Geology and Uranium Deposits of the Caineville Area,

Emery, Wayne and Garfield Counties, Utah

By Rudolph W. Kopf, Raymond J. Garcia and Martin Prochnik

A reconnaissance of a part of the western portion of the Colorado Plateau province

—— Rgg
—— R.W.K.
—— M.P.

Editors; in editing, please use a distinctive colored pencil or initial your corrections or suggestions, preferrably the former. Needless to say, identify your color.

Please use 2H or 3H pencils, not colored pencils, on all figures, tables and plates. Harder pencil marks are more difficult to erase.

The authors join with the editors in all efforts toward a better paper. Since criticism is always welcomed if it is constructive, sarcasm or comments other than constructive will not be acknowledged.

The authors.

[Note: This manuscript has been reviewed for conformity with the code of stratigraphic Nomenclature, published in the AAPG June '61, and adopted by the U.S. Geological Survey.

R.W. Kopf
7/24/61]

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Being an Account of little Interest to Ye Mining Industry, Ye General Publik, or Ye Scientific Profession, prepared only at Ye Constant Urging by Ye Authors' Lords and Colleagues, concerning diverse Observations made by Ye Authors whilst diligently charting Ye Positions of certain Calciferous Deposits, the same being well known since Ye Uranium Rush to Persons having Interest in such Matters, Ye Authors, ~~finding~~ found themselves much hampered in their Endeavors by Ye Stones, most of which in Truth looketh like all Ye other Stones, and by Ye Noxious Grasses and Herbs bearing Poisonous Leaves, and harboring stinging Insects, ugly Rodents, and crafty Sidewinders, the whilst effectively concealing Ye Stones from Ye Direct Observation.

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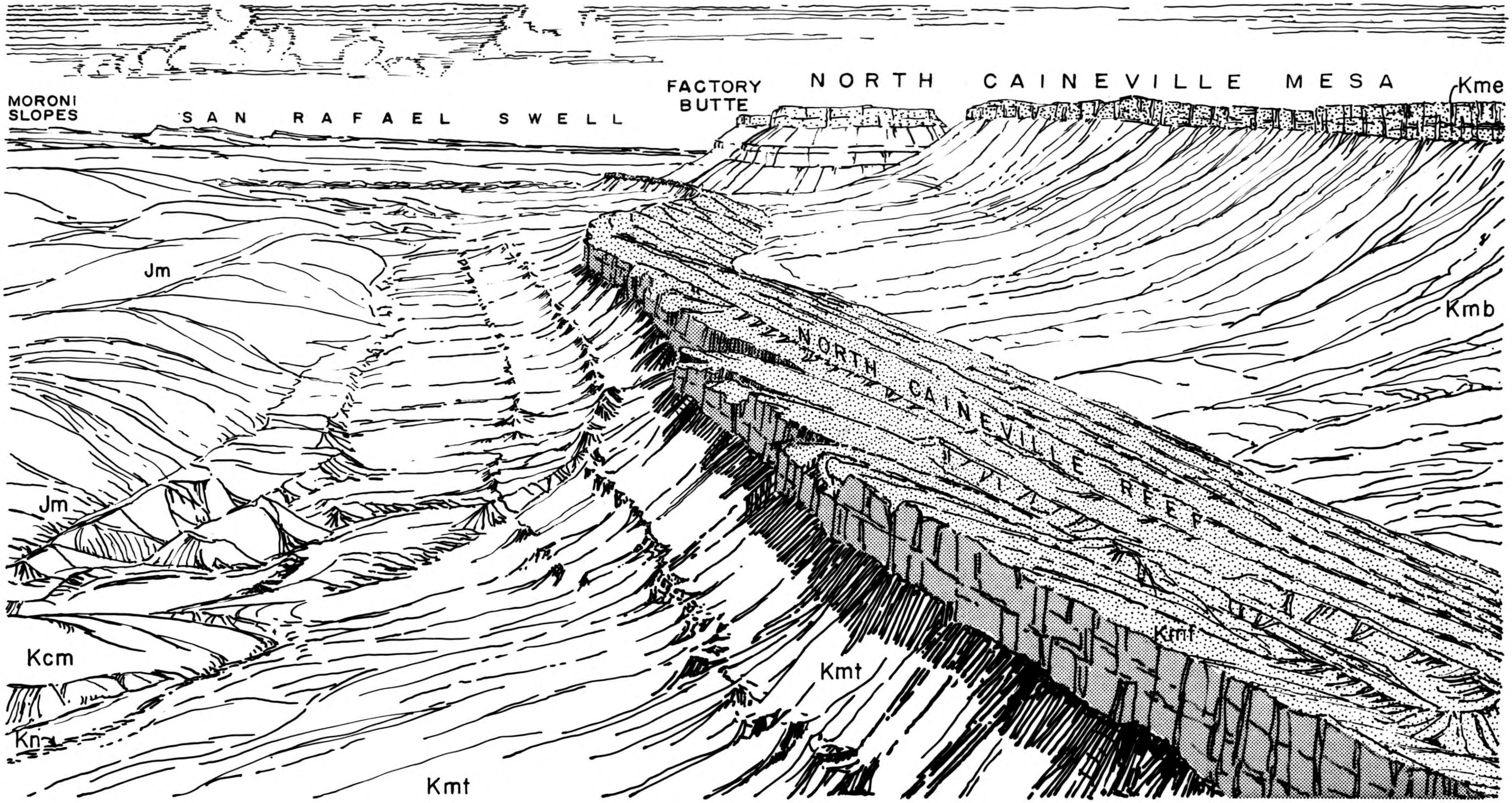
MORONI SLOPES
SAN RAFAEL SWELL
FACTORY BUTTE
NORTH CAINEVILLE MESA
Kme
Jm
Kmb
NORTH CAINEVILLE REEF
Jm
Kcm
Kmf
Kmt
Kn
Kmt

Fig.--North Caineville Reef viewed northward. Jm, Morrison Formation, shale and sandstone producing irregular rounded hills and valleys; Kcm, Cedar Mountain Formation, shale and siltstone producing rounded hills; Kn, Naturita Formation of Young (1960), poorly cemented pebbly sandstone in strike valley; Kmt and Kmb, Tununk and Blue Gate Shale Members of the Mancos Shale form strike valleys, Kmf and Kme, Ferron and Emery Sandstone Members of the Mancos Shale form hogbacks ~~on~~ or cap mesas.

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Abstract

The Caineville area is situated south and southwest of the San Rafael Swell, north and northwest of the Henry Mountains and east of the Capitol Reef in parts of Emery, Wayne and Garfield Counties, Utah.

Outcropping stratigraphic units consist of the Carmel, Entrada, Curtis, Summerville and Morrison (restricted) formations of Late Jurassic age, the Cedar Mountain formation, of Early and Late Cretaceous age, and the Naturita and Mancos formations of Late Cretaceous age. Remnants of gravel terraces of the ancestral Fremont River, determined to be of Quaternary (late Pleistocene) age, Partially sporadically blanket Mesozoic rocks while Recent alluvium occurs is located along the present drainages areas. Igneous rocks, in the form of dikes and sills, intrude Mesozoic rocks.

Structurally, the eastern portion of the area lies within ? OK. R.W.K. ~~includes~~ the northern part of the Henry Mountains structural basin. The western ~~Edge?~~ limit of the area Edge infers sharpness. Use limit is marked ~~delineated~~ by the northern part of the Waterpocket Fold, the Capitol Reef monocline. The intervening area is ~~includes~~ a marked structural plateau or terrace of relatively low structural relief consisting of imbricating and coalescing anticlines and synclines of shallow closure and with general northeast to northwest axial orientations. This terrace includes the southern extent of the San Rafael anticline. Although a highly faulted area ~~an area of anomalously high degree of faulting~~ occurs in the northeastern portion, the region ~~area~~, generally, has been only moderately faulted. A series

of small ~~thrust,~~ high angle reverse faults east of and paralleling the San Rafael anticlinal axis are believed to be due to the same east-west compressional force which produced most of the folding in that area ~~is interpreted to represent a general east-west compressional force believed to have been instrumental, locally, in the origin of these structures.~~

Because complete stripping of Tertiary deposits within the area has removed indications of crustal disturbance during Tertiary time, ages of the individual tectonics cannot be determined from local geologic features. However, ~~from evidence still in existance~~ in adjoining areas, several periods of warping are recognized and are believed to be of Tertiary (Eocene, Oligocene or Miocene) and possibly even of Quaternary (Recent) age.

I can't help think that the Henry Mountains structural basin, to the east, is of a different age and cause, such as subsidence accompanying extrusion. That's why I qualify my statement.

Detailed measuring of the outcropping Mesozoic rocks reveals what appear to be small open folds of late Mesozoic age which are of such small amplitude as to be almost completely masked by the more pronounced and superimposed Tertiary folding.

The number and size of uranium deposits within the area is small. 18 ~~Twelve~~ [CHECK TO CONFORM WITH ECONOMICS SECTION OF REPORT] * groups of claims are known to have produced ore-grade material. Past production has been marginal, small and sporadic in activity. At the time of writing (January, 1961) ~~(June, 1959)~~, ONE ~~three~~ property ~~properties are~~ is in operation. Potential reserves of the entire area is believed to be less than 5,000 tons of 0.20% U_3O_8.

Where are the two tables which supposedly list the properties? I never received them.
R. H. K.
7/24/61

Introduction

~~I Introduction~~

A.1 Purpose, scope and method

The purpose of this study was twofold. The initial program was designed to determine surface stratigraphic and structural features of the area. The concluding stage of the program was to determine possible genetic relationships between these geologic features and known occurrences of scattered uranium mineralization in order to develop criteria for establishing local ore guides, thereby defining favorable and unfavorable ground.

The scope of the project consisted of the preparation of a geologic map, preparation of a structure map, assembling of detailed lithologic descriptions of measured sections, presentation of variations in thickness of the Morrison and Cedar Mountain formations as represented by isopach maps and, finally, presentation of selected detailed mine maps representative of uranium mineralized localities within the area.

The geologic map, plate 1, is presented on a scale of 1:48,000. It was prepared by use of ~~A~~ Fairchild radial line plotter ~~was used~~ in conjunction with areal photographs having a scale of 1:24,000 and flown in 1948 by a private concern under ~~having had~~ an Atomic Energy Commission contract. The structure map, plate 2, of the same scale as the geologic map, utilizes the base of the Morrison formation as a datum. It was compiled by use of the following data; 1) seventeen stratigraphic sections measured with plane table and alidade, and an additional eighteen measured sections using ~~the~~ Brunton compass, generally measured between sections having had plane table accuracy, 2) about four hundred and fifty determinations of elevations of stratigraphic contacts by using plane table and alidade and Wallace and Tiernan roving altimeters, and 3) about six hundred determinations of the attitude of beds determined by plane table and Brunton compass. Profile construction and subsequent thicknesses of the Morrison and Cedar Mountain formations were determined by use of the method employed by Busk (LeRoy and Low, 1954, pp. 140-143, 158-161). The selected mines were mapped by Brunton and tape.

Location and accessibility

The Caineville area, as herein defined, includes 712 square miles south and southwest of the San Rafael Swell, north and northwest of the Henry Mountains and east of the northeastern portion of the Waterpocket Fold, locally termed the Capitol Reef. The area occurs between 38°07'30" and 38°35'00" north latitude and 110°52'30" and 111°12'30" west longitude in Emery, Wayne and Garfield Counties, southeastern Utah (see index map, fig. 1.).

Only two settlements occur in the area. The agricultural village of Caineville, with from six to eight persons, and the hamlet of Notom, with from two to eight seasonal mining and agricultural inhabitants, are all that remain of the original half-a-dozen Mormon settlements formerly in the area. The population density of the area has declined since the 1897 flood (Hunt, 1953b, p. 19) to the present 0.025 persons per square mile.

Vehicular accessibility to the area is by means of the ~~now~~ (June, 1959) partially paved state highway 24, connecting the towns of Green River and Hanksville to the north and east, respectively, with the settlements in Rabbit and Sevier Valleys to the west. The old Emery-Caineville trail, built about 1920 (Gilluly, 1929, p. 75) as well as the Fish Lake-Aldrich roads are both in barely passable condition with four-wheel drive vehicles. The Factory Butte-San Rafael Swell road, impassible through the Muddy River gorge since 1957, was ~~has been~~ reopened in 1959.

Physiography

The Caineville area is physiographically situated in the Canyon Lands Section near its western boundary with the Aquarius Plateau of the High Plateaus Section, all within the Colorado Plateau Province (Fenneman, 1931, pp. 306-312). The area is moderately to extremely dissected by arroyos, draws, gulches and canyons. These lowlands are interspersed by buttes and mesas often of 1,000 feet in relief although the total relief of the area approaches 2,000 feet.

Water and wind gaps, hogbacks, strike valleys, cliffs, landslide blocks, breached anticlines, pirated streams, gravel covered pediments, badlands, bahada slopes and other features often characteristic of an arid climate are common in this area having a mean annual rainfall of slightly greater than five inches (Butler, 1920, pp. 60-65).

The Fremont and Muddy Rivers, draining the area, are approaching a stage of late youth to early maturity in their development.

Previous investigations

The first geologic reconnaissance within the Caineville area was made by Gilbert in 1875 and 1876 in his classic studies of the Henry Mountains (~~Gilbert~~, 1877a, p. 447, 1877b, 160 pp.). In 1924 and 1925, Gilluly and others mapped the northern part of the area as a geologic map of the San Rafael Swell with structure contoured on the "Shinarump conglomerate" (Moss Back member of the Chinle formation of present usage)(~~Gilluly~~, 1929, pp. 69-130). In 1928, the U. S. Geological Survey published additional work on parts of this area, particularly the area north of Caineville (Gilluly and Reeside, 1928, pp. 61-110), and in 1939, the Federal Survey published the results of field work on the Capitol Reef area which adjoins this area on the west (Gregory and Anderson, 1939, pp. 1827-1850). In 1935, Hunt and his associates instigated their study ~~the field work~~ of the Henry Mountains region, the results of this monumental work being published as a professional paper (Hunt, 1953b, 234 pp.). He geologically and structurally mapped that part of the Caineville area east of and including the Caineville Reef monocline.

Acknowledgements

To enumerate the names of persons who were directly or, even more, indirectly concerned with the task of compiling data for this project would encompass listing the majority of personnel within the Production Evaluation Division of the U. S. Atomic Energy Commission, some of whom have since left government service. The authors are deeply indebted for the splended and laudably unselfish cooperation with other government agencies, mining concerns and private individuals, from men of various branches of the U. S. Geological Survey, from petroleum geologists of oil and gas companies, geophysicists of seismic crews and, particularly, residents of Wayne County. The senior author particularly wishes to gratefully acknowledge the whole-hearted interest, support and constructive criticism of ~~Dr.~~ Mr. Robert G. Young, whose enthusiasm for observing and, more importantly, interpreting the causes of geologic features has made this a rewarding experience.

Finally, the senior author accepts the responsibility for the accuracy of interpretations contained herein as solely his.

PLATE 5

GILBERT, ~~1879~~ 1877b

AGE	GROUP	FORMATION	MEMBER & THICKNESS
CRETACEOUS		MA-SUK' SS.	500'
		MA-SUK' SH.	500'
		BLUE GATE SS.	500'
		BLUE GATE SH.	1,000'
		TU-NUNK' SS.	100'
		TU-NUNK' SH.	400
	HENRY'S FORK GP.		10'
			190'
			300'
JURA-TRIAS	FLAMING GORGE GROUP		1,200'
	GRAY CLIFF GP.		500'
	VERMILLION CLIFF GP.		500'

PR 78-79 GILLULY, 1929

SER.	GROUP	FM.	MEMB. & THKN.
(QUAT.)		ALLUVIUM, ETC.	
UPPER CRETACEOUS		MANCOS SHALE	4,000 ±
		DAKOTA (?) SS.	0-55'
LOW. CRET. (?)		MORRISON FM.	415-847' (TOTAL) SALT WASH SS.
UP. JUR.	SAN RAFAEL GP.	SUMMERVILLE FM.	125-331'
		CURTIS FM.	76-252'
		ENTRADA SS.	266-844'
		CARMEL FM.	170-650'
JUR(?)	GLEN CANYON GROUP	NAVAJO SS.	440-540'
		TODILTO(?) FM	44-240'
		WINGATE SS.	360-400'

GREGORY & MOORE, 1931

AGE	GROUP	FM.	MEMB. & THKN.
CRETACEOUS		MESAVERDE FM.	MASUK SS. 297'
		MANCOS SHALE	700'
			BLUEGATE SS. 230'
			1,200'
			TUNUNK SS. 50-75'
			975'
		DAKOTA (?) SS.	0-15'
CRET. (?)		MORRISON FM.	563'
JUR.	SAN RAFAEL GP.	SUMMERVILLE FM. ?	90'
		ENTRADA SS.	1,070'
		CARMEL FM.	450 ±
JUR. (?)	GLEN CANYON GROUP	NAVAJO SS.	1,350'
		TODILTO(?) FM	175'
		WINGATE SS.	300'

HUNT, 1946 & 1953

SER.	GR.	FM.	MEMB. & THKN.
(QUAT.)		ALLUVIUM, ETC.	
UPPER CRETACEOUS		MESAVERDE FM.	400'
		MANCOS SHALE	MASUK 600-800'
			EMERY SS. 198-256'
			BLUE GATE SH. 1,500
			FERRON SS. 150-300'
			TUNUNK SH. 525-650'
		DAKOTA SS.	0-50'
UPPER JURASSIC		MORRISON FM.	500-600'
	SAN RAFAEL GP.	SUMMERVILLE FM.	40-250'
		CURTIS FM.	0-175'
		ENTRADA SS.	300-700'
		CARMEL FM.	100-626'
JUR. (?)	GLEN CANYON GROUP	NAVAJO SS.	515-815'
		KAYENTA FM.	240-320'
		WINGATE SS.	270-380'

THIS PAPER

SER.	GR.	FM.	MEMB. & THKN.
PLEIST. & REC.		ALLUVIUM, ETC.	0-60'
UPPER CRETACEOUS		MANCOS SHALE	MASUK SH. 100+'
			EMERY SS. 192-206'
			BLUE GATE SH. 1577-1760'
			FERRON SS. 186-460'
			TUNUNK SH. 548-839'
	DAKOTA GROUP	NATURITA FM.	0-29'
LOW. CRET.		CEDAR MOUNTAIN FM.	0-278'
			BUCKHORN CGL. 0-38'
UPPER JURASSIC		MORRISON FM. (RESTR.)	BRUSHY BASIN SH. 135-636'
			SALT WASH SS. 124-389'
	SAN RAFAEL GP.	SUMMERVILLE FM.	196-279'
		CURTIS FM.	64-73'
		ENTRADA SS.	280-300'
		CARMEL FM.	392-403'
JUR.	GLEN CANYON GROUP	NAVAJO SS.	?
		KAYENTA FM.	?
UP. TRIAS.		WINGATE SS.	?

TABLE I. REVISIONS IN STRATIGRAPHIC TERMINOLOGY FOR THE CAINEVILLE AREA.

GWK

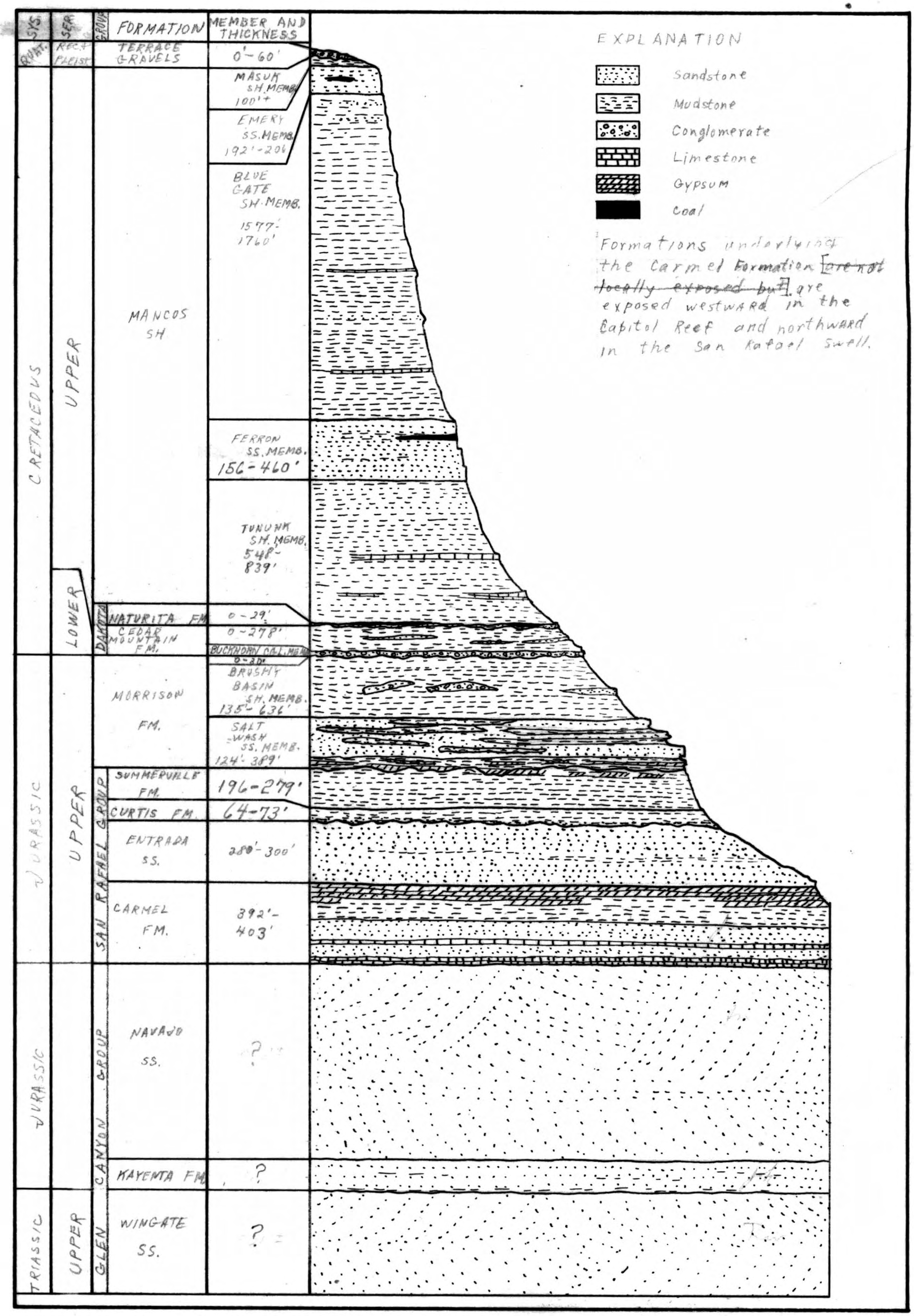


Figure 2. Generalized stratigraphic column, Caineville area, Emery, Wayne and Garfield Counties, Utah

II General Geology

A. Sedimentary rocks

The oldest rocks exposed in the area are of Late Jurassic age but

Mesozoic deposits

Progressively older Jurassic and Triassic ~~surficial~~ rocks occur to the west ~~westward~~ because of the eastward ~~dipping~~ dip off the monoclinal Waterpocket Fold~~, where rocks of Late Triassic and Jurassic age XXXXXXXX crop out.~~ These were not studied because they occurred outside of the area under consideration.

