UTAH GEOLOGICAL AND MINERALOGICAL SURVEY
AFFILIATED WITH
THE COLLEGE OF MINES AND MINERAL INDUSTRIES
UNIVERSITY OF UTAH
SALT LAKE CITY, UTAH

THE MINERAL RESOURCES OF UINTAH COUNTY

by

ROBERT G. PRUITT, JR.

Bulletin 71 June, 1961

Price $2.00

UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

The Utah Geological and Mineralogical Survey was authorized by act of the Utah State Legislature in 1931; however, no funds were made available for its establishment until 1941 when the State Government was reorganized and the Utah Geological and Mineralogical Survey was placed within the new State Department of Publicity and Industrial Development where the Survey functioned until July 1, 1949. Effective as of that date, the Survey was transferred by law to the College of Mines and Mineral Industries, University of Utah.

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2. "The survey of the geological formations of the State with special reference to their economic contents, values and uses, such as: the ores of the various metals, coal, oil-shale, hydro-carbons, oil, gas, industrial clays, cement materials, mineral waters and other surface and underground water supplies, mineral fertilizers, asphalt, bitumen, structural materials, road-making materials, their kind and availability; and the promotion of the marketing of the mineral products of the State.

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4. "The consideration of such other scientific and economic problems as, in the judgment of the Board of Regents, should come within the field of the Survey.

5. "Cooperation with Utah state bureaus dealing with related subjects, with the United States Geological Survey and with the United States Bureau of Mines, in their respective functions including field investigations, and the preparation, publication, and distribution of reports and bulletins embodying the results of the work of the Survey.

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THE MINERAL SOURCES OF UINTAH COUNTY

Bulletin 71

Of The

Utah Geological and Mineralogical Survey

June, 1961

Page 7: Paragraph 4, line 10, should read:
10,300 tons annually; (not, 1,300 tons).

Page 13: Footnote #2, second sentence, should read:
Section 7; (not, Section 8).

Page 25: Paragraph 1, line 3, should read:
18 or more feet; (not 28 or more feet).

Page 32: Figure 10, subscript, line 2, should read:
100 pound burlap bags; (not, 200 pound burlap bags).

Page 36: Figure 11, explanatory note, middle of page:
40° slope; (not 40% slope).

Page 40: The name of the town should be spelled:
Randlett; (not, Randelett).

Page 48: Paragraph 2, line 9, the 7th word, should read:
vertical; (not verticle).

Page 56: The footnote number opposite the top line is:
13; (not, 3).

Page 87: The 5th and 6th words of the last line of text should be:
phosphate reserves; (not, phosphate reserved).

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FOREWORD

In September 1959 the GEOLOGIC ATLAS OF UTAH --- DAGGETT COUNTY, by Howard R. Ritzma came off the press. This (Bulletin 66 of the Utah Geological and Mineralogical Survey) covers the northeast corner of Utah and the site of the Flaming Gorge Dam, now under construction on the Green River.

Uintah County also is bound-up with the construction and power development on the Green River. Because of the imminent change in the industrial potential of this county, high priority has been given to the study of its resources.

The following treatise (Utah Geological and Mineralogical Survey Bulletin 71) THE MINERAL RESOURCES OF UINTAH COUNTY, by Robert G. Pruitt, is designed to furnish ready-reference geologic material for the burgeoning industrial development of northeastern Utah. In addition, a six-colored geologic map of Uintah County (R. S. 90 of the Utah Geological and Mineralogical Survey) by G. E. Untermann, and B. R. Untermann will be available through the Utah Geological and Mineralogical Survey in two segments, at $1.50 for the pair, postage paid to the customer (the scale is one-half-inch-to-the-mile); and a bulletin by the same authors on the geology of the county is now being edited.

Robert G. Pruitt was selected for authoring the MINERAL RESOURCES OF UINTAH COUNTY because of his comprehensive training, experience, and unusual fitness for this particular undertaking. From Emory University in Georgia he holds the Masters' Degree in Geology, with an emphasis on mineral deposits. He is now a senior in the University of Utah Law School, working toward an LL.B. to prepare him as a legal consultant on geologic problems. He is a keen student in the history of the legal battles that have made the "Uinta Strip," the Uncompahgre Indian Reservation, and the checkered withdrawals and validations of gilsonite, and oil shale claims an enigma to those who would trace the history of the "Reservation."

Mr. Pruitt has gained an enviable reputation as a member of the staffs of the Georgia Geological Survey, the U. S. Atomic Energy Commission, and the Minerals Division of the U. S. Bureau of Land Management. In the latter position he has made extensive minerals and land appraisals.

Before accepting the request to author a bulletin on the mineral resources of Uintah County, Mr. Pruitt, like many other public-spirited geologists, had given freely of his valuable, but gratis, services to the Utah Geological and Mineralogical Survey. For these the Survey and the State of Utah will ever be indebted.

The importance of the subject matter of this investigation was deemed so pertinent to the program being sponsored by the Bureau of Economic and Business Research that this branch of the University of Utah contributed $700.00 toward the expense of the investigation, in addition to putting at Mr. Pruitt's disposal all the available information on existing mineral leases gathered by Mrs. Ann Moffat of the Bureau staff. For this whole-hearted cooperation, the Survey wishes to make due acknowledgement.

Arthur L. Crawford, Director (1949-1961)
UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

ABSTRACT

Uintah County, located in the Uinta Basin of northeastern Utah, is the site of unusual and valuable hydrocarbon deposits and other minerals. The author has researched published and unpublished sources, brought the information up to date, and collected in one volume the work of many experts. Major mineral resources of commercial value are gilsonite, oil-shale, bituminous sandstone, oil and gas, phosphate, and coal.

Gilsonite, a unique solid petroleum substance, occurs in large veins in the Uinta Basin, and sustains a multi-million dollar mining industry. Veins on the order of 4 to 17 feet wide total 141 miles in length. All known veins are mapped at a scale of 3 miles to the inch. Oil-shale, a kerogen-rich marlstone which yields oil upon heating, underlies over 2,000 square miles of Uintah County. In the richer, more accessable deposits of eastern Uintah County, over 7.5 billion barrels of shale oil are estimated in a 15- foot thickness yielding 30 gallons per ton in the Green River formation. Rich bituminous sandstone deposits are found on Asphalt Ridge, the White Rocks River, and Raven Ridge. Asphalt Ridge contains over two billion barrels of the viscous, parafine-base oil, which is recoverable by Hot-Water Separation.

New legislation in late 1960 opened bituminous sandstone and gilsonite deposits on federal lands to public leasing. Previously, for upwards of fifty years, these substances on federal lands were withdrawn from all forms of exploitation, although many valuable deposits were known. Competition for the available gilsonite deposits on the limited private lands has in the past been very great. The release of these minerals on federal lands is expected to have a great effect on the search for bitumen and gilsonite, and the development of the known, but heretofore unavailable, reserves.

Oil is produced from five fields in Uintah County. The Ashley field produces a light gravity oil from Pennsylvanian-Permian marine sediments, and has reserves of 20 million barrels. The Red Wash, Roosevelt, Brennan Bottoms, and Gusher fields produce a high gravity, waxy oil from lacustrine Tertiary sediments. The Red Wash field has reserves of 200 million barrels. Large gas deposits in the Tertiary sediments are estimated to exceed 2 trillion cubic feet, and have sparked a recent exploratory effort. Coal deposits in the Frontier and Mesaverde formations are on the order of four feet thick and have a high ash content. Early mines produced an estimated 1,300 tons, but are currently idle.

Phosphate deposits in the Park City formation north of Vernal average 20% P_2O_5 over a thickness of 20 feet. A newly opened mine upgrades the phosphate by flotation for use in fertilizers. Estimated reserves under less than 43 feet of overburden total 250 million tons of phosphatic rock. Small deposits of copper and lead occur in the Uinta Mountains and in Tertiary sediments of the Uinta Basin. Water-soluble molybdenum salts, uranium, iron, flake placer gold, and gypsum also occur in small sedimentary deposits scattered throughout the county.

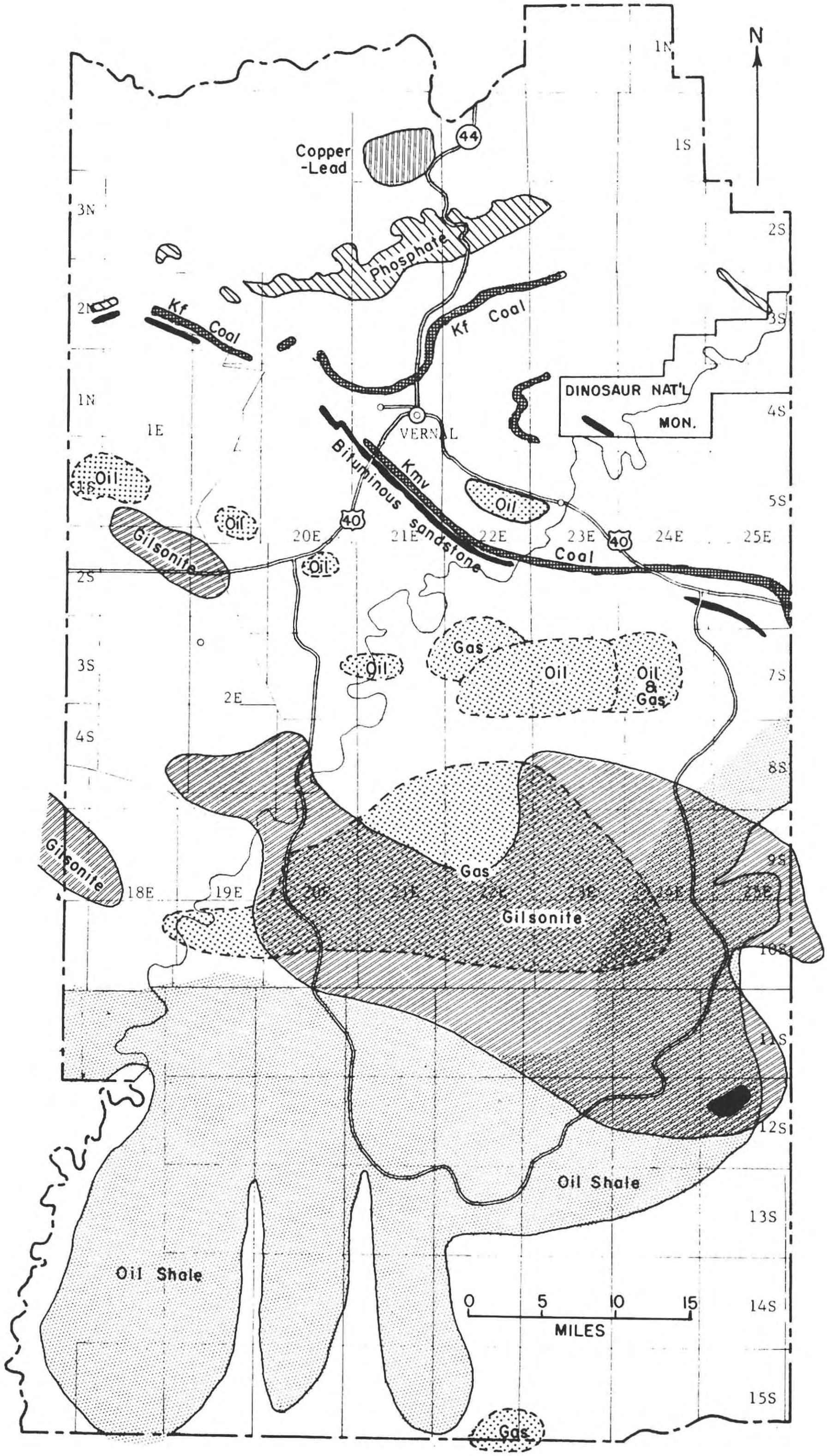

PLATE I. INDEX MAP OF THE MINERAL RESOURCES OF UINTAH COUNTY.

CHAPTER I — INTRODUCTION

Uintah County[1] is located in northeastern Utah, in that region between the Rocky Mountains of Colorado and the Wasatch Range of central Utah. It is bounded on the north by the Uinta Mountains and on the south by the Book Cliffs escarpment overlooking the Colorado Plateau. Most of Uintah County lies in the Uinta Basin, a great topographical, structural and sedimentary basin of Tertiary age. This basin is the location of several large and valuable hydrocarbon deposits which have received much attention in the literature over the past 70 years. These deposits, and the more recent developments in oil, gas, and phosphate, are discussed in this bulletin on the basis of these earlier published reports, and such unpublished sources as were available, for the purpose of acquainting the reader with the total mineral resources of Uintah County, and as a means of access into the more detailed available literature. This bulletin is planned as a companion volume to Utah Geological and Mineralogical Survey Bulletin 72, GEOLOGIC ATLAS OF UTAH--Uintah County, by G. E. and B. R. Untermann.

In examining the contents of this bulletin, the reader will recognize that each chapter deserves to be a separate bulletin, in order to adequately treat the subject. Space does not permit the inclusion of as much detail as is available on some subjects, while others demand original field mapping and research to complete our knowledge or bring it up to date. The subjects of gilsonite, oil shale, and bituminous sandstone, particularly need additional attention from field workers. Ground water from bedrock sources is an important and little known resource in Uintah County; however, it is not discussed in this bulletin.

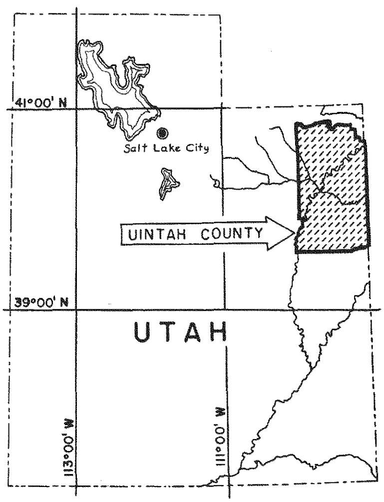

Figure 1. Index Map, Location of Uintah County.

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1. In keeping with a confusing tradition, the spelling "Uintah" is used to refer to political and cultural names, while the preferred spelling "Uinta" is used to refer to natural and geographical objects.

In the chapters which follow the reader will become acquainted with the large and valuable deposits of bituminous sandstone, locally called tar sands, which occur on Asphalt Ridge and at other localities in the county. These bituminous deposits are capable of yielding many billions of barrels of petroleum simply by extracting the viscous black bitumen as asphalt. Some novel methods of extracting the bitumen, and the uses to which it can be put are briefly described in this chapter.

Gilsonite, in the succeeding chapter, is a unique solid petroleum substance which occurs in pure form in large veins in the basin. There are over 15 major vein systems in Uintah County, which have a total length of over 156 miles, not counting the smaller veins or veinlets in the area. Gilsonite already supports a multi-million dollar industry, and estimates of reserves run as high as 30 million tons, worth at today's prices over $1,350,000,000.

Oil-shale, the sleeping giant of northwestern Colorado, northeastern Utah, and southwestern Wyoming, is present in abundance beneath the Uinta Basin in the county. Estimates of oil yield reserves in Uintah County alone total many tens of billions of barrels, and represent a worthwhile goal for future technological advancements.

Oil and gas, especially the latter, are found in abundance in the county, mainly in Tertiary non-marine stratigraphic traps. This is the most valuable single mineral resource in the county and is growing rapidly. Limited space and the difficulty of treating the subtle geological problems of sedimentation and stratigraphy in a purely economical work such as this have resulted in a too-brief summary of oil and gas activities which should nevertheless acquaint the uninformed reader with the highlights of this industry. Forthcoming publications cited in the chapter on oil and gas will adequately answer the detailed questions the reader may have.

The coal deposits in the county are idle at this writing, but represent a ready-source of fuel should local demand increase. The deposits are sub-bituminous coals of Cretaceous age, occurring at two separate horizons in beds up to $4\frac{1}{2}$ feet thick.

Phosphate mining is the most recent mineral development in Uintah County, from large, moderate-grade deposits, estimated to contain over 600 million tons of minable phosphate rock. These deposits, except for grade, are similar to the phosphate deposits of southeastern Idaho, and their mining is expected to become a major industry in the region.

Uintah County contains very few metallic mineral deposits, and several of these are more mineral curiosities than mining properties. The metallic and a few minor non-metallic deposits are treated in the last chapter.

The writer is indebted to the Utah Geological and Mineralogical Survey and to Arthur L. Crawford for the assistance rendered in researching this bulletin and obtaining some of the unpublished material. Also, the cooperation received from the U. S. Geological Survey Library, the University of Utah Engineering Library and many other sources should be acknowledged. Space does not permit a listing of their names.

