HAPPY JACK MINE, WHITE CANYON, UTAH

By Philip H. Dodd

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HAPPY JACK MINE, WHITE CANYON, UTAH

INTRODUCTION

The Happy Jack mine was studied as a part of the general program of geologic investigations of uranium-bearing mineral deposits of the Colorado Plateau. The property came under detailed study in order to gain an up-to-date picture of the property and to learn principles of ore habit, genesis, and criteria for prospecting and evaluating undeveloped copper-uranium mineral deposits. The Happy Jack mine has previously been briefly investigated by various persons representing offices of the Commission and the U. S. Geological Survey.

The writer and the Atomic Energy Commission are indebted to the owners of the Happy Jack for their courtesy and cooperation in answering questions and permitting underground work which may have caused them some inconvenience.

Location and accessibility

The Happy Jack mine on the claim of the same name, together with contiguous claims under the same ownership, is located on the south rim of White Canyon in San Juan County, southeastern Utah (see Index Map, Fig. 1). No General Land Office subdivision or U. S. Mineral Monument to which the property can be tied is within reasonable distance. It is estimated that the Happy Jack mine is situated in unsurveyed T. 36 S., R. 14 E., Salt Lake principal meridian.

Travel to the Happy Jack mine by motor vehicle is accomplished via Utah State Road 95 for a distance of 73 miles west from Blanding, Utah, the nearest town. Portions of this road are graveled, while the remainder is
Fig. 1—Index map, showing the location and accessibility of the Happy Jack mine.
unsurfaced, generally rough, and often impassable during the winter months due to snow or mud in the Elk Ridge "high country". A new truck trail bypasses the "high country" and connects upper White Canyon with Comb Wash near Bluff, Utah. It is also possible to gain access from Hanksville, Utah, 87 miles west of the Colorado River. A short, undulating airstrip, suitable only for light aircraft, has been constructed about one-half mile west of the property. A good strip, 3,000 feet in length, at Hite, Utah, sixteen miles to the west on the Colorado River, is suitable for light, twin-engine aircraft.

Supplies and Water

Mining supplies, and minor machining and blacksmith work, can be obtained in Monticello, Utah. Groceries and petroleum products are available in Blanding and to a very limited extent at Hite.

Water is a critical item in the White Canyon district. Domestic and industrial water is available at Hite in any quantity that is likely to be required. The spring in Frey Canyon, 16 miles east of the mine, can supply approximately 20,000 gallons daily.

Ownership

The Happy Jack mine is located in the southern two-thirds of the unpatented Happy Jack claim. Eleven additional unpatented buffer claims contiguous with the Happy Jack are: Happy Jack No's. 2, 3, 4, and 5; El Capitan No's. 1, 2, 3, and 4; and Inspiration No's. 1, 2, and 3. These claims, plus others in the White Canyon district, are owned in partnership by Joe W. Cooper, Fletcher Bronson, and Grant L. Bronson, of Monticello, Utah. Mr. Cooper and Mr. Fletcher Bronson purchased the Happy Jack claim, together with several
others located in the district, as a copper prospect, and the additional contiguous claims have been staked by them for possible extension of the ore body (see Plate I).

GEOLOGY

Regional

No detailed geological or stratigraphic information about the White Canyon district has come to the attention of the writer. The work of H.E. Gregory contains the best general geologic and stratigraphic information available. The following discussion, with minor exceptions, is based on the work of Gregory.

The rocks exposed in the White Canyon district are nearly all clastic sedimentary deposits ranging from Permian to Jurassic in age. Siliceous limestone lenses interspersed in the shale are present in minor amounts. No igneous rocks are known within the area but are present in the Abajo Mountains (Blue Mountains) and the Henry Mountains, respectively ten to twenty miles from the White Canyon district. A generalized section applicable to the district (Figure 2) has been reproduced from Professional Paper 188.