Jurassic system Upper Jurassic Series

For reason for capitalizations, see footnote, title page. R.W.R.

San Rafael group

Carmel formation

The oldest rocks exposed within the area are those of the San Rafael group, of Late Jurassic age. The Carmel formation, the basal unit of the group, was named by Gilluly and Reeside (1926, USGS Press Bull. 6064, Mar 30, 1926) ~~Gregory and Moore (1931, p. 73)~~ from exposures at Mount Carmel, ~~south~~western Kane County, Utah. Locally, because of its soft, unresistant nature, it occurs as strike valleys west, north and east of the Henry Mountains structural basin. This formation, examined along the east flank of the Waterpocket Fold both north and south of the hamlet of Notom, varies considerably in lithology. The basal portion, unconformably overlying the Navajo sandstone of the Glen Canyon group, may be easily examined near the mouth of the Capitol Reef gorge. Thick portions of evenly bedded, light gray, somewhat sandy limestone ~~beds~~ and red sandstone beds, indicative of a marine facies, occur at the base. These are overlain by thick, white to pink and green sandy and shaly beds which, upward, are interbedded with thick white to pink gypsum beds, all representative of a marginal marine [redacted] facies. These upper beds are often highly contorted, as may be noted along the Notom-Capitol Reef road. Clear selenite commonly fills Joints in the upper part of the formation ~~are commonly filled with clear selenite which,~~ in this arid climate, these are more resistant than the host rock, and ~~thereby conspicuously~~ stand~~ing~~ out as straight ridges on the surface. Large, well developed gypsum crystals, often over a foot in length and several inches in diameter, occur in structurally controlled cavities in South Desert, north of Notom.

Only two sections, varying from 392 to 403 feet in thickness, were measured. Ohio Oil Company's No. 1 unit in the Caineville anticline reportedly encountered over 306 feet of Carmel. However, greater variations in thickness are known from ~~in~~ adjacent areas (Hunt, 1953b, p. 68)

Although fossil assemblages are well known from rocks representing the marine facies, none were collected in this study. Those collected by Gilluly (1929, p. 100) in the San Rafael Swell indicate Late Jurassic age.

Entrada sandstone

The Entrada sandstone was named by Gilluly and Reeside (1926, [illegible] Bull 6064, mar. 30, 1926) ~~(1929, p. 76)~~ ~~from~~ for strong development of fm. on ~~typical exposures at~~ Entrada Point in the northern part of the San Rafael Swell, Emery Co., Utah. In this area it crops out as steep cliffs to the west, north and east of the Henry Mountains structural basin as well as in a fenster within the Caineville anticline (See geologic map, plate 1). It conformably overlies the Carmel formation, from which it is often difficult to differentiate. The major portion of the unit is ~~representing~~ an easily eroded red earthy facies, ~~is~~ composed of thick red, siltstone and shale beds interbedded with massive-bedded red sandstones, this unit characteristically forms badland topography. These beds are ~~characteristically~~ very continuous over long distances. This unit is overlain abruptly, but apparently conformably, by light gray to buff, fine to medium-grained resistant ledge-forming sandstone beds which are generally highly cross laminated, representing a sandy phase of deposition. In the extreme southwestern portion of the breached Caineville anticline, the interval between these two facies is occupied by a thin lens of dark red mudstone differing markedly from both ~~these~~ lithologic types.

Several measured sections indicate thicknesses of between 392 and 403 feet for the formation in the area near Notom.

The only fossils recognized in the Entrada formation were small malachite coated casts, up to six inches long, of plant twigs and branches ~~material which were coated with malachite~~. These were derived from the north and south ends of the Caineville anticline from light gray cross-laminated sandstone beds representative of the sandy facies. Although none of the woody material was preserved sufficiantly to be submitted for identification, the fossils collaborate a subaerial paleoenvironment during deposition of the Entrada sandstone.

Figure 3 .-Exposure at Cathedral Valley, northwest of the Caineville area, illustrates thick pink gypsum beds,often contorted,forming the upper beds of the Carmel formation (in foreground) overlain by the Entrada sandstone composed primarily of a red earthy facies conformably overlain by buff-colored sandy facies.

Curtis formation

(1926, Utah Press Bull. 6064, Mar. 30, 1926)

The Curtis formation was named by Gilluly and Reeside (1929, p. 78) from its type locality on Curtis Point on the northeast side of the San Rafael Swell Emery Co., Utah. It has the same outcrop pattern as that of the Entrada sandstone which it conformably overlies. ~~where~~ it typically forms strike valleys. ~~It conformably overlies the Entrada sandstone~~. Lithologically, it is composed of thin, evenly bedded shale and interbedded, fine grained, more resistant sandstone beds, all ranging in color from gray to green ~~caused by~~ due largely to the presence of included glauconite. ~~and~~ These beds grad~~ing~~e upward into maroon beds of the Summerville formation the contact being drawn arbitrarily at the color change. Certain beds in the upper half of the formation contain concentrations of red to pink siliceous geodes and concretions, ~~often~~ commonly saucer shaped which, because of their greater resistance to weathering, ~~often~~ are strewn over the lower slopes of the unit. Beds of conglomerate near the base of the formation, recorded both by Gilluly and Reeside (1929, p. 105) and Hunt (1953, p. 72) were not recognized on the east flank of the Caineville anticline but may occur in other parts of the area not critically examined.

A section measured on the Caineville anticline showed a thickness of 61 feet and, at Notom, 74 feet. However, greater variations in thickness are ~~XXXXXXXXXX~~ assumed.

No fossils were ~~encountered~~ found in this formation although Gilluly and Reeside (1929, p. 108) and Hunt (1953, p. 73) report the presence of Late Jurassic marine invertebrates. These, together with the presence of glauconite, indicate deposition in a marine environment ~~XX a marine paleoecology for the formation.~~

OK
RWH

Summerville formation

~~The summerville~~ The uppermost unit of the San Rafael group, (1926, USGS Prof. Bull 6064, Mar. 30, 1926)

The summerville formation, was named by Gilluly and Reeside, (1928, pp. 79-80) from exposures at Summerville Point at the north end of the San Rafael Swell, Emery Co., Utah. forms gentle slopes where not capped by more resistant beds of the Morrison formation. It

In this area, it [redacted]conformably overlies the Curtis formation. The formation consists of reddish brown evenly bedded mudstones, XXXXXXXXXX siltstones, sandstones and gypsum beds. Mudstones generally range in thickness from a half to five feet in thickness, and range in color from reddish brown to gray-green. They are ~~is~~ evenly bedded, slightly to highly calcareous and Commonly ~~often~~ contain beds of pink to orange gypsum and varicolored siltstone ~~beds~~. Siltstone beds are generally light green to light brown ~~in color~~. They are thinly bedded, highly calcareous, ~~and~~ and Commonly ~~often~~ contain ~~in~~ light brown mudstone stringers ~~and~~, varicolored chert and other silicate of grit ~~and~~ to pebble size. Nodular orange gypsum commonly occurs interbedded in these units. Sandstone beds are commonly colored various hues of brown, white and greenish white. Cross laminations are commonly developed in these beds. Gypsum beds are common, ranging in thicknes from isolated nodules less than one inch thick to beds several feet in thick-ness. All gypsum beds vary in contained impurities which color them shades of pink, orange and even dull brown. Gypsum veins, usually ~~often~~ of clear selenite, fill fractures, particularly in the upper part of the unit. OK RKZ

~~XXXXXXXX~~ An almost complete absence of disturbance of the beds prior to the ensuing Morrison deposition is evidenced by the ~~high degree of~~ apparent perfect concordance of bedding along the disconformity ~~unconformity~~ between these two formations in this area. OK RKZ

No fossils were found ~~encountered~~ during field investigation.

Morrison formation (restricted)

The term McElmo formation, first used by Cross (1899) for beds exposed in McElmo Creek, Montezuma County, southwestern Colorado, was replaced by the term Morrison formation by Eldridge (1896), named from ~~from~~ exposures near the town of Morrison, Jefferson County, central Colorado. Later, Gilluly and Reeside (1928, p. 118) abandoned the term McElmo replacing it by the term Morrison formation for use in this area. The term Morrison is ~~herein~~ retained but vertically restricted ~~downward~~ to exclude rocks herein recognized as ~~now termed~~ the Cedar Mountain formation, of Early and Late Cretaceous age, which unconformably overlies the Morrison in this area (see table 1).

Salt Wash sandstone member

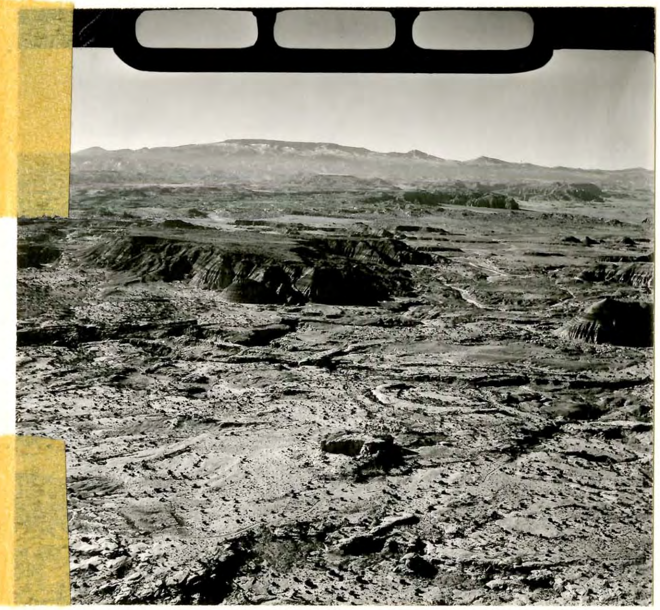
The term Salt Wash sandstone member, the lower member of the Morrison formation, was proposed by Lupton (1914, p. 127) for coarse grained sandstones in the basal portion of his McElmo formation at Salt Wash, Grand County, Utah. Later, Gilluly and Reeside (1928, p. 118) reallocated the Salt Wash member into the Morrison formation by the action described above.

Locally the Salt Wash sandstone member unconformably overlies the Summerville formation. This erosion surface is generally quite smooth and concordant with beds of the Summerville but, in places, has been scoured by wide but shallow channels as much as 50 feet in depth (Hunt, 1953, p. 73). The lowest few feet ~~portion~~ of the Salt Wash commonly resembles the immediately underlying Summerville beds both in color and lithology, often making recognition of the contact difficult. Because of this transition zone, one must guard himself, in this area ~~at least locally~~, against selecting the contact too high in the section resulting in abnormally thin sections of the Salt Wash Member.

Figure 4.-Northward view of Wood Bench, Wayne County. Paleostream channels lie exposed on the surface.

Figure 5.-Westward view toward lava-capped Fish Lake Mountain at skyline. Crescent-shaped paleostream channels within the Salt Wash member, seen in foreground, are overlain by the variegated Brushy Basin member of the Morrison formation (Upper Jurassic) and disconformably overlain by the Buckhorn conglomerate member of the Cedar Mountain formation (Lower Cretaceous) capping the mesa. Sections 4, 5, 7 and 9, T. 28 S., R. 8 E., Wayne County.

6



7

#6

Paleostream channels in Jmsw on Wood Bench

#19

Westward view toward lava-capped Fish Lake Mtn at skyline. crescent-shaped Paleostream channels are seen in Jmsw in foreground, overlain by variegated Jmbb, disconf. capped by Kcmb. + ~~truncated~~ ~~capped~~ truncated by Qal. in secs 4, 5, 7+9, T 28S, R8E

The Salt Wash consists of heterogeneous lenses and discontinuous beds of gypsum, sandstone, siltstone, and minor amounts of conglomerate, mudstone, shale and limestone, with intermixtures of these lithologic types being common. Colors range from red, purple, pink, brown and green through various hues of white, gray and black. In cross section, as seen along canyon cliffs, massive beds of sandstones appear to lens in and out, often with sudden abruptness, but where these beds occur on weathered dip slopes, they commonly are recognized as gently meandering or crescent-shaped paleo-channel fillings, some of which may be traced for more than a mile (see figs. 6 and 7). These meandering channels were apparently flanked by flood plain terraces or flats composed principally of finer grained siltsXXXXX and mudsXXXXX. Where exposed to present day forces of erosion, the less resistant flood plain deposits are relatively rapidly eroded, leaving the more resistant channel fillings conspicuously exposed, often in the form of shoestring sands (see figs. 6 through 9). Apparently channels were not restricted to their courses but commonly shifted, thereby reworking adjacent flood plain deposits and causing the development of an imbricating network of channel deposits, reminescent of sluggish braided streams on a XXXXXXXX terraine of low relief.

Variations in thickness are shown by the fence diagram, figure 4, as well as the isopachous map, figure 5.

Two collections of fossils were submitted to the Paleontology and Stratigraphy Branch of the U. S. Geological Survey. Richard Rezak (Rezak, written comminication) identified poorly preserved phycolites, precipitated of lime which were entrapped in the mucilaginous sheaths of fresh water algae, thereby causing growth of these "water biscuits"

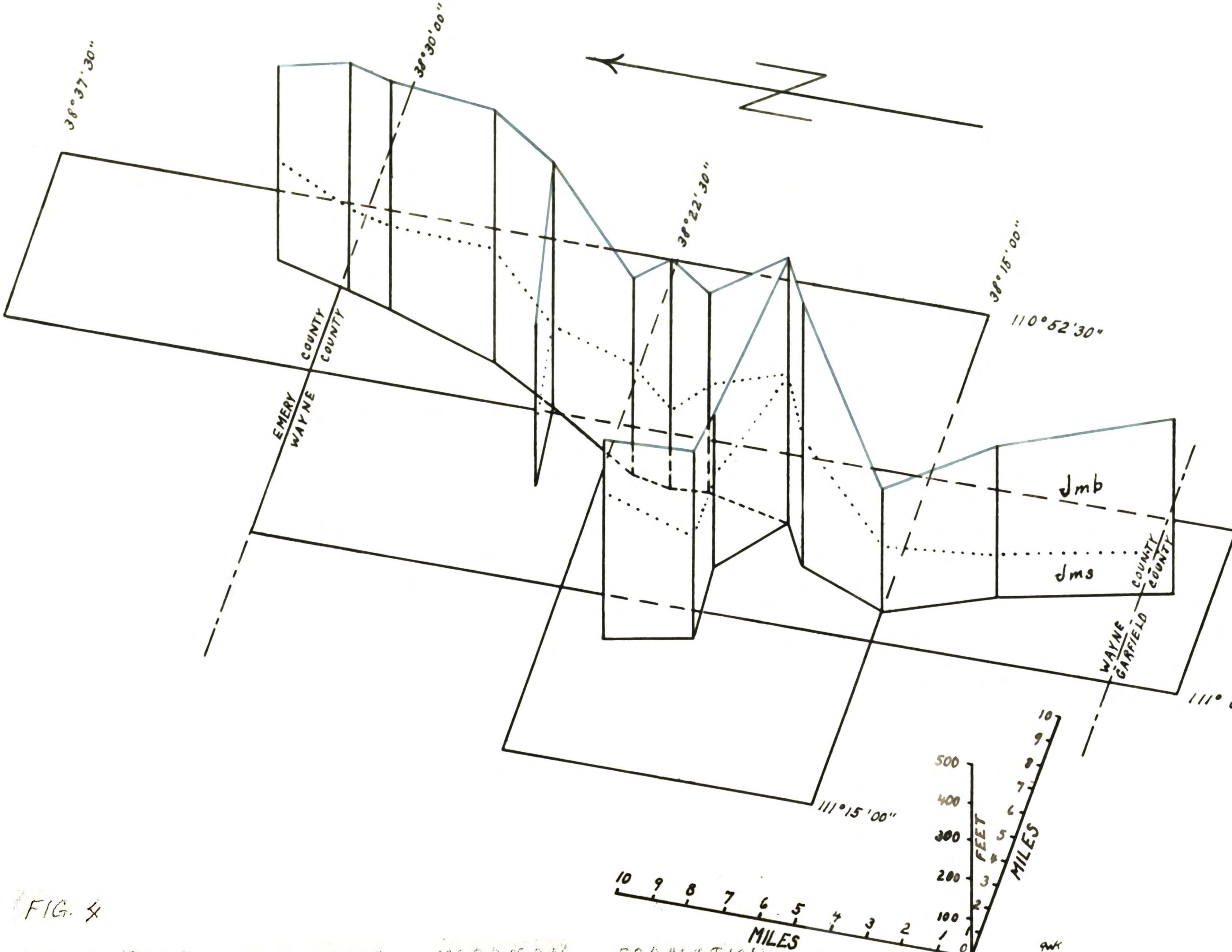


FIG. 4

THICKNESSES OF THE MORRISON FORMATION, CAINEVILLE AREA, UTAH

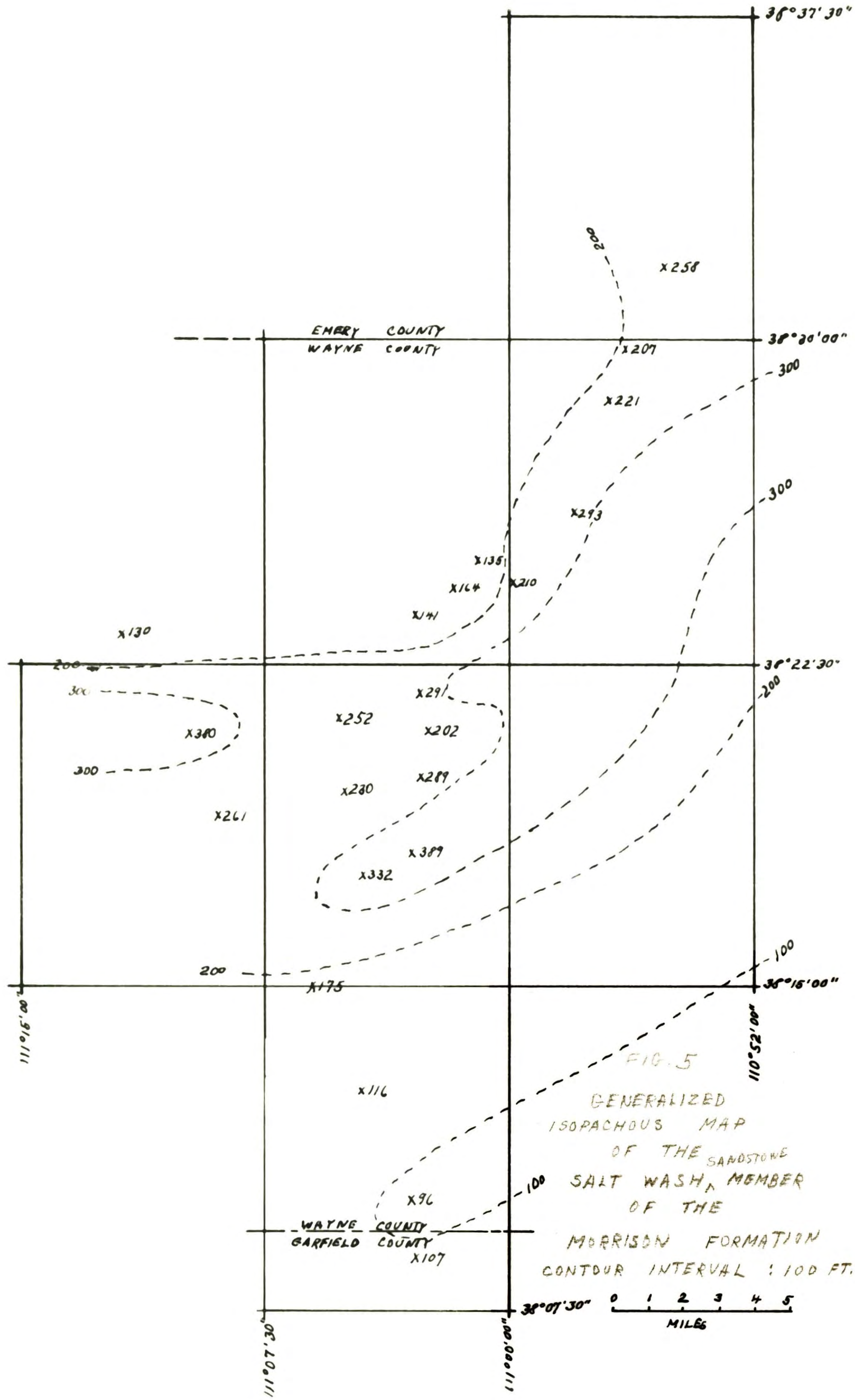


FIG. 5

GENERALIZED ISOPACHOUS MAP OF THE SALT WASH SANDSTONE MEMBER OF THE MORRISON FORMATION

CONTOUR INTERVAL : 100 FT.

by accretion. These undiagnostic fossils were derived from ~~XX~~ a limestone bed of fresh water origin 36 feet above the base of the member in SW$\frac{1}{4}$, sec. 27, T. 28 S., R. 8 E., Salt Lake Principal Meridian, Wayne County.

The late Mr. John B. Reeside Jr. (written communication) identified the fresh water pelecypod Unio aff. U. felchii White collected from a cross-laminated conglomerate 293 feet above the base of the member in the NE$\frac{1}{4}$, SE$\frac{1}{4}$, NW$\frac{1}{4}$, sec. 4, T. 27 S., R. 9 E., Wayne County. Other fossils encountered but not submitted for identification include abundant plant debris and reptilian bone fragments. The fossils collaborate a subaerial and fluviatile paleoenvironment during deposition of this member.