CHAPTER II — BITUMINOUS SANDSTONE

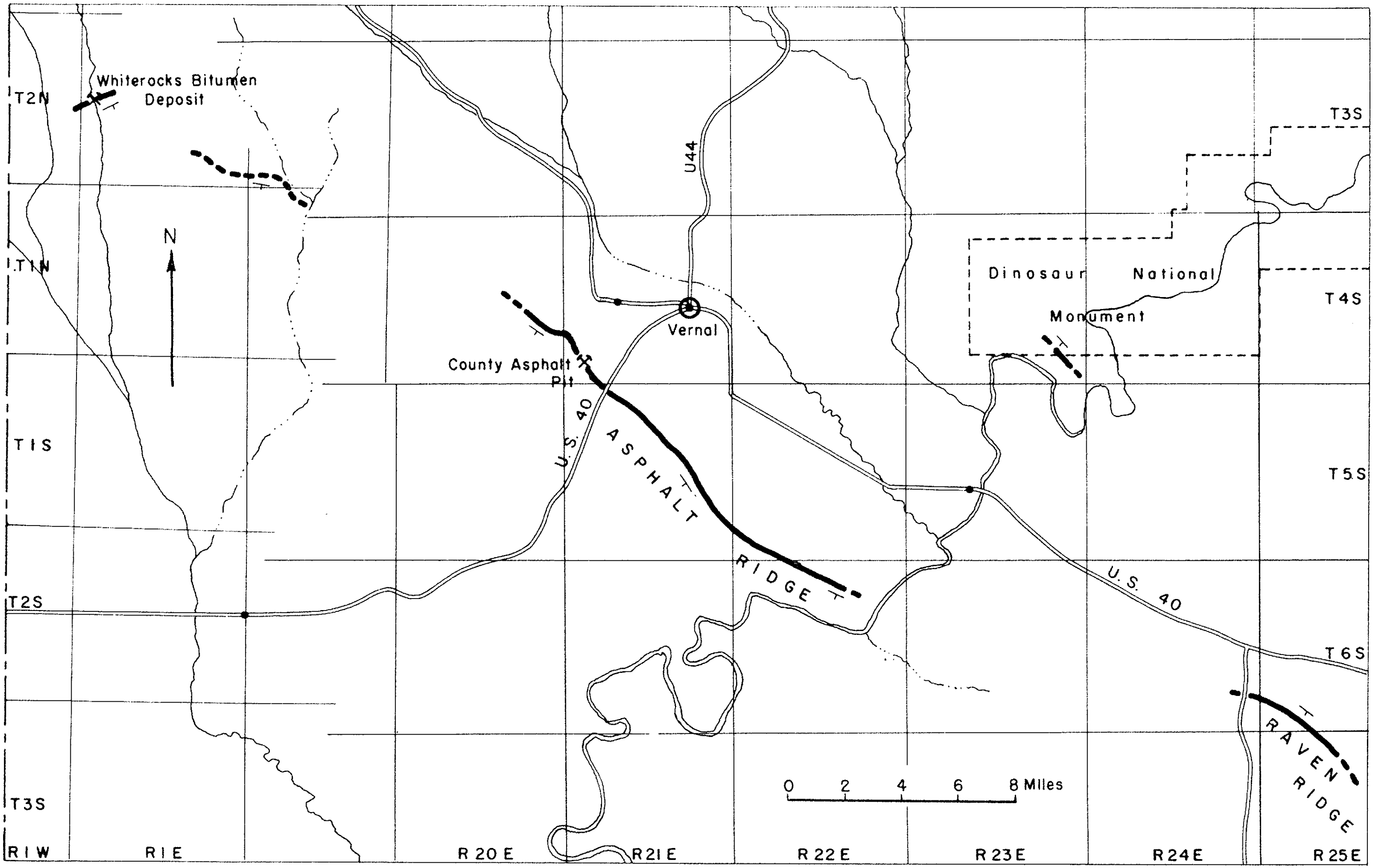
Bituminous sandstones occur in several localities in the Uinta Basin, the most prominent being Asphalt Ridge, west and southwest of Vernal. The bituminous substance in the sandstones is a tarry residuum of liquid petroleum filling the pore space in coarse sandstones or forming the cement in loose unconsolidated sands. Deposits are found in rocks ranging in age from Permian (in Dinosaur National Monument), to Jurassic (Whiterocks River), to late Cretaceous-Early Tertiary (Asphalt Ridge and Raven Ridge), and finally Eocene (near Dragon). Obviously these widespread deposits are derived from different sources, but they appear to have been deposited under similar environments.

The bituminous substance in Asphalt Ridge is natural asphalt derived from paraffin-base petroleum which contained a high proportion of paraffin series and other saturated hydrocarbons (Covington, 1957). The sandstones in this deposit yield an average of one barrel of oil per cubic yard of rock, or 8 to 15% bitumen by weight (1 barrel of oil contains 42 gallons). Spieker (1930) estimated up to 1,175,000,000 cubic yards of bituminous sandstone occur in the Asphalt Ridge deposit, in a block 11½ miles long along the outcrop, by 1½ miles back from the outcrop, containing as much as 2,000,000,000 bbls. of bitumen. The bituminous beds range from a few feet to over 190 feet thick along the east flank of Asphalt Ridge, and dip westward 8-30°. Oil wells drilled down dip along these beds recovered limited quantities of viscous oil, indicating that the bitumen becomes more liquid back from the surrace exposures. It is a well known fact that exposed surface deposits of bituminous sandstone are much leaner than freshly exposed rock a few feet back from the outcrop. Most of the samples reported below were taken at or near the surface outcrops.

DEPOSITS AND EARLY DEVELOPMENT

Bituminous sands and sandstone are exposed more or less continuously for a total distance of almost 15 miles along the eastern scarp slope of Asphalt Ridge, from a point about due west of Vernal and Maeser, southeastward to the bluffs overlooking the Green River. This deposit is a zone of impregnation along the Mesaverde-Uinta unconformable contact, extending downward into the Mesaverde formation (Cretaceous) and upward into the Uinta formation (Eocene). Old surface exposures of the bituminous sandstone are blue-gray, but beneath weathered surface outcrops, the sandstone is dark brown to black. The bitumen content of the various beds varies from lean, barely stained sandstone to rich, black stained beds which sweat viscous tar when exposed to the hot sun.

From an early time the residents of Vernal and Uintah County have used the bituminous sands from the richest outcroppings to pave streets and walkways in the area. The raw bituminous sand, mixed with about one-third clean sand, makes a serviceable paving material, although the composition is not uniform enough to meet state paving requirements. Also, since liquid tar dripping from the ledges suggests a nearby source of petroleum, efforts were made to discover oil beneath Asphalt Ridge at quite an early date. Two wells were drilled in 1911-1912, in section 6, T. 5 S., R. 21 E., and section 35, T. 4 S., R. 20 E., about one mile back from the bituminous sand


Whiterocks Bitumen Deposit
T2N
T1N
T1S
T2S
T3S
N
County Asphalt Pit
Vernal
U44
U.S. 40
ASPHALT RIDGE
Dinosaur National Monument
T3S
T4S
T5S
T6S
U.S. 40
RAVEN RIDGE
0 2 4 6 8 Miles
R1W
R1E
R20E
R21E
R22E
R23E
R24E
R25E

outcroppings. Each well yielded a small quantity of black oil, too viscous to be pumped, and the wells were abandoned. In 1926 a well in the SE¼ of section 6, T. 5 S., R. 21 E., penetrated oil saturated sandstone at 1270 feet and encountered a small amount of gas at 1300-1500 feet (Spieker, 1930). As late as 1947 the Carter Oil Company drilled a deep well to tap the bituminous sands, but the well did not produce commercial oil (Kinney, 1955). In 1957 (I.A.P.G., plate 1, sheet 1) 13 wells are shown on the dip slope of Asphalt Ridge, four or less miles from the outcropping bituminous sandstones. None could be classified as commercial producers in the bituminous sands zone.

In the 1880's and later, much of the land containing these deposits was purchased from the federal government as "coal patents," based on traces of coal in the Mesaverde formation. Prior to 1920 numerous placer mining claims were located on these deposits, and in 1916-1924 three claims were patented. The recent Act of September 2, 1960[2], opens these deposits to mining leases and gives a one year preference to holders of valid mining claims on the deposits.

Asphalt Ridge Deposits

In 1930 a survey of the Asphalt Ridge deposits was published by the U. S. Geological Survey (Spieker, 1930). The following excerpts and summary from this report are still today the best information available to the public. The sites described below are identified on the map of the Asphalt Ridge deposit by corresponding numbers. (See Plate III, page 20.)

The northernmost exposure of bituminous sands on Asphalt Ridge is located in the NW¼ of section 30, T. 4 S., R. 21 E., (site 1). Northwest of this point the beds are covered by Duchesne River sediments (Oligocene). A fault cuts the bituminous sandstones at this locality, but to the southwestward the bituminous rocks are well exposed. The section at Site 1 shows:

Bituminous sandstone (rich)	25 feet thick
Concealed interval (possibly bituminous)	10 feet thick
Bituminous sandstone	22 feet thick
Bituminous sandstone, with white pellets and seams	10 feet thick
Bituminous sandstone (very rich)	56 feet thick

Several openings and one 150 feet long drift in the bituminous sandstones were observed at this site in 1926 (Spieker, 1930).

Site 2 is located in the NE¼ of section 31, T. 4 S., R. 21 E., and is the location of a large quarry from which bituminous sands have been mined to pave the streets of Vernal and nearby areas. Between Sites 1 and 2 the bituminous sandstone is apparently uniform. A section at Site 2 shows:

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2. An act to amend the Mineral Leasing Act of 1920, enacted September 2, 1960 (74 Stat. 781). Section 8 of the Act applies to "asphalt" deposits.

Figure 2. View of the County Asphalt Pit on Asphalt Ridge, looking northwest. This pit has furnished much of the paving material in Uintah County, and is the site of the richest bituminous deposit on Asphalt Ridge. In this picture the bituminous beds dip 10 degrees to the west and underlie the ridge. The bituminous sandstone beds are exposed along the scarp slope of Asphalt Ridge for a length of 12½ miles.

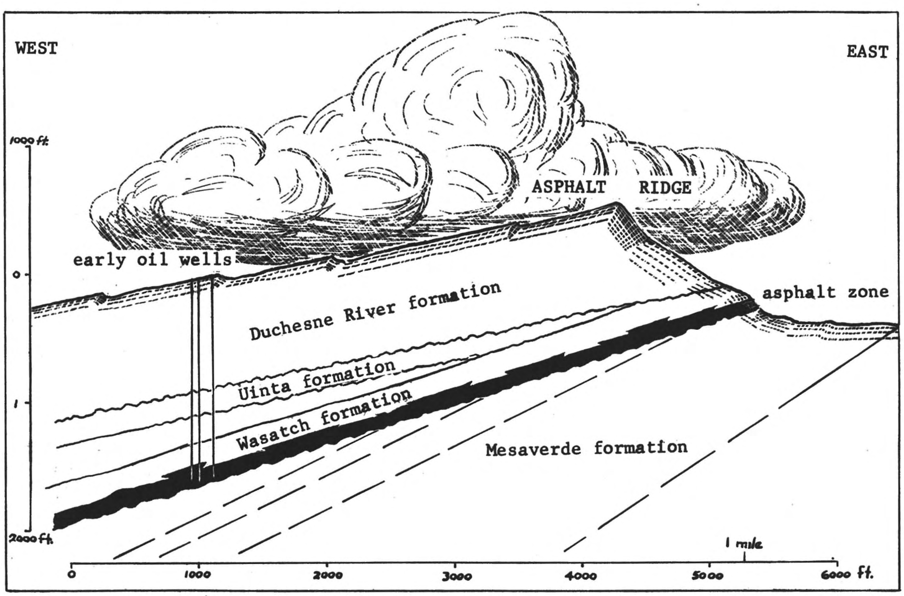

Figure 3. Generalized sectional view of the Asphalt Ridge bituminous sandstone deposits.

Bituminous sandstone (moderate to rich)	70 feet thick
Bituminous sandstone (very rich, with white pellets)	120 feet thick

Spieker was undecided if the bituminous material was in Cretaceous or Tertiary rocks at this site. Beds in the Mesaverde formation dip 11° toward the south at this location. Covington (1957) remarks that a pre-Duchesne River fault has localized saturation to the southwest side of the fault at this site. Interesting exposures of tar dripping from the fresh black sandstone may be viewed at this site on a hot sunny day, and the county quarry pit affords an excellent view of the great extent of this unusual deposit. (See figures 4 and 5, page 16.)

Site 3 is located in the SW¼ of section 32, T. 4 S., R. 21 E., east of U. S. Highway 40. In a gravel pit is an exposure of moderately impregnated bituminous sandstone measuring 30 feet or more thick, but the base of the bituminous zone is not exposed. Spieker remarks that the beds here are not as thick as at Sites 1 and 2, and that southeast of Site 3 the bituminous beds seem to become irregular, but still occupy the same general horizon.

Site 4 is located in the SW¼ of section 14, T. 5 S., R. 21 E., at the steepest part of Asphalt Ridge. The beds here appear to be about 200 feet above the base of the Uinta formation (Spieker, 1930, p. 86). A section here shows:

Conglomeritic bituminous sandstone	4 feet thick
Shale	5 feet thick
Bituminous sandstone (irregularly impregnated)	3 feet thick
Concealed interval	30 feet thick
Sandstone (barren)	8 feet thick
Bituminous sandstone (dip 17° SW)	5 feet thick
Shale and Sandstone (locally bituminous)	6 feet thick
Shale (barren; red, yellow and green)	30 feet thick
Bituminous sandstone	16 feet thick
Sandstone (barren; white)	5 feet thick
Bituminous sandstone (base of zone concealed)	4 feet thick

Site 5, also located in the SW¼ of section 14, in the next gulch southeast of Site 4, presents a very different section:

Bituminous zone (mainly bituminous sandstone)	30-50 feet thick
Shale and sandstone (barren; typical Uinta formation)	150-180 feet thick
Bituminous sandstone	3 feet thick
Concealed interval	15 feet thick
Bituminous sandstone (dip 17° SW)	5 feet thick
Shale (barren)	10 feet thick
Bituminous sandstone	15 feet thick
Concealed interval	50 feet thick
Bituminous sandstone (base of zone not exposed)	20-25 feet thick

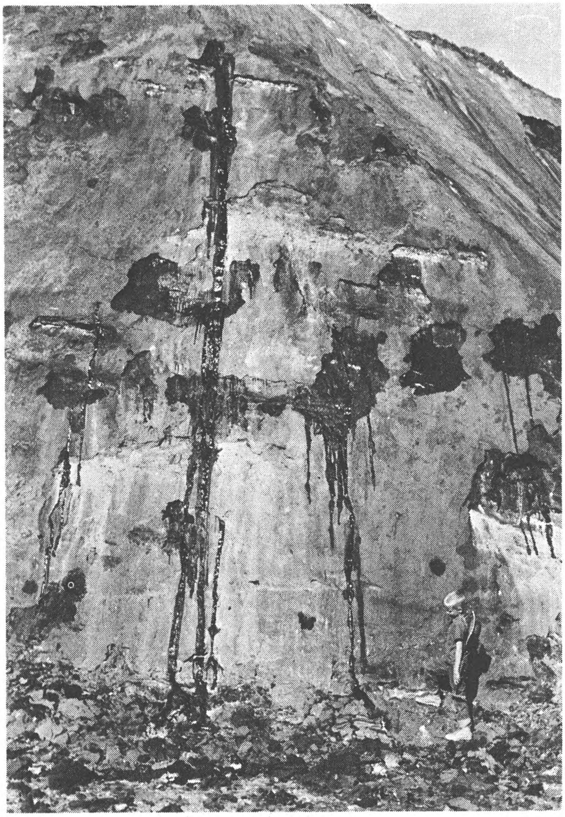

Figure 4. View of a tar seep in the County Asphe
Pit on Asphalt Ridge. The hot sun on the rich bitu
inous beds causes the liquid bitumen to "sweat" a
run down the face of the quarry. Note that the b
uminous beds quickly weather to a light gray colc
masking the rich black color beneath. The boy
the picture is the author's son, Bobby.

Figure 5. Closeup of the quarry face at the County Asphalt Pit, showing the viscous liquid bitumen, the rich fresh bituminous sandstone (which here is little more than a bituminous cemented sand), and the light gray weathered surface.

Site 6, located in the NW¼ of section 25, T. 5 S., R. 21 E., in a gap at the south end of the main part of Asphalt Ridge. A section here shows:

Sandstone (very slightly saturated with bitumen)	15 feet thick
Sandstone (slightly saturated; dip 17° W)	3 feet thick
Conglomeritic bituminous sandstone (moderately saturated)	1½ feet thick
Sandstone (slightly saturated; upper Mesaverde formation)	--------------

Approximately 500 feet to the southeast of Site 6, across a gulch, more bituminous sandstone of the same general character is exposed, measuring 50-55 feet thick. This sandstone appears to be evenly impregnated, but not very rich.

Site 7 is located in the NW¼ of section 31, T. 5 S., R. 22 E., in the bottom of a gulch. The section here shows:

Bituminous sandstone (moderately impregnated at the base)	3-8 feet thick
Sandstone (barren; gray)	9 feet thick
Bituminous sandstone (rich; dip 19° S)	1 foot thick
Concealed interval (oil soaked shaly sandstone on surface)	6 feet thick
Bituminous sandstone (rich, main bed)	6-7 feet thick
Coal (fair to poorly impregnated)	2 feet thick

Approximately 100 yards to the west, the bituminous beds are overlain by a limestone and quartzite conglomerate. For a mile or more in either direction along the strike, the bituminous beds appear to be very irregular, seeming to thicken to the west and then thin again (Spieker, 1930, p. 87). The main bed mentioned above pinches out against the Cretaceous sandstone on the south side of a big butte in section 31, T. 5 S., R. 22 E. Spieker (1930, p. 98) remarks that Site 7 could be strip mined, but the quality and quantity of bituminous sandstone is too low to appear commercially feasible.

Site 8 is located in the NE¼ section 4, T. 6 S., R. 22 E., about ½ mile west of where the old road crosses the base of the Uinta formation. A section here shows:

Sandstone (gray; impregnated with bitumen)	5 feet thick
Sandstone (barren; gray)	3 feet thick
Bituminous sandstone (dip 18° SW)	18 feet thick

A short distance to the east of Site 8 the bituminous sandstone pinches out between the shale and the overlying rocks. Some 15 miles to the east, on Raven Ridge, bituminous sandstones are exposed in the same general stratigraphic horizon.

More will be said below concerning the mining, treatment, and uses of the Asphalt Ridge deposits, but beyond doubt these deposits, particularly in the vicinity of Site 2, are the most interesting "asphalt" deposits in the Uinta Basin.

Whiterocks River Deposit

Steeply dipping beds of the Navajo sandstone (Jurassic) to the east and west of the Whiterocks River in sections 17, 18, and 19, T. 2 N., R. 1 E., Uintah Special Meridian, are rich in bitumen, forming the second most important deposit of bitumen in Uintah County. C. L. Severy (1943) wrote an unpublished report for the U. S. Bureau of Mines on this deposit. Most of the information on this deposit is taken from that report. (See Plate III, page 20.)

The Navajo sandstone dips 75 to 90° southeast at this locality, and the upturned beds are covered by the Bishop conglomerate (Miocene?) to the east and west within a short distance of the river bluffs. The bituminous impregnated zone is approximately 900 feet thick (or wide), and contains an average of 20 gallons of bitumen per ton of rock, with a range from 5.5 to 31.4 gallons per ton. At the time of Severy's examination there were two tunnels and a quarry opened on the west side of the river. One tunnel was 25 feet long and the other was caved. East of the river were three small quarries. Several bulk samples were taken from different places at this deposit and tested by the Bureau of Mines. The results are tabulated below:

Sample	Description and Location	Bitumen Content	Bitumen Yield 1st Test	Bitumen Yield 2nd Test
1	Poorest strata, east of river	3.40%	8.7gal.	7.5gal.
2	Medium strata, east of river	4.50%	11.2	10.0
3	Richest strata, east of river	6.69%	15.0	11.4
4	Poorest strata, west of river	2.53%	6.5	5.5
5	Medium strata, west of river	3.51%	8.7	8.3
6	Richest strata, west of river	9.25%	21.2	19.8
7	Dump material from long tunnel, west of river	10.57%	23.0	21.7

(Samples 1-6 were from surface exposures which characteristically contain less bitumen than fresh rock.)

