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GEOLOGY AND RESOURCES OF THE TAR SAND TRIANGLE, SOUTHEASTERN UTAH

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TAR SAND TRIANGLE - THE U.S. LARGEST TAR SAND DEPOSIT?

by

G. F. Dana[1], R. L. Oliver[2], and J. R. Elliott[3]

ABSTRACT

The Tar Sand Triangle is located in southeastern Utah between the Dirty Devil and Colorado Rivers and covers an area of about 200 square miles. The geology of the area consists of gently northwest dipping strata exposed in-the box canyons and slopes of the canyonlands morphology. Strata in the area range in age from Jurassic to Permian. The majority of tar sand saturation is found in the Permian White Rim Sandstone Member of the Cutler Formation. The White Rim Sandstone Member consists of a clean, well-sorted sandstone which was deposited in a shallow marine environment. Resources were calculated from analytical data from the three coreholes drilled by the Laramie Energy Technology Center and other available data. The total in-place resources, determined from this study, are 6.3 billion barrels. Previous estimates ranged from 2.9 to 16 million barrels. More coring and analyses will be necessary before a more accurate determination of resources can be attempted.

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INTRODUCTION

The Tar Sand Triangle is located in the triangular shaped area between the Dirty Devil River and the Colorado River in southeastern Utah (Figure 1). The tar sand deposit covers an area approximately 10 by 20 miles with an areal extent of about 200 square miles. The majority of the area is shown in the southeast corner of the Salina 1° x 2 topographic sheet in the eastern portions of Garfield and Wayne Counties (Figure 2). Much of the deposit underlies Federal lands. A few hundred acres in the northeastern part are within Canyonlands National Park and about half of the area is within the Glen Canyon Recreation Area (Figure 3). The Triangle can be reached from the south by State Highway 95 which runs from Blanding to Hanksville, Utah. Access from the north is by all weather gravel roads.

Many exploratory wells have been drilled in the Tar Sand Triangle. The locations of these wells are shown on the base map in Figure 3. Wells identified with numbers have information available to the public, which is listed in Table 1. Those labeled with letters have no available analytical data. These wells are listed in Table 2. Wells labeled with a "P" designate proprietary wells, whose approximate location and operator (if known) are listed in Table 3. Gamma ray geophysical logs and/or core and cuttings descriptions are available for many of the wells listed in Table 1. These data sources were used to select formation tops which served as control points for the construction of structural and stratigraphic cross sections. Tables 4 and 5 list this data in depths and feet above sea level.

Previous Investigations

Discussion of previous investigations is limited to public information. A number of private companies have conducted resource investigations in the Tar Sand Triangle. One company has conducted a short-term in situ experiment in the area but almost all of the data is proprietary. A number of geophysical logs were used in stratigraphic correlations and several sources were used to pick geologic formation and member tops and bases.

One of the major contributors to information on the Tar Sand Triangle has been Howard Ritzma, former employee of the Utah Geological and Mineralogical Survey, who has, with others, evaluated most of the tar sand deposits in Utah (Ritzma, 1969; Campbell and Ritzma, 1979). His field work and other investigations have resulted in the highest estimate of 12-16 billion barrels of oil in place. Recent estimates by Lewin and Associates (Interstate Oil Compact Commission, 1984) resulted in lower estimates. More characterization and corehole data is required to resolve the resource estimate.

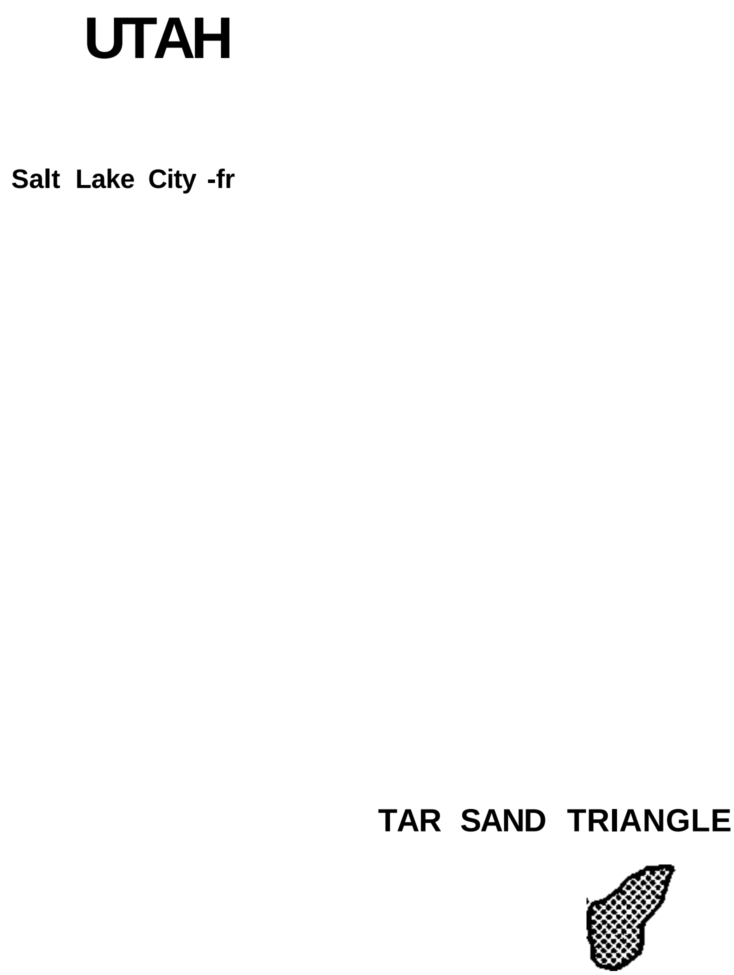

Figure 1. Location map for the Tar Sand Triangle, southeastern Utah.

Figure 2. The Tar Sand Triangle area showing topography and approximate boundary of the deposit.

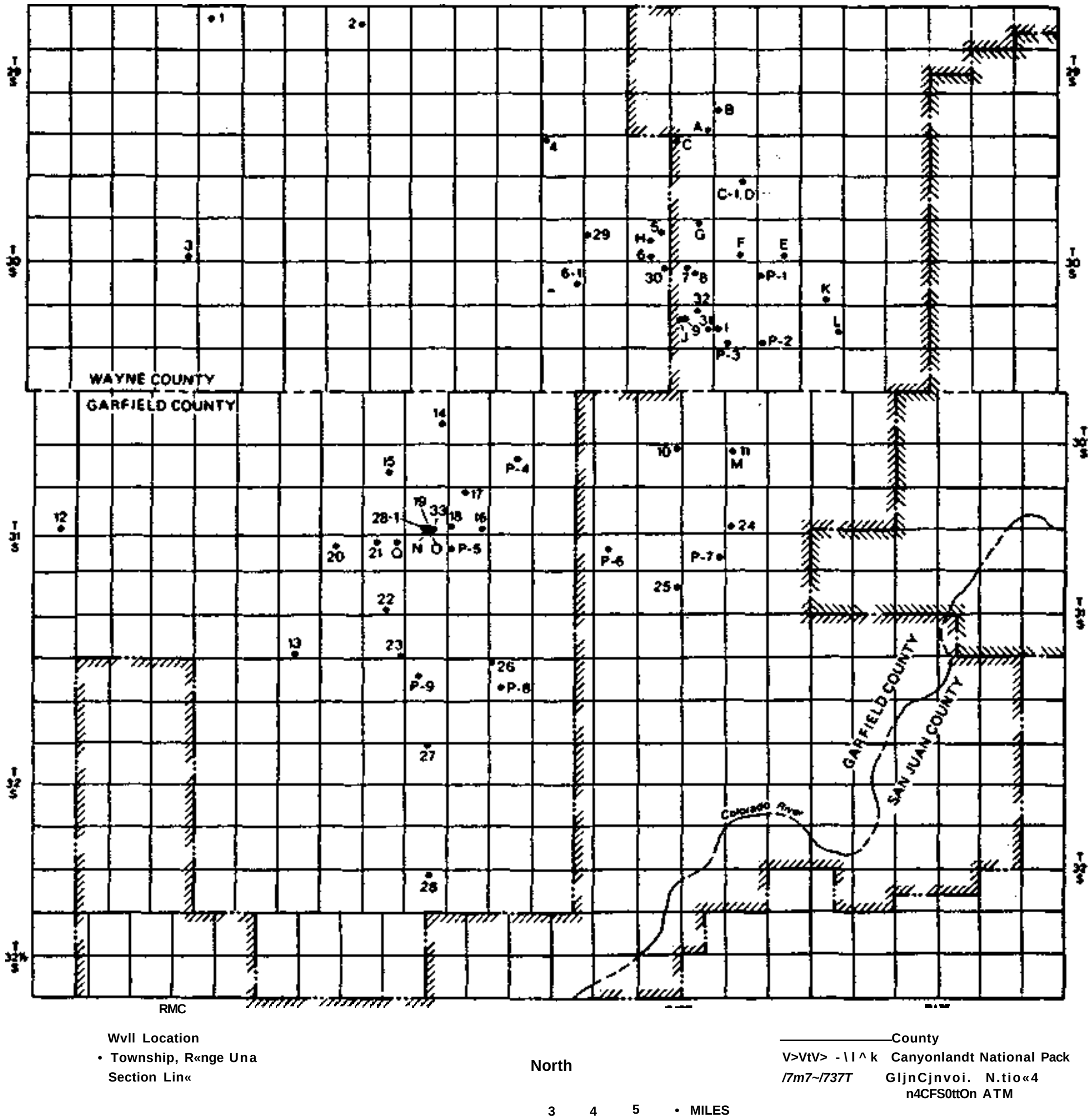

Figure 3. Base map showing locations of wells drilled in the Tar Sand Triangle area (numbered wells - data available, lettered wells - no available data, P-numbered wells - proprietary).

TABLE 1. WELL DATA AVAILABLE FROM THE TAR SAND TRIANGLE AREA, SOUTHEASTERN UTAH

HAP I	COMPANY NAME	WELL NAME	LOCATION	ELEV (FT.)	TOTAL DEPTH (FT.)	TOP WRSS DEPTH (FT.) (ELEV. (S.L.)	BOT. WRSS DEPTH (FT.) (ELEV. (S.L.)	THICKNESS WRSS (FT,) (SATURATED)	COMMENTS
1	Frank H. Whitney	11 Whitney-Federal	29S, 14E, Sec. 23, SE NW	5818 gr	5018	2070 (3748)	253D (3288)	460 (")	
2	Conoco	11 Hoover-Federal	29S, 15E, Sec. 20, SE NE	6249 kb	6886	2205 (4044)	2635 (3614)	430 <--)	
3	Mountain Fuel Supply Co.	#4 Dirty Devi Unit	30S, 14E. Sec. 15, (SW) SE SE	5477 kb	4494	1670 (3B07)	(")	(")	
4	Skyline Oil Co.	#6-11 Federal	30S, 16E, Sec. 6, NW NW	6415 kb	2156	1955 (4460)	(")	>200 (")	T.D. in White Rin
5	Sagadahoc Oil *i* Gas Corp.	11 Skyline State	30S, 16E, Sec. 16, SE NE	6362 gr	1712	1470 (4892)	(-)	>240 (50)	T.D. in White Rin
6	Oil Developnent Co. of Utah	116-1 Gordon Flats Unit	305, 16E, Sec. 16, SW SE	6298 kb	1676	1420 (4878)	(")	>230 .(58)	T.D. in White Rin
6-1	Oil Developnent Co. of Utah	119-1 Gordon Flats Unit	30S, 16E, Sec. 19, (SW NE) NE SE	6231 gr	1735	1530 (4701)	(")	>210 (82)	T.O. in White Rin
7	Sagadahoc Oil & Gas Corp.	#2 Skyline Federal	30S, 16E, Sec. 22, NE NW	6381 gr	1581	1344 (5037)	(")	>240 (>89)	T.D. in White Rin
8	01) Development Co. of Utah	' #22-1 Gordon Flats Unit	30S, 16E, Sec. 22, (SE NE NW) SW NE	6542 kb	1670	1392 (5150)	1656 (4886)	264 (20D)	
9	Phillips	11 French Seep Unit	30S, 16E, Sec. 27, SE NW	6465 kb	5916	1390 (5075)	1618 (4847)	228 (115)	
10	Mobil Oil Corp.	#41-33 Robbers Roost	30^5. 16E, Sec. 33. NE NE	6604 df	4380	1425 (5179)	1610 (4994)	185 (>130)	
11	LETC/DOE	TST-2	30HS, 16E, Sec. 35, (SE) NW NW	6812 gr	1582	1412« (5400)*	>1580 (>5232)	>168 (>163)	On pad of Shell #6 (Estimated thickness of WRSS for Shell 16 • 239'?)
12	Standard Oil of California	#1 Bart Hesi	31S, 13E, Sec. 13, (NE) SW SE	4499 gr	4390	S13 (3986)	870 (3629)	357 (")	

* Estl«ated. >• White Rial Sandstone, gr * ground level, kb - Kelly bushing, df - derrick floor

TABLE 1. (Continued)

MAP #	COMPANY NAME	WELL NAME	LOCATION	ELEV (FT.)	TOTAL OEPTH (FT.)	TOP WftSS OEPTH (S.L.)	BOT. WftSS DEPTH (S.L.)	THICKNESS WRSS (FT.) (SATURATED)	COMMENTS
13	Kirkwood Oil & Gas	114-36 Technology	31S, 14E, Sec. 36, (NE) SE SW	4823 gr	1000	200 (4623)	435 (4388)	235 (14)	
14	Kirkwood Oil » Gat	144-4 White Kin	31S. 15E, Sec. 4, (SE) NE SE	6034 gr	1640	1400 (4634)	(")	>156	
IS	Kirkwood Oil & Gas	123-8 Magnus	31S, 15E, Sec. 8, (SE) NW SE	5084 gr	1100	483 (4601)	854 (4230)	371 (>57)	
16	Kirkwood Oil / Gas	#44-15 Garfield	31S, 15E. Sec. 15, (SW) SE SE	S321 gr	1000	507 (4814)	810 (4511)	303 (124)	
17	Kirkwood Oil t Gas	#21-15 Winfield	31S, 15E, Sec. IS, (NE) NE NW	6127 gr	1800	1424 (4703)	(")	(186)	
16	Kirkwood Oil I Gas	#14-15 Reiifngton	31S, 15E, Sec. IS, (NW) SW SW	5307 gr	1540	529 (4778)	830 (4477)	301 (169)	
19	Kirkwood Oil t Gat	#34-16 State	31S, 15E, Sec. 16, SW SE	5058 gr	620	32S (4733)	>620 (4438)	>295 (175)	T.D. in White Dili
20	Superior Oil Co.	#22-19 Utah Southern-Govt	31S, ISE, Sec. 19, SE NW	48S0 kb	4306	244 (4606)	577 (4273)	333 (190)	
21	Kirkwood Oil t Gas	#22-20 Monroe	31S, 15E, Sec. 20, (NE) SE NW	4988 gr	806	307 (4681)	643 (4345)	336 (86)	
22	Kirkwood Oil I Gas	#33-29 Cromwell	31S, ISE, Sec. 29, (NW) SW SE	5060 gr	700	228 (4832)	487 (4573)	259 (60)	
23	Kirkwood Oil t Gat	#44-32 State	31S, 15E, Sec. 32, (SE) SE SE	5001 gr	700	110 (4891)	341 (4660)	231 (...)	
24	LETC/DOE	TST-J	31S, 16E, Sec. 2, (NE) SW SW	6882 gr	""	1398* (5484)"	(")	<")	Abandoned at 1482 ft. in the White R1»
25	LETC/DOE	TST-4	31S, 16E, Stc. 16, (NE) SE NE	6859 gr	1555	1J95* (5464)»	1525* (5334)*	130* (123)	

TABLE 1. (Continued)