Brushy Basin shale member (restricted)

The Brushy Basin shale member, named by Gregory (1938, p. 59) from exposures in Brushy Basin, San Juan County, southeastern Utah, is herein vertically restricted in the Caineville area to exclude rocks herein recognized as the Cedar Mountain formation, of Early and Late Cretaceous age, which unconformably overlies the member. This member, the upper of the two members of the Morrison formation, represents a continuation of Salt Wash deposition but differs from the Salt Wash in that thick mudstone and siltstone sections predominate over coarser clastics. True sandstones are almost entirely absent. Colors are typically variegated hues of purple, red, pink and brown to light gray and green although others were encountered. Color bands commonly coincide with certain lithologic entities but are not necessarilly restricted to ~~XXXXXX~~ definite beds of a lithologic unit, but often cross them at low angles. The upper part of the member is characteristically bleached to pastel shades of the variegated

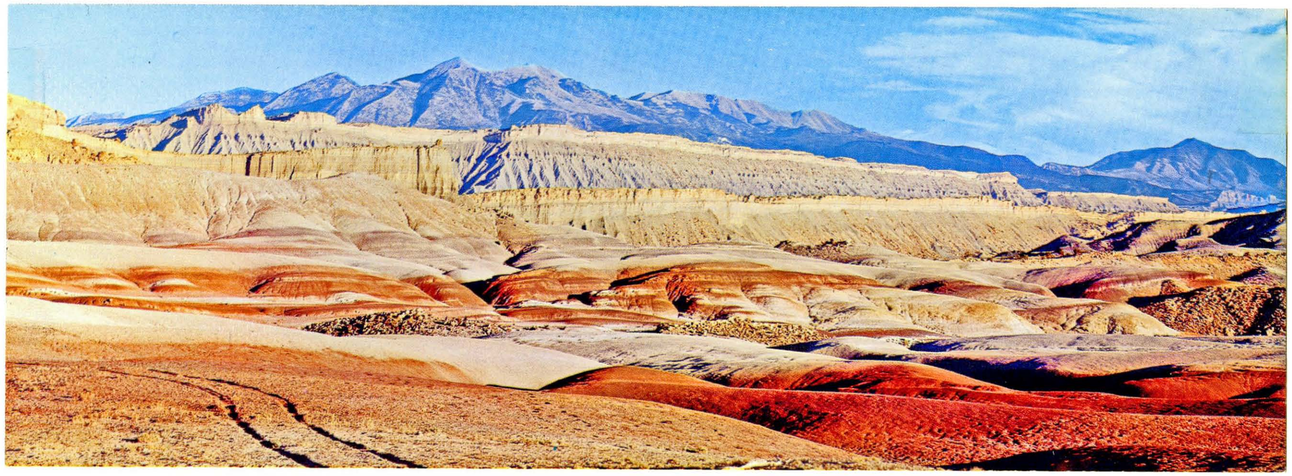
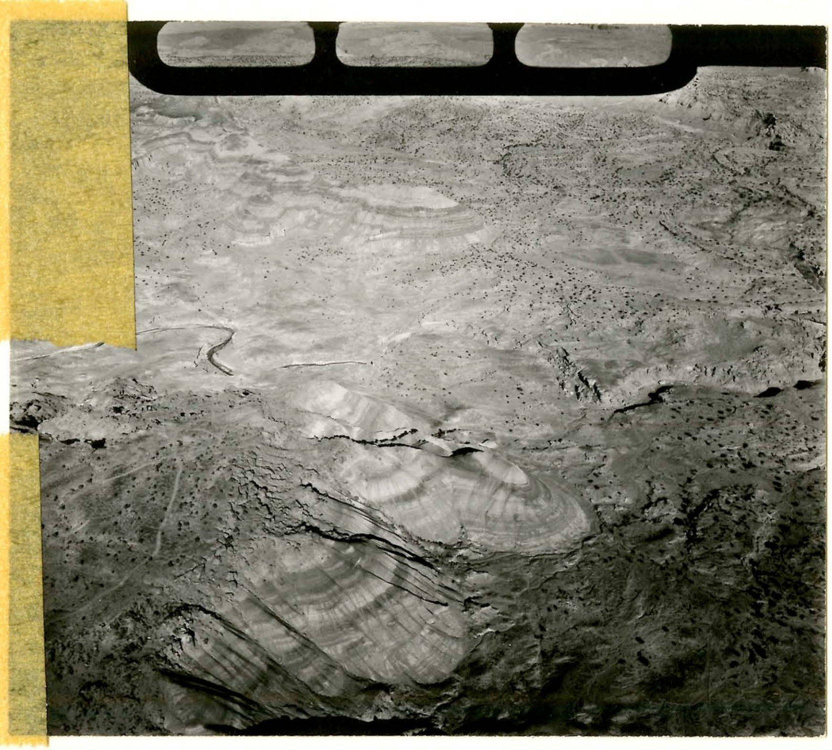


Figure .-View southeast of Notom of southern Caineville Reef Monocline illustrating topography due to weathering characteristics of variegated Brushy Basin shale member of Morrison formation (foreground), Cedar Mountain formation (left center) and cliff-slope forming Mancos shale. Henry Mountains are in background.

Figure ~~6~~ 8.-Northeastward view across Salvation Creek synclinal axis. Caineville Wash, center right, is entrenched in ~~the~~ Salt Wash member while outliers of ~~the~~ Brushy Basin member, lower and upper center, illustrate typical variegated bedding. Mesa in lower left is capped by ~~the~~ Buckhorn conglomerate member of ~~the~~ Cedar Mountain formation. Note scour and fill within ~~the~~ Brushy Basin member ~~of the Morrison formation~~ in ~~the~~ knob in right center. Section 4 (unsurveyed), T. 28 S., R. 8 E., Wayne County.

Figure ~~7~~ 9.-Southeastward view of ~~the~~ Naturita formation ~~, lower right, capping the Morrison formation~~ east of Factory Bench. Note ~~the~~ angular unconformity at ~~the~~ base of ~~the~~ Naturita ~~formation~~ where it overlies ~~the~~ Morrison formation. ~~The Naturita formation~~, ~~which here, exhibits prominent jointing.~~
Note prominent jointing in ~~Naturita~~ sandstone of Naturita Formation.



8

9

#3

Northeastward view across Salvation Creek synclinal axis in area including sec. 4 (unsurveyed), T28S, R8E, Wayne Co.

Caineville Wash, center right, is entrenched in Jmsw. Jmbb outliers (lower and upper center) depict typical varigated bedding. Thick Buckhorn cgl. memb. of Lower. K. Kcm. unconf. overlies Jmbb., forming mesa with 350' relief.

Note angular nonconformity produced by scour and fill within Jmbb knob in right center

5440
5080
360

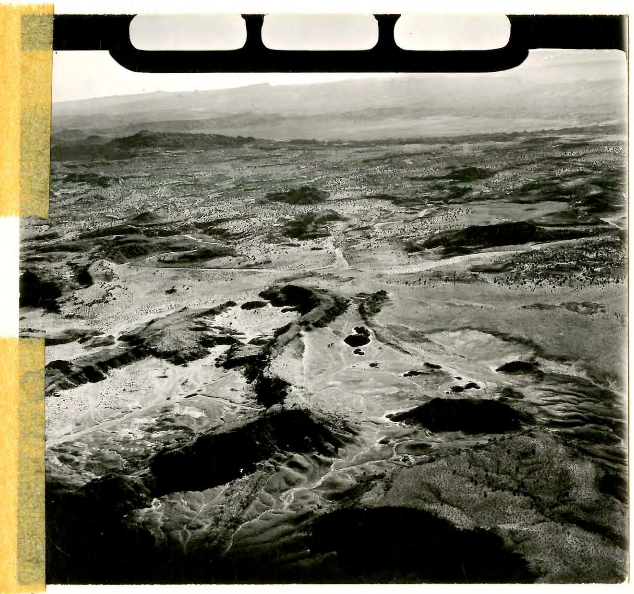
#23

Southeastward view of Kd capped Jmbb east of Factory Bench and north of the Fremont River. Note angular unconf. at base of Kd, in foreground and prominent jointing displayed by Kd.

Figure ~~8~~ 10.-Westward view toward Waterpocket Fold (at horizon) from Caineville Wash (in foreground) viewed across ~~the~~ breached Caineville anticline. Note curved Salt Wash paleochannel. Rocks in foreground are eastward dipping Morrison and Cedar Mountain formations. Section 28, T. 28 S., R. 8 E., Wayne County.

Figure 9.-Southwestward view from Hartnet Draw toward South Desert (broad flat valley below skyline). Paleochannels in foreground cap ~~the~~ Brushy Basin member ~~while~~ but, in background, ~~become a part of~~ are within the Salt Wash member of ~~the~~ Morrison formation. 38° 24' north latitude, 111° 11' 30" west longitude, Wayne County.

10



11

24

#13

Westward view toward Waterpocket fold
(at horizon) from Caineville Wash in
foreground, viewed across axis of faulted Caineville
anticline. Note cupped Salt Wash paleochannel

(Sec. 28, T 28S, R. 8E
Rocks in foreground are eastward dipping Jmbb + Kcm.

#4

Southwestward view from Hartnet draw
across axis of Saleratus creek syncline
toward South desert (broad flat valley in
distance) and Waterpocket Fold at
skyline. 38°24' lat. 111° 11'30" long.
Note paleochannels composed of
conglomeratic sandstone which cap
underlying mudstone of Brushy Basin(?) in
foreground as well as numerous Salt Wash
channels in flat near rim.

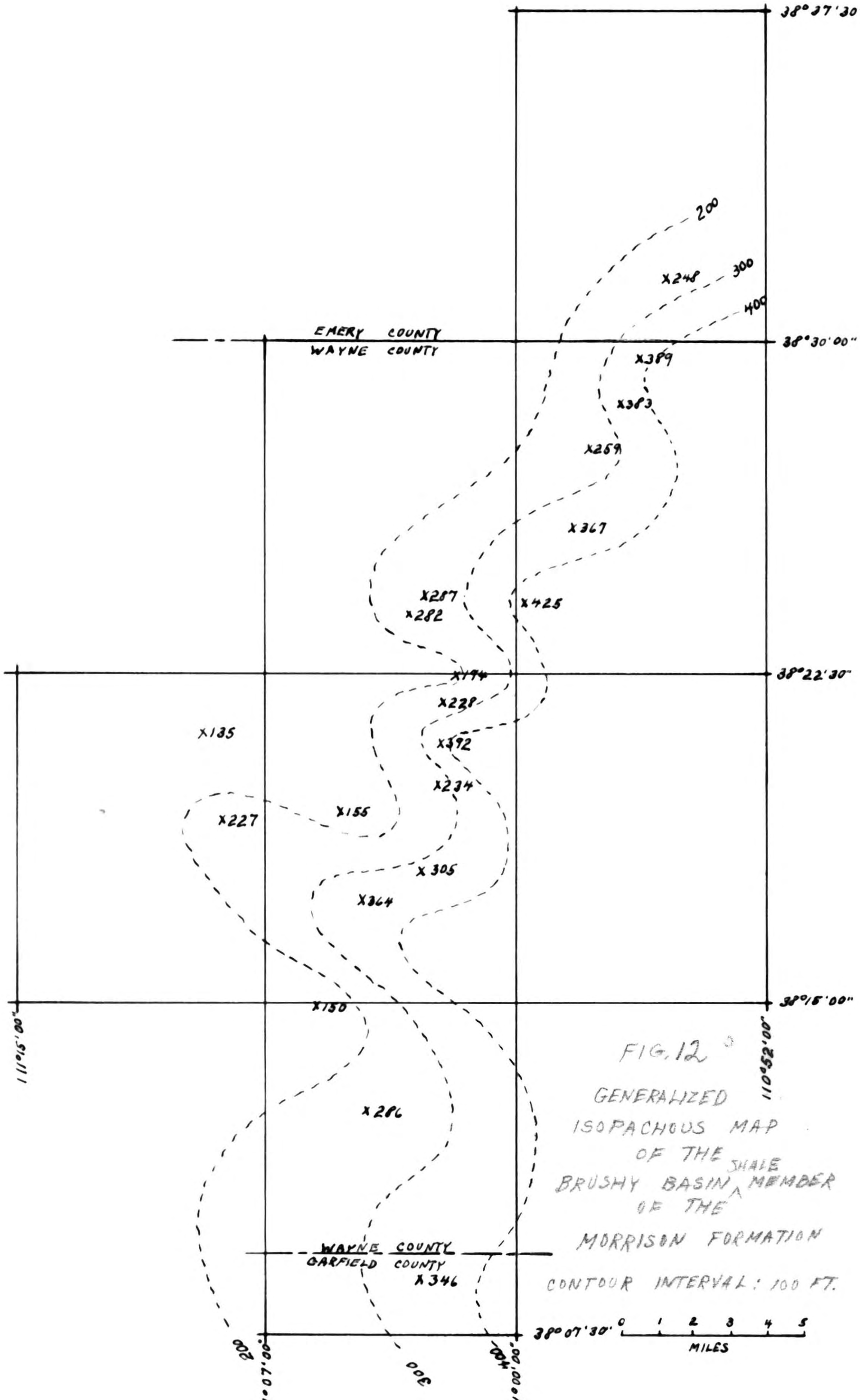


FIG. 12

GENERALIZED ISOPACHOUS MAP OF THE BRUSHY BASIN SHALE MEMBER OF THE MORRISON FORMATION

CONTOUR INTERVAL: 100 FT.

PWK

colors noted in the lower portions of the member (see fig. 16). The thickness of bleaching below the upper contact appears to be genetically related to the presence of carbonaceous beds within the overlying Naturita formation where the intervening Cedar Mountain formation is missing. Studies by Young (oral communication) have indicated that thicker sections of low grade coals within the Naturita formation result in thicker zones of bleaching in mudstones of the immediately underlying unit, regardless of whether it be the Morrison or the Cedar Mountain formation.

Like the Salt Wash, the Brushy Basin shale member had a fluviatile origin and contains well developed paleostream channels as seen in figure 11. However, because of the smaller amount of course grained clastics within the member, fewer channels are recognized than in the underlying member. The area east of Factory Bench includes many well developed channels in this member.

Variations in thickness of the member are shown by fence diagram, figure 4, as well as the isopachous map, figure 12.

The only fossils submitted for identification was a silicified cephalopod, obviously of marine origin, but reworked and transported into the area. This ammonoid was collected from a massive conglomerate bed 404 feet above the base of the formation in the NE$\frac{1}{4}$, NE$\frac{1}{4}$, SW$\frac{1}{4}$, sec. 1, T. 28 S., R. 3 E., Wayne county. Mr. Mackenzie Gordon, of the U. S. geological Survey (written communication) identified the ammonoid as a glaphyritid. He added that *Glaphyrites drakei*, *G. multiseptum* and *G. modestus* are the closest affinities to this species, that *G. modestus* is known from the Late Pennsylvanian of Texas while *G. drakei* and *G. multiseptum* are known from similar Late Pennsylvanian strata near Socorro, New Mexico. Concerning a more probable source of the fossil, and therefore a possible source area for at least part of the sediments comprising the member, Mr. Gordon adds: "I have talked with C. A. Repenning of the Fuels Branch [U. S. Geological Survey] who has studied the Mesozoic rocks of the western part of the Colorado Plateau province. He suggests rocks to the west or southwest as a likely source of these conglomerates in the [Brushy Basin member of the] Morrison formation. The western edge of Morrison depositional area describes a north-northeastward sigmoidal curve through southeastern Utah and northwestern Utah. As the Ely formation (unrestricted) [Pennsylvanian] ~~eastern Nevada~~ in the Confusion Range of western Utah and at its type locality [eastern Nevada] includes a hiatus representing part of Middle Pennsylvanian and probably all of Upper Pennsylvanian time, it would seem more likely that the ammonoid might have been derived from the Bird Spring formation [Pennsylvanian] of southern Nevada in which Upper Pennsylvanian equivalents are known. Although no ammonoids have been described from this formation, we have a Lower Pennsylvanian species of *Glaphyrites* collected recently near the base of the formation by C. R. Longwell in the Spring mountains near Las Vegas."

This source area agrees with the contention of Eardley (1951, plates 11 through 13) who indicates the existance of a Paleozoic highland in southcentral and southeastern Nevada to southeastern California with subsequent deposition to the west into the Utah trough during Triassic and all of Jurassic time. Furthermore, Eardley (plate 14) indicates the presence of surficial Pennsylvanian rocks in this positive area near the close of Jurassic time.

Cretaceous System

Lower and Upper Cretaceous series

Dakota group

The term "Dakota" has long been used in this area (see table 1) for rocks overlying the Morrison as used in older reports and underlying the Mancos shale. Young (in preparation) has raised the term to group status for the area within the Colorado Plateau and includes the largely noncarbonaceous Cedar Mountain formation as the basal unit and the carbonaceous Naturita formation of Young (in preparation) as the upper unit. This action was deemed advisable XXXXXXX by him because Cedar Mountain deposits pass laterally into those of the Naturita and thus must represent facies of a larger unit, ~~B., please complete~~ the Dakota group. This report follows the usage as proposed by Young.

Cedar Mountain formation

The Cedar Mountain formation, formerly considered the upper part of the XXXXXXXX unrestricted Morrison formation (see table 1) was named by Stokes (1944, pp. 966-967) from its type locality at Cedar Mountain, Emery County, Utah. The Caineville area includes the southwesternmost known limits of the formation. It crops out only along the western and northern parts of the Henry Mountains structural basin, and is not represented in the eastern part. Because of the XXXX great amount of included mudstones, it typically forms badlands resembling the underlying Brushy Basin shale member of the Morrison from which casual inspection may make differentiation difficult.

Buckhorn conglomerate member

The Buckhorn Conglomerate Member was named by Stokes, 1944, p. 958, 965-966 for exposures near Cedar Mountain, Emery County, Utah. This member consists of ~~In many places,~~ discontinuous lenses of a well to medium well-sorted, well-indurated, calcareous, cross-laminated conglomerate consisting of chert pebbles of multi-colored silicates and even of clear quartz ~~are recognized~~ at the base of the Cedar Mountain formation. These pebbles are well rounded and up to 3/4 inches in diameter. ~~are coated with a dark gray to black mineral resembling~~

~~desert varnish.~~

The thickness of this member varies from 0 to a maximum of 38.2 feet at the Muddy River. Generally, however, the member rarely exceeds 17 feet in thickhess within the area.

This member is corrrelated with the persistant chert-pebble conglomerate referred to by Gilluly(1929, p. 111) as being within and about 200 feet below the top of his Morrison formation (unrestricted). He, however, did not recognize the existence of this unit south of the Muddy River.

Chert pabbles containing marine bryozoa, crinoidal fragments and spicules, were collected from the member in the NE¼, SW ¼, sec. 6, T. 29S., R. 8 E., S. L. M., Wayne County. Of these, Miss Helen Duncan of the U. S. Geological Survey (~~Duncan~~, written communication) was able to recognize fistuliporoid, stenoporoid, rhomboporoid, fenestellid and acanthocladid bryozoans. Of the assemblege, she recognized forms that are not known in pre-Carboniferous rocks. Miss Duncan adds; "A Carboniferous or Permian source is indicated, but I am unable to narrow down the possibilities very much. I regard it as unlikely that they are earlier than Upper Mississippian. Examples of the genera I have come to rely on as indicative of post-Mississippian age were not found, but the absence of these types does not necessarily mean that the source is pre-Pennsylvanian. Diagnostic Kaibab genera are not present, but a possible Permian age cannot be eliminated."

Late Paleozoic fossil assemblages are also known to have been identified by Stokes (1944,) from more northerly exposures of this member.

Upper member of Cedar Mountain formation [~~(undifferentiated)~~]

The Buckhorn conglomerate member is conformably overlain by an upper, unnamed member, consisting ~~XX~~ almost entirely of thick mudstone and siltstone units with minor amounts of sandstone and conglomerate beds, containing pebbles up to 2 inches in diameter. Calcareous gray to buff mamillary nodules often several inches in diameter and containing quartz veins are common in certain beds. These, the absence of carbonaceous material, the more pastel hues, and the presence of large, well-rounded silicate pebbles and cobbles, often referred to as "gastroliths", help to distinguish this unit from the often immediately underlying Brushy Basin shale member of the Morrison formation, which it often resembles. Colors are commonly variegated, ranging from white, light brown, buff, gray, gray green, pale to olive green to brown, chocolate brown, red, lavender and purple. Commonly the upper part, particularly where overlain by low-grade coal deposits within the Naturita formation, displays bleaching of colors to pastel shades with deeper colors of the mudstone effected most greatly. Bleaching commonly effects certain beds more than others, but may cross bedding with seemingly complete disregard toward any lithologic control.

The Cedar Mountain ~~formation~~ attains a maximum thickness of over 300 feet near the Caineville anticline but thins eastward to a feather-edge, apparently by local westward tilting, warping, and subsequent beveling by erosion rather than by non-deposition. This is evidenced by the apparent removal of the upper part of the Morrison formation southward of the southernmost limits of the Cedar Mountain formation south of Notom. Regional and local variations in thickness of the Cedar Mountain ~~formation~~ are shown by the fence diagram, figure 14, as well as the isopach maps, figures ~~7~~. 13 and 15.

No fossils were collected ~~encountered~~ from the upper member of the formation but a fluviatile environment similar to that of the Morrison is indicated by bedding characteristics.

Bob; I would like to use this or the latest revised illustration to
accompany this paper if I may. Several points of order; It requires
a title. I believe this to be an <u>isopach</u> rather than a structure
map of the Cedar Mountain fm. (rather than of the entire Dakota group).
Right? Do the blackened dots refer to well logs and the crosses
refer to measured sections? I would like to add this in the legend.
What map was used as a base? Since the prospective reader will, I assume, be
more interested in the Cainerville area and its relationship to nearby
areas in Utah, I would like to ~~superimpose~~ add the location of the
Cainerville area as well as the towns of Price, Green River, Moab,
Monticello or Blanding and Boulder or Torrey. O.K? Any other comments?

This is an isopach map of the <u>Cedar Mtn. fm.</u> As a base I used an index map of the Colo. Plateau. I'll send a copy of it plus one of the latest isopach.