The samples yielded a very limpid, light gravity oil. A specimen of this oil yielded 14% gasoline, 8.5% kerosene, 32.5% gas, oil and diesel fuel, and 45% fuel oil. Similar tests of the same bituminous samples yielded an average of 21.7 gallons of light gravity distillate and 22 lbs. of gas/ton of rock. Severy (1943) remarked that cracking the oil in a retort ought to yield more gasoline products and that the oil produced seems to be equal to the oil produced from the Asphalt Ridge bituminous sandstone deposits.

Kinney (1955) reports that a sample from an adit at the Whiterocks River deposit was virtually natural asphalt, with a specific gravity of 1.011 at 60° F. The sample contained 0.47% sulphur and 1.28% nitrogen, as compared with 0.50% sulphur and 1.18% nitrogen for the Asphalt Ridge deposits.

Severy (1943) thought the deposit was suitable to open pit mining, involving the removal of some overburden. Beds 900 feet thick (wide) and 1500 feet long were visible on the surface. Approximately 20,000,000 tons of rock containing 20 gal./ton or 9,520,000 bbls. of oil, were calculated as "in sight", with the strong possibility of richer yields at depth.

Raven Ridge Deposit

In many respects Raven Ridge, in T. 6 and 7 S., R. 25 E., may be thought of as a continuation of Asphalt Ridge to the east. The Mesa Verde-Wasatch unconformity is present and exposures of bituminous sandstone are found in this zone (I.A.P.G., 1957, p. 212). It does not appear that this deposit has the potential of the Asphalt Ridge and Whiterocks River deposits, and very little is known about its actual extent and quality. Old workings on the bituminous rock outcroppings can be seen from State Highway 45, just south of the intersection with U. S. Highway 40, but the bituminous material exposed is not very saturated.

Other Small Occurrences

The Uinta Basin contains numerous small occurrences of bituminous rock which appear to be unimportant economically, but about which very little information is available[3].

A deposit in Three Mile Canyon, in section 8, T. 12 S., R. 25 E., is reported by Cashion (1956) in the Douglas Creek member of the Green River formation. Other sandstone beds are locally asphaltic in the same area, southwest of Evacuation Creek. Winchester (1918, p. 31) noted bituminous saturated sandstones in section 9, only a few feet below the oil-shale beds.

Kinney (1955) briefly noted that small areas of oil-impregnated sandstone are exposed in basal Tertiary beds between Deep Creek and the Whiterocks River, and in NW$\frac{1}{4}$NE$\frac{1}{4}$ of section 24, T. 2 N., R. 3 W., U. S. M., between the Uinta River and Dry Gulch.

The Untermanns (1954 and personal communication) have observed bituminous seams and impregnated zones in the Upper Park City formation (Permian) in Red Wash, west of Split Mountain Gorge in Dinosaur National Monument. Also the Weber sandstone (Pennsylvanian) is locally impregnated near its contact with the Park City formation in the Hell Canyon-Castle Park area of the Monument.

ECONOMIC SIGNIFICANCE OF THE BITUMINOUS DEPOSITS

Clearly the deposits on Asphalt Ridge and on the Whiterocks River are the only areas of commercial importance at this time. The Asphalt Ridge deposit is the more important of the two, and as recently as 1960 had been scheduled for serious commercial exploitation. Standard Oil Company of Ohio (Sohio) had extensive plans to erect a large treatment plant to produce gasoline and oil products from the Asphalt Ridge deposit, but in the summer of 1960 Sohio closed its Vernal office and apparently postponed its plans for this project. No projects involving the Whiterocks River deposit have been proposed to this writer's knowledge.

Several novel methods have been suggested for economically recovering the bitumen from the sandstone. Severy (1943) suggested removal of the bitumen from the sands by hot water and flotation,

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3. The large bituminous deposits on the edge of the Uinta Basin near Sunnyside in Carbon County, Utah, are beyond the sphere of this report, but should not be overlooked. Reports by Holmes and Page (1956) and Shea, et al., (1952) should be consulted.

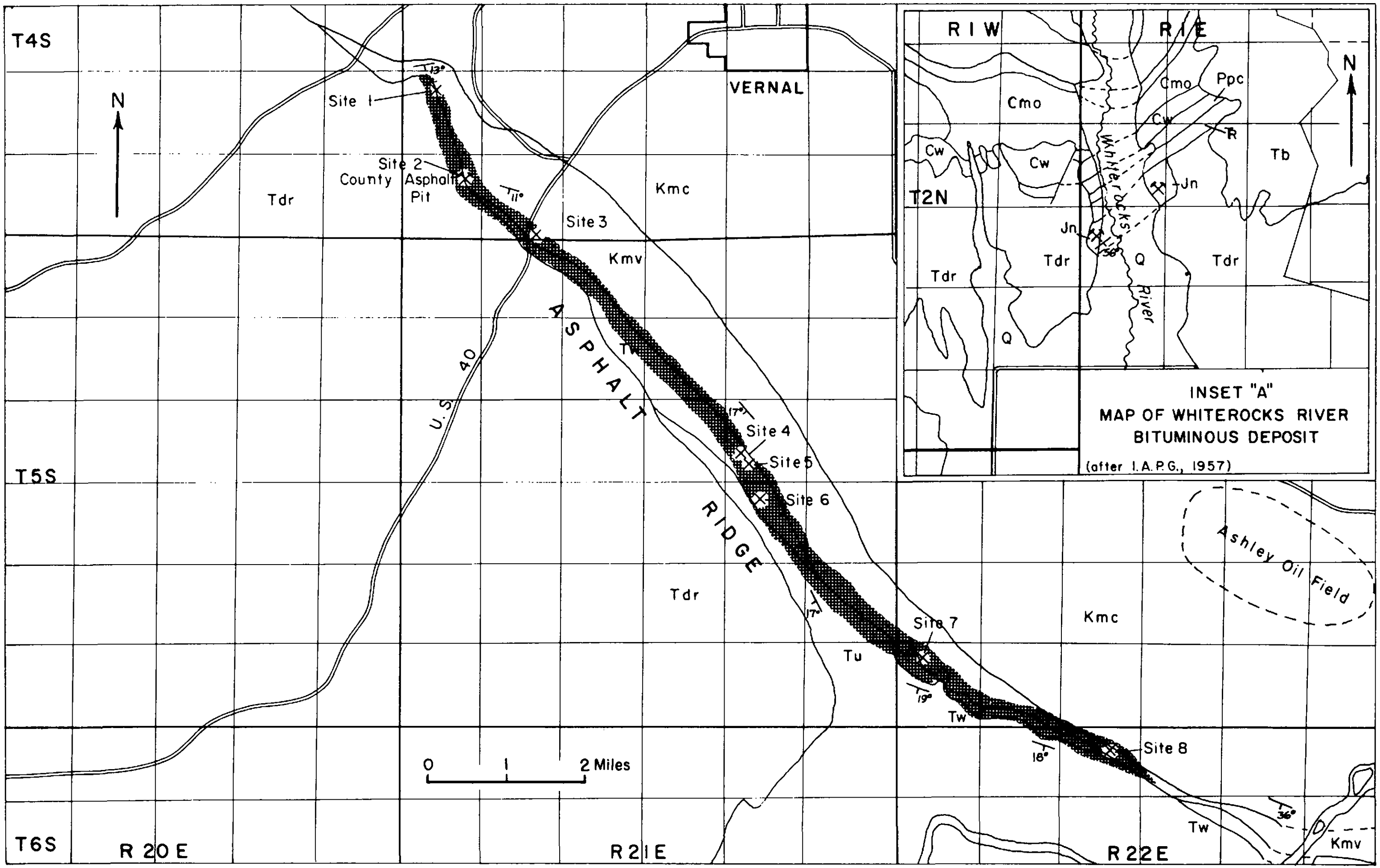

PLATE III. BITUMINOUS SANDSTONE DEPOSITS ON ASPHALT RIDGE AND WHITE ROCKS RIVER (INSET).

by use of solvents or by heat retorting (with simultaneous cracking). He also speculated upon the possibility of distilling the bitumen from the sands in place, which with present nuclear technology might not be impossible.

Because of the great interest in the future potential of the Asphalt Ridge deposit, the U. S. Bureau of Mines undertook extensive research studies which were published in 1952 (Shea, et al., 1952). Some of the technical data in this report is reproduced here because it is the most reliable detailed information available on asphalt in Uintah County.

The Hot-Water separation method, tested by the Bureau of Mines (Shea, et al., 1952, p. 5):

> "... is based on the well-known phenomenon that water, because of its preferential wettability for silica, will displace crude oil from quartz sand grains and other siliceous particles. . . . Experience has shown that certain alkaline solutions are more effective than plain water as a displacing medium and that virtually complete displacement of the bitumen readily takes place when the water is alkaline enough to neutralize any acidity that may be present in the bituminous sandstone. Complete displacement also depends on the disintegration of the bituminous sandstone into individual sand grains and thorough mixing with water. The (inclusion) of enough air (as) small bubbles in the pulp to form an oil froth effectively facilitates rapid flotation of the displaced bitumen."

The basic treatment of the Asphalt Ridge bituminous sandstone may be outlined in four steps (based on Shea, et al., 1952):

1. Charges of disintegrated bituminous sandstone are pulped with an aqueous solution of sodium silicate (1-4 lbs./ton of rock, to reach pH 8 in the pulp mixture) and a diluent (a light-gravity fuel oil, about 8 gal./ton of rock).

2. The pulp is introduced into hot water cells (200° F.) and agitated for about 7 minutes. Air introduced as small bubbles is injected to form a frothy pulp (variations in pulp consistency did not seem to affect the efficiency of separation). The froth quickly separates the bitumen from the sand and floats to the surface.

3. The froth is skimmed off and into a trough where more diluent is added. The washed and settled sand is continuously conveyed from the cell and the plant water may be recirculated into the cell.

4. Sand, silt, or water trapped in the oil froth is separated, by conveying the diluted froth to a cone-shaped settling tank filled with hot water. The oil overflows into a second settling tank (heated to 200° F.) where the oil-silt separation is completed. The quantity of diluent added to the froth (not to exceed three parts diluent to one part bitumen) directly affects the silt-water separation from the bitumen. The more diluent, the better the separation.

The above mentioned method recovered 96 percent of the bitumen contained in the sandstone (that is, sandstone containing 12 percent bitumen was made to yield 29 gallons of bitumen per ton of rock). Water and silt content, separated by centrifuge, was less than 2.0 percent, and ash content was less than 0.6 percent.

Other tests demonstrated that water alone could be used to achieve nearly complete displacement of the bitumen, but the action was slower and required more aeration to facilitate flotation.

The final product of the Hot-Water Separation method is a mixture of bitumen and diluent. The diluent must be recovered by batch distillation at 200° F. and 40 mm. of Hg. pressure. As much as 2 percent diluent remained in the bitumen, and approximately 2 percent of the bitumen was removed with the diluent.

The resulting bitumen is a viscous substance with a high boil point, containing 0.39 percent sulphur and 1.18 percent nitrogen. The recovered bitumen could be used as fuel oil or as asphalts. To be used as asphalt the bitumen would require little or no further processing. Grade 6 fuel oil (suitable for burners equipped with preheaters) could be prepared by mild cracking provided too much sediment was not produced. Grade 5 fuel oil could not be produced without distillation.

If the bitumen were cracked by retorting (a process similar to oil-shale recovery), the distillate could be made to produce a variety of fuels, lubricants, gas and wax. The carbon residue in the bitumen is removed as coke. By a simple cracking operation of the bitumen from this deposit, 45.3 percent was converted to motor fuels (representing 56.8 percent of the retort distillate), with an ultimate yield of motor fuels estimated to approach 75 percent by volume of the bitumen by further cracking.

There can be little doubt that the Asphalt Ridge deposits, and probably the Whiterocks River deposit, will someday be mined and treated to recover this vast reserve of petroleum. But the investment required to successfully compete with other abundant sources of petroleum is so great that immediate exploitation is unlikely. Recent availability of the deposits on federal owned lands for leasing (Act of September 2, 1960, 74 Stat. 781) will undoubtedly facilitate any plans already in existence, and possibly accelerate research and development.

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CHAPTER III — GILSONITE

Gilsonite is a black, pitch-like substance which occurs in pure form in large veins in the Tertiary sediments of the Uinta Basin. It is a homogenous petroleum substance (technically it is a predominentely aromatic asphaltite) which fuses relatively easily and burns like tar. Gilsonite is brittle and has a distinctive conchoidal to hackly fracture. Fresh gilsonite has a brilliant black luster, but weathered gilsonite and some of the more refractory varieties have a dull, soot-black appearance. Gilsonite has a specific gravity of 1.07, just slightly denser than water, and a hardness of 2 to 2.5 on Moh's Scale. Gilsonite is soluable in asphalt-based petroleum, and is frequently employed to change the consistency of lighter petroleum products. Finely pulverized gilsonite is chocolate brown in color and exceedingly penetrating to the skin and lungs.

Gilsonite is a bitumen and approximates the composition of an asphalt-based petroleum, with most of the volatile constituents missing. It should not be confused with the other natural solid hydrocarbons which are found in veinlets in the eastern Uinta Basin, which are pyro-bitumens for the most part. A typical analysis of gilsonite is given by Eldridge (1896):

Carbon	88.30%
Hydrogen	9.96%
Sulphur	1.32%
Ash	.10%
Oxygen and Nitrogen	.32%

On the other hand, a chromatographic analysis of liquid gilsonite (Hunt, et al., 1954) shows:

Parafines and naphthenes	18% (by weight)
Aromatics	48%
Nitrogen, sulphur, and oxygen compounds	34%

When gilsonite is heated to 250° F. or higher (up to 500° F. for the more refractory varieties), it melts and liberates some volatile constituents. It can be heat refined to produce high octane gasoline, motor oil and other petroleum products, leaving a residue of pure carbon coke.

In mining and marketing gilsonite two grades of ore are distinguished. "Selects," or massic conchoidal gilsonite, usually contain more volatile substances and have a lower melting point. "Seconds" or fractured gilsonite contain considerably less volatiles, and have a higher melting point. The origin of the two types is discussed below.

Gilsonite Veins

Gilsonite occurs in long, thin, nearly vertical veins, most of which trend N 35-65°W in essentially horizontal beds of Tertiary age. These unusual veins are found in an area 60 miles east-west by 24 miles north-south in the Uinta Basin, and apparently originate from the underlying oil shale beds of the Green River formation (Hunt,

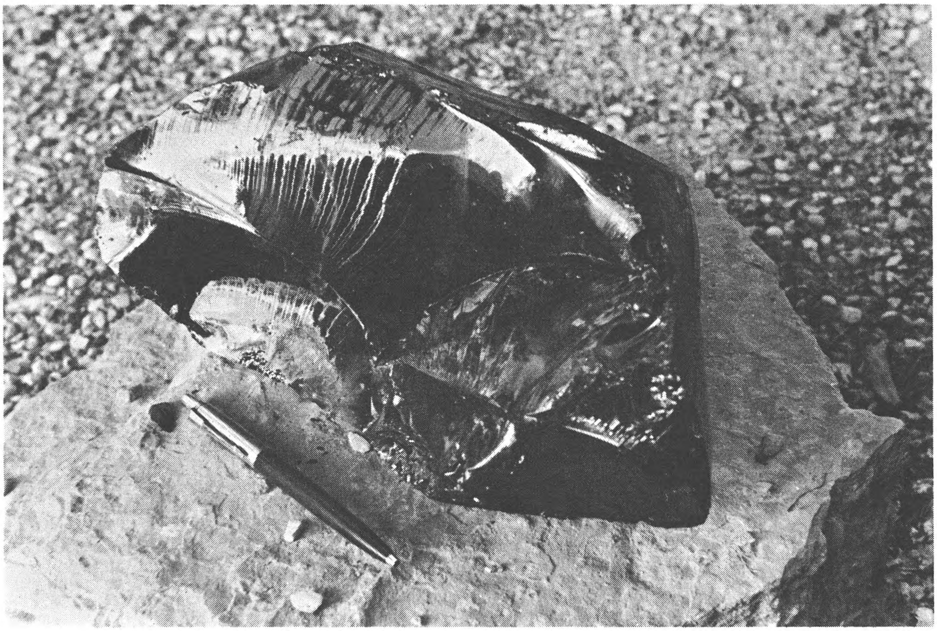

Figure 6. Specimen of "select" gilsonite showing the distinctive conchoidal fractures and vitreous luster. Gilsonite is soft and brittle, and melts at 250-450 degrees Fahrenheit. When exposed to sunlight and atmospheric conditions, gilsonite will become dull and develop minute cracks, gradually breaking down to become "seconds," or more hackly, refractory gilsonite. (Specimen courtesy of G. E. and B. R. Untermann.)

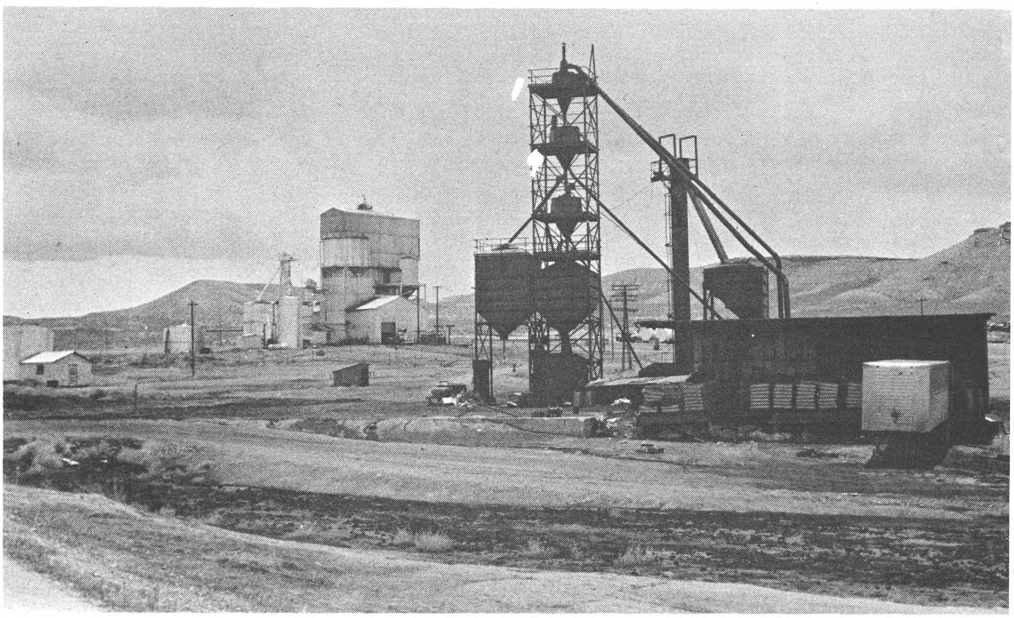

Figure 7. View of the mining and treatment facilities of the American Gilsonite Company at Bonanza, Utah. This highly mechanized mine area is in contrast to the other small mines in the gilsonite area. The shed in the foreground contains 100 pound paper bags of gilsonite ore ready for shipment.

et al., 1954). The Pride of the West-Black Dragon vein, whose maximum width is 10 feet, can be traced for 24 miles. The widest vein, the Cowboy, is 28 or more feet wide at one place and is exposed for 13½ miles. Numerous small veins occur with the larger veins, but lacking immediate commercial significance, they have received little attention.

