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SHALLOW OIL SHALE RESOURCES OF THE SOUTHERN UINTA BASIN, UTAH

BY

George F. Dana, John Ward Smith, and Laurence G. Trudell

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Laramie Energy Technology Center
Laramie, Wyoming

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REPORT OF INVESTIGATIONS

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George F. Dana¹, John Ward Smith², and Laurence G. Trudell³

ABSTRACT

The shallow Green River Formation oil shales in the southern part of Utah's Uinta Basin are potentially developable by strip mining or by subsurface techniques which take advantage of limited overburden. The resource of potential shale oil represented by the shallow deposits is evaluated in detail from corehole oil-yield data. Cross-sections are constructed to readily correlatable stratigraphic units selected to represent resources in the shallow shale. To define each unit, the thickness, average oil yield, and oil resource of each unit in each core are calculated. Contour maps constructed from these data define the resource variation across the shallow resource. By measuring areas enclosed in each resource unit within the defined limit of 200 feet (61 meters) of overburden, the resource represented by the shallow oil shale is evaluated. The total resource is measured as 4.9 billion barrels (779.1 billion liters) of potential shale oil at depths less than 200 feet (61 meters). The rich zone incorporates the Mahogany bed, the best shallow oil-shale unit. This section, currently being exploited by Geokinetics, Inc. for in situ production of shale oil by horizontal combustion, represents 2.2 billion barrels (349.8 billion liters) of potential shale oil in place.

INTRODUCTION

The Mahogany zone of Utah's Green River Formation is found at or near the ground surface over a substantial area in the southern Uinta Basin. This shallow oil shale (at depths to 200 feet (61 meters)) represents an important oil resource potentially developable by strip mining or by horizontal in-situ methods. Geokinetics Inc., has demonstrated a horizontal in-situ production technique directly applicable to such a resource (Lekas, 1979). This paper defines the shallow oil shale resource, detailing the sections potentially attractive for shale-oil production from shallow deposits.

To determine the oil resource and the deposit characteristics represented by this shallow section of the Green River Formation, the Laramie Energy Technology Center (LETC) drilled 10 coreholes in the southern Uinta Basin. In addition, information from 12 cores taken by private companies is incorporated in the resource evaluation. Eighteen

¹George F. Dana, Acting Division Manager, Division of Resource Characterization, Laramie Energy Technology Center, Laramie, Wyoming

²John Ward Smith, Consultant, Laramie, Wyoming

³Laurence G. Trudell, Section Supervisor, Division of Resource Characterization, Laramie Energy Technology Center, Laramie, Wyoming

other exploration testholes provided some data useful for construction of structural contour and overburden maps. Stanfield and others (1964) present the only data previously published. The Mahogany zone and the overlying oil shale in the area was divided into correlatable units. Three cross-sections constructed from oil-yield histograms correlate these units stratigraphically. Thickness, average oil yield, and oil resource in place are presented on contour maps which outline the resource. The oil-shale resource in and above the Mahogany zone at depths suitable for Geokinetics-style development is summarized.

Production of shale oil from near-surface horizontal retorts, as practiced by Geokinetics, Inc., involves creating permeability in the oil-shale bed using explosives (Lekas, 1979). This method lifts the ground surface to provide the subsurface void space required for gas passage in horizontal in-situ production of oil from oil shale. To date experimental horizontal retorts have been created and operated successfully by Geokinetics to depths of more than 60 feet (18.3 meters). Further experimentation is expected to increase this applicable depth (Britton, 1980).

GEOLOGIC SETTING, STRUCTURE, AND STRATIGRAPHY

The area lies in the southern portion of the Uinta Basin, in Uintah County of northeastern Utah. Shallow oil shales underlie approximately 1/6 of the 560 square mile (901 square kilometers) area in Figures 1 and 2. The Uinta Basin is both a structural and depositional basin, bounded on the north by the Uinta Mountains, on the east by the Douglas Creek arch, on the south by the Roan Cliffs, and on the west by the Wasatch Range. The Basin's axis is in its northern part. In the southern part of the basin where the shallow oil-shales are found, the deposit dips gently north and northwest at $1\frac{1}{4}^{\circ}$ to $2\frac{1}{4}^{\circ}$.

A particular easily correlated point, the top of the richest sample in the Mahogany bed, was used as the datum for structure and overburden. Trudell and others (1974) define the Mahogany bed as the 2 to 5-foot (0.6 to 1.5 meters) interval of extremely rich, shiny brown to black oil shale always occurring in the Mahogany zone. The Mahogany bed is the richest of the oil shale and will probably always be included in developed sections. Figure 3 is a structural contour map using the richest sample as datum.

Contours are solid where drawn within the Mahogany bed outcrop and where data control is available. Long dashed lines are found within the Mahogany bed outcrop where data is absent and the structure is inferred. Short dashed lines represent inferred structure but where the datum is absent by erosion.