Figure 13. Generalized isopachous map of the Cedar Mountain Formation in Utah, Colorado and New Mexico. After Young, 1960

141

From R. G. Young, "The Dakota group of the Colorado Plateau"

1960 AAPG Vol 44 No. 12

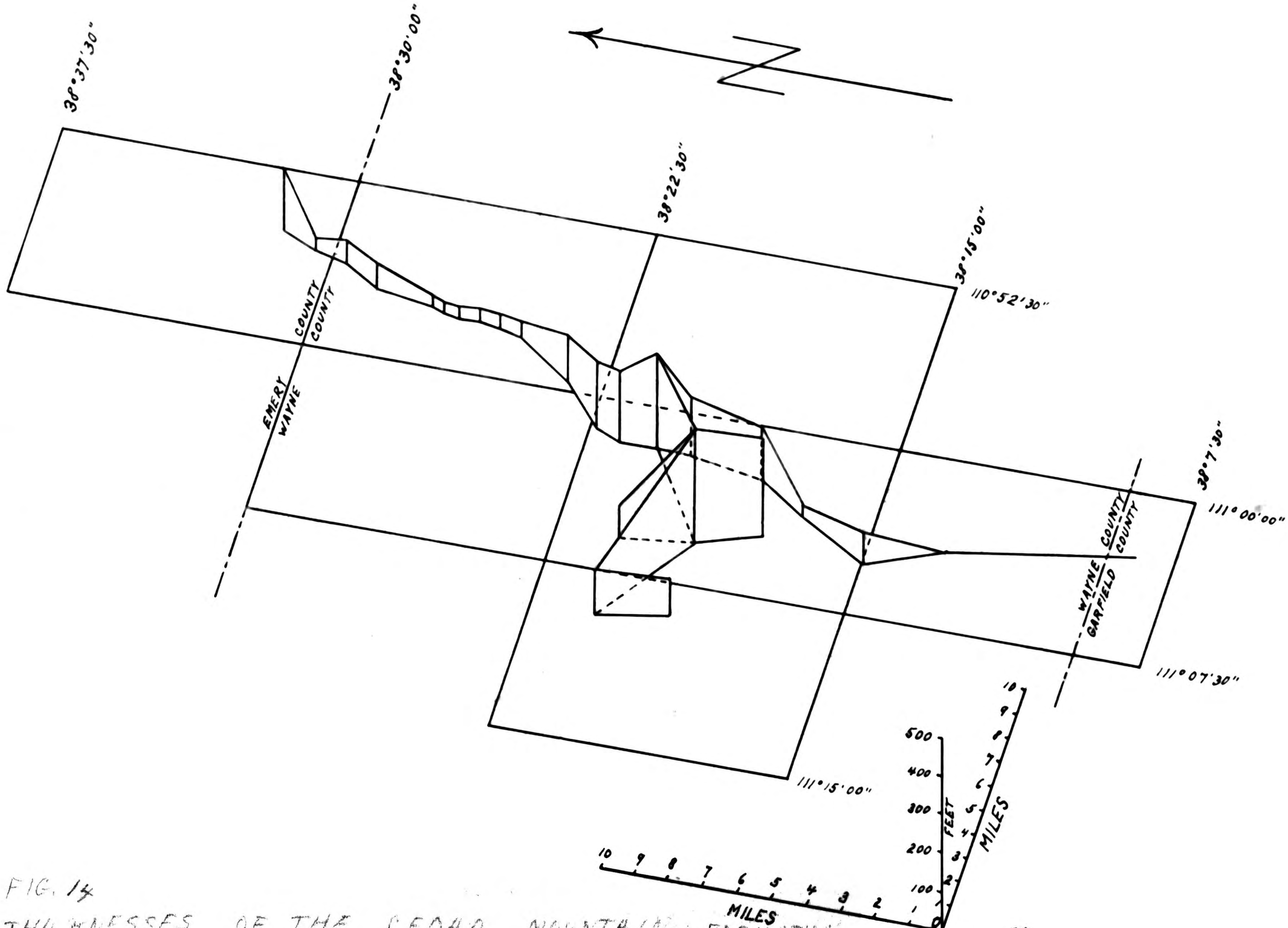


FIG. 14
THICKNESSES OF THE CEDAR MOUNTAIN FORMATION,
CAINEVILLE AREA, UTAH

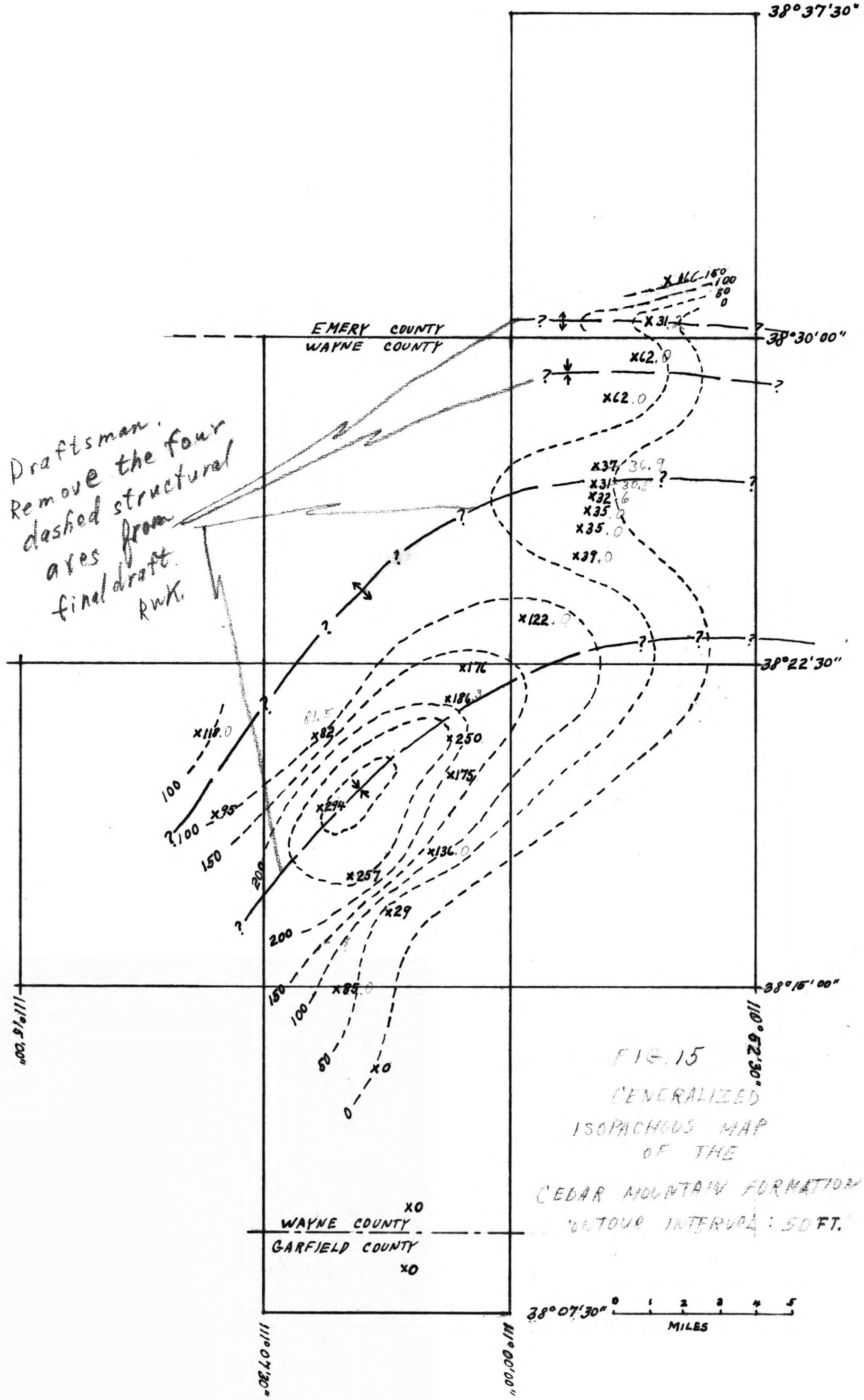


FIG. 15
GENERALIZED ISOPACHOUS MAP OF THE CEDAR MOUNTAIN FORMATION
CONTOUR INTERVAL: 50 FT.

RWK

Upper Cretaceous Series

Naturita formation of Young

The term Naturita formation, named by Young (~~in preparation~~ 1960, p.) from its type locality near Naturita, Montrose County, Colo., is hereby geographically extended to apply to rocks formerly referred to as the Dakota or Dakota (?) sandstone by previous workers in the Caineville area (see table 1).

Because of the greater resistance to erosion as compared to underlying and overlying strata, the formation characteristically forms benches or hogbacks along its area of outcrop. It is exposed around the west, north and east sides of the Henry Mountains structural basin as well as along the flanks of the Saleratus Creek syncline. It unconformably directly overlies the Cedar Mountain formation in the major portion of the area and unconformably overlies the Morrison formation east and south of the pinchout of the Cedar Mountain formation (see fig. 7) where the intervening Cedar Mountain is absent.

The lithology of the formation varies considerably throughout the area, ranging from lens-like beds of pebble conglomerate to mudstone. Beds of conglomerate, generally shades of brown and consisting of subangular to well rounded pebbles generally ½ inch in diameter, but reaching a known maximum of 3 inches, are present. Pebbles are generally of cross-laminated, light gray to white quartzite and commonly coated with a dark gray to black mineral resembling desert varnish. A light gray, silty to sandy somewhat calcareous matrix is generally present. Sandstone beds, often conglomeratic to gritty, are generally light brown, very fine to coarse-grained, poorly to well sorted, thinly th thickly laminated, calcareous, often ripple marked and often noticeably friable. Siltstone beds are generally green to buff, dark gray to brownish black, very fine to coarse grained, slightly carbonaceous to coaly.

Mudstone beds are commonly light gray to black, coaly with papery to shaly laminations. In places, dark brown to black low grade coal beds up to 4 feet thick are well developed as in sec. 1, T. 28 S., R. 8 E., S. L. M., Wayne County.

Certain beds are commonly discolored by the presence of secondary limonite and jarosite. Selenite crystals are also common as fracture fillings.

The formation is not everywhere present in the area. Generally, however, the unit is expressed as a thin veneer several inches to less than 10 feet in thickness, although a maximum recorded thickness of 64 feet was measured by Hunt (1953, fig. 19, p. 78) at Blue Valley in the Saleratus Creek syncline area.

~~XXXXXXXXXXXXX~~ The only fossils submitted for identification were four specimens of silicified wood collected from a single log in a cross-laminated sandstone matrix in SW ¼, SE ¼, sec. 1, T. 28 S., R. 8 E., S. L. M., Wayne County. Because of the poor preservation of histological features, Mr. Richard A. Scott of the U. S. Geological Survey (written communication) was unable to identify the specimens other than that they are of conniferous origin. In most places the upper part of the formation contains fragmentary fossil remains of a fauna composed principally of the mollusks Gryphaea cf. G. newberryi, Inoceramus sp. and Exogyra ~~sp~~ columbella + E. olisiphonensis. None, however, were submitted for identification.

~~XXXXXXXXXX~~ Two types of paleoecology are recognized from the lithology and paleontology. ~~Pediment~~ Flood plain gravels and near-shore fluviatile and lagoonal deposits are represented by conglomerates and finer-grained clastics often supporting a coal-forming thick vegetal cover. Later the initial transgression of the ~~Upper~~ Late Cretaceous sea reworked part and, in places, all of the deposits, introducing a marine faunal assemblage in the reworked portion.

Mancos shale

In his studies of the Henry Mountains, Gilbert (1877b, p. 4) originally subdivided the series of alternating shales and sandstones overlying his Henry's Fork group (Morrison, Cedar Mountain and Naturita formations of this report) into three shale and three sandstone units, each shale and overlying sandstone being named, in ascending order, Tu-nunk', Blue Gate and Ma-suk' (see Table 1). Later, because duplication of names is contrary to the practice of the U. S. Geological Survey, only Gilbert's names for the sandstone units were adopted, the shale units thereby losing formal recognition pending further correlative studies with adjacent areas (Longwell and others, 1923, p. 15). Still later the term Mancos shale, named by Cross (1899, p.) from exposures near the town of Mancos, Montezuma County, Colorado, was extended westward to encompass Gilbert's lowest five units (the term Mesaverde formation being applied to the uppermost unit) and the terms Tununk, Blue Gate and Masuk reinstated to apply to the shale units as members of the Mancos shale. Names for the remaining sandstone members, the Ferron and Emery, were introduced into the area by Hunt (1953, p. 79) "in accordance with the usage in adjoining parts of Utah".

Tununk shale member

The basal or Tununk shale member, named by Gilbert (1877b, pp. 4 to) as the Tu-nunk' shale from exposures on Tununk Plateau in the Henry Mountains region, unconformably overlies rocks of the Dakota group or, where the group is absent, the underlying ~~Morrison~~ Cedar Mountain or Morrison formations. This member, typically a slope-and-cliff and strike valley former, is characterized by thin but very even bedded dark gray shales and somewhat calcareous interbedded sandstones and siltstones, commonly weathering to a light gray. Shales are generally dark gray, weathering to blue-gray and dark-brown hues. They are usually thinly laminated, well indurated, highly bentonitic in certain beds and commonly highly fractured with gypsum or selenite and limonite concentrated along bedding and fracture surfaces.

Siltstone beds are generally white to tan, medium to coarse grained, calcareous and poorly cemented. The frequency of sandstone beds increase markedly in the upper part of the member where they form a transitional boundary with the overlying Ferron sandstone member. The member varies in thickness from 595 feet south of the Muddy River to 690 feet in the southern part of the area. However, variations in thickness of from 478 to 839 feet were measured.

Although no fossils were submitted for identification, the unit is highly fossiliferous in marine micro- and macrofossils. Gryphaea cf. G. newberryi is particularly common at or just above the base, forming a cochina-like zone several feet in thickness and traceable over large parts of the area. In places, this zone has been stripped and used as road metal. A single dental plate of an oyster-feeding shark was found on a weathered slope in the SW¼, NW¼, sec. 21, T29S, ~~R9E~~ R8E, S. L. M., Wayne County.

Ferron sandstone member

The Ferron was named by Lupton (1914, p 128) from exposures south of Ferron, Emery County, Utah for rocks locally termed Tu-nunk' sandstone by Gilbert (1877b, pp. 4 to)(see table 1). The base of this member everywhere contains decreasing numbers and thicknesses of sandstone lenses forming a transitional boundary with the underlying Tununk shale member. It commonly forms dip slopes, benches and vertical cliffs (see frontispiece).

The member is characterized by thick, light gray to buff, silty sandstones, often ripple-marked, with minor amounts of thinly-bedded siltstones and dark to medium-gray shales. Low-grade coal beds (subbituminous A to bituminous C coal (Hunt, 1953, p. 216 are common in the upper part and have been mined sporadically at the Factory Butte coal mines where it attains a thickness of 7 feet. Some of the coal beds, as in the eastern part of sec. 11, T27S, R9E, have been burned underground. Evidence that these coal deposits represent dense vegital growth in situ, rather than by rafting, is seen in a small arroyo in NW sec. 24, T27S, R9E where coalified roots extend downward from a coal bed well into an underlying mudstone unit.

Few fossils were found. A collection from a shale bed 42 feet above the base of the transition zone in $NW\frac{1}{4}$, $NW\frac{1}{4}$, $NW\frac{1}{4}$, sec. 3, T27S, R9E, SLM, was identified by the late Mr. John B. Reeside, Jr., (written communication) of the U. S. Geological Survey, as containing Ostrea lugubris Conrad and Cyprimeria sp., probably new. He added that the oyster is considered of late Carlisle age.

Although the bulk of the member is recognized as being of littoral, lagoonal, and barrier beach deposits, the fossils identified above indicate a marine interfingering in the lower or transitional portion as regression of the Mancos shore line continued eastward.

Thicknesses vary from 156 in the east to 460 feet westward. However, much of the variation in thickness may be due to arbitrary selection of the base within the transition zone.

Blue Gate shale member

The term Blue Gate was originally applied by Gilbert, 1877b, p. 4, to a thick shale and overlying sandstone unit on the Blue Gate plateaus overlying the 'Tu-nunk' (Ferron of modern usage) sandstone Member. Later, Hunt (1946, 1953) restricted the Blue Gate term to exclude Gilbert's sandstone unit. Although the term ~~been~~ was adopted by the U. S. Geological Survey for the sandstone unit referred to herein, (Wilmarth, 1938, p. 219), the usage as proposed by Hunt is herein adopted.

The Blue Gate shale member disconformably overlies the Ferron sandstone member of the Mancos shale. Its topography forms slopes and strike valleys (see frontispiece). The unit consists predominently of dark gray, thinly-laminated and commonly highly bentonitic shale beds with interbedded sandy shales and impure limestones. In areas where the unit occurs on the surface or is overlain unconformably by Quaternary river terrace deposits, the upper 20 feet or so is commonly weathered a light brown to buff (see section color.

Only three stratigraphic sections were measured. Thicknesses were found to vary from 1577 to a maximum of 1760 feet ~~XXXXXXXXXXX~~ in the southern part of the area.

Although marine invertebrate fossils were found during the course of the field work, none were collected for identification.

This member is believed to represent the last westward invasion of the Mancos sea into the area.

Emery sandstone member

This member was named by Spieker and Reeside (1925, GSA Bull., vol. 36, p. 439) for exposures southwest of the town of Emery, Sevier County, Utah. Locally it caps buttes and mesas which protect the more unresistant underlying Blue Gate Shale member by its great thickness and degree of induration. Its contact with the underlying Blue Gate Shale member resembles the Tununk-Ferron contact in its lithologic transition.

Only two stratigraphic sections were measured; on North Caineville Mesa it is ~~XXX~~ 192 feet thick while on Factory Butte, 206 feet were measured.

Masuk shale member

Gilbert (1877b,)applied the term Ma-suk' to 500 feet of shale and 500 feet of the overlying sandstone~~XXXX~~ as exposed in the Masuk Plateau of the Henry Mountain region. Hunt (1946 and 1953) restricted the term to the shaly portion of Gilbert's Ma-suk', relegating the sandstone ~~in~~to the Mesaverde formation.

In the Caineville area, the ~~member~~ Masuk represents the ~~XXXXXX~~ youngest Cretaceous deposit, where isolated outliers up to 100 feet thick are found on North and South Caineville Mesas.

Mancos shale (concluded)

Because of difficulty of access, it was examined solely from aerial photographs where it appears to unconformably overlie the Emery Sandstone member ~~where the contact was thus examined~~.

