Geology of the Jomac Mine, White Canyon Area San Juan County, Utah

GEOLOGICAL SURVEY BULLETIN 1046-H

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Trites, Hadd—GEOLOGY OF JOMAC MINE, WHITE CANYON AREA, UTAH—Geological Survey Bulletin 1046-H

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By ALBERT F. TRITES, Jr., *and* GEORGE A. HADD

CONTRIBUTIONS TO THE GEOLOGY OF URANIUM

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CONTRIBUTIONS TO THE GEOLOGY OF URANIUM

GEOLOGY OF THE JOMAC MINE, WHITE CANYON AREA, SAN JUAN COUNTY, UTAH

By Albert F. Trites, Jr., and George A. Hadd

ABSTRACT

The Jomac mine is about 13 miles northeast of the town of White Canyon, Utah. The mine workings consist of two adits connected by a crosscut.

Sedimentary rocks exposed in the Jomac mine area are of Permian to Late Triassic age and have combined thickness of more than 1,700 feet. An ancient stream channel, from 200 to 400 feet wide and about 4 feet deep, enters the mine area from the southwest, swings abruptly northwest near the mine workings and continues to the northern tip of Jomac Hill. This channel, including depressions that apparently were scoured into its floor, was cut into the upper beds of the Moenkopi formation and filled by Chinle and Shinarump sediments. A tributary channel may have joined it from the southeast at a point near the mine workings. Beds of the Chinle intertongue with beds of the Shinarump along the southwestern part of the channel. After the main channel was partly filled by siltstone of the Chinle formation, the stream was apparently diverted into the tributary channel, and scours were cut into siltstone of the Chinle and filled by sandstone, conglomerate, and siltstone of the Shinarump. Statistical study of wood orientation in the beds of the Shinarump conglomerate indicates a channel trend about N. 23° W. Basal siltstone-pebble conglomerates appear to mark the edge of channels and scours.

Jomac Hill is on the crest of a southwest-plunging fold on the west flank of a larger syncline. The area surrounding the hill is broken by intense faulting, but no faults were noted in the vicinity of the mine. The major fractures in the mine workings strike N. 70°–80° E. and dip steeply. Secondary steeply dipping fractures strike N. 40°–60° E., and N. 10° E.–N. 10° W. The fractures are believed to be related to the anticlinal structure rather than to the faults.

Most of the uranium is contained in coal in association with jarosite and gypsum in sandstone, conglomerate, or sandy siltstone near the base of the Shinarump conglomerate. Uranium occurs in metazeunerite, a fibrous green secondary mineral, in an unidentified fibrous yellow mineral, and in an unidentified massive yellow mineral. Secondary copper minerals, including malachite, azurite, and chalcanthite, occur locally with the uranium minerals. Principal ore guides at the Jomac mine are channels, scours at the bottom of these channels, coal-bearing sandstone or conglomerate at the base of the Shinarump conglomerate, coal, and jarosite.

INTRODUCTION

LOCATION AND ACCESSIBILITY

The Jomac mine is on the east side of the Colorado River about 13 miles northeast of the town of White Canyon, San Juan County, Utah (fig. 20). The property is reached from the town of White

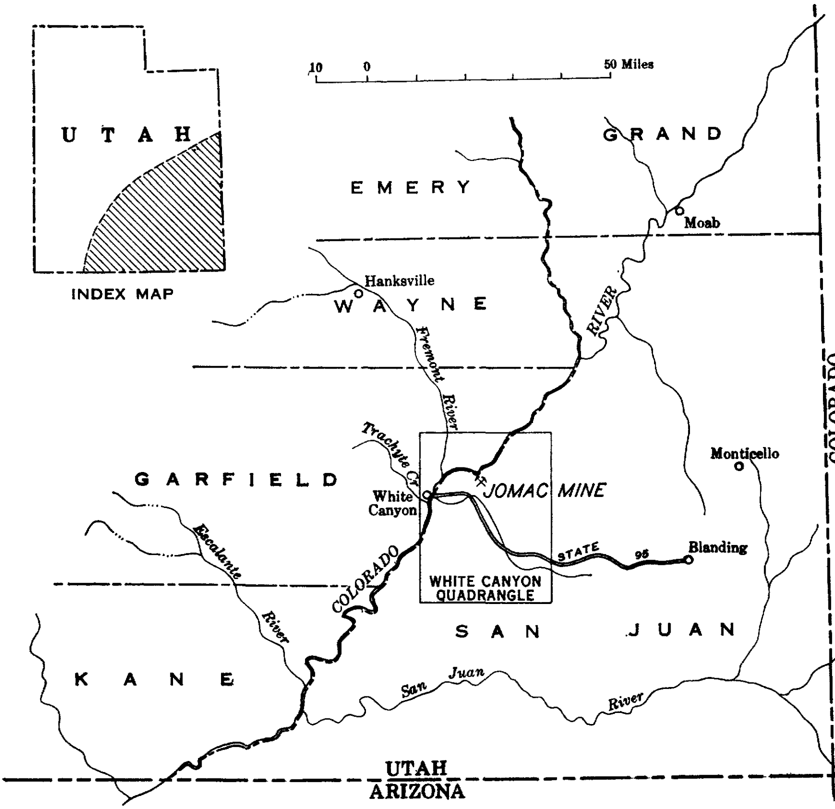

FIGURE 20.—Index map of parts of Utah and Arizona showing location of Jomac mine, White Canyon area, San Juan County, Utah.

