-1-

UNITED STATES ATOMIC ENERGY COMMISSION

RME-2014

COPPER-URANIUM DEPOSIT AT THE RIDENOUR MINE, HUALAPAI INDIAN RESERVATION, COCONINO COUNTY, ARIZONA, PART I

By Richard D. Miller

Supplement: Results of an Aerial Radiometric Examination of the Ridenour Mine District, Hualapai Indian Reservation Coconino County, Arizona

By Earl M. P. Lovejoy

August 1954

Division of Raw Materials
Salt Lake City, Utah

Technical Information Service, Oak Ridge, Tennessee

2

Subject Category, GEOLOGY AND MINERALOGY.

Printed in USA, Price 20 cents. Available from the Office of Technical Services, Department of Commerce, Washington 25, D. C.

AEC, Oak Ridge, Tenn.

UNITED STATES ATOMIC ENERGY COMMISSION
DIVISION OF RAW MATERIALS
SALT LAKE EXPLORATION BRANCH

COPPER-URANIUM DEPOSIT AT THE RIDENOUR MINE, HUALAPAI INDIAN RESERVATION, COCONINO COUNTY, ARIZONA

Part I

by
Richard D. Miller

SUPPLEMENT: RESULTS OF AN AERIAL RADIOMETRIC EXAMINATION OF THE RIDENOUR MINE DISTRICT, HUALAPAI INDIAN RESERVATION COCONINO COUNTY, ARIZONA

by
Earl M. P. Lovejoy

August 1954

(Salt Lake City, Utah)

TABLE OF CONTENTS

Part I

Supplement

Supplement

COPPER-URANIUM DEPOSIT AT THE RIDENOUR MINE, HUALAPAI INDIAN RESERVATION, COCONINO COUNTY, ARIZONA

Part I

ABSTRACT

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

INTRODUCTION

Location and Access

The Ridenour mine is in the northern part of the Hualapai Indian Reservation in Section 6, Township 31 North, Range 8 West, about two miles southeast of the Colorado River (Figure 1). Final access to the mine is by a trail, steep in places, winding downward from the end of the road for a distance of about four miles and a difference in elevation of about 1,500 feet. The head of the trail is at an elevation of about 6,200 feet, and can be reached by a poor dirt road which branches from the main reservation road at the sawmill near Frazier's Well. The road passes through Prospect Valley and onto Ridenour Mesa for a total distance of twenty-five miles.

Scope of Study

This report is based on a three-day field examination. Twenty-three samples were taken and part of the workings were mapped with

Brunton compass and tape. Results of an investigation of the general area are reported separately in "Reconnaissance for Uranium, Hualapai Indian Reservation Area, Mohave and Coconino Counties, Arizona" by Richard D. Miller,(USAEC, DRM, RME-2007).

Topography

The mine workings are on the steep slope of a narrow promontory with a boulder-covered flat top overlooking a canyon which drains into the Colorado River. The promontory juts northward from a mesa that constitutes a lower bench of Ridenour Mesa, an elongated block lying between the Hurricane and Toroweap faults. Deep canyons and steep cliffs characterize the general area.

History and Production

The property was worked intermittently for copper prior to and during World War I. Initial discovery reportedly took place sometime during the 1870's. During the most active period between 1916 and 1918 the property was owned by William Ridenour, Sr., now deceased. The land on which the properties lies was then ostensibly owned by the Atchison, Topeka and Santa Fe Railroad as part of a federal land grant which included every alternate section of the reservation. At a later date this land reverted back to the Hualapai Indian Tribe by court action.

Published records of production are not available. However, local sources indicate that about 1,000 tons of copper ore were carried out by burro to the top of the rim and transported by wagon to the railhead at Nelson, just east of Peach Springs. The ore was hand-sorted to exceed a grade of perhaps 15 percent copper. It is estimated that surface dumps contain about 12,000 tons of rock, and a similar amount was left in the workings as back fill.

Mine Workings and Facilities

The mine workings closely follow the geologic structure in a semicircular pattern (Figure 2). The main level is about eighty feet from the surface and was reached by two inclined shafts and a haulage adit whose portal is now almost covered by the dump. The upper stopes have access holes to the surface, and the remaining workings consist of short prospect adits and small open cuts. The old mining camp was on the promontory at the top of a 100-foot cliff overlooking the mine. One cabin in fair condition now remains.

Water for domestic use and for drilling is available at Cave Spring in a canyon to the southwest. A two and one-half mile trail leading from the mine to the spring was used during mining operations. A closer source of drill water might be made available by blasting sides of the narrow canyon below the workings to form a catchment basin for run-off during the rainy season (July and August). Stored water would have to be lifted about 150 feet to the surface workings and 100 feet higher to the top of the promontory above and in back of the workings. Mine timbers would normally be available at the sawmill near Frazier's Well.

An access road to the property would involve construction of about four miles of new road of which two miles would require considerable blasting for the steep descent from the end of the present road and for final access to mine workings. At least one and one-half miles of additional road would be necessary to connect this road with Cave Spring.

GENERAL GEOLOGY

Stratigraphy

The Ridenour mine is near the middle of the top member of the Permian Supai formation. Total thickness of the Supai formation is estimated to be about 900 feet in this area. Rocks traversed by the mine trail and which overlie the Supai sandstone are in turn the Hermit shale, Coconino sandstone, Toroweap formation, and the Kaibab limestone. The underlying Redwall limestone is exposed by a high cliff north and downstream from the mine. Table I briefly describes formations in the general area. The Supai sandstone in and near the stratigraphic position occupied by the mine is made up of thick beds of dull red sandstone, alternating with thin beds of red mudstone or claystone. The sandstone consists of fine to medium, well sorted, subangular grains, composed almost entirely of quartz. Mica and iron oxides appear to be the main cementing agents. The beds are almost horizontal with local cross-stratification at low angles.