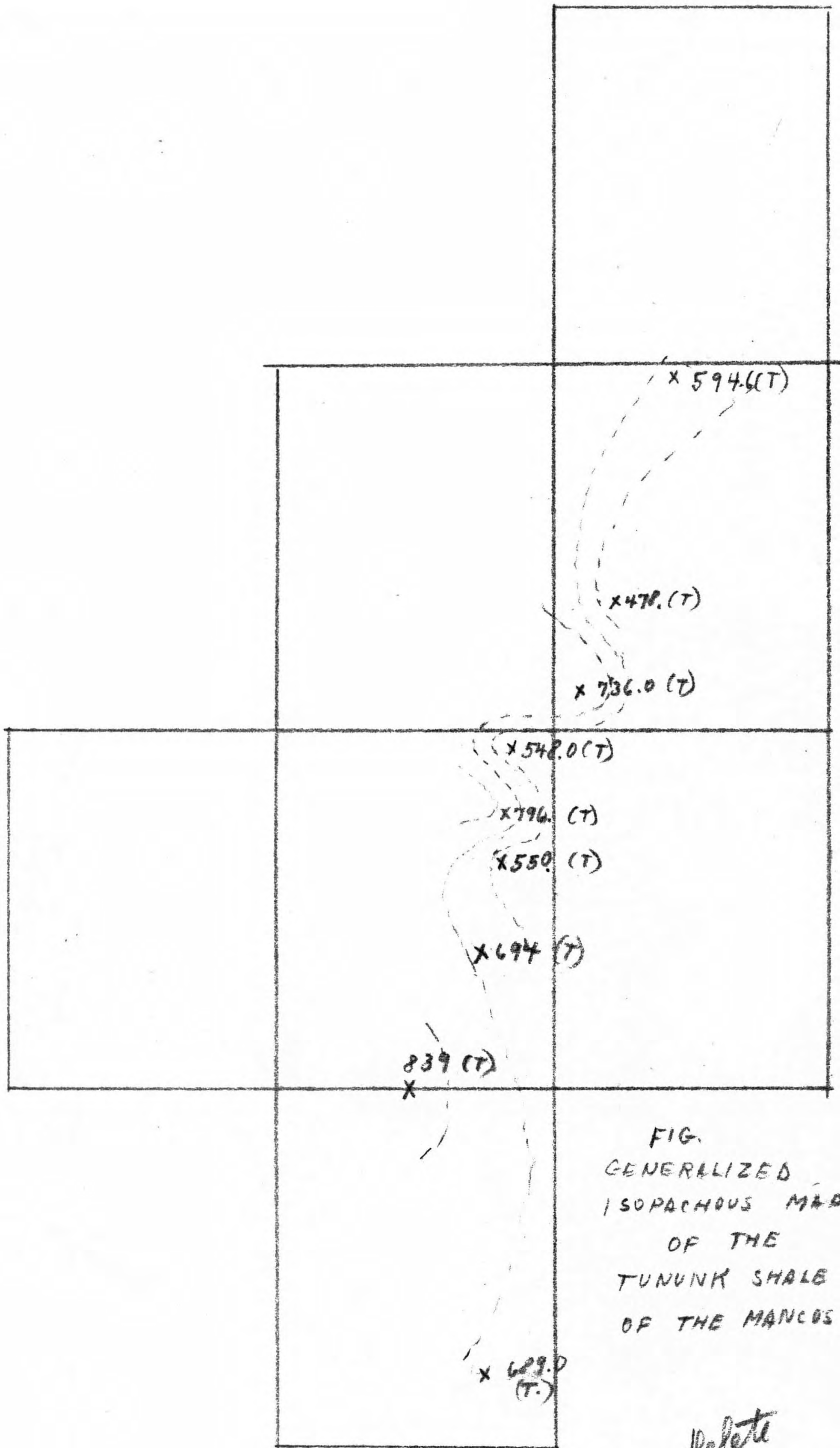


FIG.
GENERALIZED
ISOPACHOUS MAP
OF THE
TUNUNK SHALE MEMBER
OF THE MANCOS SHALE

Delete

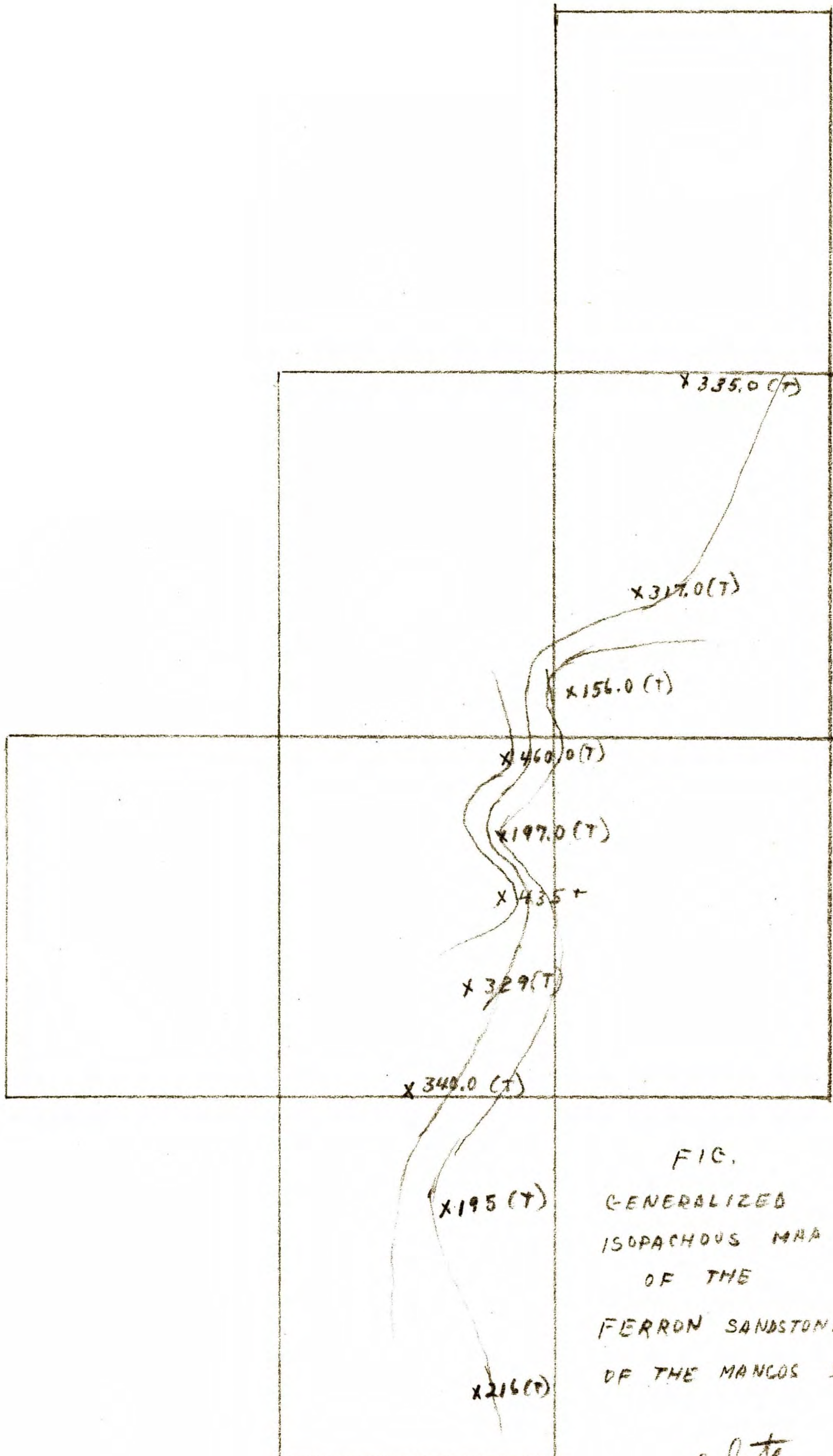


FIG.
GENERALIZED
ISOPACHOUS MAP
OF THE
FERRON SANDSTONE MEMBER
OF THE MANCOS SHALE

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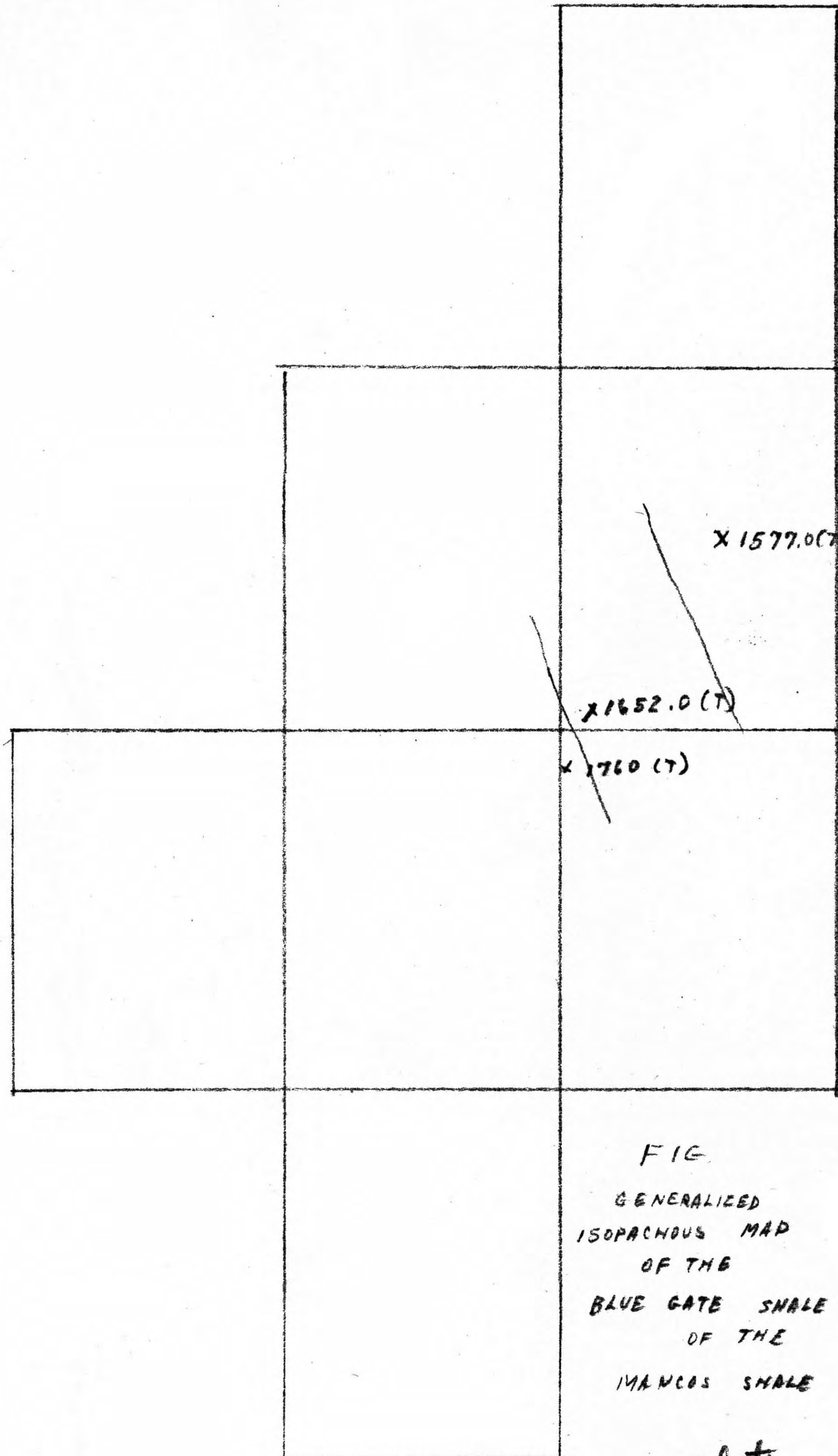

FIG

GENERALIZED ISOPACHOUS MAP OF THE BLUE GATE SHALE MEMBER OF THE MANCOS SHALE

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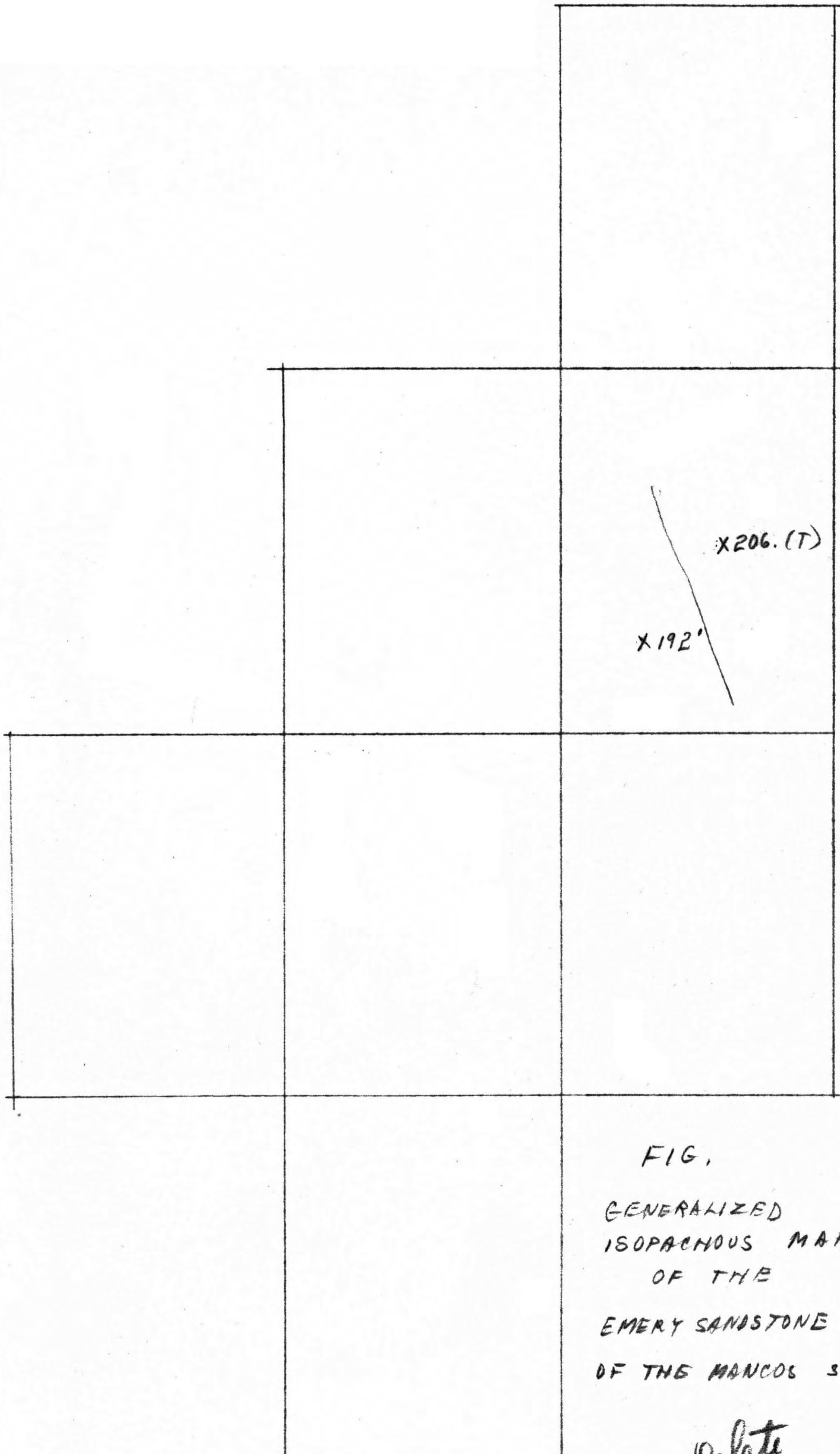

FIG.

GENERALIZED ISOPACHOUS MAP OF THE EMERY SANDSTONE MEMBER OF THE MANCOS SHALE

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Quaternary system

No sedimentary rocks of Tertiary age are known to exist in the area in spite of published information to the contrary (Alexander and Reid, 1954, p. 121). Although there is structural evidence that deposits of early Tertiary age, such as the Paleocene Flagstaff and Eocene Green River and later lacustrine deposits once blanketed the area (Hunt, 1956, figs. 55, 56 and 57), subsequent erosion has not only stripped away all remnants of these deposits but has deeply eroded ~~XXXXXX~~ underlying Mesozoic strata.

Quaternary deposits in the form of terrace boulder gravels of the ancestral Fremont and Muddy Rivers exist as discontinuous pediment cover (figures 18 through 21) while sand dunes, colluvium and other water and wind blown deposits of Recent age generally occur in the low lands. Composition of terrace gravels mentioned above are discussed in greater detail under the topic "Geologic History" (pp 61-63).

Igneous rocks

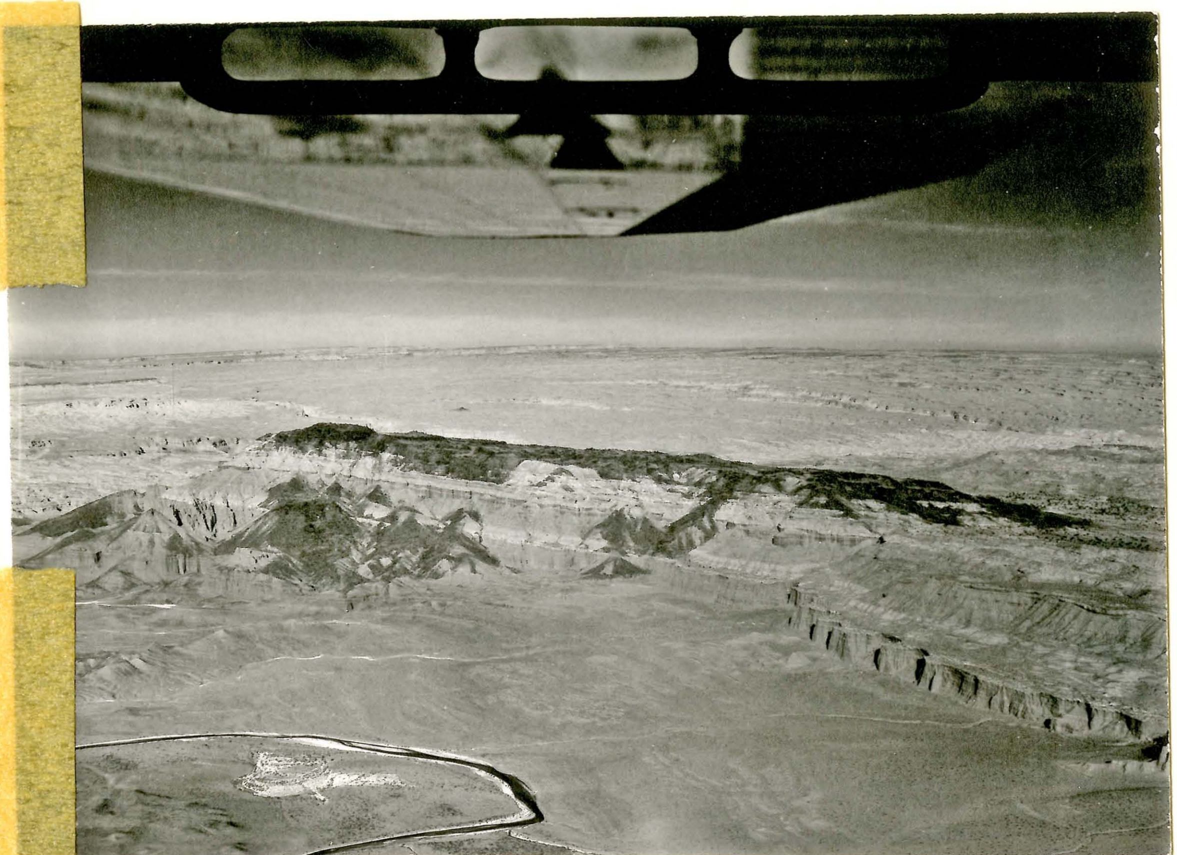
A broad area containing intrusive rocks exists in the western portion of the San Rafael Swell (Gilluly, 1928, pp. 199-211) as well as on Fish Lake Mountain on the Aquarius Plateau (Luedke, 1954, p. 59) and extends into the west-central portion of the Caineville area. Although, locally, these rocks are all in the form of dikes and sills, several large plugs of similar petrology, apparently acting as feeder stocks, occur immediately to the west of the area in the northern part of South Desert. A conspicuous, approximately 80 foot thick, dark colored sill intruding Morrison rocks on Black Mountain, T. 27S., R. 7 E., is described by Gilluly (1929, pp. 120-121) as one of the diabase and syenite composite sills (Figure 17).

A series of northwest trending dikes exists north of Black Mountain, disappearing southeastward before they reach the Caineville Reef monocline. Of these,one of a group of three parallel but discontinuous en échelon type dikes whose width ranges from 0 to 5 feet and which occupies a joint system trending N 35° W in section 36, T. 27 S., R. 8 E., was sampled. Results (S. R. Austin, personal communication) indicate that the 2½ foot wide dike consists of analcite-biotite diabase and alkalic syenite. Therefore, similarity in composition to the Black Mountain and nearby intrusives suggests a common origin and time of emplacement. Chip samples of the center and outer contact of the dike and the country rock (Summerville Formation) immediately in contact with the dike indicated that only the center of the dike contained a trace of chemical U_3O_8 while V_2O_5 assays indicated a reduction from 0.05% throughout the dike to 0.02% in the country rock. These assays are not anomalously high, even for basaltic rocks, and appear to rule out these intrusives as a source of uranium-vanadium bearing solutions in this area.

Because of denudation of rocks younger than Jurassic in the area of the intrusives, no more definite age assignment to these intrusives can here be given from local evidence than a post-Jurassic (post-Morrison) age. Gilluly (1929, p. 121) believes the intrusives to be of Tertiary age by analogy with igneous rocks of the Henry Mountains and the High Plateaus. A closer age determination may yet be obtained from field evidence on the Aquarius Plateau to the west where a more complete Tertiary record exists and where acidic extrusives in the form of extensive lava flows are considered by Williams (1954, pp. 74-75) to be Miocene(?) and basalt and olivine-basalt extrusives to be of early and, again, late Quaternary age.

Figure 17 ~~14~~.-Northeastward view of Black Mountain. The Morrison formation is intruded by resistant diabase and syenite composite sills. 28° north latitude, 111° 7' west longitude, Wayne County.

Figure 18 ~~15~~.-North-northeastern view of ~~the~~ breached Caineville anticline floored and rimed by ~~the~~ Entrada sandstone. ~~The~~ sinuous Caineville Reef is discernable at ~~the~~ foot of North Caineville Mesa in ~~the~~ upper right. Note dark-colored Quaternary gravel caps truncating ~~XXXXXXX~~ ~~the~~ Morrison formation (Upper Jurassic) in ~~the lower~~ foreground. Sections 6 and 8, T. 29 S., R. 8 E., Wayne County.



17

18

#5

Northeastward view of Black Mtn, 28° lat, 111° 7' Long., having 875' relief. Jcu is intruded by resistant — sills.

Moroni slopes ~~at skyline~~ of southern San Rafael Swell at skyline

#9

NNE view of breached trimmed Caineville anticline floored by Je. Note Quat gravel caps truncating Jms + Jsdf in lower foreground. Simmons [illegible] Reef is seen at foot of North Caineville mesa in upper right

Structural features

A structure map of the Summerville-Morrison erosion surface in the Caineville area was prepared (plate 2 in pocket) by determining strike and dip of beds by the use of plane table and alidade, brunton and photogeologic maps, by measuring thicknesses of Mesozoic rocks of post-Summerville age with plane table and alidade and brunton and, finally, by determining elevation of key beds by use of Wallace and Tiernan roving altimeters and plane table and alidade, once variations in thickness of strata were determined for the area.

General structural setting

The area includes, and is bounded, structurally, by two major features; on the east by the southward plunging Henry Mountains structural basin and, on the west, by the northeast trending Capitol Reef monocline, the northern extension of the Waterpocket Fold. (See plate 2). A strong monoclinal feature, the Caineville Reef monocline, termed the Blue Gate Flexure by Gilbert (1877, pl. 2), forms the western boundary of the Henry Mountains structural basin and coalesces southward with the Waterpocket Fold. The area between these two monoclinal flexures is occupied by a structural terrace which has been, by comparison, only slightly deformed. The terrace consists of two gently folded, imbricating and coalescing, nearly symmetrical anticlines and synclines which have distorted strata into a maximum relief of 1,800 feet on this terrace as compared to a total structural relief in the area of over 4,000 feet.

~~Types of~~ folds

Henry Mountains structural basin This basin, one of the major structural basins on the Colorado Plateau, is a broad, gently flexed assymetrical trough with a steep western limb, its gently dipping eastern flank having been intruded by the Henry Mountains laccolithic intrusions southeast of this area. The northern limit of the structure occurs in this area and is traceable southward beyond the Colorado River (Hunt, 1953, plate 5) where it is recognized as the Nokai syncline in Monument Valley, near Kayenta, Arizona.

San Rafael anticline Only the southward plunging nose of the San Rafael assymetrical anticline is present in the central part of the area. As northward, where it attains its maximum relief, the east side is expressed as a sharp monoclinal flexure typically forming a "reef" or hogback, locally expressed as the Caineville Reef monocline. The San Rafael anticlinal structure is traceable northward to beyond the Book Cliffs (Gilluly, 1929, plate 30).

A. Bentz, A.A.P.G., '56; '57; '58? German structure map showing crossing folds.

Salvation syncline Crossing the southern nose of the San Rafael anticline is the broad, gently folded Salvation syncline. This structure demarcates the San Rafael structure from the Caineville anticline to the south and continues to plunge southeastward inth the Henry Mountains structural basin where it disappears.

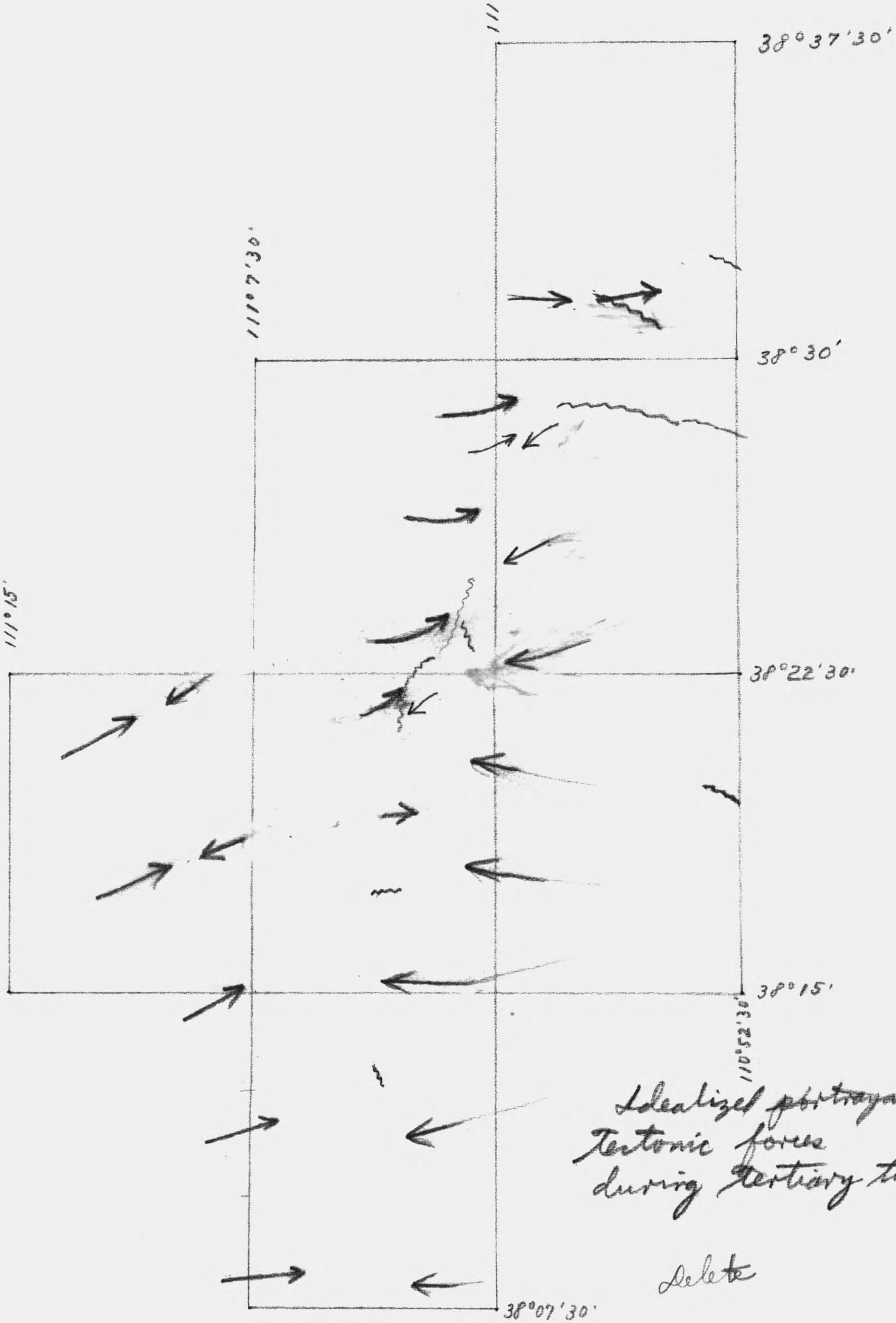
Salvation Creek anticline The Starvation Creek anticline, described by Hager (1954, p. 96) as the Last Chance anticline, is an assymetrical anticline facing the southwest end of the San Rafael anticline in a general north to northwest arc (Gilluly, 1929, p. 123). It plunges both northwest and southeast into structural saddles.