Canyon by traveling about 3 miles east along Utah Highway 95 and then turning to the northeast on a bulldozer road that leads to the mine. An airstrip, suitable for light planes, is available on the flats above the Colorado River 2 miles northeast of the Jomac mine. The nearest ore-receiving plant is at Mexican Hat, Utah. The mine workings are on the southeast side of Jomac Hill at an altitude of about 5,200 feet.

HISTORY AND PRODUCTION

The Jomac mine is on a claim located by J. B. Plosser and A. M. McLeod in November 1950. The property, consisting of three contiguous lode claims known as the Jomac I, Jomac II, and Jomac III, in unsurveyed T. 34 S., R. 14 E., Salt Lake principal meridian, is owned by the Ellihill Mining Company, White Canyon, Utah, a corporation formed to explore for and to develop uranium deposits.

Nearly 300 tons of ore, containing both uranium and copper, was shipped from the mine from May 1951 to January 1954.[1]

MINE WORKINGS

Two adits, 315 and 130 feet long, had been driven into the uraniferous deposit by August 1953. These adits have been connected by a 75-foot crosscut. Another crosscut was being driven from adit 2 to intersect the extension of adit 1 at a point approximately 140 feet behind the rim. A short drift, 25 feet along, has been driven northward from adit 1.

DIAMOND DRILLING

The owners, with financial assistance from the Defense Minerals Exploration Administration, completed 2,983.5 feet of exploratory diamond drilling between December 1952 and June 1953. These holes tested the eastern part of Jomac Hill where beds of Shinarump conglomerate are exposed at the rim. The drill holes ranged from 33.8 to 159.0 feet deep; all of the holes were collared in beds of the Chinle formation above the Shinarump rim and all except four of the holes were bottomed in beds of the Moenkopi formation. Core was recovered in both the Chinle and Shinarump and was logged in detail in the Shinarump section.

FIELD METHODS

The writers studied in detail the Jomac mine during May 1953. A surface map was prepared on a scale of 1 inch to 100 feet by planetable methods. Structural contour lines were drawn on the bottom of the basal sandstone of the Shinarump conglomerate, on the top of the Moenkopi formation, and on an upper resistant siltstone bed of the Moenkopi formation, to determine what effect channels and the regional dip of the strata may have had on the localization of the uranium deposits. Structural contour lines drawn on the bottom of a basal sandstone of the Shinarump conglomerate and the top of the Moenkopi were corrected for regional dip by using the contours of the siltstone bed of the Meonkopi formation. The Shrinarump

[1] Data furnished by the Ellihill Mining Company. Published with permission.

conglomerate was logged in detail in each of 31 holes, and these logs were used in interpreting the mode of uranium occurrence and in determining the grade and reserves of the unraniferous rock.

A transit survey was made of part of the mine workings, and wall maps were prepared on a scale of 1 inch to 5 feet. More than 40 samples of the Shinarump were collected in the mine workings. Twenty-eight of these samples were analyzed for equivalent uranium and 10 for copper.

ACKNOWLEDGMENTS

T. L. Finnell, J. D. Sears, L. C. Huff, and Roger Morrison mapped the Jomac area in the course of the areal mapping in the White Canyon district during the 1952 field season. This mapping was on a scale of 1 inch to 0.5 mile and is shown on plate 4. Charles Lough assisted in the underground geologic mapping.

The writers thank Mr. J. B. Plosser, president, and Miss Margaret Jordan, secretary, of the Ellihill Mining Company for many favors and much helpful information furnished during the investigation. This work was done by the U. S. Geological Survey on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

GEOLOGY

STRATIGRAPHY

Jomac Hill is composed of sedimentary rocks of Permian to Late Triassic age. These rocks are on the west flank of the Monument upward; the beds in general strike N. 25° W. and dip 2° SW. The Monument upwarp is a large north-trending anticlinal structure more than 60 miles long, extending for 30 miles on each side of the San Juan River.[2] The upwarp has a gentle west slope with dips ranging from 0.5° to 2°, and a steeper east slope with dips locally exceeding 50°. The exposed sedimentary rocks in the vicinity of Jomac Hill have a combined thickness of more than 1,700 feet.

In places reddish-brown siltstone of the Moenkopi formation underlies sandstone and conglomerate of the Shinarump conglomerate and in places the siltstone of the Moenkopi underlies siltstone that can be traced into beds of the lower part of the Chinle formation (pl. 4). The Shinarump conglomerate, the uranium-bearing formation, intertongues with the lower part of the Chinle formation and is present on the surface only on the east side of the hill where it crops out as a ledge beneath the Chinle formation. A sandstone

[2] Gregory, H. E., 1938, The San Juan country, a geographic and geologic reconnaissance of southeastern Utah with contributions by M. R. Thorpe and H. D. Miser: U. S. Geol. Survey Prof. Paper 188, v. 123, p. 85–88.

bed of the lower member of the Chinle formation caps the hill; the Chinle formation is composed of carbonaceous siltstone and claystone and three conspicuous beds of sandstone or conglomerate.

