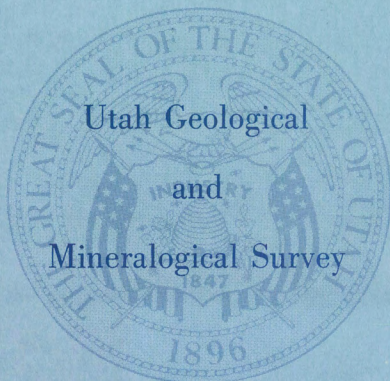


UINTAH COUNTY, UTAH

**Bituminous Sandstone Deposits
Asphalt Ridge**



Special Studies 19

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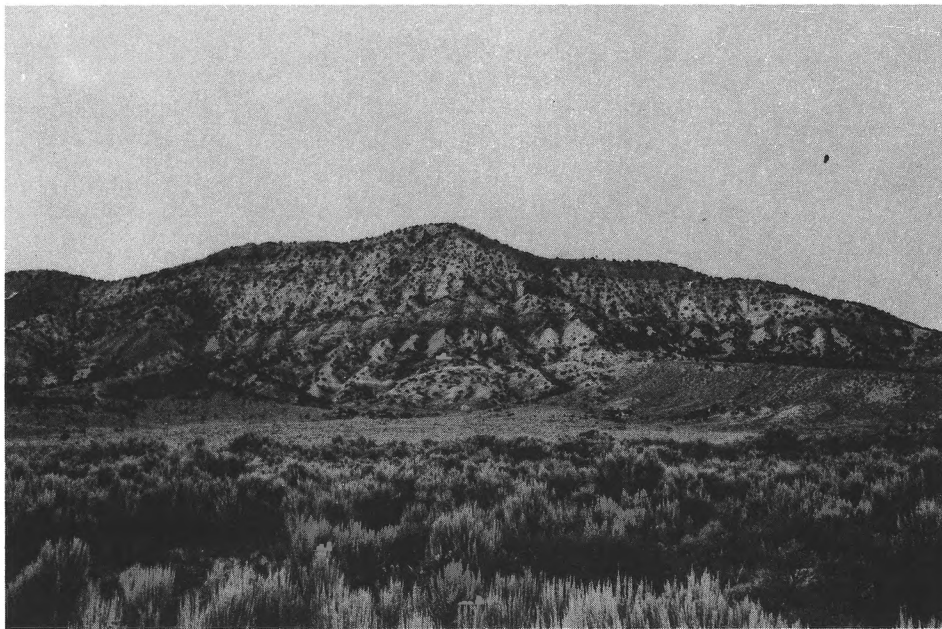
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UINTAH COUNTY, UTAH

Bituminous Sandstone Deposits Asphalt Ridge

by Robert B. Kayser



North end of Asphalt Ridge showing saturated Rim Rock Sandstone (Cretaceous Mesaverde Formation) overlain by Tertiary Duchesne River Formation.

*Utah Geological and Mineralogical Survey
affiliated with
The College of Mines and Mineral Industries
University of Utah, Salt Lake City, Utah*

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ABSTRACT

Asphalt Ridge probably is the second largest bituminous sandstone deposit in north-eastern Utah's Uinta Basin. Discontinuous concentrations of bitumen occur in the Rim Rock Sandstone of the Mesaverde Group of Cretaceous age, in the overlying Uinta Formation of Eocene age and the Duchesne River Formation of Oligocene age.

Future economic utilization of the Asphalt Ridge deposits depends on how efficiently the sand's petroleum products can be extracted and marketed. In the past, the cost of producing oil from bituminous sands has been prohibitive. However, with development of "in situ" (thermal) recovery methods such as those discussed in this report, the projected production costs may be reduced to a level at which oil from bituminous sands can compete with oil from conventional sources.

Because the bituminous layers dip southwestward under prohibitively deep cover, only a small part of the sandstone can be mined by open pit methods. However, the Asphalt Ridge deposits are well suited to thermal recovery techniques. The thick, uniform sands of the Mesaverde Group are the best targets for such methods. It is estimated the bituminous sands in the Mesaverde contain reserves of oil totalling nearly 700 million barrels. The recovery factor probably would be between 50 and 70 per cent; so total recoverable reserves in the Mesaverde should be at least 350 million barrels of oil.

Many factors have a direct effect on the degree of saturation and probability of successful extractions of the bitumen. A few seeming to favor the possibility of successful production of Asphalt Ridge are: physical properties of the reservoir rock, size of the reservoir, proximity to an existing pipeline, abundant water supply, and favorable depth of occurrence.

Bituminous Sandstone Deposits, Asphalt Ridge

by Robert B. Kayser¹

INTRODUCTION

Asphalt Ridge near Vernal in Uintah County, Utah, is one of several bituminous sandstone deposits in the Uinta Basin (Figure 1) that contains large amounts of bitumen from which petroleum products may be extracted. It is a hogback or cuesta trending northwesterly, in which the Cretaceous and Tertiary formations dip southwesterly. The author's studies were devoted to T-4-S and T-5-S, R-21-E, and T-5-S and T-6-S, R-22-E (Plates 1A and 1B), an area crossed by U. S. Highway 40.

In 1964, the Utah Geological and Mineralogical Survey selected the Asphalt Ridge deposits for detailed study to determine their potential worth to the State of Utah should this area be among parcels of Federal land allocated to State ownership. With field work completed in September, 1964, maps and sections were placed on open file the following year. Allocation of these lands to the State was completed in June, 1966.

Purpose of the field work was to determine surface extent, thickness and degree of saturation of the bituminous sands. A detailed geologic map of Asphalt Ridge (Plates 1A and 1B) was made up from field mapping on aerial photographs at a scale of 1 inch equals 400 feet. Structure and general stratigraphy are shown in the maps (Plates 1A and 1B and Figure 2) and sections (Plate 2). Laboratory investigations were made on selected samples submitted to State, Federal, and commercial laboratories. Current field work on the P. R. Springs bituminous deposits was begun by the Survey as a collateral study in 1965.

The bituminous deposits were known in pioneer times. However, the first detailed report was published by E. M. Spieker in 1930 and included descriptions of the general geologic setting, an estimate of reserves, and several analyses of bitumens and the sediments in which they are found. Many geologists subsequently examined Asphalt Ridge and the geology of the surrounding area. J. O. Ball (1944) reported on the location and nature of the bitumens, and in 1955, D. M. Kinney reviewed the occurrences. R. E. Covington's more recent work (1957 and 1964a) dealt, in some detail, with the geology of bituminous sand deposits at Asphalt Ridge and elsewhere in the Uinta Basin. Possible methods of extraction were discussed by J. Pfeiffer (1950), G. B. Shea and others (1952), R. E. Covington (1964b and 1965) and J. V. Howard (1965). Cretaceous stratigraphy was considered in papers by Walton (1944 and 1957), who worked on the Cretaceous of the Uinta Basin; by Burger (1959), who studied the Mesaverde Group in Utah, Colorado and Wyoming, and by L. A. Hale and F. R. Van De Graff (1964). Tertiary stratigraphy was described by J. L. Kay (1934), W. Abbott (1957), C. H. Dane (1954), M. D. Picard (1957), and E. E. Murany (1964).

1. Geologist, Bear Creek Mining Company.

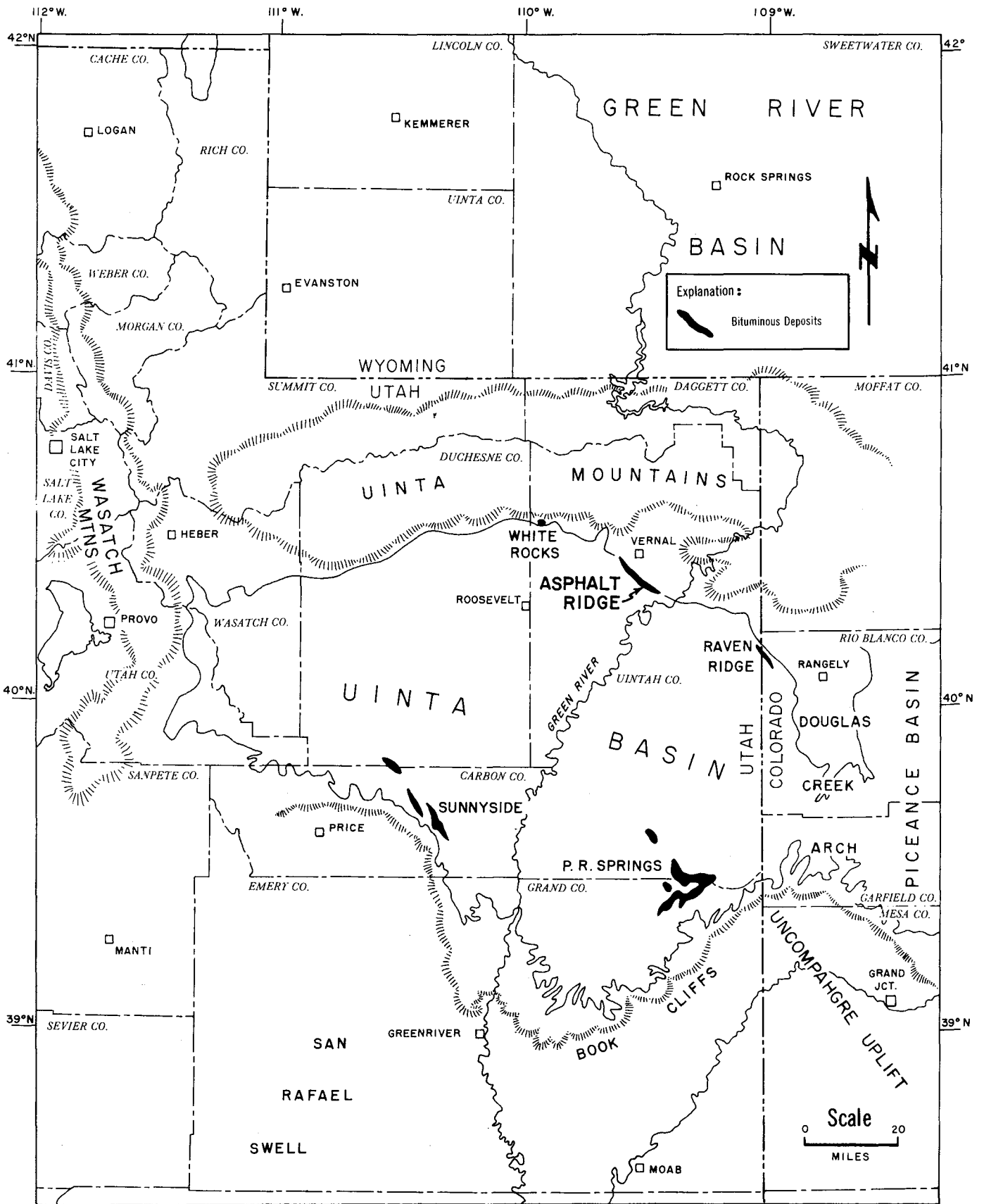


Figure 1. Index map of Uinta Basin showing location of Asphalt Ridge and principal bituminous sandstone localities.

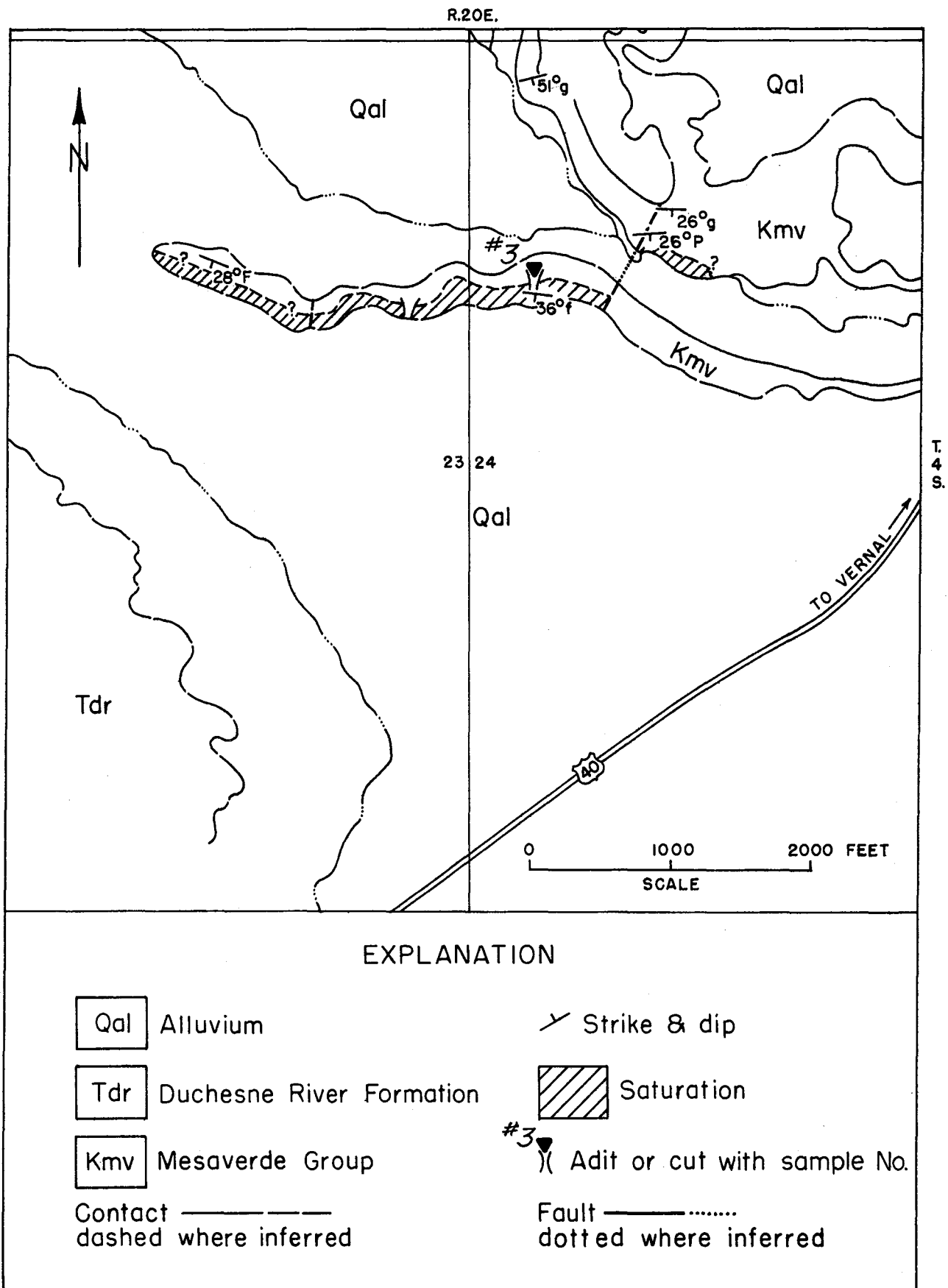


Figure 2. Geologic map of bituminous sandstone outcrops north of Maeser-Lapoint highway at Asphalt Ridge.

Table 1. Classification of bituminous substances (Abraham, 1945).

GENUS	SPECIES	MEMBER	REMARKS
Bitumens	Petroleums	Non-asphaltic petroleum	Contains an appreciable quantity of crystallizable paraffin and no asphalt.
		Semi-asphaltic petroleum	Contains crystallizable paraffin, also asphalt.
		Asphaltic petroleum	Contains an appreciable quantity of asphalt and no crystallizable paraffin.
	Native mineral waxes	Ozokerite Monton wax	A paraffinaceous mineral, called ceresine when refined. The wax extracted from lignite or pyropissite by means of solvents.
Native asphalts	Associated with mineral matter	Pure or fairly pure	Comparatively free from associated mineral matter (less than 10 per cent on the dry weight).
		Containing a substantial proportion of sand, sandstone, limestone, clay or shale, or filling the voids in a matrix of rock (i.e., "rock asphalt").	
Asphaltites	Gilsonite Glance pitch Grahamite	Extremely pure Pure to moderately pure Pure to quite impure	} Have a higher fusing-point than asphalts--derived from petroleum.
Pyrobitumens	Asphaltic pyrobitumens	Elaterite Wurtzilite	
		Albertite Impsonite Asphaltic pyrobituminous shales	Depolymerizes partially on heating Does not depolymerize on heating. Mineral matters predominate. Infusible and insoluble.
	Non-asphaltic pyrobitumens	Peat Lignite Bituminous coal Anthracite coal Lignitic and coal shales	} Pure or fairly pure. Infusible and insoluble. Contain more or less oxygenated bodies. Derived from vegetable growths. Gradual transition from peat to lignite to coal. Mineral matters predominate, otherwise the same as the foregoing.