Physiographically, the White Canyon district consists of a broad canyon about 40 miles in length, with steep to vertical walls. Throughout most of its length, the floor of the canyon is formed by the White Cedar Mesa sandstone member of the Permian Cutler formation. An abrupt inner gorge, making crossing difficult, has been cut 50 to 200 feet into the resistant Cedar Mesa, but nowhere does it expose the base. The outer walls of the canyon are formed by steep slopes and cliffs of predominantly red color, carved into rocks ranging in age from Permian to Jurassic.

Fig. 2—Generalized section of the White Canyon district.
Permian rocks - Cutler formation

Cedar Mesa member. Within White Canyon itself, the oldest rocks exposed are white sandstones of the Cedar Mesa member. In Dark Canyon to the north, these attain a thickness in excess of 1,200 feet. Only about 200 feet of Cedar Mesa is exposed in the inner gorge of White Canyon. The sandstone occurs in beds ranging in thickness from 20 to 80 feet, in part crossbedded. The rock consists of small well-rounded quartz grains with calcareous cement.

Organ Rock member. The Organ Rock member forms a prominent basal escarpment at the outer wall of White Canyon. Gregory records thicknesses of from 250 to 421 feet for this member. The lower portion consists of sandy shales with thin ribs of sandstone and weathers into red-brown steep slopes, often slightly stair-stepped. The upper portion tends to form a vertical cliff of red-brown sandstone.

De Chelly member. Regionally, the De Chelly sandstone member of the Cutler ranges in thickness from 0 to 90 feet. The sandstone is supposedly present in the western end of White Canyon, as Gregory states, "Along White Canyon for some 20 miles above its mouth, this conspicuous horizon marker is in many places conformable with the Organ Rock." However, in his measured section 11 at Rock Springs in White Canyon, and section 12, at Rasp Trail, five miles above the mouth of White Canyon, the De Chelly is not listed. The writer has not identified the De Chelly member near the Happy Jack locality.

Hoskinnini member. The existence of the Hoskinnini member is a subject of controversy. In his generalized section for the San Juan Country, Gregory shows 0 to 50 feet of this member. Within White Canyon, the member is missing, either because of non-deposition, facies change, or because of removal during a Permian-Triassic erosion interval.
Triassic rocks

Moenkopi formation. The Moenkopi formation represents the Lower Triassic in the White Canyon district and it crops out continuously in the outer walls of the canyon. The aggregate thickness of the Moenkopi sandstones and shales ranges from 186 to 390 feet. The color is characteristically chocolate brown, especially in the lower half of the formation, while the upper half may be represented in places by a predominance of gray to gray-green and maroon shales. Locally, a light buff, gray, gritty sandstone or conglomerate may be found near the middle or upper two-thirds of the Moenkopi. Where developed, this horizon forms the locus of copper-uranium mineral deposition. For the most part, the Moenkopi beds are irregular in thickness, composed of fine-grained sandstone and arenaceous shale which are often gypsiferous. Ripple marks and mud cracks are common, suggesting fluviatile or lacustrine environment of deposition. It is suspected that the unconformity at the base is of considerable magnitude (perhaps removing the Hoskinnini, De Chelly, and possibly portions of Organ Rock).

Shinarump formation. Although seldom exceeding 100 feet in thickness, the Shinarump formation is recognized over considerable geographic distances in Nevada, Arizona, and Utah. In the White Canyon district, the Shinarump was measured by Gregory and found to range from 1 to 48 feet in thickness. To the east in the Elk Ridge area, the thickness exceeds 100 feet. The writer has observed localities within White Canyon where the typical facies is completely absent; whereas immediately adjacent, the thickness appears to be in excess of 50 feet. Where present, the well-cemented, coarse sandstone, grit, and conglomerate of the Shinarump form a resistant vertical cliff with
a flat bench on top. The light buff weathering of the pale gray, conglomeratic
grit generally stands out in sharp contrast to the red beds above and below
it. The lens-like distribution with its rapid variation in thickness, yet
widespread regional distribution, suggests fluviatile deposition on an erosion
surface of considerable extent developed at the expense of the Moenkopi.