CUTLER FORMATION

The Cutler formation of Permian age exposed in the area of Jomac Hill includes the Cedar Mesa sandstone member, the Organ Rock tongue, and the White Rim sandstone member. The Cedar Mesa sandstone forms the base above which the hill rises. This member is about 1,000 feet thick and consists of cream-colored crossbedded sandstone with local red shale beds near the top. Reddish-brown siltstone and very fine grained sandstone of the Organ Rock tongue form the lower slopes of the hill and part of the nearly vertical wall above the lower slopes. The Organ Rock tongue is about 300 feet thick in the area. The White Rim sandstone (not shown on pl. 4), ranging from 10 to 20 feet in thickness, forms a light-colored ledge beneath the Moenkopi formation. It is cream colored and fine grained.

MOENKOPI FORMATION

The Moenkopi formation of Early and Middle(?) Triassic age is about 300 feet thick in the Jomac mine area and consists of thinly laminated dark reddish-brown siltstone and fine-grained sandstone in beds ranging from a few inches to 4 feet in thickness. The upper beds of the Moenkopi have been altered to light olive gray for a thickness of as much as 7 feet and for an average thickness of 3 feet beneath the Shinarump conglomerate and the lower member of the Chinle formation. These altered beds of the Moenkopi are distinguished from siltstones of the Shinarump and Chinle by the fact that they are devoid of carbonaceous plant material, whereas the siltstones of the Shinarump and Chinle commonly contain carbonaceous matter; also many of the siltstones of the Moenkopi split along micaceous cleavage planes, whereas the siltstones in the Chinle and Shinarump are not readily split.

The alteration zone at the top of the Moenkopi formation attains its greatest thickness in drill hole 19, where a low hill of Moenkopi is partly encircled by a bend in the channel cut into the Moenkopi formation. This long narrow projection of red siltstone in the Moenkopi would have been in a very favorable position for chemical attack by waters passing through the Shinarump- and Chinle-filled channel either when the sediments were being deposited or at a later time. The degree of alteration appears to be independent of the type of rock above the Moenkopi formation, suggesting that the alteration was caused by solutions associated with the original stream

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rather than by later solutions which would be mostly restricted to the more permeable rock.

SHINARUMP CONGLOMERATE[3]

The Shinarump conglomerate of Late Triassic age at the Jomac mine fills a channel that has been cut into the Moenkopi formation on the east side of the hill and into siltstone of the Chinle formation west of the mine workings. The Shinarump conglomerate ranges from slightly more than 10 to 30 feet in thickness in the area of the Jomac mine and consists of very fine grained to coarse-grained sandstone, conglomerate, siltstone, and claystone. Geologic sections of the Shinarump cut by the diamond drilling and exploratory drifting are shown on plate 5. The sandstone beds of the Shinarump conglomerate are cross-laminated and range from slightly less than 1 to 7.6 feet in thickness. The basal sandstone beds are coarser grained than those higher in the section. Most of the sandstones are very pale orange, freckled with limonite. The rock is composed of subangular quartz grains and a few pale-yellow microcline grains set in a matrix of claystone or siltstone. Some of the sandstone beds contain both wood fragments that have been altered to coal, and wood that has been replaced by limonite and hematite. Many of the beds contain limonite and jarosite impregnations.

Occasional conglomerate beds, from 0.5 to 5.0 feet thick, occur at various horizons in the Shinarump conglomerate, although the conglomerates are most commonly at either the base or top of the Shinarump. Where conglomerate occurs at the base of the Shinarump, beds of the lower part of the Chinle formation are not present beneath the Shinarump, and the conglomerate rests upon the Moenkopi formation. In general, these basal conglomerates occur along the upper edges of channels or at edges of depressions on the floor of the channel as shown in drill hole 1 on plate 5*D*. The conglomerate beds at the top of the Shinarump appear to intertongue with siltstone beds of the lower part of the Chinle formation and are believed to fill scours cut into underlying beds of sandstone and claystone.

The basal conglomerate beds of the Shinarump conglomerate are medium gray to grayish yellow and contain an average of about 20 percent Moenkopi siltstone pebbles in a matrix of siltstone or fine- to coarse-grained sandstone. Pieces of coal are abundant in most of this conglomerate and are associated with jarosite, gypsum, limonite, and local pyrite. Wood replaced by hematite and limonite is present in minor quantities.

[3] After this report was prepared, the Geologic Names Committee of the U. S. Geological Survey classified the Shinarump conglomerate as a member of the Chinle formation.

The conglomerate beds near the top of the Shinarump conglomerate range from very pale orange to grayish orange and consist of as much as 50 percent carbonaceous siltstone pebbles set in a very fine to fine-grained sandstone matrix. Hematite- and limonite-replaced wood is abundant, and carbonized wood (coal) is present in chunks as long as 1 foot. Impressions of limonitized wood more than 9 feet long and 1.5 feet across have been found; the larger pieces apparently caused pebble beds to form behind them.

Thin beds of gray carbonaceous siltstone are common throughout the Shinarump conglomerate and are abundant in the upper part of the formation. Most of these siltstone beds are less than 1 foot thick. A bed of gray claystone 2.9 feet thick was cut in the upper part of the Shinarump conglomerate by drill hole 13 (pl. 5*A*, *C*); a seam of light-gray siltstone, less than 0.5 foot thick, occurs at the base of the ore-bearing carbonaceous sandstone in the outer parts of the mine workings. This basal siltstone bed has been included with the Shinarump conglomerate because locally it contains quartz grains similar in appearance to the sandstone beds above it.

