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PROGRESS REPORT ON GEOLOGIC STUDIES IN THE CAPITOL REEF AREA, WAYNE COUNTY, UTAH

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This preliminary report is released without editorial and technical review for conformity with official standards and nomenclature, to make the information available to interested organizations and to stimulate the search for uranium deposits.

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GEOLOGY AND MINERALOGY

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PROGRESS REPORT ON GEOLOGIC STUDIES IN THE CAPITOL REEF AREA, WAYNE COUNTY, UTAH

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ABSTRACT

During 1951 about 60 square miles of the Capitol Reef area, Wayne County, Utah, the northern end of the Waterpocket Fold, was mapped by plane-table methods on a scale of 1:62,500. Formations, with an approximate aggregate thickness of 3,200 feet, range from the Coconino sandstone of Permian age to the Navajo sandstone of Jurassic (?) age. About 35 linear miles of Shinarump conglomerate of Triassic age was examined in detail. Cliffs 900 to 1,000 feet high form the west face of Capitol Reef, which is on the east and northeast flanks of a structural and topographic dome.

The uranium deposits are in the basal part of the Shinarump conglomerate. Zippeite and metatorbernite are the uranium minerals found, and are associated with copper minerals, carbonaceous matter, clay beds, a thick bleached zone at the top of the Moenkopi formation, and channels or scours in the top of the Moenkopi. The highest radioactivity is in a clay bed at the base of the Shinarump conglomerate, and was detected at 7 localities between Grand Wash and Capitol Gorge, at the Birch Spring prospect in Moonie Draw, and at the Oyler mine in Grand Wash.

INTRODUCTION

Purpose of work

This report deals with the first season's field work on the uranium deposits and on the sedimentary rocks in the Capitol Reef area, south-central Utah (fig. 1). The objectives of the work are three-fold: (1) to find geologic guides for prospecting and determine controls and habits of the uranium deposits, (2) to select areas favorable for exploration for concealed deposits, and (3) to study the areal setting of the deposits by general geologic mapping and by detailed studies of the Shinarump conglomerate, the formation in which most of the uranium is found, and associated formations. The work reported here was done on behalf of the Division of Raw Materials of the Atomic Energy Commission.

Previous work

Little geologic work has been done in the Capitol Reef area, and it was of a reconnaissance nature. Dutton (1880), during his studies of the High Plateaus of Utah, examined the Aquarius Plateau and Thousand Lake Mountain, located southwest and northwest of the Capitol Reef area, respectively. He mapped the western part of the area on a scale of 1 inch to 5 miles. Gregory and Anderson (1939) wrote a report on the Capitol Reef National Monument. They measured stratigraphic sections in the area but did not map geology. Hunt, Averitt, and Miller, (in press), as part of their work on the Henry Mountains to the east, mapped the Waterpocket Fold in the southeastern part of the Capitol Reef area. Geologic work in adjacent areas has been done by Gilluly (1929) and Gilluly and Reeside (1928) in the San Rafael Swell to the north, and by Gregory and Moore (1931) on the Kaiparowitz Plateau and the Circle Cliffs to the south. Examinations of the Oyler mine were made by D. L. Everhart, 1950, pp. 4-6) of the Atomic Energy Commission in 1950 and by D. G. Wyant of the Geological Survey.

Field methods

About 60 square miles was mapped on a scale of 1:62,500, and approximately 35 linear miles of the Shinarump conglomerate was examined in detail in 1951 (fig. 2). Mapping was done by a combined use of plane-table methods and aerial photographs. Control for the plane-table mapping was expanded as a

