HEAVY OIL PROSPECT
NW ASPHALT RIDGE
UINTAH COUNTY, UTAH

Tom Brown, Inc.
P.O. Box 2608
Midland, Texas 79701
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Isopach, total Mesaverde Formation

Isopach, net sand, Mesaverde Formation

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Isopach, total Asphalt Ridge Member

Isopach, net sand, Asphalt Ridge Member

Isopach, net pay, Asphalt Ridge Member

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Isopach, total Rimrock Member

Isopach, net sand, Rimrock Member

Isopach, net pay, Rimrock Member
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SUMMARY

A 150 million barrel accumulation of heavy oil (14° API) underlies an 1120 acre Tom Brown, Inc. tract located six miles west of Vernal, Utah. A recently completed six-well corehole project provided the data to delineate this major accumulation. The following combination of geological and engineering factors make this an attractive target for thermal and/or chemical recovery:

1) Concentration of reserves - approximately 150 million barrels of oil underlying an area of only 500 acres (300,000 B/ac).

2) Shallow depth - drilling depths range from 300' to 2000' with most reserves concentrated in the 500' to 1500' depth range.

3) Excellent reservoir rock quality - sandstones of the Mesaverde Formation, containing an estimated 126 million barrels of oil in place, exhibit good reservoir continuity and individual beds are as much as 70' thick. Further, a combination of high average porosity (31%) and high average oil saturation (69%) results in an average oil in place of 1660 B/ac ft for the Mesaverde sands. Tertiary age sandstones contain an additional 25 million barrels of oil in place.

4) Formation dip - all strata dip south-southwest into the Uinta Basin. Whereas the average dip of the Cretaceous Mesaverde Formation is 45°, the average dip of the unconformably overlying Tertiary strata is about 25°. These large dips enhance the potential for significant gravity drainage.
5) Sweet Crude – based on several published analyses, Asphalt Ridge crude is unusually low in sulphur, averaging only about 0.4% by weight.

The prospect is further enhanced by good accessibility, moderate topographic relief (elevations range from 6000' to 6500') and proximity to a major oil field supply center, Vernal, Utah.

The U. S. Bureau of Mines has recently announced plans for an experimental thermal recovery project on a ten-acre tract located one half mile east of the tract owned by Tom Brown, Inc. This U.S.B.M. field experiment is particularly relevant to our prospect because the reservoir-fluid conditions underlying the experimental tract are expected to be identical with those known to exist in the subsurface of the Tom Brown, Inc. tract. Because the experiment, which is in essence a pilot test, is being conducted by a Federal agency, the results will be made available to interested parties.
HEAVY OIL PROSPECT
NW ASPHALT RIDGE, UINTAH COUNTY, UTAH

INTRODUCTION

During January 1974, Tom Brown, Inc. acquired a ten-year State of Utah oil, gas and hydrocarbon lease on an 1120 acre tract located six miles west of Vernal in northeast Utah. Subsequently, six coreholes were drilled on this tract, providing the data to delineate a 150 million barrel deposit of heavy oil (14° API). The low mobility of the crude at existing subsurface temperatures precludes exploitation by conventional primary means; nor is the deposit amenable to strip mining because of the large amount of overburden. We believe, however, that this large oil accumulation is well suited for in-situ thermal recovery methods such as steam or fire floods.

This report describes the geology of the NW Asphalt Ridge heavy oil accumulation and documents the volume of oil in place under the Tom Brown, Inc. 1120 acre tract. No attempt is made herein to estimate potential recoverable oil. It is hoped, however, that this report provides an adequate geologic base for the engineering studies required to make such estimates.
GEOLOGICAL SETTING

The geology of the prospect area is a continuation of the geology of Asphalt Ridge, a prominent topographic feature located on the northeast flank of the Uinta Basin in northeast Utah (Figure 1). Asphalt Ridge is a hogback or cuesta trending northwesterly in which the Cretaceous and Tertiary Formations dip southwesterly into the Uinta Basin. Tertiary age sandstones as well as sandstones of Cretaceous age (Mesaverde Formation) are locally highly oil saturated where they crop out along Asphalt Ridge. These well-known deposits, sometimes referred to as "tar sands" or "bituminous sands" are described in several published reports. These same Tertiary and Cretaceous strata contain the heavy oil reserves in the NW Asphalt Ridge prospect.

The subject prospect is located just northwest of the northern terminos of Asphalt Ridge as shown in Figure 2 (Tom Brown, Inc. lease). Cross sections X-X' and Y-Y' (Figure 2) show the structural relationship of the Cretaceous Mancos and Mesaverde Formations with the unconformably overlying Tertiary strata.

Tom Brown, Inc. drilled six coreholes on their tract in early 1974. The locations of these coreholes are shown on Figure 3, the cross section index map.
The structural relationship of the Cretaceous strata (Mancos and Mesaverde Formations) with the overlying Tertiary strata in the prospect area are shown in Figures 4, 5, 6, and 7. ** Comparison of these four sections with sections X-X' and Y-Y'(Figure 2) shows that the Northwest Asphalt Ridge prospect is essentially a subsurface extension Asphalt Ridge, at least with respect to the primary objective Mesaverde Sands (Rimrock and Asphalt Ridge Members). Asphalt Ridge proper (the topographic feature) is actually a giant stratigraphic trap that has been exhumed as a result of the present erosion cycle. Probably half of the original oil in place has been lost as a result of this erosion. In contrast, virtually all of the original oil in place in the NW Asphalt Ridge prospect remains intact, the only loss occurring, possibly, from the stripping away of some oil-saturated Tertiary strata.

** STRATIGRAPHY

Kayser describes the stratigraphy of the Asphalt Ridge area in a report published in 1966 by the Utah Geological and Mineralogical Survey. Portions of Kayser's summary of the stratigraphy are pertinent to the present prospect and, therefore, are quoted below. Comments in brackets are ours, and have been inserted where appropriate.

** Oil saturated zones within the Tertiary strata were encountered in all six Tom Brown, Inc. coreholes. These zones are not shown on the diagrammatic cross sections (Figures 4, 5, 6, and 7).
Cretaceous:

Mancos Shale

"The Mancos Shale or 'Upper Shale Unit' is the oldest formation exposed in the immediate vicinity of Asphalt Ridge. The Mancos Shale consists of a uniform sequence of gray to buff, soft marine shales with a few thin, hard brown sandstone beds near the top. It generally crops out in front of the Ridge on the floor of Ashley Valley. No bituminous material was seen in the formation in this area." [Minor zones of oil saturation were encountered in the upper Mancos sandstone beds in the NW Asphalt Ridge prospect.]