Chinle formation. As the Chinle formation is exposed only in isolated remnants
on small buttes within White Canyon and the higher outer canyon walls well
above the known ore horizon, no attempt was made to observe its local charac-
teristics. Of the formation, Gregory says 2:

"Like the Shinarump conglomerate, the Chinle formation is nearly
coextensive with the plateau province and presents at all exposures
much the same lithology and erosion forms. Its outstanding features
are fossil wood, a peculiar limestone conglomerate, and series of
richly colored variegated shales—gray, red, pink, lavender, yellow,
green—that weather in the manner of marls. In the San Juan Country,
as in regions immediately adjoining, measured sections of the Chinle
show four rough subdivisions—(1) at the base, brown and gray sand-
stones that weather into steps and benches; (2) variegated sandy and
calcareous shales or "marls" that weather as mammillary mounds and
immature mesas with typical badland expression; (3) light-red, dark-
red, and mottled shales and massive or conglomeratic limestone in
alternating beds, weathering as a stepped slope on which the resistant
limestone forms the top of long, narrow benches and small mesas; (4) red
and brown sandstone and sandy shale, weathering as a cliff that, con-
tinued upward, includes the Wingate sandstone."

Jurassic rocks

Wingate formation. The Wingate formation, like the Chinle is exposed only in
isolated buttes and in the uppermost sheer cliff of the canyon walls, and
was not included in the study of the Happy Jack mines. Gregory 3 measured

2. Gregory, Herbert E., loc. cit., p. 49.
a thickness of 300 feet of vertical, cliff-forming, "fine-grained, cross-bedded, massive sandstone".

**Kayenta formation.** The Kayenta formation exposed in White Canyon is inaccessible and was not investigated. Only partial sections are exposed on the tops of narrow escarpments which separate White Canyon from adjacent canyons to the south. Gregory reports: "The Kayenta is made up of beds of sandstone, shale, and limestone, all lenticular, uneven at their tops, and discontinuous within short distances."

**Structure**

No prominent structural features are expressed in the White Canyon district. The canyon is cut in gently dipping beds several miles west of the Mitten Butte anticline. The floor of the canyon closely parallels the 1° to 3° westward regional dip, and the exposed upper surface of the Cedar Mesa is, in general, a dip slope. In lower White Canyon, a steepening of the dip to approximately 8° to 10° causes the Cutler formation to disappear under the Colorado River.

No major faults have been seen in the White Canyon district. Fractures, however, are abundant and are easily discernible on aerial photographs and seen in the portions of the canyon wall occupied by massive sandstones. These fractures have a strike of N20°W to N40°W, with dips ranging from 75° northeast to 75° southwest. A minor system is commonly found at right angles to the major, northwest-striking set. Gregory reports 4 that

"faults are associated with wide joint cracks now filled with yellow sandstone" in lower White Canyon.

**HAPPY JACK DEPOSIT**

**Rocks**

The local stratigraphic sequence appears to be normal for the White Canyon district (see Plate I for the areal geologic relationships). In previous reports, the mineralization in the White Canyon district has been variously classified as to its stratigraphic position. Gregory ⁵ states: "In White Canyon, many prospect holes record the hope that the blue-stained sandstones in the Shinarump and Chinle formations might mark the position of workable deposits of copper ore". In official government reports, which are not available for distribution, the following opinions have been expressed. Fischer and King ⁶ state: "The known uranium deposits are in the basal part of the Shinarump formation, generally in the conglomeratic lenses but at places also in shale." Smyth ⁷ says: "Between the top of the Organ Rock member and the Shinarump conglomerate, projecting as a narrow, white rim in the canyon walls, are 350 feet of chocolate-brown and gray, thin-bedded sandstones and shales forming a slope area. About midway in the series

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occurs a massive, light colored sandstone member with irregular lenses of quartzite conglomerate near the base. The conglomerate is usually overlain by fifteen to twenty feet of sandstone. Most of the ore deposits occur in this member. Granger and Beroni state: "The uraniferous deposits of the White Canyon area occur in the Shinarump conglomerate or the white, silty sandstones and siltstones at the top of the Moenkopi formation." Gruner and Gardiner write: "So-called Shinarump conglomerate which may, however, be a part of the Moenkopi, forms beds from 8 to 12 feet thick".