Only 2 faults are reported, both of which are minor in displacement (Cashion 1967). The overburden map, Figure 4, shows approximate thicknesses of sediments from the surface of the ground to the datum. The datum information was derived from detailed core analysis or from the top of the richest 10 or 30-foot (3.1 or 9.2 meters) drill cutting samples from Fischer assay results of drilled (not cored) holes.

Figure 1. Location of Study Area, Southern Uinta Basin, Utah

LEGEND

- COREHOLE LOCATION (NUMBERS REFER TO COREHOLES LISTED IN TABLE 1)

Figure 2. Cross-section Locations

LEGEND

- CORE SAMPLE, ELEVATION OF MAHOGANY BED AT SAMPLE POINT IN FEET
- DRILL CUTTING SAMPLE, ELEVATION OF MAHOGANY BED AT SAMPLE POINT IN FEET (NUMBERS REFER TO DRILLHOLES LISTED IN TABLE 2)
- MAHOGANY BED OUTCROP
- 6700-100 ft. CONTOUR INTERVAL

Figure 3. Structural Map of Southern Uinta Basin, Datum - Mahogany Bed

LEGEND

- 64 CORE SAMPLE, THICKNESS OF OVERBURDEN ABOVE MAHOGANY BED IN FEET
- 75 DRILL CUTTING SAMPLE, THICKNESS OF OVERBURDEN ABOVE MAHOGANY BED IN FEET
- MAHOGANY BED OUTCROP
- 100- 100 ft. ISOPACH

Figure 4. Overburden Above Mahogany Bed

The oil-shale section in the study area is in the Parachute Creek member of the Eocene Green River Formation, composed principally of oil shale, with some marlstone, siltstone, sandstone, and tuff. The tuffs are comparatively thin and can be used as stratigraphic marker beds for correlation over large areas of the basin. The fine-grained oil shales and marlstones were deposited in a deep lacustrine environment. This Eocene lake, named Lake Uinta, covered both the Uinta Basin and the Piceance Creek Basin during the time the Green River oil shales were deposited. Depositional mechanism and stratification of these lacustrine environments producing sections of oil shale have been described elsewhere (Trudell and others 1974, Smith 1974).

RESOURCE EVALUATION PROCEDURES

The Uinta Basin oil-shale resource suitable for development by near-surface horizontal in-situ methods is located in the southern and eastern parts of the basin. Evaluation of this resource is presented in terms of stratigraphic and oil yield data.

Data Base

Fischer assay made on cores and drill cuttings by the Laramie Energy Technology Center provide the primary oil yield data base for the evaluation of this resource. Oil-yield data obtained by the Fischer assay method, standardized by the Laramie Energy Technology Center (ASTM 1980), were available for the 22 coreholes shown on Figure 1. The corehole numbers are identified in Tables 1 through 3 with the name of the company that took the core, the corehole name, its location and its elevation. All locations are given in relation to the Salt Lake Meridian and all elevations are above mean sea level. Additional data for overburden and structural contour maps was obtained from Fischer assay of drill cuttings from the petroleum exploration wells identified in Table 4.

Cross Sections

Vertical and horizontal definition of comparable sections is required to evaluate an oil-shale resource. Three correlated cross sections of the Mahogany zone and adjacent strata were constructed based on oil-yield histograms. The histograms are stratigraphic richness profiles used for each well on each cross section. On the histograms, missing samples are denoted by plotting oil yields of missing intervals below the zero oil-yield line, thus distinguishing between a missing sample and a barren sample. Each histogram is labeled with its map number, the agency who drilled it, and the well name. On the depth scale of each histogram are indicated the top and bottom of the assayed core. Histograms are entered along the cross-sections at fairly equal intervals but the true horizontal scale and position is given at the top of each plate. The two Brewer cores (No. 6 and 7 in Figure 2) show anomalous stratigraphic oil-shale distribution in the rich zone represented by Unit 11. The balance of the stratigraphy for these two cores appears normal and the core results are included for their other contributions. No reason for these anomalies is available but it appears unlikely that they represent reality.

OIL YIELD AND RESOURCE DATA BY OIL SHALE UNIT

TABLE 1.
COREHOLES USED TO CONSTRUCT CROSS-SECTION A-A'.