The writers restrict the name Shinarump conglomerate at the Jomac mine to the sandstone, conglomerate, and interbedded siltstone and claystone. The variegated and carbonaceous siltstones that intertongue with and underlie the sandstone beds of the Shinarump conglomerate west of the mine workings are continuous with beds of the lower part of the Chinle formation and are believed to be a part of this member. Intertonguing between the Shinarump conglomerate and the lower part of the Chinle formation may be of two types: upper beds of sandstone of the Shinarump conglomerate extend as fingers into siltstone or claystone of the lower part of the Chinle formation, or a lens of Shinarump conglomerate extends upward from the top of the Moenkopi formation into the Chinle formation. Sandstone beds resting directly on the Moenkopi formation at one point have been found 40 or 50 feet vertically above the Moenkopi within less than 600 feet. Both types of intertonguing occur at the Jomac mine. Gradational contacts between the Shinarump conglomerate and the lower part of the Chinle formation were observed at the Jomac mine. In general, the Shinarump conglomerate is finer in grain size near the top, and the contact between the Shinarump conglomerate and the lower part of the Chinle formation would not be placed at the same horizon by every observer.

LOWER PART OF CHINLE FORMATION

The lower part of the Chinle formation of Late Triassic age forms the upper 170 feet of Jomac Hill. This unit is composed of gray carbonaceous siltstone and claystone and three conspicuous beds of sandstone and conglomerate.

The upper conglomeratic sandstone, ranging from 4 to 6 feet in thickness, forms the crest of the hill. This sandstone is equivalent to the prominent conglomeratic sandstone capping many buttes and benches in the White Canyon area.

A less prominent sandstone crops out about 65 feet above the top of the Moenkopi formation and forms a discontinuous narrow bench around the hill. This sandstone ranges from 5 to 14 feet in thickness; it is a thinly laminated, very fine grained, very pale orange, freckled sandstone consisting of subrounded quartz grains cemented by limonite-impregnated clay. In some places a thinner bed of limonitic conglomerate underlies this sandstone, and the sandstone grades laterally into conglomerate.

A third sandstone, from 7 to 14 feet thick, is 40–50 feet above the top of the Moenkopi formation. It is a thinly laminated, poorly sorted, medium- to coarse-grained, white, very pale orange and grayish-orange sandstone composed of clay pebbles and quartz grains in limonitic clay cement. Limonitized wood as much as 9 inches in diameter is concentrated in this sandstone and in places a 1-foot bed of conglomerate underlies this sandstone. This conglomerate ranges from pinkish gray to light olive gray, and consists of siltstone and clay pebbles and quartz grains in a matrix of clay and limonite. Gypsum and limonitized wood are abundant in local accumulations; one fragment of limonitized gypsiferous wood showed slightly abnormal radioactivity.

SEDIMENTARY STRUCTURES

CHANNELS

The top of the Moenkopi formation (pl. 6*A*) forms a surface that strikes approximately N. 25° W. and dips 2° SW. This surface has a 4-foot rise near the north end of the hill, a 3-foot rise centered on drill hole 19, and a valley that trends N. 70° W. and separates these rises. By superimposing the structural contours of the regional dip shown on plate 6*B* upon the structural contours of the top of the Moenkopi formation (pl. 6*A*), the Moenkopi surface is restored to a horizontal position (pl. 6*C*).

An ancient stream course, scoured into the upper beds of the original Moenkopi surface (pl. 6*C*), enters the mineworkings area from the southwest, turns abruptly in the vicinity of drill hole 13, and continues N. 23° W. to the north tip of Jomac Hill. This channel is about 400 feet wide where it enters the mapped area; it narrows to less than 200 feet at the north end of the hill. It has an average depth of about 4 feet and at drill hole 25 is marked by a depression 4 feet deep scoured into its bottom. The channel west of the line representing the base of the Chinle formation (pl. 6*C*) has been filled mainly with siltstone beds of the Chinle formation and east of this line by sandstone, conglomerate, and siltstone beds of the Shinarump conglomerate.

The contour of the bottom of the basal sandstone of the Shinarump conglomerate (pl. 6*D*) indicates a channel, about 150 feet wide and 4 feet deep, that trends N. 24° W. from a point about 100 feet southwest of the portal of adit 2 to a point about 150 feet southwest of the north tip of Jomac Hill. This channel corresponds with the channel in the top of the Moenkopi formation (adjusted for regional dip, pl. 6*C*), including the channel from the bend at drill hole 13 to the north end of the hill. This Shinarump-filled channel is marked by three basinlike scours in its bottom at drill holes 2, 24, and 29. These scours range from 2 to 4 feet deeper than the channel. Another scour to the southwest of the main channel is 5 feet deep and is centered in drill hole 27. A somewhat similar channel at the bottom of the basal sandstone of the Shinarump conglomerate, after adjustment for regional dip, is shown on plate 6 *E*.

The edge of channels seems to be marked in places by siltstone-pebble conglomerates. These conglomerates are believed to represent material that slumped from the upper banks of the streams and was incorporated into the stream sediments. The presence of such conglomerates may prove to be a guide in exploratory drilling for channels.