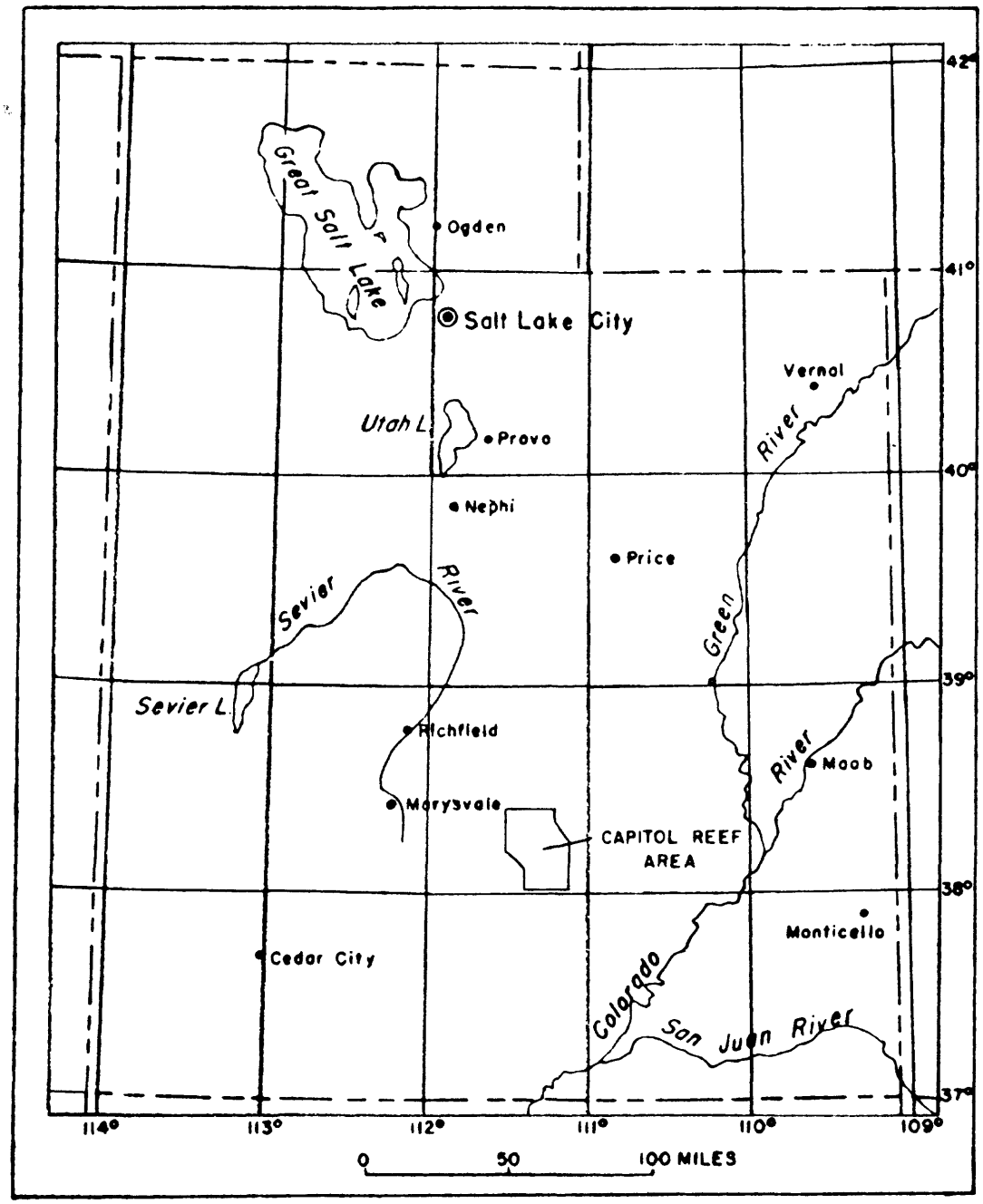

FIGURE 1.—INDEX MAP UTAH

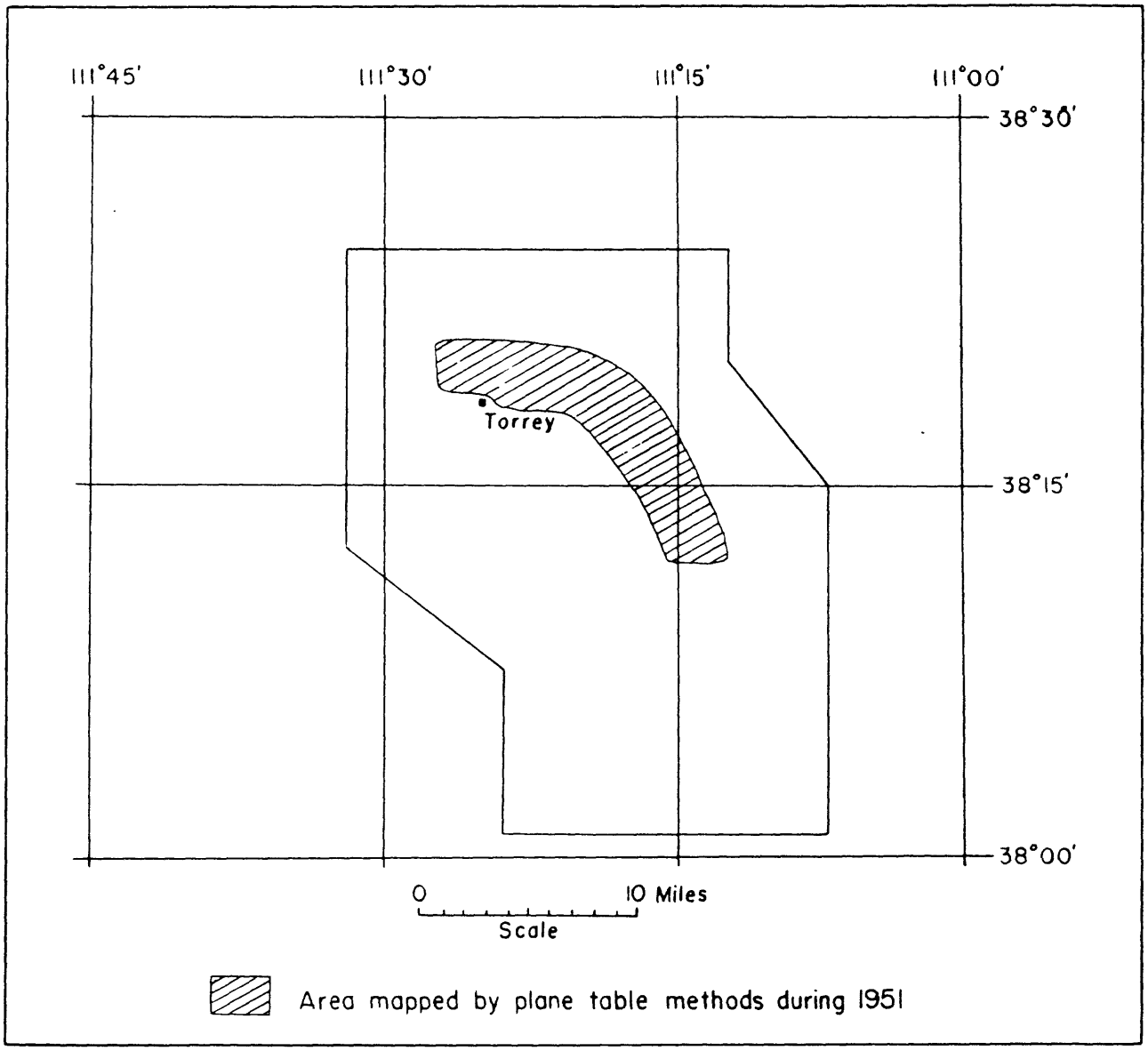

FIGURE 2.—CAPITOL REEF AREA, WAYNE COUNTY, UTAH

primary triangulation net from a measured baseline, and points on formational contacts were located by intersection. Contacts were first mapped on aerial photographs that were used as guides in sketching on the plane-table sheets.

Topography and drainage

Utah Highway 24 divides the area mapped during 1951 into 2 topographic units: (1) Capitol Reef, an arc of cliffs facing in general to the southwest, and (2) the structural and topographic dome lying between the reef and the Aquarius Plateau to the west.

The crest of Capitol Reef is 900 to 1,000 feet above its base on the west. The northern part is indented with several deep re-entrants, whereas the southern part is a more even curve of cliffs. A vertical cliff of massive red-brown sandstone forms the top 325 to 400 feet. Below it are steep slopes and ledges of varicolored claystone, siltstone, and sandstone covered in places by large talus boulders of sandstone. Low hills and buttes have been eroded in the shales and siltstone in and near the re-entrants.

The dome southwest of the Reef is cut on the eastern flank by gorges and canyons 50 to 500 feet deep. Eastward-flowing streams, all tributaries to the major perennial stream, the Fremont River, have cut through the sediments on the eastern flank. Beds dip on the average 10° E. and NE., and form the dip-slope surface between canyons.

Four canyons extend eastward through the Reef. From north to south they are: (1) the Fremont River canyon, (2) Grand Wash, (3) Capitol Gorge, and (4) Pleasant Creek canyon. The western ends of the first three canyons are shown on figure 3. These 4 canyons are steep-walled and narrow; their meandering courses are in part joint-controlled.

In the mapped area all streams except the Fremont River and Sulphur Creek are intermittent. The Fremont River is the largest perennial stream and drains most of the area. Intermittent streams are dry during all but a few days a year, but they rise rapidly after even moderate rains and cause flash floods. Run-off is rapid, because little or no soil and vegetation hold the water that falls on the steep slopes.

STRATIGRAPHY

Formations range from the Coconino sandstone of Permian age to the Navajo sandstone of Jurassic (?) age (fig. 3). Table 1 gives brief descriptions of the bedrock units. Quaternary sand and gravel cap benches and pediments, and Recent alluvium covers bedrock along the major streams.

Permian rocks

Two formations of Permian age are exposed; they are the Coconino sandstone and the Kaibab limestone, having a total thickness of at least 650 feet. These Permian rocks are in general buff or white in contrast to the dark reds and browns of the overlying rocks.

Coconino sandstone

The Coconino sandstone, exposed in small areas west of the Reef, forms the lower walls of steep-sided canyons. The total thickness was not measured but an estimated minimum of 500 feet is exposed in the canyon of the Fremont River.

The sandstone is very fine- to fine-grained, white, cross-laminated, and in massive beds 3 to 30 feet thick. Quartz, the chief constituent, is in well-rounded grains that are well-sorted in most beds. Muscovite and a few dark minerals constitute a very small percentage of the rock, which is cemented by silica but is not exceptionally hard in most places. Pyrite concretions, as much as 6 inches across, some of which have been altered to limonite, are abundant locally. Scattered chert nodules range in diameter from half an inch to 1 1/2 inches.

The base of the Coconino sandstone is not exposed.

The contact with the overlying Kaibab limestone is a transition zone of interbedded sandstone and limestone. The contact has been drawn at the top of the cross-laminated sandstone beds.