Caineville anticline The Caineville anticline is formed by the coalescence of the southward extensions of the Starvation Creek and San Rafael anticlines. The structure has been of interest to the petroleum industry, having been twice drilled with negative oil and gas results (Hager, 1954, p. 96-97). (Fig. C)

Saleratus Creek syncline Paralleling the east side of the Capitol Reef monocline is the Saleratus Creek structure, another broad, gently flexed depression resembling, on a minor scale, the Henry Mountains basin into which it plunges southeastward.

Caineville Reef monocline This structure, first described as the Blue Gate Flexure by Gilbert (1877, plate 2), coalesces southward with the Capitol Reef monocline and continues sinuously northeastward to form the San Rafael Reef. Locally, alternating competant and incompetant beds of the Mancos formation are ~~sinuously deformed~~ tilted and eroded to form the Caineville Reef.

Capitol Reef monocline This structure, forming the western border of the area, is the northwestern portion of the nearly 80 mile long Waterpocket Fold. The northern end of the monocline is concealed beneath sedimentary rocks of Eocene (Dutton, 1880, pp. 286-295) and lava flows of later Tertiary age capping Thousand Lake Mountain. Dips decrease northward from 35° in Garfield County to 5° at the northwest end as expressed in the reef-forming rocks of the Jurassic Glen Canyon group (Luedke, 1954, pp. 59-62).



Idealized portrayal of tectonic forces during Tertiary time

Delete

Table 2 STATISTICAL ANALYSES OF THE STRUCTURES

Name of structure	General trend of axis in this area	Direction of dip of axial plane	Amount of closure (ft.)	Maximum dip in area	Total area (sq. mi.)
ANTICLINES					
San Rafael	N 30° E	SW	4,000+	6°E	2,600[4]
Caineville	N - S	W	380	20°E	15
Starvation Creek	N 40° W	W	600[2] 700[3]	10-12°E	110
SYNCLINES					
Salvation	N 30° W	Vert.	40	12°W	75
Saleratus Creek	N 30° W	Vert.	460	13°E	20+
Henry Mountains	N 15° E	W	4,000+[1]	46°SE	2,100[4]
MONOCLINES					
Caineville Reef	N 25° E	W	- - -	27°E	- - -
Capitol Reef	N 30° W	W	- - -	5 - 35°E[6]	- - -

1) Hunt, 1953, p. 88
2) Hager, 1954, p. 96
3) Gilluly, 1929, p. 123
4) Kelley, 1955, pp. 22, 27
5) Luedke, 1954, p. 61
6) Gregory and Moore, 1931, p. 119

Minor folds

In addition to the major structural features just discussed, minor crustal movements of small amplitude and believed to be of late Mesozoic age which were subsequently masked by the later,more pronounced folding, are believed to have existed in the area as evidenced by results of detailed section measurements. These have been treated more fully in the section governing stratigraphy. In addition to these folds, micro-folds, consisting of symmetrical to westward dipping recumbant folds of less than ten feet of vertical ~~displacement~~ deformation, are common paralleling the east side of the San Rafael anticlinal axis as expressed in deformation of the relatively incompetant Summerville beds in this region.

Fractures

Fractures in the area consist of faults and joints. As evidenced by the number and amount of their displacement, faulting was moderate (see Fig. X). An anomalously intense area of faulting occurs in the northern part of the Henry Mountains structural basin. Although poorly exposed because of the incompetant nature of surficial beds of the Mancos shale, it can be stated that the faults consist of generally high angle (65-89°) normal faults trending between east-west and N65°W with throws (vertical components of dip slips) ranging from 2 to 30 feet. Of seventeen en échelon faults measured, fifteen of the scarps were normal or gravity faults. Of the two remaining reverse faults, the east-northeast trending Muddy River fault scarp exhibited the greatest amount of throw. Although exposures of this fault are sketchy because of Tertiary alluvium cover, it is safe to estimate up to almost 200 feet of vertical displacement.

A series of low angle (22-38°) westward dipping scarps of reverse or thrust faults occur in surficial Summerville beds in the same belt as the recumbant folds previously described as occurring east of and essentially paralleling the crest of the San Rafael anticlinal axis. No faults with throw greater than 4 feet were encountered. This zone of recumbant folding and reverse faulting is interpreted by me as indicating the presence of general east-west compressional forces which at first resulted in developing the structural terrace containing the southern nose of the San Rafael anticline and finally resulting in rupture along the east side of the San Rafael and Caineville structures.

These views are strengthened by the interpretation given by Hunt (1953, p. 89) to the origin of the en échelon faults previously discussed. He believes these faults "strongly suggest shearing along the south side of an eastward thrust, as if the San Rafael Swell had been bodily thrust eastward with respect to the Henry Mountains structural basin." Although he adds that these faults apparently belong to an independent and larger system of fractures widespread in the Green River Desert to the east, the senior author feels that, at least locally, the first interpretation given by him is correct, being validated by the presence of the previously mentioned westward dipping thrusts and recumbant folds which strongly indicate shearing in a general east-west direction due to compressional forces apparently instigated after the development, locally, of the structural nose of the San Rafael anticline which obviously did not extend this far south until rather late in the stage of, and therefore, time of deformation of the Swell.

Additional faults of small vertical displacement occurring sporadically throughout the area are interpreted as caused by post-deformational elastic rebound.

Because of the weathering characteristic of widely outcropping incompetant beds of the Mancos shale, few joints are sufficiently exposed to be mapped. Aerial photos and photogeologic maps indicate the presence of two sets of essentially vertical joints which trend perpendicularly northeast and northwest within the Henry Mountains structural basin as developed in massive sandstone units of the Mancos shale (see plate 2). These joints are beleived to represent shear fractures as a result of east-west compressional forces in the basin.

A set of paralleling joint fractures in section 36 (projected), T. 27 S., R. 8 E., which strike N 35° W and dip 85°N (previously described under "Igneous rocks") acted as conduits for a system of en échelon Tertiary(?) dikes which can be traced northwest for many miles. Hunt (1953, pl. 5) depicts additional northeast-northwest trending joint sets as exhibited by outcropping Glen Canyon rocks along the southern limit of the San Rafael Swell as well as a north trending system along the Waterpocket Fold.

Three major joint trends are recognized in the area, vis; between N 60 and N 25 W, between N 25 and 35 E and between N 40 and 55 E (see fig. 18a). Peter Badgley (personal communication), although admitting that more conclusive evidence is required, believes that these trends are suggestive of a pre-Laramide orogeny ~~and are~~ with some trends probably parallel to older pre-existing lineaments of possible preCambrian origin, which may have been rejuvinated.

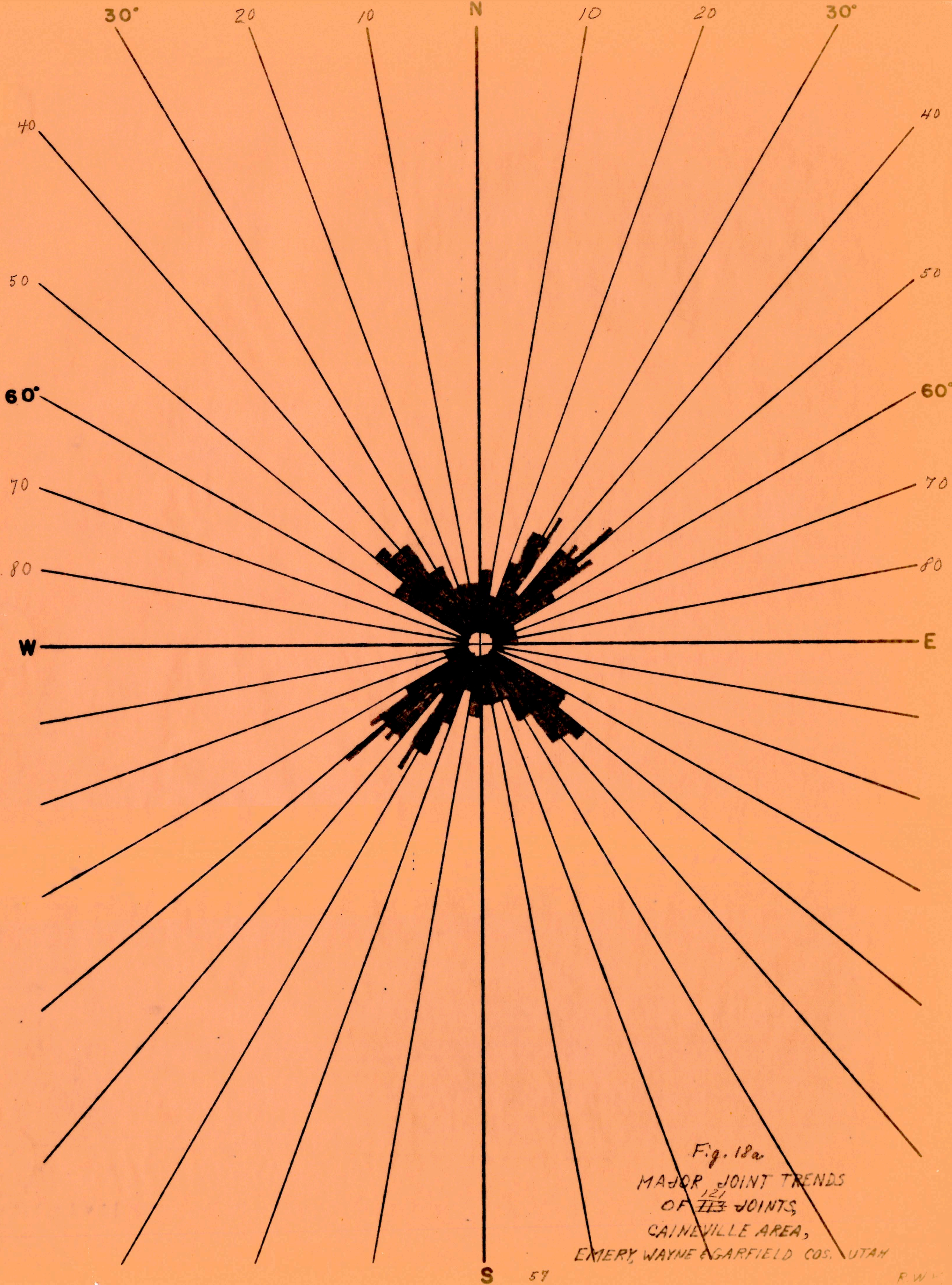


Fig. 18a

MAJOR JOINT TRENDS

OF ~~113~~ 121 JOINTS,

CAINEVILLE AREA,

EMERY, WAYNE & GARFIELD COS. UTAH

R.W.K.

Geologic history of the area (continued)

Cretaceous history

Probably during the close of the Jurassic and certainly during the advent of the Early Cretaceous, slight regional uplift accompanied by warping on a minor scale was followed by peneplanation of the Morrison-covered surface with resultant variations in thickness of the Morrison at the expense of the upper or Brushy Basin member. Early Cretaceous deposition began as fluviatile deposits of an initial conglomeratic phase, representing the basal Buckhorn conglomerate member, ~~XX~~ followed by interbedded argillaceous and arenaceous deposits comprising the bulk of the Cedar Mountain formation. This was followed by a more severe regional uplift, principally expressed as tilting of the area in a northwestward direction and accompanied by minor crustal warps. The resulting denudation of these incompetant beds by peneplanation not only beveled the Cedar Mountain formation to a featheredge along the eastern and southern portions of the area (see figure 15) but eroded part of the older Morrison formation in the southern portion and even progressively older beds south of the area.

Peneplanation of the Early Cretaceous land surface apparently reached a stage of marked maturity. At best, if peneplanation was not completed before deposition of the Late Cretaceous fluviatile clastics and lagoonal coal beds of the Naturita formation of Young, 1960, planation was certainly completed by the ensuing erosive beveling force of the advancing shoreline of the Mancos sea. This erosive action, armed with surficial Naturita and Cedar Mountain debris, often caused redeposition of a thin veneer of terrestrially derived but reworked ~~"~~Naturita~~"~~-type deposits containing conspicuously well rounded pebbles and thin mudstone beds containing a marine fauna. These reworked beds, where present, unconformably overlies undisturbed Naturita clastics.

The advance of the initial Mancos sea deposited the thick calcareous and gypsiferous mudstone sequence of the Tununk shale member in a marine environment which, at its maximum advance, is believed to have been at a minimum depth of 500 feet. The first of several retreats of the Mancos sea, reflecting crustal unrest in the form of renewed uplift, is represented by the upward transition of Tununk lithology into cross-laminated sandstones and, finally, interbedded coal beds of the Ferron sandstone member, representative of littoral, lagoonal, and barrier beach deposits.

These beds are disconformably overlain by marine mudstones of the Blue Gate shale member, indicating a second advance of the Mancos sea. A second gradual retreat of the sea is reflected by an upward transition into shoreline and coal-bearing lagoonal deposits represented by the Emery sandstone member. This unit is overlain by argillaceous marine deposits representative of the third major westward advance of the Mancos sea, the Masuk shale member. Although nearly all evidence of the remaining geologic record is missing because of denudation, other nearby areas including the Henry Mountains and the Book Cliffs indicate that at least a third major retreat of the sea deposited beach sands and possible coal beds, represented by the Mesaverde formation, reflecting a repetition of Ferron and Emery paleoenvironment.

Presumably then, early Late Cretaceous downwarping of the crust took place pulsatingly causing not only the westward advancing Mancos sea

Geologic history of the area (continued)

Cretaceous history (continued)

to inundate the area, but downwarping the area sufficiently to accomodate accumulation of between 2700 and 4000 feet thickness of Mancos clastics in this part of the geosyncline. Downwarping was interrupted by at least two major periods of uplift as evidenced by shoreline and lagoonal deposits comprising Ferron and Emery clastics. These regressions of the Mancos sea may be traced over large areas of the Colorado Plateau.

Tertiary history

Sometime after Mancos and Mesaverde deposition, the area, presumably, was deformed. Dutton (1880, pp. 286-295) indicates that, on the northern end of the Waterpocket Fold, older rocks are folded, truncated and overlain by rocks classified as Eocene in age while Young (verbal communication) indicates crustal unrest in the Book Cliffs as evidenced by thinning of Paleocene beds along the northward projected axis of the San Rafael Swell.

There is gathering evidence that the San Rafael Swell probably began its history of uplift as early as Early Cretaceous (Young, verbal communication) but did not attain maximum deformation till probably Eocene time. As each deformational "pulse" was renewed, the limits of the anticlinal axis were simultaneously extended both north into the Book Cliffs area and south into the Caineville area. Local absence of thinning of Mancos clastics near this present axis indicates that this area was uneffected by such initial uplift. Unfortunately, denudation of Tertiary rocks has removed with it evidence to indicate which structure, the San Rafael Swell, the Henry Mountains structural basin or the Waterpocket Fold, of Late Cretaceous or Tertiary age (Hunt, 1953, p. 209) initially effected the area.

In o

Later the area, as an intrinsic part of the Colorado Plateau, was uplifted in late Eocene to early Miocene time and probably thereafter throughout late Tertiary and perhaps even Quaternary time (Hunt, 1953b, p. 221; 1956,)

In order the date the age of the structural deformation more closely, the age of the youngest rocks truncating the Caineville anticline, namely gravel terrace deposits considered by Alexander and Reid (1954, pp. 121, 122) to be late Tertiary in age, was questioned. These flood plain deposits (see figures 17, 18, 19 and 20), derived from the ancestral Fremont River, are composed of sand, pebble, cobble and boulder-sized rocks (see sections and in appendix). Although most of the smaller sized material is composed of the less competant sedimentary rocks, almost all of the cobbles and boulders, some exceeding three feet in diameter, are composed of well-rounded, slightly weathered, highly vesicular basalt. Representative samples of basaltic boulders were taken from flood plain terraces of the Fremont, two samples near Caineville, two farther upstream near Aldrich, and one at Torrey, 38 river miles west of Caineville. Petrographic examination (Austin, 1958, written communication) indicated that all samples consisted of trachybasalts composed of plagioclase feldspar, slightly greenish pyroxene, olivine more or less altered to iddingsite, magnetite, and minor amounts of aplite, all in a microcrystalline to glassy groundmass. In all specimens submitted, the plagioclase phenocrysts contained inclusions of groundmass material, principally glass.

Geologic history of the area (continued)

Tertiary history (continued)

The large body of igneous rocks closest to this area, those of the Henry Mountains, is described by Hunt (1953b, p. 152) as being wholly intrusive, consisting of porphyritic diorite, porphyritic monzonite, aplite and basalt. This ~~The~~ basalt is located in and around the shattered zone of Mount Ellen, about 22 miles southeast of Caineville. This basalt, with phenocrysts too small to be visible in the hand specimen (Hunt, 1953b. p. 157), constitutes less than 1% of the total volume of the Henry Mountains intrusives.

The Henry Mountains, therefore, could not have been the source of the basalt-contained flood plain deposits because 1) gravel deposits contain basalt as the <u>sole</u> igneous constituent, 2) the mass of basalt deposited as boulders outweighs the mass of basalt as presently exposed in the Henry Mountains, 3) basalt having such large vesicles would indicate an extrusive lava source, and 4) no tributary streams of the Fremont River in the Caineville area presently drain the Henry Mountains.

Boulder Mountain, a flat-topped feature south of, and extending to within 9 miles of Torrey, rises 5,000 to 6,000 feet above the Caineville area to the east. It has an area of nearly 70 square miles and rises over 11,000 feet above present sea level, According to Gould (1939, p. 1373), it is capped by 1,000 to 2,000 feet of basaltic lava flows, the topmost of which, at least, are vesicular. He and Flint (1958, p. 119) have aptly demonstrated the presence of sheet glaciation of Boulder Mountain, which glaciation spilled over the rim forming ice tongues or outlet glaciers. Flint (1958, p. 117, fig. 25 and plate 6), in mapping these glacial deposits, found that the distal end of the Carcass Creek drift of the Fish Creek-Grover drift lobe flowed northward to the Fremont River. It apparently dammed the river for a short time, then accumulating melt water broke through the barrier carrying drift material composed of basalt-contained outwash by sheet flooding to distances over 40 miles downstream.

That the source of the basalt boulder-contained flood plain deposits of the Caineville area was the Boulder Mountain region is indicated by 1) petrographic similarity of basalt boulders with those of extrusive lava flows of Boulder Mountain, 2) a reasonable source area of large volumes of fast moving water, conceiveably derived from meltwaters, required to transport boulders up to 12 feet in diameter (Flint, 1958, p. 123), 3) well-rounded cobbles and boulders which apparently were glacial erratics, partly rounded by glaciation, partly by stream transportation, 4) the large volume of basaltic lava flows which would account for the large amount of basalt boulders in terrace gravels, and 5) tributaries of the Fremont River which drain Boulder Mountain both presently and during glacial time.

Examination of the highest (oldest) flood plain terraces was made in an effort to determine whether any post-depositional tilting could be recognized. ~~These surfaces~~ The study indicates that no anomalous tilting occurred (a maximum of $\frac{1}{2}^{\circ}$ was recognized) and, therefore, that all major structural movement must be dated as between post-Mancos (post Late Cretaceous) ~~to~~ and pre-terrace (pre-Bull Lake(?) stage of the Sangamon interglacial stage, late Pleistocene) time.

Figure ~~16~~ 19.-Northward view along ~~the~~ west limb of ~~the~~ northward trending Caineville anticline illustrating apparent post-Pleistocene tilting of dark-colored Quaternary gravel terraces which here truncate beds of ~~the~~ Morrison formation. Sections 6 and 8, T. 29 S., R. 8 E., Wayne County.

Figure ~~17~~ 20.-Southeastward view of ~~the~~ west limb of ~~the~~ Caineville anticline toward ~~the~~ Henry Mountains in background. Note dip slope of Morrison beds truncated and capped by remnants of dark-colored Quaternary pediment gravels deposited by the ancestral Fremont River. Sections 6 and 8, T. 29 S., R. 8 E., Wayne County.

19

20

#11

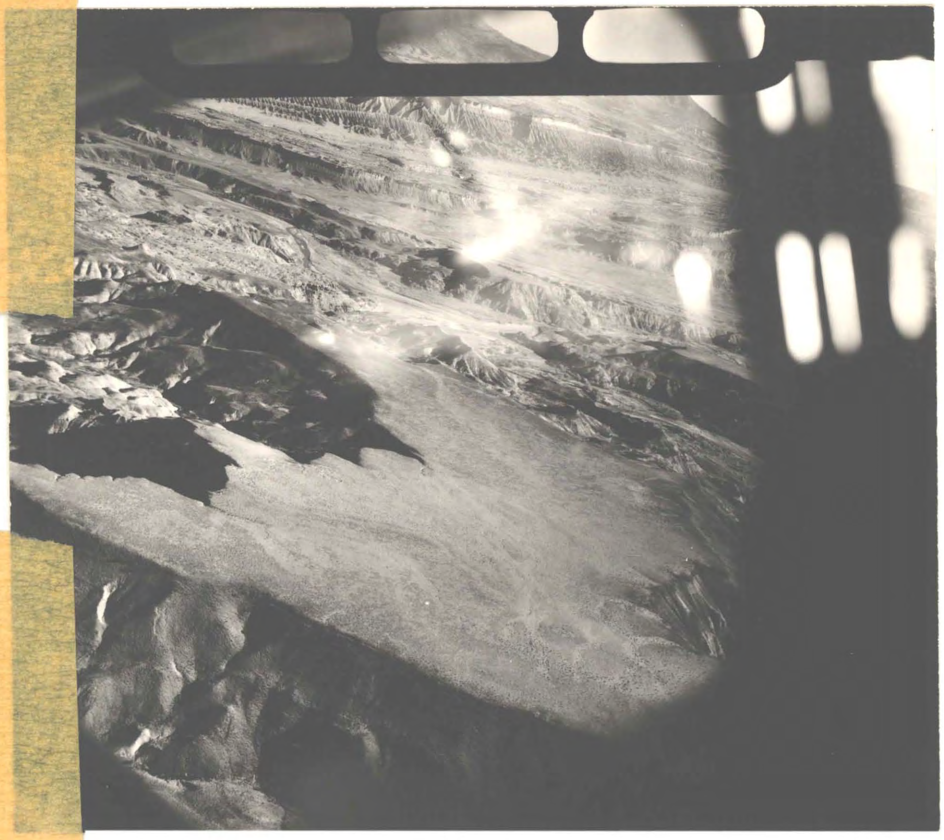
Northward view along west limb of northward trending Caineville anticline illustrating apparent tilting of dark colored Quat. gravel terrace surfaces which here truncate Morrison beds.

8

Southeastward view from west limb of breached Caineville anticline toward Henry Mountains

note dip slope of Salt Wash truncated and capped by remnants of dark-colored Quat. pediment gravels deposited by the ancestral Fremont River

Figure ~~18~~ 21.-Southeastward view of partially dissected terrace of ancestral Fremont River which here bevels beds of ~~the~~ Morrison formation. Present Fremont River, seen in upper center, is 600 feet lower than surface of terrace. Section 13, T. 29 S., R. 7. E., Wayne County.