Sandstone in the immediate vicinity of the mine is bleached from the normal red color to light gray and resembles that observed in the Morrison formation in uranium-producing districts of the Colorado Plateau.

SUMMARY OF ROCK UNITS - HUALAPAI INDIAN RESERVATION AREA ARIZONA

Age	Formation	Approx. Thickness	Description
Quaternary & Tertiary			Alluvial fans, sand dunes, and floodplain deposits in Aubrey Valley. Pleistocene (?) basalt overlies Blue Mountain gravel. Robber's Roost gravels derived from Kaibab and Toroweap limestones. Tertiary volcanic rocks (west of Mt. Floyd) are largely basalt with some rhyolite, pitchstone, and pumice.
	Unconformity		
Permian	Kaibab fm.	340	Massive cherty magnesian limestone, very fossiliferous, at top (50 ft.). Underlain by alternating beds of chert, sandy limestone and calcareous sandstone. Forms cliffs.
Permian	Toroweap fm.	260	Irregularly bedded, fluvial buff and red sandstone (130 ft.). Underlain by massive magnesian limestone with alternating beds of sandstone and limestone at base. Middle member forms cliff.
Permian	Coconino ss.	100-300	Light yellow to white sandstone composed of uniform, medium-fine grains of quartz with siliceous cement. Conspicuously cross-stratified. Persistently forms cliff.
Permian	Hermit sh.	400	Red sandy shale or mudstone and fine-grained sandstones. Forms slope.
Permian (may be Pennsylvanian at base)	Supai fm.	900	Upper 300 ft: Buff to red, fine to medium-grained cross-stratified sandstone with thin red mudstone partings. Forms ledges and cliffs. Middle 400 ft.: alternating beds of sandy mudstone, thick cross-stratified sandstone, and thin sandy limestone. Forms ledges in upper part and cliff at bottom. Lower 200 ft.: alternating beds of red shale, purple-gray limestone and buff to red calcareous sandstone. Forms ledgy slope.
	Unconformity		
Mississippian	Redwall ls.	600	Massive blue-gray, crystalline limestone. Forms shear, red-stained cliff.
Devonian	Temple ~~Butte~~ ls.	0-75	Thin bedded, mottled, buff and light purple, sandy limestone.
	Unconformity		
Cambrian	Muav ls.	450	Massive buff dolomite at top, underlain by buff calcareous sandstone. Lower 300 ft. consists of alternating beds of limestone and sandstone with shale partings. Cliffs at top and bottom.
Cambrian	Bright Angel sh.	375	Thin bedded micaceous shale and fine-grained sandstone with 3 or more interbedded layers of yellow-brown glauconitic dolomite. Forms slope broken by dolomite.
Cambrian	Tapeats ss.	325	White to light gray cross-stratified sandstone at top; very coarse-grained in Grand Wash Cliffs area. Underlain by brown cross-stratified sandstone, massive and coarse-grained at base. Middle members are quartzite in Grand Wash Cliffs Area. Forms ledges near top with steep cliff at base.
	Unconformity		
Pre-Cambrian			Metamorphic rocks. Chiefly gneissic granite with large orthoclase phenocrysts. Some quartz-biotite schist, quartz veins, and pegmatites.

Table I: STRATIGRAPHY IN VICINITY OF RIDENOUR MINE

Relation of Mineral Deposits to Regional Structure

The deposit is about midway between the Hurricane and Toroweap faults. Several other radioactive mineral deposits have been found along or between these major faults across the Colorado River in northerly direction from the Ridenour mine. Prospects within a few miles include the Copper Mountain, Copper House, and Chapel.

ORE DEPOSITS

Structural Control

The ore minerals occur in veins and brecciated zones forming a semicircular pattern in plan view (Figure 2). The shape of the ore body can be visualized by truncating a hollow-cone and then halving it vertically. The half-shell would represent the curving mineralized zone having an average width of about four feet. The ore body is terminated at the top by a bed of mudstone ranging in thickness from two to five feet. Interbedded thin mudstones exposed in the mine forced the mineralized solutions to locally follow bedding planes and seek fractures through the mudstone. Changes in dip and minor vein splitting resulted. The bottom level of the mine about 80 feet below the surface reaches another mudstone bed in which the veins become very thin, pinched out in places, and tend to follow bedding planes. The higher grade copper ore appears to be largely mined out down to this level. The underlying rocks are not sufficiently exposed by outcrops or workings to determine possible downward persistence of the mineralized zone. However, the copper-bearing fractures diminish to the east and largely pinch out before reaching the canyon below the workings.

Rocks in the central core enclosed by the ore body are intensely fractured and bleached where exposed along the lower haulage adit and by small outcrops protruding from dumps, but no copper minerals or significant radioactivity were found.

Offset beds show that movement along shears in the ore zone varies from a few inches to a maximum of about four feet, although greater movement may have taken place in the largely unexposed central core. The strike of veins changes rapidly along the mineralized zone, but the dip of the more persistent veins is usually between 45 and 55 degrees.

Copper Minerals

Widths of individual copper veins range from a few inches to about two feet. The ore zone contains many close-spaced veinlets less than one inch wide which follow minor fractures and brecciated zones. Copper carbonates fill interstices of sandstone adjacent to veins.

The copper minerals consist largely of malachite, azurite, and chalcocite, with small amounts of chrysocolla, bornite, and chalcopyrite. Gangue minerals are chiefly pyrite and limonite.

