparse.

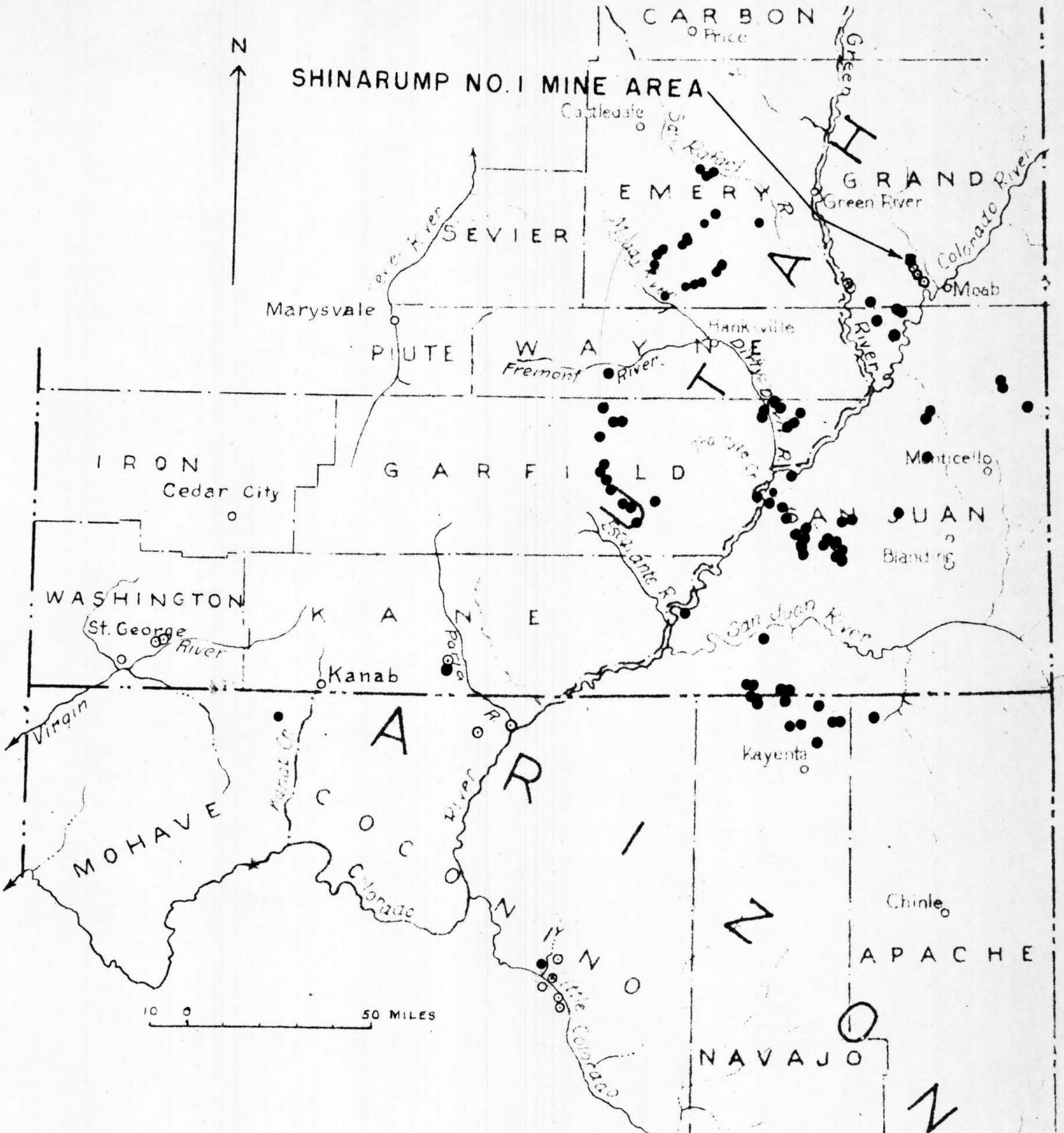
A study was made of the geology of the Shinarump No. 1 mine in order to determine the habits, ore controls, and possible origin of the deposit. This study was made by the U. S. Geological Survey on behalf of the Division of Raw Materials of the Atomic Energy Commission. Vance Thornburg, owner of the claims, was most cooperative and helpful throughout the investigation.

Field study began in January 1952 and was carried on intermittently until April 1953. The Shinarump No. 1 mine workings were mapped in detail by tape and open-sight alidade early in 1952. Later a plane-table map was made of the area surrounding the mine to relate the mine geology to the stratigraphic and structural features. A total of 31 samples of ore-bearing and barren rock were taken in the area and analyzed chemically and spectrographically. Stratigraphic sections were measured near the mine and in Little Canyon south of Seven Mile Canyon.

Previous work in the area includes a study of the geology of the area between the Green and Colorado Rivers by McKnight (1940) and recent studies of the Seven Mile Canyon area in connection with exploration by the Atomic Energy Commission by Droullard (1951) and Droullard and Jones (1952).

## GENERAL GEOLOGY

Rocks of Permian, Triassic, and Jurassic age crop out in the area mapped. Uranium-bearing rock occurs in lower beds of the Upper Triassic rocks. Copper-bearing rock occurs in a large talus block that may be Cretaceous Dakota sandstone and in the Moab fault gouge zone. Outside the Shinarump No. 1 mine area, uranium-bearing rock also occurs in the Upper Jurassic Morrison formation (fig. 2). Copper-bearing rock occurs along the Moab fault northwest of the area mapped.




- Uranium deposit or group of deposits in the Shinarump conglomerate
- ⊙ Uranium deposit or group of deposits in the Chinle formation

Figure 1. MAP OF PART OF THE COLORADO PLATEAU SHOWING THE LOCATION OF THE SHINARUMP NO. 1 MINE AREA AND THE DISTRIBUTION OF URANIUM DEPOSITS IN THE SHINARUMP AND CHINLE FORMATIONS

The nearest igneous rocks crop out in the La Sal Mountain laccolith about 20 miles to the southeast. The major structural features are the Moab anticline and Moab fault. The general geology of the surrounding area is given by McKnight (1940). Below is a brief discussion of the stratigraphy and structure of the Shinarump No. 1 mine area.

## Stratigraphy

In the Shinarump No. 1 mine area, the Permian Cutler formation, Triassic Moenkopi, Shinarump, and Chinle formations, and Jurassic (?) Wingate sandstone form an escarpment along the west side of the Moab fault. The Upper Jurassic Morrison formation on the east side of the fault has been faulted against the Cutler formation. Thus, in the area mapped, Jurassic rocks between the Wingate and Morrison are not exposed. A measured section of the rocks near the mine is included as Appendix A of this report.

### Cutler formation

Only the upper 66 feet of the total 1,000 feet or more of the Permian Cutler formation is exposed in the area mapped. The exposed Cutler consists of medium- to coarse-grained sandstone and muddy sandstone and pale-red shale. Bleaching along fractures and bedding planes is common. Cross-laminated sandstone forms a prominent rounded ledge near the top of the Cutler. Locally along the Moab anticline an angular and erosional unconformity exists between the overlying Lower Triassic Moenkopi and the Cutler. However, the contact between Triassic and Permian rocks in the Shinarump No. 1 mine area is difficult to determine.

### Moenkopi formation

The Lower Triassic Moenkopi formation is 20 feet thick in the measured section near the Shinarump No. 1 mine (Appendix A) and pinches out about 450 feet to the north. A few miles south, the Moenkopi attains a thickness of about 450 feet. Thin-bedded shale and mudstone, and massive sandstone make up the Moenkopi beds. A distinct moderate reddish-brown color, abundance of mica, and ripple-marking characterize the Moenkopi. The overlying Upper Triassic beds were deposited on an erosional surface formed on the Moenkopi and, in places, on the Cutler.

### Shinarump conglomerate and Chinle formations

The Upper Triassic Shinarump conglomerate is absent in most of the area mapped. McKnight showed that the Shinarump conglomerate pinches out along an irregular east-west line about 15 miles north of the intersection of the Green and Colorado Rivers, and only isolated outcrops of Shinarump conglomerate were mapped north of this line. One such isolated outcrop was mapped in the vicinity of Little Canyon (fig. 2). The Shinarump conglomerate in Little Canyon ranges from 5 to 10 feet in thickness and consists of a friable, white, coarse-grained to conglomeratic quartz sandstone. The Shinarump becomes discontinuous and lenticular near the northern edge of this outcrop. The Chinle siltstone and fine-grained sandstone truncate many of the Shinarump lenses. In an open cut adjacent to the Shinarump No. 1 mine, a white coarse-grained to conglomeratic quartz sand lens corresponding to the Shinarump conglomerate is truncated by the fine-grained sediments containing the ore deposit. Thus, the Shinarump north of the main area of deposition was deposited as small thin lenses or channel-fills and was, at least in part, removed before or during the deposition of the overlying Chinle.

The Upper Triassic Chinle formation is 297 feet thick in the section measured at the mine. In the Seven Mile Canyon area, the Chinle formation may be divided into a lower and an upper member. The base of a prominent ledge of fine-grained sandstone and limestone pebble conglomerate that is characterized by slump-bedding, marks the division of the two members. The lower member is composed of thin- and irregular-bedded light-green to pale-red siltstone, sandstone, and limestone pebble conglomerate. Much of this member is covered by talus. A limestone pebble conglomerate bed about 10 feet above the base of the Chinle serves as a "marker bed" in the Shinarump No. 1 mine area (see section A-B-C, fig. 2). The upper member is composed mostly of pale-red shale and sandstone which forms for the most part a covered slope. Near the Moab anticline, the contact between the Chinle and the Wingate sandstone is a local unconformity.