ORIENTATION OF WOOD FRAGMENTS

Wood replaced by limonite and hematite occurs above the basal carbonaceous sandstone beds of the Shinarump conglomerate and is especially abundant in conglomerate beds exposed in the upper parts of the mine workings. The orientation of 37 pieces of wood less than 12 inches long and of 38 pieces of wood more than 12 inches long is shown in figure 21.

These diagrams suggest that, in general, the wood fragments, regardless of size, have a resultant orientation of N. 21°–24° W. (or S. 21°–24° E.). These pieces of wood were deposited at the bend of a channel; the part of the channel north of the mine workings trends about N. 23° W. (or S. 23° E.) and the part south of the mine workings trends about N. 45° E. (or S. 45° W.). The resultant direction is nearly parallel to the part of the channel north of the mine workings and only a few pieces of wood measured were alined parallel to the part of the channel south of the workings. The general northwest dip of the cross-stratification in the Shinarump conglomerate in the mine

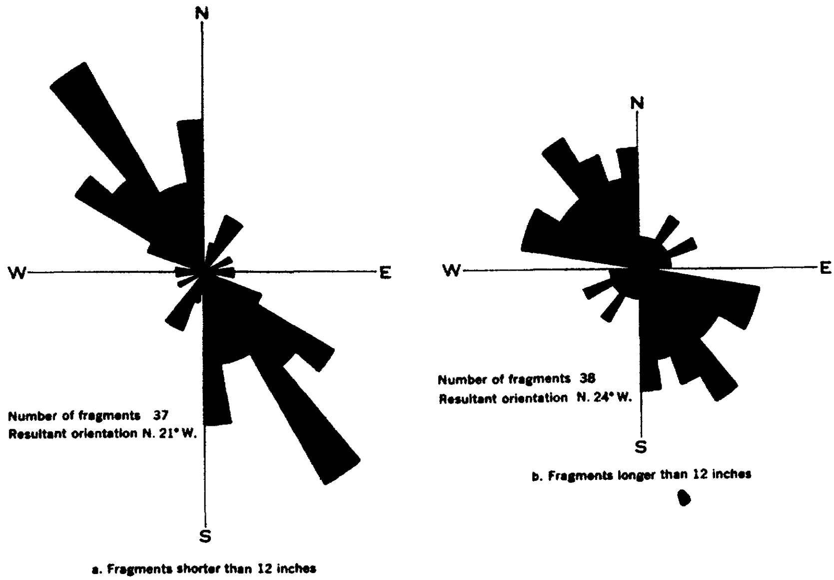


FIGURE 21.—Diagrams showing the orientation of wood fragments at the Jomac mine.

workings suggests that the streamflow was from south to north in the channel. If this flow direction is correct, the wood at the bend has been deposited in a general orientation nearly parallel to the direction of flow. This high consistency in direction of wood orientation suggests that orientation studies of other Shinarump-filled channels may be of considerable assistance in planning exploration. Observation of perhaps fewer than 40 pieces of wood may suffice to determine the trend of a channel.

STRUCTURE

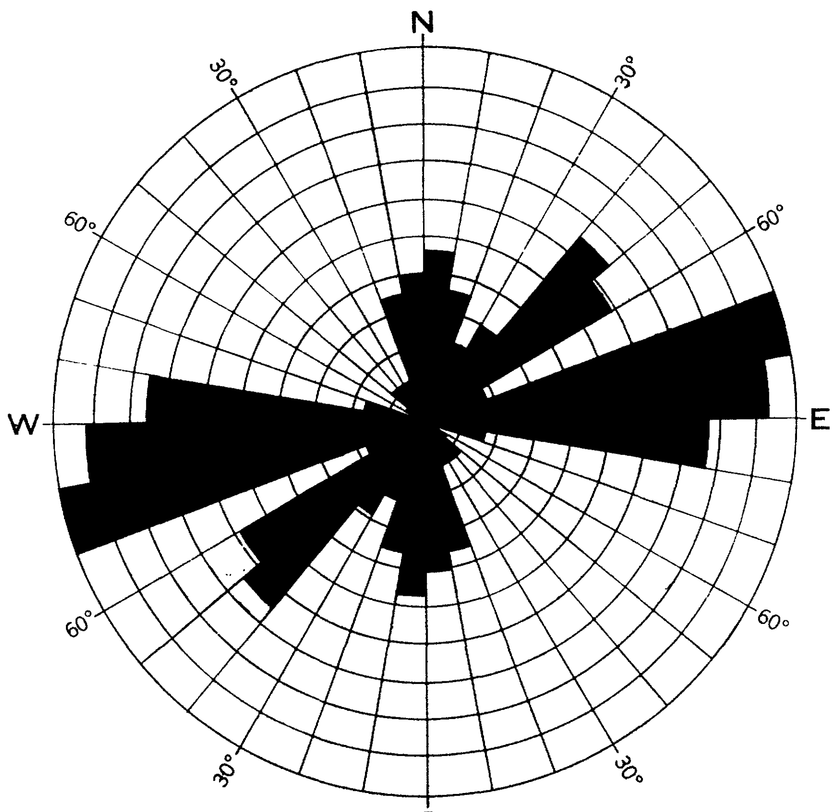
FOLDS

The structure contour lines on an upper bed of the Moenkopi formation (pl. 6*B*) indicate that Jomac Hill is along the crest of a southwestward-trending flexure. This flexure is on the west flank of a northeastward-trending syncline which extends from a few hundred yards east of Jomac Hill to the south side of White Canyon.