Uranium-Vanadium Minerals

Uranium and vanadium occur in significant quantity and grade in at least three stopes and in one short crosscut in northern and western parts of the mine. Figures 2, 3, and 4 show the crosscut (Adit No. 4) and two stopes with sample locations. Table II is a tabulation of the results of sample analyses. The third stope is about 25 feet below the surface and is reached by the inclined shaft near Station 12 in the southwestern part of the workings (Figure 2). This stope was not mapped due to lack of time, but counter readings of 6.0 MR/hr. were obtained on the hanging wall and a grab sample assayed 1.8 percent U_3O_8. Minor zones of radioactivity are found in workings on the south side and in lower workings on the north side.

Most of the uranium and vanadium minerals are in the hanging wall of the zone containing the copper minerals, locally forming a thin enclosing shell ranging in thickness from a few inches to about two feet. In Stope No. 1, the interval between the two mineralized zones consists of about two feet of almost barren sandstone. A vein of carnotite 0.1 foot wide in No. 4 Adit (an eighteen-foot crosscut into the hanging wall) is 12 feet in the hanging wall of the main copper veins and dips less steeply (Sample No. 34979). An irregular pod of interstitial carnotite about two feet in longest dimension is found on one wall of the crosscut between the copper and carnotite veins. This working is the only one which penetrates the hanging wall immediately in back of an area of significant radioactivity. In the other two radioactive stopes uranium-vanadium and copper minerals are in contact with local intermixing; however, division into separate zones appears to be warranted.

Laboratory reports indicate that the carnotite is associated with carbon (in one sample), iron oxides, copper minerals, traces of cobalt, and other vanadium minerals as cementing material in the sandstone and locally follows bedding planes. In addition it forms coatings along fracture surfaces. An unidentified dark vanadium mineral (vanoxite ?) is associated with carnotite, and in Stope No. 1 this mixture has a mottled appearance resembling ore from the Morrison formation in other parts of the Colorado Plateau. In several places elsewhere in the workings dark vanadium minerals are found with little or no carnotite in areas of low radioactivity. A platy yellow to green vanadium mineral identified as volborthite (a basic copper vanadate) is conspicuous in shallow workings on the south side in close association with copper sulfides and carbonates. This nonradioactive mineral is also found on the dumps where it resembles carnotite in appearance (Samples No. 34998 and 100506).

Additional samples taken from the property but not included with those shown in Table II are:

	%eU_3O_8	%cU_3O_8	%V_2O_5
Dumps, No. 100506	0.01	0.017	7.99
Stope #1, No. 100506A (Select)	2.3	2.50	11.5
Stope #3, No. 100754 (Select)	2.10	1.80	--

CONCLUSIONS

The deposit appears to be structurally controlled by shears of small displacement enclosing a slump block or zone of subsidence. Length of the mineralized zone increases with depth.

Uranium in the form of carnotite is found in significant quantities in the hanging wall of three stopes from which copper has been mined. Width of the uranium-vanadium zone usually cannot be determined because of a lack of crosscuts penetrating radioactive areas. A very thin veinlet of high-grade carnotite is 12 feet back of the copper vein in the one crosscut (Adit No. 4) where observations can be made. Radioactivity is present in scattered small areas in other parts of the mine workings.

Possible downward persistence of uranium-vanadium minerals below the bottom level (80 feet) cannot be determined by examination of outcrops or present workings.

The vanadium-uranium ratio is generally much greater than 10 to 1, and vanadium is more widely distributed than uranium.

The higher grade copper ore has been mostly mined out to the 75-foot level.

The mine dumps appear to contain an appreciable quantity of copper, some vanadium minerals, and a very small amount of carnotite. This is probably a result of the occurrence of copper and uranium in somewhat separate zones.

Outcrops of veins on the surface are thin and discontinuous, and consist principally of copper minerals with very little uranium.