Kaibab limestone

Kaibab limestone crops out in the canyons west of Capitol Reef and locally caps divides between canyons. It is 154 feet thick along Sulphur Creek but has not been measured elsewhere. Creamy white

Table 1.--Sedimentary formations mapped in the Capitol Reef area during 1951

System	Group	Formation	Thickness (feet)	Description
Jurassic (?)	Glen Canyon	Navajo sandstone	500 +	White to tan massive sandstone with large scale cross-bedding and cross-laminations
		Kayenta formation	240 ±	Fine- to medium-grained yellow to brown sandstone, massive- to thin-bedded, evenly laminated and cross-laminated; numerous lenses; conglomerate
		Wingate sandstone	320-380	Fine-grained tan and red brown massive sandstone, large scale cross-bedding and cross-laminations; cliff-forming
	Unconformity			
Triassic		Chinle formation		
		upper	190 ±	Variegated claystone, siltstone; thin beds limestone, conglomerate, cross-laminated sandstone
		lower	280 ±	Variegated claystone; shale; siltstone; very fine- to medium-grained cross-laminated, ripple-marked sandstone in lower part; beds 1-5 feet thick
		Shinarump conglomerate	0-75	Massive, white to light brown cross-laminated medium- to coarse-grained sandstone, conglomeratic; clay pebbles; thin clay layers; carbonaceous plant remains; basal bed of clay, sandstone, carbonaceous material, some copper minerals, uranium minerals
	Unconformity			
		Moenkopi formation		
		upper	670 ±	Upper part: Reddish-brown siltstone and claystone in beds 1-3 feet thick, ripple-marked; beds of sandstone 1/2 to 3 inches thick, very fine-grained; much gypsum in layers parallel to and at angles to bedding; copper minerals at top in places. Lower part: thin and massive beds of very fine-grained sandstone and siltstone, pale reddish-brown, cross-laminated, ripple-marked
		lower	150 (?) - 213	Upper part: massive limestone, oolitic limestone, calcareous siltstone, sandy limestone, calcareous sandstone, yellowish, cliff-forming. Lower part: thinly bedded siltstone and shaly beds 1/8 inch to 1 1/2 inches thick; pale reddish-brown; yellowish-gray in lower 20 feet; ripple-marked; gypsum along bedding and in cross-cutting seams
Permian		Kaibab formation	150 ±	Calcareous siltstone; chalky beds 6 inches thick; shale partings in lower few feet; beds generally 1/2 foot to 2 feet thick but weather to appear more massive; abundant chert nodules, mainly 1/4 inch to 2 inches in diameter; chert layers 6 inches thick in places; a few nodules contain hydrocarbons
		Coconino sandstone	500 +	Massive very fine- and fine-grained sandstone; large scale cross-laminations; chiefly well-rounded quartz grains; some muscovite and dark minerals; siliceous cement

calcareous siltstone and in places, sandstone and chalky beds make up the Kaibab. Few beds of nearly pure limestone were found in the area mapped. Chert nodules are prominent throughout the formation.

The contact between the Kaibab limestone and the overlying Moenkopi formation is regular in the short distances where it is not obscured by talus. In most places it is a sharp boundary between the creamy white calcareous beds of the Kaibab and the yellowish-gray and pale reddish-brown thin-bedded siltstone of the Moenkopi

Triassic rocks

Triassic rocks, about 1,400 feet in total thickness, cover approximately two-thirds of the area mapped during 1951. In ascending order the Triassic units are the Moenkopi formation, the Shinarump conglomerate, and the Chinle formation. These rocks vary widely in composition, color, grain size, and texture, but most are red and gray clay, claystone, siltstone, and sandstone.

Moenkopi formation

The Moenkopi formation, exposed along the base of Capitol Reef and on the dome west and south of the Reef, is 897 feet thick from sec 6, T. 29 S., R. 5 E. to Sulphur Creek. It is divisible into four main units, which are in ascending order: 1) thin-bedded siltstone, 2) limestone, sandy limestone, and calcareous siltstone, 3) massive sandstone and siltstone, and 4) siltstone, and claystone with very thin beds of sandstone. The lower Moenkopi formation shown on figure 3 by the symbol Trml consists of units 1 and 2; the upper Moenkopi formation, Trmu, consists of units 3 and 4.

The lowest unit of siltstone is 94 feet thick along Sulphur Creek but appears to thin to the southeast. It is chiefly pale reddish-brown with a lower section of yellowish-gray. Beds range in thickness from an eighth of an inch to 1 1/2 inches, most are slightly less than half an inch thick. Small ripple marks are abundant. The thin beds weather into platy fragments and stand in steep slopes because the overlying limestone forms cliffs. Pods of pink rock gypsum are parallel to the bedding, and veinlets of white selenite are parallel to and at angles to the bedding.

The limestone unit forms extensive dip slopes on the dome west of Capitol Reef. It is 136 feet thick

along Sulphur Creek in sec. 7, T. 29 S., R. 6 E. To the southwest it thins and may be no more than 50 feet thick west of Capitol Wash. The unit contains limestone, oolitic limestone, sandy limestone, and calcareous siltstone. It may be correlative with the Sinbad member of the Moenkopi formation in the San Rafael Swell (Gilluly, 1929, p. 83).

Limestone beds are a variety of yellowish colors. Weathered surfaces are slightly darker than fresh surfaces. Limestone strata are both massive and thin, ranging from half a foot to 10 feet in thickness. In places the beds are thinly laminated. A zone about 40 feet below the top of the formation in Sulphur Creek contains numerous small pelecypods and gastropods; fossiliferous limestone also forms the cap of much of the dome west of Capitol Reef. Pockets in the limestone, as much as 1 inch long, contain specks of hydrocarbons.

Other beds in the limestone unit are: oolitic limestone in beds 2 to 8 inches thick, calcareous siltstone in beds 2 to 6 feet thick with an eighth to half an inch thick laminations, and sandy limestone and calcareous sandstone in beds generally a half to 1 1/2 feet thick.

This unit forms prominent cliffs along canyon walls.

Unit 3, sandstone and siltstone, is 304 feet thick in secs. 5, 7, and 8, T. 29 S., R. 6 E. Fresh surfaces are pale reddish-brown, and weathered surfaces are the same color throughout the unit except for some lighter-colored beds of sandstone that comprise a very small percentage of the entire formation. Sandstone is fine- to very fine-grained in beds ranging from half an inch to about 12 feet in thickness. The evenly bedded lower 50 feet is in beds half an inch to 1 foot thick, and above the lower 50 feet beds are more massive and as much as 12 feet thick. Abundant small-scale cross-laminations are in the massive sandstone. Scours and channel fillings are common in the upper half of the unit; scours range in depth from a few inches to about 15 feet. Large and small ripple marks, chiefly oscillation ripples, are abundant throughout this unit.

In areas where these beds are exposed streams have cut steep-sided canyons and gulches to form greatly dissected terrain of low relief. The massive beds form ledges along the valley sides and, in many places, box canyons near stream heads.

The upper unit of the Moenkopi formation, 363 feet thick in the SW 1/4 of sec. 5, T. 29 S., R. 6 E., is chiefly siltstone with some claystone and a few thin beds of very fine-grained sandstone. The dominant

color is reddish brown. Siltstone beds range in thickness from 3 inches to 3 feet; most are between 1 and 3 feet and are thinly laminated. In places the red-brown silt rock is bleached along the bedding to a very pale green. The bleached zones range from half an inch to about 10 inches in thickness. Much salmon-pink rock gypsum is parallel to the bedding, and veins of white satin spar cut the bedding at varying angles.