Many of the uranium deposits in the area between the Green and Colorado Rivers lie near the northern edge or north of the pinchout of the Shinarump conglomerate (fig. 1). In the Seven Mile Canyon area, the uranium deposits lie north of the Shinarump outcrop in Little Canyon. Thus, the uranium deposits are related to the edge of Shinarump deposition on a regional and local scale.

Uranium-bearing rock in the Seven Mile Canyon area is found in many zones in the lower member of the Chinle, but the ore deposits are found mainly in three zones in the lower 25 feet of the Chinle (section A-B-C, fig. 2). The Shinarump No. 1 mine is in the lowermost ore zone.

### Jurassic rocks

The Jurassic (?) Wingate sandstone consists of massive yellowish-gray fine-grained sandstone that weathers pale red and is characterized by surface coatings of black desert varnish. In the Seven Mile Canyon area the Wingate, which forms a massive cliff, is over 200 feet thick.

In the vicinity of the Shinarump No. 1 mine the Brushy Basin member of the Upper Jurassic Morrison formation is faulted against the Permian and Triassic rocks. The Brushy Basin consists mainly of light-green mudstone. Boulders of the Cretaceous Burro Canyon or Dakota formations cover some of the Brushy Basin slope.

## Structure

The Shinarump No. 1 mine is located on the west flank of the Moab anticline and is about 700 feet west of the Moab fault. The beds strike N. 15° E. and dip 8° NW. at the mine. The joints occur in two sets, one major set strikes N. 5°-75° W. and dips 50° NE. to vertical, and a minor set strikes N. 35°-70° E. and dips 70° SE. to vertical.

The Moab anticline, a result of salt intrusion, extends about 15 miles northwest of the Colorado River. The Moab fault, a normal fault, lies a short distance southwest of the crest of the Moab anticline. The fault extends about 30 miles northwest from the Colorado River and has a general trend of about N. 45° W. nearly parallel to the axis of the Moab anticline. In the Shinarump No. 1 mine area, the fault has a maximum displacement of about 1,800 feet and dips about 65° NE. It makes a gentle turn to the west near the Shinarump Nos. 1 and 3 mines.

The Moab anticline was in existence at the end of the Permian as shown by the angular and erosional unconformity between the Moenkopi and Cutler formations. McKnight reports that the deformation was renewed in mid-Triassic, prior to the deposition of the ore-bearing Chinle beds, and was resumed once again during the Laramide orogeny at the end of the Cretaceous. However, Stokes and Phoenix (1948) and Shoemaker (1951), find in similar structures on the Colorado Plateau, that the intrusion of salt was continuous from Permian to Upper Jurassic. The author believes that the Moab anticline had a similar history. McKnight correlates the faulting along the Moab Valley anticline with the normal faulting of the Wasatch Plateau that is later than pre-Eocene folding and is possibly late Tertiary. The Moab fault may be related to the Laramide orogeny or the collapse of the salt structures later in the Tertiary or Quaternary periods. Field relations are so obscure that the dating of the Moab fault is uncertain.

## HISTORY AND PRODUCTION

The Shinarump No. 1 mine was discovered in February 1948 by Gordon Babbel and Nicholas Murphy of Moab, Utah. During the following year claims were staked throughout the Seven Mile Canyon area. A few tons of ore were shipped in 1949. The mines were idle during 1950. In 1951, mining from several prospects was resumed and since then has been continued intermittently. Over a thousand tons of ore were shipped from the Shinarump No. 1 mine between 1948 and January 1953. The Shinarump Nos. 1, 3, and 4 mines are owned by the Thornburg Mining Company, Grand Junction, Colorado.

## ORE DEPOSITS

Copper-bearing rocks occur separate from uranium-bearing rocks in the Shinarump No. 1 mine area. Copper-bearing rock is found along the Moab fault and in a talus block that is thought to be Dakota sandstone of Cretaceous age. Copper carbonates are found along fractures and bedding planes as well as disseminated in sandstone in a prospect in the talus block. Fractured rock along the fault in an abandoned shaft at the base of the talus block contains copper carbonates. The copper prospects are not commercial in size or grade. No uranium is associated with the copper.

The uranium-bearing material in the Shinarump No. 1 mine area occurs mainly in three zones in the lower 25 feet of the Chinle formation. The zones include, in ascending order, a basal siltstone unit, the top of the overlying limestone-pebble conglomerate "marker bed", and an irregular dominantly siltstone zone 5 to 10 feet above the conglomerate (fig. 2).

The highest zone consists of small calcareous nodules of rich concentrations of uranium minerals associated mainly with wood and carbonaceous trash in greenish siltstone and minor limestone-pebble conglomerate beds. Some wood is almost completely replaced by uraninite which, in places, has been altered to becquerelite. If the frequency of occurrence of nodules is great enough, an economic deposit results. At the Shinarump No. 3 mine (fig. 2) this zone, although discontinuous, is as much as 3 feet thick.

The middle zone is in the upper part of the conglomerate "marker bed". Limestone pebbles are rimmed and, in part, replaced by uraninite. This conglomerate is mineralized north of the Shinarump No. 1 mine (fig. 2). Most of the uranium-bearing material in these two zones is associated with calcite nodules or limestone pebbles and gray or green rock.

The Shinarump No. 1 mine is in the lowermost ore zone. The zone is made up mostly of siltstone with some interbeds of mudstone, sandstone, and conglomerate. It ranges from 5 to 10 feet in thickness. Where this zone is mineralized, the beds are bleached from red to gray and green. The bleaching of the ore-bearing beds extends from 1 to 15 feet laterally beyond the limits of the deposit and the bleached area is, in general, saucer shaped. The limestone-pebble conglomerate "marker bed" is fairly uniform and massive throughout the area except above the Shinarump No. 1 deposit and above the deposit in the lower uranium-bearing zone at the Shinarump No. 4 prospect. The thinning and less massive character of this "marker bed" above the deposits in the lower zone may be significant in prospecting for ore in the Seven Mile Canyon area.

On the basis of the major metal content, uranium deposits of the Colorado Plateau may be divided into vanadium-uranium, copper-uranium, and uranium _ore_ deposits. The Shinarump No. 1 deposit contains only minor amounts of copper and vanadium and thus, is a uranium _ore_ deposit. Oxidation of the uranium _ore_ deposits such as the Shinarump No. 1 is generally slight and deposits of this type are less obvious to the prospector because secondary uranium minerals are scarce at the outcrop.

## MINERALOGY

Other writers have studied the mineralogy of the Seven Mile Canyon area (Weeks, 1952, and Rosenzweig in report by Droullard and Jones, 1952). Only the mineralogy of the Shinarump No. 1 mine is discussed here.

Uraninite (pitchblende), $UO_2$, is the principal uranium mineral. It occurs as microscopic grains mixed with chalcocite and other sulfides replacing carbonaceous material and disseminated in siltstone. Rich concentrations of uraninite occur in seams as much as a half an inch thick along bedding planes.

Some uraninite is slightly altered to a burnt-orange material resembling gummite. Halos of this material are present about unaltered uraninite. Schroeckingerite $NaCa_3(UO_2)(CO_3)_3(SO_4)F \cdot 10H_2O$, a pale yellowish-green mineral, and becquerelite $2UO_3 \cdot 3H_2O$, a yellowish-orange mineral occur along fractures and bedding planes near the edges of the deposit nearest the surface. No secondary vanadium-uranium minerals were found.

The sulfides present in the ore are chalcocite, pyrite, bornite, chalcopyrite, and blue chalcocite (digenite ?, solid solution of covellite and chalcocite). All the sulfides, except the blue chalcocite, occur as scattered grains in both barren and uranium-bearing rock. Chalcocite and pyrite are more abundant in the uranium-bearing rock. Uraninite is associated with all the sulfides but most commonly with pyrite and chalcocite. Although much of the chalcocite looks like galena, no galena was found in this study. Some malachite is found coating chalcocite.

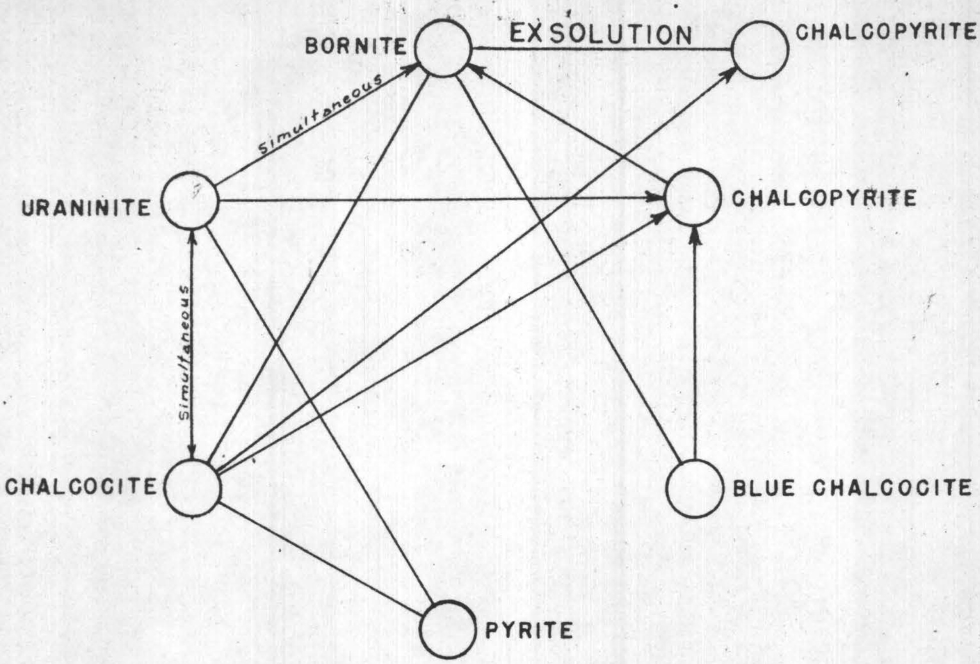
Gangue materials include barite, calcite, gypsum, and carbonaceous matter. Carbonaceous matter in the form of leaves, twigs, and small pieces of wood is most abundant right above the uranium-bearing beds. There is no megascopic difference in the physical properties of barren and radioactive carbonaceous matter. Limonite is rare whereas hematite is abundant in places.

