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PRELIMINARY REPORT
ON THE WHITE CANYON AREA,
SAN JUAN COUNTY, UTAH

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Trace Elements Memorandum Report 325

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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UNITED STATES
DEPARTMENT OF THE INTERIOR
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AEC - 641/2

Dr. Phillip L. Merritt, Assistant Director
Division of Raw Materials
U. S. Atomic Energy Commission
P. O. Box 30, Ansonia Station
New York 23, New York

Dear Phil:

Transmitted herewith for your information and distribution are 6 copies of Trace Elements Memorandum Report 325, "Preliminary report on the White Canyon area, San Juan County, Utah," by William E. Benson, Albert F. Trites, Jr., Ernest P. Beroni, and John A. Feeger, February 1952.

No reserves of uraniferous deposits have been estimated as yet from the 1951 field season's work. Areas to be recommended for exploration are under consideration and will be presented in a later report.

We plan to publish Part I as a Geological Survey circular. We are asking Mr. Hosted, by means of a copy of this letter, whether the Commission has any objection, on grounds of security, to such publication.

Sincerely yours,

O. E. McKelvey

for W. H. Bradley
Chief Geologist

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Geology - Mineralogy

This document consists of 26 pages,
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Series A.

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

PRELIMINARY REPORT ON THE WHITE CANYON AREA, SAN JUAN COUNTY, UTAH *

By

William E. Benson, Albert F. Trites, Jr.,
Ernest P. Beroni, and John A. Feeger

February 1952

Trace Elements Memorandum Report 325

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.

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

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PRELIMINARY REPORT ON THE WHITE CANYON AREA, SAN JUAN COUNTY, UTAH

By William E. Benson, Albert F. Trites, Jr., Ernest P. Beroni, and John A. Feeger

ABSTRACT

The White Canyon area, in the central part of San Juan County, Utah, consists of approximately two 15-minute quadrangles.

Approximately 75 square miles have been mapped by the Geological Survey on a scale of 1 inch equals 1 mile, using a combined aerial photography-plane table method. Structure contours were drawn on top of the Organ Rock member of the Cutler formation. Parts of the Gonway and North Point claims, $\frac{1}{4}$ mile east of the Happy Jack mine, were mapped in detail.

The principal objectives of the investigations were: (1) to establish ore guides; (2) to select areas favorable for exploration; and (3) to map the general geology and to determine the regional relationships of the uranium deposits.

The White Canyon area is comprised of sedimentary rocks of Carboniferous to Jurassic age, more than 2,000 feet thick, having a regional dip of 1° to 2° SW. The nearest igneous rocks are in the Henry Mountains about 7 miles west of the northern part of the area.

The Shinarump conglomerate of late Triassic age, the principal ore horizon in the White Canyon area, consists of lenticular beds of sandstone, conglomeratic sandstone, conglomerate, clay, and siltstone. The Shinarump conglomerate, absent in places, is as much as 75 feet thick.

The sandstones locally contain molds of logs and fragments of altered volcanic ash. Some of the logs have been replaced by copper and

uranium minerals and iron oxides. The clay and siltstone underlie and are interbedded with the sandstone, and are most common in channels that cut into the underlying Moenkopi formation. The Shinarump conglomerate contains reworked Moenkopi siltstone fragments, clay balls, carbonized wood, and pebbles of quartz, quartzite, and chert.

Jointing is prominent in the western part of the mapped area. The three most prominent joint trends are due east, N. 65°-75° W., and N. 65°-75° E. All joints have vertical dips. The red beds are bleached along some joints, especially those that trend N. 65°-75° W.

All uranium ore produced has been from the lower part of the Shinarump conglomerate, where it commonly occurs with copper as disseminations and fracture coatings in sandstone. Uranium and copper minerals also occur in low-grade disseminated deposits in the lower Chinle and in the Moenkopi formation and in veins cutting these formations.

Although some uranium deposits occur in Shinarump channels and scours, copper and uranium minerals along fractures suggest that channel control may be secondary. Logs and clay balls apparently have exerted some chemical influences for deposition.