MAP I	COMPANY NAME	WELL NAME	LOCATION	ELEV (FT.)	TOTAL OEPTH (fT.)	TOP WRSS OEPTH (S.L.)	BOT. WRSS OEPTH (S.L.)	THICKNESS WRSS (FT.) (SATURATED)	COMMENTS
26	Kirkwood Oil S. Gas	IH-2 State	32S, 15E, Sec. 2, (NW) NW NW	5320 gr	520	140 (5180)	320 (5000)	180 (84)	
27	Kirkwood Oil S. Gas	131-16 State	32S, 15E, Sec. 16, (NE) NW NE	5535 gr	1780	397 (5138)	585 (4950)	188 (26)	
28	Texas Pacific Coal & Oil Co.	11 USA-Rock Canyon	32S, 15E, Sec. 33, (C) NW NE	5400 gr	5087	130 (5270)	290 (5110)	160 (80)	
2B-1	Kirkwood Oil S. Gas	134-166 State	31S, 15E, Sec. 16, SW SE	5058 gr	800	287 (4771)	(")	178?	Located very close to Kirk-wood Oil & Gas #34-16 State (*19 on Map Key)
29	Shell Oil Co.	#7	30S, 16E, Sec. 17, SW NW	6163 kb	1798	1481 (4682)	(")	>167 (>77)	
30	Shell Oil Co.	#1	30S, 1EE, Sec. 21, (NE) NE NE	6333 kb	1E40	1375 (4958)	(")	>197 (>161)	
31	Oil Development Co. of Utah	127-1 Gordon Flats Unit	30S, 16E, Sec. 27, NE SE	6567 kb	1680	1432 (5135)	1645 (4922)	213 (196)	
32	Shell Oil Co.	19	30S, 16E, Sec. 27, NW NE	6540 kb	1677	1428 (5112)	1677 (4863)	249 (249)	
33	Kirkwood Oil & Gas	134-16A State	31S, 15E, Sec. 16, SW SE	5088 gr	440	319 (4769)	(")	(>118)	
	Tennessee Gas Transmission	TGTS 33	29S, 12E, Sec. 33			2260 (")	2460 (")	200 (")	Out of base map area
	Sinclair Oil	#1 Orange Cliffs	29S, 16E, Sec. 8, SW SE	5874 gr	6675	1640 (4234)	1954 (3910)	324 (")	Out of base map area
	Tennessee Gas Transmission	ll-A USA- Poison Springs	31S, 12E, Sec. 4, (SW) SW NE	4889 gr	6491	2273 (2616)	2725 (2164)	452 (-)	Out of base map area
	Tennessee Gai Trantalison	12-A USA- Potion Sprlngl	31S, 12E, Sec. 4, NE SE	4883 gr	5358	2252 (2631)	2668 (2215)	416 (")	Out of base nip area

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TABLE 2. WELL LOCATIONS WITH NO AVAILABLE ANALYTICAL DATA, TAR SAND TRIANGLE, SOUTHEASTERN UTAH

	COMPANY NAME	WELL NAME	LOCATION	ELEV (FT)	TOTAL DEPTH (FT)	COMMENTS
	Texaco		29S, 16E, Sec. 34 SE SE	6550 gr*	2200	
	Millard		29S, 16E, Sec. 35 (SW) SW NW	6705 gr		
	Texas Production		30S, 16E, Sec. 3 NW NW			Reported no saturation
1	Shell Oil Co.	*li*	30S, 16E, Sec. 11 NW NE	6423 kb	1963	
	LETC/OOE	TST-1	30S, 16E, Sec. 11 (SW) NW NE	6406 gr	1220	Abandoned at 1200' in Moenkopi on pad of Shell 18
	Oil Oevelopntnt Co. of Utah		30S, 16E, Sec. 13 SW SE	5020 gr*		
	Oil Development Co. of Utah		30S, 16E, Sec. 14 SW SE			
C	Sagadahoc Oil 4 Gas Corp.	fl Federal	30S, 16E, Sec. 15 NW NE	6645 gr	1727	
H	Sagadahoc Oil 4 Gat Corp.	13 Skyline State	30S, 16E, Sec. 16 NW SE	6280 gr*		
	Altex Oil Co.	fl Government	30S, 16E, Sec. 26 (SE) NW SW	6614 gr 6626 kb	1666	
	Shell Oil Co.		30S, 16E, Sec. 27 SE NW	6470 gr*		
	Oil OevtlopMnt Co. of Utah		30S. 17E, Sec. 19 SW SE			
	Oil Development Co. of Utah		30S, 17E, Sec. 30 NE SE			
	Shell Oil Co.	16	30>sS, 16E, Sec. 35 NW NW	5423 gr		Same pad as 111
	Kirkwood Oil 4 Cat	134- 16C	31S, 15E, Sec. 16 SW SE	5058 gr	510	Located very close to 119
O	Kirkwood Oil • Gas	134-160	31S, 15E, Sec. 16 SW SE	5058 gr		Located very close to 119
q	Kirkwood Oil • Gas	141-20 Etsttx	31S, 15E, Sec. 20 (NE) NE NE	4941 gr		

* Estimated

TABLE 3. COREHOLES IN THE TAR SAND TRIANGLE WITH PROPRIETARY STATUS

Map #		Company Name	Well Name	Location
P-l		Shell Oil Co.		30S, 16E, Sec. 24, SW NW
P-2		Shell Oil Co.		30S, 16E, Sec. 25, SW SW
P-3		Shell Oil Co.		30S, 16E, Sec. 26, SE SW
P-4		Unknown		31S, 15E, Sec. 11, SW NE
P-5		Unknown		31S, 15E, Sec. 22, SW NW
P-6		Unknown		31S, 16E, Sec. 8, SE NW
P-7		Unknown		31S, 16E, Sec. 10 (?), NE SE (?)
P-8	v	Unknown (Arco?)		32S, 15E, Sec. 2 NE SW (?)
P-9		Unknown (Arco?)		32S, 15E, Sec. 4 SE NW (?)

Locations identified from "Major Tar Sand and Heavy Oil Deposits of the U.S.", Figure 125, page 209.

TABLE 4. FORMATION TOPS, IN DEPTHS AND FEET ABOVE SEA LEVEL, PICKED FROM GAMMA RAY LOGS

KAP r (ELEV.)	NAVAJO (S.L.)	KAYENTA (S.L.)	WINGATE (S.L.)	CHINLE (S.L.)	MOSS BACK (S.L.)	HOENKOPI (S.L.)	UPPER WHITE RIM (S.L.)	WHITE RIH (S.L.)	ORGAN ROCK (S.L.)	CEDAR MESA (S.L.)	OLDER PERHIAN (S.L.)
1 (5818)	...	...	....	....	....	....	2010 (3808)	2070 (3748)	2530 (3288)	2640 (3178)	....
2 (6249)	225 (6024)	745 (5504)	1015 (5234)	1315 (4934)	1715 (4534)	1765 (4484)	2160 (4089)	2205 (4044)	2635 (3614)	2755 (3494)	3590 (2659)
4 (6415)	...	490 (5925)	740 (5675)	1015 (5400)	1410 (5005)	1510 (4905)	1910 (4505)	1955 (4460)			
5 (6362)	...	...	245 (6117)	570 (5792)	970 (5392)	1070 (5292)	1450 (4912)	1470 (4892)			
6 (6298)	...	—	185 (6113)	505 (5793)	915 (5383)	1005 (5293)	1395 (4903)	1420 (4878)			
6-1 (6231)	...	...					1500 (4731)	1530 (4701)			
8 (6542)	...	...	197 (6345)'	502 (6040)	930 (5612)	1000 (5542)	1360 (5182)	1392 (5150)	1656 (4886)		
9 (6465)	...	...	175 (6290)	478 (5987)	868 (5597)	988 (5477)	1330 (5135)	1390 (5075)	1618 (4847)	1768 (4697)	2642 (3823)
10 (6604)	...	—	....				1390 (5214)	1425 (5179)	1610 (4994)	1750 (4854)	
12 (4499)	•••	...	....	....			470 (4029)	513 (3986)	870 (3629)	1040 (3459)	
13 (4823)	″••		....				180 (4643)	200 (4623)	435 (4388)	590 (•1233)	
15 (5084)	...	...	....			56 (5028)	460 (4624)	483 (4601)	854 (4230)	899 : (4185)	
20 (4850)	...	...					195 (4655)	244 (4606)	577 (4273)	700 (4150)	
23 (5001)	...	...					85 (4916)	110 (4891)	341 (4660)	488 (4513)	
26 (5320)	...	...	....	....			125 (5195)	140 (5180)	320 (5000)	435 (4885)	
27 (5535)	...	—					380 (5155)	397 (5138)	585 (4950)	800 (4735)	1642 (3893)
28 (5400)	—	...						130 (5270)	290 (5110)	500 (4900)	1310 (4090)

Upptr niabtr * depth In fttt
(lowtr mafctr) • fttt ibovt >tt ltvtl

TABLE 5. FORMATION TOPS, IN DEPTHS AND FEET ABOVE SEA LEVEL, PICKED FROM CORE AND CUTTINGS DESCRIPTIONS

WAP * (ELEV.)	VINGATE (S.L.)	CHINLE (S.L.)	MOSS BACK (S.L.)	HOENKOPI (S.L.)	UPPER WHITE RIH (S.L.)	WHITE RIH (S.L.)	ORGAN ROCK (S.L.)	CEOAR MESA (S.L.)
11 (68)5)	180 (6635)	580 (6235)	950 (5865)	1005 (5810)		1412 (5403)		....
14 (6034)	...	680 (5354)	? ?	1060 (4974)	1320 (4714)	1400 (4634)	....	....
16 (5321)	...	...	? ?	110 (5211)	450 (4871)	507 (4814)	810 (4511)	820 (4501)
17 (6127)	—	450 (5677)	7 7	1020 (5107)	1352 (4775)	1424 (4703)		
IS (5307)	...	...	?	160 (5147)	470 (4837)	529 (4778)	830 (4477)	840 (4467)
19 (5058)	...	—	—		250 (4808)	325 (4733)	...	...
a (4966)	—	...	...		2C4 (4724)	307 (4681)	643 (4345)	680 (4308)
22 (5060)	...	...	...		184 (4876)	228 (4832)	487 (4573)	556 (4504)
24 (6682)	2007 (6682)	610 (6272)	925 (5957)	1010 . (5872)		1398 (5484)	...	...
25 (6859)	155 (6704)	570 (6289)	930 (5929)	990 (5869)		1395 (5464)	...	...

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Upper Number ' Oepth tn feet
(Lower Number) * Feet above sea level

GEOLOGY

The geology of the Tar Sand Triangle consists of northwest gently dipping Paleozoic and Mesozoic strata with only minor fracturing and faulting. The general geology of the area is shown in Figure 4.

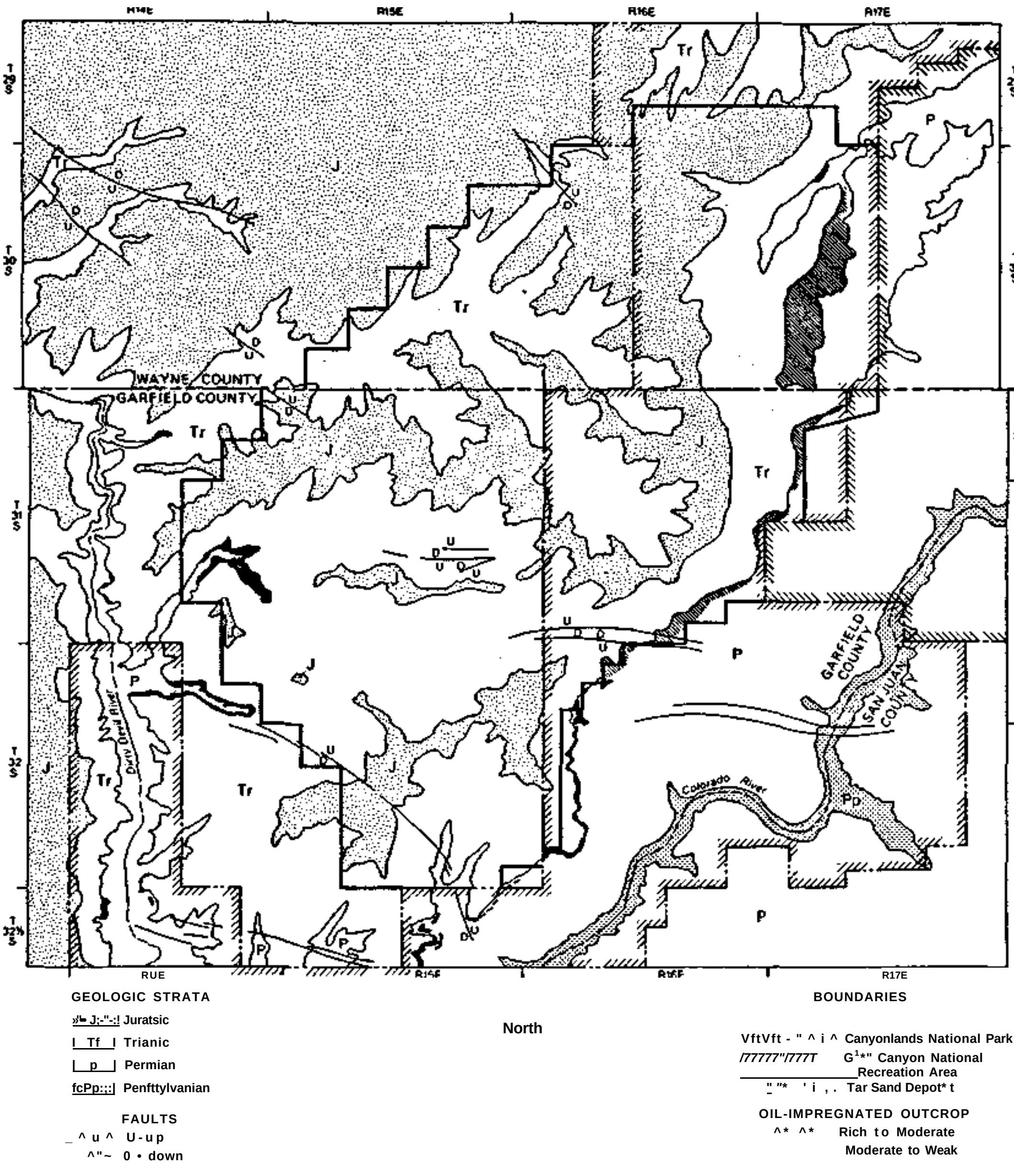
Surface Features

The area of study lies in the middle of the Canyonlands section of the Colorado Plateau in southeastern Utah. It is remote and rugged with flat-topped mesas, vertical cliffs, and deeply incised canyons (Figure 2). The area lies north and west of the Colorado River between the Dirty Devil River on the west and the Green River on the east. The Navajo Sandstone, Kayenta Formation, and Wingate Sandstone form the pronounced cliffs and cap the high mesas in the area. Beneath the massive, vertical cliffs formed by outcrops of these units are steep slopes of the Chinle and Moenkopi Formations. The oil saturated White Rim Sandstone forms an escarpment west of the Colorado River.

The landscape represents erosion of essentially flat-lying or gently dipping strata in an arid to semi-arid region producing local relief of up to 3,700 feet. The topographic features are controlled by the relative competence of rock layers. Infrequent heavy rains with the resultant high runoff and erosion of both competent and softer rocks produce the steep cliffs, benches, and slopes that characterize the very angular topography. This rugged topography poses significant constraints for access and operations. Although mesas are essentially flat-topped, crossing between mesas is very difficult due to vertical cliffs and deep canyons. Access from the mesa tops into the canyons is difficult due to the terrain and unstable slopes.

Structure

The Tar Sand Triangle is located on the northwest flank of the Monument Uplift, a north-trending anticlinorium extending 75 miles south into northern Arizona, between the Henry and Abajo intrusive mountains. Strata in the area dip gently (1° to 3°) to the northwest. Minor normal faulting, with displacements of generally less than 50 feet, is present in the area. The general structure of the area is shown on the diagrammatic cross section in Figure 5. The White Rim Sandstone dips generally northwestward to depths of approximately 1500 feet at the oil-water contact along the western edge of the deposit. The structure of the Tar Sand Triagle area is shown in detail on the fence diagram on Plate I. The northwest dip of strata in the area is shown on cross sections B-B' and C-C. Cross section A-A^1 parallels the strike of the beds and exhibits the stratigraphic relationships discussed in the next section. The structural configuration of the top of the White Rim sandstone is shown on the structure contour map in Figure 6. The general trend of northwest dip is shown with north and west dips represented in the northeast and southwest parts of the area, respectively.



IModitivd from C*mpb*li And Aaim*, 1979)

Figure 4. General geologic map of the Tar Sand Triangle area.