In both barren and uranium-bearing rock, the quartz has been etched and crushed. Bornite, chalcocite, pyrite, uraninite, calcite, and barite are later than etching. Fractures in crushed quartz are either void or contain calcite. Uraninite, pyrite, and chalcocite are associated with poorly sorted parts of a rock and, in general, follow bedding planes. Stringers of these minerals wrap around and are deflected by the large quartz grains. Many blebs of uraninite and pyrite are zoned with the uraninite forming rims about fine-grained pyrite. Pyrite was observed in very fine fractures in siltstone. Chalcocite occurs in vertical veinlets as much as half a millimeter wide that strike east-west. Nuclear-track plates on thin-sections of these veinlets indicated the absence of radioactive minerals. However, copper and uranium minerals extend outward along bedding planes away from these fractures. Calcite and more rarely barite have filled voids in the rock.

Paragenesis of uraninite and sulfides from the Shinarump No. 1 mine is given in figure 3. The conventional line diagram is shown with the circular diagram (Robertson and Vandeever, 1952) to compare the two methods of showing paragenesis. The circular diagram shows the minerals observed in contact; pyrite, for example, was observed in contact with only uraninite and chalcocite. The line diagram shows that some pyrite is later than chalcopyrite even though the two were never observed in contact. It is difficult to show two groups of simultaneous minerals in the circular diagram. The two diagrams, thus, complement each other.

In general, in the Shinarump No. 1 deposit uraninite is later than or simultaneous with most sulfides. Chalcocite may be of two ages with some being later than uraninite. Rosenzweig (Droullard and Jones), writing about the Seven Mile Canyon area, states: "It appears that the time of formation of the copper sulfides followed closely or possibly overlapped that of uraninite." Thus, the paragenetic relationship of uraninite and sulfides in the Shinarump No. 1 deposit found by this study is not in complete agreement with the Seven Mile Canyon area taken as a unit.

Photomicrographs in figure 4 show some of the paragenetic relationships. Chalcocite cross-cutting uraninite that has completely replaced wood is shown in photomicrograph A. Photomicrographs C and D show the relationship of etched quartz grains, uraninite, and chalcocite. Note the uraninite-free areas surrounding the etched quartz grains. A peripheral line of uraninite is concentric with the shape of the etched quartz grain. Stringers of uraninite radiate from these peripheral lines. It appears that cracks may have formed in the chalcocite which were later filled with uraninite. Other, but less likely, explanations are that these crack fillings represent the replacement of crushed or distorted cellular structure of wood or that chalcocite replaced quartz grains in places and the uraninite replaced the interstitial clay material.



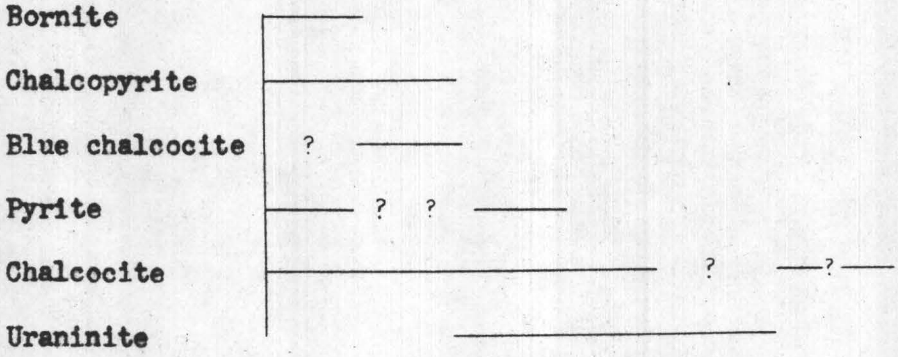

——————Simultaneous deposition.

Simultaneous ——→Simultaneous with replacing tendency shown by arrows.

——————→Replacement, example: chalcopyrite replacing bornite.

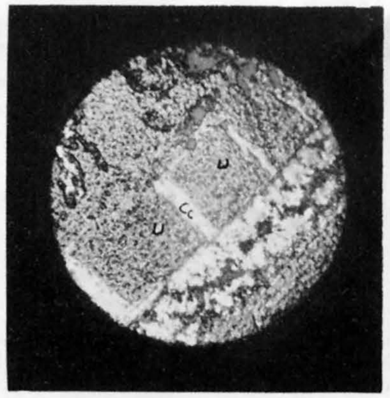
Note - Lines connect only those minerals observed in contact.
Minerals arranged clockwise in approximate order of deposition.
Modified after Robertson and Vandeever (1952)

(A)

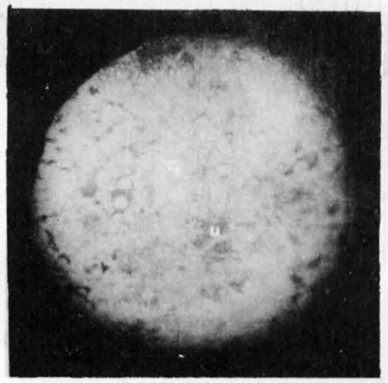



(B)

Figure 3. PARAGENESIS OF URANINITE AND SULFIDE MINERALS, SHINARUMP NO. 1 MINE, GRAND COUNTY, UTAH

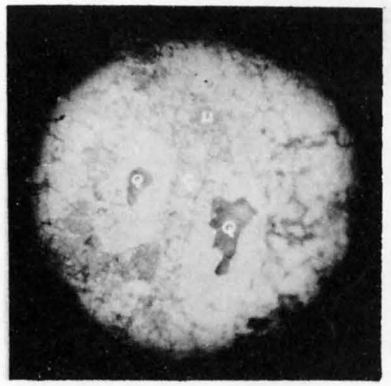


A. X8

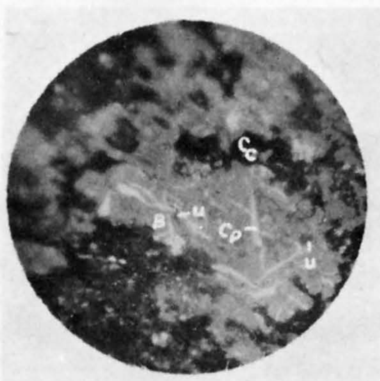


B. X95

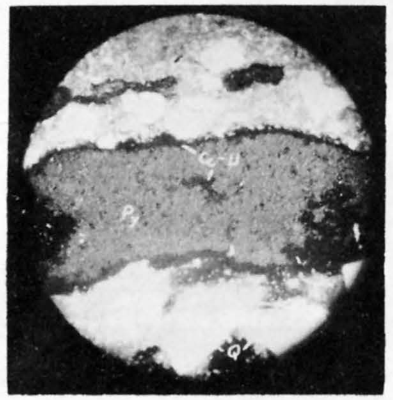

C. X52



D. X95




E. X340




F. X20

A. Polished section of sample No. 22 showing replacement of wood by uraninite (U, light gray) and chalcocite (Cc, white). About X8 magnification.

B. Polished section of sample No. 23 showing relation of chalcocite (Cc, white) and uraninite (U, dark gray). About X95 magnification.

C & D. Polished section of sample No. 23 showing etched quartz (Q, dark gray) grains surrounded by chalcocite (Cc, white) which is free of uraninite (U, light gray) and uraninite filling minute cracks in chalcocite which are oriented radially about the quartz. About X52 and X95 magnification, respectively.

E. Polished section of sample No. 26 showing a texture interpreted as caused by exsolution of chalcopyrite (Cp, white) in bornite (B, light gray), replacement of bornite by chalcocite (Cc, dark gray), and uraninite (U, medium gray) cutting all other minerals. About X340 magnification.

F. Thin section of sample No. 5 with reflected and transmitted light showing bleb of minerals, pyrite (Py, light gray) surrounded by border of chalcocite and uraninite (Cc-U, black) in sandstone. Note encroachment of quartz, (Q, white) by ore minerals. About X20 magnification.

Figure 4. PHOTOMICROGRAPHS OF POLISHED AND THIN SECTIONS FROM SHINARUMP NO. 1 MINE, GRAND COUNTY, UTAH

53323

Photomicrograph E shows a texture interpreted as caused by the exsolution of chalcopyrite in bornite. Photomicrograph F of a thin section of sample No. 5 shows the zoning of uraninite and chalcocite about a pyrite core.