Owing to the almost vertical attitude of the gilsonite veins, an areal plot of each vein is remarkably straight. Veins can be readily traced from point to point where they crop out or have been exposed by workings. The writer used aerial photographs to trace these veins from exposure to exposure, and noted remarkably few departures from an essentially straight course. The Tabor Vein has a prominent fork, forming two large veins, and the Black Dragon vein splits to form two closely parallel veins. One prominent intersection of two veins was seen where the Pride of the West and the Rainbow veins join, forming a very obtuse angle.

Gilsonite veins maintain their uniform widths for remarkable horizonal distances and vertical depths. Veins a few inches wide can be traced for miles in many places. Many of the larger veins will vary less than a foot in width for distances of a mile or more. Vertically a vein may narrow or thicken, but the change is usually very gradual. Some severe pinch-outs have been encountered in mining, but these are rare. It is stated as a general proposition that veins in the eastern part of the Uinta Basin can be expected to narrow and split up with depth, whereas veins in the western part of the basin can be expected to gradually widen with depth. This proposition is an over simplification, but basically correct. Veins in the eastern part of the basin have, for the most part, been eroded down close to the "roots", so that at relatively shallow depths the veins branch and split and only narrow veins continue downward. The veins in the western part of the basin crop out at a higher stratigraphic horizon, and the "roots" of a vein are at a greater depth. Douglass (1928) observed that many of the gilsonite veins reach their maximum width in the upper Green River formation and the lower Uinta formation. Above this horizon the veins thin upward until they pinch out in the upper Uinta and Duchesne River formations. Below the upper Green River formation the veins tend to split up as they pass downward into the rich oil shale beds which are believed to be their common source (Hunt, et al., 1954).

Where early miners have exposed the gilsonite veins by pits and shafts, the conspicuous black spoil is easily traced from point to point along a vein. In virgin areas a vein may be indicated by chips of gilsonite float in the soil and in anthills, or in heavy vegetation areas by the characteristic strips of sparse vegetation which mark veins of gilsonite. Until a pit is dug on a vein, little can be learned about its width, and even then little is learned about the quality of the ore, since characteristically gilsonite "slacks" and loses volatile constituents when exposed to air, sunlight, or moisture near the surface. Many veins were discovered at points where streams and ravines cut the veins, and this is still a useful means of tracing a vein in the area.

Gilsonite Ore

Early mining methods consisted of trenching along in the soft vein to whatever depth was considered safe. Later, shafts were sunk

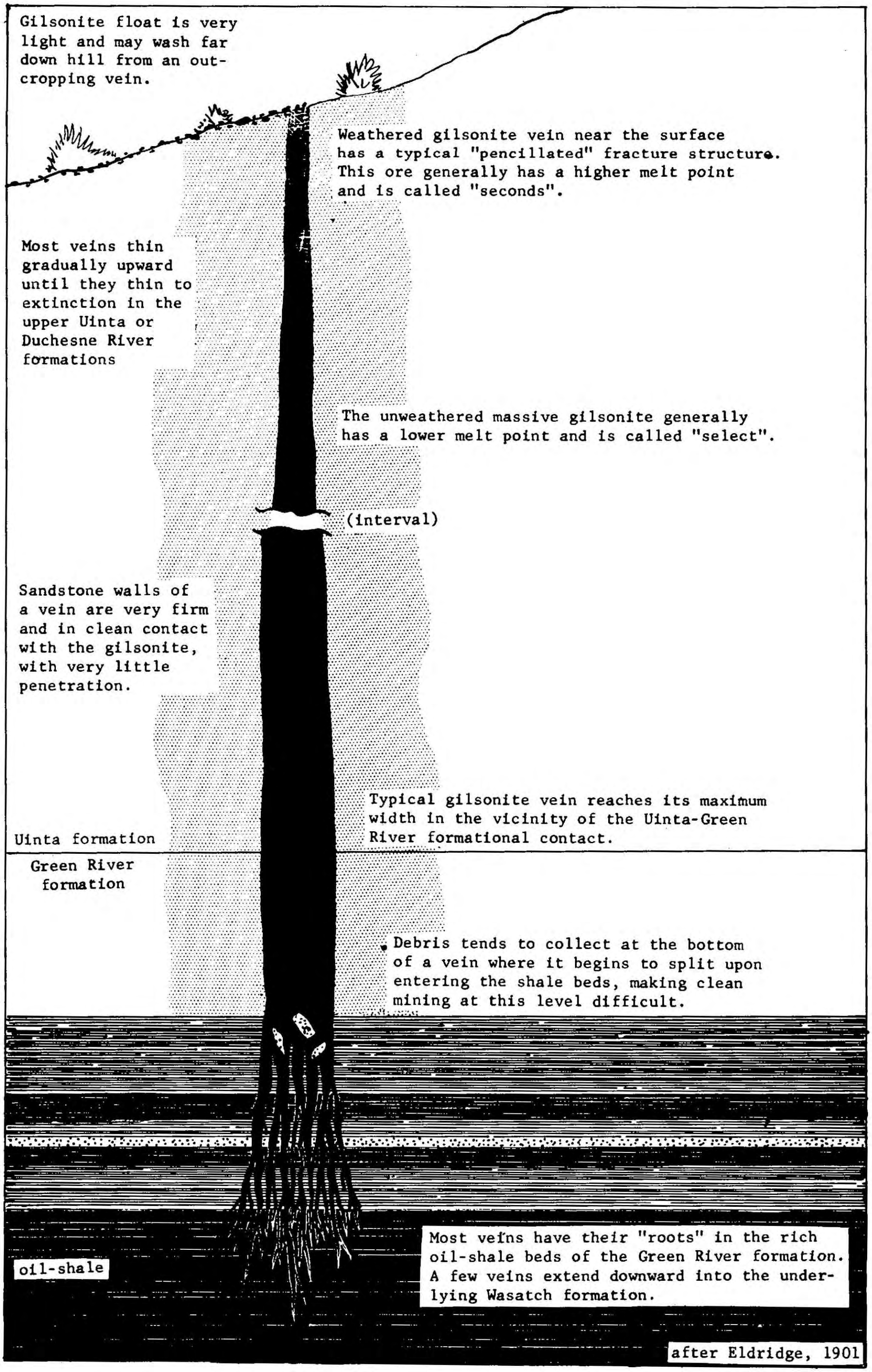

PLATE IV. GENERALIZED SECTIONAL VIEW OF A GILSONITE VEIN.

to shallow depths, and the veins were stope-mined to either side, often to the surface. The smooth, unbroken sandstone walls of the veins required only occasional support and wooden stulls were used. Mining was by hand methods using a pick and sacking the broken gilsonite in 200 pound bags for shipment. The highly combustable gilsonite dust created an explosion hazard in the mines, and many disasterous explosions and fires occurred in the early mines. Until recently mining was carried on by primitive, high cost methods, but in 1954 experiments were begun with mechanized water jet mining on the Cowboy vein, and mechanized cutters have been employed in some of the other large veins. Much of the "select" ore is still bagged for shipment to buyers, bringing roughly $47 per ton in 100 pound bags F.O.B. mine[4].

Traditionally gilsonite has been marketed in two catagories: (1) "select", the massive fresh mineral, having a bright black conchoidal fracture and low melting point, and (2) "seconds", the pencillated, slacked or harder mineral, which is dull black and fractured, generally crumbling to small granules or flakes, with a higher melting point. The select contains more volatiles and historically had a higher value, being utilized in paint and varnish bases and other high cost uses. Seconds were originally literally rejects, being useful only for low cost purposes, such as paving, certain insulations, etc. Most fines, regardless of melting point, used to be marketed as seconds because buyers refused to pay premium prices for mineral not obviously "select" and unmixed. High-melt-point ore from the Uintah vein is marketed as "jet" in defiance of the tradition, and brings premium prices despite its high melting point. Instances are recorded where miners remelted "seconds" to obtain bright, fresh looking lumps of gilsonite which resembled "select" ore, but buyers soon discovered that the ore still had a high melt point, and was unsuited for their uses.

Seconds are apparently select ore which has lost many of the volatiles found in the fresh gilsonite. Often this is due to exposure to atmosphere and heat from the sun at surface outcrops and at shallow depths. At greater depths the change from selects to seconds is attributed to reactions with circulating groundwater, possibly in fractured zones. In some instances the circumstances behind the change are not so plain and a theory postulating two or more distinct injections of gilsonite, possibly from different sources, has arisen. The occurrence of whole veins of seconds, or of lenses of seconds at depths in select veins, without any indication of the presence of groundwater or prefracturing, is cited as evidence of a second injection. The answer is not clear, but it is unlikely that the gilsonite is derived from more than one source or was emplaced at more than one time (Hunt, 1954), so it may be presumed that the gilsonite gave up volatiles at some time subsequent to emplacement and became "seconds".

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4. The June 1961 quotation for gilsonite from American Gilsonite Company was:
   - Select ore, 1/4-3/4 inch lumps, $47/ton in 100 lb.-multi-wall paper bags,
   - Select ore, 1/4-3/4 inch lumps, $43/ton in bulk loads,
   - Seconds ore, $43/ton in 100 lb.-multi-wall paper bags,
   - Pulverized ore (all -40 mesh, 50% -200 mesh) $57/ton in special 100 lb. bags.
   - All prices F.O.B. at Bonanza, Utah.

Historical Background of Gilsonite

As early as 1865 specimens of "an unusual variety of asphaltum" from "central Colorado" found their way into mineral collections in the Eastern colleges (Remington, 1959), but the first recorded discovery of gilsonite from the Uinta Basin came in 1869. A blacksmith at the Whiterocks Indian Agency near Ft. Duchesne tried to burn some gilsonite from a nearby vein in his forge, mistaking it for coal. When the gilsonite was thrown into the forge it burned hot, giving off a heavy black smoke and a strong petroleum odor, and ran flaming from the forge, nearly burning down the blacksmith shop (Remington, p. 32).

In 1885 the substance was classified and named "Uintaite" by Professor Wm. P. Blake. However, in 1886 Samuel H. Gilson began to prospect the area and was successful in promoting a market for the new mineral, and a new name, "Gilsonite", was adopted in his honor by the people who later came to mine and market the mineral. At first gilsonite was merely a local name, later a trade name for the marketed substance, and finally it became the accepted technical name for this unusual mineral.

The first gilsonite veins to be discovered were the Raven and Carbon veins, near Ft. Duchesne in 1869-1888. The Pariette, Baxter, and Castle Peak veins in Duchesne County were discovered soon after. Then in 1887 the Cowboy-Bonanza vein system was discovered by cowboys on the Uncompahgre Indian Reservation, near the Utah-Colorado state line. Not until about 1896 did the existence of the great Rainbow system of veins become known, although the Black Dragon vein was known earlier. At an even later date the Willow Creek and lower White River gilsonite fields were discovered, and these last veins are still relatively unexplored today.

As the many early discoveries of gilsonite became known, it was recognized that practically every vein of gilsonite in the basin occurred within one of two Indian reservations, and hence the deposits were not open to acquisition and mining under the Federal Mining Laws. Nevertheless, excited prospectors poured onto the Indian reservations in wholesale trespass, locating "claims" as though no prohibition existed. From 1886 until 1903 a running war was waged between the trespassing prospectors and the patroling Indian agents. Claim monuments were destroyed and discovery pits filled, only to be secretly restored at a later time by the resourceful miners. Indeed, some of the more active prospectors did double duty, serving at times as patrolmen for the Indian tribes, keeping out their competitors (Remington, 1959).

In 1903 Congress passed an Act (Act of March 3, 1903; 3 Stat. 998, c. 994) which gave legal recognition to all trespassing "claims" located prior to 1891, and provided for a sealed bid sale of the mineral bearing tracts on the even-numbered sections of the reservations not covered by pre-1891 claims. Fortunately Congress provided a 90-day period during which the miners could re-record their claims in the local mining records. As a result a large number of claims on the Rainbow vein system and elsewhere, probably discovered considerably after 1891, achieved legality and were subsequently patented.

By chance or design most of the pre-1891 mining claims had been purchased cheaply prior to the Act of 1903 by the Gilson Asphaltum Company. The company also narrowly out-bid their competition in the sealed bids for the mineral tracts on the even-numbered sections (Remington, 1959). As a result of their acquisition of the pre-1891 claims and their successful bidding at the auctions, the Gilson Asphaltum Company emerged as the giant in the gilsonite mining industry. This position was strengthened in 1906 when President Theodore Roosevelt issued a proclamation stating that all lands not disposed of by 1910 would be henceforth withdrawn from acquisition and reserved. Until September 2, 1960, all gilsonite not in private ownership by 1910 was closed to exploitation and the Gilson Asphaltum Company, which by a series of mergers and purchases emerged as the American Gilsonite Company, became virtually the sole source of raw gilsonite in America today. The legal restrictions imposed against gilsonite mining on the public domain, in effect for 50 years, have accounted in large part for the lack of information on certain undeveloped gilsonite areas encountered in collecting data on the deposits and chronicaling the development of the industry.

Early Geological Investigations

As early as 1896 G. H. Eldridge, of the U. S. Geological Survey, published a comprehensive report on the gilsonite deposits known at that date. His reports to Congress undoubtedly influenced the decision to take some action to solve the acute problems arising from the discovery of this valuable resource on Indian lands. Eldridge's report is cited in House Documents, vol. 14, page XXXVII (1895-1896). In his published report of 1901 many of the deposits south of the White River were unknown, and so little information on these deposits is given.

In 1928 Earl Douglass, a prominent paleontologist whose early explorations of dinosaur deposits in the Uinta Basin had made him the leading expert on the basin, was employed by the Gilson Asphaltum Company to make a technical appraisal of their holdings. While not a geologist of the economic sense, Douglass prepared a report of the gilsonite veins he examined which is complete and detailed. His main attention was devoted to the larger veins in eastern Uintah County, which fortunately supplements the reports by Eldridge. Much of the information in this chapter is reproduced from the Douglass report.

Following a long period of no publications on gilsonite, Crawford (1949) wrote a comprehensive discussion of the gilsonite deposits as part of a publication on the Oil and Gas Possibilities of Utah. Much of the article is devoted to a discussion of the origin of gilsonite based on earlier works and Crawford's own original observations as a gilsonite mine operator.

The most recent important publication on the geology of gilsonite is by Hunt and others (Hunt, et al., 1954). Based on rapidly evolving theories in support of the non-marine origins of oil in the Uinta Basin, and supplemented by exhaustive field and laboratory studies, this article authoritatively demonstrates that the gilsonite veins throughout the Uinta Basin, as well as other solid hydrocarbons, originated from the rich oil shale beds of the Tertiary Green River formation.

One recent work on gilsonite is not a geological treatise, but nevertheless deserves prominent mention in this section. Remington (1959), in an unpublished Master's thesis for the History Department, University of Utah, has compiled an up-to-date factual account of

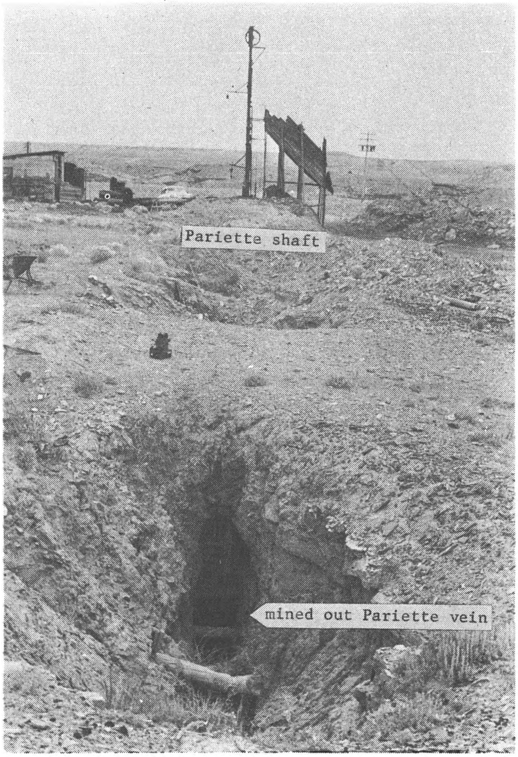

Figure 8. View of the Pariette vein and mine, south of Myton, Utah. Note that the narrow vein, only about 18 inches wide at the surface, has been stoped to the surface. The vein cavity remains open supported by an occasional wooden stull. In the background is the main shaft and ore bin.

Figure 9. The Pride-of-the-West vein, west of Rainbow, Utah, showing how the firm vein walls are supported by wooden stulls with practically no caving. Note the small offset in the right vein wall and the fact that the walls are clean of gilsonite. This view is looking along an old mining and hauling level, as evidenced by the supporting stulls all on the same level. The plank flooring has been removed. (Photograph by Don Preston)

gilsonite mining and historical background that is without equal. Using the old records of the Gilson Asphaltum Company, and assisted by personnel from the American Gilsonite Company, Remington collected a great many facts, figures, names, and dates that have been of great aid to this writer in compiling the chapter on gilsonite.

Other short articles on gilsonite and reference to hydrocarbon deposits in the Uinta Basin are listed in the bibliography.

DESCRIPTION OF THE DEPOSITS

The gilsonite vein systems in the Uinta Basin can be classified into six distinct geographical units. Veins within a given unit are also closely related in geological environment and stage of development. Interrelationships between the six units discussed below are largely inferential due to early legal restrictions which have discouraged new exploration in areas where gilsonite was not known prior to 1903. (See Plate V, beginning on page 40.)

Ft. Duchesne Area

This is the locality where the first reports of gilsonite originated in 1869. Only two gilsonite veins, the Carbon and the Raven, are found in this area. Both veins are presently idle after a long history of production.