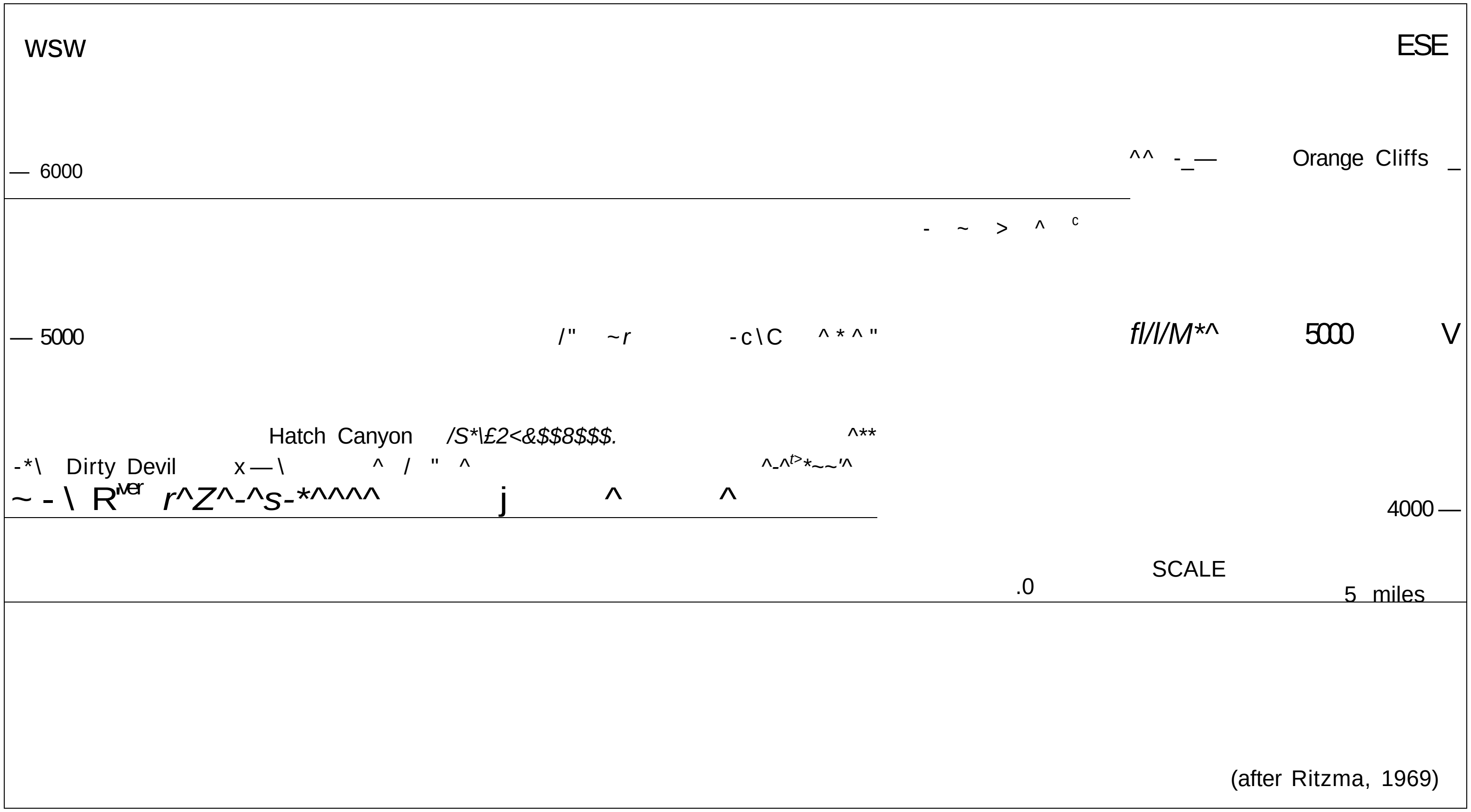
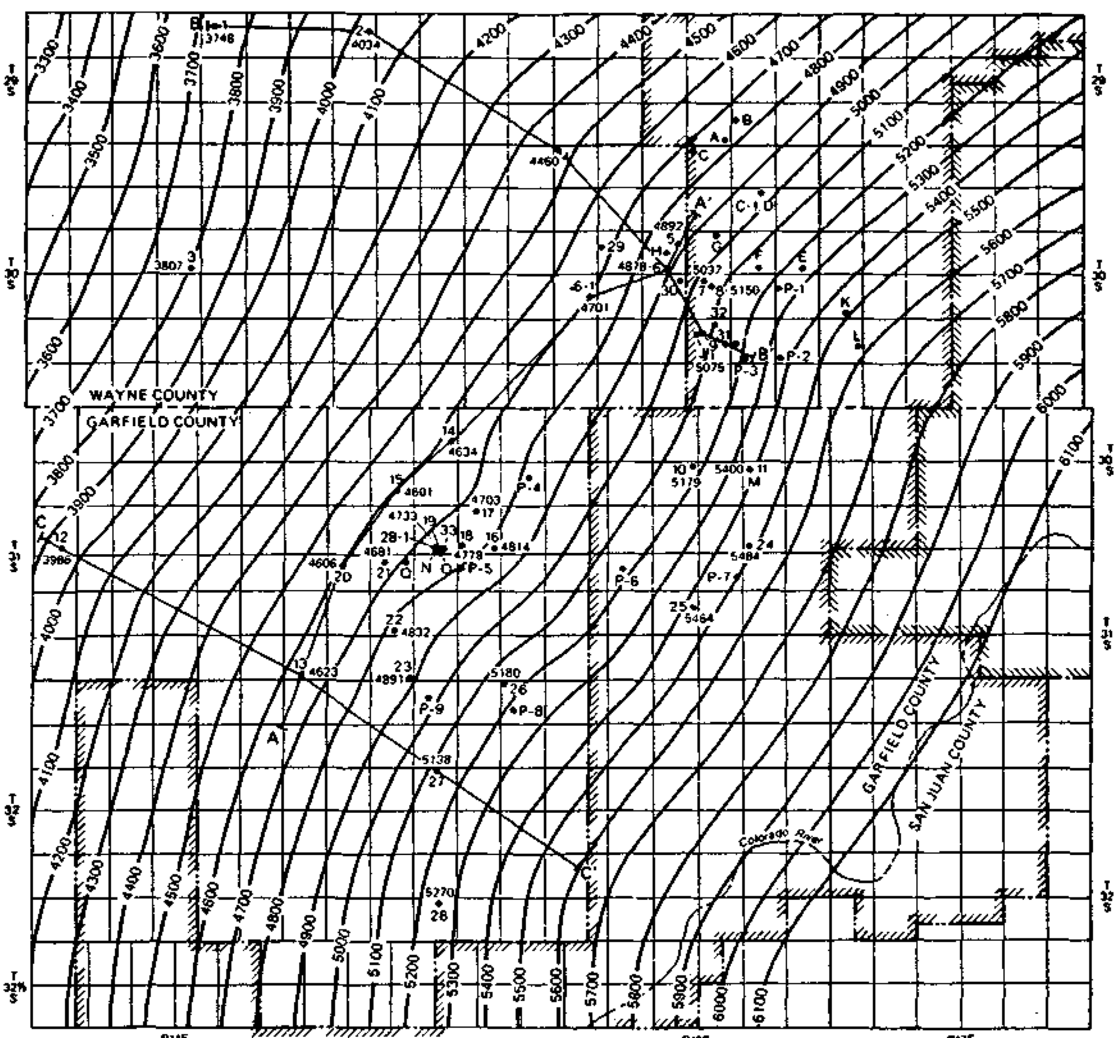


Figure 5. Diagrammatic cross section of the Tar Sand Triangle, southeastern Utah.



- Well Location
- Townthip, Range Line
- Section Line

O
North

County
Canyonlands National Park
Glen Canyon National Recreation Area

Contour Interval - 100 ft.

Figure 6. Structure contour map - Top of the White Rim Sandstone, Tar Sand Triangle, southeastern Utah.

Stratigraphy

The Tar Sand Triangle deposit is in the Paradox Basin along the northwest end of the Monument Uplift. The area contains Paleozoic and Mesozoic sedimentary rocks that dip gently into the basin towards the northwest. The stratigraphic units present in the area are shown with brief lithologic descriptions in Figure 7. Major units in the area are, in descending order, the Jurassic (or Late Triassic and Jurassic) Navajo Sandstone, the Triassic/Jurassic (?) Kayenta Formation, the Triassic (and Early Jurassic?) Wingate Sandstone, the Triassic Chinle and Moenkopi Formations and the Permian Cutler Formation which contains the White Rim Sandstone, the major oil bearing unit in the area.

Navajo Sandstone

The Jurassic Navajo Sandstone is a buff to gray sandstone with some orange-red, fine-grained sandstone and thin limestone. The Navajo is characterized by large-scale, tangential cross-bedding indicative of its eolian depositional environment. In this area, it is found as high domes capping the highest parts of the mesa. The Navajo Sandstone in this area is 420 to 550 feet thick and lies conformably on the Kayenta Formation.

Kayenta Formation

Underlying the Navajo Sandstone is the Triassic/Jurassic (?) Kayenta Formation which consists of grayish-maroon, fine- to coarse-grained, irregularly bedded sandstone with siltstone stringers. The Kayenta weathers to an orange-red color and forms both vertical cliffs and irregular ledges. These ledges are the source for springs in most areas and locally seem to be the source for French Spring and Flint Spring. Due to erosion, little of the total thickness of this formaton remains where found in outcrop, but enough remains to protect the softer underlying Wingate Sandstone from erosion. Where present in the northern part of the area, the total thickness of the Kayenta Formation ranges from 270 to 300 feet.

Wingate Sandstone

Lying conformably under the Kayenta Formation is the Wingate Sandstone of Triassic age. In outcrop, the Wingate forms very high, vertical, nearly columnar cliffs and box canyons. Its red-brown to light orange-red colors are mostly responsible for the "Orange Cliffs" which form the high mesas in this area. When fresh cuttings are obtained from this formation, the sandstone varies from very fine to fine-grained and from white to buff to light pink with some stringers of red and pink slightly silty shale. Cross-bedding is evident in some samples. Where present in its entirety in the northern part of the area, the Wingate is 300 feet thick and it rests conformably on the Chinle Formation.

Chinle Formation

Generally, this formation consists of silty red, green, maroon, and purple shales with lenses of sandstone. Thin limestone and calcareous siltstone may be encountered locally along with some rather massive, fine-grained, light red-orange sandstone. The Chinle is 400 feet thick throughout most of the area, but shows some thinning to the south and

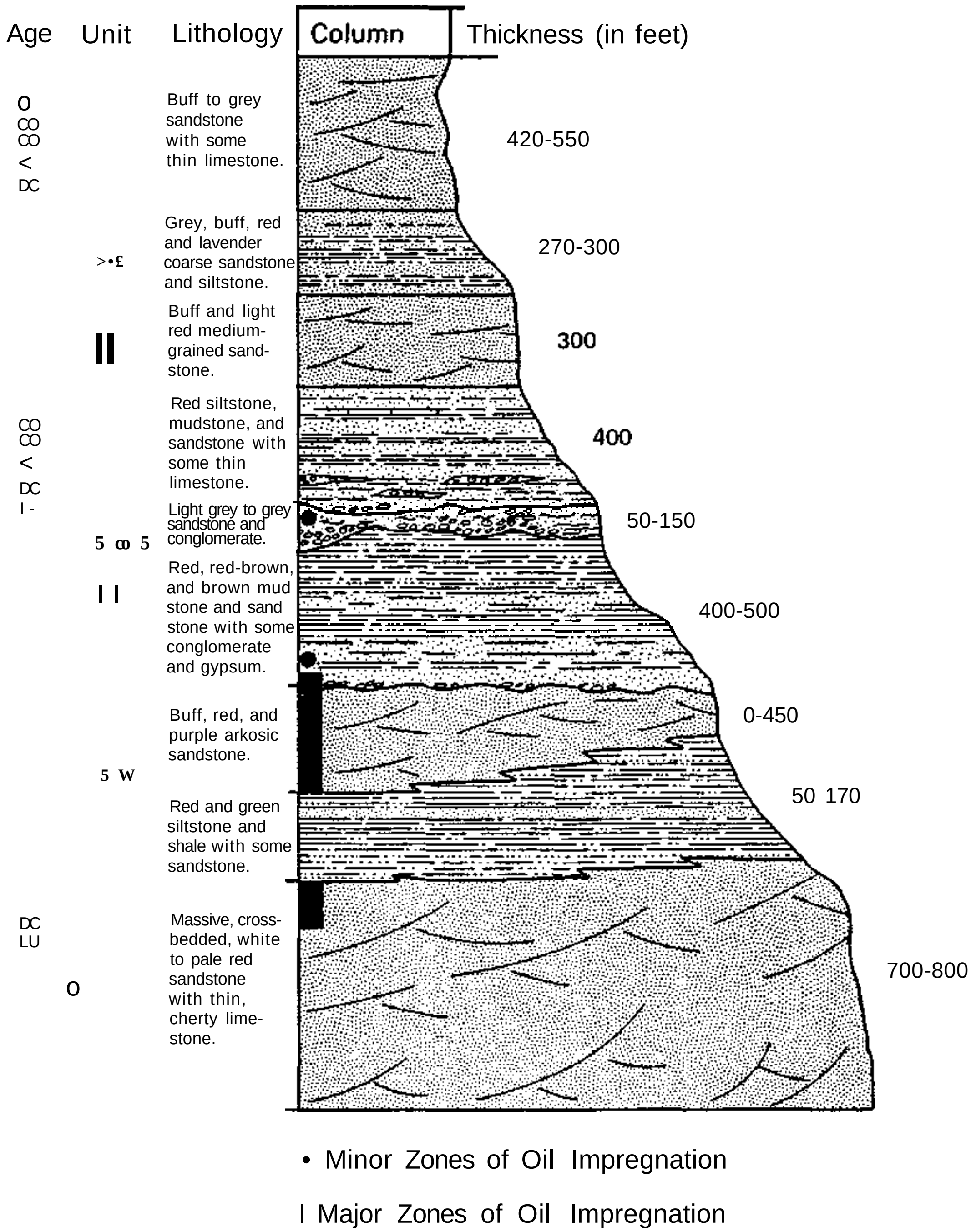


Figure 7. Lithologic column **for strata present in the** Tar **Sand** Triangle **of southeastern** Utah.

southeast (see stratigraphic cross section D-D' of Plate II; Figure 8). This thinning probably represents onlapping of this formation onto the Uncompahgre Uplift to the northeast and/or onto an uplift to the southeast informally named the Ancestral Monument Uplift in this paper. The uplift probably had a structural separation of only a few hundred feet and it was probably associated with the Permian and Triassic tectonics exhibited in this region by the Uncompahgre and Ancestral Rocky Mountain Uplifts.

Five to 50 feet above the base of the Chinle, a facies change in some localities has resulted in the deposition of a thin (3 to 7 ft) bed of coal and carbonaceous shale. The coal appears to be subbituminous in rank and is relatively clean, bright, and brittle. The coal bed could be used as a marker bed when exploring for tar sand in this area. A thickening towards the southeast in "the section of rock between the Moss Back Member and the coal is evident as shown on the lithologic column cross section in Figure 8. The paleo-environment seems to have been consistent with a system that results in the deposition of fine- to coarse-grained sandstone, i.e. a braided stream or flood plain environment. It is conceivable that the coal facies was deposited in a poorly drained swamp environment on the periphery of a hydrologic low which received clastic influx for a short time from the Ancestral Monument Uplift to the southeast. Coal deposition took over as hydrologic gradients decreased and the low became filled or nearly filled with sediment. Other evidence for the Ancestral Monument Uplift is seen in the unconformably underlying Moss Back Member of the Chinle.

Moss Back Member

The Triassic Moss Back Member (also named Shinarump and Monitor Butte members) of the Chinle Formation is a light gray to gray sandstone and conglomerate. It ranges in thickness from 50 to 150 feet and is unconformable at both its upper and lower contacts. These contacts are generally erosional in nature. The general trend shown on the fence diagram in Plate I is a thinning towards the northwest although thicknesses are locally variable as shown in cross section D-D" on Plate II. The lithologic column cross section in Figure 8 shows a definite trend of thinning and fining of facies towards the north-northwest. This is further evidence of the proposed Ancestral Monument Uplift to the southeast as conglomeratic detritus shed off the uplift grades into coarse- to fine-grained alluvial plain deposits towards the northwest, away from the uplift. Another probable source of Moss Back detritus was the Uncompahgre Uplift located to the northeast of the study area.