Pyrogenous distillates	Pyrogenous waxes	Wax tailings	Distillate from petroleum obtained immediately prior to coking.
		Petroleum paraffin Peat paraffin Lignite paraffin Shale paraffin	Solid paraffin obtained from non-asphaltic petroleum. Solid paraffin obtained from peat tar. Solid paraffin obtained from lignite tar. Solid paraffin obtained from shale tar.
	Tars	Oil-gas tar Water-gas tar Pine tar Hardwood tar Peat tar Lignite (brown coal) tar Shale tar Gas-works coal-tar Coke-oven coal-tar Blast-furnace coal-tar Producer-gas coal-tar Bone tar	Produced by cracking petroleum vapors in manufacturing oil gas. Produced by cracking petroleum vapors in manufacturing carburetted water gas. Produced by the destructive distillation of the wood and roots of coniferae. Produced by the destructive distillation of hardwoods. Produced by the destructive distillation of peat. Produced by the destructive distillation of lignite (brown coal). Produced by the destructive distillation of pyrobituminous shales. Produced from gas-house retorts in manufacturing gas from bituminous coal. Produced from by-product coke-ovens in manufacturing coke from bituminous coal. Produced from blast-furnaces upon smelting metals with bituminous coal. Produced from gas-producers in manufacturing producer gas from coal. Produced by the destructive distillation of bones.
Pyrogenous residues	Pyrogenous asphalts	Residual oils Pressure tars Blown petroleum asphalts Residual asphalts Sludge asphalts Wurtzilite asphalt	Produced by the dry distillation of non-asphaltic petroleum, the dry or steam distillation of semi-asphaltic petroleum or the steam distillation of asphaltic petroleum. Produced from petroleum by cracking at high temperatures under pressure. Produced by blowing air through heated residual oils. Produced by the steam distillation of semi-asphaltic and asphaltic petroleum. Produced from the acid sludge obtained in the purification of petroleum distillates with sulfuric acid. Produced by depolymerizing wurtzilite in closed retorts.

Table 1. Classification of Bituminous Substances (continued).

Pyrogenous residues	Pitches	Oil-gas-tar pitch	Residues obtained by the partial evaporation or distillation of the corresponding tars.
		Water-gas-tar pitch	
		Wood-tar pitch	
		Peat-tar pitch	
		Lignite-tar pitch	
		Shale-tar pitch	
		Gas-works coal-tar pitch	
		Coke-oven coal-tar pitch	
		Blast-furnace coal-tar pitch	
		Producer-gas coal-tar pitch	
Bone-tar pitch	Residue obtained by the partial distillation of the resinous sap of coniferae.		
Rosin pitch			
Fatty-acid pitch	Residue obtained by the steam distillation of fatty-acids.		

ECONOMIC FEATURES

Terminology

Considerable confusion has resulted from the use of such terms as asphalt, asphaltite, tar, and bitumen for deposits like those at Asphalt Ridge. The classification of bituminous substances prepared by Abraham (1945, p. 62-63 and reproduced as Table 1) has been adopted for this report. Abraham defined the term bitumen (1945, p. 55) as follows:

"Bitumen - a generic term, applied to native substances of variable color, hardness and volatility; composed principally of hydrocarbons, substantially free from oxygenated bodies; sometimes associated with mineral matter, the non-mineral constituents being fusible and largely soluble in carbon disulfide, yielding water-insoluble sulfonation products."

The term "bituminous sandstone," as used in this paper, refers to sandstone which contains variable amounts of bitumen in its pore spaces. The term "oil" is used informally for the general family of products which the bitumen yields on treatment.

Exploration and Development

A number of individuals and companies have examined the exposures of bituminous sand shown on Plates 1A and 1B. The county asphalt pit has been operated for many years, and two abandoned pits evidence still earlier activity. Oil well tests -- the earliest dated 1911 -- are shown in Plate 3. Various petroleum companies made numerous core tests, also shown in Plate 3, but neither company names nor test results were available for this publication. Therefore, no attempt is made to show subsurface distribution of bitumen. Logs of some oil well tests are on open file in Utah Geological and Mineralogical Survey offices. These are attached as an appendix to this report. Distribution of Federal lands allocated to the State of Utah in June, 1966 also is shown in Plate 3. Interest is high in this area, at present (1966), and leasing activity with production intent is expected, when titles and procedures are established.

Economic utilization of these deposits in the future will depend on extraction and marketing of the petroleum products bitumen will yield on treatment. As the cost and risk of exploring, drilling, and developing conventional domestic oil reserves increase, other hydrocarbon resources, such as bituminous sandstones, will become economically attractive. The location of the bituminous sandstone deposits is known generally; so exploration simply entails selection of the best available land in a known area and determining its reserves.

Small-diameter drilling to shallow depths usually is adequate for determining thickness, degree of saturation and extent of the bituminous sands. When reserves have been calculated, various economic factors affecting profitable operation can be

assessed. In the past, the high cost of producing oil from bituminous sands has been the principal economic hurdle. With development of "in situ" production methods, production costs can be reduced to a level at which oil from bituminous sands can compete with production of oil from conventional sources.

Reserves

Spieker (1930, p. 97) estimated bitumen content of the Asphalt Ridge sands at about 2 billion barrels. Covington (1965, p. 1280) revised this figure downward. He estimated proved reserves at 900 million barrels -- 400 million barrels in the Mesaverde Group and 500 million barrels in the Duchense River Formation.

An estimate of reserves in saturated Rim Rock Sandstone of the Mesaverde Group has been prepared by the writer using data from field work finished in 1964 and a compilation of all other available information.

Between the two areas (Plate 3) for which reserves were calculated, sandstone outcrops are irregularly saturated.^{1/} The northern area of the two shown is designated area A, and is located in portions of Secs. 25 and 36, T-4-S, R-20-E, Secs. 31 and 32, T-4-S, R-21-E, and Secs. 5 and 6, T-5-S, R-21-E. Area A, approximately rectangular, is about $2\frac{1}{4}$ miles long by about 1 to $1\frac{1}{2}$ miles wide. It encloses an area of about 1750 acres. The Rim Rock Sandstone is partly covered in portions of area A, but an average saturated thickness of 90 feet is believed to be a conservative estimate.

Area B is located near the southern end of the ridge and includes portions of Secs. 23, 25, 26, 35, and 36, T-5-S, R-21-E, Sec. 31, T-5-S, R-22-E, and Secs. 5, 6, and 7, T-6-S, R-22-E. This area is slightly less than 4 miles long by $\frac{1}{2}$ to 1 mile wide and encloses an area of about 3500 acres. The Rim Rock Sandstone is partly covered in area B, but is believed to have an average saturated thickness of about 50 feet.

Assumptions made for these calculations are based entirely on surface information and may not represent conditions at depth. Estimates are included only to give the reader some impression of the potential of these deposits.

A method, similar to that described by Todd (1958, p. 797-800), was used to calculate reserves. The formula used is: $R=7758 \times A \times T \times P \times (1-I) \times S$, in which R represents the total bitumen reserve in barrels. Variables and constants in the equation are:

1. Saturated segments of Tertiary formations, while shown on the map (Plates 1A and 1B), are not in the reserve calculations.

7758 - the number of barrels of tank stock oil needed to fill one acre, one foot deep.

A - the number of acres in the reservoir (see Plate 3).

T - vertical thickness of the producing zone in feet (see Plate 3).

P - the reservoir porosity average, 30 per cent -- estimated from sample analysis data.

(1-I) - one minus percentage of connate or interstitial water (1-10)=90 per cent.

S - shrinkage factor -- believed to be insignificant because of low percentage of gas in solution, but no available data.

R - may be expressed as recoverable reserves rather than total reserves, if a recovery factor -- expressed as a percentage -- is inserted in the right hand side of the equation. The recovery factor probably lies between 50 and 70 per cent for most methods.

Using this formula, the author estimates the reserve total at 330 million barrels of oil for area A (Plate 3). Assumed factors are: A=1750 acres, T=90 feet (average thickness), P=30 per cent, (1-I)=90 per cent. For area B (Plate 3) total reserves are estimated at 367 million barrels of oil. Assumed factors are: A=3500 acres, T=50 feet (average thickness), P=30 per cent, (1-I)=90 per cent. The total estimate for these two areas in the Mesaverde would be 697 million barrels of oil, or nearly 700 million barrels. Total recoverable reserves in the Mesaverde Group might be about 350 million barrels of oil.^{1/}

The importance of deposits such as those at Asphalt Ridge is apparent. Additional concealed saturated sand may be found by drilling in the Mesaverde Group on Asphalt Ridge. Highly saturated lenses also occur in the Duchesne River and Uinta Formations (geologic map, Plate 1A and 1B). Inclusion of these lenses might double the total reserve figure given above. The position of an oil-water contact will have an important effect on the extent of saturation and -- probably more than any single factor -- will determine the amount of oil recovered.

Production Methods

Underground Mining

Underground mining was tried on a limited scale early in the history of Asphalt Ridge, and short adits still are to be found in zones of saturation. However, it is doubt-

1. According to the Utah Oil and Gas Conservation Commission, the all-time cumulative production of oil from conventional oil reserves in the State of Utah as of November 1, 1965, totaled 256,387,811 barrels.

ful that underground mining methods could compete economically with "in situ" or open pit methods.

Open Pit Mining

Open pit mining may be feasible in several parts of Asphalt Ridge, but its use is limited by such controlling factors as the thickness and extent of the zone of saturation, the ratio of overburden to saturated material and the local topography. One area favorable for open pit mining lies in the $E\frac{1}{2}$ Sec. 23 and the $W\frac{1}{2}$ Sec. 24, T-4-S, R-20-E (Figure 4). Bituminous sand crops out at the surface and dips to the southwest under a relatively thin gravel cover. In all probability, the ratio of overburden to saturated material is less than 1 to 1.

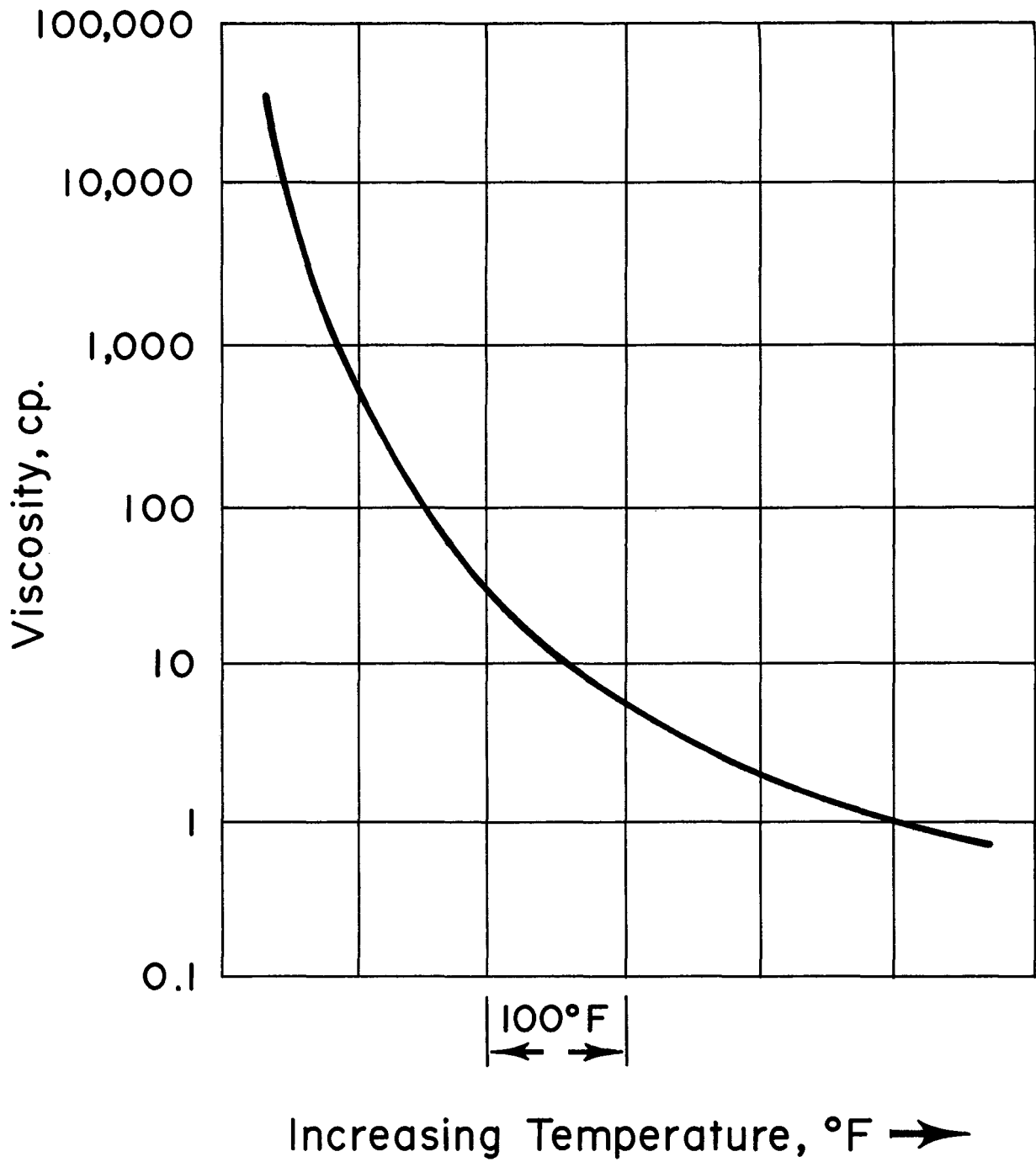
Open pit mining on a small scale currently is being carried on at the Uintah County asphalt pit in Sec. 30, T-4-S, R-21-E. Here, during the summer months, bituminous sandstone is mined for use as paving material on Uintah County roads. Little drilling or blasting is necessary. Most of the material can be ripped and bulldozed by a tractor. Bituminous sand is too rich for direct application as paving material and must be mixed with dry sand. Open pit mining also could be used in much of the area surrounding the county pit. This particular mining method may be practicable in several areas near the southern end of the ridge, especially in Secs. 30 and 32, T-5-S, R-22-E. Most of the saturation is in beds of the Uinta Formation and, although they are fairly thin, they may be sufficiently shallow to mine by open pit methods. Several small pits were opened and abandoned in this area during the early years.

"In Situ" Recovery Methods

Probably most of the Asphalt Ridge bitumen will be recovered by some type of "in situ" method. "In situ" methods often are termed thermal methods, because they depend on the application of heat to the bitumen in the reservoir. Thermal processes reduce the viscosity of very viscous, low gravity crude oils to a point at which they will flow from reservoir sands into a drilled well.

The potential effectiveness of thermal methods presented by Howard (1965, p. 96) is graphically shown in Figure 3, which shows the reduction of viscosity with increasing temperature. Howard points out that crude oil with a reservoir viscosity of 1,000 cp (centapoises) at 100° F has a reservoir viscosity of about 50 cp at 200° F, dramatically illustrating the tremendous potential of thermal techniques in recovery of extremely viscous crude oils.

The most common thermal recovery methods, (Howard, 1965), are steam flooding, hot water flooding, and combustion, or fire flooding. *Steam flooding*, probably the oldest and best known of the thermal recovery methods, necessitates the injection of steam into the formation via wells drilled in a regular, closely-spaced pattern. Mechanisms principally responsible for high recovery include: (1) thermal expansion of oil in place; (2) viscosity reduction; and (3) steam distillation. Recovery



Universal Temperature-Viscosity Chart

Figure 3.

depends, to a lesser extent, on gas drive and solvent extraction. The amount of steam and pressure needed depends on depth, reservoir characteristics, and crude oil properties. Shell Oil Co. has proposed that this method be used to extract oil from the Athabasca tar sands of Alberta, Canada (Bell, 1964; Lyon, 1964). A four-acre, five-well spacing arrangement is proposed, with one producing well in the center and a steam injection well at each corner of the area. Lateral communication between wells may be increased by induced horizontal fracturing. Solutions of sodium hydroxide would be pumped into the formation, along with the steam, to aid in reducing the oil viscosity. With this method Shell proposes to maintain a reservoir temperature of about 350° F. A system similar to that proposed by Shell probably would be effective at Asphalt Ridge.

Hot water flooding (Howard, 1965) is the simplest and safest of thermal recovery processes. The displacement efficiency of hot water flooding is comparable to steam flooding as far as thermal expansion and viscosity reduction are concerned. The effects of steam distillation, gas distillation, and solvent extraction are not present in hot water flooding -- under certain reservoir conditions this may be unimportant. In general, hot water injection is no less expensive per BTU injected than steam.

All *combustion or fire flood* recovery methods depend on heat supplied by burning part of the oil in place and on air supplied from injection wells.^{1/} A description of the forward "in situ" combustion method follows. Air is injected into the zone of combustion through a burned-out section of the reservoir which is completely devoid of saturation. Here, the fire feeds on coke derived from thermal cracking of oil immediately downstream from the fire. The next zone inward contains lighter, more volatile fractions driven off by thermal cracking. This material is mixed with condensed water and forms what Howard calls a "water bank." Oil is displaced ahead of the water bank and becomes available at a production well. Displacement efficiency of the combustion front is nearly 100 per cent, less the amount of coke consumed by the fire -- approximately 10 per cent. In a second method, the reverse "in situ" combustion method, a combustion zone is created at the producing well and the fire burns from the producing well to the injection well. According to Howard, this method vaporizes most of the oil in the reservoir and yields a product of higher gravity than the original reservoir fluid.