The uranium occurs as the oxide in some deposits, and as secondary hydrous sulfates, phosphates, oxides, and silicates in these and several other deposits. Charcoal, iron and manganese oxides, and veinlets of hydrocarbon are abnormally radioactive in most of the deposits. Base-metal sulfides are commonly found inside the oxidized zone. Secondary copper minerals include the hydrous sulfates and carbonates.

Gangue minerals include quartz, clay minerals, iron and manganese oxides, dickite (?), calcite, gypsum, pyrite, and chalcedony (?).

Principal wall-rock alteration appears to have been silicification, clay alteration, and bleaching.

Most of the shipped ore has contained more than 0.2 percent uranium and some has contained more than 0.3 percent uranium. The ore also contains copper, commonly in grades lower than 1.0 percent.

Criteria believed to be most useful for prospecting for concealed uranium deposits are: (1) visible uranium minerals; (2) sulfide minerals; (3) secondary copper minerals; (4) dickite (?); (5) hydrocarbons; and (6) bleaching and alteration of the Moenkopi formation.

INTRODUCTION

Location

The White Canyon area, in the central part of San Juan County, Utah (fig. 1) is approximately 30 miles long by 15 miles wide. It is bounded on the north by Dark Canyon, on the east by Elk Ridge, on the south by Red Canyon, and on the west by the Colorado River; it is about the size of two 15-minute quadrangles.

The area is accessible from the east and west by Utah Highway 95, a graded dirt road. Blanding, Utah, is 50 miles to the east and Hanksville, Utah, is 65 miles to the west across the Colorado River. A ferry at Hite, Utah, provides the only vehicular crossing of the Colorado River in the area.

Previous work

A reconnaissance of the White Canyon area was made between 1925 and 1929 by H. E. Gregory (1938, 123 pp.). Reconnaissance examination of some of the uranium deposits in White Canyon was made by H. C. Granger

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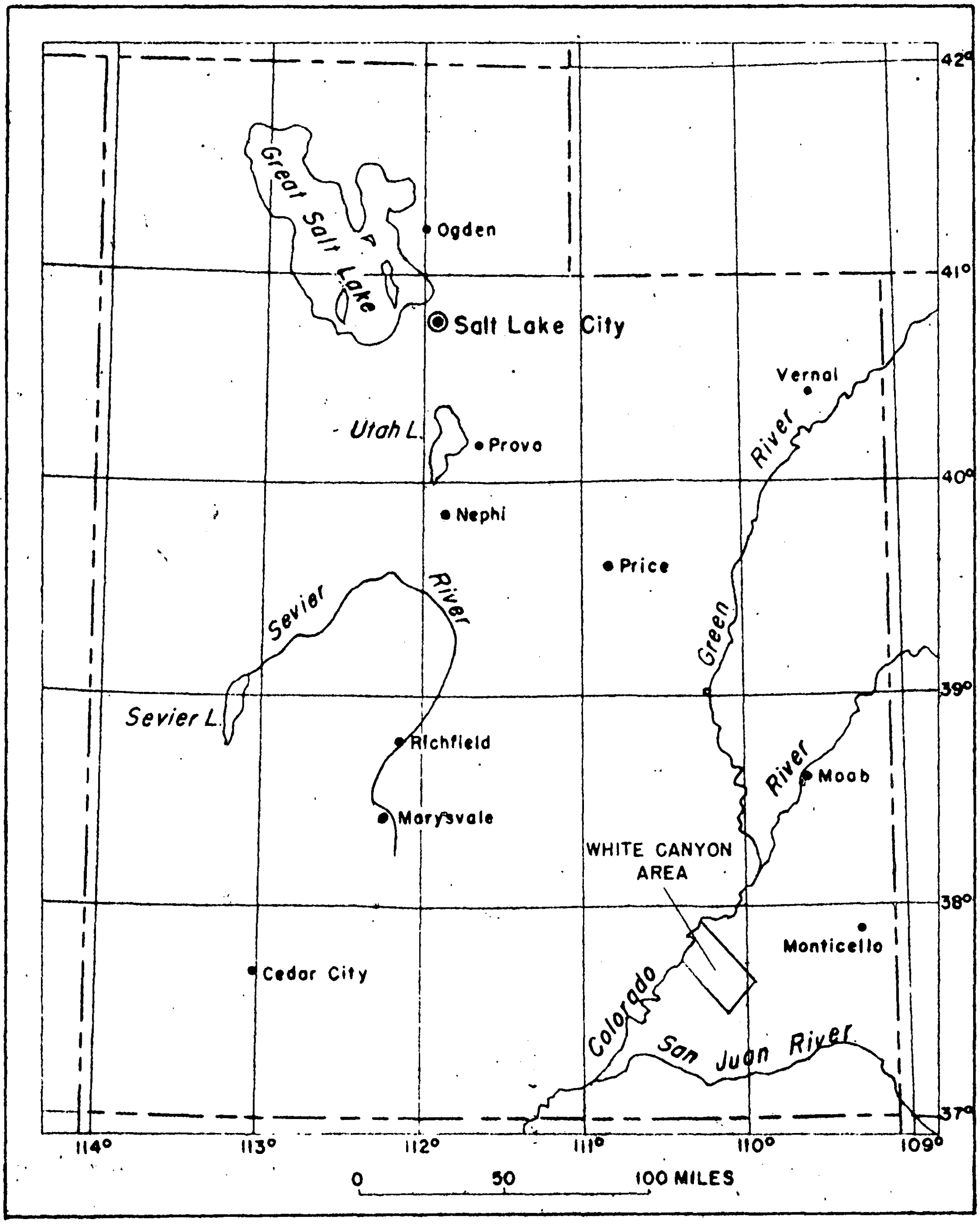