Moenkopi Formation

The Triassic Moenkopi Formation is primarily a reddish-brown and gray-green mudstone with gray-green siltstone, some of which is calcareous. The top of the formation is marked by a massive, fine- to very fine-grained, light green sandstone. Minor zones of saturation are present in the basal sections of the Moenkopi. The presence of fossilized mudcracks, raindrop imprints, and salt casts, plus the color and

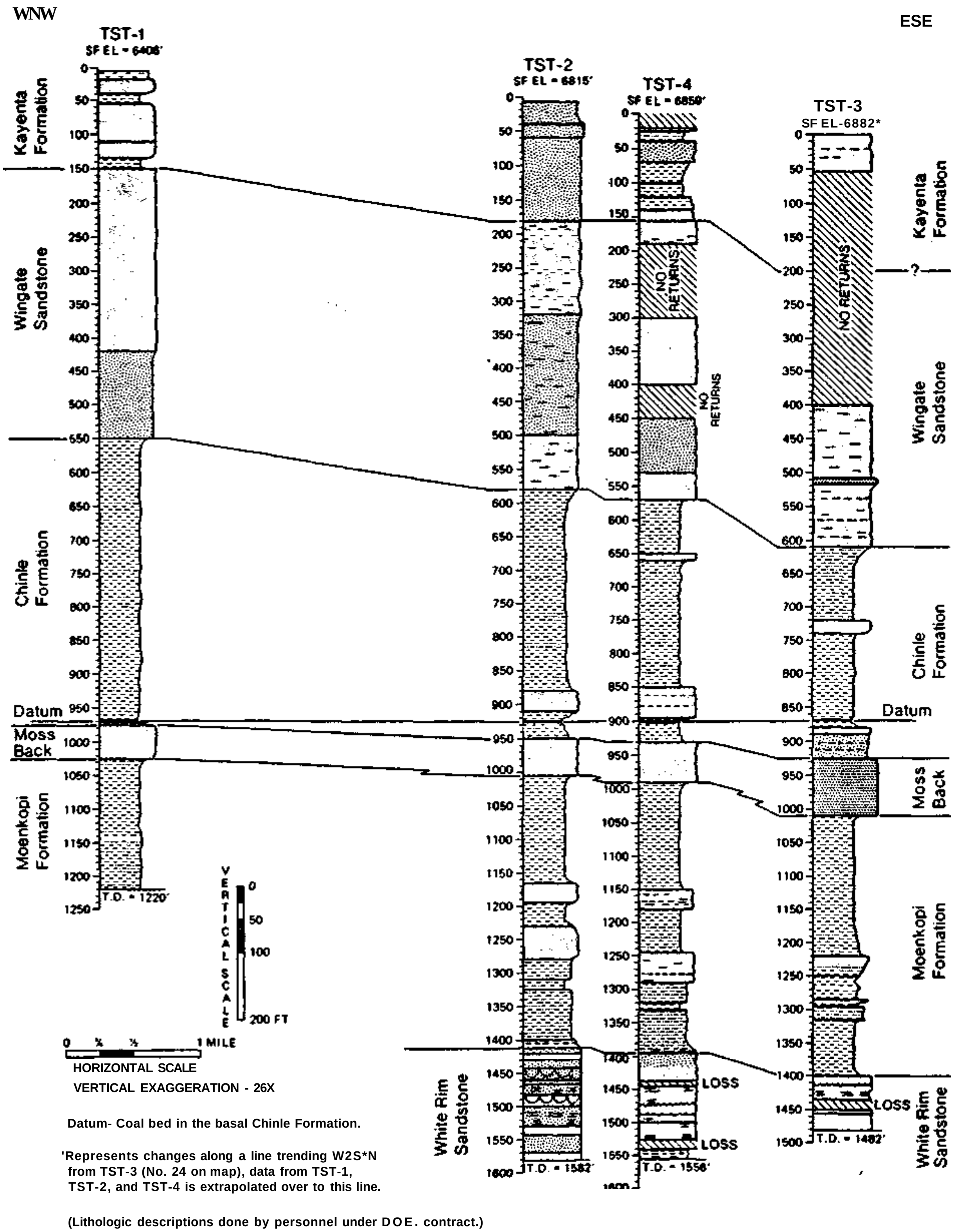


Figure 8. Diagrammatic lithologic column cross section representing facies and thickness changes from ESE to WNW*, Tar Sand Triangle, southeastern Utah.

character of the sediments *are* all suggestive of a continental tidal flat or alluvial plain depositional environment. The Moenkopi ranges in thickness from 400 to 500 feet and unconformably overlies the Permian Cutler Formation.

Cutler Formation

This Permian formation lies stratigraphically below the Moenkopi Formation and was derived from the Late Pennsylvanian to Early Permian Uncompahgre Uplift to the northeast of the study area and the proposed Ancestral Monument Uplift to the southeast. Facies changes modify the coarse clastic nature of the undifferentiated Cutler Formation east of the study area into five distinct but stratigraphically complex units in the Tar Sand Triangle locale. These are in descending order: 1) the informally designated upper member of the White Rim Sandstone, 2) the White Rim Sandstone Member, 3) the Organ Rock Shale Tongue, 4) the Cedar Mesa Sandstone Member, and 5) a basal unit which interfingers northwestward with the Elephant Canyon Formation, herein designated as older Permian strata, undivided.

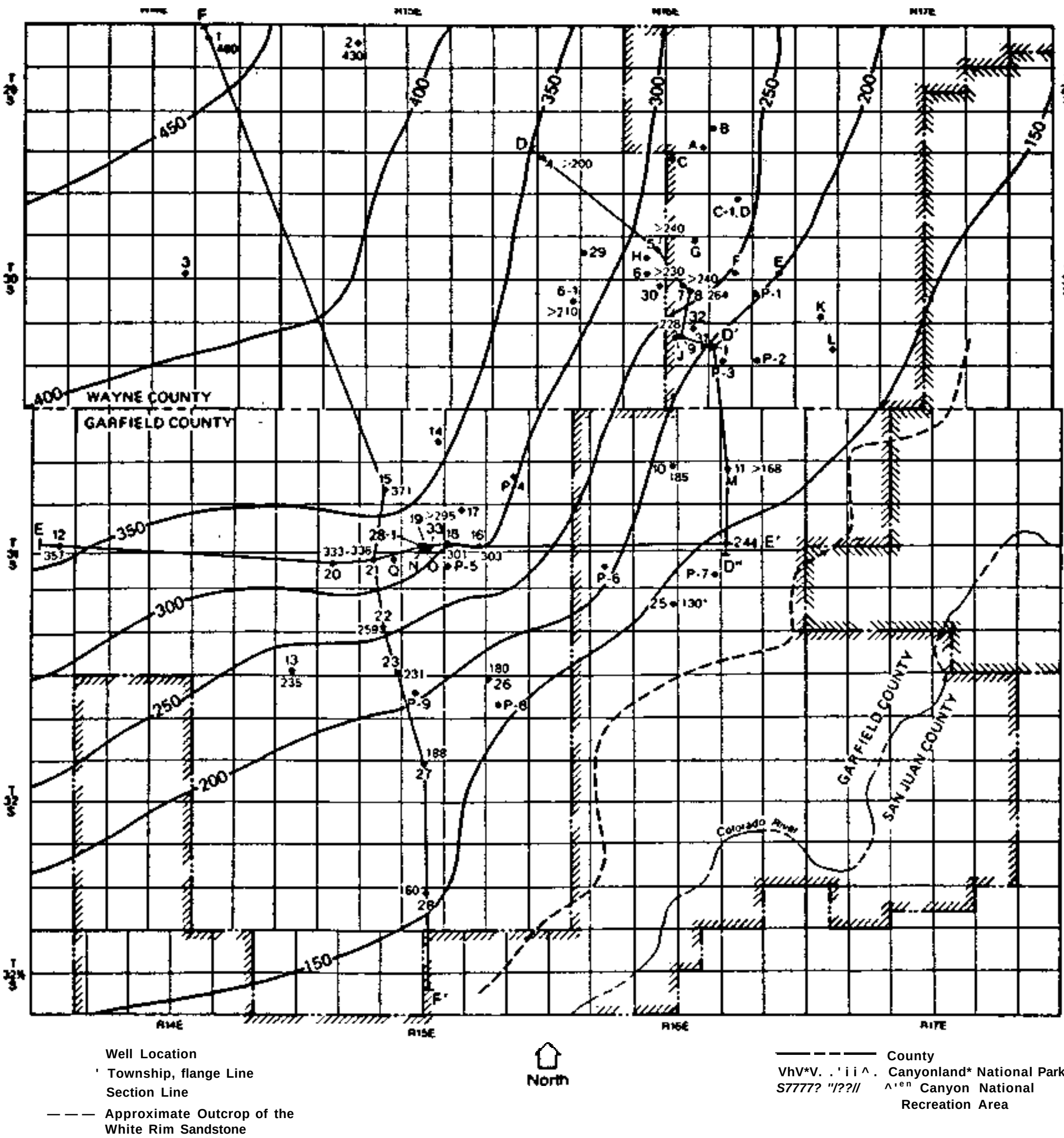
Upper Member of the White Rim Sandstone

In core descriptions from Kirkwood Oil and Gas (written communication) this informal upper member of the White Rim Sandstone is described as interbedded or interlayered dolomite and sandstone. It ranges in thickness from 0 to 75 feet and often shows oil saturation. This stratigraphic unit commonly appears as a strong kick (increasing) on gamma ray logs. The upper contact is unconformable and appears to be erosional in nature (see cross sections on Plate II). It also pinches out a few miles northwest and west (seaward) of the White Rim Sandstone pinchout along the Orange Cliffs. This unit perhaps formed from a sandy limestone deposited as the Late Permian sea regressed. The regression resulted in subaerial exposure of the deposit, causing dolomitization and erosion of the surface prior to continental deposition of strata of the Moenkopi Formation.

White Rim Sandstone Member

This member of the Cutler Formation is a light gray to reddish-brown sandstone which forms cliffs and irregular ledges in outcrop. Considerable oil impregnation occurs in the White Rim resulting in tar sands which vary from light to dark brown. It thickens to the northwest in a clastic wedge ranging from 0 to 450 feet in thickness. An isopach map of the White Rim Sandstone is shown on Figure 9. This member interfingers with beds of the underlying Organ Rock Shale Tongue.

Prominent, large-scale cross-bedding led early workers to believe that the White Rim was deposited under eolian conditions. Baars and Seager (1970), however, presented evidence to support a nearshore marine environment of deposition. This evidence included tabular form of cross-bed sets with a relatively low cross-strata dip of 15 to 28 degrees



Contour Interval = 50 ft.

Figure 9. Isopach map of the White Rim Sandstone, Tar Sand Triangle, southeastern Utah.

and foreset tops with long, sweeping shapes; and the common occurrence of oscillation and interference ripples with a ripple index of 4 to 6. Their cross-stratification studies indicated that the White Rim Sandstone was derived from the northwest and transported to the site of deposition by southeast moving longshore currents.

The White Rim Sandstone thins southeastward (see cross sections on Plates I and II) and forms an updip pinchout in exposures just **west** of the Colorado River. The pinchout is the trap for petroleum accumulation in the Tar Sand Triangle. Erosion has dissected the trap allowing for oil seeps and devolatilization of the hydrocarbons present. The characteristics of the reservoir will be discussed further in the following main section.

Organ Rock Shale Tongue

This unit of the Cutler Formation consists of red and green siltstone and shale with some light gray to red sandstone. It varies in thickness from 50 to 170 feet and generally thickens to the northwest (Plate II) with some local variations. This unit was probably deposited in a fluvial-coastal lowland environment. The Organ Rock Shale interfirigers with beds of the underlying Cedar Mesa Sandstone Member.

Cedar Mesa Sandstone Member

The Cedar Mesa Sandstone consists of massive, cross-bedded, white to pale red sandstone with some thin, cherty limestone. It is 700 to 800 feet thick in the study area. Like the White Rim Sandstone, the Cedar Mesa was originally considered to be eolian, but sedimentary structures indicate an aqueous depositional environment. The Cedar Mesa conformably overlies older Permian strata.

RESOURCES

Reservoir Characteristics

The oil saturated deposit in the Tar Sand Triangle consists of several sub-areas known as the Elaterite Basin, Fault Point, Red Cove, Teapot Rock, Cove, Fiddler Cove Canyon, French Seep, North Hatch Canyon, Orange Cliffs, South Hatch Canyon, and Gordon Flats (State of Utah, 1980).

These sub-areas are all part of a single giant stratigraphic trap and are not separate deposits as once believed. The original trap was the updip pinchout of the White Rim Sandstone on the southeast margin of the Tar Sand Triangle along the Orange Cliffs. Erosion breached the trap at the updip end first, and the downdip end was then breached at a later time. This breaching allowed the dissolved gas energy and volatile constituents of the oil to escape and the formation water drive on which the oil reservoir floated was allowed to drain away (Utah, State of, 1980). At the present time, the viscous oil is probably moving slowly downward and outward by gravity and percolation of meteoric water. The eastern (or updip) limit of the deposit is at the permeability change caused by the lateral pinchout of the sandstone and the western limit is at the inferred contact between original formation water and the petroleum from which the tar was derived. The limits of the deposit are outlined on the map shown in Figure 10.

The oil saturation occurs principally in the White Rim Sandstone and upper White Rim, with minor saturation zones in the Cedar Mesa Sandstone, Moenkopi Formation, and Moss Back Member of the Chinle Formation. The White Rim Sandstone is composed of well-sorted, sub-angular to subrounded, fine quartz grains with scattered grains or laminae of medium- to coarse-grained, well-rounded, and frosted quartz. It is poorly cemented and very friable. Campbell and Ritzma (1979) reported the pay thickness in a range from 5 to 300 feet. An isopach map of saturated thickness in the White Rim Sandstone is shown in Figure 10. The deposit underlies a surface area" of 126,720 acres which is outlined on the isopach map. Depth of the White Rim Sandstone ranges from surface exposures on the southeast side of the area to depths of more than 2,000 feet on the northwest.

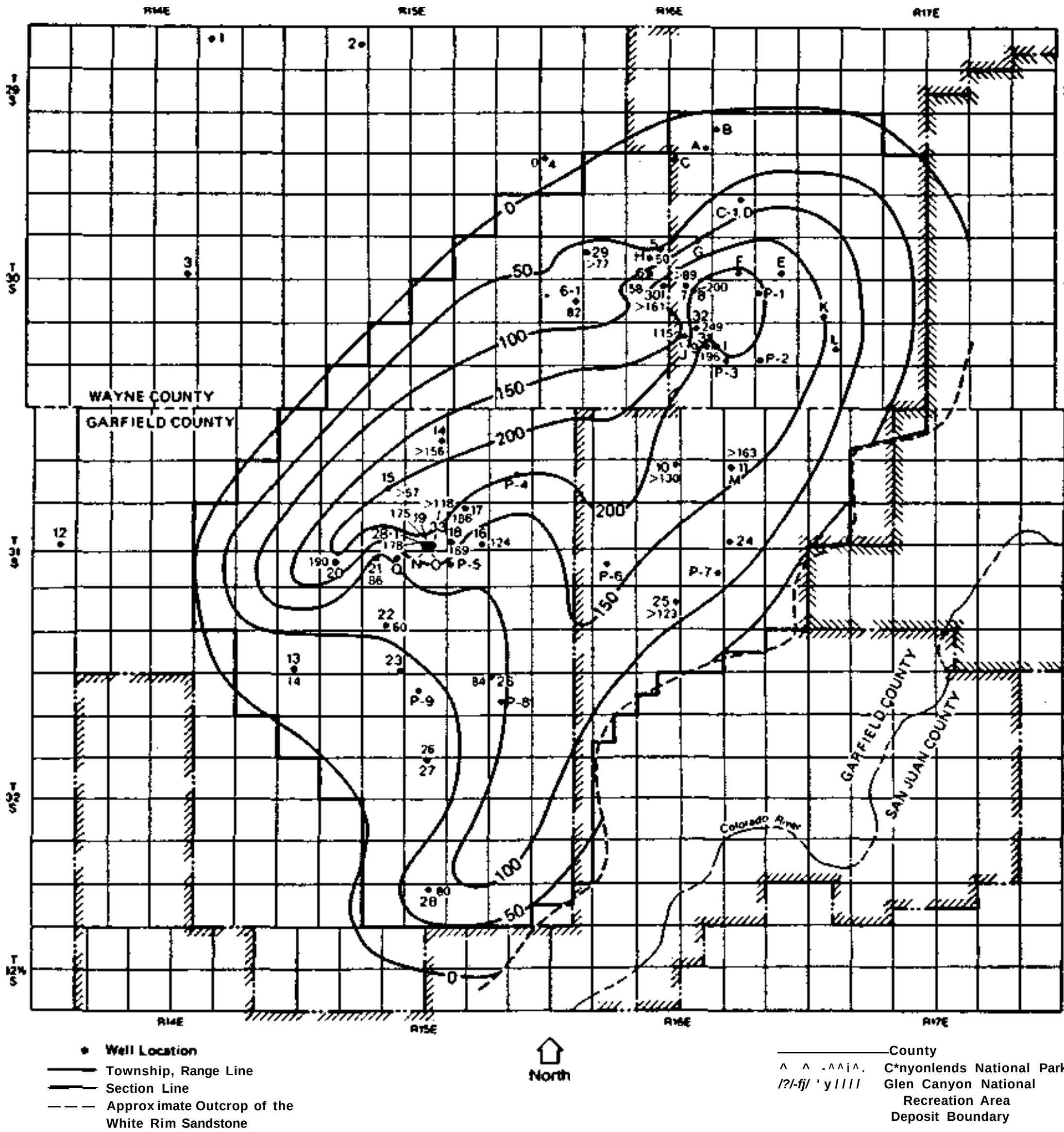
The oil-bearing strata are encased in organic-clean rocks excluding a local or nearby source for the hydrocarbons. The oil probably originated in the rich Phosphoria Formation, a lateral time equivalent present on the northwest (State of Utah, 1980). The oil probably migrated prior to Laramide time over a distance exceeding 100 miles. Uplift and erosion of the reservoir area then followed during Tertiary time.