Howard (1965) and Covington (1965) cite numerous factors governing effective use of thermal recovery methods in any area, the most important being the depth to the bituminous sand; the optimum is between 500 and 2500 feet. In depths less than 500 feet, low formation pressures and loss of fluids to the outcrop or through faults may occur. At depths greater than 2500 feet, it is difficult to deliver and maintain heat and pressure in the saturated formation. A successful thermal recovery program usually depends on a minimum of 1000 barrels per acre foot of oil in place. Fifty feet of pay sand generally is regarded to be minimum thickness, but exceptional porosity and permeability may permit the working of thinner sands. Howard

1. Two recovery methods are discussed by Howard (1965).

notes that thicker sands are favored for steam and hot water floods because vertical heat losses are less significant. Fire floods do not perform well in very thick sands, because the vertical conformance of combustion throughout the reservoir tends to be poor. High porosity and permeability increase the efficiency of the oil recovery. Numerous other factors such as degree of water saturation, homogeneity of the reservoir, reservoir temperature, and the nature of the bounding surfaces of the reservoir also affect efficiency of thermal recovery. These, together with economic factors, should be evaluated carefully whenever thermal recovery is considered.

Asphalt Ridge deposits are well suited to thermal recovery techniques. Reserves are large enough to justify the initial capital investment, and the deposits are near a pipeline to refineries and markets in Salt Lake City, Utah. The Green River at the south end of the Ridge is an abundant supply of good quality water. Moreover, the Rim Rock Sandstone of the Mesaverde Group has excellent reservoir characteristics for thermal recovery techniques. At Asphalt Ridge, the depth limit probably runs less than 2500 feet owing to the presence of the water-bitumen contact. Thermal recovery methods are less likely to succeed in the saturated sands of the Duchesne River and Uinta Formations. The Tertiary sediments generally have lower porosities and permeabilities than the Cretaceous sediments, because of a high content of clay, silt, and very fine sand. Also, the Tertiary sands are irregular, discontinuous, and lenticular; so maintenance of lateral communication between injection and producing wells would be difficult. The thick, uniform sands of the Mesaverde Group, therefore, are the best targets for thermal recovery methods.

Thermal recovery tests have been conducted on two widely separated areas at Asphalt Ridge. The first of these was an "in situ" fire flood test conducted by the SOHIO Petroleum Company in the Asphalt Ridge Sandstone of the Mesaverde Group. The test site is in the SE $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 23, T-4-S, R-20-E, in the area shown in Figure 2. For this test a short adit was driven into the bituminous sand outcrop and a concrete bulkhead built in the entrance. Several holes were drilled downdip, apparently for air injection and combustion control. The results of the test were not released, but it is believed they were encouraging. A second test, probably of the fire flood type, was conducted by the Gulf Oil Corporation in the bituminous sands of the Duchesne River Formation near the center of the NE $\frac{1}{4}$ Sec. 16, T-5-S, R-21-E. Two wells drilled to depths of 666 and 720 feet, intersected saturated sands. Results of this test have not been released, but probably were unfavorable. The highly lenticular nature and low porosity and permeability of the Tertiary sediments suggest poor test results.

GEOLOGIC SETTING

Because of intensive exploration for petroleum and natural gas, as well as bitumens, oil shale and solid hydrocarbons, the geology of the Uinta Basin has been studied comprehensively and summarized in a number of publications (I. A. P. G.¹ 1964, U. S. G. S. and others, 1964, Untermann and Untermann, 1964).

1. Intermountain Association of Petroleum Geologists.

Asphalt Ridge lies on the northeastern margin of the central part of the Uinta Basin at the contact of the Tertiary beds with the underlying Cretaceous Mesaverde Group. Both dip southwestward into the basin. The basin (Figure 1) trends west-northwest between the Uinta Mountains on the north and the San Rafael Swell and Uncompahgre uplift on the south. In Colorado, to the east, it is separated from the Piceance Basin by the Douglas Creek arch. The west end terminates against the Wasatch Mountains.

The Uinta Basin came into being during early Cenozoic (Paleocene) times (I. A. P. G., 1964, p. 45) and -- except for the uppermost part -- the entire thickness of Tertiary sediments is of Eocene age. Its deepest part was adjacent to the Uinta Mountains northwest of Roosevelt (I. A. P. G., 1964, p. 55). In the western part of the basin, there is evidence of almost continuous deposition from uppermost Cretaceous through lowermost Tertiary (Untermann and Untermann, 1964, p. 49). At Asphalt Ridge, however, uplift and erosion occurred so that Eocene (Uinta) and Lower Oligocene beds (Duchesne River) rest on the eroded surface of formations of the Mesaverde Group (Figure 4). Subsidence of the Uinta Basin was rapid and a thick sequence of organically rich sediments (oil shales) of the Green River Formation deposited. These occur in the subsurface immediately southwest of Asphalt Ridge (Figure 5). As Lake Uinta diminished, fluvial sediments of the Uinta Formation and the subsequent Duchesne River Formation were deposited. During the last major accumulation of sediment, the Miocene Browns Park Formation was deposited on -- what are now -- the flanks of the Uinta Mountains. Late Tertiary history was characterized by uplift and erosion that led to the basin's present configuration.

STRATIGRAPHY

Cretaceous

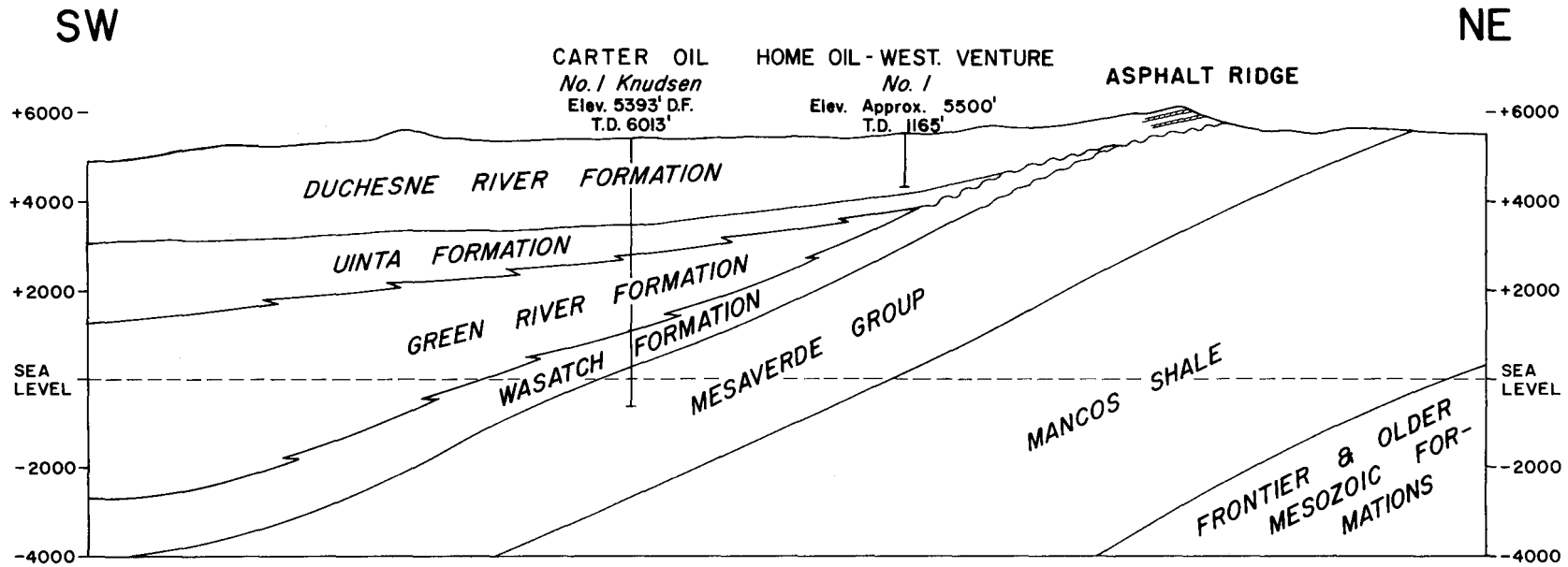
Mancos Shale

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.

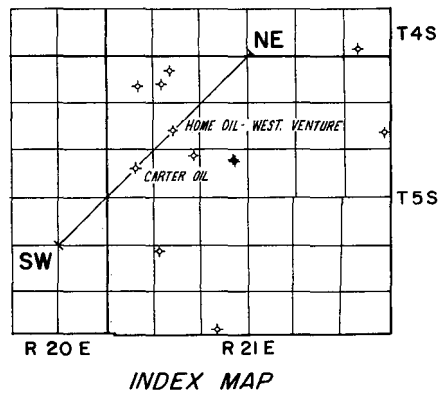
Mesaverde Group

Walton (1944) divided the Mesaverde Group at Asphalt Ridge into three formations: the Asphalt Ridge Sandstone at the base; the Rim Rock Sandstone, and the Williams Fork Formation. The Asphalt Ridge and the Rim Rock Sandstones are marine littoral sediments separated by a thin bed of shale, usually referred to as Mancos Shale. 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



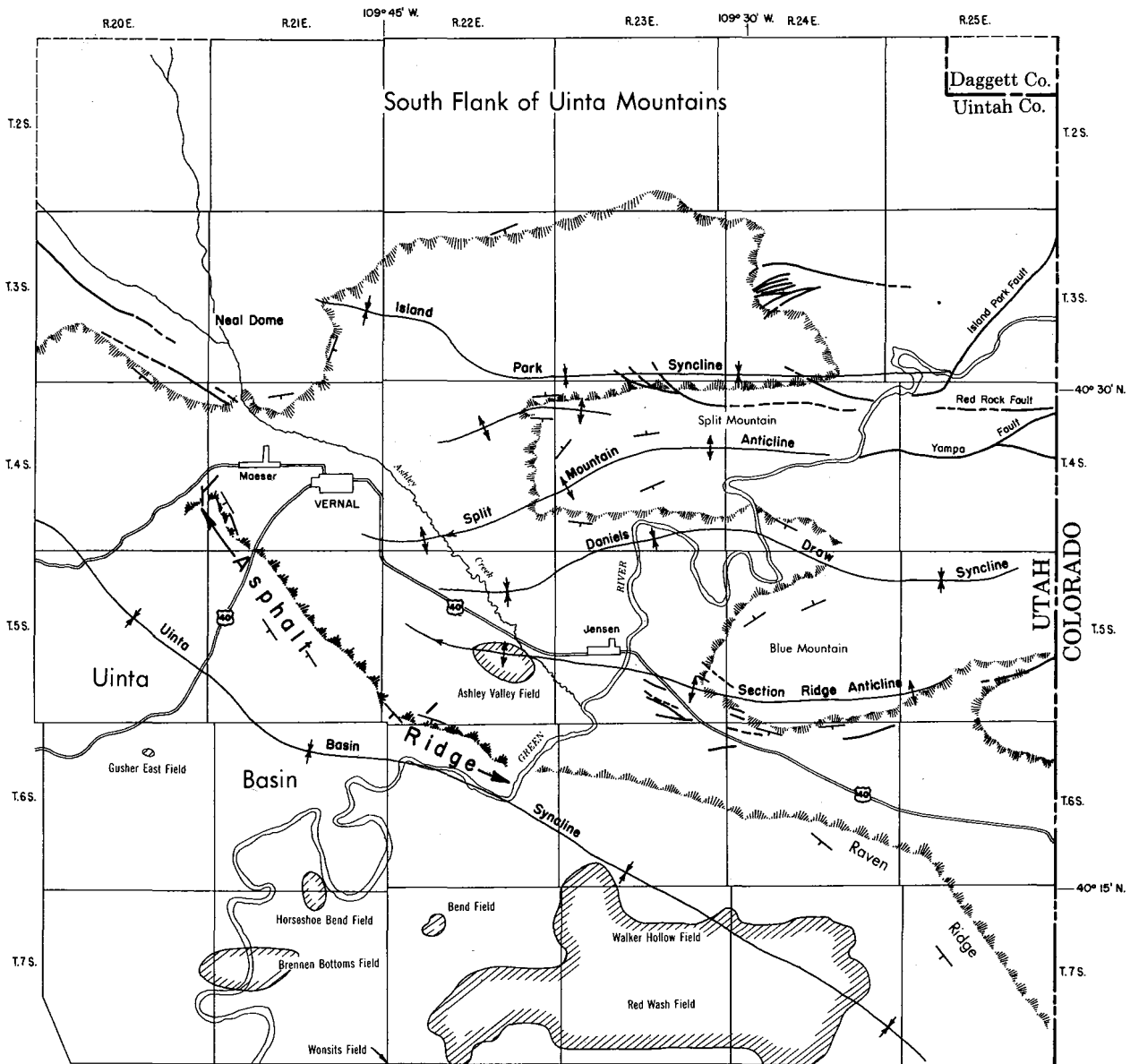
21



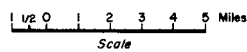
GENERALIZED GEOLOGIC SECTION, ASPHALT RIDGE AREA, UINTAH COUNTY, UTAH

File No. 339A

Figure 4.



- EXPLANATION**
- Oil and/or Gas Field
 - Anticlinal Axis
 - Synclinal Axis
 - Fault



STRUCTURAL FEATURES AND OIL FIELDS IN ASPHALT RIDGE AREA, UINTAH COUNTY, UTAH

Figure 5.

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, it is richly saturated with bitumen.

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

Because of variable erosion of the Mesaverde Group prior to Tertiary deposition, the thickness of the Rim Rock Sandstone ranges from less than 100 feet to more than 300 feet. The Asphalt Ridge Sandstone generally thins eastward and pinches out between the Green River and the Utah-Colorado border, whereas the Rim Rock Sandstone thickens eastward and merges with the basal Iles Formation in Colorado. According to Walton (1957), both the Asphalt Ridge Sandstone and the Rim Rock Sandstone probably are correlative with the basal Iles Formation of western Colorado.

The beds above the Rim Rock Sandstone and below the Tertiary unconformity have been grouped in the Williams Fork Formation by Walton (1944). These beds are poorly exposed and found only in the central part of Asphalt Ridge where they consist of continental and brackish water shale, sandstone, and thin coal beds.

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. The rapid lateral and vertical variations in the sediments make correlation over widespread areas difficult. Figure 4 is a generalized geologic section of the area of this report.

According to most stratigraphic interpretations, the Uinta and Duchesne River Formations are the only Tertiary formations exposed on Asphalt Ridge. However, some workers are of the opinion that the Wasatch Formation is exposed at various places along Asphalt Ridge, where it has been incorrectly mapped as the Duchesne River. Others believe that what has been mapped as Uinta Formation is a continuation of the Green River Formation exposed at Raven Ridge.

It is not within the scope of this study to attempt to solve the problems of the Tertiary stratigraphy on the northeast flank of the Uinta Basin. Therefore, the nomenclature used by Untermann and Untermann (1964) has been adopted as most convenient for this report, with the realization that further detailed work may alter and improve the stratigraphic picture.

Wasatch and Green River Formations

It is believed generally that these two formations are absent in the Asphalt Ridge area. In order to present a complete stratigraphic section, their occurrence in the

nearby Raven Ridge area (see Figure 1) is discussed briefly here. The oldest formation exposed in the Raven Ridge area is the late Paleocene-early Eocene Wasatch Formation which unconformably overlies the Mesaverde Group and grades upward into the Green River Formation. According to Abbott (1957, p. 104), the Wasatch in Raven Ridge is about 850 feet thick and consists of fluviatile red and green mudstone and shale, discontinuous lenticular sand layers and, in places, a basal conglomerate. Murany (1964, p. 145) states that the Wasatch-Green River contact, though gradational, generally is placed at the first occurrence of ostracodal and oolitic limestone, or oil shale, or black and green, dense, calcareous siltstone and claystone, whichever facies of the overlying Green River Formation is represented locally.

A change in environment took place between the time the fluviatile Wasatch Formation was laid down and deposition of the lacustrine Green River Formation. In a detailed description of the stratigraphy of the Raven Ridge area, Sanborn and Goodwin (1965) point out that the Green River Formation, exposed along the margins of the basin, is a sequence of intertonguing beds of sandstone, shale, limestone, and marlstone with rapid facies changes. The complexity of the sequence makes correlation with units in the interior part of the basin difficult. The Green River Formation conformably overlaps the Wasatch and, in places, rests unconformably on the beveled upper surface of the Mesaverde Group. Minor bituminous saturation and staining are found in the Green River Formation at Raven Ridge.