FIGURE I.— INDEX MAP OF UTAH

and E. P. Beroni (1950) for the U. S. Geological Survey, and a report on the Happy Jack mine was made by P. H. Dodd (1950, 23 pp.) for the U. S. Atomic Energy Commission. Other reports on the area are by Fischer and King (1948), Smyth (1949), and Gruner and Gardner (1950).

Purpose of work

The principal objectives of the investigations in the White Canyon area were: (1) to study the physical and mineralogic characteristics of the uranium deposits so that useful ore controls and guides can be established; (2) to select areas of the Shinarump conglomerate and other Triassic formations favorable for exploration for concealed deposits; and (3) to map the general geology and to determine the regional relationships of the uranium deposits. This work was done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

Field methods

Approximately 75 square miles have been mapped on a scale of 1 inch equals 1 mile. The method used combined the advantages of a plane table with the advantages of aerial photographs. Triangulation control was established by plane table, and points on the geologic contacts were located by intersection. The contact lines were first mapped on the photographs and transferred to the plane-table sheets by inspection.

Structure contours were drawn on top of the Organ Rock member of the Cutler formation. Parts of the Gonway and North Point claims, $\frac{1}{4}$ mile east of the Happy Jack mine, were mapped by plane table on a scale of 1 inch equals 20 feet.

GENERAL GEOLOGY

Rocks in the White Canyon area consist of sediments ranging in age from Pennsylvanian to Jurassic; the entire section is more than 2,000 feet thick. These beds are on the southwest flank of the Elk Ridge anticline and have a regional dip of 2°-3° SW. The nearest exposed igneous rocks are in the Henry Mountains, about 7 miles to the west.

Gregory (1938, pp. 40-56) has described most of the rocks exposed in the area. The general stratigraphic features of the formations are summarized in the following table, part of which is taken from Gregory:

Age	Formation	Description	Thickness (feet)
Jurassic	Glen Canyon group		
	Navajo sandstone	Cream-yellow, massive cross-bedded sandstone (not examined yet)	300 ±
	Kayenta formation	Dark red, thin-bedded sandstone (not examined yet)	200 ±
	Wingate sandstone	Reddish-brown, massive cross-bedded sandstone	300 ±
Upper Triassic	Chinle formation		
	Upper member	Reddish-brown, thin-bedded calcareous sandstone, siltstone, and mudstone	100 ±
	Middle member	Variegated calcareous and bentonitic mudstone and siltstone	300-330
	Lower member	Gray to variegated clays and gray to brown lenticular sandstone and conglomerate	220-245
	Shinarump conglomerate	Yellow to gray sandstone, conglomerate, siltstone, and clay	0-75