Beds stand in cliffs and fluted walls for heights of 150 feet and more where the Shinarump forms a ledge at the top. In places these cliff beds weather into knobby forms and shaly ledges. Away from cliff faces this siltstone unit weathers to form round-topped slopes and ridges covered with debris. Commonly, steep slopes are thinly covered with well-cemented fragments.

The contact of the Moenkopi formation and the Shinarump conglomerate is erosional. In most places it is only slightly irregular; elsewhere small scours 1 to 2 feet deep are at the top of the Moenkopi, and locally the top has been channeled and filled with Shinarump sandstone to a maximum depth of 15 feet.

Shinarump conglomerate

The Shinarump conglomerate, exposed discontinuously along the base of Capitol Reef, is chiefly a medium-to coarse-grained sandstone. The thickness is as much as 75 feet, but at several places, a mile or more long, the Shinarump conglomerate is absent. When seen from a distance, the formation appears as a white or light-brown cliff separating the slopes of the Chinle formation above and the Moenkopi formation below. From sec. 5 T. 29 S., R. 6 E. southeast along Capitol Reef the Shinarump conglomerate is discontinuous and lenticular. The maximum thickness is 50 feet. West of sec. 5, T. 29 S., R. 6 E. it is continuous except at the common corner of secs. 29, 30, 31, and 32, T. 28 S., R. 5 E.

The Shinarump conglomerate is composed of subangular to well-rounded quartz grains, and contains some clay pebbles as much as 3 inches long, and smaller quartz and quartzite pebbles scattered locally through the sandstone or in lenses as much as 2 inches thick and 2 feet long. Many grains of white clay and brown iron oxide are visible under the hand lens. In the large remnant north of Sulphur Creek (sec. 30, T. 28 S., R. 5 E.) pyrite nodules as large as 2 by 3 by 6 inches were found in a zone 10 feet thick, about 20 feet above the base of the formation. The surrounding sandstone is white and contains small grains

of green and blue copper minerals, probably copper sulfates. The overall color of the fresh rock is very pale orange. Weathered rock is generally darker because of oxidized iron or because of red-brown wash from overlying beds.

Beds are massive, with laminations generally a fourth of an inch to 2 inches thick; cross-laminations are common through thicknesses of 1 to 3 feet. From sec. 5, T. 29 S., R. 6 E. south to Capitol Wash most cross-laminations dip generally eastward.

A bed of clay with a small amount of sandstone comprises the base of the Shinarump over most of the area. This basal bed ranges in thickness from about 6 inches to 8 feet. Locally it contains much carbonaceous matter. Clay and sandstone are in thin beds half an inch to 3 inches thick, are mixed with small pockets of sandstone in clay, or are mixed with pebbles and pockets of clay in sandstone. Mixtures of clay, shale, sandstone, silicified wood, and carbonized wood are common, particularly where the Shinarump conglomerate fills channels that have been cut into the underlying Moenkopi formation. The channels that have been found in the mapped area are less than 20 feet deep and 250 feet wide.

About 1 1/2 miles south of Grand Wash (NW 1/4 sec. 36, T. 29 S., R. 6 E.) a bed of calcareous siltstone, 1 1/2 feet thick, is mapped as Shinarump conglomerate. This siltstone contains a layer of jasper, 2 to 6 inches thick, spotted and coated with hydrocarbons. The jasper layer extends about 200 feet north where it is in the typical basal bed of clay and sandstone.

The Shinarump conglomerate is essentially a basal member of the overlying Chinle formation, and in places the two formations are difficult to separate. Chinle sandstone is generally finer grained and darker than Shinarump sandstone, but where it rests on Shinarump sandstone the boundary is gradational. In many places lenses of siltstone and claystone of the Chinle formation separate Chinle sandstone and Shinarump sandstone, and where the lenses pinch out the two sandstones are in contact. For this report, the Shinarump conglomerate is restricted to the lower coarser-grained, cross-laminated sandstone, and the variegated beds above are included in the Chinle formation. This differs from past mapping in adjacent areas (Hunt, Averitt, and Miller, in press; Gilluly 1929, Gregory and Moore 1931) where variegated beds have been included in the Shinarump conglomerate; in those areas the contact was drawn to include all the lower sandstones and conglomerates.

Chinle formation

The Chinle formation consists chiefly of claystone and siltstone, with smaller amounts of sandstone, limestone, and conglomerate. It is 425 to 475 feet in thickness. The claystone beds commonly weather to form steep slopes below the cliff-forming Wingate sandstone. Sandstone, limestone, and conglomerate beds form small ledges and bluffs.

The Chinle formation is divided into two units; a lower unit of claystone, siltstone, and sandstone, and an upper unit of chiefly claystone and siltstone with beds of impure limestone. The top of the lower unit is drawn at the top of a persistent bed of sandstone about 280 feet above the base of the formation.

The lower unit is chiefly claystone with a small amount of sandstone. It can be divided roughly into three parts, which in ascending order are: (1) greenish gray to light olive gray claystone in beds 2 to 3 feet thick, composing about 80 percent of the total section, and very fine- to medium-grained gray and brown chiefly quartz sandstone in beds and lenses having some small scale cross-laminations and ripple marks; (2) red and reddish brown claystone and siltstone and lenticular beds of quartz sandstone containing clay pebbles in places and having a calcareous cement locally; and (3) thin- and massive-bedded fine- to medium-grained gray and reddish brown sandstone of chiefly quartz and clay containing lenses, 6 to 8 inches thick, of siltstone- and claystone-pebble conglomerate. The upper sandstone is persistent through the area mapped. It contains both even- and cross-laminations and has an average thickness of about 30 feet.

Chiefly siltstone and beds of impure limestone comprise the upper unit of the Chinle formation. Most siltstone beds are pale reddish brown. Limestone beds, 2 to 3 feet thick, are more resistant than the siltstone and form small ledges or prominent beds along the slopes, but pinch out in places; they are pale red and light greenish-gray.

In parts of the area between Grand Wash and Capitol Wash a prominent bed of conglomerate and sandstone crops out about 30 feet below the top of the formation. The conglomerate is composed chiefly of pebbles of red siltstone and claystone generally a fourth to a half inch across and subangular to subrounded. A few irregular elongate pebbles of white clay are five inches long. In places the conglomerate is cross-laminated, and interbedded with cross-laminated fine-grained calcareous sandstone.

The conglomerate contains many bone fragments.

In most places the top of the Chinle formation is a siltstone or claystone, but locally it is a sandstone containing numerous clay pebbles. The contact between the Chinle and the overlying Wingate sandstone appears to be conformable over long distances, but in places Chinle beds are truncated by Wingate strata. Locally V-shaped wedges of Wingate sandstone extend down into the Chinle for depths of 1 to 2 feet; these wedges probably are filled cracks but may be filled small channels.

Jurassic (?) rocks (Glen Canyon group)

Jurassic (?) rocks exposed in the part of Capitol Reef mapped in 1951 are the Wingate sandstone, the Kayenta formation, and the Navajo sandstone. Nearly all the rock is fine-grained sandstone, but a small amount is thinly bedded conglomerate.