Blue chalcocite, observed in one polished section, may be digenite which is a solid solution of covellite and chalcocite. However, the common digenite texture is absent. Wandke (1953) points out that if the specimen is heated above 68° C, during the preparation of the sample, digenite may be formed from covellite and chalcocite. However, covellite was not observed, so that either all covellite was adjacent to chalcocite and transformed or digenite was present before preparation of the sample. The author prepared the specimens in sealing wax which may not have heated the specimen above the critical temperature. The problem of blue chalcocite (digenite ?) is important from the standpoint of temperature of ore formation (Buerger 1941).

## PETROLOGY

Samples of barren and uranium-bearing rock from the Shinarump No. 1 mine (table 1) were studied in thin section, slides of light and heavy grains, and by size analysis. In general, the ore-bearing rocks are siltstone and fine-grained sandstone that are more poorly sorted than the barren siltstone and fine-grained sandstone. Barren rocks include siltstone, fine- to coarse-grained sandstone, limestone-pebble conglomerate, and mudstone. Reworked Moenkopi siltstone and sandstone in the form of pebbles and grains are common in many beds. Visually, packing is good in both barren and ore-bearing rocks. Calcite and clayey material cements barren and ore-bearing rock. In general, the grains are subangular to well-rounded. Angular and broken feldspar is abundant in one uranium-bearing siltstone.

The composition of light constituents, specific gravity less than 2.9, of the uranium-bearing and barren Chinle samples is mostly quartz and chert. Minor amounts of microcline, muscovite, orthoclase, and oligoclase are present. Some chert grains contain pyrite cubes. Heavy nonopaque detrital minerals, specific gravity greater than 2.9, include mostly zircon, tourmaline, and biotite with minor amounts of rutile, chlorite, spinel, garnet, and staurolite. Opaque detrital minerals include ilmenite, leucoxene, and hematite. Authigenic barite is abundant in both barren and uranium-bearing rock and has been precipitated in open spaces. Counts of the heavy detrital minerals from barren and uranium-bearing samples show no correlation of any mineral or group of minerals with uranium-bearing rock.

Table 1.--List of samples from Seven Mile Canyon area

| Sample No. | Specific location _/ | Description |
|---|---|---|
| 1 | Wall MN | Uranium-bearing unbleached siltstone stringers |
| 2 | Wall MN | Uranium-bearing sandstone; very fine- to coarse-grained |
| 3 | Wall MN | Limy siltstone |
| 4 | Wall GH | Highly radioactive carbonaceous material |
| 5 | Wall MN | Uranium-bearing muddy siltstone |
| 6 | Wall MN | Uranium-bearing silty sandstone |
| 7 | Wall MN | Uranium-bearing siltstone |
| 8 | Wall CD | Uranium-bearing silty sandstone |
| 9 | Wall CD | Uranium-bearing siltstone |
| 10 | Wall EF | Muddy siltstone; forms back of mine |
| 11 | Wall EF | Limestone pebble conglomerate above ore |
| 12 | Wall MN | Uranium-bearing siltstone |
| 13 | Wall EF | Limy sandstone below ore |
| 14 | Wall EF | Barren siltstone |
| 15 | Wall CD | Uranium-bearing siltstone north of fracture |
| 16 | Wall CD | Barren siltstone north of fracture |
| 17 | Wall CD | Altered siltstone south of fracture |
| 18 | Wall CD | Unaltered siltstone south of fracture |
| 19 | Wall IJ | Nonradioactive carbonaceous material |

_/ Figure 9 unless otherwise noted.

Table 1.--List of samples from Seven Mile Canyon area--Continued

| Sample No. | Specific location_/ | Description |
| --- | --- | --- |
| 20 | Copper Queen (fig. 2) | Secondary copper minerals in Moab fault zone |
| 21 | Copper prospect (fig. 2) | Copper-bearing material from Moab fault zone |
| 22 | 20 feet N. 3° W. of Station R (fig. 8) | Fractures filled with chalcocite |
| 23 | 28 feet N. 11° W. of Station R (fig. 8) | Uraninite and chalcocite layer |
| 24 | Wall CD | Conglomerate below ore |
| 25 | Kellog No. 1 claim (fig. 2) | Uranium-bearing sandstone from the Morrison formation |
| 26 | Third stope from left (fig. 8) | Uraninite, bornite, chalcocite in seam |
| 27 | North portal (fig. 8) | Barren Chinle siltstone |
| 28 | North portal (fig. 8) | Barren Shinarump sandstone |
| 29 | Wall IJ | Uranium-bearing siltstone, chalcocite veins |
| 30 | Wall KL | Uranium-bearing siltstone and sandstone |
| 31 | Little Canyon (fig. 2) | Shinarump conglomeratic sandstone |

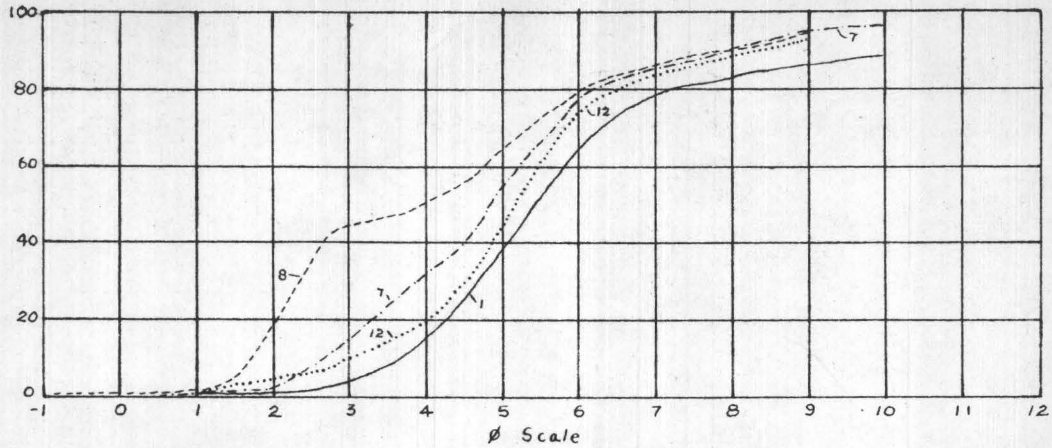
_/ Figure 9 unless otherwise noted

X-ray spectrometric determinations of material smaller than 4 microns, from barren and ore-bearing samples made by the Trace Elements Laboratory of the Geochemistry and Petrology Branch of the Geological Survey, indicate the presence of quartz (fine cryptocrystalline ?), hydromica, and kaolin in every sample. Small amounts of feldspar, calcite, dolomite, chlorite, and montmorillonite are present in some samples.

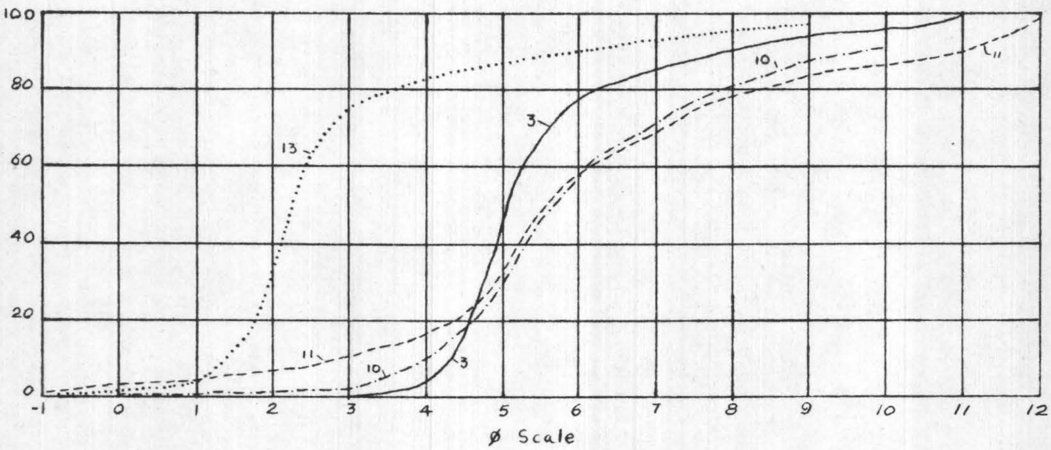
Results of size analysis are shown in figures 5, 6, and 7. Sample No. 31 (figs. 5C and 6C) is from the Shinarump conglomerate in Little Canyon (fig. 2). Sample No. 28 (figs. 5C and 6C) is taken near the mine from a lens of similar sandstone which has been eroded and cut out by the overlying ore-bearing siltstone of the Chinle. The frequency and cumulative curves of the two samples are similar. The suite of heavy minerals from the two samples is identical but different than the suite from the Chinle samples. It is concluded that the lens near the mine is an erosional remnant of Shinarump near the margin of Shinarump deposition. The coarse grains in several samples cause bimodal frequency curves (fig. 6A, samples 7 and 8, fig. 6C, sample 24). This suggests a source for the coarse grains similar to the Shinarump or suggests that the coarse grains came from the Shinarump that was, in part, eroded before the deposition of the Chinle. Uranium-bearing samples are more poorly sorted than barren samples.