Age	Formation	Description	Thickness (feet)
Unconformity			
Lower Triassic	Moenkopi formation	Dark-brown to grayish-red thin-bedded siltstone, brown to yellow shale, and white to pink fine-grained sandstone with local clay balls	200-350
Permian	Cutler formation		
	White Rim sandstone member	Cream-colored fine-grained sandstone (not examined yet)	10+
	Organ Rock tongue	Reddish-brown micaceous siltstone and very fine-grained sandstone	200-300
	Cedar Mesa sandstone member	Cream, cross-bedded sandstone with local red shale near the top	1,000 +
	Rico formation	Interbedded gray, red, and purple sandstone, siltstone, shale, and limestone	575 ±
Pennsylvanian	Hermosa formation	Gray cherty limestone with gray, buff, and red calcareous sandstone and shale	400-1,000

Pennsylvanian rocks

Hermosa formation

The Hermosa formation of Pennsylvanian age is exposed only in Dark Canyon, and has not yet been examined. Gregory (1938, p. 40) describes the formation as interbedded limestone, sandstone, and shale, from 400 to 1,000 feet thick.

Permian rocks

Rico formation

The Rico formation of Permian age, like the Hermosa formation, is exposed only in Dark Canyon, and has not been studied. Baker (1946, pp. 32-36) has described the Rico formation of the Green River Desert-Cataract Canyon region north of White Canyon as consisting of approximately 575 feet of interbedded sandstone, shale, siltstone, and limestone, with sandstone predominating.

Cutler formation

The Cutler formation, in southeast Utah, consists of six members and tongues, namely, the Halgaito tongue, the Cedar Mesa sandstone member, the Organ Rock tongue, the De Chelly sandstone member, the Hoskinnini tongue, and the White Rim sandstone member. Of these, only Cedar Mesa, Organ Rock, and White Rim are present in the White Canyon area. The upper part of the Organ Rock tongue is a cliff-forming red sandstone, similar to the Hoskinnini tongue. It may actually be the equivalent of the Hoskinnini.

Cedar Mesa sandstone member.--The Cedar Mesa sandstone member of the Cutler formation forms the floor of White Canyon and has been intrenched by streams to depths of 50 to 200 feet. It is made up of thick beds of light-cream colored, cross-bedded fine-grained calcareous sandstone with local thin beds of red shale near the top. The cross bedding is eolian-type and is foreset to the southeast. In Dark Canyon, the Cedar Mesa sandstone directly overlies the Rico formation with apparent conformity.

Organ Rock tongue.--The Organ Rock tongue of the Cutler formation is composed of from 200 to 300 feet of pale and dark reddish-brown micaceous siltstone and very fine-grained sandstone, the upper 50 to 100 feet of which forms a cliff. Gray sandstone beds occur in the upper 50 feet of the formation near the western end of the mapped area. The upper cliff-forming sandstone may be the equivalent of the Hoskinnini tongue.

White Rim sandstone member.--The White Rim sandstone member, described by Baker (1946, pp. 44-48) and Hunt (in preparation), occurs only in the lower part of White Canyon, where it is a light-colored fine-grained sandstone, less than 10 feet thick. It thins and pinches out a few miles east of the Colorado River.

Triassic rocks

Moenkopi formation

The Moenkopi formation of early Triassic age is comprised of about 200 to 350 feet of thin-bedded dark-brown to grayish-red siltstone, brown to yellow shale, and grayish-red to light-gray sandstone. Many of the sandstone beds contain abundant clay balls. In the western part of the mapped area the lower part of the Moenkopi contains lenticular beds of light-gray sandstone, and beds of dark-gray, petroliferous cherty conglomerate, the lowest of which forms the base of the formation and channels into the underlying Organ Rock tongue. The lower Moenkopi and upper Organ Rock beds are crumpled locally by small folds.