Wingate sandstone

Wingate sandstone forms the red-brown vertical cliff of Capitol Reef. Alidade measurements indicate that the thickness of this formation is between 320 and 380 feet. Fine-grained quartz sandstone comprises most of the formation. Small pockets and stringers of medium- to coarse-grained amber quartz pebbles are common at or near the base. Beds are few, massive, and cross-bedded and cross-laminated on a large scale. The cross-laminations dip in random directions.

The contact with the overlying Kayenta formation is drawn at the base of the sandstone beds that are evenly laminated or have small-scale cross-laminations; these Kayenta beds are lenticular in most places.

Kayenta formation

Beds of the Kayenta formation form the upper part of the cliff of Capitol Reef in places and the terraced ledges within several hundred feet of the cliff edge. The thickness of the Kayenta is about 240 feet, but it varies laterally. The most easily accessible exposures are in the washes cut through the Reef. Yellow to brown sandstone and conglomerate comprise the formation. Beds are massive to thin-bedded, are both evenly laminated and cross-laminated, are in short lenses and in fairly continuous beds, and are channeled locally.

Navajo sandstone

The Navajo sandstone is exposed on the crest and back sides of Capitol Reef. White "whalebacks" or rounded ridges formed along north-trending joints, and rounded cones and bosses of Navajo sandstone are conspicuous erosional forms atop the reef. The minimum thickness of the formation is probably at least 500 feet, but it has not been measured.

Nearly the entire formation is white, tan, or buff sandstone with prominent tangential cross-bedding on a large scale

No beds above the Navajo sandstone have been mapped, but the Carmel formation of the San Rafael group of Jurassic age overlies the Navajo sandstone.

Quaternary sediments

Quaternary sediments mapped in the Capitol Reef area during 1951 consist of sand and gravel which cap pediments and terraces and Recent alluvium which is found along Sulphur Creek and the Fremont River.

STRUCTURE

The area mapped in 1951 is along the north and east flanks of a northwest-trending dome, the east flank of which is a continuation of the Waterpocket Fold. Dips range from 4° to 15° E., NE., and N., and change gradually between the extremes. Upper Moenkopi beds on the east limb of the dome have been folded in two small areas; one fold trends N. 50° E., the other N. 70° W.

Normal faults are prominent in the north part of the area. They trend west-northwest, and the maximum throw on any fault is about 200 feet; the northernmost ones are downthrown on the south, the southernmost ones downthrown on the north. Dips of faults are steep to vertical. In secs. 6 and 7, T. 29 S., R. 6 E. several small normal faults trend almost north, dip 75° to 85° E. and W., and have throws of as much as 30 feet.

Prominent joints are in the massive sandstone strata. The most prominent set trends generally within 20° of north North-trending joints cut the massive Wingate and Navajo sandstones along the crest of

Capitol Reef. These joints are accentuated by the erosion of narrow gorges along them. In the northern part of the area many joints are also parallel to the west-northwest trending faults, and a pattern of nearly right angle joints is formed.

Locally, prominent joints in the Shinarump conglomerate trend between N. 10° W. and N. 20° W. and dip about S. 70° W. They are best observed in the few small areas where dip slopes have been developed on the Shinarump. In sec. 12, T. 30 S., R. 6 E., the cliff face on the Shinarump has smooth surfaces parallel to these joints.

Small joints break the sandstone beds of the Moenkopi formation, but not enough observations have been made to determine the pattern. In the Coconino sandstone along the Fremont River, joints trend generally north, and small meanders in the river are present along them.

URANIUM DEPOSITS

Types of deposits

Uranium deposits are in the basal part of the Shinarump conglomerate. Uranium minerals present are zippeite, a hydrous uranium sulfate, (Hess, 1924, pp. 70-73) and metatorbernite, a copper uranium phosphate. Secondary copper minerals, chiefly hydrous copper sulfates, are associated with the uranium deposits. Chalcopyrite was found in one place in the Moenkopi formation about 1 1/2 feet below the base of the Shinarump in the Oyler mine.

The highest radioactivity noted is in a clay bed at the base of the Shinarump conglomerate. This bed ranges from 6 inches to 8 feet in thickness, but in most places is 6 inches to 1 foot thick. It contains pods, stringers, and a half- to 2 inch-thick beds of sandstone, and commonly contains carbonized wood, some silicified wood, and clay pebbles. In the NW 1/4 of sec. 36, T. 29 S., R. 6 E., a layer of jasper extends for about 400 feet in the basal clay, in part siltstone at this locality. The jasper layer is coated and spotted with hydrocarbon in places, has some copper stain, small amounts of pyrite, and is slightly radioactive. The hydrocarbon appears to be the radioactive material.

On the Colorado Plateau many uranium deposits in the Shinarump conglomerate are in sandstone and conglomerate beds deposited in channels cut into the underlying Moenkopi formation. Such channel fills

are likely places for uranium deposits in the Capitol Reef area. Two definite channel fill deposits have been found in the area mapped: one at the Oyler Mine and the other at the Birch Spring prospect on the south side of Moonie Draw. Fills of possibly shallow channels occur between Grand Wash and Capitol Wash, but at all these localities the channels are obscure. Channel fills appear to be likely places for uranium concentration, but on the basis of present knowledge other favorable features, particularly clay beds and carbonaceous material, must be part of the fill for the formation of a deposit.

Oyler mine

The Oyler mine is on the north side of Grand Wash in the SE 1/4 sec. 26, T. 29 S., R. 6 E. Mine workings consist of 2 adits connected by a cross-cut and 3 other short cross-cuts (figs. 4 and 6). Little development work has been done because prospecting and mining were until recently prohibited in the Capitol Reef National Monument. Previous examinations of the mine have been made by D. L. Everhart (1950, pp. 4-6) of the Atomic Energy Commission and by D. G. Wyant (personal communication of the Geological Survey.

The deposits are in the Shinarump beds filling a channel cut into the underlying Moenkopi (fig. 5); the channel is about 30 feet wide and slightly less than 10 feet deep. The trace of clay bed, half a foot to about 1 1/2 feet thick, at the base of the Shinarump shows the configuration of the Moenkopi-Shinarump contact at this locality. The base of the channel fill is irregular, as is the contact elsewhere, so that the exact course of the channel is difficult to determine. It appears to have a general trend that is a few degrees east of north.

The uranium minerals and other radioactive materials are in the tan and yellowish clay beds at the base of Shinarump (fig. 6). Most copper minerals are also in the same clay bed. The clay contains pods and stringers of white clay (probably alunite and natroalunite), 1 to 2 inches thick and as much as 30 feet long, and fragments of carbonized wood. Most carbonized wood in the clay is radioactive. Effluorescent crusts of gypsum coat the clay in places and veinlets of gypsum cut the clay and the underlying Moenkopi. Shinarump sandstone beds, containing carbonized wood fragments and clay pebbles, overlie the clay. In most places the sandstone directly above the clay is cross-laminated and is overlain by massive sandstone, but some massive sandstone lies on the clay. Concentrations of thin carbonized wood fragments in the sandstone are either not radioactive or are very mildly so.