Mesaverde Group

"Walton (1944) divided the Mesaverde Group at Asphalt Ridge into three formations: the Asphalt Ridge Sandstone at the base; the Rimrock Sandstone; and the Williams Fork Formation. The Asphalt Ridge and Rimrock Sandstones are marine littoral sediments separated by a thin bed of shale, usually referred to as Mancos Shale [called Mancos Tongue in the NW Asphalt Ridge prospect; see Figures 4, 5, 6, and 7], The Williams Fork Formation consists of brackish water sandstones interbedded with sandy, red, pink and purple shales and thin coal seams."

"The Asphalt Ridge Sandstone, which conformably overlies the shale unit, is a light gray to buff, very fine to fine-grained, soft, friable sandstone, a little more than 100 feet thick at the northern end of the Ridge. The Asphalt Ridge Sandstone crops out along the base of the Ridge front and is barren in the main Ridge area. However, in a limited exposure in the area shown in Figure 2 [Sohio patented tract, Figure 2 of this report], it is richly saturated with bitumen."

"The Rimrock Sandstone crops out conspicuously along the entire length of the Ridge. In the northern part, the Rimrock Sandstone is saturated by bitumens which mask its lithology. In bitumen-free areas, the Rimrock generally is light gray, fine to medium-grained and speckled with numerous black chert grains."

The Mesaverde Group was deposited during a major west to east regression that occurred during late Cretaceous time in the Utah-Colorado area. Whereas regional Mesaverde stratigraphic relations are shown in Figure 8, local Mesaverde correlation
is illustrated in Figure 9.

In the NW Asphalt Ridge corehole program some 948 feet of Mesaverde core was cut, including approximately equal amounts of Rimrock Member and Asphalt Ridge Member. Descriptions of these cores are included in Appendix A.

Tertiary;

"Tertiary stratigraphy in the Asphalt Ridge area is complicated by the discontinuous and intertonguing nature of the sediments on the margin of the Uinta Basin. Asphalt Ridge is in a transition zone between on shore fluvial-flood plain and deltaic environments and an open basin lacustrine environment [which was located in the approximate center of the present structural Uinta Basin]. The rapid lateral and vertical variations in the sediments make correlation over widespread areas difficult." [Figure 10 illustrates Tertiary correlation in the NW Asphalt Ridge prospect. Specific beds are difficult to correlate, but larger units can be correlated. For example, the green shale unit shown on Figure 10 is present throughout the prospect area.]

Wasatch Formation (Paleocene/early Eocene)

"... the Wasatch ... consists of fluviatile red and green mudstone and shale, discontinuous lenticular sand layers and, in place, a basal conglomerate."

Uinta Formation (late Eocene)

"... at Asphalt Ridge, the Uinta Formation consists of fluviatile interbedded, gray to buff to brown sandstone beds, gray to white to red mudstone and shale, and lenses of grit and conglomerate. The sandstone, grit and conglomerate generally are poorly sorted and crossbedded to irregularly bedded. These probably represent channel deposits..."

Duchesne River Formation (Oligocene)

"The Duchesne River Formation of lower Oligocene age conformably overlies the Uinta Formation in the southern part of Asphalt Ridge and unconformably overlies the Mesaverde Group in the central and northern part. The Duchesne River Formation resembles the fluviatile beds of the upper Uinta but has a higher percentage of sandstones and conglomerate of a darker, more uniform red color ... sandstones, grit and conglomerate of the Duchesne River Formation commonly contain bituminous saturations in the central and northern parts of Asphalt Ridge."
COREHOLE PROGRAM

Tom Brown, Inc. completed a six-well corehole program in the NW Asphalt Ridge prospect early in 1974. This program was undertaken to establish the volume and distribution of heavy oil under the State lease acquired in January 1974. Conventional 4-inch diameter cores were cut in four of the wells (no cores were cut in well #1 or well #2). A total of 1322 feet of core was cut, of which 1175 feet (89%) was recovered. Primary emphasis in the core program was on the Mesaverde Formation because it was anticipated that sandstones of this formation were the most lucrative exploitation targets. A list of intervals cored is shown in Table 1 and a description of each core, as recorded at the wellsite, is included in Appendix A.

All cores were submitted to Core Laboratories, Denver, for routine analysis. Three hundred thirty-two samples were analyzed for permeability (before and after extraction), porosity and fluid saturation. Selected samples were analyzed for grain density. Core analysis reports, by well, are submitted herewith as separate enclosures.

The open-hole logging program consisted of an SP/resistivity survey, a compensated density log with gamma ray and a compensated neutron log. All logs were digitized and computer processed utilizing the Schlumberger "tar sand analysis" program (Saraband). Results of the computer processing are presented in the form of a Schlumberger "Synergetic" log showing lithology, porosity, permeability index,
<table>
<thead>
<tr>
<th>Corehole</th>
<th>#</th>
<th>Interval</th>
<th>Amount Cut</th>
<th>Amount Recovered</th>
<th>Formation</th>
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<td>36'</td>
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<td></td>
<td>2</td>
<td>780' - 835&quot;</td>
<td>55'</td>
<td>52'</td>
<td>Kmv</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1094' - 1153'</td>
<td>59'</td>
<td>59'</td>
<td>Kmv</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1153' - 1212'</td>
<td>59'</td>
<td>59'</td>
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<td></td>
<td>5</td>
<td>1212' - 1262'</td>
<td>50'</td>
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</tr>
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<td></td>
<td>6</td>
<td>1262' - 1325'</td>
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</tr>
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<td>Kmv</td>
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<td>57'</td>
<td>Kmv &amp; Mancos</td>
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<tr>
<td></td>
<td>9</td>
<td>1429' - 1461'</td>
<td>32'</td>
<td>30'</td>
<td>Mancos</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>1461' - 1515'</td>
<td>54'</td>
<td>52'</td>
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</table>

| CH #6    | 1 | 780' - 835"   | 55'        | 52'              | Kmv         |
|          | 2 | 835' - 867'   | 32*        | 28'              |             |
|          | 3 | 915' - 915'   | 48*        | 47'              |             |
|          | 4 | 1001' - 1022' | 21'        | 20"              |             |
|          | 5 | 1022" - 1070" | 48'        | 48*              |             |
|          | 6 | 1070' - 1093' | 23*        | 19'              |             |
|          | 7 | 1093' - 1118' | 25'        | 24'              |             |

| CH #7    | 1 | 205' - 235*   | 30'        | 27*              | Tertiary    |
|          | 2 | 396' - 434'   | 38'        | 33'              | Kmv         |
|          | 3 | 434' - 479'   | 45'        | 34'              | Kmv         |
|          | 4 | 529' - 581'   | 52'        | 44'              | Kmv         |
|          | 5 | 581' - 620'   | 39'        | 39'              | Kmv & Mancos|
|          | 6 | 620' - 657"   | 37'        | 15'              | Mancos      |