A special study was made on a single siltstone bed along wall C-D (fig. 9). The purpose of this study was to find what changes might be present in a bed which has been mineralized and bleached. A fracture between the uranium-bearing rock and the unaltered rock is parallel to the truncated ore as well as the line between bleached and unbleached rock. The possible effect of this fracture on mineralization was also studied. The results of the size analysis of 4 samples are given in figure 7. The frequency curves and thin section study show the siltstone to be poorer sorted to the north, on the mineralized side, of the fracture, than to the south. Study of the light and heavy detrital minerals shows no correlation of any mineral or group of minerals with the uranium-bearing part of the siltstone. However, spectrographic analysis of these samples indicates a marked increase of some elements in uranium-bearing rock over barren rock but no difference between bleached and unbleached rock. The increase of some elements in uranium-bearing rock is not reflected as a halo about the uranium-bearing rock. The position of the fracture with relation to uranium-bearing and bleached rock is probably a coincidence as the spatial relationship of this fracture along strike shows no similar relationship to uranium-bearing or barren rock.

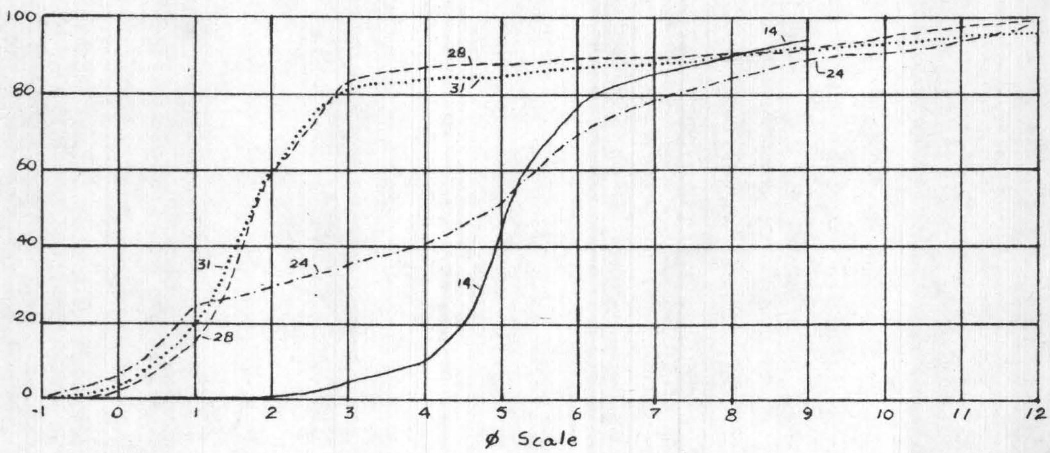
The results of the petrographic study show the uranium-bearing rock to be more poorly sorted than barren rock. Detrital grains in the uranium-bearing and barren rock are essentially the same in mineralogy and quantity. The mineralogy of the coarse fractions of the ore-bearing beds indicate original source rocks to be schists and acid to intermediate igneous rocks. The ore-bearing beds are thought to be mostly second-cycle and, in some part, third-cycle sediments.