FAULTS, FRACTURES, AND JOINTS

Jomac Hill is in an area of intense faulting as shown on plate 4. Most of the faults are steeply dipping, strike N. 50°–75° W., and have vertical displacements from a few feet to more than 80 feet. The nearest fault to the Jomac mine is about half a mile north of the workings and may be seen from the mine road below the hill. This fault strikes N. 65° W. and dips from 75° NE. to vertical. The stratigraphic throw measured by T. L. Finnell is 10 feet; the north side of the fault is downthrown.

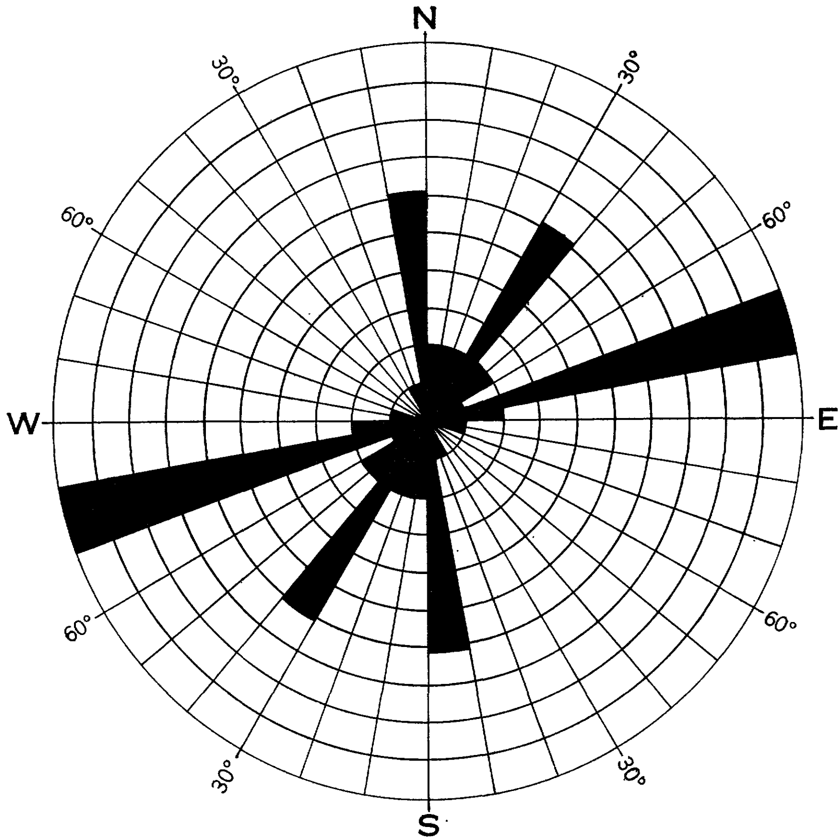
No displacement was noted in the fractures at the Jomac mine. A study was made of 154 fractures in the mine workings to determine the major systems and the amount of fracture filling for each system. Most of the fractures are steeply dipping; relatively few cut all the beds of the Shinarump exposed in the wall at the points of observation. Instead, the fractures tend to end at contacts between rock units. The strikes of three prominent sets of fractures are shown (figs. 22 and 23); N. 70° E. to S. 80° E.; N. 40° to 60° E.; and N. 10° E. to N. 10° W. All strikes were recorded in the northern hemisphere but were plotted on both the northern and southern



Circular graph showing percentage of 115 fractures having strikes within 10° of arc

Each division equals 1.5 percent

FIGURE 22.—Diagram showing the strike of unfilled steeply dipping fractures, Jomac mine.



Circular graph showing percentage of 39 fractures having strikes within 10° of arc

Each division equals 2.5 percent

FIGURE 23.—Diagram showing the strike of steeply dipping fractures that have been filled with iron oxide and gypsum at Jomac mine.

hemispheres. The major trend (N. 70° E. to S. 80° E.) is roughly parallel to the axis of the flexure and may represent the longitudinal set of fractures. None of these fractures appears to be related to the faults in the area.

A diagram showing the strikes of 39 fractures that have been filled with iron oxide and gypsum is shown in figure 23. The three major sets of fractures have been filled by these secondary minerals; these sets strike N. 70° to 80° E.; N. to 10° W.; and N. 30° to 40° E. In general, these sets are similar to the sets of fractures that contain no secondary minerals, and apparently each of the three principal sets was favorable for secondary mineral deposition. This also suggests that all the fracture systems predated the movement of at least some of the secondary solutions containing iron and sulfates. If some of the unfilled fractures were caused by the underground mining operations, the fractures were formed along preexisting planes of weakness parallel to the filled-fracture planes. For this reason, it appears to make very little difference whether filled or unfilled fractures are chosen for study to determine direction of large fractures.