| CH #8    | 1 | 1169' - 1177' | 8'         | 7'               | Tertiary    |
|          | 2 | 1277* - 1303' | 26'        | 23*              | Kmv         |
|          | 3 | 1521' - 1539' | 18'        | 15'              |             |
|          | 4 | 1539' - 1561' | 22"        | 17"              |             |

| TOTALS   |  | 1322'         | 1175'      | 319              |             |

**PROJECT TOTALS**

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<th>Footage Cored</th>
<th>Recovery</th>
<th>Samples Analyzed</th>
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<td>Tertiary</td>
<td>100'</td>
<td>75'</td>
<td>13</td>
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<td>Mancos</td>
<td>274'</td>
<td>222'</td>
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<td><strong>1322'</strong></td>
<td><strong>1175'</strong></td>
<td><strong>332</strong></td>
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hydrocarbon saturation and oil in place (B/ac. ft.). The results are also presented in the form of a computer-printout listing of the same reservoir parameters calculated at one-foot intervals. The Tertiary strata were analyzed separately from the Cretaceous strata. Thus, there is a set of "Synergetic" logs and corresponding printouts for the Cretaceous formations (Mesaverde and Mancos) and another set for the Tertiary strata. There are two reasons for making separate computer analyses. First, the Tertiary strata is more complex lithologically; and, second, the formation water resistivities (Rw) are different for the two groups of strata.

A complete set of open-hole logs, computer generated "Synergetic" logs and computer printout sheets are included as separate enclosures with this report.

OIL IN PLACE – MESAYERDE FORMATION

The Rimrock Member of the Mesaverde Formation contains an estimated 89,000,000 barrels of oil in place under the Tom Brown, Inc. tract; and, the Asphalt Ridge Member contains an additional 37,000,000 barrels. Thus, the total oil in place within the Mesaverde sandstone reservoirs is estimated to be 126,000,000 barrels. These figures were arrived at by determining acre feet of oil saturated sandstone for each member and multiplying by the average B/ac. ft. appropriate for each member. These average numbers (B/ac. ft.) were determined by combining core analysis data with log calculations as discussed in the following paragraphs.
**Average Oil in Place (B/ac. ft.);**

**Core Analysis Data**

A total of 948 feet of Mesaverde core was cut during the core program. Of this total, 878 feet was recovered and submitted for core analysis. Three hundred nineteen plug-size Mesaverde sandstone samples were analyzed by Core Laboratories, Denver. The Mesaverde core analysis data are summarized in Table 2.

Based on core analysis (152 samples) the sandstones of the Asphalt Ridge Member average 38% porosity and 61% oil saturation, resulting in an average of 17 98 B/ac. ft. oil in place. By comparison, the Rimrock Sandstones average 39% porosity, 72% oil saturation and 2178 B/ac. ft. oil in place, based on 167 samples.

**Log Calculations**

The resistivity of Mesaverde Formation water (Rw) at subsurface conditions is approximately 3.0 ohm meters. This value was established by analysis of the logs obtained in corehole #2. The massive sands which occur in corehole #2 in the depth interval 1825' to 2364' are relatively uniform in log response (SP, gamma ray, bulk density and resistivity). Based on this observation, it is apparent that these sands are either all hydrocarbon bearing or all water bearing. Ditch cuttings from this interval contain virtually no shows. This fact, coupled with the uniform low resistivity supports the conclusion that these clean Mesaverde Sands (below 1825', corehole #2) are essentially 100% water bearing. Assuming
### TABLE 2
SUMMARY OF CORE ANALYSIS DATA - MESAVEE FORMATION

Note: Numbers in parenthesis refer to number of samples analyzed

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<td>#5</td>
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<td>(78) 24 nd</td>
<td>(66) 534 md</td>
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<td>#6</td>
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<td>Asphalt</td>
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### COMBINED CORE ANALYSIS AVERAGES

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<tr>
<td>Rimrock</td>
<td>(164) 21 nd</td>
<td>(150) 523 nd</td>
<td>(167) 39</td>
<td>(167) 72</td>
<td>(167) 8</td>
<td>(167) 2178</td>
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<td>Asphalt Ridge</td>
<td>(130) 72</td>
<td>(133) 611</td>
<td>(152) 38</td>
<td>(152) 61</td>
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<td>(152) 1798</td>
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this to be so, an approximate Rw was "back calculated."

The value so established is 3.0 ohm meters and is the value used in the computer analysis of the Mesaverde logs. Oil saturations calculated using this Rw value are consistent with oil saturation data available from core analysis.

The computer-generated log calculations for the Mesaverde Formation are summarized in Table 3. The data used to compile this table was taken directly from the Mesaverde computer printouts, copies of which are enclosed with this report. In determining net feet of pay (column 3, Table 3) an oil-in-place cutoff value of 500 B/ac. ft. was used.

Based on log calculations (Table 3), the Rimrock sandstones contain an average of 1285 B/ac. ft. oil in place whereas the Asphalt Ridge sandstones average 1246 B/ac. ft.

Table 4 compares log-derived average porosity, average oil saturation and average oil in place with corresponding core analysis averages. Log-derived porosity values are much lower than core analysis porosity values. This results in low values for log-derived oil in place (B/ac.ft.) when compared to core values. The reasons for the discrepancy between core and log porosities are not apparent. The cores were analyzed using standard techniques and no unusual logging procedures were used. It is of interest to note that the Utah Geological and Mineralogical Survey uses 30% as the average Mesaverde porosity in their Asphalt Ridge oil-in-place calculations.

For the purpose of making oil-in-place estimates, a value of 1732 B/ac.ft. was assumed for the Rimrock Member.
## SUMMARY OF LOG CALCULATIONS - MESAVEKDE FORMATION

<table>
<thead>
<tr>
<th>Corehole</th>
<th>Member</th>
<th>Net Pay (feet)</th>
<th>Ave. Porosity (% Pore Vol.)</th>
<th>Ave. Oil Sat. (% Pore Vol.)</th>
<th>Ave. Oil in Place (B/Ac. Ft.)</th>
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</thead>
<tbody>
<tr>
<td>#1</td>
<td>RLMrock</td>
<td>118' Wet</td>
<td>22%</td>
<td>82%</td>
<td>1399</td>
</tr>
<tr>
<td>#2</td>
<td>Rimrock</td>
<td>36 Truncated</td>
<td>22</td>
<td>51</td>
<td>870</td>
</tr>
<tr>
<td>#5</td>
<td>Rimrock</td>
<td>149 Wet</td>
<td>23</td>
<td>83</td>
<td>1481</td>
</tr>
<tr>
<td>#6</td>
<td>Rimrock</td>
<td>111 Wet</td>
<td>29</td>
<td>73</td>
<td>1642</td>
</tr>
<tr>
<td>#7</td>
<td>RLMrock</td>
<td>92 Truncated</td>
<td>24</td>
<td>79</td>
<td>1471</td>
</tr>
<tr>
<td>#8</td>
<td>Rimrock</td>
<td>183 Wet</td>
<td>22</td>
<td>60</td>
<td>1024</td>
</tr>
</tbody>
</table>