The Carbon vein, discovered in 1869, was also the first to be mined, in about 1888, by Sam Gilson. The old St. Louis mine, northeast of Gusher, Utah, is in SE¼ section 18, T. 2 S., R. 2 E., Uintah Special Meridian. The vein passes under U. S. Highway 40 a short distance southeast of the mine workings. Eldridge (1896) described the vein in detail (mistakenly calling it the Duchesne vein). The vein is also known as the St. Louis vein.

The Carbon vein trends N 40° W over a distance of 3 miles or more. Its maximum width of 3-4 feet occurs near the middle of the vein and is maintained for a length of about 1½ miles, diminishing toward either extremity of the vein. Transverse faults with a throw of less than 8 inches cut the vein at places, and fragments of wall rock have been found in the vein, completely enclosed and suspended in gilsonite. The walls of the vein are well defined, showing little or no impregnation of gilsonite into the sandstone wallrock (Eldridge, 1896). The gilsonite ore in this vein is of the highest quality except near the surface. Workings reach a depth of 660 feet (Douglass, 1928) or more. Ore from the Carbon vein sold for $120 per ton in 1889, and in 1946 the vein produced 68,407 tons at $20.47 per ton (Murray, 1950). The vein crops out in the Duchesne River formation (Oligocene), and was worked by stoping the soft gilsonite between the firm vein walls, leaving a deep narrow cut in the earth traceable for hundreds of yards.

The Raven vein, known also as the Duchesne vein, was apparently unknown to Eldridge in 1896, although it occurs partially within the old Fort Duchesne Military Reservation. It may have been gilsonite from this vein that caused the legendary fire in the blacksmith shop in 1869. This vein trends N37°W, averaging 18 to 24 inches wide. It was worked mainly by the Raven Mining Company from 1904 to 1939, but is now idle. This vein contains a total of 14 shafts ranging

Figure 10. Small mines on the Bonanza vein, near Little Bonanza. The three shafts in a straight line indicate the strike of the vein. Gilsonite ore in 200 pound burlap bags stands nearby ready for shipment to buyers. This picture is a good illustration of the mining practices employed in these small
[illegible] ss (and sometime [illegible] n) of
and roduce ore [illegible] ities

from 100 to 700 feet deep. Indicated reserves are 1,231,000 tons to a depth of 1,500 feet with inferred reserves of double that amount to a depth of 3,000 feet (Remington, 1959). The vein terminates under alluvial deposits in the bed of Uintah River near the NE¼ section 15, T. 2 S., R. 1 E., Uintah Special Meridian. It is traceable upon the surface for approximately 3 miles. Gilsonite ore from this vein was of good quality, classified mainly as "selects".

Pariette Area

The Pariette area has a long history of gilsonite production, and is often looked upon as a maverick among gilsonite deposits in the Uinta Basin. In many respects the Pariette and Castle Peak veins defy the orderly pattern of the gilsonite veins to the east.

The Pariette vein, located 8 miles south of Myton, Duchesne County, Utah, is an historical landmark in this region. Discovered prior to 1889, it was known as the Culmer or Toquor vein and is still in operation today. Actually part of a vein system, it may be thought of as a northward extension of the Castle Peak vein, discussed below. The Pariette vein trends N35°W for a length of about 7 miles (Hendricks, 1943). It dips 85-88° westward, with an average width at the surface of 18 inches. The vein widens gradually with depth, reaching 36 inches at the 800 foot level, and 40 inches at the 1,060 foot level (Crawford, personal communication and notes). The sandstone walls are impregnated in places to a depth of 20 feet from the vein. Ore from the Pariette mine, located in SE¼ of section 30, T. 8 S., R. 17 E., S.L.M., contains a large percentage of "selects" with a melt point of 275° F. (Hendricks, 1943). In 1960 a shaft on the vein had reached a depth of 1,500 feet, making the Pariette the deepest gilsonite mine in the basin (Baker, personal communication).

Cropping out in rocks of the Uinta formation (upper Eocene), this vein was first mined in 1890. Federal authorities surveying the boundary of the Uncompahgre Indian Reservation were persuaded to shift the boundary line a mile or more to the east to permit part of this vein to be legally owned by white men. In 1896, Eldridge (p. 932) stated that the Pariette vein was the only workable vein in the area, and this with difficulty.

The Pariette vein is broken at intervals by short transverse post-vein faults, with horizontal offsets of 1 to 6 feet, moving each segment toward the west, en echelon. The vein does not appear to be seriously affected by these faults. Lateral veins up to 16 inches wide occur within a fractured zone 250 feet wide, mostly east of the Pariette vein (Eldridge, 1901). The Pariette vein is owned by the Standard Gilsonite Company of Salt Lake City, Utah, and had produced an estimated 110,580 tons of gilsonite by the end of 1952 (Remington, 1959).

The Castle Peak vein, also called the Seaboldt or Baxter vein, is a southeast extension, offset somewhat, of the Pariette vein. It was discovered in about 1887 on the Uncompahgre Indian Reservation (Remington, 1956, p. 74). The Castle Peak vein lies about 100 feet east of the trend of the Pariette vein, striking S35°E for a distance of 7 miles to the southeast. The Castle Peak vein is about 12 inches wide at the northern end, and splits into two veins 12 to 16 inches apart at the southern end (Eldridge, 1896, p. 933). The ore from the Castle Peak mine, located in section 4, T. 9 S., R. 17 E. S.L.M., is similar in most respects to ore from the Pariette mine.

In 1949 the vein had been mined to a depth of 1200 feet. The ore on the 1200 foot level is considered to be a better grade than ore found at higher levels. Some ore was so soft it could be wound on a stick like soft tar (Carey and Roberts, 1949). The mine is owned by G. S. Ziegler of Great Neck, New York, and is still in operation.

The Baxter vein, or "Dalton area," also called the January vein, is actually a broken area of gilsonite veins and veinlets in the region where the Pariette and Castle Peak veins meet. It is owned by the American Gilsonite Company and held in reserve (Remington, 1959).

The April vein, located 2 miles northeast of the Pariette mine, runs parallel to the strike of the Pariette vein for about 3000 feet. At the 240' level it is 42 inches wide (Lawrence Wall and James R. Hall, personal communication).

Cowboy-Bonanza Area

The discovery of gilsonite veins in eastern Uintah County in 1887 by cowboys on the Uncompahgre Indian Reservation quickly lead to the exploration of the 9 or 10 large veins in this area. The Cowboy vein, the largest of the gilsonite deposits, and the other large veins in the area have supported large scale mining operations continuously since the turn of the century.

The Cowboy vein, the northernmost large vein in the Cowboy-Bonanza system, reaches a maximum width of 22 feet and runs for over $13\frac{1}{2}$ miles. The vein begins on the north wall of the White River canyon, near the Utah-Colorado state line, and trends N60-65°W with a dip ranging from vertical to 87° N. At the Bandanna Mine, section 17, T. 9 S., R. 25 E., the vein is $17\frac{1}{2}$ feet wide in the lower Uinta formation (upper Eocene). The vein seems to have its roots below the Mahogany oil shales, deeper than the other veins in the area, and widens rapidly in the upper Green River sandstones (Eocene), narrowing again in the overlying Uinta formation, until it pinches out in the upper Uinta beds (Douglass, 1928, p. 16).

Ore from this vein is classed as "seconds", with a melt point of 350° F. (Hendricks, 1943). The ore is pencillated and fractures easily. Since 1956 the Eureka mine has utilized the highly successful hydraulic jetting method. The gilsonite is reduced to minus 1/8 inch chips for transportation as a slurry mixture with water via a 72-mile long, 6-inch diameter pipeline to the gasoline and carbon-coke producing refinery at Gilsonite, Colorado, at a rate of 325-350 gallons per minute. The Cowboy ore is uniquely suited to this type of mining and transportation, and since it is too refractory for higher uses, such as varnish or paint base, the operation is considered highly successful (Remington, 1959). Douglass (1928) estimated ore reserves of 8,763,750 tons[5]. Since 1928 the vein has been traced farther to the west. The lower 500 to 600 feet of the vein is broken and irregular, in places filled with sandstone debris making recovery impossible.

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5. J. M. Baker of American Gilsonite Company, in a personal communication, remarked that Douglass' ore estimates of the Cowboy and other veins have since been found to be optimistically high, failing to exclude ore not commercially recoverable by present methods.

The "E. B." vein is a 5 to 6 foot wide vein which parallels the western part of the Cowboy vein approximately 100 feet to the north. "E. B." is said to be an abbreviation for Extra Black (Hendricks, 1943), and the ore is of a very high quality, being presently used as a rubber substitute in industry. Total length of this vein is about 4 miles.

The Tabor vein, which branches to the west to form the Bonanza and Little Bonanza veins, strikes N 56° W for a length of 3 miles and is 10 to 14 feet wide. The vein has its roots in the upper oil shales of the Green River formation and extends upward to within 100 feet of the top of the Uinta formation. Like the other veins in the area, it is widest in the lower Uintah formation (Douglass, 1928). The gilsonite exposed on the surface of the vein is deeply weathered, possibly to great depth.

The Bonanza vein, also known as the Independent vein, is the northern branch of the Tabor vein west of the point where the Tabor vein splits. Striking N 61° W, this vein runs nearly 7 miles and has its maximum width of 14 feet near where State Highway 45 crosses the vein. The Bonanza vein had not been fully explored in 1928 when Douglass made his report, but was estimated to be 993 feet deep. Near the northwest end of the vein (in section 16) the ore is very rich, forming tarry balls when heated by the sun. It is thought that the Bonanza and Little Bonanza veins join at depth (Douglass, 1928). The Bonanza vein is 6 feet wide near the junction of the Little Bonanza, reaches 13½ feet wide some 2 miles to the northwest, and decreases to 7 or 8 feet wide 3½ miles from the junction.

The Little Bonanza vein is the southern branch of the Tabor vein. Until recently it was the most important vein in the area. Striking N66°W, the vein averages 9 feet or more wide for a distance of nearly 6 miles. At its western end the vein measures 4 feet wide and begins to branch. The eastern end of the vein measures 16 feet wide and varies little with depth. The ore is mixed, with selects occurring as lenses in the pencillated "seconds" ore even to great depth. The Temperance mine, operated from 1904-1914 and revived again in 1935, is known today as the Bonanza Mine. Both open pit and underground mining are carried on at this mine. The Little Bonanza mine, to the northwest, produced large amounts of ore from 1908 to 1917. Shafts are reported to have reached a depth of over 800 feet on this vein, exposing good ore with a soft film of gilsonite on the vein walls. The width of the vein increases slightly with depth and the percentage of selects is said to increase with depth. Ore reserves for the vein are estimated at 5,506,180 tons (Douglass, 1928). The melt point of ore from the Little Bonanza ranges from 290° to 300° F. (Hendricks, 1943).

The Chapita and Little Chapita veins[6] occur parallel to, and a short distance south of, the Tabor vein. The Little Chapita is only a few hundred feet southwest of the Tabor, while the Chapita is about ½ mile southwest of the Tabor. Approximately midway between the Chapita and Little Chapita veins is a third unnamed vein, about which very little is known.

The Little Chapita vein is narrow, ranging from 1 to 2½ feet wide for a length of 1½ miles. The Chapita vein is 1 to 1½ feet wide and has a total length of almost 4 miles. It is widest in the lower Uinta formation and reaches an estimated depth of 800 feet (Douglass 1928).

6. Variously spelled Chipeta, Chepetta, Chepita.

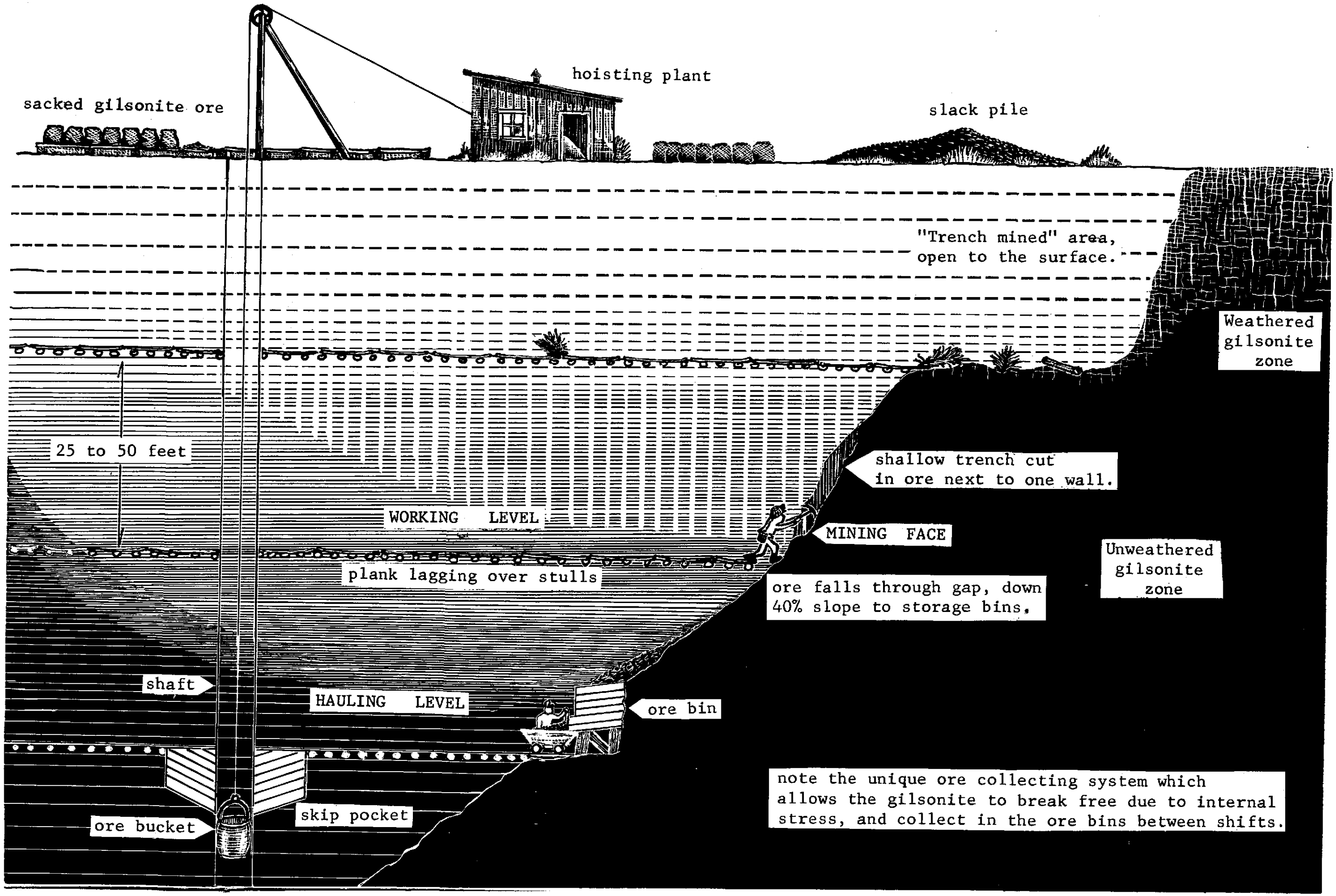


Figure 11. Generalized diagram of a small gilsonite mine.

The Wagon Hound, Weaver and Colorado veins are, in all probability, the same vein with different names in different areas. The Wagon Hound vein is located about $1\frac{1}{2}$ miles south of the Little Bonanza vein. It strikes N65°W and can be traced northwestward from the bluffs on the White River for a distance of about 5 miles. The greatest width is over 3 feet, near the western end. The vein has its roots 63 feet into the Green River oil shales, where it splits up into smaller veinlets (Douglass, 1928).

The Weaver vein strikes N61-65°W, on line with the Wagon Hound vein, and runs southeast from a point near the White River. Where it crosses the state boundary and enters Colorado the vein is called the Colorado and Black Diamond vein. Because it lay in Colorado, outside the Uncompahgre Indian Reservation, this vein was one of the earliest to be mined in the Basin, in about 1890. The vein is reported by Douglass to be over 1000 feet deep, extending 300 feet into the Wasatch formation. It measures 3 feet wide near the Colorado state line and runs 6 miles to the southeast, eventually thinning to 6 inches wide. The vein has been worked to depths of 100 to 300 feet and contains pencillated, or "seconds", ore. The vein was abandoned in 1904 (Douglass, 1928; Cashion, 1956). No measurements on the Weaver vein are available, but the ore is reported to be "select".

The Uinta vein, also known as the Little Emma, is located less than a mile south of the Wagon Hound vein. It strikes N65°W for a total distance of $5\frac{1}{2}$ miles, beginning in the bluffs of the White River near the bridge on State Highway 45. The vein has a maximum width of 4 feet (Cashion, 1956) and increases slightly with depth. The Little Emma mine was opened in 1920 and by 1928 had reached a depth of 752 feet, where the width of the vein had increased by 6 inches. The estimated maximum depth of this vein is 750 to 800 feet (Douglass, 1928). The ore from this vein is considered as better than "select", and is presently used to undercoat the interiors of new automobile bodies (Baker, personal communication).

Rainbow-Watson Area

This great area of gilsonite veins is not as actively mined today as it has been in the past. From 1904 to 1936 the eastern part of this area was served by the famed Uintah Railway, and the great bulk of gilsonite production came from these veins. Since 1936 the mining effort has shifted to the Cowboy-Bonanza area, and the mines of the Rainbow-Watson area are idle.

The Pride-of-the-West, Rainbow and Black Dragon veins, are segments of the same vein system which can be traced without interruption for over 19 miles. It is the longest vein in the Uinta Basin, and certainly the most important vein south of the White River. The southeast segment of the vein strikes N50°W and is called the Black Dragon vein. The northwest segment strikes N63°W for a distance of almost 14 miles, and is known as the Pride-of-the-West vein. The Rainbow vein is the name for the eastern end of the Pride-of-the-West vein, in the vicinity of the Rainbow mine. At a point in $S\frac{1}{2}$ section 14, T. 11 S., R. 24 E., the two segments of the vein intersect, forming an obtuse angle with short extensions continuing on for a short distance past the intersection. This intersection is a convenient boundary between the Pride-of-the-West and Rainbow segments.

The Black Dragon vein was known prior to 1896, and had been considerably prospected near its southern (eastern) end when Eldridge (1896) reported on the area. At that time the southern end was reported to measure 8 feet 6 inches wide, with the vein walls impregnated with asphalt 1 to 3 feet from the vein. The vein in this area is very pockety and splits into two closely spaced parallel veins in the middle Green River oil shales, but does not extend upward through the upper Green River oil shales. In this respect it is the deepest vein in the basin, and would appear to underlie the Rainbow vein without any vertical connection between the veins (Douglass, 1928, p. 94). Eldridge (1896, p. 937) observed two 18-inch wide zones of gilsonite-impregnated sandstone passing upward from the upper termination of the Black Dragon vein, and speculated that these zones might indicate an open fissure which had subsequently closed while the gilsonite was still fluid. Whether these zones pass upward into the Rainbow vein, and thus afford a possible connection, has never been determined. The northwest "end" of the Black Dragon is approximately where it crosses the Township 11-12 South line.