Shinarump conglomerate

The Shinarump conglomerate, the principal ore horizon in the White Canyon area, is regarded by Gregory (1938, p. 49) as the basal conglomerate of the Upper Triassic Chinle formation, and rests unconformably on Moenkopi beds. The most striking feature of the formation is its extreme lenticularity. Shinarump beds 40 feet thick may pinch out completely in an outcrop length of less than 2,000 feet. Thickening of the formation has resulted both from the filling of channels in the Moenkopi beds at its base and from thickening at the expense of the Chinle shales at its top. It reaches a maximum thickness of 75 feet.

The Shinarump conglomerate is composed of yellowish-gray to gray, red, and brown sandstone, conglomeratic sandstone, conglomerate, and gray to yellowish-gray clay and siltstone. Sandstone beds, locally conglomeratic, form the top of the formation in most exposures, and range in thickness from less than 1 foot to more than 30 feet. Sandstone comprises the entire formation along some segments, especially where the Shinarump is less than 10 feet thick.

Gray clay and siltstone beds underlie the sandstone and are interbedded with it in some localities. They are most common in the channel fills, comprising the greater part of the fill in some exposures. These beds range from 2 to 30 feet in thickness.

Locally, a conglomerate bed forms the base of the formation, and the bottom few inches commonly consists of a reworked zone containing subrounded to rounded Moenkopi fragments in a matrix of sandstone, conglomerate, or siltstone.

The sandstone consists of well-rounded to subangular quartz grains with calcite, clay, and iron-oxide cement. In some places molds of logs remain, the wood itself having been removed. A few logs have been replaced by copper and uranium minerals and iron oxides; other logs have been silicified. Fragments of volcanic ash_/ have also been noted, many of

_/ Waters, A. C., personal communication.

which have been altered to a montmorillonite-type of clay.

The Shinarump conglomerate contains reworked Moenkopi siltstone fragments, clay balls, carbonized wood, and quartz pebbles. Where all these types of fragments are present it gives the conglomerate a "trashy" appearance.

Many of the clays and siltstones contain abundant carbonaceous material, part of which has been identified as charcoal._/ Some clay beds

_/ Waters, A. C., personal communication.

appear to have a high montmorillonite content.

Chinle formation

The Chinle formation has been divided into three parts: upper, middle, and lower. The lower Chinle ranges from approximately 220 to 245 feet in thickness and consists of gray bentonitic clay, which is locally variegated, and lenticular beds of sandstone and conglomerate. A resistant sandstone and conglomerate bed, 10 to 100 feet thick, forms the top of this unit in many places. This sandstone bed has been confused with the Shinarump conglomerate by some geologists.

The middle Chinle is composed principally of variegated calcareous and bentonitic mudstone and siltstone with minor amounts of cherty conglomeratic claystone. Much of this unit may be altered tuffaceous sediments. Measured sections range from about 300 to 330 feet in thickness.

The upper Chinle is made up of about 100 feet of reddish-brown, very fine-grained, calcareous sandstone, siltstone, and mudstone with some thin beds of gray and purplish-gray clay.

Jurassic rocks

Glen Canyon group

Wingate sandstone.--The Wingate sandstone has not been studied in detail yet in the White Canyon area. Gregory (1938, p. 54) has described the formation as consisting of about 300 feet of reddish-brown fine-grained cross-bedded massive sandstone. The beds form a vertical cliff capping the higher points in the area.

On the south rim of Frey Canyon the lowermost 30 to 40 feet of the Wingate consists of laminated coarse- to fine-grained sandstone with fluvial-type cross bedding. The fine-grained sandstone above these basal beds is probably of eolian origin.

Kayenta formation.--Kayenta formation caps the Wingate sandstone in many spots; it has not been examined yet.

Navajo sandstone.--Remnants of Navajo sandstone cap the Kayenta in a few places, but are inaccessible in the area studied.