### COMBINED LOG CALCULATION AVERAGES

<table>
<thead>
<tr>
<th>Member</th>
<th>Ave. Porosity (% Pore Vol.)</th>
<th>Ave. Oil Sat. (% Pore Vol.)</th>
<th>Ave. Oil in Place (B/Ac. Ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rimrock</td>
<td>24%</td>
<td>69%</td>
<td>1285</td>
</tr>
<tr>
<td>Asphalt Ridge</td>
<td>22</td>
<td>73</td>
<td>1246</td>
</tr>
</tbody>
</table>
TABLE 4
Comparisons of Core and Log Data for Mesaverde Formation

<table>
<thead>
<tr>
<th>Member</th>
<th>Ave. Porosity, %</th>
<th>Ave. Oil Sat., %</th>
<th>Oil in Place, B/ac ft</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Core</td>
<td>Log</td>
<td>Core</td>
</tr>
<tr>
<td>Rimrock</td>
<td>39%</td>
<td>24%</td>
<td>72%</td>
</tr>
<tr>
<td>Asphalt Ridge</td>
<td>38</td>
<td>22</td>
<td>61</td>
</tr>
</tbody>
</table>
and 1522 B/ac.ft. was assumed for the Asphalt Ridge Member, These values are the average of the log and core values (Table 4), and correspond to 31% porosity for the Rimrock Member and 29% porosity for the Asphalt Ridge Member.

**Acre Feet of Oil Saturated Sandstone**

The Asphalt Ridge Member contains approximately 24,500 ac. ft. of oil-saturated sandstone as shown in Figure 17, the net pay map for this Member. Figure 17 is based on net feet of pay as determined from logs, structure on the top and bottom of the Asphalt Ridge Member (Figure 13 and Figure 14, respectively) and net sand (Figure 16). Figure 15 is an isopach map of the total Asphalt Ridge Member and is included for comparison with the net sand map, Figure 16. The oil-water contact for the Asphalt Ridge Member, shown on Figures 13 and 14, is approximate and is based on logs and samples from coreholes #2 and #8. The position of the Asphalt Ridge Member subcrop is projected from the true-scale cross sections (Figures 4, 5, 6, and 7).

The Rimrock Member was analyzed in a manner analogous to that described above for the Asphalt Ridge Member. Figure 18 is a structure map contoured on the top of the Rimrock Member which is an unconformity surface resulting from late Cretaceous and early Tertiary erosion. The oil-water contact shown on Figure 18 is based on logs and samples from corehole #2 in conjunction with the sample logs for the Union Oil Company dryhole located just west of the Tom Brown, Inc. lease boundary (Figure 18). The Union Oil Company sample log is
included in the Appendix to Utah Geological and Mineralogical Survey Special Studies No. 19, a copy of which is enclosed with this report. Figure 19 is an isopach of the total Rimrock Member whereas Figure 20 is a net sand isopach of that member. Figure 21 is an isopach map showing net pay for the Rimrock Member. Based on this map, the Rimrock contains 51,500 acre feet of oil-saturated sandstone.

In summary the Asphalt Ridge Member contains an estimated 37,000,000 barrels of oil in place (24,500 ac. ft. X 1522 B/ac. ft.) and the Rimrock Member contains 89,000,000 barrels of oil in place (51,500 ac. ft. X 1732 B/ac. ft.). Therefore, the total oil in place within the Mesaverde reservoirs is estimated to be 126,000,000 barrels.

**OIL IN PLACE - TERTIARY STRATA**

The Tertiary strata in the prospect area contain an estimated 25 million barrels of oil in place. This is a very "rough" estimate, which may be conservative. The difficulty of assigning a reliable oil-in-place value to the Tertiary strata is attributable to several factors:

1) Lenticularity of Tertiary reservoirs (non-marine sandstone and conglomerate beds) make correlation difficult.

2) Lack of well control - several more coreholes would be required to reliably evaluate the Tertiary strata.

3) Varied lithology makes log evaluation difficult.

4) Formation water resistivity (Rw) is not known with any degree of certainty and, in fact, is probably variable.
5) Lack of core data - cores provide a useful means of "calibrating" open hole logs.

Oil saturation was logged in Tertiary samples in all six Tom Brown, Inc. coreholes. The zones of oil shows for coreholes #1, #6 and #5 are shown on Figure 10 and are considered representative.

As noted previously, the primary evaluation effort was directed toward the Mesaverde reservoirs. Tertiary cores were cut, however, in coreholes #5, #7 and #8 (Table 1). A total of 100 feet of Tertiary strata was cored, resulting in 75 feet of recovered core. Thirteen Tertiary samples were analyzed by routine core analysis. The analyzed samples are from corehole #8. A copy of Core Laboratories core analysis report is included herewith.

Table 5 summarizes Tertiary log calculations for the six Tom Brown, Inc. coreholes. This table is based on a computer analysis of open hole logs utilizing a Schlumberger interpretation program. The output from the computer analysis consists of "Synergetic" logs and data printout sheets (copies of each enclosed).

The Tertiary reservoirs have an average porosity of 20%, based on logs (Table 5). The actual average porosity, however, may be several porosity percent higher than the log-determined average. This is based on the observation that where core control is available, the core analysis porosity values are consistently higher than the log values. The core analysis porosities for Mesaverde Sandstone, for example, average about 15 porosity percent higher than the log porosities (Table 4).
## TABLE 5
SUMMARY OF LOG CALCULATIONS - TERTIARY STRATA

<table>
<thead>
<tr>
<th>Gorehole</th>
<th>Net Pay (feet)</th>
<th>Ave. Porosity (% Pore Vol.)</th>
<th>Ave. Oil Saturation (% Pore Vol.)</th>
<th>Ave. Oil in Place (B/Ac. ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>35'</td>
<td>18%</td>
<td>69%</td>
<td>964</td>
</tr>
<tr>
<td>#2</td>
<td>14</td>
<td>21</td>
<td>44</td>
<td>717</td>
</tr>
<tr>
<td>#5</td>
<td>41</td>
<td>19</td>
<td>53</td>
<td>781</td>
</tr>
<tr>
<td>#6</td>
<td>38</td>
<td>20</td>
<td>50</td>
<td>776</td>
</tr>
<tr>
<td>#7'</td>
<td>37</td>
<td>20</td>
<td>59</td>
<td>915</td>
</tr>
<tr>
<td>#8</td>
<td>48</td>
<td>22</td>
<td>46</td>
<td>785</td>
</tr>
</tbody>
</table>

**COMBINED LOG CALCULATION AVERAGES**

<table>
<thead>
<tr>
<th>Ave. Porosity (% Pore Vol.)</th>
<th>Ave. Oil Sat. (% Pore Vol.)</th>
<th>Ave. Oil in Place (B/Ac. ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>54</td>
<td>838</td>
</tr>
</tbody>
</table>
The limited core data available for Tertiary reservoir sandstones suggest that the same relationship holds for these strata.