MAP NO.	COREHOLE		OIL SHALE UNIT							TOTAL SECTION
			I	II RZ	III	IV	V A-GR	VI	VII	
1	H. M. BYLLESBY AND CO., INC. AGENCY COREHOLE SUNNESE SEC 1 T13S R20E SURFACE ELEVATION: 5836	TOP	183.2	157.4	135.0	112.2	88.2	68.6	41.5	41.5
		BOT	204.0	183.2	157.4	135.0	112.2	88.2	68.6	204.0
		THK	20.8	25.8	22.4	22.8	24.0	19.6	27.1	162.5
		AVE	11.32	25.17	5.04	11.74	2.02	9.94	5.61	9.84
		RES	18650.	46480.	9435.	21130.	4162.	15610.	12640.	128100.
2	ERDA/LERC SOUTHERN UINTA BASIN COREHOLE 6 NUNWNE SEC 31 T13S R22E SURFACE ELEVATION: 6628	TOP	163.6	142.0	121.6	97.5	81.4	62.1	37.6	37.6
		BOT	179.4	163.6	142.0	121.6	97.6	81.4	62.1	179.4
		THK	15.8	21.6	20.4	24.0	16.2	19.3	24.5	141.8
		AVE	11.29	26.29	5.80	11.66	2.24	11.48	7.17	10.76
		RES	14130.	40330.	9813.	22090.	3115.	17530.	14390.	121400.
3	ERDA/LERC SOUTHERN UINTA BASIN COREHOLE 4 NESWNE SEC 35 T13S R22E SURFACE ELEVATION: 6700	TOP	136.0	115.0	99.3	77.3	60.2	44.0	20.6	20.6
		BOT	151.3	136.0	115.0	99.3	77.3	60.2	44.0	151.3
		THK	15.3	21.0	15.7	22.0	17.1	16.2	23.4	130.7
		AVE	11.60	30.48	7.40	15.43	2.24	12.60	6.98	12.32
		RES	14030.	44210.	9507.	26040.	3277.	16010.	13420.	126500.
4	ERDA/LERC SOUTHERN UINTA BASIN COREHOLE 8 NENESW SEC 26 T13S R23E SURFACE ELEVATION: 6419	TOP	50.5	26.3	16.8	5.0 T				5.0 T
		BOT	63.4	50.5	26.3	16.8				50.5
		THK	12.9	24.2	9.5	11.8 P				45.5
		AVE	16.36	28.40	10.58	23.16				22.98
		RES	16080.	48130.	8006.	19830.				75970.
5	ERDA/LERC SOUTHERN UINTA BASIN COREHOLE 9 NWSWNE SEC 6 T13S R24E SURFACE ELEVATION: 6268	TOP	208.8	180.1	168.6	153.5	143.3	130.5	113.2	113.2
		BOT	222.5	208.8	180.1	168.6	153.5	143.3	130.5	222.5
		THK	13.7	28.7	11.5	15.1	10.2	12.8	17.3	109.3
		AVE	17.94	31.48	10.65	20.52	3.90	16.13	9.21	17.58
		RES	18520.	61990.	9748.	22910.	3361.	15750.	12830.	145100.

(A-A' CONTINUED ON NEXT PAGE)

TABLE 1.
COREHOLES USED TO CONSTRUCT CROSS-SECTION A-A'. (CONTINUED)

MAP NO.	COREHOLE		OIL SHALE UNIT							TOTAL SECTION
			I	II RZ	III	IV	V A-GR	VI	VII	
6	FRANK A. AND F. ALLEN BREWER	TOP	90.5	63.7	52.0	37.8	27.5	13.5	0.0 T	0.0 T
	COREHOLE 8-1	BOT	103.5	90.5	63.7	52.0	37.8	27.5	13.5	103.5
	CNWSW	THK	13.0	26.8	11.7	14.2	10.3	14.0	13.5 P	103.5 P
	SEC 8 T13S R24E	AVE	17.60	30.15	11.23	21.38	4.57	15.18	3.88	16.59
	SURFACE ELEVATION: 6322	RES	17270.	55930.	10410.	22300.	3945.	16330.	4416.	130600.
7	FRANK A. AND F. ALLEN BREWER	TOP	106.2	79.2	69.2	55.0	45.3	30.7	11.0	11.0
	COREHOLE 9-1	BOT	118.4	106.2	79.2	69.2	55.0	45.3	30.7	118.4
	CSWNE	THK	12.2	27.0	10.0	14.2	9.7	14.6	19.7	107.4
	SEC 9 T13S R24E	AVE	18.12	27.53	11.94	19.92	3.29	15.80	8.34	16.28
	SURFACE ELEVATION: 6497	RES	16630.	52360.	9408.	21880.	2705.	17650.	13340.	133300.
8	ERDA/LERC	TOP	174.5	150.7	140.8	126.0	117.4	103.6	86.6	86.6
	SOUTHERN UINTA BASIN COREHOLE 10	BOT	187.3	174.5	150.7	140.8	126.0	117.4	103.6	187.3
	SWSENE	THK	12.8	23.8	9.9	14.8	8.6	13.8	17.0	100.7
	SEC 10 T13S R24E	AVE	16.94	34.34	11.67	20.64	3.68	15.75	10.01	17.95
	SURFACE ELEVATION: 6677	RES	16450.	55060.	9126.	22560.	2677.	16640.	13620.	136100.
9	NATIONAL FARMERS UNION EXPL. CO.	TOP	137.0	112.5	102.3	89.9	81.0	69.5	51.0	51.0
	COREHOLE 6	BOT	148.8	137.0	112.5	102.3	89.9	81.0	69.5	148.8
	SW	THK	11.8	24.5	10.2	12.4	8.9	11.5	18.5	97.8
	SEC 2 T13W R24E	AVE	17.26	32.08	11.86	22.06	3.49	16.89	9.44	17.62
	SURFACE ELEVATION: 6789	RES	15420.	53710.	9537.	20000.	2633.	14740.	14050.	130100.
10	GENERAL PETROLEUM CORP.	TOP	38.0	15.5	5.0	0.0 T				0.0 T
	COREHOLE 42-29	BOT	48.5	38.0	15.5	5.0				48.5
	SENESE	THK	10.5	22.5	10.5	5.0 P				48.5 P
	SEC 29 T12S R25E	AVE	19.25	32.29	11.83	17.40				23.0
	SURFACE ELEVATION: 6799	RES	15070.	49590.	9798.	6578.				81040.