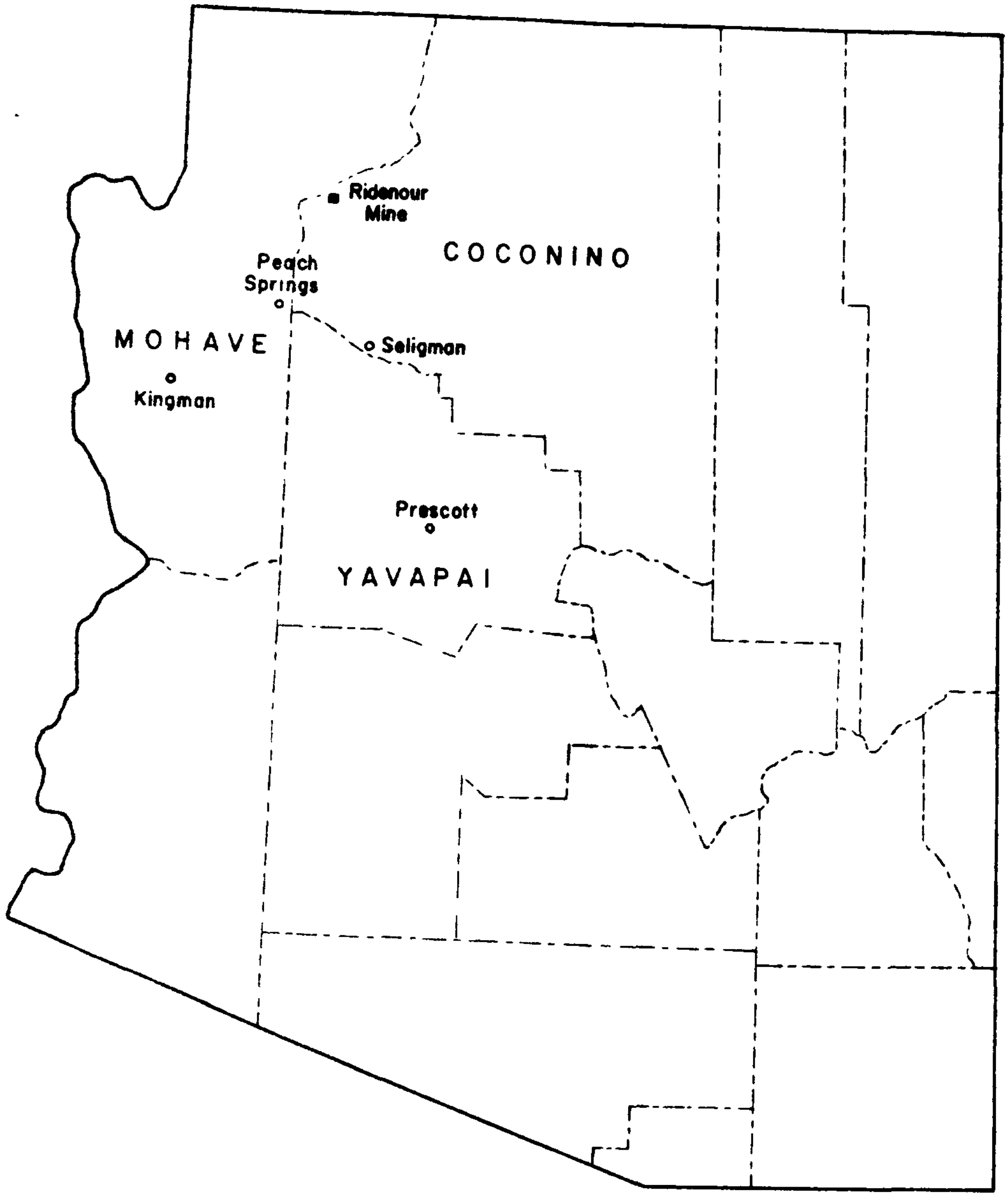
REFERENCES

1. Darton, N. H., A Resume of Arizona Geology, University of Arizona, Bulletin No. 119, Geol. Series No. 3, 1925.

2. Koons, Donaldson, Geology of the Eastern Hualapai Reservation, Plateau, Vol. 20, No. 4, 1948.

3. Miller, R. D., Reconnaissance for Uranium in the Hualapai Indian Reservation Area, Mohave and Coconino Counties, Arizona, USAEC, DRM, RME-2007.