In corehole #8 the Tertiary interval from 1277' to 1284" averages 24.3% porosity by core analysis compared to 21.2% porosity based on logs. A second Tertiary interval in corehole #8 (1169' to 1175') has an average core analysis porosity of 25.6% compared to an average log porosity of only 11.5%.

In calculating oil in place for the Tertiary strata an average porosity of 23% is assumed. This is a 3 porosity percent upward adjustment of the average value determined from logs alone. Assuming 23% average porosity, the recalculated average oil saturation is 60% rather than 54% which is the oil saturation value shown in Table 5. Consistent with 23% average porosity and 60% average oil saturation, the average oil in place for the Tertiary reservoirs is approximately 1070 B/ac. ft.

The downdip limit of Tertiary oil saturation in the prospect area is not know, as all six Tom Brown, Inc. coreholes encountered oil saturated Tertiary sandstones. The lenticularity of the sandstones, however, precludes the determination of oil water contacts with the present limited well control. The area of Tertiary oil saturation is no less than 500 acres and may be as much as 900 acres or more. For calculation purposes, an areal extent of 650 acres is assumed.

The value in Table 5 is based on 20% porosity and is not valid if the porosity is actually higher.
In summary, Tertiary reservoirs in the prospect area contain an estimated 25,000,000 barrels of oil in place. This assumes 650 acres areal extent, 36' average net pay thickness, 23% average porosity and 60% average oil saturation.

**PHYSICAL AND CHEMICAL PROPERTIES OF THE OIL**

The physical and chemical properties of oil extracted from Asphalt Ridge oil impregnated sandstones are described in several published reports.\(^4\) \(^5\), \(^6\)

Table 6 shows analyses of oil extracted from oil impregnated sandstones throughout the Uinta Basin. This table is reproduced from Utah Geological and Mineralogical Survey Special Studies No. 39 published in 1972. The analysis shown for sample No. 69-18E (Table 6) is particularly relevant because this sample was collected from the Mesaverde Formation at an outcrop located in SE NE 23-4S-20E, approximately one half mile east of the present prospect (refer to Figure 2).

Oil sample No. 69-18E (Table 6) has a sulphur content of 0.4% by weight. This low sulphur content is a favorable characteristic which has a bearing on the engineering aspects of casing/equipment design of an exploitation program.

In common with most of the other samples listed in Table 6, sample No. 69-18E was collected at an outcrop rather than a wellbore. It is reasonable to assume that physical properties, such as API gravity, may improve somewhat in the subsurface as compared with surface outcrops. Therefore, 14.3° API, the value measured for sample no. 69-18E, Table 6, is considered a minimum value so far as the NW Asphalt Ridge prospect is concerned.
Table 6  Analyses of oil extracted from oil-impregnated sandstones, Uinta Basin (northeast Utah): assay.

<table>
<thead>
<tr>
<th>UGMS SAMPLE NO.</th>
<th>DEPOSIT</th>
<th>FORMATION (AGE)</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>TAR</td>
<td>C</td>
</tr>
<tr>
<td>69-19E</td>
<td>Asphalt Ridge</td>
<td>Rim Rock Mbr. of Mesaverde Fm. (Upper Cretaceous)</td>
<td>17.0</td>
</tr>
<tr>
<td>69-18E</td>
<td>Asphalt Ridge, Northwest</td>
<td>Asphalt Ridge Mbr. of Mesaverde Fm. (Upper Cretaceous)</td>
<td>13.4</td>
</tr>
<tr>
<td>69-15E</td>
<td>Chapita Wells</td>
<td>Uinta Fm. (Eocene)</td>
<td>1.7</td>
</tr>
<tr>
<td>69-1A</td>
<td>Cow Wash</td>
<td>Parachute Creek Mbr. of Green River Fm. (Eocene)</td>
<td>2.7</td>
</tr>
<tr>
<td>69-11C</td>
<td>Hill Creek</td>
<td>Douglas Creek Mbr. of Green River Fm. (Eocene)</td>
<td>11.2</td>
</tr>
<tr>
<td>69-14E</td>
<td>P. R. Spring (Draggon-Asphalt Wash)</td>
<td>Douglas Creek Mbr. of Green River Fm. (Eocene)</td>
<td>12.4</td>
</tr>
<tr>
<td>69-14E</td>
<td>P. R. Spring (Draggon-Asphalt Wash)</td>
<td>Parachute Creek Mbr. of Green River Fm. (Eocene)</td>
<td>14.8</td>
</tr>
<tr>
<td>67-1A</td>
<td>P. R. Spring</td>
<td>Douglas Creek Mbr. of Green River Fm. (Eocene)</td>
<td>97.6</td>
</tr>
<tr>
<td>67-5A</td>
<td>Raven Ridge</td>
<td>Parachute Creek Mbr. of Green River Fm. (Eocene)</td>
<td>8.6</td>
</tr>
<tr>
<td>67-8A</td>
<td>Raven Ridge</td>
<td>Green River Fm. (Eocene)</td>
<td>7.0</td>
</tr>
<tr>
<td>67-10A</td>
<td>Raven Ridge</td>
<td>Parachute Creek Mbr. of Green River Fm. (Eocene)</td>
<td>7.3</td>
</tr>
<tr>
<td>67-4A</td>
<td>Rim Rock</td>
<td>Wasatch Fm. (Eocene)</td>
<td>12.6</td>
</tr>
<tr>
<td>67-6A</td>
<td>Rim Rock</td>
<td>Green River Fm. (Eocene)</td>
<td>10.6</td>
</tr>
<tr>
<td>67-7A</td>
<td>Rim Rock</td>
<td>Green River Fm. (Eocene)</td>
<td>9.0</td>
</tr>
<tr>
<td>67-9A</td>
<td>Rim Rock</td>
<td>Wasatch Fm. (Eocene)</td>
<td>11.3</td>
</tr>
<tr>
<td>68-17D</td>
<td>Split Mountain</td>
<td>Park City Fm. (Permian)</td>
<td>1.12</td>
</tr>
<tr>
<td>68-23D</td>
<td>Spring Branch</td>
<td>Duchesne River Fm. (Eocene)</td>
<td>10.7</td>
</tr>
<tr>
<td>68-24D</td>
<td>Spring Branch</td>
<td>Duchesne River Fm. (Eocene)</td>
<td>14.1</td>
</tr>
<tr>
<td>68-18D</td>
<td>Spring Hollow</td>
<td>Duchesne River Fm. (Eocene)</td>
<td>2.6</td>
</tr>
<tr>
<td>68-15C</td>
<td>Tabiona</td>
<td>Uinta (?) Fm. (Eocene)</td>
<td>5.45</td>
</tr>
<tr>
<td>68-16C</td>
<td>Tabiona</td>
<td>Currant Creek Fm. (Paleocene ?)</td>
<td>2.55</td>
</tr>
<tr>
<td>68-20D</td>
<td>Tabiona</td>
<td>Currant Creek Fm. (Paleocene-Eocene)</td>
<td>8.25</td>
</tr>
<tr>
<td>69-2A</td>
<td>Upper Kane Hollow</td>
<td>Parachute Creek (?) Mbr. of Green River Fm. (Eocene)</td>
<td>1.3</td>
</tr>
<tr>
<td>68-1 OA</td>
<td>Whiterocks</td>
<td>Navajo Ss. (Jurassic)</td>
<td>7.8</td>
</tr>
</tbody>
</table>
The U. S. Bureau of Mines is planning to conduct thermal recovery experiments on a 10-acre tract located one half mile east of the Tom Brown, Inc. lease boundary (Figure 2). Installation of necessary equipment is scheduled for fall 1974. The planned in-situ combustion experiment will involve the reverse burn method. Details of the project are described in an article published recently in the Oil and Gas Journal and reproduced herein in Appendix B.