TABLE 2.
COREHOLES USED TO CONSTRUCT CROSS-SECTION B-B'.

MAP NO.	COREHOLE		OIL SHALE UNIT							TOTAL SECTION
			I	II RZ	III	IV	V A-GR	VI	VII	
11	H. M. BYLLESBY AND CO., INC.	TOP	201.1	171.0	152.0	137.4	106.0	95.0	71.5	71.5
	WINDY COREHOLE	BOT	220.4	201.1	171.0	152.0	137.4	106.0	95.0	220.4
	SWNWSW	THK	19.3	29.3	19.0	14.6	30.6	11.0	23.5	140.9
	SEC 24 T12S R20E	AVE	13.26	24.32	6.00	14.93	1.60	10.61	6.10	10.46
	SURFACE ELEVATION: 5503	RES	19960.	51300.	9962.	16790.	4423.	9972.	11050.	124200.
12	ERDA/LERC	TOP	150.0	123.2	104.0	80.9	61.0	49.1	26.5	26.5
	SOUTHERN UINTA BASIN COREHOLE 1	BOT	170.0	150.0	123.2	104.0	80.9	61.0	49.1	170.0
	NENENE	THK	20.0	26.0	10.4	15.9	27.9	11.9	22.6	143.5
	SEC 30 T12S R21E	AVE	12.32	24.04	6.01	13.45	2.06	10.05	5.06	10.41
	SURFACE ELEVATION: 5496	RES	19360.	47750.	9156.	16660.	4930.	10260.	10990.	119100.
13	ERDA/LERC	TOP	140.0	122.2	104.0	87.5	59.3	46.4	25.4	25.4
	SOUTHERN UINTA BASIN COREHOLE 2	BOT	167.5	140.0	122.2	104.0	87.5	59.3	46.4	167.5
	SESUNE	THK	19.5	25.0	10.2	16.5	20.2	12.9	21.0	142.1
	SEC 35 T12S R21E	AVE	11.52	26.20	6.32	14.15	1.74	10.22	5.41	10.30
	SURFACE ELEVATION: 5029	RES	17770.	40160.	9490.	10090.	4230.	10530.	9450.	117700.
14	ERDA/LERC	TOP	117.2	94.0	75.0	56.4	33.0	20.7 T		20.7 T
	SOUTHERN UINTA BASIN COREHOLE 3	BOT	135.0	117.2	94.0	75.0	56.4	33.0		135.0
	SENUNW	THK	17.0	23.2	10.2	19.4	22.6	13.1		114.3 P
	SEC 17 T13S R22E	AVE	12.13	27.64	7.13	13.92	2.12	11.50		12.22
	SURFACE ELEVATION: 6103	RES	16990.	45130.	10640.	20960.	4103.	11920.		109000.
3	ERDA/LERC	TOP	136.0	115.0	99.3	77.3	60.2	44.0	20.6	20.6
	SOUTHERN UINTA BASIN COREHOLE 4	BOT	151.3	136.0	115.0	99.3	77.3	60.2	44.0	151.3
	NESUNE	THK	15.3	21.0	15.7	22.0	17.1	16.2	23.4	130.7
	SEC 35 T13S R22E	AVE	11.60	30.40	7.40	15.43	2.24	12.60	6.90	12.32
	SURFACE ELEVATION: 6700	RES	14030.	44210.	9507.	26040.	3277.	16010.	13420.	126500.
15	ERDA/LERC	TOP	60.3	40.0	32.4	11.4	0.5 T			0.5 T
	SOUTHERN UINTA BASIN COREHOLE 5	BOT	01.5	60.3	40.0	32.4	11.4			01.5
	NESWE	THK	13.2	20.3	15.6	21.0	10.9 P			01.0 P
	SEC 35 T13S R22E	AVE	11.60	20.67	7.66	15.52	1.57			14.20
	SURFACE ELEVATION: 6727	RES	12100.	40600.	9750.	24990.	1470.			09090.
16	ERDA/LERC	TOP	60.1	49.0	32.3	11.0	5.0 T			5.0 T
	SOUTHERN UINTA BASIN COREHOLE 7	BOT	00.4	60.1	49.0	32.3	11.0			00.4
	NUNUNE	THK	12.3	19.1	16.7	21.3	6.0 P			75.4 P
	SEC 14 T14S R22E	AVE	9.07	26.75	6.30	16.50	.57			13.96
	SURFACE ELEVATION: 6909	RES	9729.	36100.	0600.	26740.	300.			01640.