21

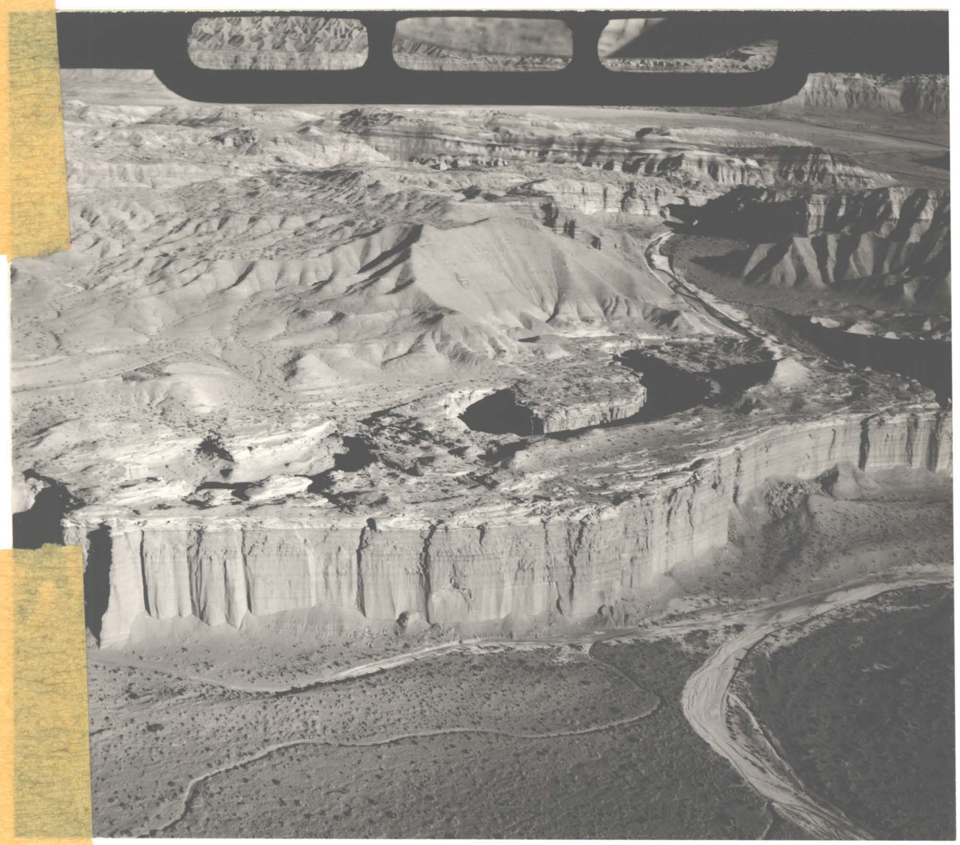
10 a partially dissected
Southeastward view of Quat gravel
terrace of ancestral Fremont River
which to [illegible] beveled Smth. Present
Fremont River, upper center, is 600 feet
lower than surface of terrace.

sec 13, T29S, R 7E

Figure ~~19~~ 22.-Northwestward view across ~~the~~ northern part of ~~the~~ Caineville anticline. Stream in foreground is present and only drainage of valley to left. Note two pirated entrenched meanders in center of photo. Fish Lake Mountain at skyline. Section 28, T. 28 S., R. 8 E., Wayne County.

Figure ~~20~~ 23.-Eastward view of figure 19. Note ~~the~~ red earthy facies of the Entrada sandstone overlain by ~~the~~ sandy facies, both of which are entrenched by the encised meanders.

22



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#14

Northwestward view from sec. 28, T 28 S, R 8 E across N part of Caineville anticline

Note two ~~abandoned~~ pirated entrenched meanders in dip slope of ~~Jcu~~ Je + basal Jcu in center of ~~photo~~

Stream in foreground, is only present drainage ~~Red Desert, to~~ to floor of ~~to~~ anticline to left.

Fish Lake mountains at skyline

#16

Eastward view down dip slope of Caineville A. from Red Desert. showing resistant basal Jcu capping Je, both entrenched by incised meanders.

Geologic history

A summary of geologic events of the Caineville area, following deposition and erosion of the Navajo sandstone, is herewith presented.

1. Deposition of marine limestones in the Carmel sea, followed by gypsum and red bed evaporites in the retreating Carmel sea within the Late Jurassic Utah trough.

2. Deposition of the shallow water earthy facies and terrestrial sandy facies of the Entrada sandstone.

3. Truncation and reworking of the uppermost Entrada and deposition of marine glauconite-bearing Curtis shales and sandstones by the eastward advancing Curtis sea.

4. Continued deposition of the Summerville formation as marginal marine evaporites and fine-grained clastics.

5. Broad gentle uplift accompanied by gentle erosion with maximum paleotopographic relief of 50 feet.

6. Deposition of reworked Summerville clastics and evaporites followed by typical argillaceous and arenaceous deposits of the Morrison formation, the latter deposits by northeastward flowing aggrading streams. Later deposits ~~are~~ were principally fine-grained clastics derived possibly from positive Paleozoic highlands as far west as southern Nevada.

7. Gentle uplift and erosion terminating Late Jurassic time.

8. Deposition of a fluviatile basal conglomerate phase derived from Paleozoic highlands, probably to the west and followed by deposition of fluviatile clastics of the Early and Late Cretaceous Cedar Mountain formation.

9. Slight warping accompanied by differential uplift resulting in tilting and truncating the Cedar Mountain and, to the south, the upper part of the Morrison formation during early Late Cretaceous time.

10. Deposition of the fluviatile and lagoonal Naturita formation, probably as a shoreward facies of the Mancos sea.

11. Subsidance of a large part of Utah below sea level, resulting in the westward advance of the Mancos sea into the area, reworking deposits of the Naturita formation by wave action and introducing a marine fauna in the reworked portion,

12. Continuation of deposition of off-shore fine marine sediments comprising the Tununk shale member of the Mancos shale.

13. Eastward retreat of the Mancos (Tununk) sea accompanied by deposition of near shore, barrier beach and lagoonal sandstones and coals of the Ferron sandstone member.

14. Westward readvance of the Mancos sea, truncating sandy deposits of the Ferron and depositing tununk-like clastics of the Blue Gate shale member.

15. Eastward retreat of the Mancos (Blue Gate) sea accompanied by deposition of near shore, beach and lagoonal sandstones and coal beds of the Emery sandstone member.

16. Readvance of the Mancos sea, truncating sandstones of the Emery sandstone member and depositing Tununk-like marine clastics of the Masuk shale member.

17. Final eastward withdrawal of the Mancos sea with deposition of Star Point and Blackhawk equivalents of the Mesaverde group, apparently under fluviatile and sub-aerial conditions.

18. Initial upwarp of the ancestral San Rafael Swell to the north, accompanied by erosion representing early Laramide orogeny.

19. Continuation of deposition of Late Cretaceous non-marine Mesaverde group, including possible equivalents of the Price River formation.

20. Renewed uplift of the San Rafael Swell to the north, accompanied by erosion.

21.Deposition of equivalents of the North Horn and possibly Tuscher formations of latest Cretaceous and early Paleocene age.

22. Renewed uplift of the San Rafael Swell, apparently extending the structural axis southward into the Caineville area, and accompanied by major deformation and erosion of the Circle Cliffs, Waterpocket and Monument upwarps during early Paleocene time.

23. Deposition of the lacustrine Flagstaff limestone in lowlands along the west edge of the Colorado Plateau during middle and late Paleocene time.

24. Probable deposition of the Wasatch, predominantly fluviatile Colton and lacustrine Green River formations and possible other younger units during early and middle Eocene time.

25. Possible instigation of epirogenic uplift of the Colorado Plateau accompanied by deformation of the Henry Mountains structural basin during late Eocene time. Period of normal, en echelon and reverse faulting in the Caineville area.

26. Block faulting in the Basin and Range Province to the west during Oligocene and Miocene time, with the High Plateaus becomming outlined during early Miocene time.

27. Advent of igneous activity in the form of the Henry Mountains laccolithic intrusions to the south and extensive sialic andesite and trachyte lava flows in the High Plateaus to the west. Probable emplacement of the analcite-biotite diabase and alkalic syenite dikes, sills and stocks in the Caineville area, all apparently during middle Miocene time. Establishment of ancestral drainage of the Fremont, Muddy and Dirty Devil Rivers.

28. Continuation of epeirogenic uplift of the Colorado Plateau. Possible short-lived deposition of the fresh water Browns Park and Bidahochi formations or their equivalents. Extensive basalt extrusions in the High Plateaus to the west during late Miocene to middle Pliocene.

29. Volcanic eruptions of olivine basalts continuing in High Plateaus, with eastern limits possibly extending into Caineville area, during and after late Pliocene time. Advent of extensive denudation of surface of the Colorado Plateau.

30. Faulting, causing up to 2,000 feet of uplift of the High Plateaus, continues intermittantly into Pleistocene time. Denudation of land surface in Caineville area continues, stripping all post-Mancos deposits from these lowland areas.

31. Glaciation of lava-capped areas over 11,000 feet in parts of the Aquarius Plateau to the west during the Sangamon interglacial stage.

32. Melting of glaciers to west causing sheet flooding of lowlands to east by the ancestral Fremont River, resulting in deposition of basalt-strewn boulder and cobble terraces in the Caineville area.

~~33. [Renewed uplift of the Caineville anticline?]~~

33 ~~34.~~ Renewed stream erosion in recent time producing present topography, accompanied by continued faulting in the High Plateaus to the west.

Martin Prochnik; 1/19/61

As you undoubtedly recall, we have agreed to let you earn your authorship by submitting the section on uranium deposits. To make the task simple, I have last year given you all data in my possession related to the subject. These include ore production and grade from each property, all drill and mine maps and cross-sections prepared by me, and a map entitled "Location of uranium mines, prospects and areas of favorability" which should be labeled figure 24 and included with your report into our paper.

I have taken the liberty of writing the chapter on "mining history."

Required from you are chapters on

1. Types [of ore] and distribution
2. Mineralogy *
3. Description of individual deposits
4. Ore controls
5. Potential reserves.

* Results of analyses of petrographic samples # 3162 & 3163 on N.B. Hunt's mine and Billie's Dream mine, respectively, have never been forwarded by Special Services since they were submitted Sept. 24, 58!

Please mention yellow canary deposits on Little Wild Horse Mesa in your report (see report by Hinckley)

URANIUM DEPOSITS

HISTORY

Uranium exploration in the Cain^e^ville area, situated in the northern part of the Henry Mountains Mining District, became of economic interest in 1948, the year the United States Government first offered a ten-year guaranteed minimum price for the production of uranium ore over a minimum grade, (Circular 6). Although token shipments of ore were made from some properties in the area in 1948 and 1950, the area was little explored until 1952. Intensive surface prospecting activity began at that time which ultimately resulted in the staking of almost all of the exposed Morrison formation in the area.

[Mike; I believe this to be correct. But please verify. RWK]

Since earlier mining in the ~~adjoining~~ eastern part of the Henry Mountains Mining District had ~~shown~~ indicated uranium mineralization there to be almost exclusively confined to the Salt Wash sandstone member of the Morrison, ~~the prospecting activity in the~~ this horizon was most avidly prospected in the Cain^e^ville area ~~confined itself mainly to that horizon~~. The ~~Triassic~~ Chinle formation of Triassic age, the host horizon for ore ~~mined~~ in the San Rafael Mining District ~~a few miles~~ immediately to the north, is not exposed in the area under consideration in this report.

After a period of high prospecting activity from 1952 to 1957, the lack of success and gradual withdrawal of government incentives for exploration and mining of uranium ores ~~has~~ had reduced the number of active properties until at the time of this writing (January 1961) there ~~is~~ was only one intermittent producer, the Big & Little Jim group of claims.

Total production as of January 1, 1961 from all ~~the~~ 18 properties ~~(18)~~ in the area under consideration is 2,156 tons of ore with a weighted average of ~~averaging~~ 0.28% U_3O_8. The average uranium-vanadium ratio is 1:3, while individual deposits vary from 1:4 to 6:1. 95% of the production ~~has come~~ was derived from 5 properties.

The U. S. Atomic Energy Commission, using standard engineering methods, ~~has assigned a total of 3,669 tons of 0.22% U308 indicated and inferred reserve to the properties in~~ determined the total indicated and inferred reserves, effective January 1, 1961, to be 3,700 tons of 0.22% U_3O_8 for the Cain^e^ville area. A breakdown of production and reserves for each property is shown in Tables ~~Nos.~~ 1 and 2.

Where are they? Please check the original copy for these tables. They should be inserted near here. R.W.L. 7/14/61

Types and Distribution ~~of Deposits~~

Known uranium-vanadium deposits ~~ore occurrences~~ in the Caineville area are confined to the Salt Wash member of the Morrison formation in two general locales: (a) the Notom Bench sub-area and (b) the north Caineville wash sub-area. Small prospects and exploration drifts are, however, found randomly scattered elsewhere along outcrops of the Salt Wash Member.

The ore is usually ~~occurs~~ associated with carbonaceous trash along or just above the base of minor scours within relatively thick sandstone horizons. At the Billy's Dream property in the Notom Bench sub-area, however, uranium as tyuyamunite ~~, mineralization~~ occurs as a coating on sandstone grains not associated with carbon ~~with no visible carbon present~~. In general, mineralization appears ~~seems~~ to follow bedding but is not necessarily restricted to the same bed ~~bounded by it.~~ The ore-bearing sandstone is commonly light gray to tan, fine to medium grained and poorly sorted. Occasionally the ore-bearing sandstone grades into a sub-ore grade ~~mineralized~~ grit containing varicolored pebbles averaging less than 1" in diameter.

The relationship of the presence of ore in a sandstone-filled paleoscour was observed ~~Mineralization related to channeling of the ore sand horizon was seen~~ at the Green Hornet property but was not noticed at the other mines visited. No faulting of ore was seen and fracturing, though common, seemed ~~seems~~ to affect neither the continuity nor ~~or~~ intensity of the ore body ~~mineralization~~.

Uranium Mineralization is not confined to any one sandstone horizon ~~level~~ in the Salt Wash Member, though most of the production from the Notom Bench sub-area has come from the upper most 50 feet while, conversely, ~~50 ft. and~~ most of the production in the north Cainville Reef sub-~~area~~ was derived from the lower most 50 feet. Production is mainly derived from mineralized sandstone; occasionally, however, notably in the North Caineville Wash sub-area, as on the Big & Little Jim group ~~, a~~ of claims, a carbonaceous mudstone will have a grade sufficiently high ~~contain enough values in uranium~~ to make mining profitable ~~economically feasible~~.

Description of Larger ~~Mines~~ Deposits

(1) Billy's Dream Property

The claims ~~composing~~ comprising this group are situated in the Notom Bench sub-area. They were first located on July 25, 1952 by A. S. Myrup and J. S. Alden. Initial production was in September of that year when a little ~~over~~ more than 5 tons, assaying 0.13% U308 was shipped to the Climax mill in Grand Junction. The last production of record (stet) was in December 1958, although ~~Some~~ some exploration and development work took place in 1960.

This operation is unusual in that ~~an up-grader~~ a concentrator was constructed along Pleasant Creek at Notom near the mining property in order to process the large amount of low-grade ore ~~that the operators~~ believed to be present on ~~their~~ these claims. The U. S. Atomic Energy Commission estimates these low-grade deposits to total about 3,000 tons of 0.08% U308. A ~~check~~ study of the ~~up-grading~~ beneficiation ratio made by the Commission in 1959 ~~showed~~ indicated that 0.09 to 0.11% U308 ~~material~~ concentrator feed was ~~being raised~~ increased to a 0.25% to 0.35% U308 product by ~~a~~ mechanical concentrator sand-slime separation. Recently this ~~up-grader~~ has been modified to a chemical acid leach operation (see Fig. 24) in which the mill product grade is ~~, (acid leach process) and present up-graded values are~~ said by the Mio Dio Uranium Company operator, to ~~run~~ be 7% to ~~-~~10% U308.

The Billy's Dream mining operation presently consists of two short adits (see Fig. 25) in two ~~separate~~ sandstone lenses separated about 30 feet stratigraphically. An extensive amount of rim and surface stripping ~~exists~~ was done on the level of the lower drift (see Fig. 26) and a smaller amount of rim stripping on the level of the upper drift (see Fig. 27).

The ore commonly occurs as a coating of ~~T~~tyuyamunite on and between non-calcareous sand grains in a medium to coarse-grained sandstone ~~that~~ is gray to light brown in color due to the presence of iron oxides; the grains are subangular to subrounded and poorly sorted. At times the sandstone grades into a grit that contains varicolored chert and mudstone pellets averaging less than an inch in diameter. Uranium-vanadium content ~~Mineralization is found to a lesser extent~~ decreases in the grits and adjoining siltstones. The deposit is unusual in that the ore ~~The ore~~ horizons are extremely friable, almost totally lacking in cement. Limonite is present both as thin seams and small concretions.

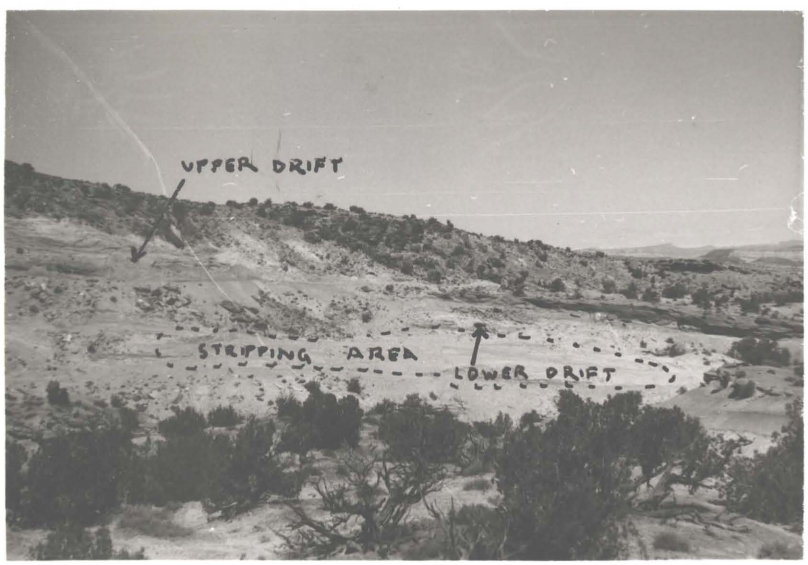
11

Figure ~~No.~~ 24

Mio Dio's concentrator ~~Upgrader~~ near Billy's Dream property

Prior to the introduction of the acid leach circuit (to right), the slurry, containing the uranium-vanadium values, entered the settling pond (in foreground), where it was dried and shipped to the mill.

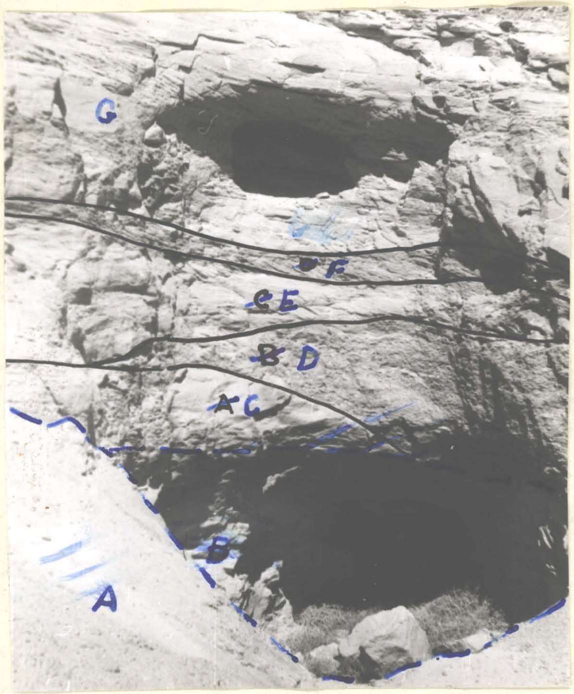
12



[Draftsman; change "stripping area" to "stripped area" R.M.K.]

Figure ~~No.~~ 25

Billy's Dream Property, viewed ~~Looking~~ north-west.



[Draftsman;
Use dashed lines
so contact is not
completely obscured
by inked line.
R.H.K.]

[In a section, units
should always be described
with highest first.
R.H.K.]

Figure ~~No.~~ 26

Billy's Dream mine, Lower ~~Drift~~ adit of

~~A. Sandstone, light gray, fine grained, well sorted. Limonite staining, Mineralized.~~

~~B. Grit, gray to buff, crossbedded, poorly sorted, chert pebbles, mineralized.~~

~~C. Sandstone, gray to buff, crossbedded, medium to coarse grained, some small lenses of gray mudstone, mineralized.~~

~~D. Sandstone, buff, medium to coarse grained, crossbedded.~~

Section consists of lithologic units B through G in Salt Wash Member of Morrison Formation;

G. Sandstone, light gray, medium grained, poorly indurated, cross laminated. Contains tyuyamunite as grains.

F. Conglomerate, dark gray to buff, pebbles 1/4 to 2" in diameter, well rounded, friable, cross laminated. Much limonite staining along cross laminae surfaces.

E. Same as F except contains mudstone galls up to 1' in diameter, mottled olive green and violet. Some tyuyamunite in zones of clear clean quartz grains.

D. Siltstone, buff, contains thin strata of quartz sandstone and well-rounded pebbles. Limonite and hematite(?). Some tyuyamunite in lower portion.

C. Conglomerate, medium gray, cross laminated, pebbles 1/4 to 1" in diameter, well rounded, occasional mudstone galls. Tyuyamunite along cross laminae surfaces and around siltstone galls. White, powdery, soluble coating (alunite?) at base.

B. Mudstone, olive green, includes sandstone unit at base similar to C. Much limonite along fractures. Jarosite.

A. Recent wind-blown sand derived from above units and deposited in a 1-year period.

Fractures trend N 30 E, dip 80 to 83° S, are devoid of uranium minerals.
75

9.1267

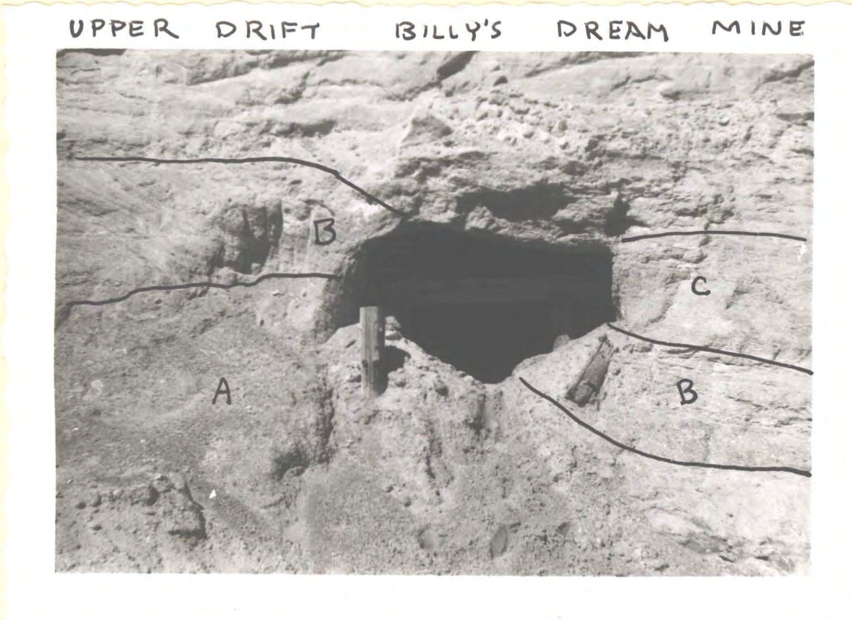


Figure ~~No.~~ 27
Billy's Dream ~~Mine~~, Upper ~~Drift~~ adit of

Transpose

A. Unconsolidated dune sand

B. Grit, medium gray, strongly crossbedded, poorly sorted, chert & mudstone pebbles $\frac{1}{4}$"-1" in diameter. Some staining by secondary uranium minerals.