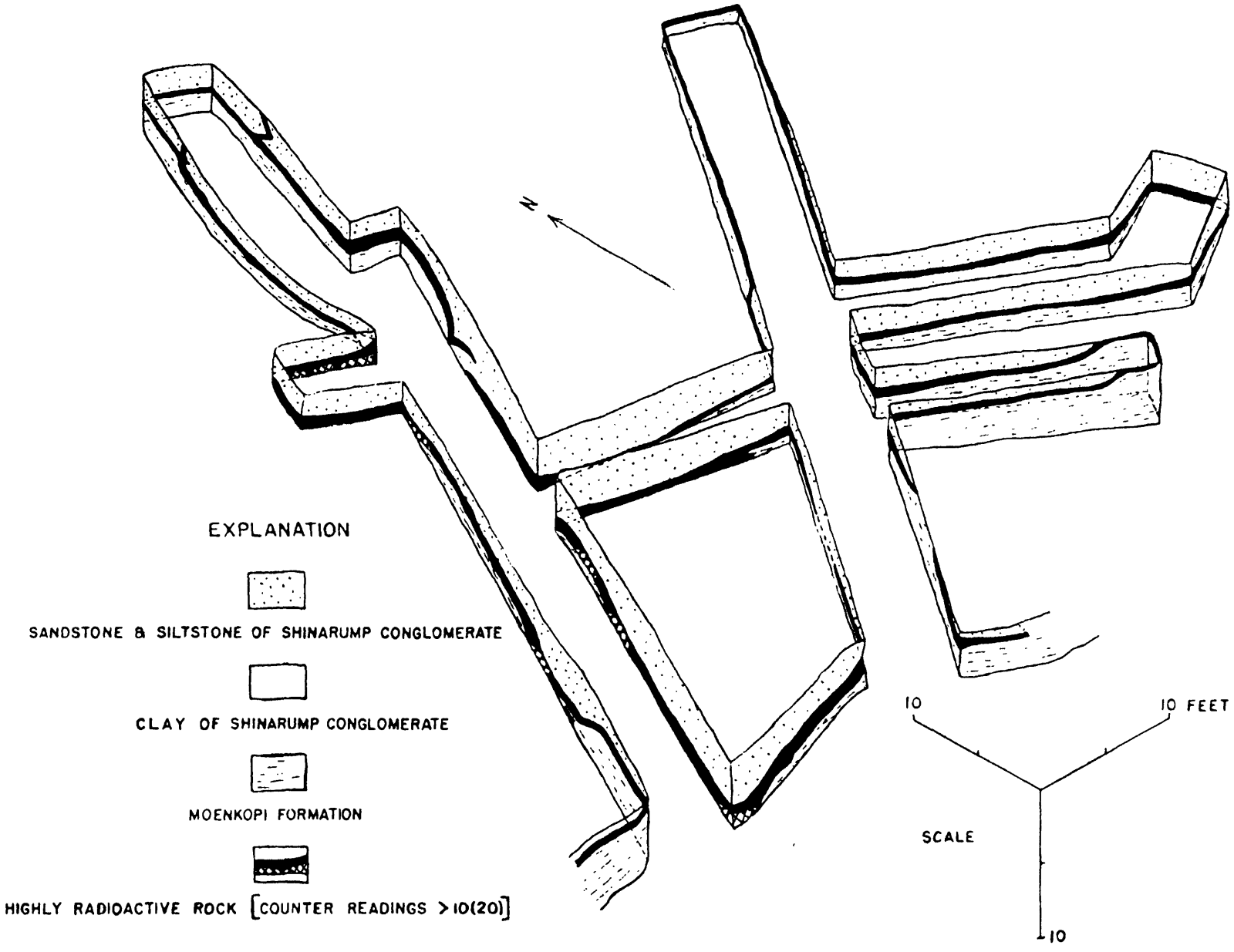

FIGURE 4.—ISOMETRIC DIAGRAM OF THE OYLER MINE

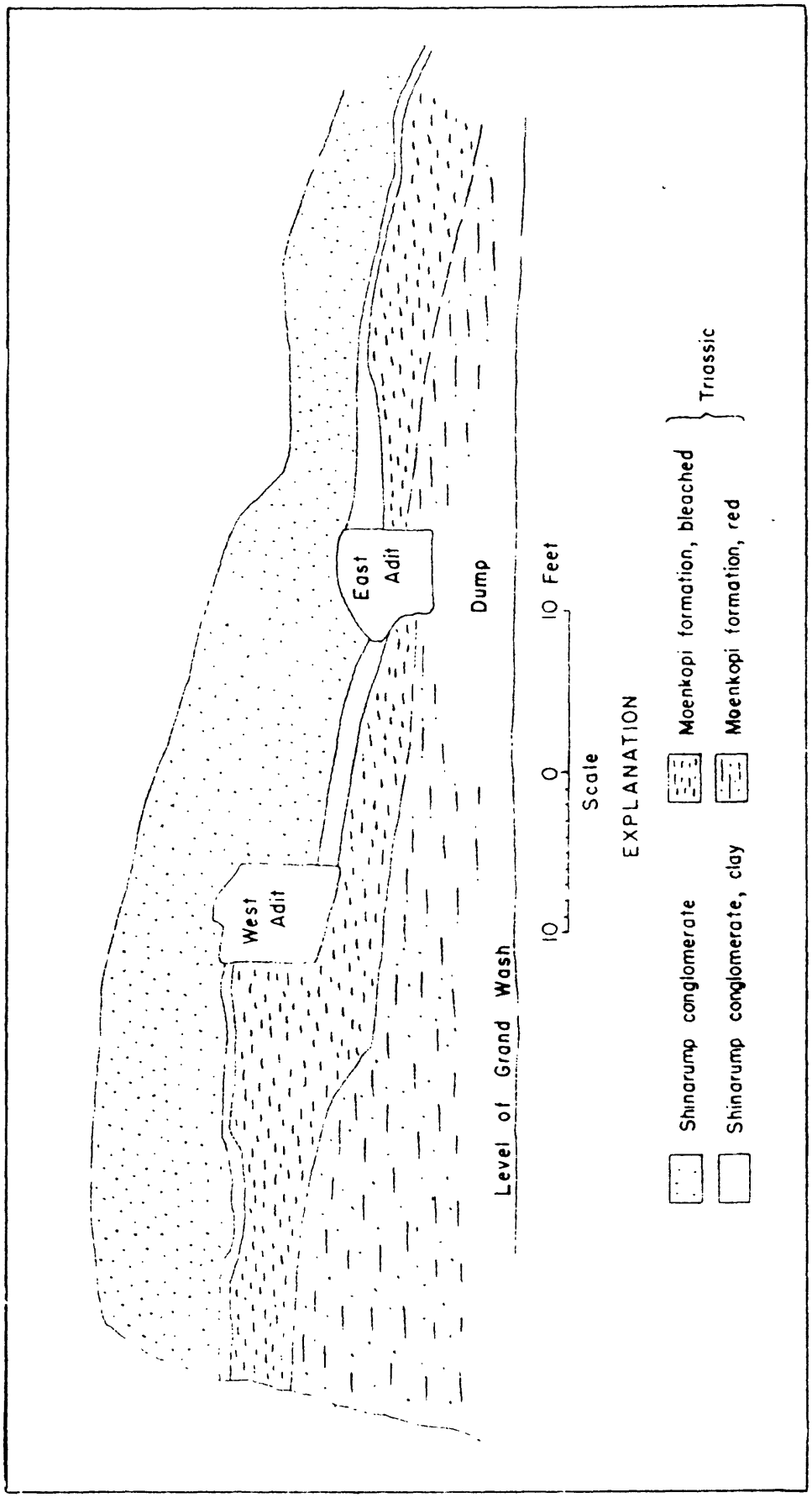

FIGURE 5.—FACE OF EXPOSURE AT THE OYLER MINE

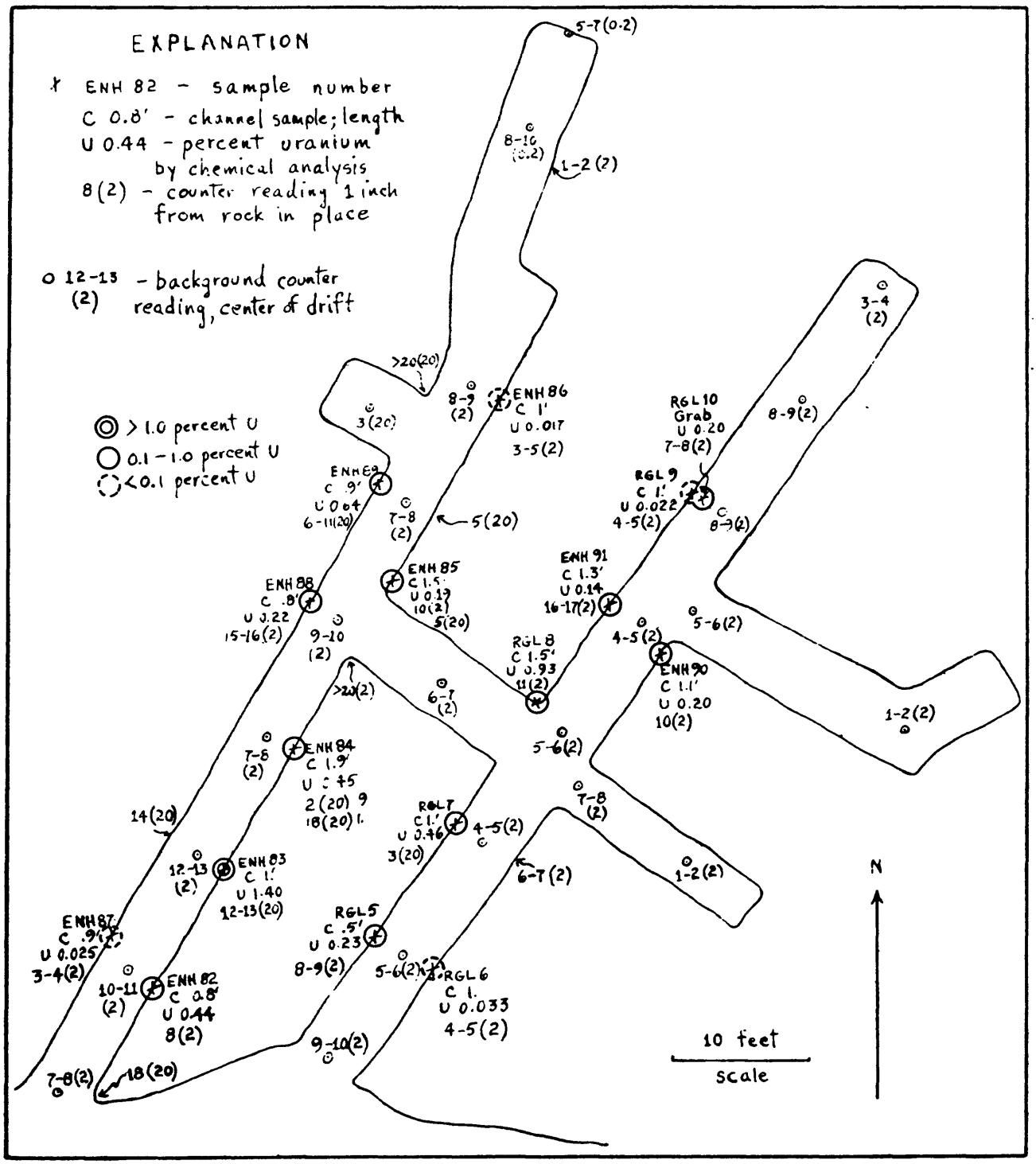

FIGURE 6.—ASSAY MAP OF THE OYLER MINE
Samples from clay bed, ½ foot to 2 feet thick, at base of Shinarump conglomerate

The most abundant uranium mineral is [illegible] described from the area by Hess, (1924, pp. 70-73). It occurs in the basal clay bed and in the lower part of the channel fill. A small amount of metatorbernite accompanies the [illegible] of gypsum [illegible] and forms a thin layer of [illegible]. Metatorbernite particles 1 to 2 mm in diameter are also scattered through part of the white clay. Chalcopyrite was exposed in one pit about 1 1/2 feet below the top of the Moenkopi. Gruner and Gardiner (1951, p. 17) list the following minerals from the Oyler mine: schoepite, parschoepite (?), sklodowskite (unknown yellow mineral), alunite, lepidocrocite, gypsum, and basic copper sulfates.

Moenkopi beds are chiefly reddish brown, but over most of the area they are bleached to a grayish green for a general thickness of a half to 1 foot at the contact with the overlying Shinarump. In the vicinity of the Oyler mine the bleached zone is much thicker than in most places, the maximum thickness is at the west side of the west adit.

The basal Shinarump clay is radioactive for about 400 feet northwest of the Oyler mine. The clay is also slightly radioactive for 60 feet east of the mine to where it passes beneath alluvium in Grand Wash. Maximum activity is 4 to 5 times background, is spotty, and decreases away from the mine. Through this area copper staining is common in the bleached clay at the top of the Moenkopi formation.