TABLE 3.
COREHOLES USED TO CONSTRUCT CROSS-SECTION C-C'.

MAP NO.	COREHOLE		OIL SHALE UNIT							TOTAL SECTION
			I	II RZ	III	IV	V A-GR	VI	VII	
17 USGS		TOP	483.9 P	459.2	447.5	435.3	425.2	416.0	400.8	400.8
	CRU-1	BOT	496.5	483.9	459.2	447.5	435.3	425.2	416.0	496.5
	SUNENE	THK	12.6	24.7	11.7	12.2	10.1	9.2	15.2	95.7
	SEC 3 T12S R24E	AVE	18.45	29.47	12.04	19.07	4.20	16.09	9.98	17.20
	SURFACE ELEVATION: 6137	RES	17440.	50620.	11090.	18000.	3635.	11790.	12140.	124700.
18 NATIONAL FARMERS UNION EXPL. CO.		TOP	196.0	174.0	165.5	153.4	150.0 T			150.0 T
	COREHOLE 5	BOT	209.2	196.0	174.0	165.5	153.4			209.2
	S1/2	THK	13.2	22.0	8.5	12.1	3.4 P			59.2 P
	SEC 2 T12S R24E	AVE	18.06	38.40	11.86	21.21	3.66			23.06
	SURFACE ELEVATION: 6059	RES	18630.	55530.	7952.	18080.	1051.			102000.
19 GULF MINERAL RESOURCES CO.		TOP	64.6	42.4	33.3	30.0 T				30.0 T
	BONANZA NO. 1	BOT	73.6	64.6	42.4	33.3				73.6
	NW1/4SE	THK	9.0	22.2	9.1	3.3 P				43.6 P
	SEC 14 T12S R24E	AVE	20.84	35.10	10.10	21.00				25.64
	SURFACE ELEVATION: 6165	RES	13300.	52310.	7407.	5287.				79200.
20 GULF MINERAL RESOURCES CO.		TOP	107.0	84.0	76.3	63.0	53.0	43.0	36.0 T	36.0 T
	BONANZA NO. 8	BOT	117.0	107.0	84.0	75.0	63.0	53.0	43.0	117.0
	NW1/4SE	THK	10.0	23.0	7.7	12.0	10.0	10.0	7.0 P	81.0 P
	SEC 18 T12S R25E	AVE	19.36	34.06	12.16	10.90	3.50	15.02	7.06	10.40
	SURFACE ELEVATION: 6340	RES	14430.	52860.	7367.	18090.	3029.	12110.	4055.	111800.
21 GULF MINERAL RESOURCES CO.		TOP	155.1	133.3	122.0	107.0	97.0	86.0	80.0 T	80.0 T
	BONANZA NO. 2	BOT	167.4	155.1	133.3	122.0	107.0	97.0	86.0	167.4
	NESWSW	THK	12.3	21.0	11.3	15.0	10.0	11.0	6.0 P	87.4 P
	SEC 22 T12S R24E	AVE	18.54	36.02	11.88	22.70	5.06	16.52	7.29	19.70
	SURFACE ELEVATION: 6225	RES	17100.	53220.	10500.	24060.	4850.	13830.	3500.	120000.
22 GULF MINERAL RESOURCES CO.		TOP	118.0	92.0	84.0	69.0	60.3	59.4 T		59.4 T
	BONANZA NO. 9	BOT	130.0	118.0	92.0	84.0	69.0	60.3		130.0
	SUNENE	THK	12.0	26.0	8.0	15.0	8.7	9 P		70.6 P
	SEC 34 T12S R24E	AVE	18.24	33.30	11.46	20.31	3.42	17.20		20.03
	SURFACE ELEVATION: 6450	RES	16440.	50820.	7250.	22560.	2519.	1172.		100500.
9 NATIONAL FARMERS UNION EXPL. CO.		TOP	137.0	112.5	102.3	89.9	81.0	69.5	51.0	51.0
	COREHOLE 6	BOT	148.0	137.0	112.5	102.3	89.9	81.0	69.5	148.0
	SW	THK	11.0	24.5	10.2	12.4	8.9	11.5	10.5	97.0
	SEC 2 T13W R24E	AVE	17.26	32.00	11.06	22.06	3.49	16.09	9.44	17.62
	SURFACE ELEVATION: 6789	RES	15420.	53710.	9537.	20000.	2633.	14740.	14050.	130100.