It is the opinion of this writer that the middle Moenkopi position chosen by Smyth is the one most nearly agreeing with the district stratigraphic sequence. It is believed that other opinions would necessarily postulate unreasonable local increases or decreases in thickness of adjacent lithologic units.

The mineralized bed is a coarse-grained sandstone and grit with occasional pebbles one to three centimeters in diameter. The sand grains are nearly 100 per cent quartz, with a high degree of sphericity, but low roundness. The pebbles are of quartz and quartzite having excellent roundness. Except in the oxidized portion of the mineral deposit where limonite is a cementing agent, the sandstone has

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a calcareous cement. The sandstone appears to have good porosity and permeability, except where there is local increase in the amount of cementing material. The unweathered rock is white, light gray, or cream in color, while the weathered sandstone is generally light buff, pale orange brown, or light brown.

Structure

The beds in the vicinity of the Happy Jack mine generally strike N10°W and dip 3 degrees west. However, the lenticular nature of the beds precludes the possibility of exact measurements divorced from primary sedimentational and erosional structures. The mineralized bed is lenticular in cross section, with an apparent elongation striking N40° - 50°E. The bed is twenty feet thick where it outcrops at the center portal of the Happy Jack mine. Five hundred feet to the northwest, the bed thins with minor undulations of the base to three or four feet, only to thicken again to fifteen or eighteen feet. Likewise, to the east and southeast from the portals, the lens thins as a lithologic unit to the point of nearly disappearing in the outcrop about 1,000 feet from the mine and again thickens to the southeast to twelve feet before finally thinning again and lensing out entirely 3,500 feet from the mine openings.

The lenticular habit, coupled with the lithology, strongly suggests a fluviatile channel environment of deposition. Although fairly obvious, it has been brought to the attention of the writer by the prospectors and miners that the mineral deposits in the White Canyon area are found in the thicker portions of this and similar lenses. In other words, the mineralization seems somewhat localized in the deposition channels of host rock. Several of the minor undulations of the base of the ore-bearing sandstone are illustrated by the structure contour map, Plate II. The contours are plotted on the top of the shale upon
which the ore sandstone rests. With a regional strike of N10°W the structure
tour map indicates a rather definite channel structure of northeast-south-
west trend. The writer does not believe it a coincidence that the ore bodies
of the district repeatedly occur in such structures and that there is a cor-
relation between the thickness and grade of the Happy Jack ore and the channel
structure of the host sandstone.

Mineralogy

Only superficial observations on the mineralogy of the Happy Jack
were made, as the ore minerals are finely crystalline or amorphous, the study
of which requires laboratory equipment more extensive than that available to
the writer. However, the report of Gruner and Gardiner gives the best
available data, and while the mineralogical work is not complete, it furnishes
valuable data. The following discussion is largely based on this report. The
following minerals have been identified.