URANIUM DEPOSITS

LOCALIZATION

Most of the uranium at the Jomac mine is believed to be contained in carbonized wood associated with jarosite and gypsum, in sandstone, conglomerate, or sandy siltstone near the base of the Shinarump conglomerate. Abnormal radioactivity has been found in carbonized wood fragments in the sandstone above the basal sandstone, but this carbonized wood is insufficiently concentrated to con-

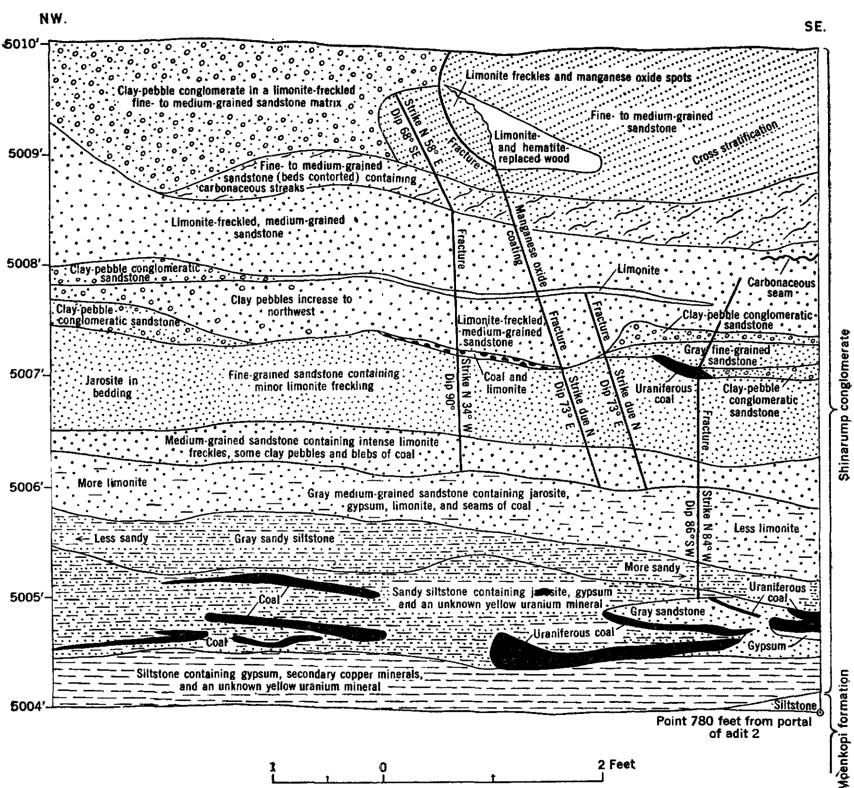


FIGURE 24.—Geologic section of a segment of the north wall of adit 2, Jomac mine, San Juan County, Utah.

stitute ore bodies. A more detailed distribution of individual pieces of unaniferous carbonized wood in the mine wall is shown in figure 24. This carbonized wood is believed to be a low-rank coal; it is dark gray to black, is light weight, has a silky sheen, and can be burned over a gas flame to give off volatiles. It may be a vitrain. Plate 6*C* and *E* shows the area in which the carbonized wood and uranium are concentrated in the lower beds of the Shinarump.

Crystals of green metazeunerite coat fracture surfaces in some of the coal, and may account for a large part of the uranium. Occasional minor concentrations of an unidentified yellow fibrous uranium mineral occur in the upper sandstone beds of the Shinarump conglomerate, and an unknown massive yellow uranium mineral is associated with the carbonized wood and gypsum in the sandstone beds near the base of the Shinarump conglomerate.

MINERALOGY

URANIUM MINERALS

Uranium minerals at the Jomac mine include metazeunerite, an unidentified fibrous yellow mineral, and an unidentified massive yellow mineral; no pitchblende nor uraninite has been found.

The metazeunerite ($Cu(UO_2)_2(AsO_4)_2 \cdot 8H_20$) occurs as pale-green plates which are as much as 2 mm across, which coat pieces of coal, and which are associated with plates of gypsum and coatings of jarosite. Some of the metazeunerite plates are in clusters radiating about a center. The results of semiquantitative spectrographic analysis of the metazeunerite are shown in the following table.

Semiquantitative spectrographic analyses of secondary uranium minerals, Jomac mine, White Canyon area, San Juan County, Utah, in percent

[Analyst, Katherine E. Valentine]

Mineral	*10*	*5-10*	*1-5*	*0.5-1*	*0.1-0.5*
Metazeunerite	U	Cu	Ca, As, Si, Al, P	Fe	None
Unidentified fibrous yellow uranium mineral.	Si, U	Al	Ba, P, K, Fe, Ca, Mg	Na	Ti
Unidentified massive yellow uranium mineral.	U, P	Al, Fe	Ca	None	Si

The unidentified fibrous yellow mineral occurs as impregnations in the upper sandstone beds of the Shinarump conglomerate a few feet north of adit 1. The mineral fluoresces an intense yellowish green. Semiquantitative spectrographic analysis suggests that the mineral is a silicate as shown in the preceding table.

The unidentified massive yellow uranium mineral, in nodular porcellaneous masses as much as half an inch wide, is associated with carbonized wood and gypsum in sandstone beds near the base of the Shinarump conglomerate. The X-ray powder pattern of the mineral matches none of the standard uranium minerals in the files of the Geological Survey.