FOOTNOTES FOR RESOURCE TABLES

<u>SYMBOL</u>	<u>MEANING</u>
P	UNIT IS INCOMPLETELY REPRESENTED (TOP OR BOTTOM OF CORE)
T	TOP OF CORE SAMPLES

<u>ABBREV.</u>	<u>MEANING</u>
TOP	TOP OF UNIT, FEET
BOT	BOTTOM OF UNIT, FEET
THK	THICKNESS OF UNIT, FEET
AVE	AVERAGE OIL YIELD, GALLONS PER TON
RES	IN-PLACE OIL RESOURCE, BARRELS PER ACRE

TABLE 4. Petroleum wells providing data for geologic structure and overburden mapping (Figures 3 and 4)

	Company	Well name	Location (Sec-Twp-Rg)
23	Shamrock Oil and Gas Corp.	Government #1-1	NWSE 1-12S-21E
24	Shamrock Oil and Gas Corp.	Government #1-5	NWSE 5-12S-22E
25	D. J. Stone	Oil Springs #3	NESW 5-12S-24E
26	Alamo Corp.	Oil Springs #3	NESW 4-12S-24E
27	Utah Geological & Mineral Survey	PR-3B	NWSW 8-12S-25E
28	Delhi-Taylor Corp.	Government #1-15	SWNE 15-12S-21E
29	Delhi-Taylor Corp.	Government #1-13	SWNE 13-12S-21E
30	Delhi-Taylor Corp.	Government #1-17	NWSE 17-12S-22E
31	Continental Oil Co.	Oil Springs #1	SWSE 15-12S-24E
32	Sinclair Oil and Gas Corp.	Uintah-Federal #178-1	SWSW 24-12S-22E
33	Utah Geological & Mineral Survey	PR-4	SESW 5-13S-25E
34	Sinclair Oil and Gas Corp.	Uintah Oil Assoc. #1	NWNW 8-13S-21E
35	Sinclair Oil and Gas Corp.	Uintah Oil Assoc. #2	NWSE 8-13S-21E
36	Sinclair Oil and Gas Corp.	Uintah-Federal #171-1	SESW 14-13S-22E
37	Continental Oil Co.	Oil Springs #3	NWNE 15-13S-24E
38	Skyline Oil Co.	Sweetwater Creek #1	SESW 26-13S-23E
39	Woodward & Co.	McCook Ridge #1	NWNW 25-13S-23E
40	Utah Geological & Mineral Survey	PR-6	SWSW 33-13S-22E

For precise determination of the oil-shale resource, the deposit was divided into eight stratigraphic units based on oil-yield histograms. Correlations are based on oil yield profiles according to the time-stratigraphic method developed for the Green River Formation by Trudell and others (1970). Precise time-line correlations identify thickening or thinning of the units, and the histograms show variations in oil-shale yield within the units. The most identifiable of these correlations is Unit II, RZ (rich zone) on the cross section representing the richest part of the Mahogany zone. Within the zone is found the Mahogany bed, the richest single layer of oil shale in the total section, easily identified on detailed oil-yield data from cores. A second readily recognizable section is A-groove (AG on the cross sections) representing a nearly barren marlstone deposit surrounded by richer oil shales.

Locations of the three cross sections constructed to correlate the Uinta Basin's shallow oil shales are shown in Figure 2. Cross section A-A' (plate 1) is a west-to-east cross-section beginning in T 13 S, R 20 E and ending in T 12 S, R 25 E, a straight-line distance of about 32 miles (51.5 meters). Tables 1, 2, and 3 list the coreholes used to construct cross sections A-A', B-B', and C-C' respectively. Generally the total section and each of the units is thicker, but not richer to the west, indicating a western source of clastics in the leaner zones.

Corehole Unit Calculations

Thickness, average oil yield in gallons per ton and in-place oil resource in barrels per acre were calculated for each unit based on the correlated cross-sections. Tables 1, 2, and 3 list all coreholes and the depth to the top and bottom of each unit. The average oil yield and oil resource were calculated by the LETC procedure that compensates for density differences in oil shale (Stanfield and others, 1964). Because the bulk of the richest oil shale is found below the base of A-groove, Units I through IV were evaluated together as a single resource. The last column of the 3 tables is entitled Total section, summarizing data from Units I through VII.