STRUCTURE

The sedimentary rocks of the White Canyon area have a dip of 1°-2° SW, except in the western part of the area, near the Colorado River, where the dips steepen. The upper beds of the Organ Rock tongue and the lower beds of the Moenkopi formation have been folded into minor flexures in the western part of the mapped area.

Jointing of the formation is rather prominent, especially in the western part of the mapped area. Many of these joints are traceable from the top of the Moenkopi through the Organ Rock to the Cedar Mesa sandstone in the canyon bottom. Some of the fractures, immediately northwest of the mapped area, appear to be faults, displacing beds of the Cedar Mesa sandstone.

The three most prominent trends of the joints are: due east; N. 65°-75° W.; and N. 65°-75° E. All of these have vertical dips. Less prominent joints, also with vertical dips, strike nearly north. The Organ Rock tongue and the Moenkopi formation have been bleached in a zone as much as 3 feet wide along some of these joints.

Fractures in the sandstones in the Shinarump conglomerate trend generally parallel to the main jointing in the area. A few inches to a foot of movement has occurred along some of these fractures.

URANIUM DEPOSITS

Types of deposits

The principal known uranium deposits in the White Canyon area are shown in figures 2 and 3. All uranium ore produced has been from the Shinarump conglomerate where it commonly occurs with copper, disseminated in the sandstone and along fractures. Uranium and copper minerals also occur in low-grade disseminated and vein deposits in lower Chinle sandstones and in Moenkopi sandstones and siltstones.

The uranium ore occurs principally in the lower one-third of the Shinarump conglomerate; the thickness of the ore-bearing sandstones in few places exceeds 10 feet, and in most deposits is less than 5 feet.

Although some uranium deposits occur in Shinarump channels and scours, they are not confined to these channels. The largest known deposit in the area, the Happy Jack mine, is without obvious channel control, although a structure map prepared by the Atomic Energy Commission (Dodd, 1950) does show a structural low on top of the Moenkopi formation at this place. Several large channels, more than 200 feet wide with scours more than 20 feet deep, contain no appreciable amounts of uranium or copper minerals. One of the best prospects is the Hideout claim, which appears to be in a channel approximately 50-75 feet wide that has a 7-foot scour. Uranium and copper minerals are in the lower 5 feet of this channel, across a width of 50 feet. The Hideout claim also has been mineralized along fractures in the Shinarump, suggesting that the channel control may be secondary.

Uranium and copper minerals have been somewhat localized by structural and chemical control. The Shinarump sandstones are jointed into blocks, 3 feet to 10 feet across, above many of the higher-grade deposits. Many of these joints are discontinuous from one bed to another, or have been deflected in crossing between beds. Shinarump channels that have been prominently fractured appear to contain significant quantities of copper and uranium minerals, whereas nearby, slightly fractured channels are nearly barren of these minerals.

Both copper and uranium minerals have a tendency to replace logs in sandstone of the Shinarump conglomerate, and coronas of secondary copper and uranium minerals have been noted around some replaced logs. Some clay balls in the sandstone apparently have exerted a favorable chemical influence, and have been largely replaced by secondary uranium and copper minerals; on the other hand, megascopically similar balls have apparently inhibited such action, remaining unreplaced, although surrounded by those minerals.

The uranium occurs as the oxide, either pitchblende or uraninite, in at least three deposits, the Happy Jack, Posey, and Hideout mines. Secondary uranium hydrous sulfates, phosphates, oxides, and silicates occur with the oxide in these properties, and in others where the oxide has not been found. The secondary uranium minerals reported from the White Canyon area include the following according to Dodd (1951, pp. 13-14):

Schoepite-Becquerelite	$2UO_3, 3H_2O$.
Johannite	$(Cu, Fe, Na_2) UO_3.SO_3.4H_2O$
Torbernite	$CuO.UO_3.P_2O_5.12H_2O$.
Uranophane	$CaO.2UO_3.2SiO_2.6H_2O$
Zippeite	Hydrous U Sulfate

Charcoal, iron and manganese oxides, and veinlets of hydrocarbon are abnormally radioactive, and the source of the radioactivity is being investigated.