Isopach Map - Zones of Saturation

Information used to construct the isopach map of the zones reported as saturated has been derived from a variety of sources including, but not limited to, written reports, geophysical and driller's logs, core analyses, and communications with people experienced in the area. Although some saturation has been reported in the Moenkopi, this section is not included in the evaluation of the thickness of saturation as reported in this paper. Only the reported saturations in the White Rim Sandstone were used in developing both the isopach map and the resource map.

It is recognized that variations in saturation are present in most of the vertical geologic section. These variations have been identified by both visual and analytical means. The most definitive results are core analysis data of porosity and oil and water saturation done for each foot of core.

The isopach map of the reported total thickness of saturated sandstone (Figure 10) reveals 2 major areas of comparatively thick sections; one in T30S, R16E where values up to 249' have been measured and one in T31S, R15E where values up to 190' are found. Several values on this map are expressed in numbers "greater than" (example >162') because information is incomplete for the hole or the hole did not penetrate the entire White Rim sandstone. Thus each value point on the map with such a designation is not a firm number used as a control for contouring.



Contour Interval - 50 ft.

Figure 10. Isopach map of saturation in the White Rim Sandstone, Tar Sand Triangle, southeastern Utah.

All numbers without the "greater than" designation are considered valid data and are used in the construction of the map.

Outcrop values were not used because of the variety of reported values and due to the great potential for obtaining an exaggerated or depressed value for the deposit by interpolating from outcrop observations. The values used by previous investigators are not thoroughly documented as to be used in this report. If future drilling and coring in the vicinity of outcrops were to substantiate horizontal continuity of saturated outcrops into the subsurface, then revisions would be made at that time.

Resources Map and Calculations

Information for calculating resources and constructing the resource' «rep (Figure 11) was obtained from: 1) core analyses available to the public and 2) an interpretation of resources made by Lewin and Associates 'interstate Oil Compact Commission, 1984) based on proprietary specific c -ta. Although a number of companies have cored the White Rim Sandstone i- the study atea, very few core analyses have been published or otherwise .Jc available to the public. Thus, the values and control points for "ir> resource map are interpreted from sparse data. An important part of Us report is the analytical core data found in the Appendix which was i«.vived from cores drilled by the Department of Energy, Laramie Energy '•chnology Center in 1982. Other information was obtained from private tcrcpanies and the Utah Geological and Mineral Survey.

As in the isopach map of saturated sandstone zones in the White Rim. only subsurface information was used. No analytical data is available from samples taken from outcrops along the east edge of the deposit or in the west and southwest where some saturation is found in White Rim outcrops, especially in Fiddler Cover and Hatch Canyons.

The total in-place resources for the Tar Sand Triangle deposit were calculated as follows. Barrels per acre yields were calculated for eight well locations for which average reservoir porosity and average percent oil saturation of available pore space values were available. The barrels per acre value was calculated using the following equation: 7758 x saturated thickness x average porosity x per cent of saturation. These yield values were then spotted on the base map and used as control points for the construction of the isogram map (Figure 11). In conjunction with these control points, the saturated thickness isopach map in Figure 10 was also used as a guide in the placement of the lines on the isogram. The isogram map represents four general zones within the deposit area based on estimated hydrocarbon yields in barrels per acre. The four zones are: 1) >100,000 bbl/acre, 2) 50,000-100,000 bbl/acre, 3) 20,000-50,000 bbl/acre, and 4) <20,000 bbl/acre.

The geographic area within each zone was obtained by adding complete and partial sections. The number of sections was then multiplied by 640 acres/section to obtain an area in acres for each zone.

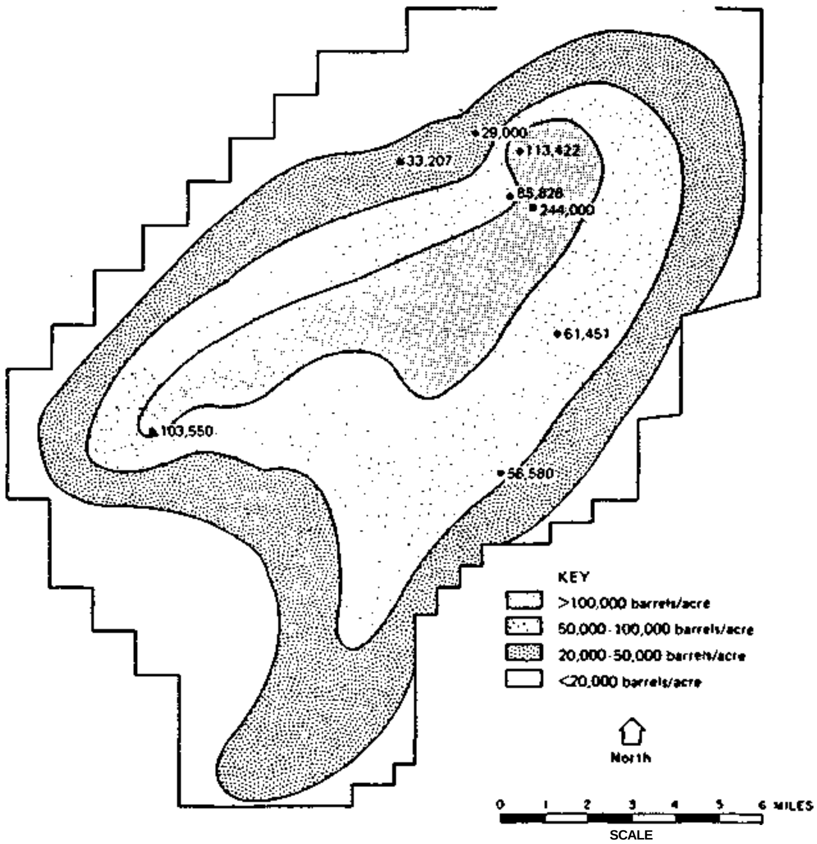


Figure 11. Isogram map of in-place barrels per acre for the Tar Sand Triangle of southeastern Utah.

The in-place resources for each zone were calculated by multiplying the area times the average barrels per acre yield. A conservative value of 110,000 barrels per acre was used for the >100,000 bbl/acre zone while mid point values were used for the other zones. The results of the calculations are shown in Table 6.

Finally, the in-place resources for each zone were added to determine the total resources for the entire deposit area. The value obtained was 6.3 billion barrels of oil in-place for the Tar Sand Triangle tar sand deposit.

The two areas of greatest known potential are centered around sections 16, 21, 22, and 27 of T30S, R16E and sections 15, 16, and 21 of T31S, R15E. Subsurface investigation methods have shown these areas to contain substantial thicknesses of oil-bearing sandstone. It is recognized that all of the vertical section is not fully saturated nor is it uniformly porous, but available sources report ranges of 16 to 35 percent average porosity and 5 to 80 percent oil saturation. Averages used in determining the total resources were determined on a per hole basis. Although the map is expressed in isogram areas, the average yield in those areas was used in calculating resources.

Leasing of Tar Sand Deposits

In 1981, Congress passed the Combined Hydrocarbon Leasing Act to provide the converting of existing oil and gas leases into both oil and gas and tar sand leases. To take advantage of the opportunity, lease holders were required to apply for the new combined lease within two years of the enactment. Most of the leaseholders filed and in the Tar Sand Triangle, these amounted to 80 leases covering 91,547 acres as of the beginning of 1984. The leases are detailed in Table 7. The locations of the leases were not included in this report, but all of them involve some sort of in situ method for recovering the products. Although the original law required projects to attain commercial production within 10 years, the U.S. Bureau of Land Management is working on modifications to permit leaseholders some flexibility in meeting that deadline.

A comparatively large amount of *acreage*, considered to be attractive for tar sand development, is located in T30S, R16E. One-half of this township is in the Canyonlands National Recreation Area. The State of Utah aids and encourages synfuel development on state-owned acreage but requirements by the National Park Service, who administrate the surface and subsurface land holdings, are stringent. Much effort and expense are necessary for compliance and mitigation of the effects of developments which are to be faced by organizations wishing to conduct any kind of development from experimental pilot projects up to and through complete commercial plants.

TABLE 6. SUMMARY OF CALCULATED IN-PLACE RESOURCES FOR THE TAR SAND TRIANGLE, SOUTHEASTERN UTAH

Isogram Area (from Fig. 11)	Average Yield (barrels/acre)		Area (sections x acres/section)		resources (billions of barrels)
>100,000	110,000	X	26 x 640	=	1.8
50,000-100,000	75,000	X	61 x 640	=	2.9
20,000-50,000	35,000	X	55 x 640	=	1.2
<20,000	10,000	X	56 x 640	=	0.4
			TOTAL		6.3

	Applicant	Number of Leases	Acreage
1.	Santa Fe Energy Co.	27	22,449
2.	W. C. Kirkwood Oil & Gas	9	18,624
3.	Raymond N. Joeckel	13	16,723
4.	Altex Oil Corp.	11	12,690
5.	Sohio Shale Oil Corp.	3	4,344
6.	Sun Exploration & Production Co. et al.	3	3,960
7.	Benson-Montin Greer Drilling Corp.	4	3,345
8.	Emery Energy Inc.	2	2,560
9.	Morton M. Pepper	2	2,560
10.	Hawthorne Oil Co. et al.	2	2,520
11.	John M. Beard	1	800
12.	Maurice W. Brown	1	440
13.	Southland Royalty Co. et al.	1	320
14.	Texaco Inc.	1	212
		80	91,547

Note: Applications are for conversion of existing oil and gas leases to confined hydrocarbon leases in the Tar Sand Triangle as of 1/1/84.

CONCLUSION

The Tar Sand Triangle may be the largest tar sand deposit in the United States. Previous estimates for the deposit range from 2.9 to 16 billion barrels of oil in-place. The major cause of the large diversity of estimates is the selected areal extent of the deposit. The necessity of extrapolating sparse porosity and saturation data is also a major factor. This paper estimates 6.3 billion barrels which, if correct, would make it (the Tar Sand Triangle) the largest single deposit in the United States. More core data is required before a more accurate resource determination can be made. Development of the deposit is aided by the uncomplex geologic nature of the area and the relatively shallow depth of the deposit (0 to 2000 feet). The rugged topography and remote loaction, however, are hindrances to development as access and transportation of product costs would be high.

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APPENDIX

Tar Sand Analyses of Core Samples taken from Wells Drilled by the Laramie Energy Technology Center (presently the Western Research Institute)

TAR SAND ANALYSIS

LARAMIE ENERGY TECHNOLOGY CENTER

TST-2

CORE LABORATORIES. INC.

Petroleum Reservoir Engineering

DALLAS. TEXAS

r - r ^ MRAME ™EBCX TECHNOLOGY CENTER p——;„„ -Pile. •* 3

Well_ TST-2 . Cores_ -File_ RP-2-693U

Field. .Drilling Fluid. -Date Report 8-23-82

County— . Stale . Elevation_____ .Analysts. 7B:PD

Location _ _ Remarks_____

CORE ANALYSIS RESULTS

*(Figttrrt in p*rrmlbttr% rrfrr to footnote rrmarkj)*

SAMPLE NUMBER	DCPTM rcct	URMEAIILITV MILLIDARCYS BEFORE EXTRACTION	AFTER EXTRACTION	POROSITY PERCENT (1)	RESIDUAL SATURATION (2)	-OIL •» PORE	OIL •b WT	OIL GAL/TON	TOTAL WATER •c PORE	SAT. KSS.	EXT. HNS.	CRN DNS
	0-11*15				M0 ANALYSIS							
1	11.15-16	•	•	1.9	7-1*	0.0	0.0		71*.3	2.61*	2.60	2.80
2	16-17	*	*	1.2	I*.7	0.0	0.0		71*.5	2.61*	2.61	2.71*
3	17-18	•	•	20.6	21*.5	6.1	0.6		9.8	2.01*	2.01	2.66
1*	18-19	•	•	9.1*	17.5	29.7	2.1		16.6	2.27	2.20	2.66
5	19-19.7	176	177	11.6	17.0	17.6	l.1*		11*.1	2.25	2.20	2.65
	11.19.7-23				CORE LOSS							
6	11*23-21..	255	259	13.1	19-1*	18.6	1.7		13-9	2.20	2.11*	2.65
7	. 21,-25	265	315	9.5	16.9	29.6	2.1		11..2	2.28	2.20	2.65
8	'25-26	•	•	10.8	18.2	25.8	2.1		11,.8	2.23	2.17	2.65
9	'26-27	•	•	9.1	17.1*	27.0	2.0		20.7	2.28	2.19	2.65
10	27-28	21*2	268	10.1*	17-7	30.5	2.5		10.7	2.26	2.18	2.65
11	28-29	201*	222	10a	16.8	20.8	1.1*		19.0	2.27	2.20	2.65
12	29-30	278	286	15.1	21.1	ll*.7	1.1*		13.7	2.11*	2.08	2.61*
13	30-31	505	520	16.0	23.5	I8.3	2.0		13.6	2.10	2.01,	2.66
11*	31-32	1500 P	1600	12.8	26.2	35.1	1*.5		16.0	2.09	1.96	2.66
15	32-33	•	•	11*.9	22.7	20.7	2.1*		13.7	2.13	2.05	2.65
	1U33-1-39				CORE LOSS							
16	11.39-1*0	510	610	ll*.5	25.1	33-5	1*.2		8.8	2.09	1.99	2.65
17	1*0-1*1	131*0	1700	11..8	27.3	37-7	5.0		8.1	2.05	1.93	2.66
18	10.-1*2	•	•	11..2	21..6	30.1	3.5		12.2	2.12	2.02	2.68
19	1.2-1*3	•	*	18.2	27.9	23.7	3.1		11.1	2.02	1.92	2.67
20	1*3-U*	379	1*88	11.3	19.9	26.6	2.3		16.6	2.21	2.12	2.65
21	1*1*-1*5	253	21*2	10.2	15.6	18.6	1.1		16.0	2.30	2.25	2.66
22	1.5-1*6	1110	1110	20.3	26.1*	12.9	1.8		10.2	2.01	1.96	2.66
23	1*6-1.7	*	*	17.9	25.1	11*.3	1.7		11*.3	2.05	1.99	2.66
21*	1.7-1.8	1550	1750	18.0	26.2	21.8	2.8		9.5	2.03	1.95	2.65
25	1.8-1.9	1*.7	7.5	3.7	7.2	23.6	0.7		25.0	2.50	2.1*7	2.66
26	1*9-50	575	655	13.2	22.5	27.6	2.9		13.8	2.15	2.06	2.66
27	50-51	765	1100	11.0	22.0	26.1,	2.1*		23.6	2.19	2.08	2.66
28	51-52	188	336	11.5	21.1*	33.2	3-3		13.1	2.17	2.08	2.6L
29	52-53	79	91	6.6	11.5	1*.3	TR		38.3	2.1*0	2.36	2.66
30	53-51*	7.8	15	3-3	8.7	28.7	0.9		33.3	2.1*7	2.1*2	2.65
31	5U-55	O.36	2.2	1.9	6.1*	31*.1*	0.9		35.9	2.52	2.1*9	2.65

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O OOVjJVJl—J —J OOVJltr- O0<r-U) O VO 00 N> OSKjJ OOU) OOfO<r-MMtr-N>0-JVOp-000\—JOOVJlM—JO\»J\
MUUIUJW VJ\VJ\U)\jJU) CO WUJUJ <r-*r- CO CO M M U H H MVJJ C* fJ N> N> M tr- CO N> N> N> M
OOU) O ONVjJ -JO\OM-400(J\-Jp->jJOVjJMOOO\Otr-MU)<r-MONOVjJONr\3M-JVJ\VJ\VJ\-J>>OrOU)
VJJ O H p U l H W M U N)<r-N>»J*r- ON M OVJWO M N)VO 00ONVOVOU) O 00O CO f ON p-—J r0 —J VO ONU)

U N U U N <r-VJ\<r-VjJ\jJ N>N>\jJfOVjJN>N>N>l>0[3MN>Qg£9|3|3|3N>U)MMMOf>OMMMMO
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ONVJIVO M fO 00ONN) -J CMO CMV)fU\OVAWJIM CO p- ONVO V/\ N> ON ONVjJ ONfMVJI Ml 00jr-00Jr--J.tr*

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CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS. TEXAS

r _ p w r LARAMIE ENERGY TECHNOLOGY CENTER ^ „ ; . „ .of.