4. Noble, L. F., A Section of the Paleozoic Formations of the Grand Canyon at the Bass Trail, U. S. Geol. Surv. Prof. Paper 131, 1922.



INDEX MAP OF ARIZONA SHOWING LOCATION OF THE RIDENOUR MINE

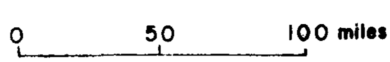
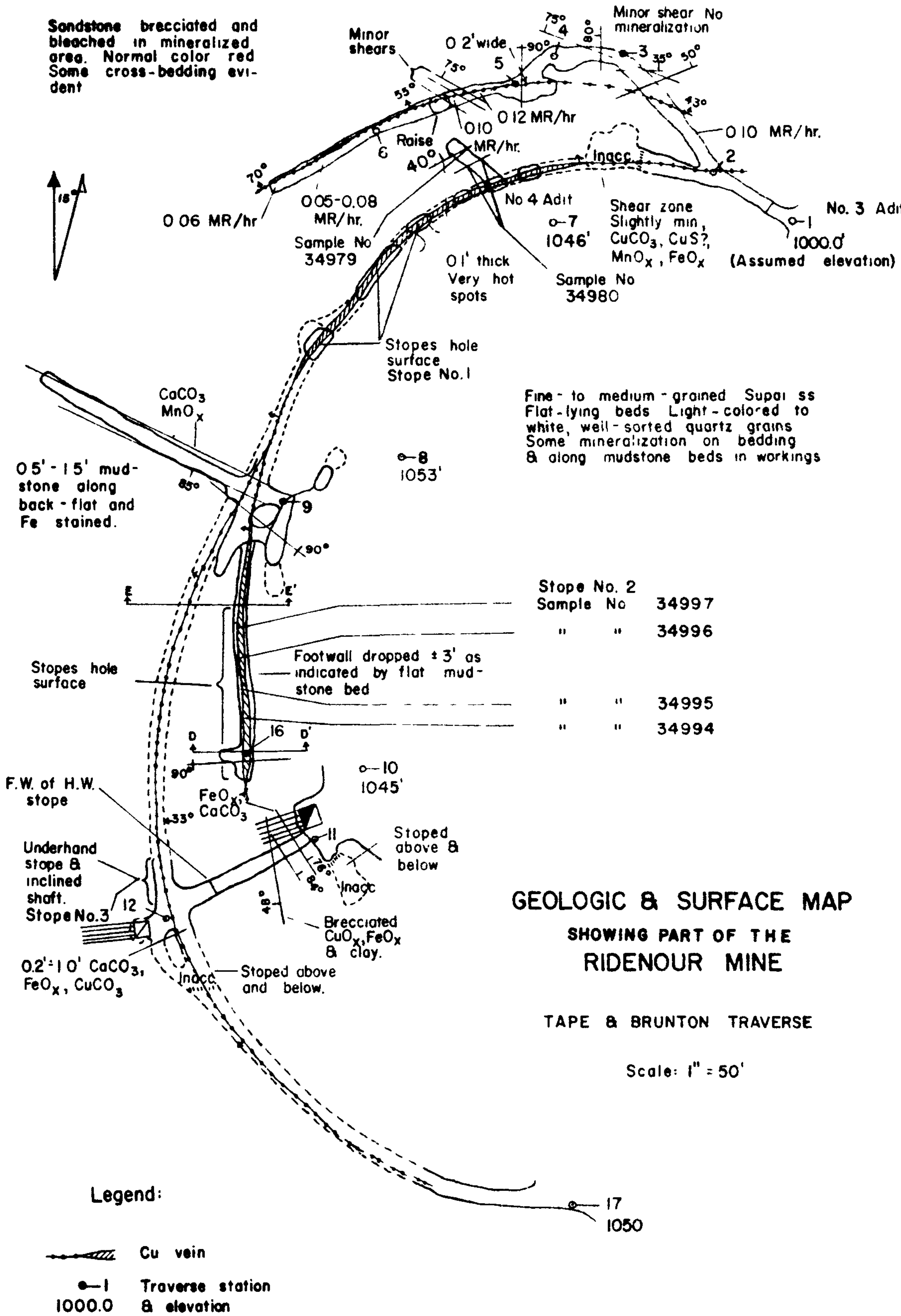
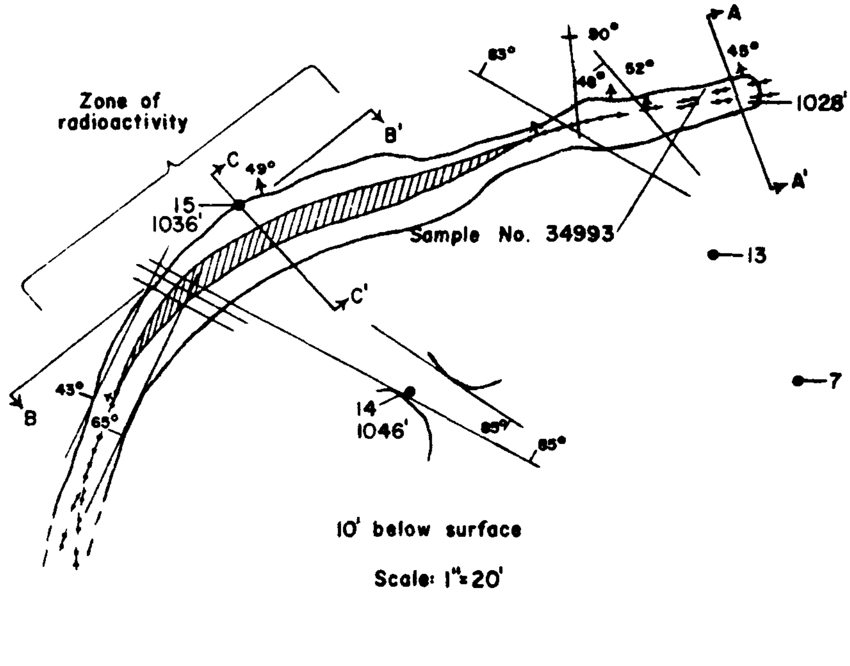