The proposed U.S.B.M. field experiment is particularly relevant to our prospect because the reservoir/fluid conditions within the objective Mesaverde reservoir underlying the experimental tract are expected to be identical with those known to exist in the subsurface of the Tom Brown, Inc. tract. Furthermore, because the experiment is being conducted by a Federal agency, the results will be available to interested parties. Thus, the U.S.B.M. project constitutes a free pilot test so far as the NW Asphalt Ridge prospect is concerned.
REFERENCES


APPENDIX A
COREHOLE #5
COKE RECORD
(Driller's Depths)

Core #1 660'-696' (36') Recovered 18'

4.5' Silt, light green, clay-filled with interbedded very fine-grained sandstone, clay-filled, scattered poor with some fair asphalt saturation.

5' Shale, light green with bentonite interbeds; one 3" chert and limestone cobble conglomerate.

5' Sandstone, white-light green, very fine-grained, clay-filled, poor stain.

3.5' Shale and silt, light green, bentonitic, clay-filled, no shows.

Core #2 1094'-1153' (59') Recovered 59'

.5 Sandstone, very fine-grained, fair-good asphalt saturation.

2.5 Sandstone, gray, quartzitic, hard and tight, no shows.

11 Shale with thin interbeds of very fine-grained sandstone, fair-good asphalt saturation.

2.5 Sandstone, gray, quartzitic, hard and tight, no shows.

17 Sandstone, very fine-grained, fair-good asphalt saturation with minor thin gray shale interbeds at top and bottom.

1 Sandstone, gray, quartzitic, hard and tight, no shows.

2.5 Sandstone, very fine-grained, fair-good asphalt saturation.

1 Sandstone, gray, quartzitic, hard and tight, no shows.

14.5 Sandstone, very fine-grained, fair-good asphalt saturation with one 13 zone of barren hard and tight sandstone.

3 Shale, gray with thin very fine-grained sandstone interbeds, fair asphalt saturation.

3.5 Sandstone, very fine-grained, fair-good asphalt saturation.

Core #3 1153'-1212' (59') Recovered 59'

39' Sandstone, very fine-grained, fair-good asphalt saturation.

2' Sandstone as above with thin gray silt interbeds; fractured.

18' Sandstone as above with micro-interbeds of shale.

Core #4 1212'-1262' (50') Recovered 48'

5' Sandstone, very fine-grained, fair-good asphalt saturation, few silt and shale interbeds.

31' Sandstone as above, fair asphalt saturation: interbedded dark gray shale.

12' Shale, black with micro-interbeds of silt with poor-fair asphalt saturation.

Core #5 1262'-1325' (63') Recovered 63'

2.5' Shale, black.

.5' Shale, black, with thin sandstone interbeds, fair-good asphalt saturation.

31 Sandstone, very fine-grained, fair-good asphalt saturation (bottom 10' richer saturation).

9' Shale, black.

3' Sandstone as above, good asphalt saturation.

3.5' Shale, black with micro-interbeds of sandstone, fair-good asphalt saturation.

13.5' Sandstone as above, good asphalt saturation, minor shale interbeds.
Core #6 1325' - 1372' (47') Recovered 41'

1.5' Sandstone, very fine-grained, good asphalt saturation.
20' Shale and silt thinly interbedded, minor thin beds of sandstone with
fair-good asphalt saturation.
15.5' Shale, gray-black.
4' Sandstone, very fine-grained, silty, good asphalt saturation.

Core #7 1372' - U29' (57') Recovered 57'

3' Sandstone, very fine-grained, fair asphalt saturation with shale
blebs and interbedded silt.
6' Shale, gray; silty in part.
19' Sandstone, very fine-grained, fair-good asphalt saturation.
8' Silt, gray with poor show; interbeds of shale.
21' Shale, gray and black.

Core #8 U29' - U61' (32') Recovered 30'

30' Shale, gray-black.

Core #9 I/.61' - 1515' (54-1') Recovered 52'

52' Shale, gray-black and gray with interbedded gray silt.
COREHOLE #6
CORE RECORD

Core §1 780'-835' (55') Recovered 52'

5' Sandstone, very fine-grained, good asphalt saturation.
4'1 Sandstone, very fine-grained, good asphalt saturation, with 1/16"-1/8" gray shale interbeds.
12' Sandstone, very fine-grained, good asphalt saturation, with scattered gray shale interbeds.
5.5* Shale, gray, with 1/16"-1/2" interbeds of silt-very fine-grained sandstone with good asphalt saturation.
5' Sandstone, very fine-grained, good asphalt saturation, with 1/2"-2" gray shale interbeds.
5' Sandstone, very fine-grained, good asphalt saturation.
1' Shale, gray, with 1/4" very fine-grained sandstone interbeds with good asphalt saturation.
5*5* Sandstone, very fine-grained, good asphalt saturation.
2.5' Sandstone and shale as above interbedded in 1/4"-2" beds.
2' Sandstone, very fine-grained, good asphalt saturation.
.25' Shale, gray with 1/2" interbeds of very fine-grained sandstone, good saturation.
1' Sandstone, very fine-grained, good asphalt saturation.
.25' Shale, gray.
.75' Sandstone, very fine-grained, good asphalt saturation.
2.25' Sandstone, very fine-grained, good asphalt saturation, with micro-2" gray shale interbeds.