Contour Maps

To complete the resource evaluation, contour maps were constructed summarizing thickness, average oil yield, and barrels of oil in place for units within the area between the Mahogany bed outcrop and the Mahogany bed at 200 feet (61 meters) depth. The corehole locations on the maps provide the data used for contouring. The solid contours cover areas which are underlain by oil shale and dashed lines indicate areas where the oil-shale units are missing due to erosion.

Units I, II, III, IV and VI were evaluated by contour maps. Unit V, A-groove, was not contoured because of low oil yield values. Unit VII and VIII were not contoured because of the dearth of available data. Units I through IV were also contoured as total resource because they comprise the developable deposits in the total oil-shale section. The resource contour maps (Figures 5-20) permit detailed evaluation at any point in the study area. Thickness, richness and oil resource of each unit are available from the contour maps. The resources are contoured

LEGEND

- MAHOGANY BED OUTCROP
- COREHOLE LOCATION
- THICKNESS OF UNIT, feet
- UNIT REMOVED BY EROSION

0 6 Mi.
0 9 Km.

Figure 5. Unit I Thickness Contours

Figure 6. Unit I Average Oil Yield Contours

Figure 7. Unit I Resource Contours

Figure 8. Unit II Thickness Contours

Figure 9. Unit II Average Oil Yield Contours

Figure 10. Unit II Resource Contours

Figure 11. Unit III Thickness Contours

Figure 12. Unit III Average Oil Yield Contours

Figure 13. Unit III Resource Contours

Figure 14. Unit IV Thickness Contours

LEGEND

- MAHOGANY BED OUTCROP
- COREHOLE LOCATION
- AVERAGE OIL YIELD OF UNIT, gal/ton
- UNIT REMOVED BY EROSION

Figure 15. Unit IV Average Oil Yield Contours

Figure 16. Unit IV Resource Contours

Figure 17. Unit VI Thickness Contours

LEGEND

- MAHOGANY BED OUTCROP
- COREHOLE LOCATION
- AVERAGE OIL YIELD OF UNIT, gal/ton
- UNIT REMOVED BY EROSION

Figure 18. Unit VI Average Oil Yield Contours

LEGEND

- MAHOGANY BED OUTCROP
- COREHOLE LOCATION
- RESOURCE IN UNIT, 100 bbl/acre
- UNIT REMOVED BY EROSION

Figure 19. Unit VI Resource Contours

Figure 20. Total Resource Contours for Units I-IV

at intervals of 100 barrels (15900 liters) per acre. The contour values designated on the contour maps must be multiplied by 100 to obtain resource levels. Depth to the bottom of each unit in the oil-shale column can be derived for any point or any area by comparing elevation contours (available from data presented) with surface topography. By comparing the above contour maps and the overburden map (Figure 4), areas best suited for shallow horizontal in-situ oil shale production can be selected.

RESOURCE EVALUATION

Discussion of Units

Characteristics of units I through VI of the vertical section are summarized as studied in the 22 coreholes.

Unit I - This unit is a part of the Mahogany zone below the rich zone. Thickness ranges from 9' (2.7 meters) in the east to 21' (6.4 meters) in the west (Figure 5). Average oil yield ranges from 10 gallons per ton (48.6 liter per tonne) in the south to 13 (63.2) northwestward and as high as 21 (102.1) northeastward (Figure 6). In-place resource ranges from 9,700 barrels (1.5 million liters) per acre to 20,000 (3.9) northwestward and to 18,600 (3.0) northeastward (Figure 7).

Unit II - This unit called the rich zone (RZ), contains the Mahogany bed, the single richest bed in the Uinta Basin. The unit should be considered first in placing any kind of oil shale development in the study area. Thickness ranges from 19' to 29' (5.8 to 8.8 meters) from south to north but is 22' or 23' (6.7 to 7.0 meters) in the northeast (Figure 8). Average oil yield ranges from 24 gallons per ton (116.6 liters per tonne) in the west to 38 (184.7) in the east (Figure 9). In-place resource ranges from 36,200 barrels (5.8 million liters) per acre in the south to 62,000 (9.9) in the central portion (Figure 10).

Unit III - This unit is a comparatively lean section. It overlies the rich zone and contains the Mahogany Marker, a tuff found about 15 feet (4.6 meters) above the Mahogany bed. Thickness ranges from 8' (2.4 meters) in the east to 22' (6.7 meters) in the west (Figure 11). Average oil yield ranges from 5 gallons per ton (24.3 liters per tonne) in the west to 12 (58.3) in the east (Figure 12). In-place oil resource ranges from a low of 7,200 barrels (1.1 million liters) per acre to 10,600 (1.7) in the east and from 8,700 to 10,000 (1.4 to 1.6) in the south and west (Figure 13).