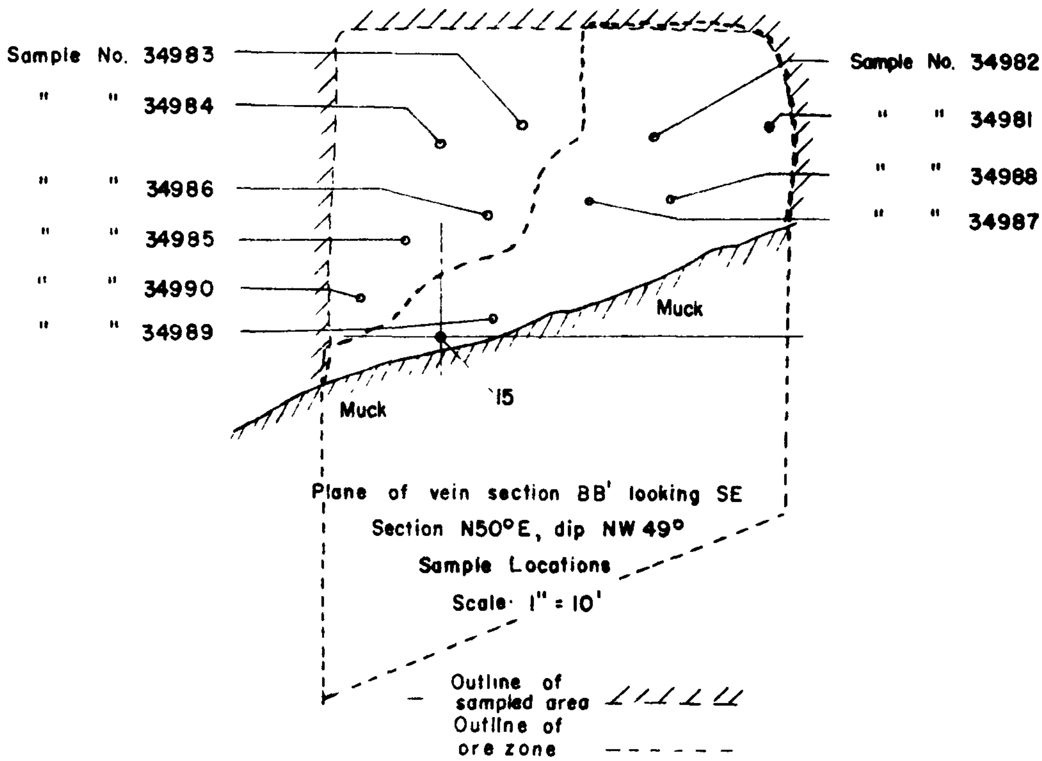
Fig. 1



GEOLOGIC & SURFACE MAP
SHOWING PART OF THE
RIDENOUR MINE
TAPE & BRUNTON TRAVERSE
Scale: 1" = 50'
Sandstone brecciated and bleached in mineralized area. Normal color red. Some cross-bedding evident
Minor shears
0.2' wide
Minor shear No mineralization
0.12 MR/hr
0.10 MR/hr.
0.10 MR/hr.
Raise
0.06 MR/hr
0.05-0.08 MR/hr.
Sample No 34979
No 4 Adit
7
1046'
Shear zone Slightly min., CuCO3, CuS?, MnOx, FeOx
No. 3 Adit
1
1000.0'
(Assumed elevation)
Inacc.
0.1' thick Very hot spots
Sample No 34980
Stopes hole surface Stope No. 1
Fine- to medium-grained Supai ss Flat-lying beds Light-colored to white, well-sorted quartz grains Some mineralization on bedding & along mudstone beds in workings
CaCO3 MnOx
0.5'-1.5' mudstone along back-flat and Fe stained.
8
1053'
Stope No. 2
Sample No 34997
" " 34996
" " 34995
" " 34994
Footwall dropped ± 3' as indicated by flat mudstone bed
Stopes hole surface
10
1045'
F.W. of H.W. stope
FeOx, CaCO3
Stoped above & below
Underhand stope & inclined shaft. Stope No.3
Brecciated CuOx, FeOx & clay.
0.2'-1.0' CaCO3, FeOx, CuCO3
Stoped above and below.
17
1050
Legend:
Cu vein
Traverse station & elevation
1000.0

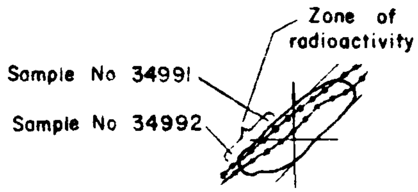
Fig. 2



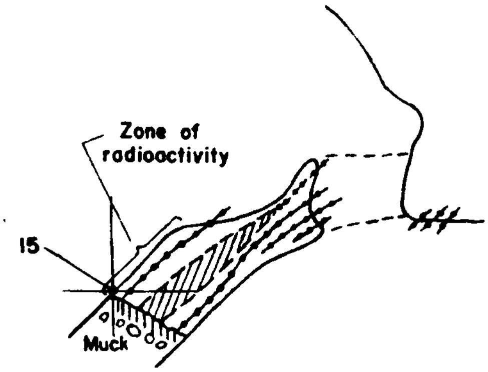


PLAN & GEOLOGIC MAP
RIDENOUR MINE

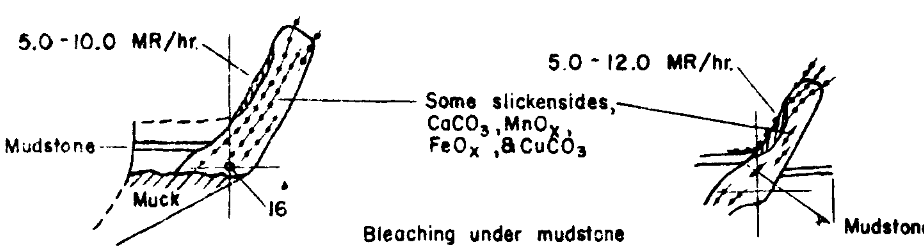
Fig. 3



Section AA', N20W, looking NE



Section CC', N40W, looking NE



Section DD', E-W, looking N

Section EE', E-W, looking N

RIDENOUR MINE

COCONINO COUNTY, ARIZONA

Scale: 1" = 20'

Fig. 4

Table II

	Sample No	% $^{e}U_3O_8$	% $^{c}U_3O_8$	% V_2O_5	% Cu
Adit No 4	34979	1 10	1 20	9 35	
	80	1 70	1 84	5.66	
	81	0 17	0 102	3 92	
	82	0 21	0 195	1 15	8 13
	83	<0 01	0 008	4 20	
Stope No 1	84	0 10	0 026	9 92	
	85	<0.01	0 012	0 61	8 70
	86	0 02	0 009	7 97	
	87	0 33	0 272	7 31	
	88	1 20	1 38	2.74	14.15
	89	0 37	0 28	10 83	
	90	0.04	0.054	4.08	
Stope No 1 E end	91	0 17	0 14	5.33	
	92	0.02	0 033	0 36	12 37
Stope No 1 middle	93	0 03	0 015	5 60	
	94	<0 01	0 022	1 43	1 85
Stope No 2	95	0 52	0 46	6 84	9.65
	96	0 06	0 08	4 62	9 35
	97	<0 01	0 015	6 20	
Dump	98	0 01	0 018	8 19	

CHEMICAL ANALYSES

RIDENOUR MINE

COCONINO COUNTY, ARIZONA

RESULTS OF AN AERIAL RADIOMETRIC EXAMINATION OF THE RIDENOUR MINE DISTRICT, HUALAPAI INDIAN RESERVATION, COCONINO COUNTY, ARIZONA

(A Supplement to the report on the Ridenour Mine by R. D. Miller)

by
Earl M. P. Lovejoy

INTRODUCTION

The Ridenour mine airborne project began on December 22, 1953 and ended February 11, 1954. During this period about fifteen hours of operational rim and grid flying were undertaken. Approximately 30 square miles of Coconino, Hermit, Supai, and Redwall and older formations were examined by airborne radiometric methods. One small zone of anomalous radioactivity was discovered east of the Ridenour mine. So far as is known, no previous airborne radiometric examination has been made in this area. The information given in this report is offered to supplement information found in "Reconnaissance for Uranium in the Hualapai Indian Reservation Area, Mohave and Coconino Counties, Arizona" and "Copper-Uranium Deposit at the Ridenour Mine, Hualapai Indian Reservation, Coconino County, Arizona" by Richard D. Miller.