Base-metal sulfides have been found in every deposit that has been explored beyond the oxidized zone. Sulfides identified from White Canyon include chalcopyrite, chalcocite, bornite, covellite, arsenopyrite, galena, sphalerite, and pyrite. Gold and silver have been reported in assays from the Happy Jack mine.

Copper minerals are associated with the uranium in all the principal uranium deposits, and are also found in the Shinarump where little, if any, uranium occurs. The secondary copper minerals identified are the hydrous sulfates and carbonates.

Gangue minerals include quartz, clay minerals, and iron and manganese oxides in all the deposits, and dickite (?), calcite, gypsum, pyrite, vein quartz, and chalcedony in some deposits.

Some of the deposits have undergone silicification and clay alteration. In places, later silica has been introduced into sandstone of the Shinarump conglomerate, producing veinlets through the rock and crystal faces on the quartz grains. A white clay mineral, tentatively identified as dickite by Waters, _/ appears to have replaced siltstone and sandstone

_/ Waters, A. C., personal communication.

of the Shinarump adjacent to some fractures. Siltstones of the Moenkopi formation have been bleached creamy-white for as much as 5 feet beneath some deposits in altered Shinarump conglomerate. Bleaching appears to have been more intense in the western part of the mapped area, especially the area near the Happy Jack mine. The Moenkopi beds have been bleached for as much as a foot along veins of copper and uranium minerals.

Grade

Figure 2 indicates the estimated grade of rock from some of the properties in the White Canyon area. A grade in excess of 0.2 percent uranium must be maintained for most operators to realize a profit. Some ore shipped from the Happy Jack, Posey, Bell, and Yellow John mines is said to contain more than 0.3 percent uranium.

Copper is contained in most of the ore, commonly in grades less than 1.0 percent, although more than 5.0 percent copper has been reported by Granger and Beroni (1950, pp. 16-19) in individual samples.

Production

Although the White Canyon area was prospected as early as 1880, production was negligible until 1949. Only a small amount of copper was mined prior to this time. Present producing properties are the Happy Jack, Yellow

John, and Bell mines in White Canyon, and the Posey mine in Red Canyon. Seven promising properties, the Frey No. 4., White Canyon No. 1, Hideout, Scenic No. 4, Scenic No. 2, Gonway and North Point, Dead Buck, and W. N. claims, are idle. In 1950 the Vanadium Corporation of America erected a pilot mill for the processing of uranium ore at Hite, Utah. This mill has been receiving ore exclusively from the Happy Jack mine.

The ore from all other properties is trucked to Monticello, Utah, where it is crushed and shipped to the Simplot Company mill at Salt Lake City.

RESULTS OF WORK

Ore criteria

The following criteria are believed useful for prospecting for concealed uranium deposits in the White Canyon area. These criteria are arranged in the order of their importance.

Criteria that always apply to ore deposits
(These features were observed only in mineralized areas)

1. Visible uranium minerals
2. Sulfide minerals
3. Copper minerals
4. Dickite (?)
5. Hydrocarbons
6. Bleaching and alteration in the Moenkopi formation

Visible uranium minerals.--Visible secondary uranium minerals, zippeite, johannite, and torbernite, were noted in the following claims (in order of their significance): Happy Jack, Posey, Hideout, Frey No. 4, White Canyon No. 1, Yellow John, Bell, Jerry, North Point, Gonway, Scenic No. 2, Scenic No. 4, Sunrise No. 1, and Ace of Hearts (fig. 2). These secondary uranium minerals may reflect the presence of a uraniferous sulfide ore deposit beyond the oxidized zone.

Sulfide minerals.--Sulfide minerals chalcocite, bornite, covellite, pyrite, arsenopyrite, chalcopyrite, galena, and sphalerite were noted in the following claims (in order of their significance): Happy Jack, Posey, Hideout, Frey No. 4, Yellow John, Bell, Found, Jerry, Gonway, North Point, W. G. J. N. W., Scenic No. 2, Woodenshoe (?), Jacob Chair, and Bankrupt (fig. 2). These sulfide minerals may indicate the presence of a uranium deposit.