The Black Dragon vein is 1 to 5 feet wide, with an average depth of 677 feet. Pockets near the bottom of the vein measure up to 14 feet wide. There is much debris in the bottom parts of the vein and it is not considered workable in the lower Green River oil shales. Most of the ore is "selects", even as shallow as 75 feet below the surface. Seams of the ore have been spoiled by groundwater which slacked the ore and in places deposited calcite crystals in fractures in the gilsonite. The vein was first worked in 1903, but after 1912 operations were limited to small leases (Douglass, 1928).

The Rainbow vein is eroded almost to its roots and bottoms out several hundred feet above the Black Dragon vein, approximately 200 feet below the Uintah-Green River contact. Whether the Black Dragon vein continues westward beneath the Rainbow vein, as envisioned by Douglass (1928), is not known. The Rainbow vein is uniformly about 8 feet wide although it splits and divides in places. Most of the workable ore is very shallow, occurring in the upper Green River and lower Uinta formations. The maximum depth of the vein on the northwest end is only 419 feet. At this depth the vein splits into four veins, then into smaller veins. The ore is mostly "selects," but contains partings with dull surfaces, causing much of it to be shipped as "seconds" (Douglass, 1928). In 1911 the Uintah Railroad was extended to the Rainbow vein and supplied five mines. In 1938 the Rainbow mine was closed, except for limited lease mining which continued into the 1950's. Watson, the camp that served the mines in this vicinity, is now abandoned (Remington, 1959).

The Pride-of-the-West vein is the western segment of the Black-Dragon-Rainbow vein system. The historical boundary between the Pride of-the-West and Rainbow veins is not certain, but a convenient boundary exists where the two veins intersect in section 14, T. 11 S., R. 24 E. West of this point the vein strikes N61°W for a distance of almost 14 miles. The vein measures 4 feet wide at the eastern end, near the intersection, and gradually tapers to 3 feet 6 inches at Asphalt Creek and finally 18 inches wide at its western end near Bitter Creek. The vein is thought to be shallower than the Rainbow vein, having an estimated average depth of only 317 feet east of Asphalt Creek (Douglass, 1928). West of Asphalt Creek the vein is virtually unexplored. This was one of the last major veins to be discovered, around 1900, and has received little attention except near its eastern end, near the Brown Bear mine.

The Alabama and Rustler veins are two separate small veins in the area north of the Pride of the West-Rainbow vein. At least three other small unnamed veins are known in the area northeast of the Rustler vein and south of the White River, in T. 10 S., R. 24 E., section 13 and 14, 23 and 24, and in 26 and 27, respectively. The Alabama vein lies parallel to and about 3/4th's of a mile north of the Pride-of-the-West vein. It has a reported length of 4 miles, ranging from less than a foot wide at either end to 18 inches wide near the midpoint of the vein. The Alabama vein crops out in the lower Uinta formation. The ore looks fresh and rich and breaks into blocks instead of the typical conchoidal fractures (Douglass, 1928). The Rustler vein is only 1½ miles long with a maximum surface width of 6 inches. It is located 1 1/3 miles northeast of the eastern end of the Pride-of-the-West vein. Both veins are parallel to the other large veins in the area.

The Harrison vein is the second largest vein in the area, striking N 40° to 58° W for a total distance of 16 miles, and ranging from 1 to 3 feet wide. Douglass (1928) reports that no select ore has been found in this vein. West of Asphalt Creek the vein has been mined, but the ore was seconds. The ore splits into plates diagonal to the vein, and appears to be disturbed and broken, rather than pencillated. The southeastern end of the Harrison arcs to the southward. This departure from the general strike pattern of veins in the area is unexplained.

The South Harrison vein is actually two or more separate veins south of the main Harrison vein. The southeast segment of the South Harrison vein is 2½ miles long and 18 to 24 inches wide. Six miles to the northwest and on the same course are three separate segments or veins, each a mile or more long and a foot or so wide. Any one of them may be a continuation of the same vein or vein system. The Snow vein is the only one which has been separately named. The other main segment of the South Harrison vein lies ½ mile to the southwest of the first segment of the South Harrison vein, and strikes N60°W. This segment or vein is 6 1/2 miles long and 1 to 3 feet wide. Douglass (1928) remarks that the filling material in this vein does not appear to be gilsonite, as it will float on water and differs in physical appearance from typical gilsonite.

The Little Chief vein is one of several small veins southwest of the South Harrison veins about which very little is known. The Little Chief is about a mile long and 12 to 18 inches wide. The nearby Fox vein is 2 miles long and 12 inches wide. The Nigger Baby vein is 6½ miles long and 1 to 3 feet wide. There is a shaft on this vein in state-owned section 32, T. 11 S., R. 24 E. The vein is said to measure 6 feet across at one point near Kings Well in Asphalt Creek (Douglass, 1928). The Neal vein is about one mile long and has been opened by a tunnel in section 32, T. 11 S., R. 24 E. Several small veins are reported south of the Neal vein, but little is known about the area. The Jim vein, in T. 12 S., R. 23 E., is reported to be a mile long and 18 inches wide, but little else is known about it.

Lower White River-Ouray Area

The area west and south of the mouth of the White River, in the vicinity of the Green River, is known to contain numerous moderate to small sized veins of gilsonite. Owing to their late discovery and the fact that most of the area has been closed to gilsonite mining by federal order, available information is scarce and sometimes con-

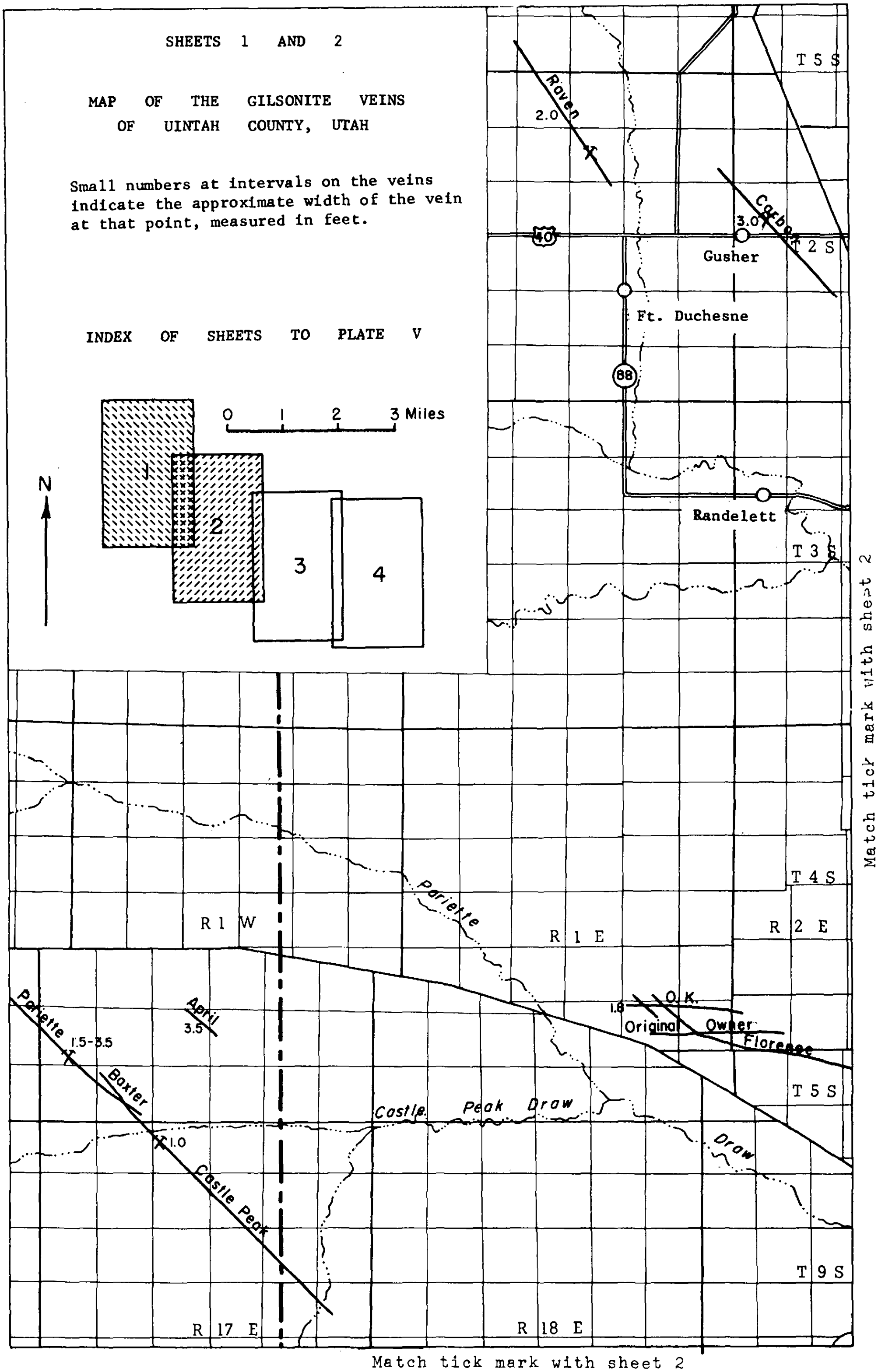
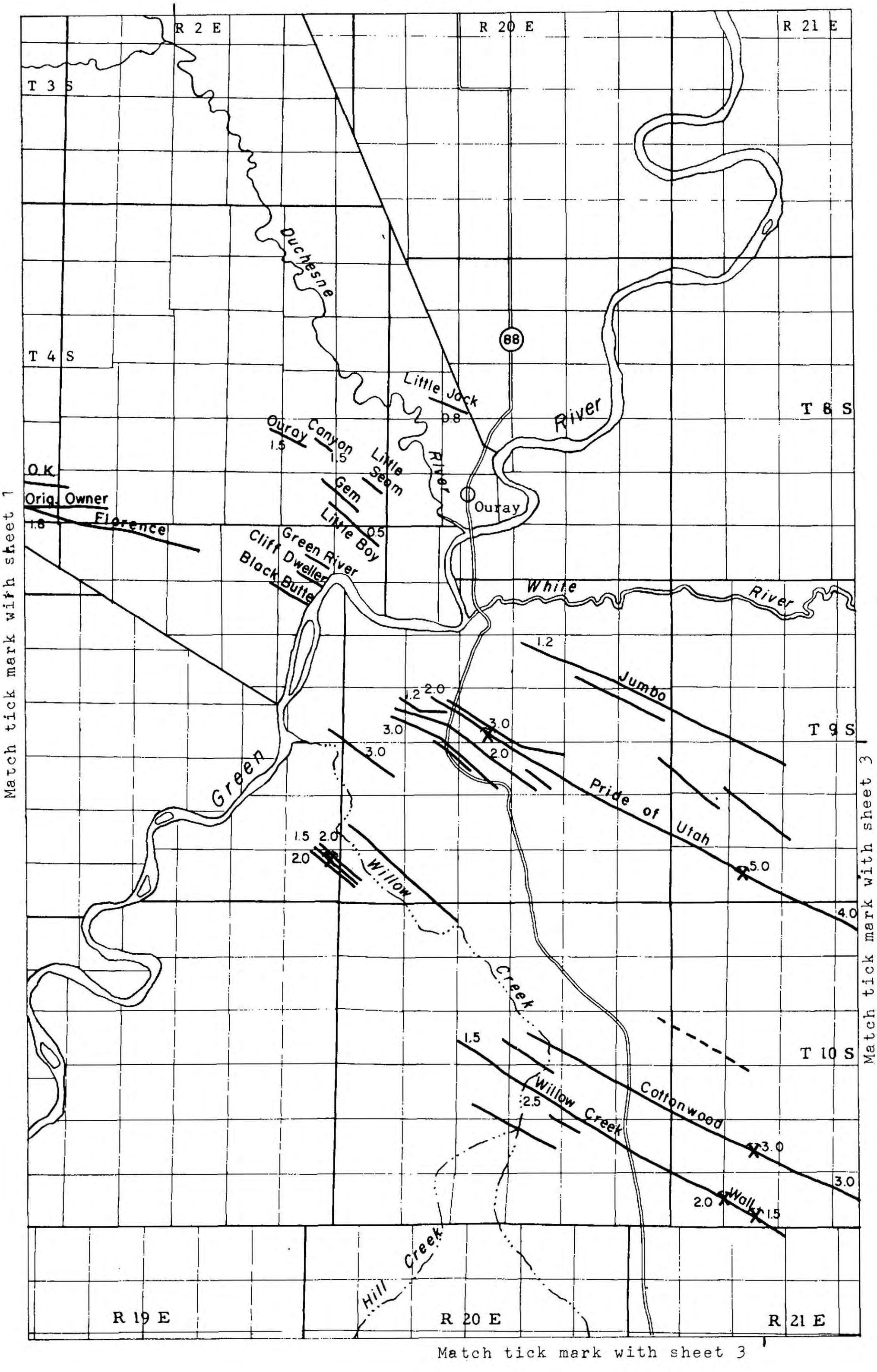


PLATE V. MAP OF THE GILSONITE VEINS.


R 2 E
R 20 E
R 21 E
T 3 S
T 4 S
T 8 S
T 9 S
T 10 S
Duchesne
River
88
Little Jack
0.8
Ouray
1.5
Canyon
1.5
Little
Seam
Gem
Little Boy
0.5
O.K.
Orig. Owner
1.8
Florence
Green River
Cliff Dweller
Black Butte
Ouray
White
River
1.2
Jumbo
1.2
2.0
3.0
3.0
2.0
3.0
Pride of Utah
5.0
4.0
Green
1.5
2.0
2.0
Willow
Creek
1.5
Willow Creek
2.5
Cottonwood
3.0
3.0
2.0
Wall
1.5
Hill
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R 19 E
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Match tick mark with sheet 1
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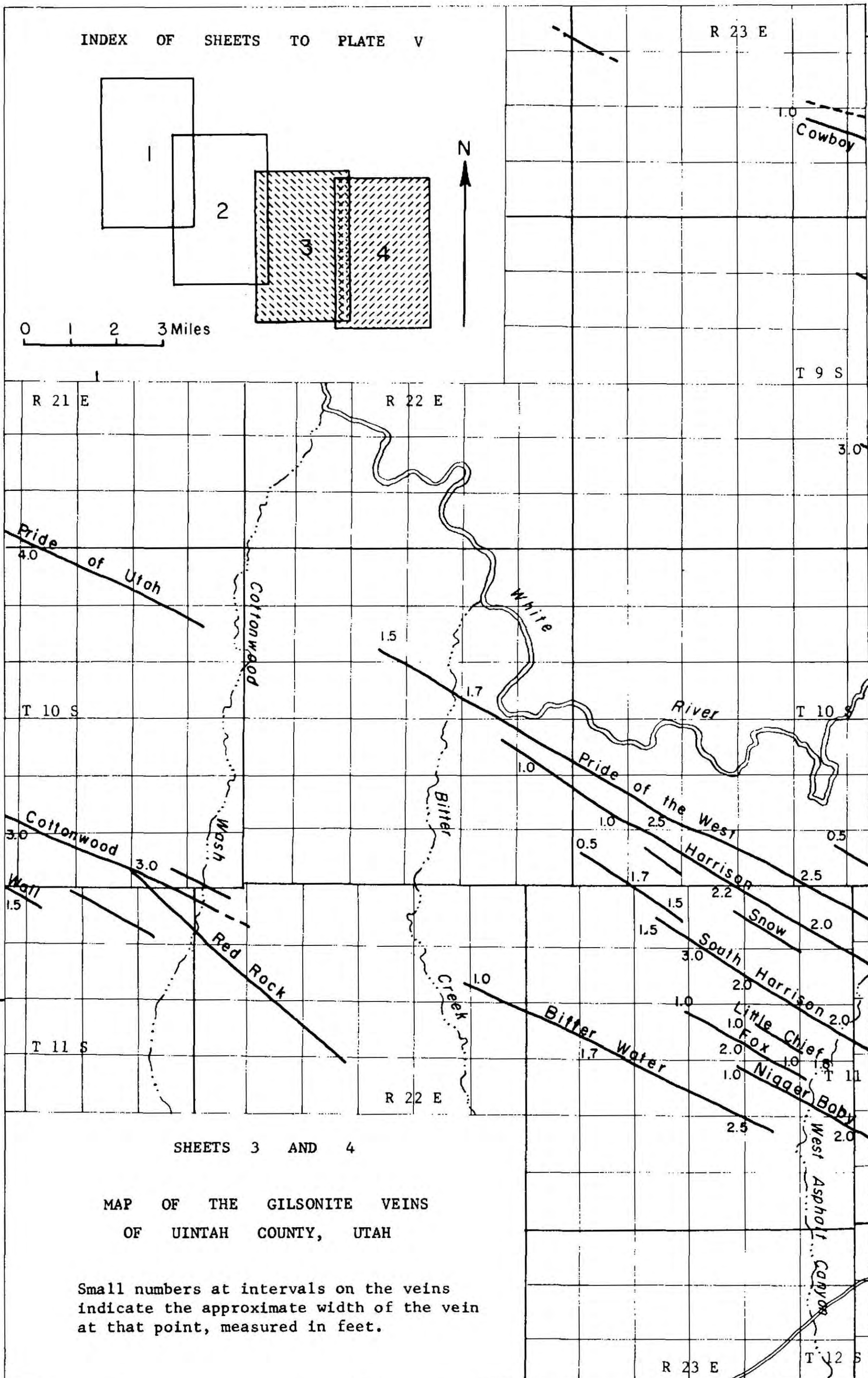