Well- TST-2 .Cores. BP-2-693U

F«l<L _ Drilling Fluid_ .Ditc Report. 8-23-82

County— . State. . Elevation_____ -Analyst!_____ TB:FD

Location _ _ Remarks_____

CORE ANALYSIS RESULTS

*(Fig*rri i» p*tenlbr*tt refrr to footnote remit Its)*

SAMPLE NUMBER		PE DM EABILITY MILLIOARCYf		POItOSITV PERCENT m	(£i	RCSIDUAL SATURATION -OIL % POPtC		TOTAL WATCH V PORE	SAT. IKS.	EXT. ESS.	CRN DNS
72	1U95-96	53	77	8.6	18.1	33.7	2.7	18.8	2.26	2.16	2.61*
71	96-97	126	153	11.1	19.1	29.8	2.6	12.0	2.21	2.13	2.61*
71*	97-98	59	82	11.3	18.6	21*.2	2.0	15.1	2.22	2.15	2.61*
75	98-99	*	*	10.0	17.1*	23.6	1.8	19.0	2.26	2.17	2.63
76	99-00	221	231	13.6	20.3	20.2	1.8	12.8	2.17	2.10	2.61*
77	1500-01	329	388	13.0	22.3	29.6	3-0	12.1	2.15	2.05	2.61*
78	01-02	*	*	13.6	19.3	16.6	1.5	13.0	2.19	2.12	2.63
79	02-03	1*97	695	11*.8	23.9	25.9	3-0	12.1	2.10	2.00	2.63
80	03-01*	U75	1*82	15.1*	21.3	15-0	1-5	12.7	2.11*	2.07	2.61,
81	01,-05	70	95	8.3	15.7	27.1*	1.9	19.7	2.31	2.23	2.61,
82	05-06	211*	21*7	7.1	16.6	ia.6	3.1	15.7	2.31	2.21	2.65
83	06-07	37	92	1*.9	15-1*	1*9.1*	3-3	18.8	2.3!*	2.23	2.61*
81*	07-08	0.1*0	17	1.5	13.2	60.6	3-3	28.0	2.1*2	2.30	2.65
85	08-09	21	33	1*.6	11*.2	1*7.2	2.9	20.1*	2.37	2.27	2.61*
86	09-10	69	83	10.9	18.3	27.3	2.1	13.1	2.23	2.16	2.61*
87	10-11	0.01	0.03	0.9	2.8	3-6	TR	61*.3	2.62	2.59	2.67
88	11-12	11*6	155	12.0	20.1	22.1*	1.9	17.9	2.19	2.11	2.63
89	12-13	150	165	10.9	20.6	27.7	2.1*	19.1*	2.20	2.09	2.63
90	13-11*	192	1*21	11.7	21.8	32.6	3.U	13.8	2.16	2.06	2.61*
91	11*-15	112	161	10.6	19.9	30.7	2.9	16.1	2.21	2.11	2.61*
92	15-16	1*05	592	12.3	22.2	28.1*	3-1	16.2	2.15	2.05	2.61*
93	I6-17	590	8ol*	12.8	22.8	26.8	3-0	17.1	2.11*	2.03	2.61*
91*	17-18	1*62	909	12.5	22.8	27.6	2.8	17-5	2.15	2.01*	2.65
95	18-19	51*5	717	13.7	22.6	25.2	2.7	11*.2	2.11*	2.05	2.61*
96	19-20	383	396	13.9	21.1	19.9	2.1	11*.2	2.16	2.09	2.61*
97	20-21	875	116C	13-7	23.1*	26.1	2.8	15.1*	2.13	2.03	2.65
98	21-22	985	1575	11.7	21*.7	1*1*.1	5.3	8.5	2.13	1.99	2.65
99	22-23	935	161*0	9.8	23.6	1*5.3	1*.8	13.1	2.16	2.02	2.61*
100	23-21*	61	75	11.1*	17.2	15.1	1.1	18.6	2.25	2.19	2.61*
	152U-27		CORE LOSS								
101	152/-23	373	397	13.3	20.5	20.5	1.9	11*.6	2.20	2.13	2.69
102	28-29	1*59	628	9.9	20.7	38.2	3-5	11*.0	2.21	2.10	2.61*
103	29-30	1*28	510	11.8	19-9	28.6	2.7	12.1	2.20	2.12	2.61*
101*	30-31	1*9	123	8.1	I6.3	33-1	2.5	17.2	2.30	2.21	2.65
105	31-32	299	31*0	10.6	18.8	31.1*	2.6	12.2	2.23	2.15	2.61*
106	32-33	131*	281*	9.8	19.2	37-0	3-2	12.0	2.23	2.13	2.61*
107	33-31*	I89	319	10.6	19-7	3U.0	3.0	12.2	2.21	2.12	2.61*
108	3U-35	1*1*	63	5.3	11*.7	1*0.8	2.7	23.1	2-35	2.25	2.61*

CORE LABORATORIES. INC.

Petroleum Rejervoir Engineering

DALLAS. TEXAS

c ^ r . . r LARAMIE ENERGY TECHNOLOGY CENTER FnrTT›ar;nn____ .of.

WAX TST-2 Cores_____ _Fil«_ EP-2-693I*

Fitld______ Drilling Fluid _

County-______ State______ Elevation______ An,ly». TB:FD

Location _ . Remarks.

CORE ANALYSIS RESULTS

*(Figvrrt in p*tr*lk>tiei rrfrr to foctmotr rrmirki)*

SAMPLE NUMBER		BEFORE EXTRACTION	AFTER EXTRACTION	ID	(£	RESIDUAL. SATURATION oit.	SAUTON	SAT. BUS.	EXT. DNS.	GRH BHS
109	1535-36	21,6	395	8.3	18.	38.	16.3	2.26	2.16	2.61,
110	36-37	0, 35	8.1*	2.1	11.	1*6.	31*. 5	2.1*1	2.33	2.62
111	37-38	130	11*7	8.9	16.	23.	21.7	2.29	2.22	2.61*
112	38-35	111	126	7.8	11*.	22.	21*.1	2-35	2.29	2.68
113	39-UO	36	61	6	11*.	28.	21*. 3	2.38	2.30	2.69
111*	UO-W.	5.	16	3	12.	1*0.8	29.2	2.1*2	2.33	2.65
115	1*1-1*2	15	30	5	13.	28,	30.8	2.39	2.32	2.66
116	1*2-1*3	0, 85	5-6	2	10,	1*0,	36.7	2.1*6	2.38	2.67
117	1*3"^	18 F	1»7F	5	11*.	39,	25.5	2.35	2.27	2.65
118	U»-U5	1*. 5	27	1*	11*.	10.	28.1*	2.1*3	2.31*	2.72
119	1*5-1*6	ft 90	7-3	2	11.	1*6,	32-3	2.1A	2.35	2.66
120	1*6-1*7	2, 7	16	3	12.8	1*1,	28.1	2.1*0	2.31	2.65
121	1*7-1*8	1 2	16	3	13.5	1*5,	29.6	2.1*0	2.30	2.66
122	1*8-1*9	2. 6	29	3.	13	1*5.	30.7	2.39	2.29	2.66
123	1*9-50	0. 69	11*	2.	13.	1*3-	36.I	2.1*2	2.31	2.67
121*	50-51	5- 1	32	3.	13.	39.	33-6	2.38	2.29	2.65
125	51-52	1*3	88	7.	17.	32.	23.7	2.29	2.19	2.61*
126	52-53	7-	23	1*.	13.	33-	32.1	2.39	2.30	2.66
127	53-51*	182	236	8	18.	31-	21.5	2.26	2.15	2.61,
128	5U-55	*	*	10	17.	15.	23.3	2.27	2.19	2.65
129	55-56	129	169	8,	17.	28.	21.6	2.28	2.19	2.61,
130	56-57	63	111	8	18.	29.	23.8	2.25	2.15	2.65
131	57-58	3U3	530	9	19.	31.	22.3	2.25	2.13	2.66
132	58-59	193	261	7	17.	27.	31.1	2.29	2.19	2.65
133	.59-60	177	200	11.8	20.	20.	21.0	2.21	2.12	2.65
131*	60-61	176	185	11*. 0	19.	10.	I8.3	2.18	2.11	2.63
135	61-62	337	356	11*	20.	12,	19.1	2.16	2.09	2.61,
136	62-63	570	61*0	15	23.	17.	.17.5	2.11	2.02	2.61,
137	63-61*	156	I63	13	19	12.	18.1*	2.19	2.12	2.61*
138	61*-65	*	*	16	19.	31	12.2	2.16	2.10	2.61
139	65-66	1230	1270	18	21*.	11,	11*.1	2.06	2.00	2.61*
11*0	66-66.8			16	22.8	11*	il».5	2.07	2.01	2.61*

1566.8 -68.1 CORE LOSS

CORE LABORATORIES. INC.
Petroleum Reiervoir Engineering
DALLAS. TEXAS

r„™p„.y TARAWIR ENERGY TECHNOLOGY CENTER F„r™,.;„„.____ -P»lte_i- _of_
TKT,11 TST-2 c„^ F;I. RP-2-6931*
Field Drilling Fluid. -Dm Rcport_S=23=22_
County— .Stitc. . Elevation. A„,l,.,« TB:FB
Location-

CORE ANALYSIS RESULTS

*(Tifutti in p*rtntbttft rtfer to footnote ttwtwrlu)*

SAMPLE NUMBER	OtPTM F(CT	PCRMCAIILITV MILLIDARCVS EXTRACTION	AFTER EXTRACTION	POROSITY PCRCCNT (1)	(2)	RESIDUAL SATURATION { *OII_ j % PORE	OiI. % WT	OIL CAL/TON	TOTAL WATER % PORE	SAT. HNS.	EXT. IKS.	GRN DNS
111	1568.1-69	389	1*23	10.5	13.1	6.1	0.3		13.7	2.3U	2.31	2.66
11*2	69-70	288	316	9.1*	12.6	7.1	0.5		I8.3	2.37	2-33	2.66
11*3	70-71	2.6	26	3-2	10.8	38.O	1.7		32.1*	2.1*5	2.37	2.66
ii*i*	71-72	136	17U	9.1	15.1	16.6	1.0		23.2	2.31	2.21,	2.61,
11*5	72-73	213	271*	10.5	16.7	16.2	1.3		21.0	2.27	2.20	2.61*
11,6	73-71*	55	108	6.8	11*.1	27.7	1.7		21*.1	2.31*	2.26	2.63
11*7	7l*-75	238	339	11.8	19.1*	21.1	1.8		18.0	2.22	2.13	2.61*
11*8	75-76	11	85	8.2	18.3	27.9	2.2		27.3	2.26	2.15	2.63
11*9	76-77	31*8	585	11.8	20.5	21*.9	2.2		17.6	2.19	2.10	2.61,
150	77-78	0.79	16	3-1	11.6	1*2.2	2.0		31.0	2.1*3	2.3«»	2.61*
151	78-79	12	50	5.7	11*.0	31*. 3	2.0		25.0	2.36	2.27	2.61,
152	79-60	33	102	6.1*	15-2	31*.2	2.3		23.7	2.3U	2.21,	2.6U
	1580-82.l			CORE LOSS								

F . = FRACTURED PERMEABILITY PLUG
•UNSUITABLE FOR PERMEABILITY MEASUREMENTS
1 = SATURATED POROSITY
2 = EXTRACTED POROSITY

TAR SAND ANALYSIS

LARAMIE ENERGY TECHNOLOGY CENTER

TST-3

CORE LABORATORIES. INC.

Petroleum Reservoir Engineering

DALLAS. TEXAS

<->npny T.ABtKTR ¥WITIF.Cy TECHNOLOGY CENTER Formation TAR SANK -P»g«- of_

Well__IS3Ug Corei Fil, RP-2-6935

Field Drilling Fluid -Date Report— 8-23-82

r„.-.r GARFIELD <„„ UTAH EW«ion_iM[2]____ An,ly.r. TB:YD

I——;„„ NE SW SW SEC 2-T31S-R16E Remlrkl

CORE ANALYSIS RESULTS

(Fi$ttrei » pirmtbnrt rrfrr to jectnott rrmjrAj)*

	DEPTH	rtRME ABILITY MILLIDAHCYS		POWOSITV PEHCEMT (1)	(2)	RESIDUAL 1ATUBATION		TOTAL WATCF V rone	SAT. BNS.	EXT. TCS.	CRN ISIS
	o-iiai.7					NO ANALYSIS					
1	iiai.7-12	*	*	19.2	21.2	2.U	Tr	7.1	2.13	2.1D	2.66
2	12-13	0.10	3.5	1.2	1.8	0.0	0.0	27.8	2.61	2.60	2.6U
3	13-11,	0.03	1.1	2-3	2.8	0.0	0.0	17.9	2.60	2.59	2.67
k	11,-15	0.01	0.90	2.8	3-2	0.0	0.0	12.5	2.58	2-57	2.65
5	15-16	*	*	3.1	U.3	7.0	TT	20.9	2.56	2.55	2.67
6	16-17	*	*	2.0	2.2	0.0	0.0	9.1	2.63	2.62	2.68
7	17-18	*	*	3.U	U.3	2.3	Tr	18.6	2.57	2.56	2.68
8	18-19	*	*	3-1	3-7	0.0	0.0	16.2	2.59	2.56	2.68
9	19-20	*	*	17.7	21.7	9.2	1.0	9-2	2.13	2.08	2.66
10	20-21	*	*	22.2	25.5	2.1,	0.1,	10.6	2.01	1.98	2.66
11	21-22	*	*	19.5	22.5	I*.9	0.5	8.U	2.09	2.07	2.66
12	22-23	*	*	16.0	18.3	6.6	0.5	6.0	2.19	2.18	2.67
13	2>2l,	*	*	16.3	19.1	5.8	o.U	8.9	2.18	2.15	2.66
II,	21,-25	*	*	22.2	25.3	2.1,	0.1,	9-9	2.02	1-99	2.66
15	25-26	*	*	11,.h	17-3	6.9	0.1,	9-8	2.22	2.20	2.66
16	26-27	*	*	18.0	21.h	U.2	o.U	11-7	2.13	2.10	2.67
17	27-28		*	17.8	21.2	U.2	o.U	11.8	2.12	2.09	2.66
18	28-29	*	*	15-7	20.3	l+.U	o.U	18.2	2.17	2.13	2.67
19	29-30		*	18.2	22.6	U.9	o.U	1U.6	2.09	2.07	2.67
20	30-31		*	17.9	21.U	3.7	o.U	12.6	2.13	2.10	2.67
21	31-32		*	21.6	21*.9	2.1,	o.U	10.8	2.03	1.99	2.65
22	32-33	*	*	23.1	26.3	1.9	o.U	10.3	1.99	1.97	2.67
23	33-3U	2150	2300	25.7	27.5	1-5	0.1,	5-1	1.93	1.92	2.65
	lWU-35-75					CORE LOSS					
2k	35-75-36	*	*	23.3	25.9	3-5	0.8	6.6	1.95	1.92	2.60
	36-52					CORE LOSS					
			*	1U.U	18.2	7-1	0.8	13.7	2.20	2.16	2.65
25	1U52-53	*	*	1U.8	17.5	5-7	o.U	9-7	2.21	2.18	2.61,
26	53-5U	*	*	21.2	23.3	0.9	Tr	8.2	2.06	2.03	2.65
27	5U-55	»•									

propor op*r«uoo,

CORE LABORATORIES. INC.