Uinta Formation

The Uinta Formation of late Eocene age conformably overlies the Green River Formation at Raven Ridge. In some outcrops at Asphalt Ridge, the Uinta rests unconformably on the Mesaverde Group. 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. The Uinta Formation has been subdivided in other parts of the Uinta Basin, but correlation of the section at Asphalt Ridge with these members is not clear. Most of the bituminous saturation in the southern part of Asphalt Ridge occurs in the thin sand beds of the Uinta Formation. The contact between the Uinta Formation and the overlying Duchesne River Formation is gradational.

Duchesne River Formation

The Duchesne River Formation of lower Oligocene age (Untermann and Untermann, 1964) conformably overlies the Uinta Formation in the southern part of Asphalt Ridge and unconformably overlies the Mesaverde Group in the central and northern part. As pointed out by Untermann and Untermann (1964, p. 61), the Duchesne River Formation resembles the fluviatile beds of the upper Uinta, but has a higher percentage of sandstone and conglomerate of a darker, more uniform red color. The lower Duchesne River contact as mapped by the author occurs at the bottom of the lowest

thick and persistent sequence of red sandstone, shale, and mudstone. Sandstone, grit, and conglomerate of the Duchesne River Formation commonly contain bituminous saturation in the central and northern parts of Asphalt Ridge.

STRUCTURE

Folds

Asphalt Ridge is a hogback situated on the east flank of the Uinta Basin syncline at a distance ranging from 5 miles (at north end) to $1\frac{1}{2}$ miles (at south end) from the synclinal axis (Figure 5). All formations strike northwest and dip southwest. The strike of beds in the Cretaceous Mesaverde Group ranges from N 80°W to N 15°W, and dips range from 12° to 28° SW. There is an angular discordance of 3° to 8° between the Cretaceous and Tertiary beds. The strike of the Tertiary beds is more westerly and the dips range from nearly zero to 20° SW. The spectacular Split Mountain and Section Ridge anticlines east of Vernal plunge westward under the floor of Ashley Valley, but their axes are believed to curve northwestward so that they are generally parallel to Asphalt Ridge. The structure of the Asphalt Ridge area is shown in detail on Plates 1A, 1B, and 2. The regional structure is shown in Figure 5.

Faults

The few faults mapped at Asphalt Ridge are confined to rocks of the Mesaverde Group and do not pass upward into the overlying Tertiary. The most prominent fault trends N 24°W at the County asphalt pit in Secs. 30 and 31, T-4-S, R-21-E. The fault surface is nearly vertical and the displacement is 150 feet downward on the west side. This fault marks the eastern limit of saturation in the area. The saturated Rim Rock Sandstone has been faulted against beds of Asphalt Ridge Sandstone. The latter formed a barrier to the eastward migration of bitumens. A fault at the north end of the ridge in Sec. 25, T-4-S, R-20-E, trends north and drops the Rim Rock Sandstone to the west (Plate 1A). It intersects and offsets another fault trending north-northeast with the downthrown side to the northwest. These faults terminate the topographically high portion of the ridge. Bituminous material occurs in the downdropped block portion north of the Maeser-Labarge highway at a much lower elevation (Figure 2). Numerous small faults and joints occur along the length of the ridge and trend from N 50°W to N 70°W. Some show slight displacement. Doubtless, close-spaced drilling through the Tertiary will reveal concealed faults in Mesozoic strata.

DISTRIBUTION OF BITUMEN: STRATIGRAPHY AND STRUCTURE

Previous workers have noted the proximity of bitumen concentration to the unconformable contact between Tertiary and Cretaceous rocks. North of Highway 40, the richest saturation occurs in the Mesaverde immediately below the contact with the Duchesne River Formation (Figure 4), although less saturated beds do occur in the Duchesne River. Covington (1957, 1964) suggested the bitumen probably originated in the lower Green River Formation and migrated updip along the unconformity.

South of Highway 40, however, the observed bitumen concentrations are generally above the contact, and essentially confined to the Duchesne River. South from the common corner of Secs. 23, 24, 25, and 26, T-5-S, R-21-E, lenses of saturated material occur in the Mesaverde at the contact and in several zones in the Uinta well above the contact. However, the Duchesne River is barren in this area (Plate 1B).

As noted above, faults tend to limit saturated areas by placing permeability barriers in the paths of bitumen migration. Concealed faults may be an important factor in bitumen distribution. Variations in porosity and permeability of host rocks as they relate to bitumen migration are believed to be more effective than either structure or stratigraphy in localizing bituminous saturation.

PHYSICAL AND CHEMICAL PROPERTIES OF BITUMEN

Tests of Utah Geological Survey Samples

With the aid of power equipment, samples for a wide range of tests were collected by the writer in two localities, at least 2 feet below any weathering. Sample no. 1, obtained from the County asphalt pit in $SE\frac{1}{4}SE\frac{1}{4}$ Sec. 30, T-4-S, R-21-E, represents saturated Rim Rock Sandstone from the northern part of the ridge. Sample No. 2, obtained from an abandoned asphalt pit in $NE\frac{1}{4}SW\frac{1}{4}$, Sec. 31, T-5-S, R-22-E, represents saturated sand from the Uinta Formation in the southern part of the ridge. Each of the samples was divided into four parts. One part of each was sent for a crude petroleum analysis to the U. S. Bureau of Mines Petroleum Research Center in Laramie, Wyoming. A second portion was sent to the Fuels Engineering Department of the University of Utah for additional analysis. A third portion was analyzed in the laboratories of the Utah Geological and Mineralogical Survey to determine petrologic characteristics of host sediments. Finally, part of each sample was sent to a commercial core analysis laboratory for porosity, permeability, and residual oil and water determinations. The results of the various tests are shown in the following tables. The crude petroleum analyses have been reproduced in Tables 2 and 3 exactly as supplied by the U. S. Bureau of Mines.

The crude petroleum analysis of Sample No. 1 (Table 2) probably presents the most accurate estimate of the bitumen from Asphalt Ridge. Loss of a portion of the volatile constituents of Sample No. 2 (Shown in Table 3) is indicated by the low API gravity.

Samples of the extracted bitumen returned to the Utah Geological and Mineralogical Survey from the Laramie Petroleum Research Center of the U. S. Bureau of Mines were referred to the Fuels Engineering Department of the University of Utah for further tests. The results of these tests, shown in Table 4, confirm some of those in Tables 2 and 3, but contain some additional data. The obvious difference in specific gravity and API gravity values may be due, at least, in part, to analysis at different temperatures. The Laramie Petroleum Research Center made gravity determinations at 60°F; and the Fuels Engineering Department, at 82°F. Sulfur analyses of Sample No. 1 differ by only .02 per cent, whereas sulfur analyses of

Table 2. Crude petroleum analysis of Sample No. 1 by United States Bureau of Mines.

Bureau of Mines Laramie Laboratory

Sample PC-65-5

IDENTIFICATION

Sample No. 1

GENERAL CHARACTERISTICS

Gravity, specific, 0.986 Gravity, ° API, 12.0 Pour point, ° F., (semifluid)
 Sulfur, percent, .28 Color, _____
 Viscosity, Saybolt Universal at _____ (semifluid) Nitrogen, percent, 0.962

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1 - Distillation at atmospheric pressure, _____ mm. Hg
 First drop, 306 ° F. 40 mm. Hg

Fraction No.	Cut temp. °F.	Percent	Sum, percent	Sp. gr. 60/60° F.	° API, 60° F.	C.I.	Refractive index, n _D at 20° C.	Specific dispersion	S.U. visc., 100°F.	Cloud test, ° F.
1	122									
2	167									
3	212									
4	257									
5	302									
6	347									
7	392									
8	437									
9	482									
10	527									

Stage 2 - Distillation continued at 40 mm. Hg

11	392	3.8	3.8	0.890	27.5	53	1.48330	143.7	39	below 5
12	437	3.3	7.1	.920	22.3	63	1.50028	141.7	59	below 5
13	482	2.1	9.2	.928	21.0	64	1.50727		92	below 5
14	527	3.5	12.7	.937	19.5	65			185	below 5
15	572	9.3	22.0	.945	18.2	65			790	below 5
Residuum .		76.3	98.3	1.005	9.3					

Carbon residue, Conradson: Residuum, 14.5 percent; crude, 11.3 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline				
Total gasoline and naphtha				
Kerosine distillate				
Gas oil	3.8	0.890	27.5	
Nonviscous lubricating distillate	4.6	.906-.929	24.7-20.8	50-100
Medium lubricating distillate	2.7	.929-.937	20.8-19.5	100-200
Viscous lubricating distillate	10.9	.937-.951	19.5-17.3	Above 200
Residuum	76.3	1.005	9.3	
Distillation loss	1.7			

Table 3. Crude petroleum analysis of Sample No. 2 by United States Bureau of Mines.

Bureau of Mines Laramie Laboratory

Sample PC-65-6

IDENTIFICATION

Sample No. 2

GENERAL CHARACTERISTICS

Gravity, specific, 1.013 Gravity, ° API, 8.2 Pour point, ° F., (semifluid)
 Sulfur, percent, .62 Color, black
 Viscosity, Saybolt Universal at (semifluid) Nitrogen, percent, 1.071

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1 - Distillation at atmospheric pressure, _____ mm. Hg
 First drop, 324 ° F. 40 mm. Hg

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr., 60/60° F.	° API, 60° F.	C.I.	Refractive index, n _D at 20° C.	Specific dispersion	S.U. visc., 100° F.	Cloud test, ° F.
1	122									
2	167									
3	212									
4	257									
5	302									
6	347									
7	392									
8	437									
9	482									
10	527									

Stage 2 - Distillation continued at 40 mm. Hg

11	392	2.1	2.1	0.893	27.0	54	1.48532	135.8	42	below 5
12	437	2.5	4.6	.913	23.5	60	1.49607	147.4	57	below 5
13	482	4.2	8.8	.937	19.5	68	1.50899		130	below 5
14	527	4.3	13.1	.948	17.8	70			480	below 5
15	572	9.5	22.6	.952	17.1	69			1160	below 5
Residuum . . .		74.8	97.4	1.034	5.4					

Carbon residue, Conradson: Residuum, 19.0 percent; crude, 14.5 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline				
Total gasoline and naphtha				
Kerosine distillate				
Gas oil	2.3	0.895	26.6	
Nonviscous lubricating distillate	2.9	.905-.927	24.9-21.1	50-100
Medium lubricating distillate	2.3	.927-.939	21.1-19.2	100-200
Viscous lubricating distillate	15.1	.939-.955	19.2-16.7	Above 200
Residuum	74.8	1.034	5.4	
Distillation loss	2.6			

Table 4. Test data obtained by University of Utah Fuels Engineering Department on bitumen extracts from Samples 1 and 2.

<u>Test</u>	<u>Samples</u>	<u>Results</u>
Total Sulfur content-Oxygen bomb Turbidimeter	#1	0.3%
	#2	0.76%
Specific gravity 82° F	#1	.952
	#2	.990
API Gravity 82/82° F	#1	17.5
	#2	11.7
Pour Point	#1	+70° F
	#2	+90° F
Carbon	#1	77.46%
	#2	77.40%
Hydrogen F & M Model 180	#1	11.75%
	#2	11.35%
Nitrogen	#1	11.30%
	#2	12.03%
Color	#1	Black
	#2	Black
Odor	#1	Tarry
	#2	Tarry

Sample # 1 - Mesaverde Formation
 From County Asphalt Pit, SE $\frac{1}{4}$, SE $\frac{1}{4}$
 Sec. 30, T-4-S, R-21-E

Sample # 2 - Uinta Formation
 From South Pit, NE $\frac{1}{4}$, SW $\frac{1}{4}$
 Sec. 31, T-5-S, R-22-E

Revised Analyses, May 1967
 (F&M Model 185)

	Sample #1	Sample #2
Carbon	85.3%	83.6%
Hydrogen	11.2%	11.0%
Nitrogen	1.01%	0.96%

Sample No. 2 differ by .14 per cent. Carbon, hydrogen, and nitrogen analyses shown in Table 4 were made on a F & M Corporation, Model 180 Carbon, Hydrogen, Nitrogen Analyser.

Analytical and Test Data From Other Sources

Analyses of bitumen and related material from the Asphalt Ridge area have appeared in several earlier reports. Many of these are reported on the following pages. Because the purposes, methods and results of the tests vary greatly, the reader is referred to the source report for a detailed explanation of each analysis.

In an early paper on Asphalt Ridge, Spieker (1930, p. 94) gave the following analysis of bituminous sand:

	<u>Per cent</u>
Loss (moisture) obtained at 105° C for 1 hour	0.20
Residue obtained upon ignition	86.45
Total sulfur by the Carius method	0.09
Soluble in carbon disulfide	12.8
Fixed carbon in residue from evaporation of carbon disulfide	7.1
Soluble in petroleum ether, specific gravity 0.644	11.0
Amount of hydrocarbon extracted by petroleum ether of chemically saturated nature (Analysis by E. T. Erickson)	65.0
Specific gravity of bitumen (By E. M. Spieker)	0.980

In addition, the analyst, E. T. Erickson, reported the bitumen contained a small quantity of paraffin. Spieker concluded the bituminous material was a residue from a paraffin petroleum, rather than a typical asphalt.

J. O. Ball (1944) provided several analyses and observations of interest. He discussed the analytical methods of steam distillation, dry distillation, vacuum distillation and blowing hot bitumen with air, and the problems associated with these procedures. He presented a revised technique for isolating the constituents of the bitumen, and discussed the effectiveness of various solvents in separating oil from other constituents. He concluded that the most promising solvents for the resins and oils are benzyl alcohol, nitroethane, furfural, and aniline. For routine preparations of bitumen from sand, he found a mixture of 10 parts benzene and 1 part methanol very effective.

On page 104, Ball lists the following analysis of the asphaltic constituents in the Asphalt Ridge bitumen:

	<u>Per cent</u>
Free asphaltous acid	none
Asphaltous anhydrides	3.6
Asphaltenes	19.0
Resins	45.8
Oily constituents	31.6

The resin content is unusually high and is probably responsible for the high adhering and ductile properties of the bitumen. In Ball's tests, the oil was cooled to -20°F without clouding or change in color. Because an oil containing wax will cloud before the pour point is reached, Ball concluded wax was not present and did not test for it. This absence of wax in the Asphalt Ridge bitumens, noted by Ball, has been confirmed by the crude petroleum analyses reported in Tables 2 and 3. In all fractions of both samples, the cloud point was below 5°F , so that the oil may be referred to as wax free (Nelson, 1958).

In 1952, Shea and others of the United States Bureau of Mines published a report on properties of the Asphalt Ridge bitumen; the results of hot water separation tests, and results of various tests on the utilization of the bitumens and cracked products of Asphalt Ridge bituminous sands. Recovery by hot water separation was 96 per cent of the bitumen originally contained in the sandstone. In general, the separation tests were successful and indicated hot water stripping may be effective on Asphalt Ridge sands. A crude petroleum analysis for a sample with no geographic or geologic location other than "Asphalt Ridge" is taken from their report, and shown in Table 5. The results of tests reported by Shea and others are reproduced in Tables 6, 7, and 8. Table 6 shows the experimental data obtained for asphalts prepared from the Asphalt Ridge bituminous sand. This asphalt was prepared by removing heavy oils from the bitumen by distillation at a maximum absolute pressure of 1.8 millimeters of mercury. In Table 7, asphalts from Asphalt Ridge (Vernal, Utah) are compared by Shea and others with asphalts from five other sources. In evaluating the Asphalt Ridge bitumen as a source of various grades of fuel oil, the U. S. Bureau of Mines determined that an A. S. T. M. 1/ Grade 6 fuel oil could be prepared from the bitumen with mild cracking, and five A. S. T. M. grades of fuel oil could be prepared by fractionation of coker distillates. According to Shea and others (1952, p. 22), a coker distillate can be prepared by cracking through retorting the bitumen until only a residue of dry coke remains. The yield of coker distillate from a sample of Asphalt Ridge bitumen is given below.

	<u>Weight, per cent</u>
Coker distillate	71.6
Coke	19.3
Loss (gas)	9.1
	<hr style="width: 100%; border: 0.5px solid black;"/> 100.0

1. American Society for Testing and Materials.

Table 5. Crude petroleum analysis. From Shea and others (1952).

Bureau of Mines _____ Laboratory

Sample _____

IDENTIFICATION

GENERAL CHARACTERISTICS

Gravity, specific, 1.010 Gravity, ° API, 8.6 Pour point, ° F., _____
 Sulfur, percent, 0.39 Color, black
 Viscosity, Saybolt Universal at 210° F., 760 sec., at 275° F., 130 sec. Nitrogen, percent, 1.18

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1 - Distillation at atmospheric pressure, _____ mm. Hg
 First drop, 135° C. ° F. (275° F.)