Unit IV - This comparatively thin unit lies immediately under A-groove. Thickness ranges from 12' (3.7 meters) in the east to 24' (7.3 meters) in the southwest (Figure 14). Average oil yield ranges from 12 gallons per ton (58.3 liters per tonne) in the southwest to 23 (111.8) in the central and east portions of the map (Figure 15). In-place oil resource ranges from 16,800 barrels (2.7 million liters) per acre in the northwest to 26,700 (4.2) in the south and from 18,000 (2.9) in the north and 24,900 (4.0) in the northcentral (Figure 16). This is the second richest unit identified in the vertical section studied. It is a secondary target for horizontal in-situ development.

A-Groove - A-groove is an accepted and widely-used term indicating a very lean marlstone zone overlying a continuous, medium to rich oil-shale section in the Uinta Basin. A-groove was not evaluated in this paper because of its negative potential for shale-oil production.

Unit VI - This unit directly overlies A-groove and is the last unit discussed under this format. Thickness ranges from 9' (2.7 meters) in the east to 20' (6.1) in the west (Figure 17). Average oil yield ranges from 10 gallons per ton (48.6 liters per tonne) in the west to 17 (82.6) in the east (Figure 18). In-place oil resource ranges from 9,900 barrels (1.6 million liters) per acre in the north to 17,600 (2.8) in the south (Figure 19).

Units I-IV

The in-place oil reserves of the combination of Units I through IV, range from 81,300 barrels (12.9 million liters) per acre in the south to 113,200 (18.0) in the central part of the area. Figure 20 is the resource contour map for this section. It represents the primary oil shale section in the southern Uinta Basin and constitutes the principal target for shallow horizontal in-situ development. The total thickness of Units I-IV shows a persistent thinning from west to east and north to south with the thickest section at 91.8' (28 meters) and the thinnest at 54.0' (16.5 meters). The richness of the combined units increases from west to east and from south to north or basinward. The lowest total of average oil yields is 53.3 gallons per ton (259.0 liters per tonne) in the western extreme and the highest is 88.1 (428.2) in the northeast.

Resource Summary

Table 5 summarizes the percent of total area per unit in each of the contour intervals of 100 barrels (1590 liters) per acre. The number of acres in each unit is Unit I - 45000 (18225 hectares), Unit II - 44400 (17982 hectares), Unit III - 44600 (18063 hectares), Unit IV - 44400 (17982 hectares), and Unit VI - 44200 (17901 hectares). The average area for Units I through IV is 44500 acres (18022 hectares).

The reserves of potential shale oil in the shallow oil shales of the southern Uinta Basin are tabulated below, expressed in billions of barrels. Unit V is not considered in the summary because it is A-groove and is a very lean resource.

<u>Unit</u>	<u>Billions of barrels</u>
VI	0.64
IV	0.97
III	0.42
II	2.16
I	<u>0.72</u>
Total	4.91

TABLE 5. Resource summary for Southern Uinta Basin
shallow oil shale deposits.

Contour Interval in 100 BBL/Acre	Acres Per Unit					
	Unit I % of total	Unit II % of total	Unit III % of total	Unit IV % of total	Unit VI % of total	Units I-IV % of total
60- 70			7.0			
70- 80			14.1			
- 90			21.5			
-100	.5		29.5		1.5	
-110	3.0		9.0		4.8	
-120	1.9		6.7		19.8	
-130	1.9		12.2		11.0	
-140	8.7		100.0		10.4	
-150	12.2				14.0	
-160	15.5				9.5	
-170	18.0			2.5	14.3	
-180	17.1			15.5	14.7	
-190	16.5			7.2	100.0	
-200	4.2			5.8		
-210	.5			6.3		
-220	100.0			23.4		
-230				17.5		
-240				5.3		
-250				4.3		
-260				2.7		
-270				9.5		
-280				.1		
				100.0		
340-360		.2				
-380		3.0				
-400		4.5				
-420		5.0				
-440		5.6				
-460		10.5				
-480		12.6				
-500		14.3				
-520		15.5				
-540		13.8				
-560		10.7				
-580		2.4				
-600		1.5				
-620		.3				
-640		.1				
		100.0				
800-840						2.6
-880						15.3
-920						13.9
-960						26.2
-1000						16.1
-1040						10.1
-1080						6.4
-1120						2.8
-1160						6.6
						100.0

The rich zone-Unit II, incorporating the Mahogany Bed, represents 2.16 billion barrels (343.4 billion liters) and Units I through IV total 4.27 billion barrels (678.9 billion liters) of potential shale oil in place. The total resource of potential shale oil represented by the shallow (less than 200 feet (61 meters) of overburden) Green River Formation oil shales of the southern Uinta Basin is 4.9 billion barrels (779.1 billion liters).

CONVERSION FACTORS

The conversion factors used in this paper to provide metric unit figures along with English units figures are:

feet x .305 = meters
 barrels x 159 = liters
 miles x 1.609 = kilometers
 gallons per ton x 4.86 = liters per tonne
 acre x .405 = hectares

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