Petroleum Reservoir Engineering

DALLAS. TEXAS

f ^ r - T TARAMTB ENERGY TECENOLOGY CEKTER p——,;,,,, TAR SAND — -Pjge- .of_

B,. HP-2-6935

Veil „ TST-3 Corel

Field Drilling Fluid -Due RT^T 8-23-82

County GARFIELD - . State UTAH . Eleviiion__i§§?_ .Analyst! T3;PD

.Locjtion NE SV SV SEC 2-T31S-R16E _ Remarks

CORE ANALYSIS RESULTS

(Figum in psrrmiottti rrfrr to footnote rrmsrkj)

		BEFORE tXTRACTION		11)	(JL		RCSIOUAL SATURATION	Oil. CAL/TOM	SIT. mis.	EXT. BBS.	CRN DOT
28	55-56	1650	1750	23.I	21*.9	2.0	0.3	5.2	2.01	1.98	2.61.
29	56-57	1550	2150F	21.8	22.8	0.9	Tr	3.5	2.CL	2.03	2.63
30	57-58	*	*	22.9	21*.2	0.8	Tr	1.5	2.02	2.00	2.61.
31	58-59	670	700	19.6	22.0	2-3	0.3	8.6	2.09	2.06	2.61.
32	59-60	280	283	ll»-9	18.5	1*.9	0.3	11*.6	2.20	2.15	2.61.
33	60-61	6hh	690	16.7	19.3	l*.l	0.1*	9.3	2.16	2.13	2.61.
31.	61-62	*	*	16.1	19.0	5.8	0.1*	9.5	2.18	2.15	2.65
35	62-63	*	*	15.2	17.9	0.6	Tr	Hi.5	2.20	2.17	2.61.
36	63-61*	393	393	11*.9	18.2	1*.9	0.1*	13.2	2.20	2.16	2.61.
37	61.-65	667	695	20.1	23.1.	2.1	0.3	12.0	2.Co	2.03	2.61.
38	65-66	*	*	21.9	21*.2	1.2	Tr	8.3	2.03	2.01	2.65
39	66-67	1*9	67	10.5	15.8	15.8	1.2	17.1	2.28	2.23	2.65
1»0	67-68	..	*	10.8	15.8	13-3	o.y	18.1*	2.28	2.23	2.65
1*1	68-69	325	371	17.5	21.2	U.7	0.3	12.7	2.12	2.08	2.61.
1*2	69-70	*	*	15.1	18.6	3-B	Tr	15.1	2.20	2.15	2.61.
1*3	70-71	137	167	10.1*	17-3	20.2	1-5	19.7	2.26	2.19	2.61.
10*	71-72	77	126	6.6	16.3	39.9	2.8	19.6	2.32	2.21	2.61.
1»5	72-73	278	298	17-3	20.1	1*.0	0.3	10.0	2.11.	2.11	2.65
1.6	73-71*	U*3	1*93	19.2	21.5	0.9	Tr	9.8	2.C9	2.07	2.61*
1*7	7l*-75	139	11*8	15.2	19.0	3.2	0.3	16.8	2.19	2.11»	2.61i
1*8	75-76	186	207	16.1	19.7	1*.6	0.3	13.7	2.17	2.13	2.65
1*9	76-77	1*23	1*39	17.9	21.2	2.1*	0.3	13.2	2.12	2.09	2.65
50	77-78	350	388	18.0	21.1.	5-6	0.3	10.3	2.12	2.08	2.65
•a	78-79	*	*	10.6	11..3	10.5	0.3	15	2.28	2.25	2.62
52	79-80	*	*	11*.7	19.2	3-6	Tr	19.8	2.18	2.Ill	2.65
53	80-81.8	*	*	17.8	22.0	1*.5	Tr	11*.5	2.12	2.08	2.67

* UNSUITABLE FOR PERMEABILITY MEASUREMENTS
F = FRACTURED PERMEABILITY PLUG
1 = SATURATED POROSITY
2 = EXTRACTED POROSITY

TAR SAND ANALYSIS

LARAMIE ENERGY TECHNOLOGY CENTER

TST-4

CORE LABORATORIES. INC.
Petroleum F.elervoir Engineering
DALLAS, TEXAS

r , „ r . - y LARAMIE ENERGY TECBHOLOGY CEHTER p ^ „ ; „ „ TUB sawn
-Pajt- -of.

TF.I1 TST-1* Coro
F;1, **RP-2-6961***

Fitld Drilling Fluid
-Date R-pnrr **9-11-82**

County—GABETJELD Statt_QIAH Elcvation_ 6859
_Analyiu

u - . ^ NE SB NE SEC. 16-T31S-R16B R.curis.

CORE ANALYSIS RESULTS
*(Ftg**r* in ptrrntbriri rrfrr to footnotr rrwtmrkj)*

SAUfLF ' DEPTH [_				*11}*	(2)	RESIDUAL SATURATION			SAT. DNS.	EXT. D:;S.	GRN INS
	0-11*01.3			NO ANALYSIS							
1	11*02-03			13.7	19.5	10.		19.5	2.19	2.13	2.65
2	IU03-0I*	62	76	10.2	18.•3	23.		21.3	2.21*	2.17	2.65
3	ll*0l*-05	81	99	10.7	19.1*	25.		19.6	2.22	2.13	2.61*
1*	11*05-06	121*	11*7	10.8	19-.9	25.		20.1	2.20	2.11	2.61*
5	11*06-07	167	258	11.0	21.0	29.		18.1	2.19	2.09	2.61*
6	11*07-08	98	152	11-3	19.6	22.		19.9	2.21	2.12	2.61*
7	11*08-09	57	72	10.	18..0	25.		17.8	2.21*	2.17	2.61*
8	11*09-10	129	176	11.	21:5	30.		15.8	2.17	2.07	2.61*
9	11*10-11	1*1*5	682	10.	23..6	37.		17.0	2.15	2.02	2.61*
10	11*11-12	261	1*32	9-	22•3	1*2.		15-3	2.17	2.05	2.61*
11	11*12-13	576	639	10.	23.1	35.		17.8	2.15	2.03	2.61*
12	11*13-11*	157	338	8.	20.9	1*2.		18.7	2.20	2.0?	2.61*
13	ll*ll*-15	155	352	7.	22.1	1*7.		18.6	2.18	2.05	2.61*
11*	11*15-16	332	701	9.	23.6	1*1*.		11*.8	2.15	2.03	2.66
15	11*16-17	1*01*	885	8.	21*.0	1*7.		17.1	2.15	2.01	2.61*
16	11*17-18	31*5	11*1*5	9.	25.0	50,		13.6	2.12	1.98	2.61*
17	11*18-19	61*	250	1*.	17.	50.		22.1	2.29	2.19	2.65
18	11*19-20	5-	1*5 *	3.	15-	52.		26.0	2.3U	2.21*	2.61*
19	11*20-21			1,	9-	12,		69.2	2.1*1*	2.1*0	2.61*
20	11*21-22	0 39	11	2.	12.	51.		31.2	2.W	2.32	2.61*
21	11*22-23	11*	11*8	5.	17-	50,	1*.0	21.0	2.30	2.18	2.65
22	11*23-21*	81	165	2.	11*.	53	3.2	28.6	2.39	2.28	2.67
23	ll*2l*-25	0 72	33	1,	12.3	52		31.7	2.1*2	2.32	2.61*
21*	11*25-26	2 8	30	2	13.1*	50		29.9	2.1*0	2.29	2.61*
25	11*26-27		*	8	15-	19		26.8	2.28	2.19	2.60
26	11*27-28	8.1*	26	5	13.	29		29.6	2.1*1	2.33	2.68
27	11*28-29	121*	327	6	16.	39		23.7	2.30	2.19	2.61*
28	11*29-30	3.1*	U*	1*	16.	1*6		21*.2	2.33	2.21	2.61*
29	11*30-31	30	68	6	17.	36		23.3	2.29	2.18	2.63
30	11*31-32			11	17.	13		20.8	2.21	2.11*	2.60

CORE LABORATORIES. INC.
Petroleum Reservoir Engineering
DALLAS. TEXAS

r^r-'-y T.tBiMTE TgUBBrtY TOHWWnT.nT.Y flrMTTO Form«i«n_TiS_SA®_ -Page__2_ -of.

Veil , TST-L Corel .File RP-2-6964

Field ; Drilling Fluid -Date Report. 9-14-82

County— . State. . Elevation. .Analyses FD

Location. . Remarks.

CORE ANALYSIS RESULTS

*(FigwtfS m p*renti>f%rt rrfrr to foot no tr remarks)*

	D"TM reeT	BEFORE EXTRACTIO*	ATTER EXTRACTION	POROSITY PERCENT ill	(JL	RESIDUAL SATURATION		OIL, CAL/TON	TOTAL. WATtf V PORE	SAT. BKS.	EXT. DBS.	GR5 DNS
31	11*32-33	*	»	10.0	16.7	15.6	1.1*		21*.6	2.27	2.19	2.63
32	11*33-31*	9.2	91	l*.l*	16.9	50.9	3-7		23.1	2.33	2.19	2.61*
33	ll*3l*-35	1.6	9.2	2.8	10.9	1*3-1	1.9		31-2	2.1*3	2.36	2.61*
31*	11*35-36	l*-8	17	5.0	11*.7	38.8	2.5		27.2	2.36	2.26	2.66
35	11*36-37	1*.9	250	2.6	17.9	63-7	5.0		21.8	2.31*	2.19	2.67
36	11*37-38	1.3	3-6	1.9	9.7	39-2	1.6		1*1.2	2.1*6	2.38	2.63
37	11*38-39	258	575	8.8	19.2	36.5	3-0		17.7	2.25	2.11*	2.65
	ll*39-U*			HISSING C0EE								
38	1U*5-U6	2.1	23	1.6	13-3	57-1	3-1		30.8	2.U	2.30	2.66
39	1U*6-1*7	8.2	71*	3.0	15-7	55-1*	3-7		25-5	2-36	2.23	2.65
l|0	11*1*7-1*8	1.2	21*	2.8	11*.2	51.1*	3-2		28.9	2.38	2.27	2.65
111	1U*8-U9	1.8	9-5	2.1*	9-3	31.2	l.1		1*3-0	2.1*3	2-57	2.61
ll?	lU*9-50	1.9	18	2.0	10.2	1*1.2	1.6		39-2	2.1*1*	2.36	2.63
I|3	1U50-51	1-7	1.8	1.9	13.0	50.8	2.7		31*.6	2.kl	2-30	2.61*
1*1*	11*51-52	5U1	610	6.8	16.5	3U.5	2.6		21*.2	2.32	2.22	2.65
l|5	11*52-53	201	286	6.8	16.5	35-8	2.5		23.O	2.30	2-21	2.65
1*6	11*53-51*	7-7	1.0	3.6	13-7	1*5-3	2.7		28.5	2.38	2.28	2.65
!i7	1U5U-55	16	70	1*.2	11*.1*	1*1*. 1*	2.7		26.1*	2.37	2.27	2.65
1*8	11*55-56	1*7	150	6.9	15.6	30.8	2.0		25.0	2.33	2.21*	2.65
1*9	11*56-57	28	132	1*.6	15.5	1*5-2	3-1		25.2	2.35	2.21*	2.65
50	11*57-58	8.7	15	6.9	11.8	13-6	0.5		28.0	2.38	2.32	2.63
51	11*58-59	1*33	1*10	13.2	20.0	11* 0	1.2		20.0	2.21	2.11	2.61*
52	11*59-60	96	105	7-9	16.1*	27-1*	2.0		21*.1*	2.32	2.21	2.61*
53	1U60-61	85	96	10.1	17.0	15 9	1.2		21*.7	2.29	2.20	2.65
	11*61-63			MISSIHG CORE								
51*	ll*61*-65	1*86	535	10.3	19.8	27.8	2.3		20.2	2.27	2.15	2.68
55	1U65-66	88	93	8.9	11*.9	12.8	0.9		27-5	2-33	2.25	2.6U
56	11.66-67	125	131	10.2	15.2	11.2	0.9		21.7	2.33	2.21*	2.61*
57	1U67-68	219	21*1*	8.0	16.7	28.7	2.0		23-1*	2.30	2.21	2.65
58	11*68-69	75	89	7-7	11*.2	18.3	1.1		27.5	2.35	2.28	2.66
59	11*69-70	371	1*07	6.9	18.9	1*2-9	3-5		20.6	2.27	2.15	2.66
60	1U70-71	625	735	6.9	18.0	liO.O	3-2		21.7	2.28	2.18	2.65

CORE LABORATORIES. INC.
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DALLAS. TEXAS

r.n,r,nr LARAMIE ENERGY TECHNOLOGY CENTER P——;,,,, TAB SAND -of.
Veil TST-1* Cores -Fdt_ RP-2-6964
Field Drilling Fluid .Date Report. 9-14-82
County . State. . Elevation., .Analysts FD
Location .

CORE ANALYSIS RESULTS

(Figmm rw bmrentbetri refer to JOOlnate remmrks)

fAMr>LC NUM|[R|	J DC^TM rcttT	PERMEABILITY MILLIDARCTI BIFOrTI • XTRACTION	AFTI* EXTRACTION	POROSITY PEUCCMT (1	RESIDUAL SATURATION (2)	•OIL. % PORK	OIL. % WT	OIL. GAL/TON	TOTAL WATER •kPORI	SAT. DNS.	EXT. HNS.	GBR 3SS
61	11*71-72	332	31*9	9.5	16.5	21.8	1.5		20.6	2.29	2.22	2.66
62	11*72-73	5.1	21*	3.2	12.0	39.2	2.0		31*.2	2.1*2	2.33	2.65
63	11*73-71*	3-7	26	2.9	12.0	1*2.5	2.2		33-3	2.1*5	2.36	2.65
61*	ll*7t*-75	1.1*	3-5	2.9	8.2	21*.1*	0.8		1*0.2	2.1*5	2.1*0	2.61
65	11*75-76	9.1*	38	3.2	13-3	1*6.6	2.7		29.3	2.1*0	2.29	2.61*
66	11*76-77	5-1*	20	1*.2	12.6	35-7	1.9		31.0	2-39	2.30	2.63
67	11*77-78	165	173	8.5	15-5	21*.5	1.7		20.6	2.31	2.23	2.61*
68	11*78-79	31	31*	5.7	12.7	22.8	1.2		32.3	2-37	2.29	2.63
69	11*79-80	68	95	5-7	11*.0	35.0	2.0		21*.3	2-35	2.26	2.63
70	11*80-81	1».9	21*	3-7	12.7	1*0.2	2.2		30.7	2.39	2.30	2.63
71	11*81-82	1.8	11	3.0	10.2	32.1*	1-3		38.2	2.1*3	2-35	2.62
72	11,82-83	351*	1*03	l*.l*	15.0	1*5.3	3-0		25.3	2.35	2.21*	2.61*
73	11*83-81*	1.0	29	2.6	12.6	1*8.1*	2.1*		31.0	2.1a	2.31	2.65
7U	11*81,-85	376	1*06	7-7	16.9	31.1*	2.3		23-1	2.30	2.20	2.65
75	11*85-86	1*1*6	1*71*	9.9	19.7	33-0	3-0		16.8	2.21*	2.13	2.65
76	11*86-87	361	378	8-3	18.6	32.3	2.7		23-1	2.28	2.17	2.66
77	11*87-88	608	615	8.3	19.9	38.7	3-5		19.6	2.21*	2.13	2.65
78	11*88-89	568	61,0	8-3	20.3	39-9	3-7		19-2	2.21*	2 12	2.66
79	11*89-50	99	11*3	3-0-	13.9	50.1*	3-0		28.1	2.38	2 28	2.65
80	11*90-91	253	570	6.8	19.2	1*7-1*	l*.l		17.2	2.27	2.11*	2.65
	11*91-93				MISSING COKE							
81	ll»9l»-95	68	605	l*-8	18.9	57-7	1*.8		16.9	2.30	2.15	2.66
82	11*95-96	37	*	3-1	ll*.l*	53-5	3--L		25.0	2.35	2.23	2.61
83	11*96-97	9-5	39	3.0	13-3	52.6	2.8		21*.8	2.1*1	2.30	2.65
81*	11*97-98	8.1,	31	3-U	13.3	1*8.9	2.8		25-6	2.1*1	2.30	2.65
	11*98-99				MISSING C0HE							
85	ll,99-eo	13	1*7	3-7	13.3	1*2.9	2.1*		29.3	2.39	2.29	2.61,
86	1500-01	11*	137	2.9	15-1*	56.5	3-8		2l*.7	2.36	2.21*	2.61,
87	1501-02	26	116	5.0	11*.9	1*0.3	2.5		26.2	2.36	2.21*	2.61*
88	1502-03	2.6	15	2.2	11.1	1*1*.l	1.9		36.0	2.1*3	2.33	2.62
89	1503-OU	26	56	3-5	13.8	1*5-7	2.8		29.O	2.38	2.27	2.63
90	l50l*-05	3.4	10	2.8	8.7	29.9	1.1		37-9	2.1*6	2.1*0	2.62

CORE LABORATORIES, INC.
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DALLAS. TEXAS

C-mpnr WWBZ EMERGY TECHNOLOGY CENTER *Vnmmtim* TAR SATO It

xg.11 TST-U Coro F.lf RP-2-6964

Field Drilling Fluid Due Report 9-14 -82

Counry— . Sute_ . Elevition- .Ana] iMr« FD

Location . . Remarks.