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<th>Mineral</th>
<th>Formula (if known)</th>
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<tr>
<td>Pitchblende</td>
<td>U₃O₈</td>
</tr>
<tr>
<td>Schoepite-bequerelite</td>
<td>2UO₃ 3H₂O</td>
</tr>
<tr>
<td>Johannite</td>
<td>(Cu, Fe, Na₂) UO₃ S0₃ 4H₂O</td>
</tr>
<tr>
<td>Torbernite</td>
<td>CuO 2UO₂ P₂O₅ 12H₂O</td>
</tr>
<tr>
<td>Uranophane (not certain)</td>
<td>CaO 2UO₃ 2S1O₂ 6H₂O</td>
</tr>
<tr>
<td>Pyrite</td>
<td>FeS₂</td>
</tr>
<tr>
<td>Gersdorffite</td>
<td>(Co, Ni, Fe) AsS</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>CuFeS₂</td>
</tr>
<tr>
<td>Covellite</td>
<td>CuS</td>
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Chalcocite $\text{Cu}_2\text{S}$
Bornite $\text{Cu}_5\text{FeS}_4$
Malachite $\text{CuCO}_3\text{Cu(OH)}_2$
Cyanotrichite $4\text{CuO}\text{Al}_2\text{O}_3\text{SO}_3\text{8H}_2\text{O}$
Antlerite $\text{CuSO}_4\text{2Cu(OH)}_2$
Chalcocanthite $\text{CuSO}_4\text{5H}_2\text{O}$
Brochantite $\text{CuSO}_4\text{3Cu(OH)}_2$
Erythrite $\text{Co}_3\text{As}_2\text{O}_6\text{8H}_2\text{O}$
Zippeite (probably) Hydrous U sulphate

The primary minerals found in the unoxidized portion of the mineral deposit are pitchblende, gersdorffite, pyrite, chalcopyrite, perhaps bornite, and covellite. The chalcocite, although present in the unoxidized zone, may well be a later product after the other copper sulphides. The unusual number of sulphate minerals present appears to be due to two factors: (1) the nearly pure quartz sandstone offers little to react with sulphate ions freed by oxidation of sulphide minerals, and (2) lack of any appreciable amount of water prohibits removal by flushing of the relatively soluble sulphate minerals when formed. The sand grains in and around the mineral deposits show a marked tendency to recrystallize, and a large proportion have developed pyramid crystal faces. Gruner says:

"The thin section shows secondary interlocking growth of the quartz grains in places. In others, the grains are cemented together by the sulphides. In these places, the quartz boundaries are very jagged and eaten into by the replacing sulphides. There is also a little extremely finely divided, brownish-black material between the quartz grains and the sulphides. This looks colloform even under oil immersion, but its genetic relationship to the sulphide mineralization is unmistakable. As the largest grains are about 3 microns in size, we are unable to identify the grains but think that they are uraninite."
Although copper and uranium minerals occur together, there appears to be no necessary connection between them. The mineral torbernite, found in the oxidized zone, is the only mineral identified which contains both copper and uranium. Specimens of high-grade chalcocite have little radioactivity. A graph was prepared, plotting uranium values against copper values, and a typical "shotgun" pattern of a scatter diagram resulted (Fig. 3). From this graph, it would seem that there is little correlation between the two metals. It strongly suggests that prospecting and mining should not be guided too closely by the visible copper minerals.

**Genesis**

The genesis of the copper-uranium ore type in sedimentary beds is not known. However, the presence of such minerals as pitchblende, chalcocite, bornite, and gersdorffite in the unoxidized portion of the Happy Jack deposits suggests a primary, hydrothermal origin. A study of the crystal habit of the chalcocite present might yield information about the temperature of formation.

If a hydrothermal origin is proposed, then the questions of a source, method of emplacement, and control of localization must be answered. No igneous rocks are known within the vicinity of the mineral deposits. The closest igneous rocks are found in the Abajo and Henry Mountains at distances of about ten and twenty miles, but it is entirely possible that other, still deeply buried, Tertiary igneous material may be present nearer at hand. Both above and below the mineralized horizon are thick sections of relatively impermeable shale, as well as a few beds with a lithology somewhat similar to
Fig. 3 — Uranium values vs. copper values.
the ore horizon. It seems probable that the mineralizing solutions moved primarily in a lateral direction within the relatively porous and permeable sandstone. Such movement of waters would be controlled by the geometry of the favorable lithologic unit. It is proposed that the channel type structure was at least partially the controlling factor in the emplacement and that prospecting or inferring ore extensions should be based upon this hypothesis. Fracture systems, if present at the time of mineralization, may also play a role by providing paths for movement of solutions and loci for deposition. Such a system should result in rich concentrations along the fractures or other exceptionally permeable zones with a gradual diminishing of disseminated minerals away from the major routes of movement. This seems to be true both from underground study and from the laboratory work by Gruner.