A. Ore-bearing Chinle samples




B. Barren Chinle samples




C. Barren Chinle (Nos. 14 and 24) and Shinarump (Nos. 28 and 31) samples

**Figure 5. CUMULATIVE CURVES OF SAMPLES FROM THE SEVEN MILE CANYON AREA, GRAND COUNTY, UTAH**

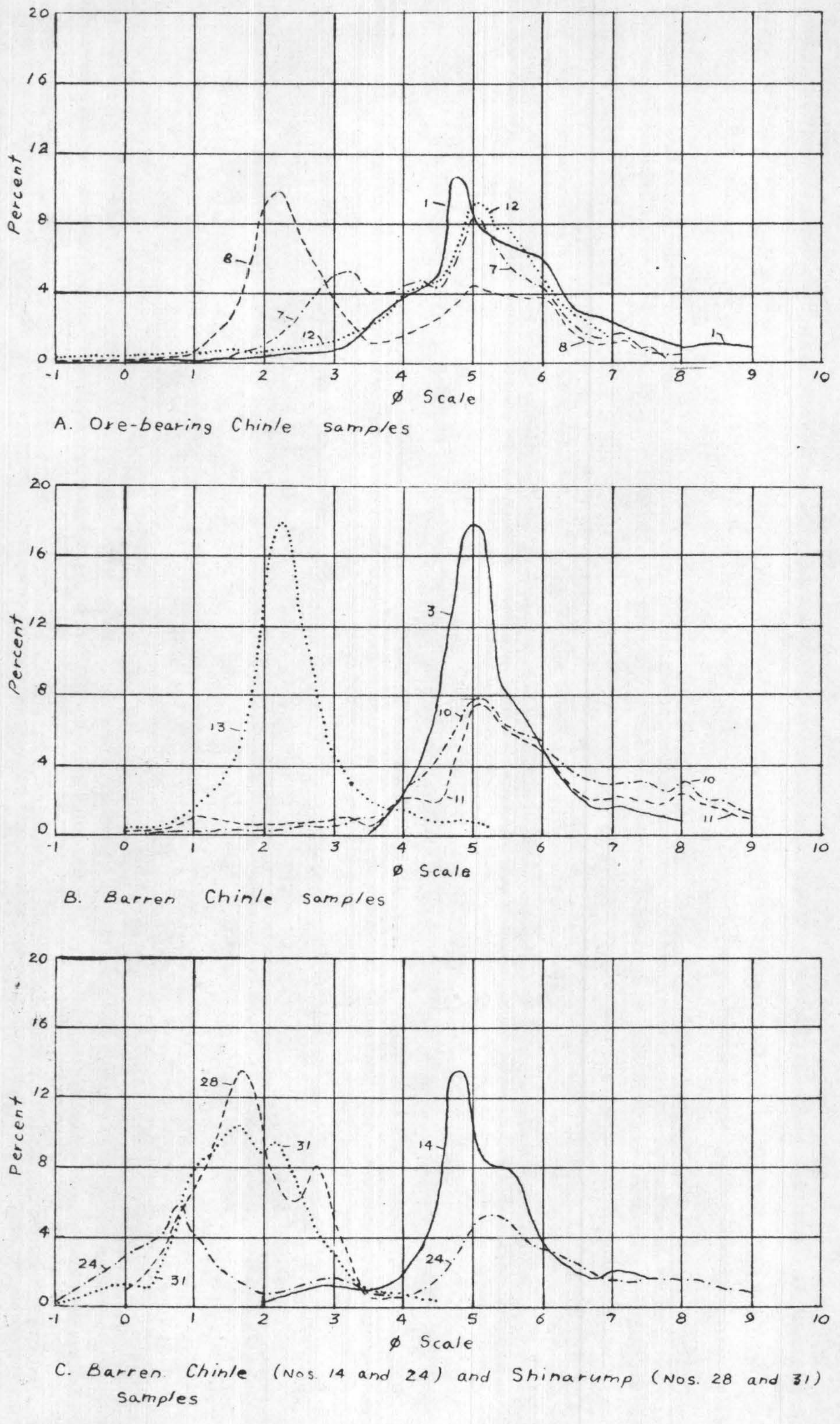



**Figure 6. FREQUENCY CURVES OF SAMPLES FROM THE SEVEN MILE CANYON AREA, GRAND COUNTY, UTAH**

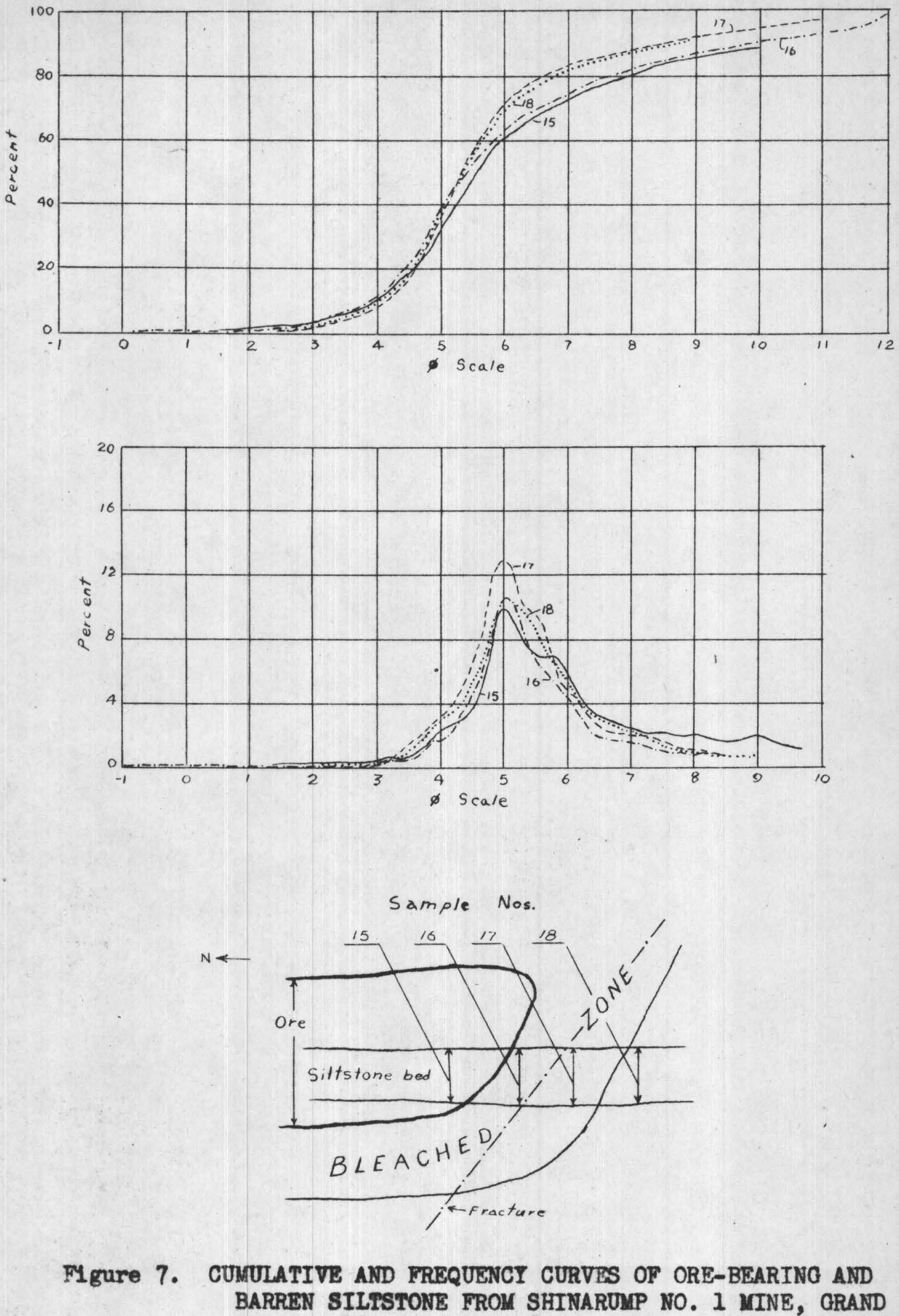



Figure 7. CUMULATIVE AND FREQUENCY CURVES OF ORE-BEARING AND BARREN SILTSTONE FROM SHINARUMP NO. 1 MINE, GRAND COUNTY, UTAH. (SKETCH AFTER WALL MAP C-D)

## HABITS OF ORE BODIES

The Shinarump No. 1 mine was mapped in plan on a scale of 1 inch equals 20 feet (fig. 8) and maps of walls and faces were made on a scale of 1 inch equals 5 feet (fig. 9). Sample locations are shown in figures 2 and 8. Uranium minerals are not generally visible, so a Geiger counter was used to outline the extent of uranium-bearing rock. Arbitrary cutoffs in counts-per-minute were used to appraise the uranium values of the mine as stated in figure 8.

The uranium-bearing rock is almost a continuous lenticular layer that, in general, follows the bedding but locally and in small detail cuts across the bedding. Ore-grade material is in discontinuous lenses which tend to be elongate about north-south. The ore averages 1 or 2 feet thick with a maximum thickness of about 5 feet. The grade of the ore ranges from 0.10 percent to 1.00 percent $U_3O_8$ with small masses greater than 1.00 percent $U_3O_8$. Near the edges of the deposit, the ore layer tends to rise in the beds so that the deposit in cross-section is saucer shaped (wall maps AB, CD, fig. 9). The north edge of the deposit has an east-west trend. The ore-bearing beds are essentially flat lying and fill irregularities of an erosional surface. Structural contours on the top of the Moenkopi indicate that no channel scour is present in the vicinity of the mine.

Most of the deposit is composed of siltstone and fine-grained sandstone impregnated with microscopic grains of uraninite, chalcocite, and pyrite. High-grade layers as much as half an inch in thickness of chalcocite and uraninite are found along some bedding planes. In one case, the high grade ore is concentrated along the base of a bed that overlies a less permeable appearing bed (fig. 9, wall map IJ). Vertical veinlets of chalcocite lead upward to this concentration.

The original color of sediments that contain the deposit is thought to have been red and altered later by solutions which may have deposited the ore. The only apparent change brought about by the alteration was a bleaching of red to gray and green. The bleaching extends 1 to 15 feet beyond the limits of the mineralized rock. Locally the limit of bleaching parallels the shape of the mineralized layers in detail.

Prospecting guides to additional ore deposits similar to the Shinarump No. 1 in the Seven Mile Canyon area are (1) presence of bleached siltstone; (2) presence of copper sulfides, especially chalcocite;

(3) presence of carbonaceous matter; and (4) thinning of the limestone-pebble conglomerate "marker bed". The last ore guide is probably only of local importance.

## SPECTROGRAPHIC STUDY

Semiquantitative spectrographic analysis of 20 samples were analyzed statistically 1/. The geometric mean values in percent of 32 elements contained in groups of samples from barren and uranium-bearing rock from the Shinarump No. 1 mine, copper-bearing rock from nearby copper prospects in the Moab fault, and uranium-bearing rock from the Kellog No. 1 mine (fig. 2) in the Morrison formation are shown in table 2. Twenty-six other elements were tested for but were not detected. In all groups of samples, common rock forming elements show no systematic variation. Comparison of barren and uranium-bearing rock from the Shinarump No. 1 mine shows a substantial increase in the uranium-bearing rock of the elements boron, beryllium, cobalt, copper, gallium, molybdenum, nickel, lead, silver, uranium, vanadium, yttrium, and zinc. In the uranium-bearing samples of the Shinarump No. 1 mine, mean values for barium, copper, vanadium, and titanium are as high as the grade of much of the uranium ore produced from the mine. Although based on few samples, the copper deposits show affinities to the barren rock at the Shinarump No. 1 mine except for the element silver. The values from a single sample from the Kellog No. 1 mine in the Morrison formation show similarities to the uranium-bearing rock from the Shinarump No. 1 mine.

Selenium content cannot be determined by spectrographic methods but it is suspected to be present in considerable quantity near the uranium and copper mines and along the Moab fault because selenium and sulfur indicator or tolerant plants are present in these areas.

---

1/ Reported assays of semiquantitative spectrographic analysis were made by the Denver Trace Elements Laboratory of the Geochemistry and Petrology Branch of the Geological Survey. The assays that are normally expressed in groups of powers of 10 were reported in subgroups whose theoretical range is shown in Appendix B. The geometric mean was obtained by applying a simple formula, which may be found in any elementary text on statistics, such as Waugh (1943), to the midpoints of the subgroups (class marks).

Table 2.--Geometric mean values (in percent) of elements contained in barren and uranium-bearing rock from the Shinarump No. 1 mine, copper-bearing rock from nearby copper deposits, and uranium-bearing rock from a nearby deposit in the Morrison formation.

| Element | Chinle barren rock 1/ | Chinle uranium-bearing rock 2/ | Copper-bearing rock 3/ | Morrison uranium-bearing rock 4/ |
|---|---|---|---|---|
| | Geometric mean in percent calculated from spectrographic analysis | | | |
| Si | 30 | 30 | 30 | 30 |
| Al | 2 | 4 | 2 | 0.3 |
| K | 1 | 2 | 0.4 | 0.3 |
| Na | 0.1 | 0.3 | 0.07 | 0.06 |
| Fe | 1 | 2 | 0.5 | 2 |
| Mn | 0.03 | 0.02 | 0.03 | 0.03 |
| Ca | 5 | 2 | 2 | 2 |
| Mg | 0.6 | 1 | 0.2 | 0.3 |
| Ba | 0.07 | 0.2 | 0.1 | 0.02 |
| Sr | 0.02 | 0.03 | 0.007 | 0.02 |
| Ti | 0.2 | 0.2 | 0.06 | 0.2 |
| Zr | 0.02 | 0.04 | 0.02 | 0.02 |
| Cr | 0.006 | 0.01 | 0.002 | 0.02 |
| Ga | 0.0004 | 0.002 | 0 | 0.0002 |
| Sc | 0.002 | 0.002 | 0 | 0 |
| La | D5/ | 0 | 0 | 0 |
| Be | 0.0001 | 0.001 | 0 | 0 |
| B | 0.01 | 0.05 | 0.005 | 0.006 |
| Y | 0.002 | 0.01 | 0.001 | 0.003 |
| Ce | D5/ | 0 | 0 | 0 |
| Nd | D5/ | 0 | 0 | 0 |
| V | 0.02 | 0.2 | 0.03 | 0.2 |
| Ni | 0.0009 | 0.008 | 0.002 | 0.003 |
| Co | 0.0003 | 0.008 | 0.002 | 0.02 |
| Cu | 0.05 | 0.2 | 5 | 2 |
| Pb | 0.002 | 0.03 | 0.003 | 0.6 |
| Zn | 0 | 0.03 | 0 | 0.2 |
| Cd | 0 | D5/ | 0 | 0.003 |
| Mo | D5/ | 0.003 | 0.001 | 0.02 |
| Sn | 0 | D5/ | 0 | 0 |
| Ag | D5/ | 0.0007 | 0.002 | 0.02 |
| U | 0 | 1.00 | 0 | 0.06 |

Looked for but not found: As, Au, Bi, Ce, Ge, In, Ir, Hf, Hg, Li, Nb, Os, P, Pd, Pt, Re, Rh, Ru, Sb, Sm, Ta, Te, Th, Ti, Yb, and W.

1/ Result of 10 samples from Shinarump No. 1 mine.
2/ Result of 7 samples from Shinarump No. 1 mine.
3/ Result of 2 samples.
4/ Values of 1 sample.
5/ Detected (D) in too few samples to take geometric mean.

Chemical and radioactivity analysis of uranium shows the uranium ore to be nearly in equilibrium. This equilibrium and the general lack of secondary minerals indicate that the ore is relatively unoxidized and that ground water has had little effect upon the ore.