SULFIDE MINERALS

Minor amounts of chalcopyrite impregnate a sandstone lens in the basal coal-bearing sandstone near the end of adit 2, in the coal-bearing sandstone in the crosscut, and in a basal siltstone of the Shinarump in drill hole 17. Pyrite occurs in some of the sandstones and siltstones of both the Shinarump conglomerate and the lower part of the Chinle formation. In general the pyrite replaces pieces of carbonized wood in these rocks, but in places it also impregnates the sandstone. The 0.5-foot coal-bearing sandstone cut by drill hole 1 contains about 4 percent pyrite, impregnating the rock and replacing the woody cells of the coal. Nodular concretions of pyrite have been found in drill cores from clays of the Chinle about 100 feet above the Shinarump.

SECONDARY COPPER MINERALS

Secondary copper minerals found at the Jomac claim include malachite, azurite, and chalcanthite, in addition to the metazeunerite previously described. Small amounts of malachite and azurite occur at the Shinarump-Moenkopi contact, associated with gypsum. Chalcanthite locally impregnates the basal coal-bearing sandstone of the Shinarump bed exposed in adit 2.

GANGUE MINERALS

The gangue minerals at the Jomac mine include hydrous iron oxides, hematite, jarosite, gypsum, and manganese oxides.

A mixture of unidentified hydrated ferric oxides, referred to as limonite, but probably principally goethite, has replaced some of the fragments of wood and has impregnated many of the sandstones and conglomerates. The limonite is believed to be of supergene origin and probably has been derived from pyrite. The limonite freckles in some of the sandstone may have resulted from the alternation of pyrite crystals that impregnated the sandstone.

Hematite has replaced some of the fragments of wood and has locally impregnated the sandstone. The hematite is nearly everywhere associated with limonite.

Jarosite is abundant in the lowermost sandstone, conglomerate, and siltstone beds of the Shinarump conglomerate. It forms part of the cementing material of some of the sedimentary rocks which contain abundant pieces of carbonized wood. The close association between jarosite and uranium-bearing carbonized wood makes jarosite a guide in determining beds that may be favorable for finding ore.

Abundant gypsum occurs in the basal coal-bearing sandstone of the Shinarump, in the upper 1 foot of the bleached beds of the Moenkopi and along fractures. The gypsum is most commonly associated with the coal in the Shinarump conglomerate; many pieces of coal are partly surrounded by a layer of gypsum as much as one-fourth inch thick. Gypsum along the fracture surfaces is commonly associated with limonite.

Manganese oxide forms a widespread coating on many bedding surfaces and fracture planes in the bleached siltstone of the Moenkopi. It also forms irregular coatings of the quartz grains and clay cement of many of the Shinarump conglomerate beds exposed in the underground workings and in the diamond-drill cores. The secondary copper minerals are commonly associated with manganese oxide.

ORE GUIDES

The principal guides believed to be useful in underground exploration for ore in the area are the Shinarump-filled channel, the included basins, carbonaceous sandstone or conglomerate at the base of the Shinarump, coal, and jarosite. Jarosite appears to be of the greatest value for exploratory drilling, especially in holes in which pieces of uranium-bearing carbonized wood may not have been found; the Jomac mine is the only deposit in the White Canyon area in which jarosite is considered a guide to ore.

CONCLUSIONS

The detailed study at the Jomac mine has helped to clarify several questions pertaining to the nature of channels and their contained sedimentary features in the White Canyon area. Geologists working in the area for the Atomic Energy Commission have maintained the belief that a better understanding of channels cut into the Moenkopi formation and filled by Shinarump conglomerate may be obtained by adjusting the structural contour maps of the surface of the Moenkopi formation for regional dip. It has been shown in this study that such adjustment for regional dip is necessary at the Jomac mine to produce a logical channel picture. It is believed that such adjustment may define more distinctly many of the channels in the area.

This study has also suggested that structural contour maps of the bottom of the basal sandstone or conglomerate bed of the Shinarump conglomerate may indicate depressions and channels imperfectly defined or not defined at all by the contours of the top of the Moenkopi formation where siltstone or claystone overlies the Moenkopi. Such channels above the Moenkopi surface may change somewhat in trend from those cut into the Moenkopi and may be the major localizing structures of many of the deposits. Shinarump and Chinle rims should be examined thoroughly with the possibility in mind that channels may exist from a few feet to perhaps tens of feet above the Moenkopi surface.

The significance of wood-orientation studies is believed to be important in determining the trend of channels, and as few as 40 observations may be sufficient. Apparently the size of the wood fragments is not important in such studies.

Edges of channels may be determined by the presence of siltstone-pebble conglomerates and conglomeratic sandstones that contain pebbles of the underlying siltstone beds. These conglomerates require considerably more study at other localities in the White Canyon area before they can be considered as a guide to channels.

Jarosite may be useful as an ore guide in the White Canyon area in deposits in which the uranium is concentrated in carbonaceous material, but it must be used carefully in connection with favorable lithology and other criteria.

An ore body surrounding the mine workings contains nearly all the reserves of uranium at the Jomac mine (pl. 6*C* and *E*). This ore body is confined to the basal coal-bearing beds of the Shinarump conglomerate. The ore is believed to have a grade of 0.10 to 0.15 percent U_3O_8 and 0.01 percent copper.

The results of analyses of samples collected in the mine workings suggest that the percent uranium is generally higher than the percent equivalent uranium in the samples of the uraniferous coal-bearing sandstone. The presence of relatively recently formed metazeunerite in the coal may account for this slight disequilibrium of uranium in excess over its distintegration products.

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