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr., 60/60° F.	° API, 60° F.	C.I.	Refractive index, n _D at 20° C.	Specific dispersion	S.U. visc., 100° F.	Cloud test, ° F.
1.	122									
2.	167									
3.	212									
4.	257									
5.	302									
6.	347									
7.	392									
8.	437									
9.	482									
10.	527									

Stage 2 - Distillation continued at 40 mm. Hg

11.	392	0.4	0.4							
12.	437	.7	1.1	0.871	31.0				40	25
13.	482	1.6	2.7	.908	24.3	54			68	35 59.6
14.	527	4.7	7.4	.943	18.6	67			230	20 60.5
15.	572	5.9	13.3	.956	16.5	71			760	Below 5-64.0
Residuum . . .		86.7	100.0	1.021	7.1					

Carbon residue, Conradson: Residuum, 17.2 percent; crude, 15.1 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline				
Total gasoline and naphtha				
Kerosine distillate				
Gas oil	1.0	0.870	31.1	
Nonviscous lubricating distillate	1.5	.884-.915	28.6-23.1	50-100
Medium lubricating distillate.	2.0	.915-.938	23.1-19.4	100-200
Viscous lubricating distillate.	8.8	.938-.963	19.4-15.4	Above 200
Residuum	86.7	1.021	7.1	
Distillation loss0			

Aniline Point, ° C.

Table 6. Experimental data for asphalts from Asphalt Ridge. From Shea and others (1952).

	Asphalt number		Estimated for 100-penetration (at 77° F.) asphalt
	21/	1	
Recovered bitumen chargegrams	935.2	-	-
Asphalt yield from recovered bitumen.....grams	883.6	-	-
Asphalt yield from recovered bitumen weight percent	94.5	100.0	97.1
Maximum pressure during vacuum distillation mm. Hg.	1.8	40	-
Maximum temperature of vapors°F.	397	-	-
Maximum temperature of liquid.....°F.	484	-	-
Ash ^{2/} percent	0.5	0.4	0.5
Ash ^{3/} percent	1.8	1.7	1.7
Bitumen ^{4/} percent	99.4	99.4	99.4
Bitumen soluble in carbon tetrachloride... percent	100.0	100.0	100.0
Carbon residue..... percent	16.4	15.1	15.8
Composition:			
Asphaltenes..... percent	15.6	14.5	15.0
Ductility:			
At 39.2° F., 1 cm. per minute cm.	13	100+	-
At 77° F., 5 cm. per minute..... cm.	100+	100+	100+
Fire point °F.	615	560	590
Flash point °F.	505	450	480
Loss on heating percent	0.11	0.57	0.2
Penetration:			
At 32° F., 200 gm. wt., 60 seconds dmm.	11	29	17
At 60° F., 100 gm. wt., 5 seconds dmm.	18	49	29
At 77° F., 100 gm. wt., 5 seconds dmm.	64	165	100
At 100° F., 100 gm. wt., 5 seconds dmm.	213	Soft	-
At 115° F., 50 gm. wt., 5 seconds dmm.	Soft	Soft	Soft
Penetration at 77° F., of residuum from loss on heating test..... dmm.	54	114	78
Softening point°F.	121	106	114
Specific gravity at 77°/77° F.	1.012	1.006	1.009
Spot tests:			
Oliensis:			
Initial.....	Positive	Positive	Positive
After 24 hours.....	Positive	Positive	Positive
Heptane-xylene equivalent ^{5/}	Passing	Passing	Passing
Sulfur..... percent	0.38	0.39	0.38
Viscosity at 210° F.:			
Furol..... seconds	1,761	760	1,180
Kinematic..... stokes	38.0	16.4	25.5
Absolute..... poises	36.7	15.7	24.5
Viscosity at 275° F.:			
Furol..... seconds	193	130	160
Kinematic stokes	4.17	2.80	3.45
Absolute..... poises	3.93	2.63	3.25

1. Used as charge stock in the preparation of asphalt No. 2.
2. Determined by A.S.T.M. Designation D4-42, Method I, A.S.T.M. Standards, 1946, Pt. II, p. 570-571.
3. Determined by direct ashing of sample.
4. Results obtained probably are high because of discrepancy in ash determination.
5. Testing solution was composed of 65 per cent heptane and 35 per cent xylene.

Table 7. Comparison of asphalt from Asphalt Ridge (Vernal) with asphalts from other sources. From Shea and others (1952).

	Sunnyside, Utah	Vernal, Utah	Edna, Calif.	Kern River, Calif.	Oregon Basin, Wyo.	Tampico, Mexico
Asphalt yield weight percent	(1/)	2/ 97.1	2/98.4	3/54.6	3/ 44.6	3/ 73.6
Ash..... percent	-	1.7	2.0	0.0	0.0	0.0
Bitumen..... percent	99.0	99.4	99.3	100.0	100.0	99.9
Bitumen soluble in carbon tetrachloride... percent	100.0	100.0	99.6	100.0	100.0	100.0
Carbon residue percent	18.9	15.8	18.9	14.2	20.1	21.7
Composition:						
Asphaltenes..... percent	23.0	15.0	20.5	12.5	20.0	29.5
Ductility:						
At 32° F., 5 cm. per minute..... cm.	-	-	-	0	-	-
At 77° F., 5 cm. per minute..... cm.	100+	100+	100+	100+	100+	-
Fire point°F.	545	590	570	635	655	595
Flash point.....°F.	450	480	495	540	565	495
Loss on heating..... percent	0.6	0.2	0.6	0.00	0.00	0.2
Penetration:						
At 32° F., 200 gm. wt., 60 seconds dmm.	27	17	21	13	21	32
At 60° F., 100 gm. wt., 5 seconds dmm.	39	29	34	28	30	43
At 77° F., 100 gm. wt., 5 seconds dmm.	100	100	100	100	100	100
At 100° F., 100 gm. wt., 5 seconds dmm.	287	-	Soft	Soft	Soft	Soft
At 115° F., 50 gm. wt., 5 seconds dmm.	Soft	Soft	Soft	Soft	Soft	Soft
Penetration at 77° F., of residuum from loss on heating test..... dmm.	66	78	80	89	85	84
Softening point.....°F.	120	114	112	108	113	117
Specific gravity at 77°/77° F.	1.019	1.009	1.035	1.010	1.026	1.036
Spot tests:						
Oliensis:						
Initial.....	Positive	Positive	Positive	Negative	Negative	Negative
After 24 hours.....	Positive	Positive	Positive	Negative	Negative	Negative
Heptane-xylene equivalent ^{4/}	Passing	Passing	-	-	-	-
Sulfur..... percent	0.50	0.38	3.24	1.23	4.81	6.12
Viscosity at 210° F.:						
Furol.....seconds	2,380	1,180	940	750	1,300	2,700
Kinematic..... stokes	51.4	25.5	20.3	15.8	28.1	58.3
Absolute..... poises	49.9	24.5	20.0	15.2	27.4	57.6
Viscosity at 275° F.:						
Furol.....seconds	315	160	120	83.0	160	290
Kinematic..... stokes	6.80	3.45	2.59	1.79	3.45	6.26
Absolute..... poises	6.46	3.25	2.49	1.68	3.30	6.04

1. A yield of 101.1 percent was used to estimate the properties of the 100-penetration asphalt by extrapolation. (Yield was based on the bitumen recovered from the Diesel-oil solution of the bitumen.)
2. Yield from recovered bitumen.
3. Yield from crude oil.

Table 8. Crude petroleum analysis of coker distillate obtained from Asphalt Ridge bitumen. From Shea and others (1952).

Bureau of Mines _____ Laboratory

Sample _____

IDENTIFICATION

GENERAL CHARACTERISTICS

Gravity, specific, 0.906 Gravity, ° API, 24.7 Pour point, ° F., _____
 Sulfur, percent, 0.27 Color, greenish-black
 Viscosity, Saybolt Universal at 100°F., 74 sec.; at 77°F., 115 sec. Nitrogen, percent, _____

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1 - Distillation at atmospheric pressure, 760 mm. Hg
 First drop, 60° C. ° F. (140° F.)

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr., 60/60° F.	° API, 60° F.	C.I.	Refractive index, n _D at 20° C.	Specific dispersion	S.U. visc., 100° F.	Cloud test, ° F.
1	122									
2	167									
3	212	1.1	1.1	.733	61.5					38.8
4	257	2.1	3.2	.738	60.2	21				37.3
5	302	3.4	6.6	.761	54.4	24				38.4
6	347	3.4	10.0	.786	48.5	29				39.1
7	392	3.0	13.0	.805	44.3	32				40.8
8	437	3.9	16.9	.821	40.8	34				45.6
9	482	5.4	22.3	.838	37.3	37				49.2
10	527	6.3	28.6	.858	33.4	41				51.9

Stage 2 - Distillation continued at 40 mm. Hg

11	392	1.7	30.3	.888	27.8	52			48	Below 5 55.5
12	437	6.5	36.8	.893	26.9	50			52	5 54.2
13	482	8.0	44.8	.908	24.3	54			72	25 55.5
14	527	12.0	56.8	.928	21.0	60			160	50 57.7
15	572	14.0	70.8	.949	17.6	67			500	65 60.2
Residuum		29.4	100.2	.975	13.6					Too Dark

Carbon residue, Conradson: Residuum, 2.0 percent; crude, 0.6 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	1.1	0.733	61.5	
Total gasoline and naphtha	13.0	0.772	51.8	
Kerosine distillate	3.9	.821	40.8	
Gas oil	14.4	.856	33.8	
Nonviscous lubricating distillate	12.5	.890-.914	27.5-23.3	50-100
Medium lubricating distillate	8.3	.914-.930	23.3-20.6	100-200
Viscous lubricating distillate	18.7	.930-.960	20.6-15.9	Above 200
Residuum	29.4	.975	13.6	
Distillation loss0			

Aniline Point, ° C.

A crude petroleum analysis of the coker distillate is shown in Table 8. A comparison of Table 8 with Tables 2, 3, and 5 shows many changes in the retorted oils compared with the original bitumen. In general, retorting lowered the viscosities, the specific gravities and the pour point, and reduced sulfur content. The coker distillates yielded considerable wax. The potential yields of motor fuels from the coker distillate are shown below. The diesel fuels were made by blending various fractions to meet the viscosity requirements of various A. S. T. M. grade fuels.

	<u>Volume, per cent</u>	
	Coker distillate	Bitumen
Coker distillate	100.0	79.8
Gasoline	13.0	10.4
Diesel fuels:		
1-D	9.3	7.4
2-D	14.5	11.6
4-D	20.0	16.0
Cracking stock	43.4	34.6

Properties of the motor fuels are shown in Tables 9 and 10. The composition, in terms of percentages of hydrocarbons, was determined by Shea and others (1952, p. 27-28), using the silica gel adsorption method of hydrocarbon analysis. As can be seen from Table 9, the fuels are highly olefinic.

Ash analyses of Uinta Basin bitumens, including 22 from Asphalt Ridge, are reported by Bell (1960, Table 3). Table 11 of this report contains three of these semi-quantitative spectrochemical analyses of ashes produced by a dry-ashing procedure which eliminates organic matter.

ORIGIN OF BITUMENS

The origin of the Asphalt Ridge bitumens is not known. There are many unpublished theories on the subject. The most popular gives as the source of the bitumen the rich organic lacustrine sediment of the Green River Formation from which the bitumen has migrated updip to its present position. Confirmation of this theory awaits a detailed study of the bitumens, crude oils, and other hydrocarbon compounds of the Uinta Basin area. Such a study may show a sufficient number of similarities between the physical and chemical properties of the various bitumens and oils to permit designation of a particular source. Unweathered samples should be used. Analyses should include structure correlation from infrared spectra, atomic ratios of hydrogen to carbon, oxygen content, fixed carbon content, trace element content of ash, and chromatographic separations of hydrocarbons from the bitumen, as well as, standard crude petroleum characteristics such as gravity, cloud point, sulfur content, refractive index, specific dispersion, pour point, etc. Evaluation of all these data together with careful consideration of known geologic conditions may point to the source of the Asphalt Ridge bitumens.

Table 9. Properties of motor fuels derived from coker distillates (Asphalt Ridge). From Shea and others (1952).

	Gasoline	Diesel		
		1-D	2-D	4-D
Composition volume percent	100	100	100	100
Paraffins + naphthenes	35	28	29	26
Olefins	56	53	51	38
Aromatics	9	19	20	36
Cetane number		32.2	34.0	31.0
Octane number	68.0			
Sulfur weight percent	.17	.15	.28	.32
Nitrogen weight percent			.39	.62
Corrosion (copper strip)	Negative	Negative	Negative	Negative
Flash point °F.	-	148	195	385
Viscosity S.U. seconds	-	32	43	115
Pour point °F.	-	Below 5	Below 5	40
Carbon residue weight percent	-	-	0.13	0.18
Ash weight percent	-	-	.00	.02

Table 10. Distillation tests of motor fuels (Asphalt Ridge). From Shea and others (1952).

Volume percent	Vernal fuels, °F.			
	Gasoline	Diesel		
		1-D	2-D	4-D
First drop	150	345	420	538
10	214	378	472	592
20	240	392	490	604
30	260	403	498	616
40	270	410	510	626
50	283	420	520	636
60	294	428	528	648
70	311	438	548	666
80	327	451	550	686
90	357	478		688
End point	406	484	560	688
Material balances		Volume percent		
Distilled	95.0	95.0	80.0	94.0
Residue	2.8	3.6	17.0	2.0
Loss	2.2	1.4	3.0	4.0

1. Distillation tests for the gasolines were carried out according to the standard method for distillation of gasoline, naphtha, kerosine, and similar petroleum products A.S.T.M. designation D 86-46. The Diesel fuels were distilled by a similar method using 50 milliliters of each fuel instead of 100 milliliters.

Table 11. Uranium and trace elements ash analysis of asphaltic sandstone of Uinta Formation of Asphalt Ridge. From K. G. Bell (1960).

		Sec. 29, T-4-S, R-21-E	Sec. 32, T-4-S, R-21-E	Sec. 20, T-4-S, R-21-E	
Lab. Serial No.		96059	96061	96065	
Oil in Rock (Percent)		2.09	.98	10.10	
Ash in Oil (Percent)		.49	.83	.53	
Uranium in	Ash (Percent)	.177	.008	.010	
	Oil (Parts per million)	8.7	.7	.5	
Composition of ash by spectrochemical analysis	V	.0x	.0x	.0x	
	Ni	.x	.x	.x	
	Cu	x.	.x	.x	
	Co	.0x	.0x	.0x	
	Pb	.0x	.0x	.0x	
	Zn	.x	.x	.x	
	Cr	.0x	.0x	.0x	
	Mo	.00x	---	.00x	
	Mn	.0x	.x	.0x	
	La	---	---	---	
	Y	.00x	---	.00x	
	B	.x	.0x	.0x	
	Other elements	xx.	Al	---	Al
		x.	Fe, Ca	Fe, Ca	Fe, Ca
o.x		Mg, Na	Al, Mg, Na	Ti, Mg, Na	
o.oX		Ti, Ba, Sc, Zr	Ti, Ba, Sr	Ba, Zr	
o.oOx		Ag, Yb	Ag, Zr	Ag, Nb, Sc, Sr	
o.oOox		Be	---	Be, Yb	

PHYSICAL PROPERTIES OF RESERVOIR ROCKS

Introduction

The physical properties of the reservoir rocks must be considered in evaluation of bituminous sandstone deposits. Porosity, permeability, grain size distribution, and cementing material have a direct effect on the degree of bituminous saturation and probability of successful extraction of the bitumen. For example, one analyzed sample with nearly 25 per cent porosity and about 17 gallons of bitumen per ton of rock, has a permeability of less than 5 millidarcys. It would be difficult, if not impossible, to extract the bitumen from this rock with "in situ" production methods. The degree of cementation will affect not only the degree of saturation, but also the hardness of the rock. Degree of cementation must be taken into account when open pit production methods are considered. A well-cemented sand would be difficult to mine and would require crushing before bitumen extraction. A high percentage of fine sand and silt in the reservoir rock might interfere with extraction methods such as hot water flotation. The physical properties of the host rocks have a direct economic effect and should be considered carefully, along with thickness and degree of saturation, in evaluating the potential of a particular zone of bituminous saturation.

Ten samples of bituminous sandstone representative of various zones and degrees of saturation were sent to a commercial core analysis laboratory for physical testing. Results are shown in Table 12. The localities from which Samples 1 to 2 and 4 to 10 were collected are shown on Plates 1A and 1B. The locality of Sample 3 is shown on Figure 2. Samples were analyzed for porosity, permeability, residual oil and water saturation (expressed as per cent of pore space), and an estimate made of the gallon per ton yield of bitumen. The specific gravity of the recovered bitumen in each sample also was determined. A permeability measurement could not be obtained for Samples 1 and 2 because they disintegrated upon removal of the bitumen.

Mesaverde Group

Analyses of reservoir rocks of the Rim Rock Sandstone Member (Samples 1, 4, and 7) and the Asphalt Ridge Sandstone Member (Sample 3) of the Mesaverde Group are shown in Table 12.