Core #2 835'-867' (32') Recovered 28'

3' Sandstone, very fine-grained, good asphalt saturation, with 2" maximum gray shale interbeds.
7' Sandstone, very fine-grained, good asphalt saturation.
9' Sandstone, very fine-grained, variable poor, fair and good asphalt saturation controlled by clay-filling; micro-3" gray shale interbeds.
6' Sandstone predominantly, very fine-grained, variable asphalt saturation as above, with gray shale micro-interbeds, clay-filled fractures; distorted, slumped bedding in part.
3' Sandstone, very fine-grained, poor asphalt saturation, and gray shale; fractured with distorted and highly slumped bedding.

Core //3 867'-915' US') Recovered 47'

10' Shale, gray, slumped and distorted with very fine-grained sandstone with good asphalt saturation inter-mixed in the shale.
5 Sandstone, very fine-grained, good asphalt saturation with thin gray shale interbeds.
2' Shale, gray.
10' Sandstone, very fine-grained, good asphalt saturation.
21' Sandstone, very fine-grained, good asphalt saturation interbedded with equal amounts of gray shale in micro-2" beds; bottom 3' fractured and slumped.
Core #4 915'-965' (50') Recovered 47'

2' Sandstone, very fine-grained, good asphalt saturation with thin gray shale interbeds.
7' Sandstone, very fine-grained, clay-filled, poor asphalt saturation with thin gray shale interbeds.
16' Sandstone, very fine-grained, good asphalt saturation with thin gray shale interbeds.
12' Sandstone, very fine-grained, poor asphalt saturation with thin gray shale interbeds.
3' Sandstone and shale interbedded, no asphalt show.
7' Shale, dark gray.

Core #5 965'-1001' (36') Recovered 34'

34' Shale, dark gray with interbedded light gray shale and minor silt.

Core #6 1001'-1022' (21') Recovered 20'

18' Shale, dark gray with interbedded gray shale and minor silt.
2' Sandstone, gray, fine-grained, quartzitic, with coarse-grained quartz and chert pebbles, hard and tight, no shows.

Core #7 1022'-1070' (48*) Recovered 48'

1.5' Sandstone, gray, fine-grained, quartzitic, hard and tight, no shows slumped and distorted into gray-black sandstone, silt and silty shale with fair and good asphalt saturation.
1' Transitional zone from above to very fine-grained sandstone with good asphalt saturation.
23o25' Sandstone, very fine-grained, good asphalt saturation.
4' Sandstone, very fine-grained, and silt, very poor asphalt saturation interbedded with dark gray shale.
2' Sandstone, quartzitic, hard and tight, no shows.
5' Sandstone and shale interbedded, poor asphalt saturation.
.25' Sandstone, very fine-grained, good asphalt saturation, with shale interbeds.
1' Sandstone and shale as above, poor asphalt saturation.
.10' Sandstone and shale as above, good asphalt saturation.
4.90' Sandstone and shale as above, poor asphalt saturation.
5' Shale and silt, dark gray with micro sandstone beds with fair-good asphalt saturation.

Core #8 1070'-1093' (23') Recovered 19'

6' Sandstone, very fine-grained, fair-good asphalt saturation with micro beds of shale, shattered and rubbled in part.
1.5' Shale, dark gray with thin sandstone stringers, poor asphalt saturation.
4' Silt, dark gray, quartzitic, hard and tight, very poor asphalt saturation with micro interbeds of dark gray shale.
3' Sandstone, very fine-grained, fair-good asphalt saturation.
4.5' Shale, dark gray with micro interbeds of gray silt, scattered very poor asphalt show.
Core #9  1093'-1H8'  (25')  Recovered 2V

5'  Sandstone, very fine-grained, fair-good asphalt saturation with micro-sized clay particles.
7'  Sandstone, very fine-grained, scattered poor-fair asphalt saturation with interbedded dark gray shale.
12' Interbedded shale and silt, very poor to no asphalt show.

Core #10  1118'-1172'  (54')  Recovered W

4.5'  Silt and shale, dark gray, micro-interbedded, trace of asphalt show.
5o5'  Sandstone, very fine-grained, good asphalt saturation with thin shale interbeds.
12 * Sandstone, very fine-grained, very poor asphalt show, interbedded with dark gray silt and shale.
22 ' Sandstone, very fine-grained, slightly glauconitic, scattered dark minerals, highly clay-filled, poor porosity and permeability, poor stain, poor fluorescence, good streaming cut that died after short duration; bled light brown stain on surface after two hours exposure; two interbedded quartzitic silt beds 1" and 2" thick, hard and tight, no shows.

Core #11  1172'-1212'  (40")  Recovered 27'

6'  Sandstone as in bottom of Core #10.
21' Shalf, gray-black with gray shale micro-inter beds and minor silt stringers.
COREHOLE #7
CORECORD

Core #1 2Q5'-235' (3Q) Recovered 27j*

.5' Sandstone, white, very fine-grained, hard and tight, poor asphalt stain in top 1".
1. ' Shale, green, waxy, with thin interlans of brown silt with poor asphalt stain.
22.5' Shale and silt, light green.
3.5' Sandstone and chert pebble conglomerate with intermixed green shale; variable poor-fair asphalt saturation in sandstone matrix.

Core #2 396'-434' (38') Recovered 33'

5. ' Sandstone, very fine-grained, fair-good asphalt saturation.
1.5' Shale, gray-black, worm-burrowed, minor interlaminated sandstone with fair asphalt saturation.
2. ' Sandstone as above with thin interlans of shale.
24.5' Shale and silt, gray and gray-black with minor micro-6" interbeds of sandstone with fair asphalt saturation.
(52 degree dip in core.)

Core #3 434'-479' (45') Recovered 34'

3. ' Shale and silt, gray and gray-black with minor micro-6" interbeds of sandstone with fair asphalt saturation.
22.5' Sandstone, very fine-grained, slightly silty, fair-good asphalt saturation.
8.5' Shale and silt, gray black with interbedded very fine-grained sandstone with fair asphalt saturation.

Core #4 479'-529' (50') Recovered 45'

45' Shale, gray and gray-black with thin (£" average) interbeds of silt and very fine-grained sandstone with fair and poor-fair asphalt saturation; approximately 70% shale and 30% silt and sandstone. 50-52 degree dip in core.