Match tick mark with sheet 4

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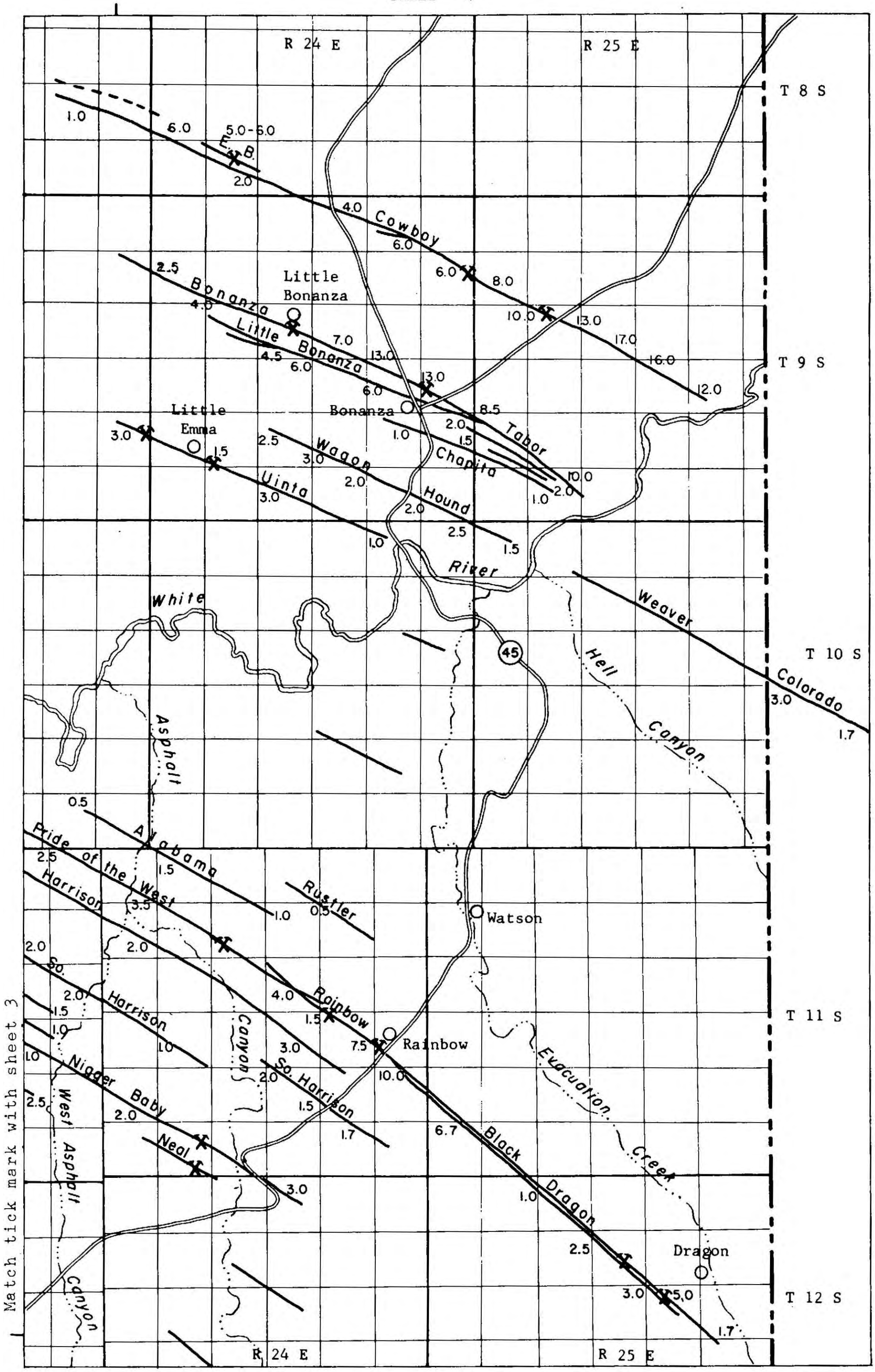
SHEET 4



R 24 E
R 25 E
T 8 S
T 9 S
T 10 S
T 11 S
T 12 S
E. B.
Cowboy
Bonanza
Little Bonanza
Tabor
Chapita
Wagon
Hound
Uinta
Little Bonanza
Bonanza
Little Emma
White
River
Weaver
Colorado
Hell
Canyon
45
Asphalt
Alabama
Pride of the West
Harrison
Rustler
Watson
So. Harrison
Rainbow
Canyon
So. Harrison
Nigger Baby
Neal
West
Asphalt
Canyon
Evacuation
Creek
Black
Dragon
Dragon
Match tick mark with sheet 3

flicting. The following descriptions were pieced together from unpublished sources considered to be reliable.

The Pride of Utah vein, south of the White River, strikes generally N63°W for a distance of almost 11 miles, ranging in width from 5 feet at the Anthill mine in section 32, T. 9 S., R. 21 E. (Hall and Wall, personal communication) to 3 feet wide at the Black Gnat mine in section 16, T. 9 S., R. 20 E. The ore at the Black Gnat mine comes from six closely spaced veins ranging from 14 to 34 inches wide, and has a melt point of 325° F. Although the mine is shallow, nearby veins are mined to a depth of 1300 feet (Hendricks, 1943b).

The Jumbo vein is located 2 miles northeast of the Pride of Utah vein, and strikes N67°W. The length is reported to be about 5 miles, possibly longer to the southeast, with a width near the west end of 12 to 14 inches. Between the Jumbo and Pride of Utah veins several short veins were observed on aerial photographs, but their commercial value is unknown.

South and west of the Black Gnat mine are numerous small veins. The Black Diamond mine[7], in section 36, T. 9 S., R. 19 E., is on three unnamed veins ranging in width from 14 to 22 inches wide, all occurring within a 200 foot wide zone (Hendricks, 1943b). The ore from this area is reported to be of poorer quality than the ore mined in the Bonanza or Rainbow areas (Hall and Wall, personal communication).

On the west side of the Green River, near Ouray, are several small veins which may well be extensions of the veins observed near the Pride of Utah and Jumbo veins. All of the veins described below are on patented mining claims within the old Uintah Indian Reservation.

The Little Jack vein, north of Ouray, on the east side of the Duchesne River, is less than 1½ miles long and 8 to 10 inches wide. The strike is N70°W. Southwest of the mouth of the Duchesne River, overlooking the west bank of the Green River are eight additional small veins. The Canyon and Little Seam veins, both of which strike N55°W, may be the same vein. The Canyon vein is reported to be 18 inches wide. The Ouray vein, about 3000 feet long and 18 inches wide, strikes N65°W, and may be a branch from the Little Seam-Canyon vein. The Gem vein and the nearby Little Boy vein strike N43°W. The Little Boy vein is reported to measure 6 inches wide. The Green River, Cliff Dweller and Black Butte veins are three roughly parallel small veins located in the bluffs west of the Green River. All three veins strike approximately N56°W. These veins are not being mined, and there is no record of any production from them.

The Florence, O.K., and Original Owner veins are part of a complex vein system north of Pariette Draw and 8 miles west of Ouray. The Florence vein appears to strike N 76° W and intersect the original Owner vein, which strikes almost east-west. The O.K. vein parallels the Original Owner to the north, and is reported to measure 20 inches in width. These veins have been mined, but the total tonage of gilsonite is reported to have been small. Two small veins are reported to strike N 55° W, apparently occurring as branches of the major veins.

7. Not to be confused with the Black Diamond Vein in Colorado, called the Colorado vein in this report.

Willow Creek Area

Three moderate sized veins occur near the junction of Willow and Hill Creeks, and in the area to the east. Numerous smaller veins have been found in the area, but since the only permissible mining has been by lease on state-owned lands, information is meager.

The Willow Creek or Wall vein strikes N60°W for a distance of approximately 8 miles. It measures 30 inches wide at Willow Creek, where shallow pits expose the vein, to 24 inches wide in NW$\frac{1}{4}$ section 32, T. 10 S., R. 21 E. The Wall mine, in section 32, exposes a width of 15 inches.

The Cottonwood vein, sometimes known as the Black Prince vein, is 1$\frac{1}{2}$ miles north of the Wall vein and mine, and strikes N64°W for a total length of almost 10 miles. Measurements at the "G.K." mine in section 29, T. 10 S., R. 21 E., and at section 36, T. 10 S., R. 21 E., show the vein to average about 36 inches wide. It is considered the best vein in the area for mining (Wall and Hall, personal communication). The G. K. mine is now closed since it was a trespass on federal gilsonite lands which were withdrawn in 1910.

Near the eastern end of the Cottonwood vein, according to unconfirmed reports, is another large vein called the Red Rock vein[8]. It is reported to strike N48°W for an approximate distance of 5 miles, apparently branching from the Cottonwood vein.

Other small veins are reported in the area, and small scale mining from veins on Wild Horse Bench, west of Willow Creek is reported from several sources (Remington, 1959).

ECONOMIC VALUE OF THE GILSONITE DEPOSITS

The gilsonite deposits of the Uinta Basin, practically all of which lie within Uintah County, represent a major mineral resource of the United States. These deposits have been mined continuously since 1888, a period of 72 years, and yet the deposits have only been tapped. Estimates of gilsonite reserves in Uintah County range as high as 30,000,000 tons, and could go higher in the event of intensified exploration.

Mining and Technology

Early gilsonite mining practices in the Uinta Basin were primitive and hazardous, and transportation to distant railheads and markets was costly. In those early days a vein was mined by trenching along surface exposures to whatever depth was considered safe. When falling debris and bad air dictated, mining switched to underground methods, sinking shafts to shallow depths and drifting along the vein at convenient intervals, or constructing plank floors at frequent intervals to keep debris out of the mine. Actually the entire vein in the vicinity of a shaft was usually one big stope, the "drift

8. This vein is shown on several maps of the gilsonite veins in the area, but no confirmation of its exact length, width, etc., could be obtained from the sources consulted. Whether such a vein actually exists is doubtful.
9. This section is based primarily upon the works of Baker (1959), Remington (1959), and Carey and Roberts (1949).

levels" being plank flooring over wooden stulls, leading to the working face of ore. Pillars of ore were left at intervals, for support, but between the pillars the mine depended upon the solid, firm sandstone walls, and a minimum of round-pole stulls were used to brace the walls. The working face of ore was inclined at 40°, and the ore fell or rolled by gravity to a lower level where it was collected in bins and trammed in small cars to the shaft for hoisting to the surface. The ore was broken by hand, using a sharp pick to cut a small trench along one vein wall. Internal stresses within the ore then caused the gilsonite to break into lumps and fall down the inclined face to the hauling level below. These practices are still followed today in a majority of the smaller mines, despite the primativeness, because gilsonite mining is not easily mechanized.

The use of explosives in gilsonite mining is highly dangerous. Gilsonite dust is a very combustable substance, and will explode and burn if exposed to an open flame. Early miners practiced exploding the dust intentionally before it accumulated in dangerous quantities, but many disastrous fires nevertheless resulted, fed by the gilsonite and wooden mine timbers. Melted gilsonite would solidify after a fire, encasing men and machinery, and filling parts of the mine. Some gilsonite fires have been known to smolder for years, only to burst forth again. According to tests, gilsonite dust must contain 90 to 95% rock dust to render it safe from explosion (as compared with coal, which must contain only 60 to 65% rock dust). In detonating explosives 100% rock dust tamping had to be used, and this practice was difficult to enforce. As a result, most gilsonite mines prohibit the use of any explosives underground (Carey and Roberts, 1949).

Attempts to mechanize gilsonite mining, particularly at the mining face, present some unique problems. Gilsonite is somewhat rubbery, and dissolves in lubricating oils. Pneumatic jack hammers have been used to break the gilsonite ore, but they tend to heat up the ore and stick in it. Also, lubricating oils for the machinery dissolved the gilsonite dust, fouling the mechanism. Rippers were also used, but the teeth would slide over the rounded conchoidal fracture surfaces, decreasing efficiency. Similarly, chain cutters, wire saws and other devices were inefficient or required excessive repair. Compressed air slushers, used without blasting, are effective, and are employed in several mines.

The most rewarding attempt at mechanizing gilsonite mining is employed at the Eureka mine on the mammoth Cowboy vein. It is called "jet-mining" and is actually a method of underground hydraulic mining. Water is jetted onto the face of gilsonite ore at 2000-2300 p.s.i. from a $\frac{1}{4}$ inch nozzle, flowing 82 g.p.m. at a velocity of 500 f.p.s. The jet action breaks the brittle Cowboy ore into chips and lumps which are flumed down a grade to a central crusher and into a sump. The ore is crushed to minus 3/4 inch and pumped 800 feet to the surface, where it is reduced to minus 1/8 inch and where all sand and other impurities are removed. The ore is then mixed with water to obtain a 40% by weight solids concentration, and this slurry is pumped at 325-350 g.p.m. via a 6-inch, 72-mile-long pipeline to a $16,000,000 refinery at Gilsonite, Colorado. Here the ore, classified as "seconds", is treated to produce petroleum products and metallurgical grade coke (Baker, 1959; Remington, 1959).

Markets and Uses for Gilsonite

Most gilsonite sold to consumers is still classified according to melting point of the crude ore, and is sold as lumps or fines, sacked in 100 or 200 pound bags or in bulk. "Select" ore, having the lowest melt point, brings the best prices. It is characteristically sold in lump form, it being too difficult to prevent blending the fines with "seconds" of poorer quality. Remelting the fines to make lumps results in a loss of volatiles and is not practiced by most mine owners. "Seconds" ore has a higher melting point and generally breaks easily into small particles and dust. It cannot be used for as great a variety of purposes as "selects", and brings a lesser price[10].

Much gilsonite is used directly in its crude form, as insulation for pipelines, particularly hot pipes, as waterproofing and undercoating for wood and metal, and as paving, roofing and other uses identical with crude asphalt. Gilsonite is also blended with refinery produced asphalt and petroleum products to obtain certain desired characteristics. It is used in saturating felts and building construction papers. Ore from the Pariette mine is sold as an additive for drilling fluids to stop loss of circulation and as a light weight cement to plug back wells and cement production liners in gas wells.

"Select" grade gilsonite will dissolve in all proportions in fatty acids, and makes an excellent base for paints, varnish, and japans. It is blended to form acid and alkali resistant coatings, and mastics for floor coverings. Gilsonite is used extensively as a filler in rubber (up to 30%), asphalt tile, battery boxes, phonograph records and a variety of other products.

By far the greatest quantity of gilsonite is processed through the refinery at Gilsonite, Colorado, where it is heat refined to produce high octane gasoline (25%), gas (15%), metallurgical grade carbon coke (50%) and other products. In this application, however, gilsonite is competing directly with cheap supplies of liquid petroleum from domestic and foreign sources.

Many historic uses and markets for gilsonite have been lost to cheap by-products of petroleum refineries. These petroleum by-products, many of which were once considered wastes, are produced at practically no additional cost, in localities more convenient to industrial markets. While new uses for gilsonite are developed from year to year, many of these applications are still in competition with the same cheap petroleum by-products. It is ironic, but not very encouraging, to note that this competition with cheap liquid petroleum has gone full cycle with the production of gasoline and oil from solid gilsonite.

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10. This early classification is giving way as modern research finds new markets for gilsonite. American Gilsonite Company markets its "select" ore as pea-sized lumps, and the fines are not separated. There is only a $3 per ton difference in the prices for "select" and "seconds" ore, and mixtures or blends are valuable for many uses. Pulverized gilsonite brings the highest price per unit, but this differential is due to costs incurred in grinding and sacking the gilsonite. Future demand for gilsonite may well shift to the more refractory grades to meet new market specifications.

Exploration and New Discoveries

Since 1910 very few new deposits of gilsonite have been discovered. Indeed, several known gilsonite veins remain unexplored both on the surface and underground, leading the observer to conclude that something basic is amiss in the gilsonite industry. The lack of exploration is not due to unproductive techniques or even to oversupply of gilsonite reserves.

Douglass (1928) observed that, at least in the Cowboy-Bonanza area, that the larger gilsonite veins characteristically pinch out as they extend upward into the upper Uinta and Duchesne River formations. The immediate inference is that veins outcropping in or above the upper Uinta horizon ought to be explored to determine if they widen with depth to become commercially minable veins. Also, the possibility of buried veins beneath this same horizon would bear examination. That buried veins exist and can be found is evidenced by reports from seismograph crews, who find that the verticle homogenous veins interfere with seismic investigations--including areas where no veins were thought to exist. Other geophysical techniques such as gravity and resistivity surveys hold promise as useful tools in mapping new gilsonite areas in the Basin. Conventional rotary drilling on the soft, tarry gilsonite in vertical veins is not usually rewarding. It is difficult to determine widths at greater depths with conventional drills, although large diameter calyx drilling might prove worthwhile.

The principal deterrent to exploring for new gilsonite veins is not physical or technical, it is legal. The Act of March 3, 1903 (32 Stat. 998) was an effort by Congress to open gilsonite mining on the Uncompahgre and Uinta Indian Reservations. Under this act mining claims located prior to 1891 would be legally recognized, and mineral tracts on even numbered sections not covered by pre-1891 claims could be purchased. The Presidential Proclamation of June 6, 1906 (34 L.D. 648) set a deadline for purchasing available mineral tracts and all lands not disposed of by 1910 were thereafter reserved to the Uinted States. The Executive Order of January 21, 1926 (No. 4371) and Secretary of the Interior Decision A-21949 of July 10, 1940, confirmed the effect of this latter action, which acted as a withdrawal of all new gilsonite deposits on whatever lands they might be discovered. Until the Act of September 2, 1960, there were no provisions for locating mining claims, obtaining prospecting or mining leases, or any other means of extracting gilsonite on the federal public domain.

On the other hand, gilsonite deposits on lands owned by the State of Utah are freely leased. In many large areas the only mining permitted is on these isolated state tracts, with the tantalizing result that isolated small mines on state lands are the only evidence along the strike of many gilsonite veins which run for miles across the empty public domain. A recent federal trespass action on the Cottonwood vein is only one of many indications of the pressure which exists to mine these valuable deposits which have lain idle for 50 years as a result of the general withdrawal.

While the writer was compiling the information for this chapter, Congress passed a new law which at long last reopens the federal lands to gilsonite prospecting and mining. The Act of September 2, 1960, (78 Stat. 781), entitled "An Act to amend the Mineral Leasing Act of Febuuary 25, 1920", contains in Section 7 an ammendment to permit the leasing of:

"...native asphalt, solid and semisolid bitumen, and bituminous rock (including oil-impregnated rock or sands from which oil is recoverable only by special treatment after the deposit is mined or quarried)..."Section 7 (a), at 74 Stat. 790.

For several months after the passage of the act, it was not generally considered that "native asphalt, solid and semisolid bitumen" might refer to gilsonite. Inquiries to Washington confirmed that gilsonite is covered by the term "native asphalt", and, therefore, is leasable under the new law[11]. At this writing, there are no leasing regulations in effect for gilsonite which would permit immediate mining, but presumably these will be drafted and released in due time. It will be interesting to see the effects of this sudden availability of long dormant deposits.

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11. Memorandum from the Director, U. S. Bureau of Land Management, dated February 7, 1961.