The Rim Rock Sandstone Member, which contains most of the bituminous saturation in the Mesaverde Group, is fairly uniform in gross lithology. Minor variations in grain size, sorting, and other factors occur both laterally and vertically in the formation. In areas where there is no bitumen, the Rim Rock Sandstone is easily identified by means of abundant gray to black chert grains. In thin section, chert content is particularly noticeable and provides an easy method of distinguishing between the Rim Rock and Asphalt Ridge Sandstones. In these areas, the Rim Rock Sandstone generally is cemented with calcite and to a lesser extent with authigenic quartz. The calcite generally forms a film on the detrital grains, cementing them well without eliminating porosity.

Table 12. Core analyses of 10 samples from Asphalt Ridge by Core Laboratories, Inc., of Dallas, Texas.

Sample Number	Formation	Permeability: Millidarcys	Porosity Percent	Residual saturation		Oil			Water		Spent Sand Wt. %	Field evaluation of saturation
				% pore space		Gal/ton	Wt. %	Spec. gravity	Gal/ton	Wt. %		
				oil	Total water							
1	Mesaverde	*	35.0	58.3	1.4	26.2	10.1	0.919	0.5	0.2	88.3	Very rich
2	Uinta	*	31.6	71.2	0.6	27.6	10.5	0.915	0.2	0.1	88.4	Very rich
3	Lower Mesaverde	30	29.5	72.6	0.7	25.7	9.7	0.903	1.0	0.4	88.9	Rich
4	Mesaverde	402	34.1	46.7	1.8	20.5	7.9	0.919	1.6	0.7	90.1	Rich
5	Duchesne River	70	28.8	52.7	2.8	19.0	7.3	0.919	1.0	0.4	90.6	Moderate-rich
6	Duchesne River	4.7	17.9	69.2	3.4	13.7	5.3	0.919	0.7	0.3	92.9	Moderate
7	Mesaverde	90	26.0	19.2	7.3	6.4	2.4	0.909	4.8	2.0	94.3	Weak
8	Uinta	4.2	24.4	63.5	2.7	17.4	6.7	0.919	1.0	0.4	92.0	Rich
9	Uinta	239	22.2	51.8	3.6	13.7	5.2	0.919	1.4	0.6	92.9	Moderate
10	Duchesne River	745	32.2	65.0	0.6	23.4	9.0	0.919	0.2	0.1	90.1	Rich

* Unable to obtain a permeability measurement

Sample Numbers refer to locations on Plate I and Figure 5

From thin-section examination of several samples the detrital mineral content of the Rim Rock Sandstone is estimated as follows: chert 60 per cent, quartz 37 per cent, orthoclase and plagioclase feldspars 2 per cent, accessory heavy minerals, in order of abundance, zircon, tourmaline, garnet, and magnetite, 1 per cent. Most of the chert grains are subangular though a few are subrounded. The quartz generally is subrounded, except where it is modified by authigenic additions. Grain size varies throughout the section, but generally is in the fine to medium range, 1/8 to 1/2 mm. A few zones contain coarse grains but, for the most part, the sand is well sorted. Ordinarily, the very fine sand and silt fraction makes up less than 10 per cent of the rock.

The Asphalt Ridge Sandstone is distinct in that it contains quartz 90 per cent, chert 7 per cent, orthoclase and plagioclase feldspars 2 per cent, accessory heavy minerals, in order of abundance, tourmaline, zircon, magnetite and garnet, 1 per cent. This sandstone is finer grained than the Rim Rock Sandstone with 1/16 to 1/4 mm-size fractions predominating. Calcite is the principal cementing material and commonly fills the pore spaces completely. The quartz is subangular to subrounded and shows good to excellent sorting.

Duchesne River and Uinta Formations

Thin, lenticular or tabular sand and conglomerate layers interbedded with shale and siltstone are the characteristic reservoir rocks of the Tertiary Duchesne River and Uinta Formations. Although they commonly contain rich zones of bituminous saturation, they are too variable in size and distribution to serve as excellent reservoir rocks. Samples 5, 6, and 10 shown in Table 12 were taken from the Duchesne River Formation, and Samples 2, 8, and 9 from the Uinta Formation. The lithology of the Duchesne River and Uinta Formations and the distribution and proportion of contained bitumen are extremely variable both vertically and laterally in any single zone. Sediments are mostly detrital and range from shales to conglomerates. Sandstones, grits, and conglomerates all contain bitumen, but, in general, the richest material is in medium to coarse-grained sand. Most of the units are made up of detrital quartz and chert cemented with variable amounts of calcite, hematite, and silica. The grains generally are subangular and poorly sorted.

Nature of Bituminous Sandstone Outcrops

Bituminous sandstone outcrops at Asphalt Ridge are extremely varied in physical appearance and may be difficult to recognize and evaluate in the field. Outcrop appearance is influenced most strongly by the degree of bituminous saturation and, to a lesser extent, by the intensity of weathering and physical characteristics of the host sediment. Richly saturated sands can ooze oil and glisten black (Figure 6). As the degree of saturation decreases, color usually changes from dull black to gray to brown to the color of barren sandstone.

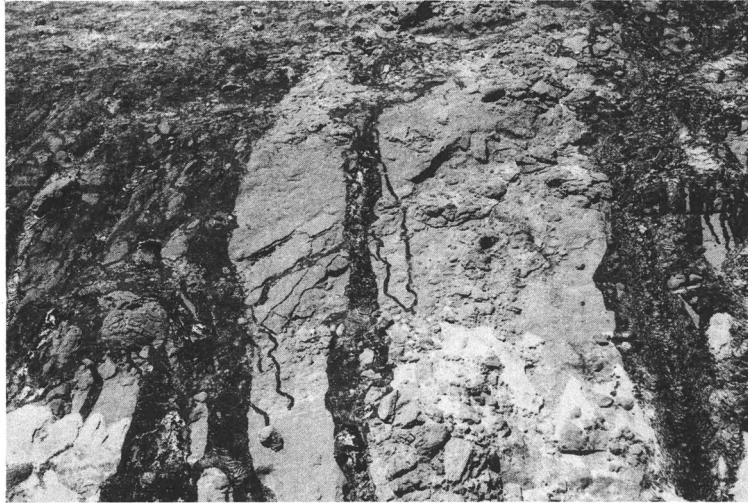


Figure 6. Flowing tar — South Pit — Tertiary Uintah.

Weathered outcrops of bituminous sandstone commonly are a dull black to blue-gray to light gray and may or may not show up in marked contrast to the surrounding sediments. Many sandstones which appear barren on a weathered surface reveal bituminous saturation on a freshly broken surface. The degree of saturation may vary greatly over short distances both horizontally and vertically giving the sediment a definite patchy appearance. Where the bituminous sandstones are more resistant than the surrounding sediments they may crop out as gray, ridge-like bands parallel with the northeast face of the ridge. The Frontispiece is an example of saturated Rim Rock Sandstone cropping out on the face of the ridge in part of area A as shown on Plate 3.

FIELD EVALUATION OF BITUMINOUS SATURATION

The bituminous saturation observed at the outcrop is extremely variable and may be representative neither of thickness nor degree of saturation at depth. From the limited subsurface information available, it is the writer's opinion that the bituminous zones are generally thicker and better developed in the shallow subsurface than the outcrop.

Numerous notes recorded in Plates 1A and 1B reflect the author's field evaluation of the degree of bituminous saturation, as well as his estimate of outcrop thickness. Thicknesses shown on Plate 1A and 1B are true vertical thicknesses established within the accuracy of the field measurements. These were obtained with Brunton Compass (hand leveling); with tape and Brunton Compass, and with a Brunton on a Jacobs staff.

A field classification of saturation which is based on observation of freshly broken samples obtained as deep into the outcrop as possible was established to facilitate consistent observations and appears below:

Very Rich	Pore Spaces completely filled with bitumen and rock oozing oil
Rich	Pore spaces completely filled and rock glistening black
Moderate	Pore spaces completely filled and rock dull black
Weak	Pore spaces incompletely filled and rock light gray
Very Weak	Pore spaces not filled with bitumen but matrix stained gray or brown
Barren	No visible evidence of bituminous saturation

REFERENCES

- Abbott, Ward, 1957, Tertiary of the Uinta Basin, in Guidebook to the geology of the Uinta Basin: Intermountain Assoc. Petroleum Geologists Guidebook, 8th Ann. Field Conf., p. 102-103.
- Abraham, Herbert, 1945, Asphalts and allied substances, their occurrence, modes of production, uses in the arts and methods of testing, 5th ed., New York, D. Van Nostrand Co. Inc. (2 vol.).
- Ball, J. O., 1944, Survey of bitumen analyses and extraction methods, in Hydrocarbons of the Uinta Basin of Utah and Colorado: Colorado School of Mines Quart., v. 29, no. 1, p. 67-115.
- Bell, K. G., 1960, Uranium and other trace elements in petroleum and rock asphalts: U. S. Geol. Survey Prof. Paper 356-B, p. 45-65 (1961).
- Bell, M. M., 1964, The beneficial use of water for the recovery of oil from bituminous sands: Presented at the annual meeting of the ASCE in Salt Lake City, Utah, May 13, 1964.
- Burger, J. A., 1959, Mesaverde Group in adjoining areas of Utah, Colorado and Wyoming: Unpub. Ph. D. thesis, Yale Univ.
- Covington, R. E., 1957, The bituminous sand of the Asphalt Ridge area, northeastern Utah, in Guidebook to the geology of the Uinta Basin: Intermountain Assoc. Petroleum Geologists Guidebook, 8th Ann. Field Conf., p. 172-175.

- Covington, R. E., 1964a, Bituminous sandstones in the Uinta Basin, in Guidebook to the geology and mineral resources of the Uinta Basin - Utah's hydrocarbon storehouse: Intermountain Assoc., Petroleum Geologists Guidebook, 13th Ann. Field Conf., p. 227-242.
- _____ 1964b, Bituminous sands and viscous crude oils: First Intermountain symposium on fossil hydrocarbons proc., sponsored by Brigham Young Univ., p. 364-374.
- _____ 1965, Some possible applications of thermal recovery in Utah: Jour. Petroleum Technology, v. 17, p. 1277-1284.
- Dane, C. H., 1954, Stratigraphic and facies relationships of upper part of Green River Formation and lower part of Uinta Formation in Duchesne, Uintah, and Wasatch Counties, Utah: Am. Assoc. Petroleum Geologists Bull., v. 38, p. 405-425.
- Hale, L. A., and Van De Graff, F. R., 1964, Cretaceous stratigraphy and facies patterns - Northeastern Utah and adjacent areas, in IAPG Guidebook to the geology and mineral resources of the Uinta Basin, 13th Ann. Field Conf., p. 115-138.
- Holmes, C. N., Page, Ben, and Averitt, Paul, 1948, Geology of the bituminous sandstone deposits near Sunnyside, Carbon County, Utah: U. S. Geol. Survey Oil and Gas Inv. Prelim. Map 86.
- Howard, J. V., 1965, Thermal recovery comes of age: World Oil, v. 160, no. 1, p. 95-104.
- Kay, J. L., 1934, The Tertiary formations of the Uinta Basin, Utah: Carnegie Mus. Annals 23, p. 357-371.
- Kinney, D. M., 1955, Geology of the Uinta River - Brush Creek area, Duchesne and Uintah Counties, Utah: U. S. Geol. Survey Bull. 1007, 185 p.
- Lyon, L. B., 1964, Primary extraction, conversion and upgrading hydrogen-deficient fossil hydrocarbons, in First Intermountain symposium on fossil hydrocarbons Proc., sponsored by Brigham Young Univ., p. 114-134.
- Murany, E. E., 1964, Wasatch Formation of the Uinta Basin, in Guidebook to the geology and mineral resources of the Uinta Basin - Utah's hydrocarbon storehouse: Intermountain Assoc. Petroleum Geologists Guidebook, 13th Ann. Field Conf., p. 145-155.
- Nelson, W. L., 1958, Petroleum refinery engineering, 4th ed.: New York; McGraw-Hill Book Co., Inc., 647 p.
- Pfeiffer, J., 1950, The properties of asphaltic bitumen, with reference to its technical applications: New York, Elsevier, 285 p.

- Picard, M. D., 1957, Green River and lower Uinta Formations - subsurface stratigraphic changes in central and eastern Uinta Basin, Utah, in IAPG Guidebook to the geology of the Uinta Basin, 8th Ann. Field Conf., p. 116-130.
- Sanborn, A. F., and Goodwin, J. C., 1965, Green River Formation at Raven Ridge, Uintah County, Utah: *Mountain Geologist*, v. 2, no. 3, p. 109-114.
- Shea, G. B., and Higgins, R. J., Laboratory hot water separation plant tests on bituminous sandstone of the Vernal and Sunnyside, Utah, deposits: Unpub. Report by the U. S. Bureau of Mines.
- Spieker, E. M., 1930, Bituminous sandstone near Vernal, Utah: U. S. Geol. Survey Bull. 822, p. 77-98.
- Todd, J. D., 1958, Valuation and subsurface geology, in *Subsurface Geology in Petroleum Exploration - a Symposium* (Haun, J. D., and LeRoy, L. W., eds.) Colorado School of Mines, Golden Colorado, 793-811.
- Untermann, G. E., and Untermann, B. R., 1964, Geology of Uintah County, Utah: Utah Geol. and Mineralog. Survey Bull. 72, 112 p.
- Walton, P. T., 1944, Geology of Cretaceous of the Uinta Basin, Utah: *Geol. Soc. America Bull.*, v. 55, p. 91-130.
- _____ 1957, Cretaceous stratigraphy of the Uinta Basin, in *Guidebook to the geology of the Uinta Basin: Intermountain Assoc. Petro. Geologists Guidebook*, 8th Ann. Field Conf., p. 102-109.

APPENDIX

Log of U. D. Co. Well #1, Sec. 34, T4S, R20E
Elevation 5800'

<u>Feet</u>	<u>Kind of Material</u>	<u>Remarks</u>
3	Soil (Conductor)	
9	Hard Pan	
45	Boulders	
50	Sand	Set 10" Casing at 85 ft.
90	Clay (Sticky)	
110	Clay (Red)	
125	Clay (Yellow)	
165	Sand (Grey soft)	
200	Shale (Red gritty)	
220	Shale (Red sticky)	
230	Sand (Grey)	
235	Clay (Red)	
255	Sand (Grey)	
265	Sand (Yellow)	
280	Sand (Hard Blue)	Smell oil in bottom of yellow and top of blue 260 to 265.
300	Clay (Red)	
308	Sand (Grey)	
315	Clay (Red)	
355	Sand (Grey soft)	
365	Conglomerate (Hard)	
380	Sand (Grey)	
400	Clay (Red)	
415	Sand (Grey)	
445	Conglomerate with boulders.	
460	Red Rock	
465	Clay (Red)	
485	Sand (Grey)	1 Bailer of water during night.
500	Clay (Red)	
520	Sand (Grey)	
525	Conglomerate	
530	Sand (Blue)	
560	Conglomerate (Hard & Close)	($\frac{1}{2}$ bailer of water during night then increase to 2 bbls. at 530.)
565	Shale (Red)	
605	Sand, Conglomerate (Hard)	
645	Lime (Hard)	Set 8 $\frac{1}{4}$ " Casing at 612'-2".
650	Sand (Blue & Water)	
655	Clay (Red)	
665	Sand	
672	Red Clay & Sand	
700	Sand (Grey)	

Log of U. D. Co. Well #1, Sec. 34, T4S, R20E

Page 2.

<u>Feet</u>	<u>Kind of Material</u>	<u>Remarks</u>
710	Clay (Red & tough)	
790	Clay (Light red, gritty)	Water at about 800, well filled 250 ft. over night. About 3 bailers per hour.
850	Sand (Hard conglomerate)	
875	Shale (Light red, gritty)	6-5/8" casing at 886.1'
945	Red clay (Cave)	
965	Sand (Fine, grey)	5 bailers of water per hour.
1010	Shale (Red, caves)	
1060	Shale, (Blue, gritty, caves)	
1090	Shale, (Light blue)	
1110	Sand (Soft blue)	
1265	Shale (Red & Blue, sand shells)	
1295	Shale (Red, gritty, caves)	
1425	Sand (Blue, with red caves)	1430' 10 bbls. fresh water per hr.
1450	Sand (Grey)	
1495	Lime (Very hard)	
1520	Sand	
1555	Fine Gravel	
1560	Fine close Sand	Showing of Oil.
1565	Sand (Fine White)	
1570	Clay (Red with sand shells)	Crooked Hole. Put in 5-3/16 casing to straighten hole.
1590	White Sand (Hard as above)	More water at 1625 increasing to 1640 showed grease, not as much as above.
1625	White Sand (Hard & Fine)	
1640	Red Clay and some Sand	Bottom Feb. 6, 1912 1655 feet.

Log of Well #2 Uintah Development Company

Loc. SE-SE 34, T. 4S, R. 20E

Elevation 5800' approx.