Secondary copper minerals.--Copper minerals have been found in the Shinarump conglomerate associated with the uranium deposits. Near the surface these minerals are principally the hydrous sulfates and carbonates, and are found disseminated and as fracture coatings. Disseminated secondary copper minerals may reflect the presence of a uraniferous-sulfide body. Some copper minerals were noted in the Chinle and Moenkopi formation, associated with fractures.

Dickite (?).--A white clay mineral, tentatively identified in the field by Waters _/ as dickite (?) occurs in some of the uranium deposits, both along fractures and in the bedding. Dickite (?) was noted in the North Point, Gonway, and Woodenshoe (?) claims (fig. 2).

Hydrocarbons.--Hydrocarbons were noted occurring as veinlets and globules in some of the copper-uranium deposits in the White Canyon district. The following claims, arranged according to their significance, contain probable hydrocarbons: Happy Jack, Posey, Hideout, Woodenshoe (?),

_/ Waters, A. C., Verbal communication.

and Four Aces (fig. 2). These hydrocarbons, themselves, are commonly uraniferous, and may indicate a favorable ore zone.

Bleaching and alteration in the Moenkopi formation.--Bleaching and alteration in the Moenkopi formation below the Shinarump conglomerate was noted at some of the more favorable ore bodies. The following claims showed considerable bleaching and alteration associated with fracturing: Happy Jack, Gonway, North Point, and Found (fig. 2). This bleaching, however, is not present under many deposits and its absence does not make an area favorable. Little or no bleaching was noted at the Frey No. 4 and Woodenshoe (?) claims.

Criteria that may apply to ore deposits
(These features were observed at many deposits but were seen in unmineralized areas as well.)

1. Fracturing
2. Iron and manganese staining
3. Carbonized wood fragments and vegetal material
4. Channel filling
5. Jarosite (?)
6. Facies change within the Shinarump conglomerate

Fracturing.--Close fracturing of the Shinarump sandstones and conglomerates is in some places a favorable criterion for prospecting. The fractured zones associated with the copper-uranium bodies generally show a considerable shattering of the rock.

Iron and manganese staining.--A red, brown, and black coating commonly occurs on fractures and outcrop surfaces over a large portion of the Shinarump and Chinle sandstones and conglomerates. However, iron and manganese staining is especially abundant near some areas showing considerable copper and uranium mineralization.

Carbonized wood fragments and vegetal material.--Considerable carbonized wood fragments and vegetal material are found in the Shinarump conglomerate. Many of these carbonized remains, especially those associated with charcoal, are highly uraniferous, and may suggest a favorable area for a concealed uraniferous ore body. Other outcrops containing carbonized wood are not radioactive.

Channel filling.--Although many channels are cut into the Moenkopi formation and are filled by the Shinarump conglomerate, especially in upper White Canyon, only a few of them contain appreciable amounts of uranium or copper minerals. Included in this group are the Posey, Hideout, Bell, Yellow John, Frey No. 4, and Scenic No. 4 claims (fig. 2).

Jarosite (?).--Considerable yellow iron staining tentatively identified in the field as jarosite (?), occurs on fractures and outcrop surfaces of the Shinarump conglomerate. This yellow staining is commonly associated with a gray silty sandstone. Although this mineral is present in many of the uranium deposits, it has also been noted where no radioactivity could be detected.

Facies change within the Shinarump conglomerate.--Conglomerates and sandstones of the Shinarump conglomerate commonly contain clay, shale, and siltstone lenses that are mildly radioactive, but generally these lenses are too small and low grade to produce any commercial uranium ore.

Criteria that do not apply to ore deposits

1. Massive sandstone
2. Conglomerate
3. Hydrous mica

4. Freckled limonite

These four criteria have been very significant in other uranium-bearing areas in finding additional ore, but are considered by the writers to have little importance in finding concealed uranium deposits in the White Canyon district.

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