Oxidation and secondary movement

Based on the distribution of oxidized minerals as compared with unaltered sulphides it appears that a large part of the development in the Happy Jack has been in the oxidized zone. This zone is outlined on Plate III. There is no sharp or clearly defined line but rather a merging of zones predominantly oxidized and unoxidized.

Minor amounts of mine waters are now being encountered. If allowed to stand for a short time in mine workings these become very acid but it is not known whether "fresh" waters are acid. The sulphides of the oxidized zone appear fresh and untarnished, which strongly suggests the water is lacking in oxygen. Since there is not sufficient area up-dip from the mine to act as a collection area - because of erosion - and since these waters appear to
be largely oxygen-free, it is suggested that they may be ancient meteoric waters which have been trapped structurally or lithologically. There is also the remote possibility that these are residual connate waters. In spite of a regional dip to the southwest where the horizon is cut by the branches of Red Canyon, the water has not drained. Perhaps the structure or lithology controlling this water also limits the mineralization.

The oxidized zone appears definitely related to the present topography rather than to fossil water tables or previous erosion surfaces. This is illustrated by the close parallelism between the boundary of the oxidized zone and the present outcrop of the ore horizon.

There is a definite indication of leaching at the outcrop of the ore body, resulting in a local reduction in uranium grade. A weighted average of six samples taken from the center of the outcrop of the ore body, as defined by underground workings, assayed 0.06% U₃O₈, whereas the weighted average of all samples taken was 0.39% U₃O₈.

Evidence is available to suggest that this difference is due to leaching rather than to original difference in grade. Figure 4 represents the chemical analyses of samples as plotted against net counts per minute. By fitting the best possible straight line to the curve data of Figure 4 and assuming it represented the average counts per minute for the chemically assayed amounts of uranium, it is possible to calculate positive or negative deviations for each sample. Upon comparing these deviations with the locations of the corresponding samples it becomes apparent that samples which assayed lower than might be expected from the radiometric determinations nearly always fall within the oxidized zone of the ore body. This can be explained by
Fig. 4—Chemical analyses of samples as plotted against net counts per minute.
assuming that part of the uranium has been removed by the weathering, but
radioactive daughter products have been retained. If the curve were
plotted from unoxidized samples only, rather than all samples, the negative
deviations would fall entirely in the oxidized zone.

From these data, it can be reasoned that in other cases of copper-
uranium mineralization in the White Canyon district where little development
has been done chances are favorable for the grade to increase appreciably
away from the outcrop and weathered zone.

Development

The development at the Happy Jack mine consists of seven tunnels
and connecting crosscuts, totaling 1,660 linear feet and averaging approxi-
mately seven feet wide and six feet high. No stoping has been started
and all production has come from the development headings. The ore has been
shipped to the White Canyon mill at Hite. During September, 1950, the ore
grade averaged 0.61% U₃O₈.

Conclusions

1. Mineralization is believed to be hydrothermal in origin, because
   of the mineral assemblage.

2. Structural control appears to be a channel deposit of porous and
   permeable sandstone surrounded by less permeable shale and sand-
   stones.

3. Stratigraphic position of the ore horizon is believed to be near
   the middle of the Moenkopi formation of lower Triassic age.

4. Studies indicate leaching of uranium from the outcrop has taken place,
   resulting in a lowering of the grade in weathered exposures.
Plate I—Areal geology and claim map for Happy Jack mine and contiguous claims. Jurassic: Wingate, 
Triassic: Chinle, Shinarump, Moenkopi and ore horizon, Permian: Cutler (Organ Rock), Cutler (Cedar Mesa), 
PCM.
Plate II—Structure contours on top of shale below ore sandstone, illustrating relationship between ore and channels.