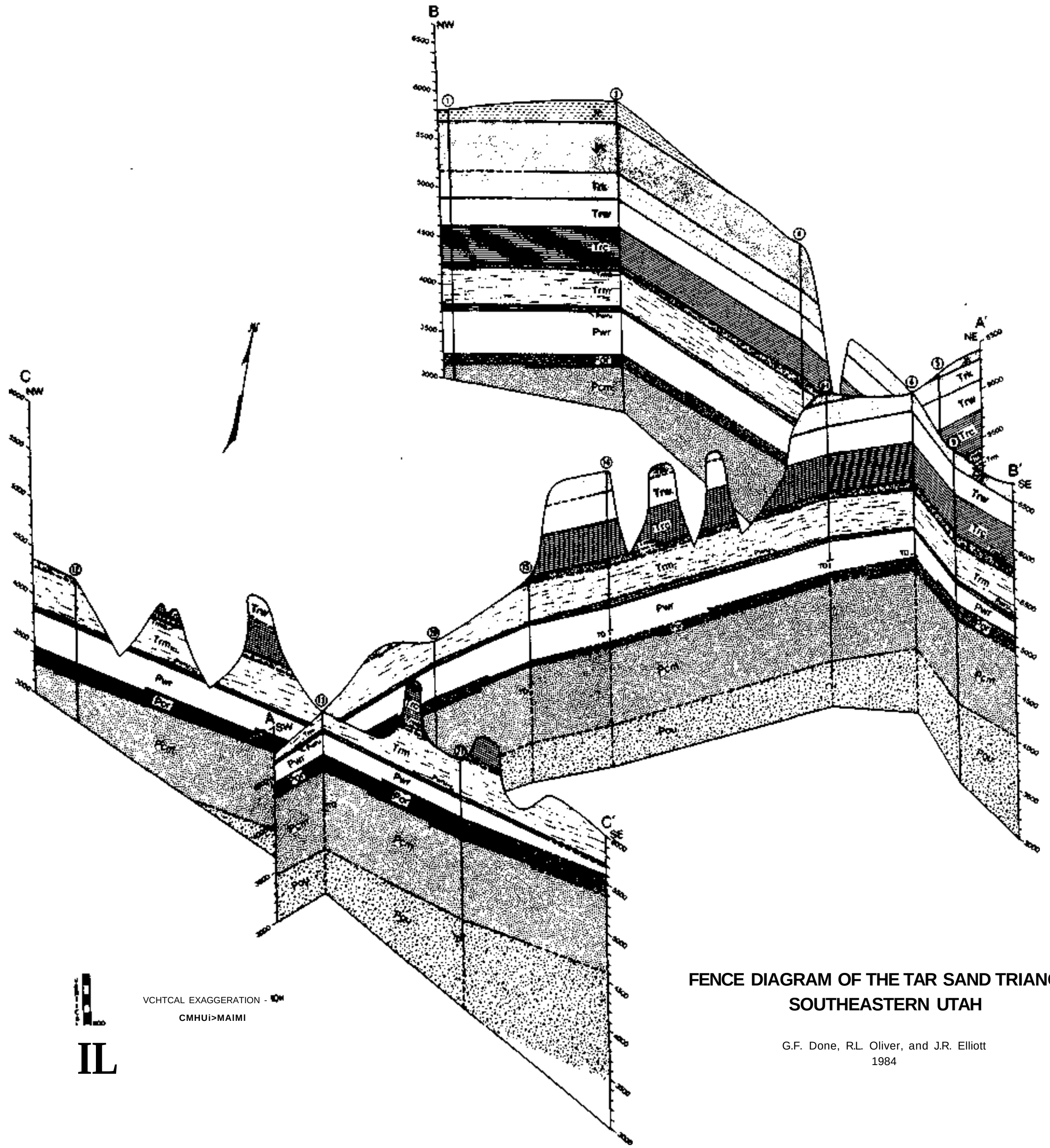
CORE ANALYSIS RESULTS

(FifU'et n ptrrntbettt rrfrr to footnott rrmsrkj)*

SAMPLE NUMBER	DEPTH FltT		PERMEA»ILITT MILLIDARCYS	POROSITY PERCENT 0)___	121	RESIDUAL SATURATION		OIL. CAW/TON	SAT. MS.	EXT. ESS.	SNS
91	1505-06	51	166	i*.i*	15-8	50.		21.5	2.35	2.22	2.61*
92	1506-07	12	92	3.U	lU-o	1*7.		28.6	2.39	2.27	2.61*
93	1507-08	30	130		15.1*	1*6.		22.7	2.36	2.23	2.61*
91*	1508-09	1*0	127		15-U	U8.		26.0	2.37	2.21*	2.65
95	1509^10	21	85		13.7	53.		21*. 1	2.39	2.27	2.63
96	1510-11	18	62		13-5	36.		28.1	2.1*0	2.29	2.61*
97	1511-(2	16	63		13.U	3U		25.1*	2.1*0	2.29	2.61*
98	1512-13	27	65		il*.o	29-		2l*.3	2.37	2.27	2.61*
99	1513-lU	63	72		13-2	6.		19.7	2.38	2.30	2.65
	1511*-15				MISSING COBS						
100	1515-16	31	56		12.5	16.8	0.8	21*. 8	2-39	2.32	2.65
101	1516-17	1*0	285		18. 1*	59.8	1*.7	17-1*	2.29	2.16	2.61*
102	1517-18	32	226		17.8	I17.8	3.6	11*. 6	2.32	2.17	2.61*
103	1518-19	33	208		17.9	1*1.9	3.3	ll*-5	2.31	2.17	2.61*
lol*	1519-20	152	250		1U	33-8	2.1	21.1*	2.36	2.26	2.61*
105	1520-21	1*.6	61*		9	15.6	0.5	33-3	2.1*2	2.35	2.60
106	1521-22	7.1*	103		11	25.6	1.3	27.1*	2.1*0	2.32	2.63
107	1522-23	10	19	5.1*	12	27.2	1-3	29.6	2.38	2.29	2.62
108	1523-21*	5.5	15	5-1	11.8	29.7	1-3	27.1	2.39	2.31	2.62
109	152U-25	1.5	2.1		8.8	10.2	0.3	36.1*	2.1*3	2.38	2.62
110	1525-26	0.01	0.01		3 2	0.0	0.0	68.8	2.69	2.68	2.77
111	1526-27	0.01	0.01		6 1	0.0	0.0	31.1	2.51*	2.52	2.68
112	1527-28	0.01	0.01		7 0	0.0	0.0	28.6	2.51*	2.51	2.70
H3	1528-29	<0.01	<0.01		U.6	0.0	0.0	23-9	2.65	2.61*	2.77
	1529-1555				SILTY SHALE - NO ANALYSIS						

UNSUITABLE FOR ANALYSIS
iS . SATURATED POROSITY
EXTRACTED POROSITY

PLATE I



LEGEND

Stratigraphic Units

.^jt>-j Carmel Formation

« f "#!* Navajo Sandstone

__7_ | T* Kayenta Formation

| Trw Wingate Sandstone

u ^ ^ j Chinle Formation

2 KjF£5| M033 Back Member of the Chinle Formation
h Easfl&g

[• -Trm J Moenkopi Formation

Upper Member ot the White Rim Sandstone

H White Rim Sandstone Member

Organ Rock Shate Tongue

Cedar Mesa Sandstone Member

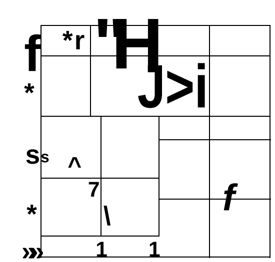
Cutter Formation

Ppu'vl Older Permian Strata, undivided

Stratigraphic Unit Contact Lines
(Dulwd whan •cwioxkniMv tociMd)

————Conformable

——~— Unconformable



VCHTCAL EXAGGERATION - 10x

CMHUi>MAIMI

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FENCE DIAGRAM OF THE TAR SAND TRIANGLE, SOUTHEASTERN UTAH

G.F. Done, R.L. Oliver, and J.R. Elliott
1984

PLATE II

LEGEND

Stratigraphic Units

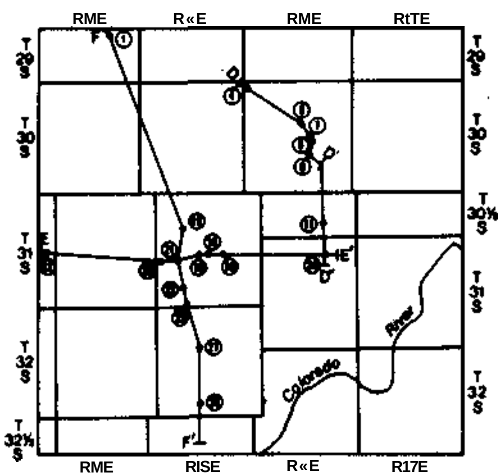
Period	Symbol	Unit	
Triassic	Tkc	Kayenta Formation	
	Tw	Wingate Sandstone	
	Trc	Chinle Formation	
	Trmb	Moss Back Member of the Chinle Formation	
	Trm	Moenkopi Formation	
Permian	Pwu	Upper Member of the White Rim Sandstone	
	Pwr	White Rim Sandstone Member	Cutler Formation
	Por	Organ Rock Shale Tongue	
	Pcm	Cedar Mesa Sandstone Member	

Stratigraphic Unit Contact Lines
(Dashed where approximately located)

———— Conformable

——.— Unconformable

Index Map



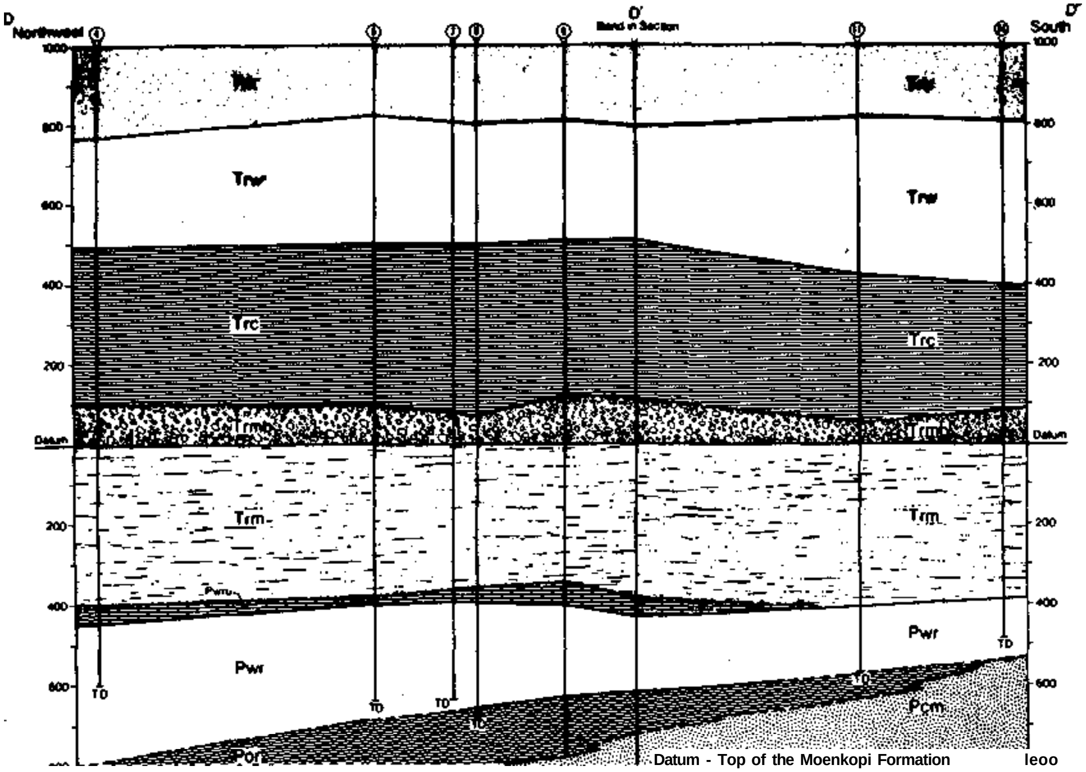
(Numbers above wells correspond to those used in table)

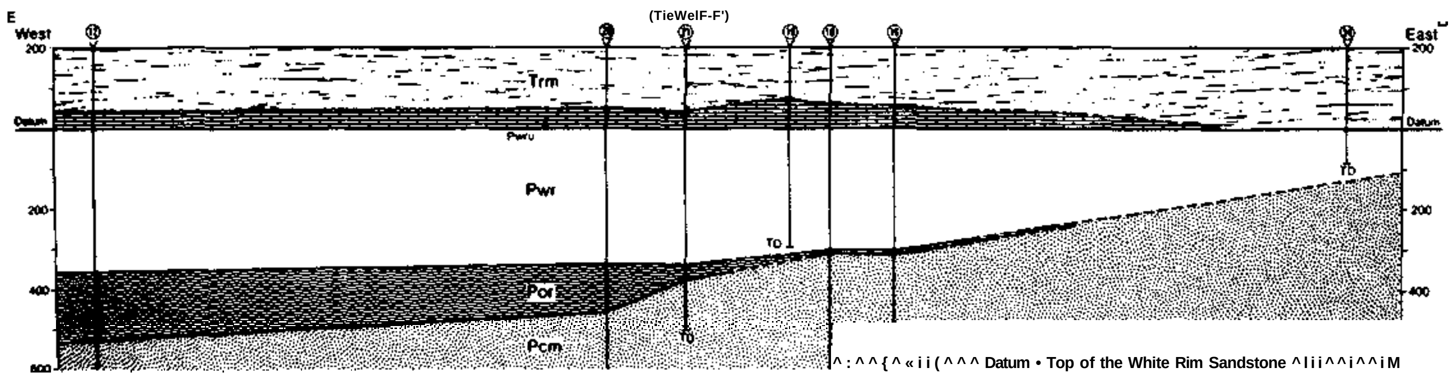
STRATOGRAPHIC CROSS SECTIONS OF THE TAR SAND TRIANGLE, SOUTHEASTERN UTAH

G.F. Dana, K.L. Olivar, and J.It. Elliott

19(4

PLATE II (CONTINUED)





VERTCAL EXAGGERATION
- 26x

HORIZONTAL SCALE

STRATOGRAPHIC CROSS SECTIONS OF THE TAR SAND TRIANGLE, SOUTHEASTERN UTAH

G.F. Dono, R.L. Oliver, and J.R. Elliott

19(4

PLATE II (CONTINUED)

A 1 VERTCAL EXAGGERATION
-26»

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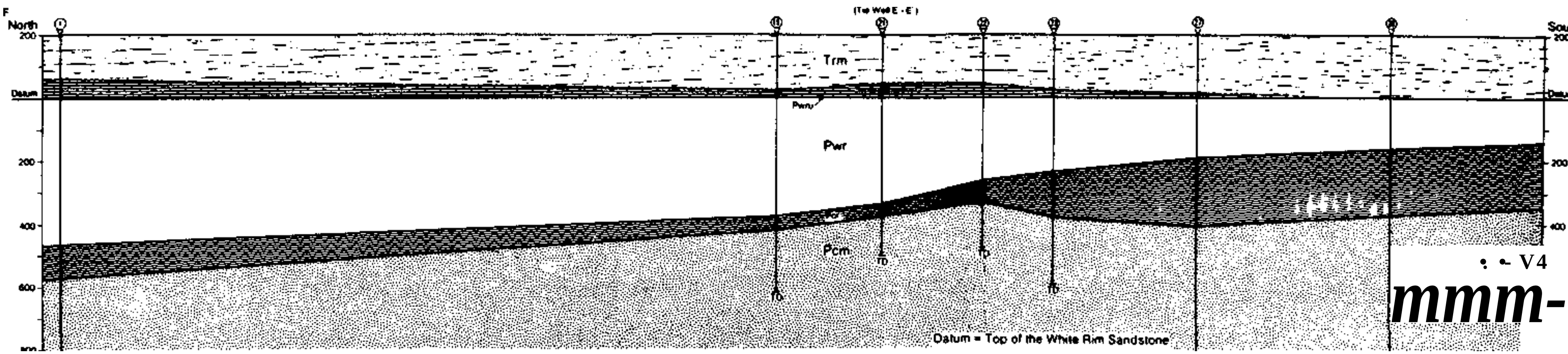

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STRATOGRAPHIC CROSS SECTIONS OF THE TAR SAND TRIANGLE, SOUTHEASTERN UTAH

G.F. Dona, **R.L. Olivor,** and **J.R.** Elliott

1984