AIRBORNE PROCEDURES

Both grid and rim methods of flying were utilized in the examination of the Ridenour mine area. Over the flat portions of the Hermit shale and the upper surface of the Supai sandstone, grid methods were used exclusively. Grid lines were spaced for about four hundred feet apart and flight lines were maintained at an altitude of about 100 feet above the terrain to obtain 50 percent coverage of the Supai and Hermit formations. Along the cliffs of the Coconino, Supai, and Redwall formations rim flying methods were utilized. Distances from the rim were generally from 30 to 50 feet. Flights along these cliffs were made at vertical distances of about 200 feet, for approximately 50 percent coverage, except, in accordance with instructions, along the horizon in which the Ridenour mine is located which received 100 percent coverage. All faulted, jointed, bleached, altered, or otherwise deformed zones were examined 100 percent. Along the slope of the Hermit formation, a combined rim-grid method of flying was utilized. Extensive areas of Kaibab-derived talus which covered much of the Hermit, Toroweap and Coconino formations were not examined in detail. In general, rim flying methods were utilized in very steep slopes and cliffs, and grid flying methods were utilized in the flatter slopes.

The maps utilized in this project included the geologic map of the State of Arizona, prepared by the Arizona Bureau of Mines and the U. S. Geological Survey (R.F. 1:500,000), and the Map of the Hualapai Indian Reservation, prepared by the Department of Interior, Office of Indian Affairs.

The airplane used was a Piper Cub, PA-18 (AEC No. 1162), and the detection instrument was a Nuclear Enterprises Mark VL Airborne-Type Scintillation Counter.

RESULTS OF AIRBORNE PROCEDURES

Only one anomaly was discovered as a result of airborne work in this area. Since the anomalous radioactivity was less than twice normal background radioactivity, it was not reported as a standard anomaly. It is located in an altered zone in the upper portion of the Hermit shale in which the brick-red portion of the formation has been altered to a light cream or yellow. So far as could be discerned, the alteration is the only visible connection with anomalous radioactivity. Neither faulting, intensive jointing, nor folding is noticeable from the air.

GROUND INVESTIGATION PROCEDURES

Ground investigation of the anomaly at Prospect Point revealed an area in which the radioactivity was from one and a half to two times background. This count was confined to a bleached shale at or near the contact of the Coconino sandstone and the Hermit shale. An outcrop of brecciated re-cemented Kaibab (?) limestone on the northwest side of the Point may possibly be a slump block or a breccia-filled sink hole. The count at the limestone was also about two times background. One sample taken at the anomaly assayed 0.01 percent eU_3O_8

CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

Alteration is the best visible guide to radioactive material in this region. However, radioactivity is not associated with all alteration.

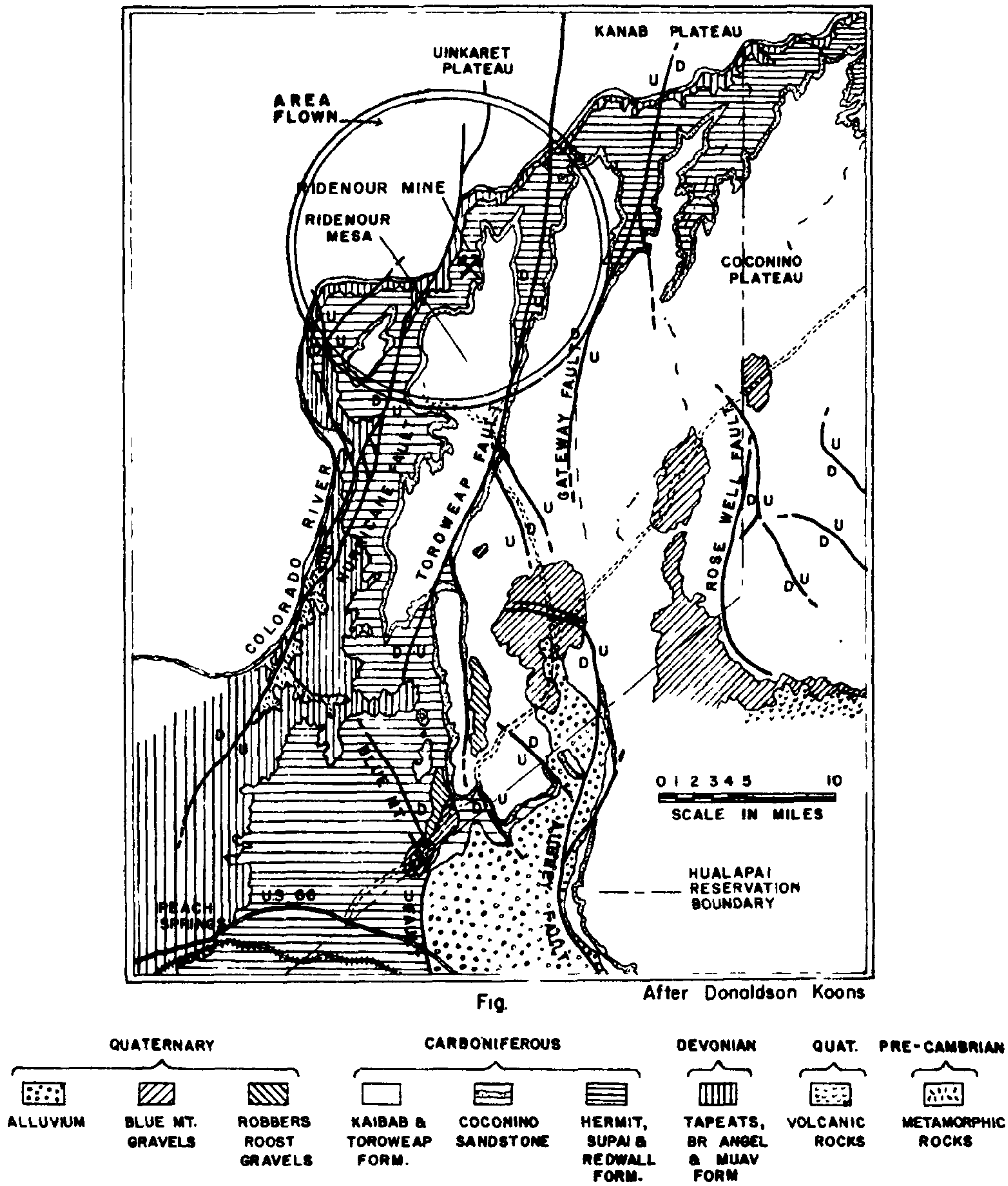
Anomalous radioactivity was not detectable over the Ridenour mine. Airborne surveys cannot be considered final in a search for radioactive material inasmuch as negative results do not rule out the possibility of finding radioactive material on the ground.