Birch Spring prospect

The Birch Spring prospect on the southwest side of Moonie Draw is in Shinarump beds filling a channel cut in the underlying Moenkopi. The channel, 100 to 250 feet wide, depending on possible curves, and 15 feet deep, is exposed on one cliff face. The channel is asymmetric: the east margin slopes steeply to the southwest and trends about N. 40° W., and the west margin slopes gently to the east and trends about N. 10° W. The basal clay bed of the Shinarump is 6 inches or less in thickness in this channel fill, and the clay and Shinarump as a whole contain little carbonaceous material. Clay pebbles are scattered through all the Shinarump beds. Approximately 40 feet in maximum thickness, and iron oxide staining in the Shinarump is more prominent than in most exposures.

High radioactivity is restricted to a gray clay bed at the base of the Shinarump and to a clay lens 1 1/2 feet above the base; both clays are in a zone 20 feet wide at the deepest part of the channel. Secondary

copper minerals form coatings on the clay partings and occur as small spots in the sandstone as much as 6 feet above the base of the Shinarump.

Analyses of three samples from the clay follow:

	Percent			
	eU[1/]	U	V_2O_5	Cu
Grab sample: copper stained gray clay, 4 inches thick, at base of Shinarump	0.16	0.33	0.09	8.22
Grab sample: gray clay, 2 1/2 inches thick, at base of Shinarump	.049	.048	.10	.30
Grab sample: gray clay lens with carbonaceous material: 1 1/2 feet above base of Shinarump	.28	.49	.09	.35

1/ eU is equivalent uranium

The sandstone is not radioactive and the clay makes up a very small percentage of the rock. The lack of a larger area of high radioactivity may be due to the very small percentages of clay and of carbonaceous material in this channel fill.