C. Sandstone, light gray to buff. Med to coarse grained, poorly sorted some staining by secondary uranium minerals

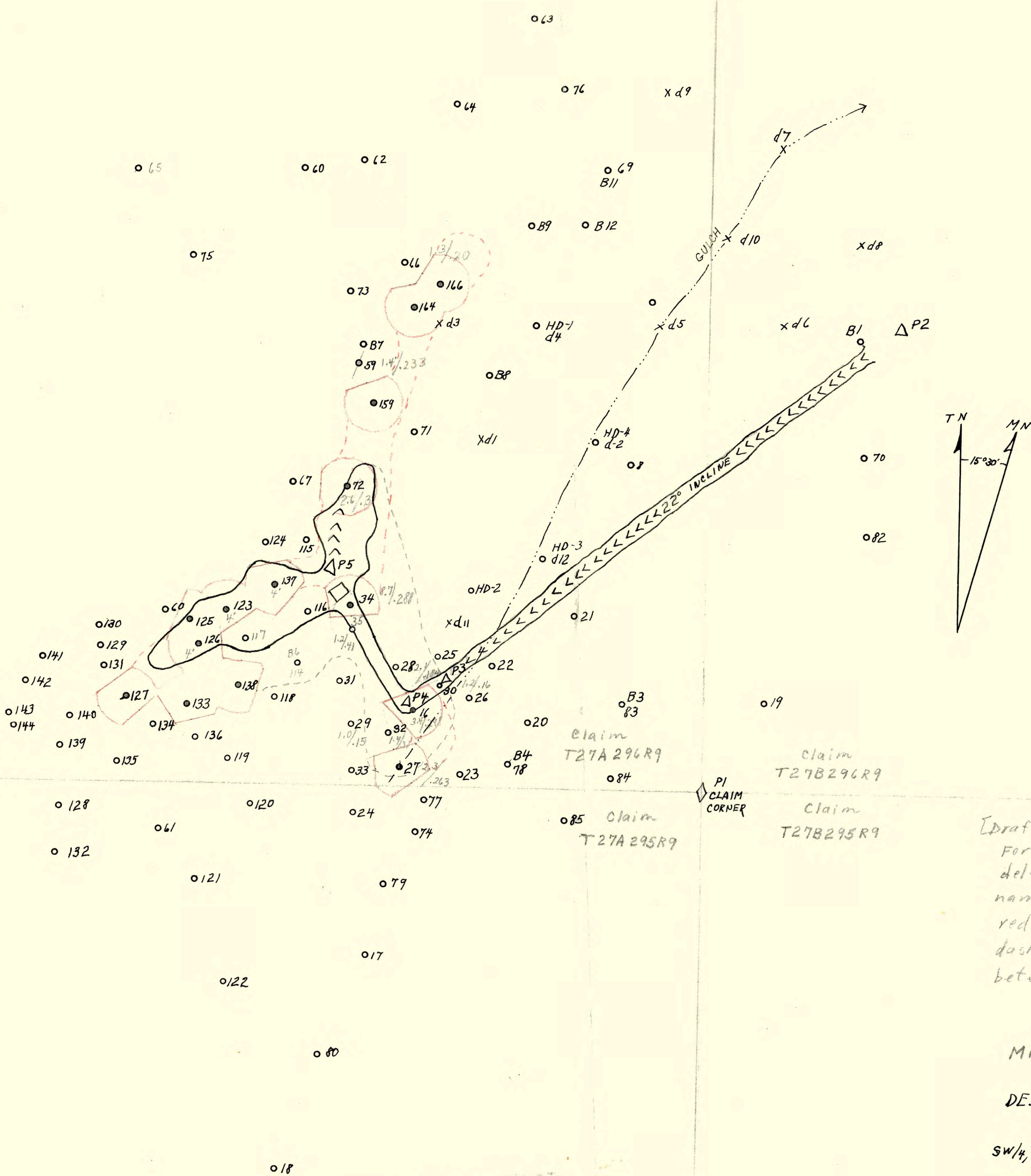
U. S. GOVERNMENT PRINTING OFFICE : 1959 O - 511171

The ore generally ~~follows bedding. Crossbedding is~~ is associated with cross laminae which are common and usually occur~~s~~ in scours within the ~~ore sand~~ host horizon. There is little or no interstitial clay and the thin mudstone seams common in nearby areas of the Salt Wash Member are entirely lacking here. Some mudstone occurs in the form of lenses, pebbles and cobbles ranging in size from 1 inch to 1 foot within the ~~sand~~ ore horizons. These fragments are usually grayish green in color and often have bleached centers. Carbon in any form seems to be entirely absent.

~~A plan map and detailed longwall map are shown in Fig. No. ___.~~

(2) Desert Mine

The Desert group of claims, in the North Caineville Wash sub-area, was located on July 1, 1955 by ~~Bob~~ Robert Hodges. Discovery of the ore body was by drilling. Initial production was attained from the Desert No. 4 claim ~~First shipment was made from this group~~ in February, 1956 ~~from the Desert No. 4 claim.~~ (Transpose) A ~~23~~ 22 degree incline (see Fig. 28) ~~has been~~ was driven 265 feet to a point 97 feet below the surface, within and near the base of the Salt Wash member ~~of the Morrison~~. 512 tons have been shipped as of January 1, 1961. There was no activity on this property from November, 1958 to January, 1961, ~~when a shipment of~~ after which 13 tons of 0.09% U308 was ~~sent~~ shipped to the Union Carbide mill at Rifle. The mine is inactive at the present time (January, 1961).



[Draftsman;
For this published version,
delete all ore reserve data,
namely thickness and grade data,
red-penciled lines, and penciled
dashed lines. Do not differentiate
between ore and non-ore holes.
R.W.K.]

Figure 28
Mine and drill hole map
of the
DESERT ~~[CLAIM NO.]~~ MINE,
~~[T27A 296 R9]~~

SW/4, NW/4, Sec. 29, T27S, R9E, S.L.M.
WAYNE CO, UTAH

TRANSIT & STADIA
1" = 50'
FEB. 10, 1958

Legend
o 130 Location and number of drill hole

As revealed by past drilling restricted to the area just east of the outcrop of the base of the Morrison Formation, the mine is situated in a relatively large area underlain by sub-ore grade uranium, apparently in isolated and irregular-shaped pods. The host rock, a massive-bedded sandstone dipping 20° southeast, is exposed between the dry wash west of the mine and the base of the Morrison west of the wash. It is interesting to note that carbonaceous material, an ore control common in the mine, is not recognizable in the outcrop of the host horizon. The area of anomalously high radioactivity is known to exist on parts of sections 29 and 31, and assumingly on section 30, of township 27 south, range 9 east.

The ore in the Desert mine consists principally of uraninite and corvusite(?) and is associated with copper and iron sulfides. The uranium-vanadium ratio, based on past production, is 1 to 2, with carbonates of calcium and other cations averaging 13.5%. The host rock is a light-tan, fine- to coarse-grained, poorly-sorted and strongly-crossbedded sandstone. In places the sandstone grades into a grit containing varicolored, well-rounded pebbles 1/2 inch or less in diameter.

The crossbedding ~~results from~~ is associated with minor scouring within the ore-bearing sandstone and is often ~~outlined~~ accentuated by bands of limonite or carbon seams. Calcite is present both as a cement in the sand and as small crystals filling fractures and small vugs within carbonized woody material. Dark gray carbonaceous mudstone is found both as seams and as inclusions within the sand. Some staining by secondary uranium minerals is found on and within the mudstone. Ore in the mine is associated with carbonaceous material which occurs both as thin seams outlining bedding and larger fragments which probably represent carbonized wood. Some of this carbonaceous material was ~~is~~ found coating vertical fractures which raises the possibility of at lease some of the carbon being in liquid form. Some support is given this theory by the fact that woody structure seems to be absent from the carbon -coated ~~coating~~ fractures.

? or, gaseous, that they are powder forms I would suggest deleting this. R.W.K.

(3) Big and Little Jim Group

These claims immediately adjoin the Desert Group to the south. They were located in July and September 1953 by J. M. Thornton and Karl Mathis. Initial production was in December 1953 from an open pit working on the Big Jim #2 claim. As of January 1, 1961 there were 22 small open pit workings, one 30 ft. incline, one 40 ft. drift and a 55 ft. drift recently ~~just~~ completed on the Little Jim No. 5 claim. This group has produced from two sandstone horizons within ~~in~~ the Salt Wash Member; most of the production so far has come from the lower horizon which has been intensively worked in the southern portion on the claim group. The ore here is associated with a zone of carbonaceous mudstone and siltstone ranging in size from 3" to 1' in thickness. The mudstone is medium to dark gray, evenly bedded and fissile. The overlying siltstone is medium gray and strongly crossbedded. The higher ore values seem to be concentrated in the mudstone.

Production from the northern part of the group is derived from ore associated with carbonaceous trash contained in a medium- to coarse-grained sandstone occasionally ranging into grit size. This sandstone is light gray to buff, poorly sorted and extremely crossbedded. The grit has sub-rounded pebbles of varicolored chert and gray mudstone; these pebbles have a tendency to follow crossbedding. The carbonaceous trash ranges in size from small specks to limb fragments 3 in. in diameter. It seems to generally follow bedding but is not limited by it. Limonite is common in the trash zones as

(

specks, thin bands and concretions. There is some limonite in adjacent barren sand material but it seems to be limited to small concretions averaging 3' in diameter. Calcite is common both as a cement in the sand and small crystals along fractures. Some coating of ~~T~~yuyamunite is evident on weathered surfaces of the ore-bearing sandstone.

(4) Green Hornet ~~G~~roup (Also known as Serf or Merin Smith ~~G~~roup)

The Green Hornet group of claims, in the Notom Bench sub-area, was located during the first ~~1/2~~ 6 months of 1954 by Merin and Cora Smith. Initial mining consisted of rim and surface stripping followed by hand sorting. The first production was shipped in July 1954 and consisted mostly of mineralized logs. Later shipments came from mineralized zones in sandstone scours and carbonaceous clay seams.

Underground mining began in the Fall of 1958 on a small ore body located by drilling. The ore proved thinner and of lower grade than had been predicted from gamma ray logging of drillings and the mining was abandoned after a few loads had been shipped. The group last produced in the third quarter of 1959 and has been inactive since that time. The underground workings are partially flooded and inaccessible. The Green Hornet property has derived its production from a sandstone bed in the upper part of the Salt Wash Member. [Mineralization seems to be related to channeling within the ore horizon (See Fig. 29).] ? [See comment, Fig. 28, R.H.K.]

Mineralization is localized along thin zones of carbonaceous material. This carbon is present as carbonaceous mud seams, as small specks and as larger coalified tree limbs up to several inches in diameter. Flattening parallel to bedding is common in the larger material. Often the carbon forms a thin film at the base of small scours within the ore sand. Both limonite and pyrite are found associated with the carbonaceous material. Calcite is present both as a cement in the ore sand and as small crystals filling fractures and small vugs. A limited amount of [Little or no] staining by secondary (I saw some) R.H.K.

~~XXX MINERALIZATION~~

Figure ~~No.~~ 29

Uranium ~~M~~ineralization associated with channeling, Green Hornet ~~M~~ine

Area of mineralization is indicated on pillar between portals.

[The base of the channel as drawn seems to cross continuous sandstone beds. Also, unless there's ore in the left drift, the ore shown here is below the channel which questions the association of this ore to channel fill, thus questions the value of this photo. I would suggest deleting it.

R.W.K.]

9.1267

 7

uranium minerals was noted within the mineralized zones. Dense growth of Astragalus Pattersonii (?) was noted growing in areas that had been surface stripped. This plant, a selenium indicator, is often found associated with uranium ~~mineralization~~ occurrences in this area.

Mineralogy

Mineralogical ~~Samples~~ samples were taken at all described localities and submitted to ~~Ralph Austin of~~ the ~~Grand Junction~~ mineralogy laboratory of the U. S. Atomic Energy Commission Grand Junction Operations Office, Grand Junction, Colo. for petrographic analyses, but no results have been released. ~~These localities are described individually but in general~~ However, it may be said that ~~the~~ uranium ~~-vanadium~~ is commonly associated with vanadium and calcium, rarely with copper, and that

 9

~~mineralization takes~~ minerals are in the form of the oxidized minerals tyuyamunite and carnotite in near-surface ~~oxidized~~ occurrences and the unoxidized minerals uraninite and corvusite in deeper deposits. All deposits except the Desert deposit have undergone surficial oxidation.

~~Production shows an average uranium-vanadium ratio of 1:3 for the area as a whole; the ratio on individual properties varies from 1:4 to 8:1.~~

Ore Controls

Investigation of the individual deposits has pointed out features that seem to be common to most of the properties described in this report. To what extent each contributed to producing the required spelling? physico-chemical environment necessary for uranium deposition cannot be strictly defined from the field work associated with this report. However, ~~Some~~ some general conclusions may be made~~, however~~. Local controls seem to be similar to those found in other areas where uranium mineralization occurs in a sedimentary environment of fluvial origin.

Uranium-vanadium ~~The~~ mineralization generally occurs in a ~~sand that is~~ light-gray to buff, medium-to coarse-grained and strongly crossbedded sandstone. This sandstone is characteristically thick, poorly sorted, and, in at least one ~~instance,~~ locality, the Green Hornet mine, obviously related to channeling~~, (Green Hornet mine).~~. This host rock ~~It~~ presumably represents a facies that, because of higher porosity and permeability, ~~is more purpus and one that~~ forms a better ~~pathway~~ conduit for ore-forming solutions than the adjacent flood plain deposits which have a higher percentage of mudstones and siltstones. Secondary scouring within the ore sands is # common and is often ~~outlined~~ accompanied by carbonaceous material ~~and limonite~~. These scour-filled sandstones encompass the same size-range of material as ~~the main~~ sandstone which do not occupy scours, but have poorer sorting, steeper crossbeds~~ding~~ and more angular material. Occasionally the ~~ore~~ host sandstone grades into a grit with pebbles of varicolored chert and gray mudstone or into a silty mudstone. Mineralization, though present in these rocks, usually is not as strong or persistent.

Carbonaceous material, both in the form of finely-disseminated specks and as larger carbonized wood fragments, is commonly associated with uranium-vanadium mineralization. Limonite and more rarely, pyrite is found in both barren and mineralized rock but is definitely more heavily concentrated in the latter, commonly in the form of bands, thin streaks and small specks. Calcite is prevalent both as cement and as small crystals filling fractures and small openings in the ore sand ~~and~~ as well as in carbonized wood.

Potential reserves

All properties that have produced over 50 tons are located in areas that have a thinning of the Cedar Mountain Formation of Early Cretaceous age (see Figure ~~No.~~ 15). This thinning may be ~~is~~ interpreted ~~(Page No.___ and figure No.___)~~ as revealing the presence of post-Cedar Mountain and pre-Naturita minor structural folds. Young (1957), independantly working in the Green River Mining District about 50 miles to the north of the area of this report, found that the location of the Green River ore bodies, also within the Salt Wash Sandstone Member of the Morrison Formation, ~~ore bodies there~~ seem~~s~~ to parallel areas in which the Cedar Mountain Formation thins by subsequent erosion. ~~the anticlinal axes of folds of post-Cedar Mountain and pre-Naturita age.~~

Ore bodies in the North Caineville Wash subarea seem to align themselves along ~~the flanks of~~ zones in which the Salt Wash Member shows an anomalous thickening (see Fig. 5). Areas where the above two features coincide are believed to represent areas of potential reserves (see Fig. 30). ~~Future exploration, therefore,~~ The presence of additional isolated orebodies seems indicated eastward ~~downdip~~ from the Desert group toward the Yellow Canary group of claims on northern Little Wild Horse Mesa east of the Caineville area as well as ~~and~~ along areas of Salt Wash outcrop on the north rim of North Blue Flats.

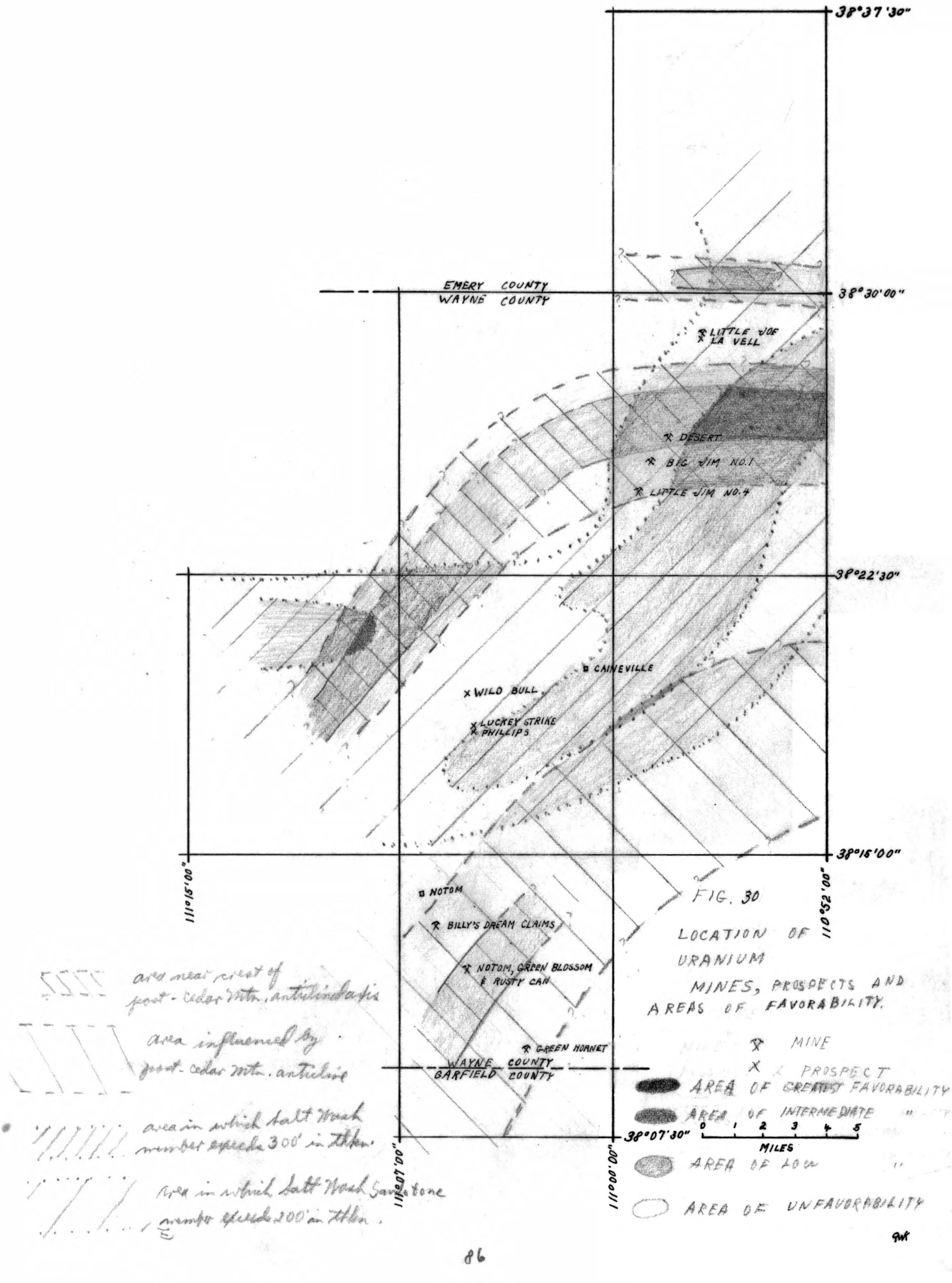


FIG. 30

LOCATION OF URANIUM MINES, PROSPECTS AND AREAS OF FAVORABILITY

Conclusions

The initial purpose of determining ~~local~~ surface stratigraphic and structural features are presented herein. The second purpose of the program, namely, to determine possible genetic relationships between these geologic features and known occurrences of scattered mineralization, are herewith presented.

Negative factors are:

1) No apparent relationship of deposit distribution to the major Tertiary structural features of the area.

2) No apparent relationship of deposit distribution to faulting or jointing, whether of Tertiary or "rejuvinated pre-Cambrian" origin.

3) No apparent relationship of deposit distribution to intrusives, nor can it be shown that these intrusives acted as sources of uranium-vanadium ore deposits in this area.

4) No apparent relationship of deposit distribution to areas of anomalously thick bleached sections of either the Morrison Formation or the Cedar Mountain Formation.

5) No relationship of deposit distribution to either the present topography or position of the present ground water table.

Conclusions (concluded)

Positive factors are:

1) Two major uranium types of ore, namely oxidized and unoxidized deposits occur in the area. Oxidized ore deposits can be demonstrated to exist in close proximity to the present outcrop distribution of the host horizon while unoxidized ore bodies are generally found to exist ~~unaltered~~ under deeper protective cover.

2) All uranium-vanadium deposits appear to be locally restricted to the basal member of the Morrison Formation, the Salt Wash Sandstone Member.

3) Based on present discoveries, uranium deposits average less than 200 tons, but may reach as much as 2,000 ton ore bodies. SEE ECONOMIC SECTION

4) Anomalous thickening of the host rock, namely coarse clastics of the Salt Wash, by cut and fill at the expense of older sedimentary rocks acted as favorable loci for uranium deposits.

5) Presence of carbonaceous vegetal material in the host horizon appears to ~~ha~~ have acted as uranium-vanadium precipitators while presence of siliceously replaced vegetal material acted unfavorably to such precipitation and accumulation

6) Distribution of favorable ground appears to be oriented along several east-west belts crossing the area.

7) The reason for the existance of these favorable belts is not completely understood. They appear, however, to coincide with areas in which Cedar Mountain deposits can be demonstrated to be anomalously thin (see fig. 15). The implication that slight ~~(see fig, 15)~~ post-Cedar Mountain wrinkling resulted in the effected host rock to be selectively mineralized by mineral-bearing aqueous solutions must be tested in similar areas in which Cedar Mountain deposits or, where absent, Brushy Basin deposits appear to be thinned by pre-Naturita tectonics ~~of pre-Naturita age~~.

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