High radioactivity is found in some seams of carbonaceous material. Comparison of the spectrographic analysis of megascopically identical relatively nonradioactive with highly radioactive carbonaceous materials (sample Nos. 19 and 4, respectively) shows the radioactive carbonaceous material to contain at least one order more of barium, zinc, cobalt, nickel, uranium, and silver. This is similar to the differences in the mean metal values of barren and of uranium-bearing rock. However, in the radioactive carbonaceous material, the values of these elements are high; barium assays about 30 percent, zinc assays about 5 percent, and cobalt and nickel assay over 1 percent. The great inequilibrium of the radioactive carbonaceous material indicated by the comparison of 6.6 percent equivalent value for uranium and 0.17 percent chemical value for uranium is due to radon. The relatively nonradioactive carbonaceous material is nearly in equilibrium.

The results of the spectrographic analyses indicate that the solutions which deposited the copper in the Moab fault zone were probably different than those which deposited the uranium in the Chinle and Morrison formations. The uranium-bearing solutions probably contained important amounts of barium, vanadium, uranium, and copper as well as lesser amounts of strontium, chromium, boron, yttrium, lead, and zinc. The abundance of sulfide minerals in the deposits indicate that the solutions were probably reducing in character and sulfur rich.

## AGE DETERMINATIONS OF URANINITE

The following is a resumé of the results of "The lead-uranium age determinations of some uraninite specimens from Triassic and Jurassic sedimentary rocks of the Colorado Plateau" by Stieff and Stern (1953). As part of their study on the origin of uranium deposits in the Triassic and Jurassic sedimentary rocks of the Colorado Plateau, 21 samples of uraninite from 13 deposits were collected for $Pb^{206}/U^{238}$ age determinations. These uraninites are believed to be the most reliable of more than 100 samples from the Plateau on which age determinations have been made. The average age of the uraninites from the Morrison is lower by a factor of two than the best estimate of the age for the Morrison formation. The average age of the uraninite samples, one from Shinarump No. 1 mine (fig. 8), from the Shinarump conglomerate is lower by a factor of three than the best estimate of the age of the Shinarump conglomerate. The average age of samples from the Upper Jurassic formation does not differ significantly from the average age of samples from the Lower Triassic Shinarump conglomerate. The average age of samples from the two formations is in very close agreement with the best available estimates for the age of the end of the Cretaceous or the beginning of the Tertiary.

Stieff and Stern conclude that:

> "Most of the lead-uranium data that we have obtained strongly suggests that the deposits are not syngenetic but were emplaced in the sediments during the Tertiary, long after the enclosing sediments were laid down. If, however, the deposits are syngenetic in origin, an event must have occurred at the end of the Cretaceous or during the Tertiary which completely redistributed the uranium and localized the ore in its present sites."

## ORIGIN OF DEPOSIT

For many years the uranium deposits on the Colorado Plateau, which included mostly oxidized vanadium-uranium ore deposits (carnotite-type) of the Morrison and Shinarump formations, were considered to have been formed shortly after the deposition (penesyngenetically) of the enclosing sediments (Fischer, 1942). Due to concentrated investigations, however, during the past several years and the discovery of relatively unoxidized uranium deposits of the vanadium-uranium, copper-uranium, and uranium-ore types in many different formations of the Colorado Plateau and adjoining regions, several hypotheses that had been discarded previously are being reconsidered. These include: hydrothermal origin, downward leaching of uranium from volcanic strata, and petroliferous origin. A brief statement of the fundamentals of each of the hypotheses follows.

The penesyngenetic hypothesis may be best expressed by quoting Fischer.

> "The primary ore minerals are thought to have been introduced into their present position not long after the sands were deposited. If this is true, the metals were probably transported and deposited by ground waters, and the ores were probably localized by delicate chemical and physical conditions that now cannot be definitely recognized. This hypothesis probably requires at least three separate periods of ore deposition, to account for the ore in the Shinarump, Entrada, and Morrison formations."

Since [illegible] studies, deposits have been [illegible] in the [illegible], Cutler, [illegible], [illegible], [illegible], [illegible], Since his studies, deposits have been found in the Hermit, Cutler, Moenkopi, Chinle, Todilto, Dakota, Mesa Verde, Wasatch, Uinta, and other formations on the Colorado Plateau.

The concept of a hydrothermal origin of the uranium deposits received impetus from the results of age determinations of uraninite specimens from uranium deposits of the Colorado Plateau (Stieff and Stern, 1953). The hydrothermal hypothesis suggests that uranium-bearing solutions were related to Tertiary igneous activity and that solutions moved vertically along fractures and then laterally until reaching favorable loci where the uranium was deposited.

Downward leaching of uranium from volcanic strata has been suggested because of the thick series of strata containing abundant volcanic debris that overlie both the Salt Wash member of the Morrison formation and the Shinarump conglomerate. Waters and Granger (1953) use the devitrification of this volcanic material to provide the silica for silicification of wood as well as for the addition of silica in the ore-bearing sandstones. Others (Proctor, 1949, and Love, 1952) have suggested these and other strata containing volcanic material as source rocks for the uranium.

Uranium-bearing material and petroleum have the same suite of trace metals, and thus a common origin has been suggested (R. Erickson, oral communication).

Any hypothesis must account for all of the following relations or facts before it can be accepted as a satisfactory explanation of the origin of the deposits:

(1) Sedimentary structures, such as channels and lenses, and sedimentary features such as bedding planes, graded bedding, and impervious barriers controlled the location of most of the ore deposits.

(2) Bleaching of red mudstones to gray or green accompanies most deposits.

(3) Most deposits are in continental-type sediments.

(4) Most deposits are associated with carbonaceous material.

(5) The common age indicated by age determinations.

(6) The persistent association of uranium with vanadium in the Morrison formation and the variety of element associations including vanadium and copper in the Triassic formations.

The origin of the Shinarump No. 1 deposit is thought to be hydrothermal. The Shinarump No. 1 deposit is clearly later than enclosing sediments. Age determinations by Stieff and Stern indicate that the uraninite in this deposit formed at the end of the Cretaceous or the beginning of the Tertiary. The mineral assemblage, particularly the presence of uraninite, blue chalcocite (digenite ?), and bornite-chalcopyrite solid solution, strongly suggests a temperature of formation warmer than the temperature of normal ground water. The localization of the ore is related to the pinchout of the Shinarump conglomerate on a regional and local scale, and to sedimentary features such as bedding planes, graded bedding, and sorting, within ore-bearing beds. Carbonaceous and clayey material may have acted as a chemical and physical attraction for the localization of the ore. Ground water probably played an important role in the precipitation of the uranium and sulfides.

## CONCLUSIONS

The Shinarump No. 1 deposit, which is located on the west flank of the Moab anticline, is in the lowermost Chinle siltstone beds that truncate erosional remnants of Shinarump conglomerate. Uranium deposits in the Seven Mile Canyon area and elsewhere to the south and west are near the margins of Shinarump deposition.

The ore is relatively unoxidized. Uraninite (pitchblende), a primary mineral, is the most abundant ore mineral. It occurs as small grains disseminated in sandstone and replacing wood structure. Uraninite, which is associated mainly with chalcocite and pyrite, is later than most sulfides except chalcocite which is, in part, later. Chalcocite occurs in vertical fractures that trend east. The ore minerals occur in more poorly sorted parts of siltstone and in stringers of coarse sand in siltstone.

The ore deposit is not in a channel fill but in flat-bedded sediments that were deposited on an irregular surface. Guides to ore in the Seven Mile Canyon area inferred from the study of the Shinarump No. 1 deposit are the presence of bleached siltstone, copper, sulfides, and carbonaceous material. The deposit lies below thin parts of the limestone-pebble conglomerate "marker bed".

The origin of the Shinarump No. 1 deposit is probably hydrothermal. Mineralizing solutions--hydrothermal and, in part, ground water--are thought to have been reducing in character and containing important amounts of barium, vanadium, uranium, copper, and sulfur as well as lesser amounts of strontium, chromium, boron, yttrium, lead, and zinc.

## LITERATURE CITED

Buerger, N. W., 1941, The chalcocite problem, Econ. Geology, v. 36, no. 10, p. 19-44.

Fischer, R. P., 1942, Vanadium deposits of Colorado and Utah: U. S. Geol. Survey Bull. 936-P.

Love, J. D., 1952, Preliminary report on uranium deposits in the Pumpkin Buttes area, Powder River Basin, Wyoming: U. S. Geol. Survey Circ. 176.

McKnight, E. T., 1940, Geology of area between Green and Colorado Rivers, Grand and San Juan Counties, Utah: U. S. Geol. Survey Bull. 908.

Robertson, F., and Vandeveer, P. L., 1952, A new diagrammatic scheme for paragenetic relations of the ore minerals: Econ. Geology, v. 47, no. 1, p. 101-105.

Shoemaker, E. M., 1951, Internal structure of the Sinbad Valley-Fisher Valley salt anticline, Colorado and Utah (Abstract): Geol. Soc. America Bull., v. 62, no. 12, part 2.

Stokes, W. L. and Phoenix, D. A., 1948, Geology of the Egnar-Gypsum Valley area, San Miguel and Montrose Counties, Colorado: U. S. Geol. Survey Oil and Gas Inv., Prelim. Map 93.

Wandke, A. D., 1953, Polishing phenomena in the copper sulfides: Econ. Geology, v. 48, no. 3, p. 225-232.

Waters, A. C., and Granger, H. C., 1953, Volcanic debris in uraniferous sandstone and its possible bearing on the origin and precipitation of uranium: U. S. Geol. Survey Circ. 224.

Waugh, A. E., 1943, Elements of statistical method: McGraw-Hill Book Co., Inc., p. 99.

## UNPUBLISHED REPORTS

Droullard, R. F., 1951, Prospective bulldozer operations in the Seven Mile area: U. S. Atomic Energy Commission RMO 689.