Prospects between Grand Wash and Capitol Wash

Several prospects and claims are between Grand Wash and Capitol Wash. At some of these, radioactive rock appears to be in very shallow channel fills with scours of about 2 feet deep; the top of the Moenkopi formation, however, is scoured to depths of 2 feet at so many places in the area that it is doubtful they should be called channels.

On the first isolated Shinarump outcrop (Bluebird claims) directly south of the Oyler mine, 9 feet of Moenkopi beds have been cut out along a channel margin. Only the west side of the channel remains, as the east part has been removed by erosion. The west margin trends about N. 45° E., and it may be a southward extension of the channel fill at the Oyler mine, although it would have to curve sharply to the west to tie to the Oyler channel: the Shinarump has been removed by erosion between the Oyler mine and this exposure. Specks and coatings of metatorbernite are in the basal clay bed of the Shinarump, and the upper part of the Moenkopi is bleached for 1 1/2 to 2 feet below the Shinarump. Analyses of two samples collected east

(also Bluebird claims) of this isolated outcrop follow:

	Percent			
	eU [1/]	U	V_2O_5	Cu
Channel sample, 2 feet long 4 inches basal Shinarump, 1 foot 8 inches upper bleached Moenkopi	0.061	0.061	0.10	0.05
Grab sample from gray clay, 5 to 9 inches thick, 2 feet 3 inches above base of Shinarump	.049	.046	.05	.26

1/ eU is equivalent uranium

At the prospect along the line between secs. 35 and 36, T. 29 S., R. 6 E. Shinarump beds fill a scour that is 2 to 3 feet deep, about 35 feet wide, and appears to trend about N. to N. 10° E. The basal 2 feet of the Shinarump is a mixture of thin clay and sandstone beds and stringers and carbonized wood fragments and seams. Bleached Moenkopi siltstone is about 1 1/2 feet thick below the Shinarump. Some copper stain is scattered in the base of the Shinarump and the upper 2 feet of the Moenkopi, and rare thin coatings of metatorbernite are in the basal 1 foot of the Shinarump. Both cross-laminated and massive Shinarump sandstone overlie the basal clay and sandstone bed; the upper sandstone contains carbonaceous fragments. Above the lower 2 feet, the Shinarump is not radioactive. Analyses of two samples from this locality follow:

	Percent			
	eU [1/]	U	V_2O_5	Cu
Channel sample 6 inches long and 4 inches wide at base of Shinarump	0.32	0.38	0.10	0.15
Channel sample 10 inches long and 3 inches wide; chiefly sandstone and some carbonaceous material at base of Shinarump	.014	.011	.09	.05

1/ eU is equivalent uranium

A layer of jasper, 2 to 8 inches thick, spotted and coated with hydrocarbon and containing secondary copper minerals, is at the prospect (the Capitol claim) in the NW 1/4 sec. 36, T. 29 S., R. 6 E. At the prospect pit the jasper is in a clay and siltstone bed in the base of the Shinarump. To the north this siltstone bed passes into thinly interbedded clay and sandstone with carbonaceous fragments similar to the basal clay bed elsewhere. A 2-foot channel sample taken from this bed of clay, sandstone, and jasper with hydrocarbon

and carbonaceous material has the following analysis:

Percent			
eU [1/]	U	V_2O_5	Cu
0.088	0.048	0.05	0.03

1/ eU is equivalent uranium

From the Capitol claim south to Capitol Wash secondary copper minerals are scattered through the basal 1 foot of the Shinarump and the upper 1 to 2 feet of the Moenkopi; gypsum is abundant near the contact in both formations and white clay is common in discontinuous beds, 1 to 2 inches thick, at the base and in the lower 1 to 2 feet of the Shinarump. No abnormal radioactivity was noted along this strip of exposures except in carbonaceous fragments and seams at the prospect (All American No. 3 claim) in sec. 1, T. 30 S., R. 6 E. The following analyses were made of two selected samples of carbonaceous material from this claim:

Percent		
eU [1/]	U	Cu
0.32	0.41	0.15
.034	.028	.17

1/ eU is equivalent uranium

These analyses represent only some of the carbonaceous material and consequently a very small percentage of rock.

RESULTS OF WORK

Guides for prospecting

During studies of the pre-Morrison rocks on the Colorado Plateau, data have been accumulated on features to note, map, and study as possible guides to finding uranium deposits. No single feature, except of course uranium minerals or radioactive rock, is positive evidence of a uranium deposit, but the presence of one or several guides in the list that follows indicates that a detailed search for uranium is warranted.

The following guides are in two groups: (1) those now considered most indicative of a possible uranium deposit in the Capitol Reef area, and (2) those used thus far in other areas on the Colorado Plateau but not considered particularly indicative now of uranium deposits in the Capitol Reef area.

Guides for prospecting in the Capitol Reef area

a. Uranium minerals

b. Radioactivity.--Though no uranium minerals are visible, even slight radioactivity indicates that the area should be closely examined.

c. Shinarump conglomerate filling a channel cut in the Moenkopi.--Channel fills are considered good guides because deposits have been found in such sedimentary structures. Channel fills lacking other favorable features, however, are not necessarily uraniferous.

d. Copper minerals.--Copper minerals are considered favorable guides for two principal reasons: 1) they are found in all places where there is radioactive rock in the Capitol Reef area, and 2) they indicate that mineralizing solutions of some type have moved through the beds. Most copper is found as blue and green stains, probably in the form of copper sulfates. Metatorbernite and chalcopyrite in one place were found in the Oyler mine, and chalcopyrite is disseminated in limestone in the lower member of the Moenkopi formation west of the area mapped in 1951. Copper staining is much more abundant than radioactive material in the basal Shinarump conglomerate and in the upper 2 feet of the Moenkopi formation.

e. Concentration of carbonaceous matter.--Carbonaceous matter, particularly concentrated in a clay bed at the base of a channel fill, is commonly uraniferous or has uraniferous rock associated with it. Locally it is slightly uraniferous where it is not in a definite channel fill.

f. Thick zone of bleached clay with sandstone at the top of the Moenkopi formation.--The top of the red Moenkopi formation is bleached to gray or greenish gray more deeply where it underlies a channel fill of Shinarump conglomerate. Over most of the area only the top 6 to 12 inches of the Moenkopi formation is bleached.

g. Layer of clay with a small amount of sandstone at base of Shinarump.--A layer of clay with a small amount of sandstone is at the base of the Shinarump conglomerate over most of the area. Commonly this layer

contains much carbonaceous matter and almost all the radioactive material. This layer in itself is not a guide to ore, but if it is less than 6 inches thick, little radioactive material is present.

h. Hydrocarbons. --The presence of hydrocarbons in the Shinarump conglomerate is an unproved guide in the Capitol Reef area. At the Capitol claim, in sec. 36, T. 29 S., R. 6 E., hydrocarbon on jasper in the Shinarump is slightly radioactive. Hydrocarbons in the Kaibab limestone and in the lower limestone member of the Moenkopi formation are not radioactive. As a result of finding radioactive hydrocarbons in the Shinarump, the hydrocarbons appear to be good guides, but, on the basis of present knowledge, they seem to be scarce.

Guides used elsewhere in the Colorado Plateau but not considered particularly indicative now in the Capitol Reef area

a. Iron-manganese stain

b. Fractures

c. Sulfide minerals

d. Concentration of clay pebbles in sandstone

e. Massive lenticular sandstone

f. Hydrous mica

g. Alunite

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