Core #5 529'-581' (52') Recovered 48'

10' Shale, silt and sandstone as in Core #4.
23' Sandstone, very fine-grained, slightly silty, fair asphalt saturation.
9' Sandstone as above, fair asphalt saturation with micro-^" interbeds of gray shale.
6* Shale, gray with interbedded very fine-grained sandstone with fair asphalt saturation.

Core #6 581'-620* (39') Recovered 39'

39* Shale, gray-black with scattered thin micro-!" interbeds of silt and sandstone with poor-fair asphalt saturation; 90% shale and 10% silt and sandstone.

Core #7 620'-657' (37') Recovered 15'

15' As above with poor asphalt show.
Core #8 657'-692' (35') Recovered 30'

30' As above in Cores #6 and #7; approximately 70% shale and 30% silt and sandstone.

Core #9 692'-725' (33') Recovered 25'

25' As above; 3' silt-very fine-grained sandstone @ 703'-706' with poor stain, bleeding small amount of fresh water.
COREHOLE #8

COREHOLE RECORD

Core #1 1169’-H77” (8’) Recovered 7’

1’ Sandstone, white, fine-grained, quartzitic, clay-filled, scattered poor asphalt saturation.

4’ Sandstone, variable fine to coarse-grained with numerous micro-flecks of light green shale, poor-fair asphalt saturation.

1»5’ Sandstone, fine-coarse-grained with good asphalt saturation; one 1” streak of chert pebble conglomerate with good asphalt saturation in sandstone matrix.

•5’ Conglomerate, white, clay-filled sandstone and dark gray chert, poor asphalt show.

Core #2 1277’-1303” (26’) Recovered 23’

7’ Sandstone, fine-coarse-grained, well rounded with good asphalt saturation; intermixed light green shale and clay pellets micro-1/4” size; few chert pebbles up to 1/4” in diameter; few thin silt streaks* near base, clay-filled, no shows.

1’2’ Sandstone, very fine-grained, light gray, clay-filled, no shows; few thin laminations of shale and clay as above; vertical fractures filled with asphalt.

13’ Shale, light green.

Core #3 1521’-1539” (18’) Recovered 15’

1’ Shale, black, carbonaceous.

3’ Silt, dark gray, no shows with interbedded black shale.

11’ Shale and coal interbedded with few streaks of silt, no shows.

Core #4 1539’-1561” (22’) Recovered 17’

17’ Shale, black with carbonaceous inclusions and thin interbedded coal and lignite streaks.
Bumines plans Utah tar-sands pilot

Uinta in situ project, set for summer or fall, to consist of nine wells. It will seek to show reverse combustion burn can work at 200 ft depth. Initial production of 25% of bitumen seen, 50% later with better controls.

THE U.S. Bureau of Mines will begin an in situ combustion pilot operation soon in Utah's tar-sand area. The project signals industry interest in the domestic deposits as a source of much-needed new oil.

The business experimental project, set for this summer or early fall, will seek to show that a reverse combustion burn can succeed at a depth of only 200 ft or so in the rich sands of Northwest Asphalt Ridge, 5 miles west of Vernal in the Uinta basin of Northeast Utah.

Cecil Cupps, engineering coordinator for the Laramie Energy Research Center, Laramie, Wy., says the pilot will consist of nine wells in three rows forming a rectangle.

Where Bumines will conduct in situ test

The center row will consist of three production wells spaced 10 ft apart. The two outside rows, each 30 ft from the center row, will consist of three wells, also spaced 10 ft apart and at right angles to the production wells.

Operators will ignite the central production wells in the formation and inject air in the outside wells and push it toward the central wells. The bitumen in the formation will heat to a vapor and be produced out the injection wells.

At the surface the vapor will be cooled down and the oil condensed out.

Cupps says he does not anticipate fracturing will be required in the formation prior to the burn, although such procedure would be required for a larger pattern.

The pilot, if it performs as hoped, will burn evenly and extract about 25% of the bitumen. Another 25% will be left in the formation as coke. The remaining 50% will stay in the formation unburned. With better controls, Bumines hopes eventually to produce up to 50%, depending on a variety of conditions.

Gravity of the produced oil, of low-sulfur content in this particular formation, is expected to be about 22°-25° gravity, compared with 8°-10° in the formation.

The burn should require some 60-90 days to complete. This means the results should become known before the end of the year.

Cupps said starting date for the operation depends on Bumines ability to contract for a drilling rig and obtain tubular goods and other equipment now in short supply. With luck, it can start in July. Otherwise, it will be early fall.

Full cost of the operation will be borne by the Government. However, Bumines is negotiating with a major oil company for the free use of leased acreage at Asphalt Ridge Northwest for the pilot burn.

The interest. While shale oil—has enjoyed greater industry investment in recent months than tar sands, Bumines and Utah officials report an upsurge in interest in the latter.

Utah's H. R. Ritzma, assistant director and chief of the petroleum section for the Utah Geological and Mineral Survey, estimates in-place oil at 25 billion bbl in the Uinta basin (see map) and the central-southeast area of Utah, where most of the known U.S. deposits lie.

With the new prices being paid for crude, owners of leases, which include most of the majors and a number of independents, have expressed renewed interest in their properties.

Virtually all of the estimated 700,000 acres of tar-sand deposits are under federal, state, or private lease. Some

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half million acres are in the Uinta basin.

While there are no commercial operations in the state, Ritzma says additional coring has been done or is planned this summer, and he expects pilot experimental work to be done on at least two deposits.

One such pilot is planned by Altex Oil Corp. of Vernal and Denver. It will be located in the Triangle area of the Central Southeast deposits in Wayne County.

Other companies which have shown past, or present, interest in developing the sands include Standard Oil Co. of Ohio, Shell Oil Co., Signal Oil & Gas Co., and Kerr-McGee Corp.

The method. Bumines is experimenting with in situ production because the bulk of Utah's tar sands must be produced in this manner—if produced at all.

While surface mining may be used for the first commercial operations, no more than 10-20% of the deposits could be tapped this way. Eventually some type of in situ extraction must be developed.

Bumines has a team of engineers and Chemists working on the project both to develop the method of production and determine the characteristics of the oil produced.

Cupps heads the section concerned with production, while William Haines heads a supporting chemical group concerned with the oil itself.

J. W. Bunger, chemist with the Haines group, told a tar-sands symposium of the American Chemical Society in Los Angeles that bitumen from the P. R. Spring deposit in the Uinta basin has a sulfur content of only 0.075%.

It has high nitrogen (1%), and low gravity (10.3°). The initial boiling point is 250° C, with more than 51% boiling above 532° C.

"These properties are grossly equivalent to those for petroleum residues," Bunger said. "Comparison of the results of this study with results obtained for petroleum residues shows that the tar-sand bitumen is twice as high in acids while containing an average amount of bases. This could be significant both in recovery processes (emulsions, caustic flooding, etc.) and in refining processes."