Droullard, R. F., and Jones, E. E., 1952, Geology of the Seven Mile Canyon uranium deposits, Grand County, Utah: U. S. Atomic Energy Commission RMO 815.

Proctor, P. D., 1949, Geology of the Harrisburg (Silver Reef) mining district, Washington County, Utah: Unpublished doctoral dissertation, Indiana University.

Stieff, L. R., and Stern, T. W., 1953, The lead-uranium ages of some uraninite specimens from Triassic and Jurassic sedimentary rocks of the Colorado Plateaus: U. S. Geol. Survey Trace Elements Inv. Rept. 322.

Weeks, A. D., 1952, Summary report on mineralogic studies of the Colorado Plateau through April 30, 1952: U. S. Geol. Survey Trace Elements Memo. Rept. 431.

# APPENDIX A

## Stratigraphic section

## UTAH - GRAND COUNTY

SHINARUMP NO. 1 CLAIM section, measured about 1,500 feet south of Corral Canyon. Line of section S. 65 W., sec. 27, T. 24 S., R. 20 E., Salt Lake meridian.

(Measured by W. I. Finch, December 1952)

| | Feet |
|---|---|
| Wingate sandstone (incomplete): | |
| 30. Top of section, not top of exposure . . . . . . . . . . . . . . . . . . . . . . . . . . . | -- |
| 29. Sandstone, yellowish gray (5Y8/1) _/, weathers pale red (10R6/2), fine- to very fine-grained, bedding not distinct. Only basal 5 ft. examined; estimated height of cliff face 220 ft. Unit not measured . . . . . . . . . . . . . . . . . . | -- |
| 28. Contact: Chinle formation and Wingate sandstone contact placed at sharp change from cliff-forming sandstone of Wingate to slope-forming shale and sandstone of Chinle. Mudcracks at base of Wingate; light green alteration of upper few inches of Chinle and of mudcrack fillings. | |
| 27. Unconformity (local ?). | |
| Chinle formation: | |
| 26. Shale and interbedded sandstone and conglomerate, pale red (10R6/2), sandstone fine-grained; conglomerate contains mostly clastic limestone concretions. Sandstone and conglomerate beds mostly 1 ft. or less in thickness. For most part unit forms steep covered slope . . . . . . . . . . . . . . . . . . . . . . . . . . | 73 |
| 25. Sandstone, light red (5R6/6), fine-grained; quartzitic; thin horizontal bedding with some low-angle cross-bedding; forms ledge; channels into lower unit . . . . . . | 7 |
| 24. Sandstone and mudstone, moderate red (5R5/4), fine-grained, irregular bedding, forms ledge . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 12 |

_/ Rock-color chart prepared by "The Rock-Color Chart Committee," E. N. Goddard and others, National Research Council, Washington, D. C., 1948.

| | Feet |
|---|---|
| 23. Sandstone and conglomerate, pale red (5R6/2) and light-greenish gray (5GY8/1), fine-grained. Conglomerate consists mainly of clastic limestone concretions. Abundant hematitic concretions scattered mainly in sandstone beds, some silicified wood, some white calcite filling cavities and fractures. Irregular bedding and penecontemporaneous slumping. This and upper two units form a single ledge which divides the Chinle into two members. Base of unit channels in lower beds and is base of upper member of Chinle formation. . . . . . . . . . . . | 16 |
| 22. Sandstone, pale red (5R6/2) with interbeds of yellowish gray (5Y7/2), fine-grained, thin-bedded, beds weather with hackly surface. Forms a steep covered slope . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 64 |
| 21. Conglomerate, yellowish gray (5Y7/2), clastic limestone concretions and some white quartz, pebbles range from one-fourth inch to 2 inches across, calcareous cement. Irregular bedding, forms ledge . . . . . . . . . . . . . . . . . . . . . . . . | 6 |
| 20. Sandstone and siltstone, moderate red orange (10R6/6); sandstone, fine-grained, in beds mainly 1 ft. thick which form discontinuous channel-fillings; small scale cross-bedding; some miniature slumping; unit forms slope . . . . . . . . . . . | 48 |
| 19. Sandstone, grayish green (5GY6/1), fine-grained; composed of quartz grains, white mica, some carbon flecks; calcareous cement; thin-bedded; weathers into small irregular crescent-shaped partings; forms slope; lenticular, channels into lower unit . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 4 |
| 18. Siltstone, dark red brown (10R3/4), some white mica and course quartz sand grains, thin-bedded forms slope. <u>Uranium-bearing</u> in places . . . . . . . . . . . | 22 |
| 17. Claystone and siltstone, light green (5G7/4) and light brown (5YR6/4), some fine quartz grains, white and green mica, wood fragments; thin-bedded, forms slope, grades into overlying beds. <u>Uranium-bearing</u> in places, some wood replaced by uraninite and becquerelite . . . . . . . . . . . . . . . . . . . . . . | 22 |

| | Feet |
|---|---|
| 16. Conglomerate, greenish gray (5GY6/1), clastic lime pebbles up to 2 in. across, some quartz grains, some limonitic stains, calcareous cement, uneven bedding, forms ledge. Uranium-bearing in upper part, uraninite forms rims about some limestone pebbles . . . . . . . . . . . . . . . . . . . . . . . . | 13 |
| 15. Mudstone, pale red (10R6/2), some limestone pellets . . . . . . . . . . . . . . . | 2 |
| 14. Conglomerate, pale green (5G7/2), clastic limestone pebbles, calcareous cement, irregular bedding . . . . . . . . . . . . . . . . . . . . . . . . . . | 1 |
| 13. Siltstone and conglomerate, moderate reddish orange (10R6/6), conglomerate contains clastic limestone pebbles and reworked Moenkopi siltstone pebbles; abundant limonite staining; some white quartz grains, irregular bedding, forms steep slope beneath conglomerate ledge. Uranium-bearing at Shinarump No. 1 mine . | 7 |
| Total Chinle formation . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 297 |
| Shinarump conglomerate: | |
| 12. Absent in line of section | |
| 11. Unconformity (erosional). | |
| Moenkopi formation: | |
| 10. Shale and mudstone, pale green (5G7/2) and moderate red (5R5/4), mica along bedding, bedding poorly developed . . . . . . . . . . . . . . . . . . . . . . . . | 1 |
| 9. Shale, grayish brown (5YR3/2), some white mica, bedding poorly developed . . . . . . | 6 |
| 8. Sandstone, moderate red (5R5/4) grading upward into grayish green (10GY5/2), coarse-grained, massive . . . . . . . . . . . . . . . . . . . . . . . . . . . | 2 |
| 7. Sandstone, very pale orange (10YR8/2) to moderate reddish brown (10R4/6), fine-grained, grading to coarse-grained near top, angular quartz grains, abundant muscovite and biotite, thick-bedded, forms rounded slope, some bleaching along and across bedding . . . . . . . . . . . . . . . . . . . . . . . . . . . | 11 |
| Total Moenkopi formation . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 20 |

| | Feet |
|---|---|
| 6. Unconformity (?) | |
| Cutler formation: | |
| 5. Sandstone and shale, moderate red brown (10R4/6), some biotite along bedding, irregular bedding, forms bench | 31 |
| 4. Sandstone, moderate reddish brown (10R4/6), medium- to coarse-grained, some mica, very thickly cross-bedded, irregular bleaching along some beds, weathers rounded, forms ledge | 24 |
| 3. Shale, pale red (10R6/2), contains mud crack fillings, bleached in places | 1 |
| 2. Sandstone, grayish red purple (5RP4/2) to moderate red (5R4/6), coarse-grained to conglomeratic, some white mica and feldspar, abundant biotite, thin-bedded to low angle cross-lamination, bleached spheres from one-fourth inch to 1.5 ft. in diameter cutting bedding; friable; forms ledge | 10 |
| 1. Base of outcrop, not base of formation. | |
| Total Cutler formation exposed | 66 |

# APPENDIX B

## Group number classification

| Assay rpt. (%) | Group No. * | Class range | Class mark |
|---|---|---|---|
| XX. + | 1 + | 46.4 - 100.0 | 68.1 |
| XX. | 1 | 21.5 - 46.3 | 31.6 |
| XX. - | 1 - | 10.0 - 21.4 | 14.7 |
| X. + | 2 + | 4.6 - 9.9 | 6.8 |
| X. | 2 | 2.2 - 4.5 | 3.2 |
| X. - | 2 - | 1.0 - 2.1 | 1.5 |
| .X + | 3 + | 0.46 - 0.9 | 0.68 |
| .X | 3 | 0.22 - 0.45 | 0.32 |
| .X - | 3 - | 0.10 - 0.21 | 0.15 |
| .0X + | 4 + | 0.046 - 0.09 | 0.068 |
| .0X | 4 | 0.022 - 0.045 | 0.032 |
| .0X - | 4 - | 0.010 - 0.021 | 0.015 |
| .00X + | 5 + | 0.0046 - 0.009 | 0.0068 |
| .00X | 5 | 0.0022 - 0.0045 | 0.0032 |
| .00X - | 5 - | 0.001 - 0.0021 | 0.0015 |
| .000X + | 6 + | 0.00046 - 0.0009 | 0.00068 |
| .000X | 6 | 0.00022 - 0.00046 | 0.00032 |
| .000X - | 6 - | 0.0001 - 0.00021 | 0.00015 |

*Subgroups overlap somewhat, but about 80 percent of cases will be in correct subgroup.