Alteration is apparently associated with both tectonic and local structures and is not usually associated with outcrops of igneous rocks.

Recommendations:

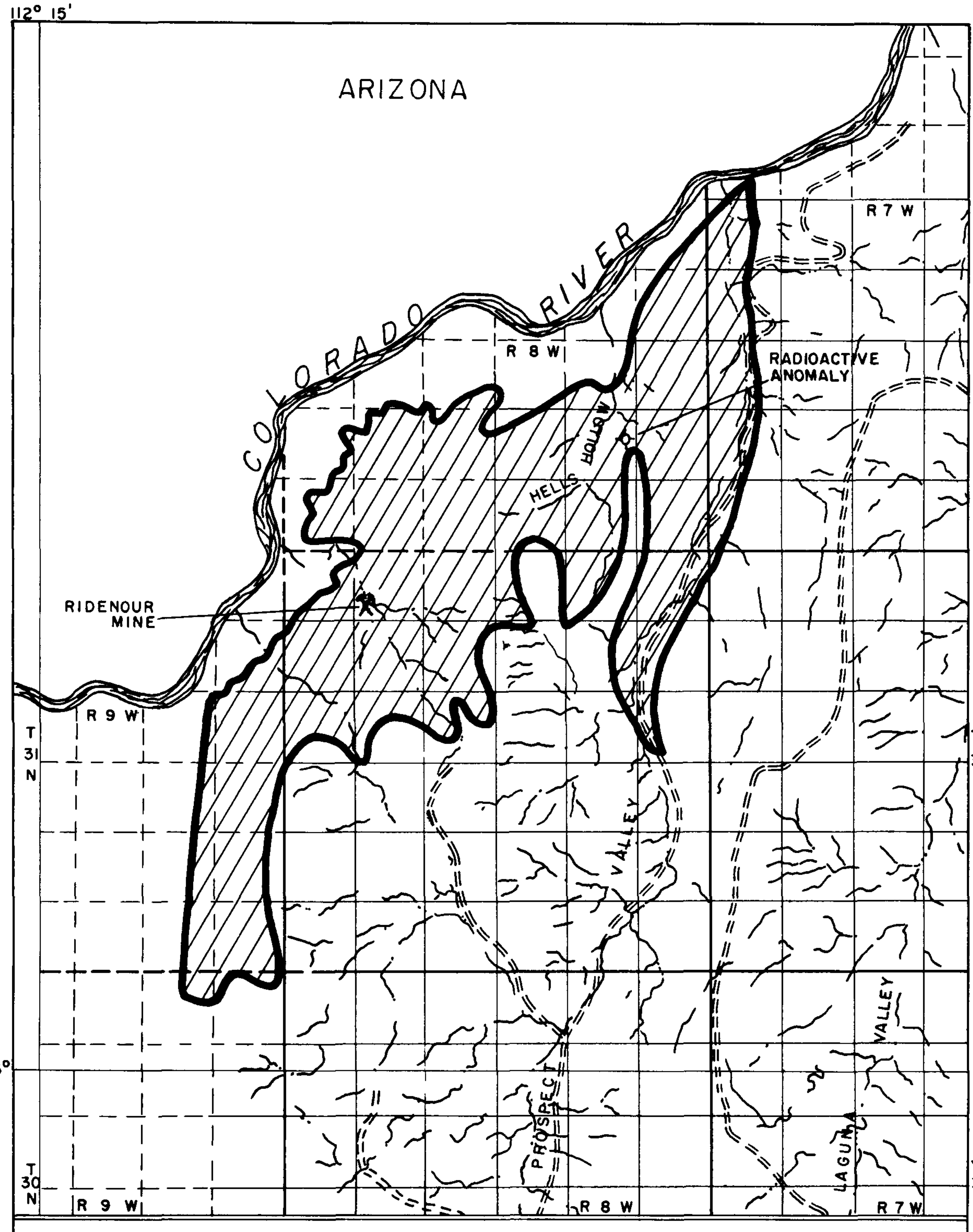
Detailed examination of all altered zones should be made on the ground where possible and otherwise from the air.

Work performed on the northern side of the river indicated that the conglomerate between the Redwall and the Supai should be examined thoroughly. Four areas of anomalous radioactivity were discovered in this horizon.



GEOLOGIC MAP
OF THE EASTERN PART OF THE HUALAPI INDIAN RESERVATION, ARIZONA SHOWING AREA FLOWN

Fig. 5



DETAILED LOCATION MAP OF AREA FLOWN