T.D. 1275

Location may be incorrect-same as U.D. Co. Well #1

<u>Feet</u>	<u>Kind of Material</u>	<u>Remarks</u>
	Clay	
4	Red sandrock	
25	Sand rock	
45	Red shale	
80	Pink shale	
130	Sand	Little water
140	White shale	
165	Pink shale	
195	White shale	
200	Red shale	210' enough water for boiler and drilling
225	Conglomerate	
250	Red shale	
255	Sand	
275	Red shale	
285	White sandy conglomerate	
305	Red shale	
310	White sandstone	
320	Red shale	
340	Sand	
385	Red shale	
415	Sand	
425	Red shale	
435	Blue shale	
500	Sand	
505	Red shale	
530	Sand	
560	White and sandy (conglomerate) ?	
600	Grey shale	
625	Red shale	
650	Lime and sand (conglomerate) ?	
665	White sand	
680	Red rock	
700	Pink shale	
725	Lime	
740	Sand	
755	Red shale	
765	Sand	
775	Very dark red shale	
855	Red sand	

<u>Feet</u>	<u>Kind of Material</u>	<u>Remarks</u>
880	Sand	
900	Conglomerate	
930	Pure white sand	
935	Pink shale	
980	Red shale	4 bailers water in 14 hours
1000	White soapy shale	
1050	Grey lime	
1115	Red shale	
1125	Conglomerate	
1135	Red shale	
1150	Conglomerate	
1175	Lime and conglomerate	
1180	Red and conglomerate	
1190	Brown lime	
1205	Conglomerate	Set 8" casing
1210	Conglomerate and red	
1225	Conglomerate	
1240	Yellow clay	
1275	Red clay and conglomerate	

Uinta Development Company Well #3
 Loc. NE/4 NE/4 Sec. 17, T. 5S, R. 21E
 Elevation 5395'

Feb. 22, 1912

<u>Feet</u>	<u>Kind of Material</u>	<u>Remarks</u>
0-16	Conductor	
16-25	Blue clay and boulders	
25-30	Grey sand	
30-45	Red clay and boulders	
45-55	Limey sand	
55-75	Blue and pink clay	
75-115	Red clay, boulders and shells	
115-125	Grey Sand	
125-135	Red clay	
135-140	Grey sand	
140-165	Conglomerate and clay	
165-195	Hard grey sand	
195-205	Sand and conglomerate	
205-225	Blue clay	
225-235	Pink clay	
235-260	Soft sand and conglomerate	
260-275	Blue shale	
275-310	Sand and conglomerate at bottom	
310-350	Blue shale and conglomerate	
350-395	Sand-shale and conglomerate	
395-410	Blue shale	
410-420	Shale and red sand	First trace oil showing peacock colors.
420-440	Blue shale	Landed 10" casing 435'
440-450	Pink shale	
450-475	Hard blue shale	
475-615	Red rock	
615-625	Blue shale	
625-695	Gritty red rock	At 640 boulders bothered us when putting in 8 $\frac{1}{4}$ " casing.
695-720	Blue shale	
720-725	Fine grey sand	Loose wash-10 bbls. black sulphur water per hr. - Crook
725-755	Conglomerate	
755-760	Dark red shale	
760-765	Blue clay	
765-790	Red clay	
790-795	Blue clay	
795-815	Sand and conglomerate	
815-820	Light colored slate	

<u>Feet</u>	<u>Kind of Material</u>	<u>Remarks</u>
820-835	Dark grey sand	
835-840	Red clay	
840-855	Light blue gritty shale	Showalter quit-after finding hole was crooked at 725 he went on to 855 then went back to 725 to straighten hole but could not do it.
770-790	Red clay	
790-800	Sand and conglomerate	
800-820		
820-835	Grey sand-gas	
835-840	Red clay	
840-863	Blue shale	Landed 8 $\frac{1}{4}$ casing
863-870	Hard blue shale	
870-883	Fine grey sand	Showing oil 870-883
883-910	Blue shale	
910-940	Blue and red shale	949' boulders bothered casing
940-965	Blue and red shale	
965-970	Strong showing gas at 970	Water rose 75' in hole
970-975	Dark brown sand	Shows oil colors-lots of gas and some water
975-995	Light blue shale	Landed 8 $\frac{1}{4}$ casing at 973.6'
995-1028	Blue and red shale	
1028-1030	Water sand	Some gas
1030-1040	Blue shale	
1040-1055	Yellow shale	
1055-1070	Blue shale	
1070-1080	Blue shale sticky	
1080-1100	Blue shale	
1100-1140	Red sandy shale	
1140-1145	Red sandy shale	
1145-1160	Grey sand	
1160-1167	Water sand	Light oil and lots of gas-some Asphalt traces in sand.
1167-1175	Gravel, sand clay	
1175-1189	Mixed shales	Some gas at 1189'
1189-1195	Hard grey sand	Gas and possibly water
1195-1206	Mixed shales	
1206-1208	Brown sand	Lots of water-some gas
1208-1218	Hard yellow sandy shale	Very gassy
1218-1224	Yellow shale and gravel	
1224-1240	Yellow shale	
1240-1245	Red shale	
1245-1255	Hard red sand	
1255-1276	Hard grey sand	
1276-1280	Hard sand shell	
1280-1285	Pink shale	
1285-1295	Hard grey sand	

<u>Feet</u>	<u>Kind of Material</u>	<u>Remarks</u>
1295-1300	Mixed shale	
1300-1310	Grey sand	
1310-1315	Red sand	
1315-1325	Hard grey sand	
1325-1328	White sandy shale	
1328-1335	Red sandy shale	
1335-1341	Hard grey sand	
1341-1345	Red sandy shale	
1345-1350	Shale, gravel, sand	
1350-1362	Hard shell-yellowish	
1362-1364	Brown water sand	
1364-1375	Red shale	
1375-1390	Very hard grey sand	Gas and water at 1390'
1390-1398	Red shale	
1398-1420	Grey shale	
1420-1430	Red sand	
1430-1440	Red shale	
1440-1460	Sand	Trace of oil
1460-1462	White shale	
1462-1480	Sand	Showing oil
1480-1485	Hard grey sand	
1485-1505	Red sandy shale	
1505-1510	Red shale	
1510-1515	Red sandy shale	
1515-1527	Hard shell	Bailings showed good
1527-1535	Red shale	
1535-1540	Pink shale	
Backing up 14' on account of error.		
1486-1496	Conglomerate	
1496-1506	Purple clay	
1506-1512	Conglomerate	
1512-1516	Sand	
1516-1521	Red shale	
1521-1525	Sand	
1525-1529	Red shale	
1529-1531	Sand	
1531-1533	Red shale	
1533-1535	Conglomerate	
1535-1538	Red shale	
1538-1545	Sand	
1545-1556	White clay	
1556-1575	Water sand	
1575-1580	Sand and blue clay	
1580-1597	Sand	
1597-1600	Reddish sand	

<u>Feet</u>	<u>Kind of Material</u>	<u>Remarks</u>
1600-1616	White sand	
1616-1621	Water sand	
1621-1633	Sand	
1633-1644	Lime	
1644-1647	Sand	
1647-1649	Mixed Clay	
1649-1666	Brownish sand	
1666-1671	Brownish clay	
1671-1676	Water sand	Good show of gas and oil.
1676-1688	Mixed clays	
1688-1692	Water sand	
1692-1707	Hard sand	
1707-1726	Dark red clay	
1726-1731	Hard sand	
1731-1736	Sand and clay	
1736-1749	Light cold clay	

T.D.

#1 Curtis Well
 Loc. SW/4 NE/4, Sec. 35, T. 4S, R. 20E
 Elevation 5800'

May 20, 1911

<u>Feet</u>	<u>Kind of Material</u>	<u>Remarks</u>
0-15	Spudded	
15-20	Conglomerate	
20-25	Conglomerate	
25-35	Conglomerate	
35-45	Red shale	
45-55	Sand rock	Laid off for line
55-75	Lime and conglomerate	
75-95	Sand rock and conglomerate	
95-120	Red shale and conglomerate	
120-145	Lime	
145-170	Lime	
170-190	Lime	
190-195	Red shale	
195-220	Red shale	
220-250	Red shale	
250-270	Red shale	
270-280	Lime	
280-315	Red shale	
315-330	Red shale	
330-355	Red shale	
355-385	Red shale	
385-405	Red shale	
405-410	Yellow shale	
410-430	Grey sand-water ?	
430-455		
455-485	Grey shale	
485-515	Red shale	
515-540	Red shale	
540-600	Conglomerate	5' sticky gravel in this section
600-625	Red shale	6 $\frac{1}{4}$ ' casing 645'
625-650	Conglomerate	
650-670	Water sand	
670-700	Conglomerate	
700-725	Conglomerate	
725-755	Conglomerate	
755-785	Red shale and conglomerate	
785-810	Red shale and conglomerate	
810-825	Conglomerate	
825-855	Conglomerate	
855-871	Conglomerate	
871-881	Conglomerate	

<u>Feet</u>	<u>Kind of Material</u>	<u>Remarks</u>
881-886	Water sand	
886-896	Brown shale	
896-911	Light yellow sand	
	Conglomerate	
	Conglomerate	
951-966	White shale	
966-976	Conglomerate	
976-981	Water sand	
981-991	Conglomerate	
991-1036	White shale	
1036-1051	Conglomerate	
1051-1066	Purple shale	
1066-1071	Conglomerate	
1071-1111	White shale	
1111-1121	Red shale	
1121-1126	Conglomerate	
1126-1136	Conglomerate	
1136-1156	Conglomerate	
1156-1166	Conglomerate	
1166-1171	Red shale	
1171-1176	Conglomerate	
1176-1196	Conglomerate	
1196-1201	Red shale	
1201-1226	Red shale	
1226-1256	White and red shale	
1256-1266	Conglomerate	
1266-1276	White shale	
1276-1306	Red shale	

Log of Well Drilled Just North of Dog Valley

#1 Reed, Location, Center NW/4, SW/4, Section 5

T5S, R21E, Elevation 5800'

May 20, 1911; 375 ft. to 385 ft.	Red Shale, oil showing.
May 30, 1911; 570 ft. to 605 ft.	Light blue sandy shale; oil and gas showing.
May 31, 1911; 605 ft. to 610 ft.	White sand; showing some asphalt oil and gas.
June 6, 1911; 610 ft. to 630 ft.	Grey sand, good showing oil and gas.
June 7, 1911; 630 ft. to 645 ft.	Cased off gas, oil showing continues good.
June 9, 1911; 690 ft. to 695 ft.	Grey sand, best showing of oil and gas.
June 10, 1911; 780 ft. to 788 ft.	Oil sand; Big oil showing, gas burns steadily; (Walsh says a similar showing in Rangely or Florence Field Colo. would mean a 300 to 400 bbl. well).
June 20, 1911; 788 ft. to 803 ft.	Oil sand; (Trachta says a similar showing in the Coolinga, Calif. field would be good for 200 bbls. or better) 100 feet water in hole hard to estimate yield.
June 20, 1911; 803 ft. to 811 ft.	Oil sand; oil showing the same, more gas.
July 11, 1911; 929 ft. to 932 ft.	Mixed clay.
July 11, 1911	Helped move house. A party of geological survey people in here to look over the coal lands. Have run off all oil insight and as far as possible covered up all evidence of it.
July 17, 1911; 932 ft. to 940 ft.	Mixed clay; struck small pocket of gas and showing of oil.
July 18, 1911; 940 ft. to 950 ft.	Mixed clay, very sticky, hard to mix.
July 18, 1911; 940 ft. to 950 ft.	Mixed clay, very sticky, hard to mix.

July 19, 1911; 960 ft. to 970 ft.	Mixed clay, oil showing improving.
July 20, 1911; 970 ft. to 982 ft.	Mixed clay, good showing of oil.
July 20, 1911; 982 ft. to 1005 ft.	Grey sand, oil showing improving.
July Plat, 1911; 1008 ft. to 1015 ft.	Grey sand, struck nice grey sand and oil showing increasing.
July 27, 1911; 1096 ft. to 1112 ft.	Oil sand, fair showing of oil.
July 27, 1911; 1112 ft. to 1117 ft.	Grey oil sand; good oil showing in bailings.
Aug. 5, 1911; 1286 ft to 1296 ft.	Dark sand.
Aug. 11, 1911; 1340 ft. to 1345 ft.	Hard sand.
Aug. 13, 1911; 1360 ft. to 1368 ft.	Water sand.
Aug. 15, 1911; 1392 ft. to 1405 ft.	Dark shale.
Aug. 16, 1911; 1405 ft. to 1430 ft.	Water sand.

T.D. = 1430'

UNION OIL COMPANY - Government No. 1

Cottonwood Springs Bow, Uintah County, Utah

Location: 1,650' from South line and 330' from East line of Sec. 21, T-4-S, R-20-E,
S.L.M.

Elevation: 6,275

Spud: April 19, 1942. Abandoned: June 12, 1942

T.D. 2,222 ft.

Casing record: 8-5/8 -- 140 ft.

5-1/2 -- 2,082 ft.

Well log Assembled from Examination of Drill Cuttings by Max. L. Krueger

<u>Feet</u>	<u>Formation</u>
0-26	Tan sandy clay and occasional boulders.
26-70	Clay and boulders.
70-105	Hard boulder conglomerate.
105-120	Hard quartz sand.
120-130	Hard sand with limestone boulder fragments.
130-160	Hard boulder conglomerate.
160-200	Sandstone with occasional boulders.
200-215	Pink sandy clay with scattered boulders.
215-225	Gray and white sandstone.
225-245	Gray and maroon clay and sandy silt with a few boulders.
245-275	Gray clay, sandy silt and silty sand.
275-280	Medium grained sandstone.
280-315	Clay, sandy white to tawny.
315-355	Clayey silt and sandy silt, maroon to pink to tawny, gypsiferous.
355-365	Clayey sandstone.
365-430	Soft sandy clay decreasing in sandiness downward.
430-435	Sandstone, tan.
435-460	Sandy gray clay.
460-470	Sandstone with some sandy clay and occasional boulders, pyrite crystals set in limestone fragments.
470-535	Gypsiferous clay, sandy red and pink.
535-550	Sandstone.
550-565	Sandy clays and sandy silts, calcareous to gypsiferous. Range in color from pink and red to maroon to white, light grey, tans, and tawny colors. The maroon intervals are more clayey and softer while the grey colored sediments are much sandier.
565-575	Sand, tan, fairly hard.
575-620	Variegated clays, silts and sand.
620-640	Sandstone with admixed clays and sandy silts on occasion.
640-665	Tan sandstone and occasional limestone boulders. Some admixed sandy silts and clay fragments.

<u>Feet</u>	<u>Formation</u>
665-675	Tan sandstone and limestone boulders. Some admixed sandy silts and clay fragments.
675-700	Sandstone and variegated sandstone and silt fragments and a few boulders.
700-730	Grey and white, maroon sandy clay and silt.
730-760	Reddish clays and sandy silts and some admixed clayey argillaceous material.
760-795	Sandstone with occasional boulders and prominent limestone boulder fragments between 790' and 795'.
795-820	Maroon and grey and cream sandy siltstone and claystone with occasional boulder fragments.
820-870	Vari-colored clays, sandy silts, silty sands containing admixed boulders.
870-900	Sandstone, with admixed vari-colored clays, silts and scattered boulders.
900-915	Clay and silt, very sandy. Maroon, grey, white and cream colored.
915-940	Vari-colored clay and silt, pinkish cast.
940-970	Sandstone with grey and white claystone or siltstone admixed.
970-1015	Sandy claystone or siltstone, vari-colored with limestone boulders.
1015-1055	Sandstone. Some admixed vari-colored sandy clay and occasional fragments of crystalline limestone.
1055-1085	Sandstone and vari-colored sandy clay and sandy silt.
1085-1165	Claystone or siltstone, very sandy, occasional limestone fragments.
1165-1205	Sandstone with occasional boulders.
1205-1230	Basal Duchesne River conglomerate. Limestone and quartzite boulders set in a sandy matrix. Very hard.
<u>1230</u>	Base Duchesne River formation -- to Uinta formation.
1230-1250	Vari-colored claystone with occasional limestone boulders.
1250-1275	Sandstone with admixed vari-colored claystone and siltstone.
1275-1290	Sandstone and vari-colored siltstone and claystone.
1290-1345	Sandstone with intercalations of clay and silt. Prominent pyrite crystals noted along with scattered boulders.
1345-1383.5	Vari-colored sandy claystone and scattered boulders.
1383.5-1393.5	Vari-colored sandy claystone and siltstone with maroon, drab brown and light blue-grey silts and sandy silt, fragments predominating.
1393.5-1400	Vari-colored clays and silts.
1400-1410	Sandstone with admixed vari-colored clays and silts.
1410-1425	Vari-colored clays and sandy silts with very occasional boulders.
1425-1440	Predominantly sandstone with admixed vari-colored clays and sandy silts. Blue-grey silts predominating.
1440-1455	Red, blue, tan and dirty brown clays and silts and sandy silts.

<u>Feet</u>	<u>Formation</u>
1455-1470	Sandstone with admixed vari-colored clays and silts.
1470-1500	Predominantly vari-colored clays and silts with some admixed sandstone. First dark grey chert grains appear at 1,490'.
1500-1530	Predominantly sandstone with admixed vari-colored clays and silts. No cuts.
1530-1585	Vari-colored clays and silts and some blue-gray chert fragments. First prominent appearance of grey chert materials at 1,530'. This point also marks the appearance of a few tar coated limestone grains. The samples give a faint cut in carbon tetrachloride between 1,530' and 1,540'. No cuts from 1,540' to 1,585'.
1585-1630	Sandstone with some admixed chert conglomerate and vari-colored clays. Pyrite grains noticeable. No cut to 1,615' and a very faint cut between 1,615' and 1,630'. At 1,630' the first time that a considerable admixture of tar stained sand grains showed on the ditch.
1630-1730	Tan sand with some tar sand. All samples down to 1,700' showing fair cut. Some vari-colored silt fragments.
1730-1755	Hard grey chert conglomerate and sand.
1755-1800	Grey chert and limestone boulder conglomerate set in a sandy matrix. Faint oil cut 1,755' to 1,770'. Good cut 1,770' to 1,800'.
1800-1850	Sandstone, tar sandstone and scattered boulders. Faint cuts throughout.
1850-1908	Black tar sand and grey chert pebble conglomerate. Cored 38' of tar sand and gas burned in the barrel at 1,885'.
1908-1940	Sandstone and chert pebble conglomerate. All samples gave good cuts so it is probably tar saturated.
1940-1968	Sandstone with some admixed vari-colored clays. Samples give cut throughout.
1968-2035	Conglomerate set in a sandstone matrix and some admixed vari-colored argillaceous material.
2035	Approximate top of the Cretaceous-Mesaverde sands and shales.
2035-2045	Sandstone?
2045-2093	Grey Cretaceous shales, lignitic shales and some thin streaks of coal with shiny lustre. Irregularly bedded.
2093-2218	Mesaverde oil sands, light brown, medium grained, fairly soft, massive. Give excellent cut. No odor.
T.D. 2,222 ft.	

WESTERN VENTURE CORP.

Log. of Well No. 1 Address 1210 First National Bank, Ogden, Utah.
Field: Vernal, Uintah County, Utah. Serial No. 045642.
Elevation 5,700 approx. Sec. 6, T-5-S, R-21-E. Meridian S.L.M.
Location 3,630 ft. S. of N. line and 1,450 ft. W. of E. line of Sec. 6
Commenced drilling Sept. 11, 1927 (Nov. 6 by engineer's report).

OIL OR GAS SANDS OR ZONES

No. 1, from 1,296 (G) to 1,300.

IMPORTANT WATER SANDS

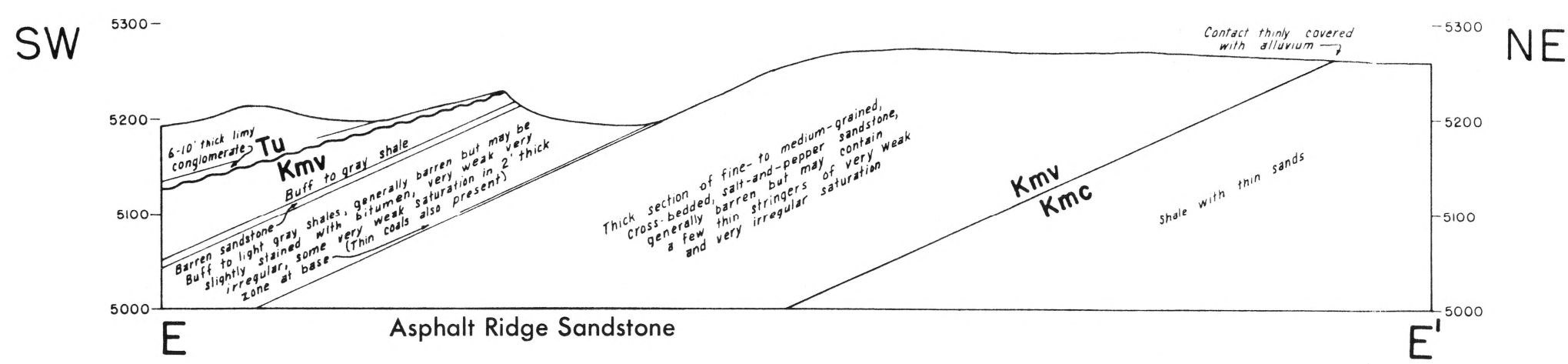
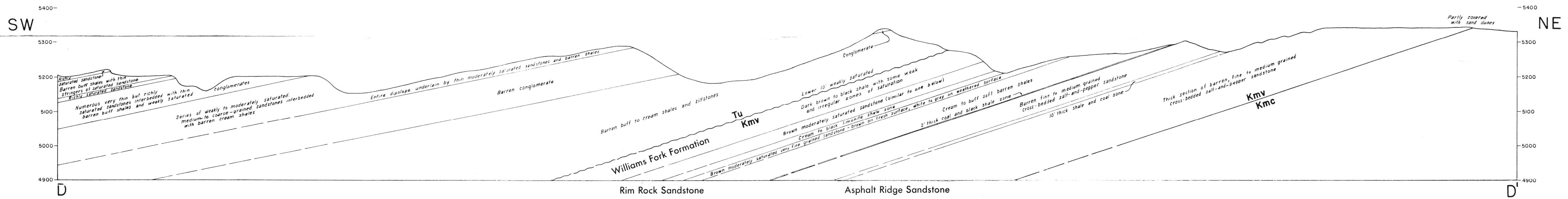
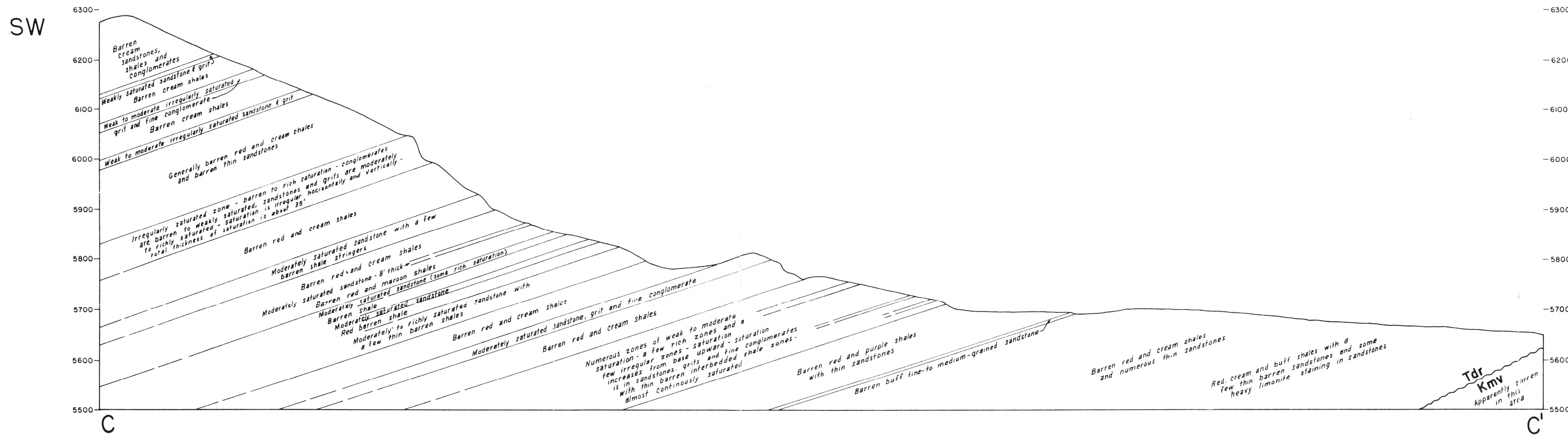
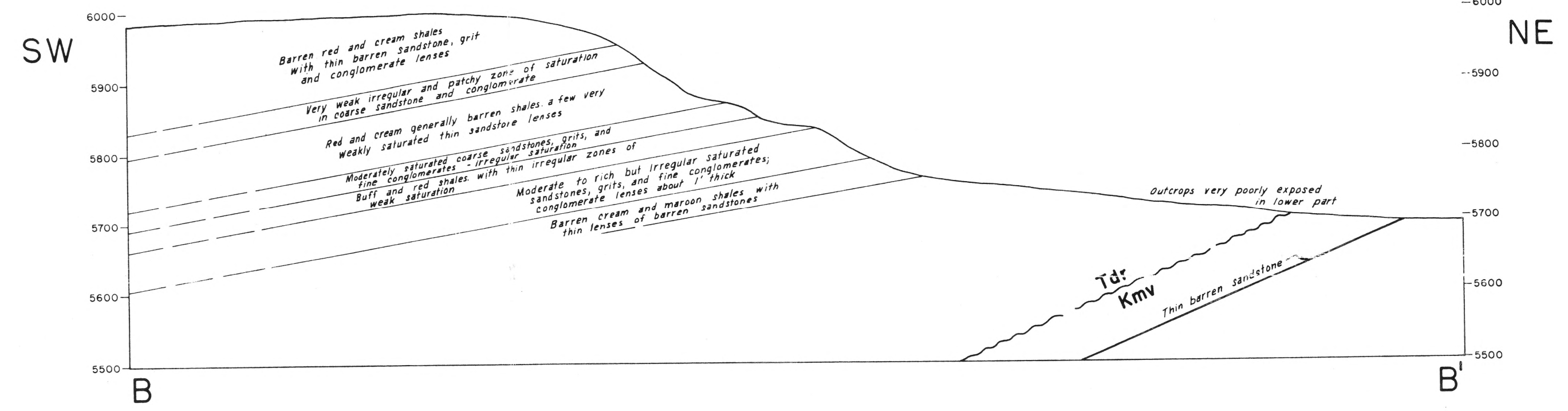
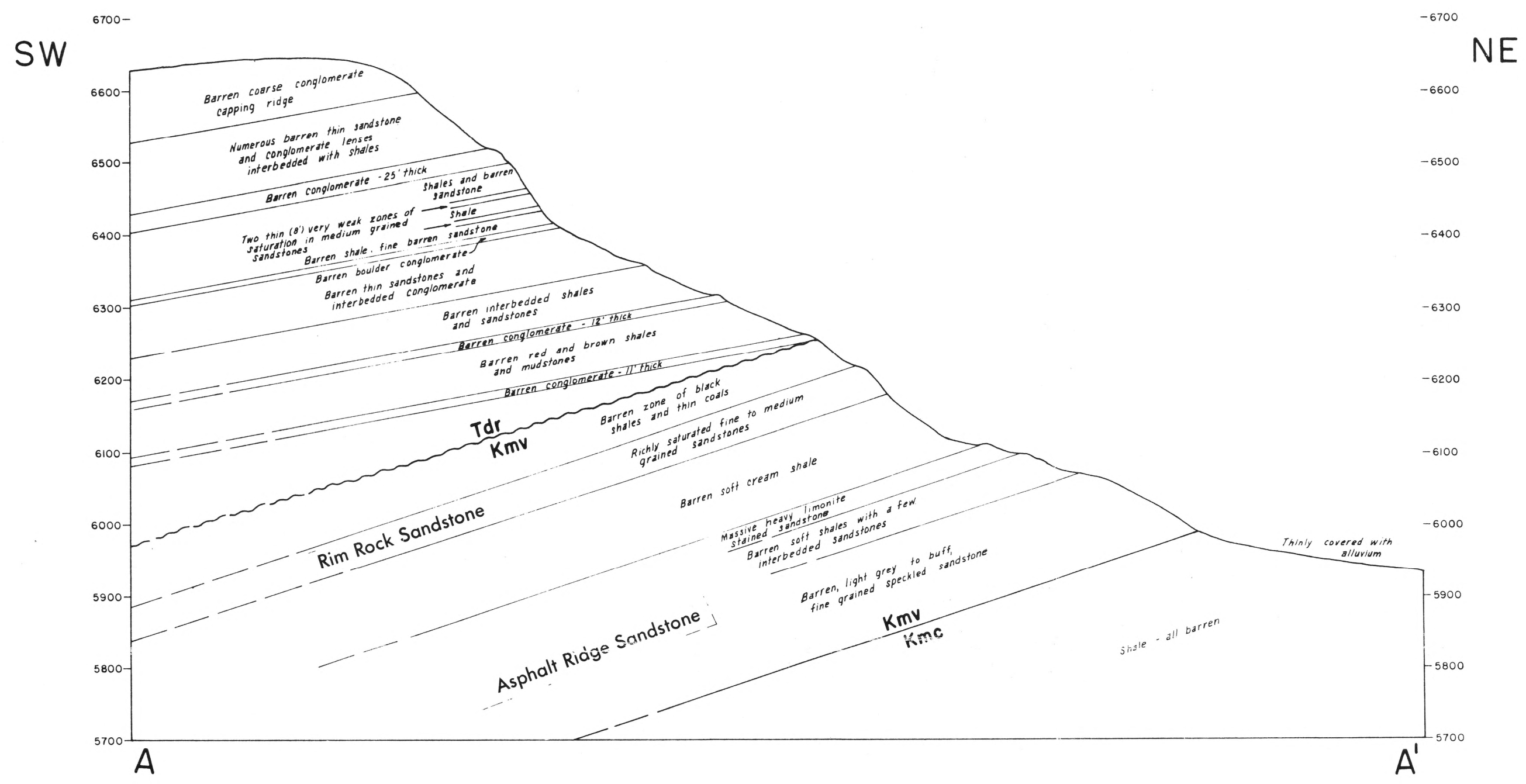
No. 1, from 709 to 712

No. 2, from 907 to 911

No. 3, from 1,265 to 1,270

<u>Feet</u>	<u>Formation</u>
0-24	Red shale
24-34	Grey sand
34-45	Red and green shale
45-58	Red sandy shale
58-70	Hard gray sand
70-77	Sandy yellow clay
77-87	Pink shale
87-98	Conglomerate
98-104	Sand
104-143	Red shale
143-146	Sand
146-163	Red shale
163-165	Sand
165-193	Red shale
193-206	Sand and shale
206-257	Red and blue, shales soft
257-266	Hard lime
266-267	Blue shale
267-274	Conglomerate
274-338	Mixed shales and conglomerate streaks
338-356	Sand and blue shales
356-364	Blue shale with dried tar particles
364-378	Blue sandy shale
378-410	Soft sand
410-415	Blue shale
415-425	White sand
425-450	Blue shale
450-458	Hard lime

<u>Feet</u>	<u>Formation</u>
458-535	Blue and red shale
535-536	White sand
536-692	Mixed blue and red sandy shales
692-697	Coarse sand
697-702	Blue and brown shale
702-709	Blue shale
709-712	Sand first water
712-753	Sandy mixed shales 742-85 green shale
753-785	Green shale 785-830 red shale
785-830	Red shale
830-848	Sand
848-875	Red shale
875-890	Blue sandy shale
890-907	Blue shale
907-911	White sand second water 8 bbl. hr.
911-920	Hard white sand
920-925	White shale
925-928	Hard sand
928-932	Light blue shale
932-945	Conglomerate and sand
945-984	Red and blue shales
984-993	White sandy shales
993-1015	White sand
1015-1069	Conglomerates
1069-1080	Hard sand fine
1080-1097	Conglomerate
1097-1105	Hard sand
1105-1135	Sandy blue shales gilsonite
1135-1145	Dark shale
1145-1155	Sand
1155-1202	Blue sandy shale
1202-1247	Blue shale
1247-1265	Blue sandy shale
1265-1270	Soft sand oil show water
1270-1276	Blue sandy shale
1276-1283	Hard sand oil show
1283-1290	Fine sand oil show (set packer)
1290-1298	Brown and saturated with oil showing gas pressure of 240 lbs.
1298-1330	Red and blue shales
1330-1434	Red sandy shales-gas 1430
1434-1444	Red sandy shales
1444-1484	Sand dry
1484-1508	Sand
1508-1515	Sand water rose 500 ft.



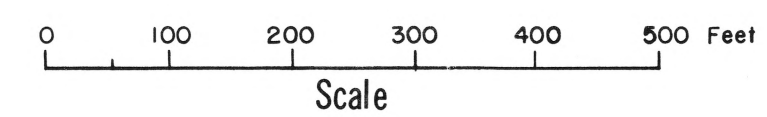
GEOLOGIC SECTIONS, ASPHALT RIDGE AREA, UTAH COUNTY, UTAH

Plane Table and Alidade Traverse of Sections

by R. B. Kayser

EXPLANATION

- Tertiary
 - Tdr Duchesne River Formation
 - Tu Uinta Formation
- Cretaceous
 - Kmv Mesaverde Group
 - Kmc Mancos Shale



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