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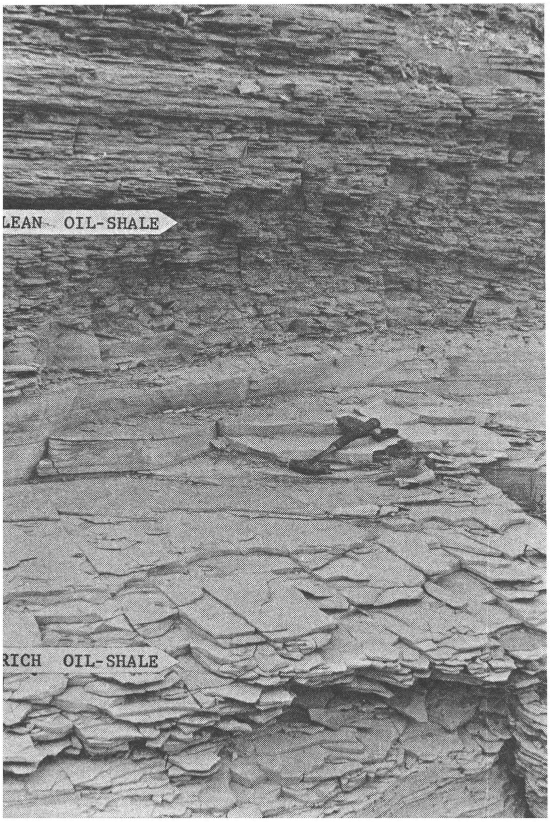


Figure 12. An outcrop of rich oil-shale near the White River. The rich beds are more resistant to erosion than the overlying shale beds and are exposed as hard, white, platy layers. Note the black interior of the freshly broken layer near the hand pick.

Figure 13. Specimen of rich oil-shale from the Mahogany ledge of the Green River oil-shale beds. Note the characteristic thin black laminations and massive appearance. As a general rule, the richer oil-shales are more black, while the leaner oil-shales grade into shades of brown (Specimen courtesy of G. E. and B. R. Untermann).

CHAPTER IV — OIL SHALE

Oil-shale as here defined is a shale or marlstone rock capable of yielding 15 gallons or more of oil per ton of rock upon destructive distillation. In the Uinta Basin the principle oil-shale beds are found in the Parachute Creek member of the Green River formation (Eocene), which underlies virtually the whole Uinta Basin. The richest and thickest bed of oil-shale is called the Mahogany bed or ledge, and is estimated to contain 14,500,000,000 bbls. of recoverable oil in the Dragon-Bonanza area alone (Cashion, 1956).

Rich oil-shale is a dark brown, fairly dense, fine-grained laminated rock which is quite resistant to weathering and forms conspicuous blue-gray ledges in the softer enclosing sediments. "Oil-shale" in reality is a marlstone composed principally of inorganic matter (50-75%), mainly dolomite and calcite, clay minerals (up to 21%), and analcite (1-16%). Organic matter in the oil-shale ranges from 0-50%, yielding up to 87 gallons of shale oil per ton of rock. The specific gravity of oil-shale varies inversely with the oil content, ranging from 1.67 for shale yielding 75 gal./ton, to 2.5 for shale yielding 10.5 gal./ton (U. S. Bureau of Mines, 1949). As a rule weathered samples of oil-shale yield as much as 50% less oil than unweathered samples taken a few feet in from the weathered surface. Cashion (1957, p. 135) states that it is possible to accurately estimate the oil yield of a sample by observing the color, luster, specific gravity, and texture of the rock.

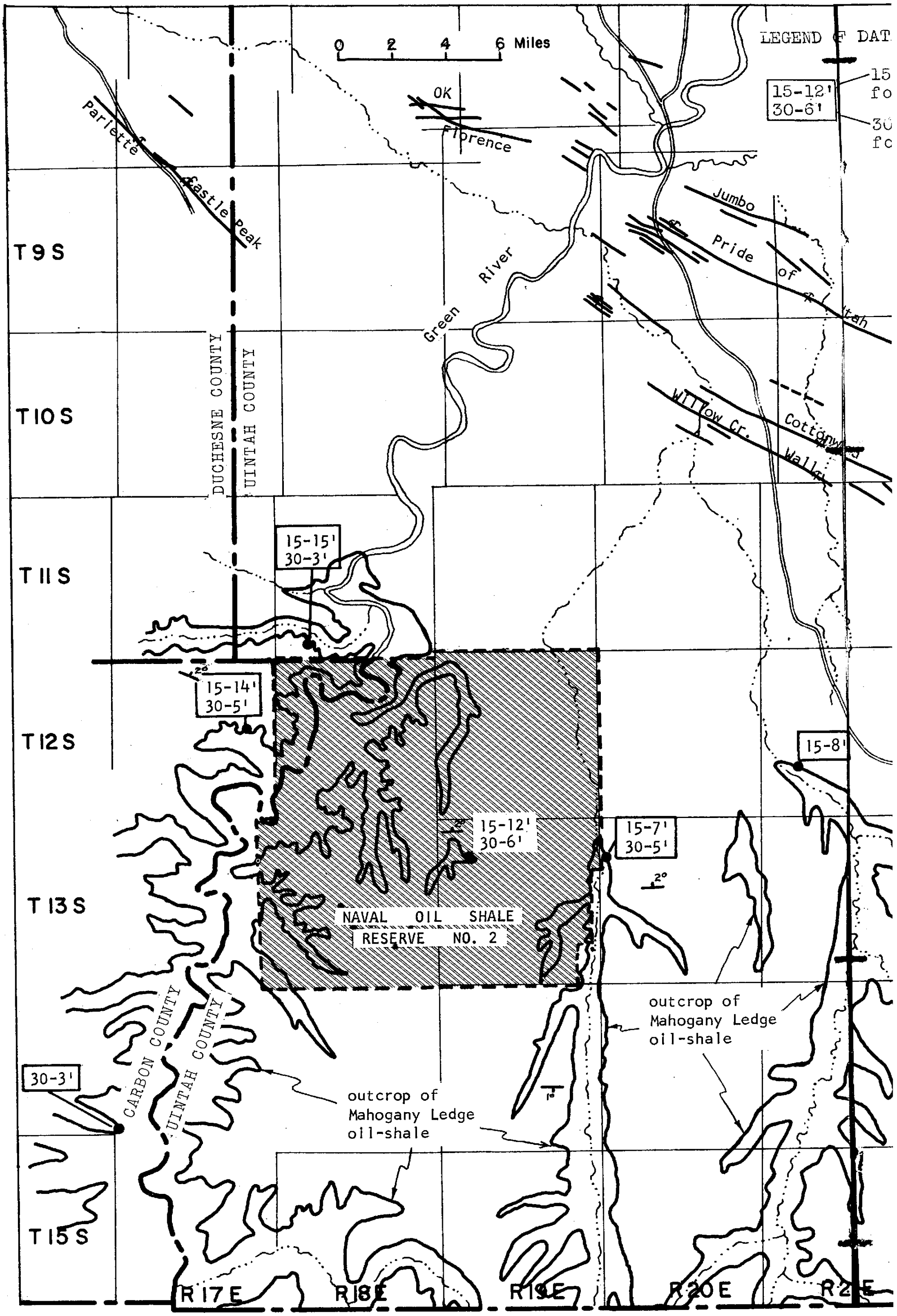
When oil-shale is heated to 400° F. or above in a closed system, part of the organic material passes off in a gaseous form and can be condensed and recovered as liquid petroleum, or shale oil. Shale oil has a specific gravity of 0.859 to 0.9327 (Winchester , 1918). It is a black, highly viscous, waxy crude oil, which at room temperatures is a soft slushy solid. Its pour point is 90° F., and transportation by pipeline of the raw shale oil is not practical. Shale-oil is a complex mixture of 50-65% by volume of pure hydrocarbons with the remainder consisting of organic compounds of sulfur, nitrogen, and oxygen. However, when properly refined, the finished products derived from shale oil are indistinguishable from their natural petroleum counterparts (Hartley, 1958).

Origin of Oil-Shale

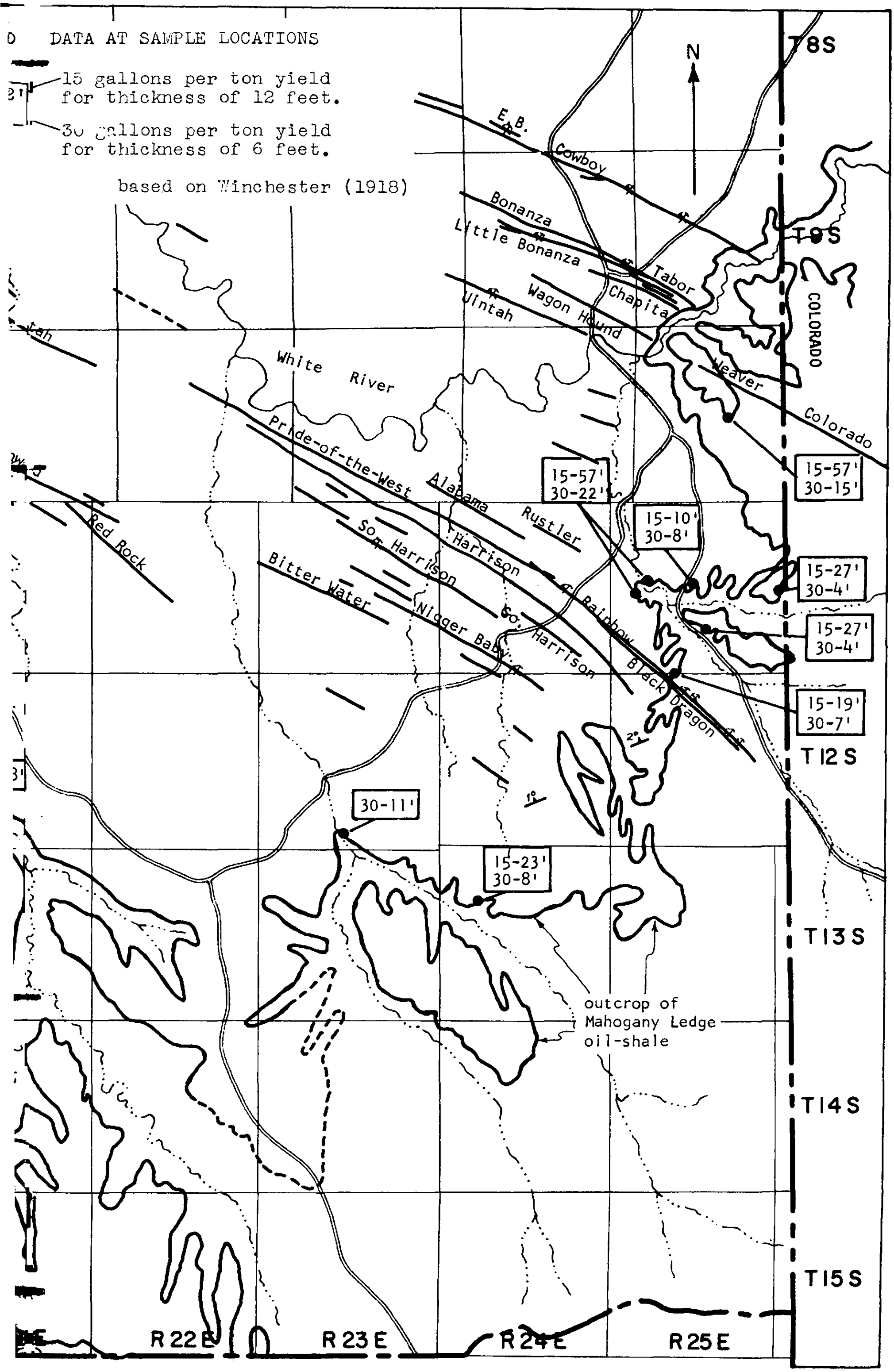
The organic matter in the rich oil-shale beds, sometimes referred to as kerogen, was deposited in the fresh waters of ancient Lake Uinta as aquatic organisms, waxy spores, pollen grains, algae, fragments of insects and larvae, fungi, and a host of structureless organic substances. These substances collected in a black fetid ooze at the bottom of the lake, in a chemically stratified saline zone which protected the organic matter from further bacterial decay. Shortly after deposition the matter was reduced to a gelatinous condition which in time was compacted and lithified without important change into the present organic material found in the rich oil-shale beds (Bradley, 1931).

Distribution of Oil-Shale

The oil yield from oil-shale in Colorado is estimated to total more than one trillion barrels of shale oil. Estimates of oil


0 2 4 6 Miles
LEGEND OF DAT
15-12'
30-6'
OK
Florence
Parlette
Castle Peak
Jumbo
Pride of Utah
Green River
Willow Cr.
Cottonwood
Wall
T9S
T10S
T11S
T12S
T13S
T15S
DUCHESNE COUNTY
UINTAH COUNTY
15-15'
30-3'
15-14'
30-5'
15-12'
30-6'
15-7'
30-5'
15-8'
NAVAL OIL SHALE
RESERVE NO. 2
30-3'
CARBON COUNTY
UINTAH COUNTY
outcrop of
Mahogany Ledge
oil-shale
outcrop of
Mahogany Ledge
oil-shale
R17E
R18E
R19E
R20E

MAJOR GILSONITE VEINS OF UINTAH COUNTY.



yield from the Uinta Basin, based on less complete information, total 120 billion barrels of shale oil recoverable from an estimated 200 billion tons of oil-shale (Robinson and Stanfield, 1960).

The oil-shale beds are most numerous and important in the Parachute member of the Green River formation, but the underlying Evacuation Creek and Garden Gulch members and the overlying Douglas Creek member contain a few beds of oil-shale. The rich oil-shale zone is thickest and richest north of the White River and west of Cowboy Canyon and decreases fairly abruptly to the north-eastward toward Raven Ridge. It appears to thicken to the westward, reaching a probable maximum thickness near the depositional axis of the Uinta Basin (Cashion, 1956, 1957). These observations are strengthened by studies in Naval Oil-Shale Reserve No. 2, in southwestern Uintah County, which show a decided thickening of rich beds to the northeastward, toward the White River (Cashion, 1959).

East of Uintah County, Utah, in the Piceance Basin of Colorado, the oil-shale beds of the Parachute Creek member achieve great thicknesses and experimental mining and processing have been undertaken there by both government and private industry. These deposits far exceed the quantity and richness of known deposits in the Uinta Basin and will be among the first to be commercially exploited. Robinson and Stanfield (1960) estimate that the Green River Basin of Wyoming contains 20 billion tons of oil-shale with an estimated oil yield of 12 billion barrels of shale oil.

Early Developments of Oil-Shale

The presence and value of oil-shale was recognized early in the Uinta Basin. In 1896, Eldridge's preliminary report on gilsonite is quoted as stating that "bituminous shale" might be of commercial value under favorable conditions of transportation[12]. The first attempt at a detailed study of oil-shale lands in Utah was made by Woodruff and Day (1914), followed by the more detailed reports of Winchester (1916, 1918, 1923). Shortly after World War I experimental mining and recovery operations were initiated by several private companies. In the Uinta Basin these operations centered about Watson, Utah. Interest in the commercial potential of oil-shale was very high during the period 1915 to about 1930. Naval Oil-Shale Reserve No. 2, consisting of 132 square miles in southwestern Uintah County, was withdrawn by Presidential Order of December 6, 1916 (Reserves No. 1 and 3 are located in Garfield County, Colorado). During 1922-1925 Wilmot Bradley (1931) conducted studies on the origins of oil-shale in the Green River formation. After an interval of almost 15 years, interest in oil-shale exploitation was revived when the U. S. Bureau of Mines began experimental studies on mining and treating oil-shale at Rifle, Colorado, in 1944. These studies, supplemented by the efforts of the Union Oil Company and the Sinclair Oil Company, are continuing to date in northwestern Colorado. Cashion (1956, 1957, and 1959) is the latest writer to study the oil-shale deposits in Uintah County, and other publications on oil-shale technology in northwestern Colorado are released each year from government and private sources.

12. At page xxxvii of House Documents, v. 14 (1895-1896), as quoted by M. J. Due, U. S. Bureau of Land Management, in an unpublished paper on oil-shale lands in the former Uncompahgre Indian Reservation.

LOCATION OF THE OIL-SHALE DEPOSITS IN UINTAH COUNTY

Oil-shale beds in the Green River formation in Uintah County are exposed at the surface as a broad arc, beginning near where the White River passes from Colorado into Utah, and swinging gently southward, passing near the headwaters of Asphalt, Bitter, Willow, and Hill Creeks, then turning sharply northward along the eastern slopes of Desolation Canyon on the Green River. The beds dip gently northward and are buried by later Tertiary sediments toward the center of the Uinta Basin. Along the northern flanks of the basin, the Green River formation is buried by overlapping sediments of the Uinta and Duchesne River formations, and is not exposed.

Dragon-Watson Area

The best surface exposures of oil-shale in Uintah County are located along the Colorado border south of the White River, near Dragon and Watson. This area has been mapped by Winchester (1918, 1923) and by Cashion and Brown (1956), and is the center of interest in oil-shale in Utah. Several thousands of acres of this area have been patented as petroleum or oil-shale placer claims, and the early attempts at commercial mining and retorting took place here in the 1920's.

Cashion and Brown (1956) made a detailed study of the area, and published the following indicated or inferred reserves:

(1) The richest part of the Mahogany ledge, 5 feet or more thick, yielding 45 g.p.t. or more in continuous section, is estimated to contain a total potential yield of about three billion bbls. of shale oil; (1 "barrel" of oil contains 42 gallons.)

(2) The part of the Mahogany ledge 15 feet or more thick, which yields 30 g.p.t. or more in continuous section, is estimated to contain a total potential yield of about 7.5 billion bbls. of shale oil;

(3) The part of the Mahogany ledge and adjacent beds 15 feet or more thick, which yield 25 g.p.t. or more in continuous section, is estimated to contain a total potential yield of about nine billion bbls. of shale oil;

(4) The Mahogany ledge and adjacent beds 15 feet or more thick, which yield 15 g.p.t. or more in continuous section, are estimated to contain a total potential yield of 14.5 billion bbls. of shale oil;

The most promising area for future development was described as a belt along the White River in T. 9 and 10 S., R. 25 E., where rich oil-shale is exposed near an available water supply, convenient to the Rangely, Colorado-Salt Lake City crude oil pipeline.

Another area, on McCook Ridge, T. 13 S., R. 23 and 24 E., and nearby deposits in the northeastern part of T. 13 S., R. 24 E., and northwestern T. 13 S., R. 25 E., are mentioned as possible sites for strip mining. The oil-shale in the two areas yields an average of 25 g.p.t. in a 15 foot section, under an overburden of 100 feet or less. This minable deposit is estimated to contain 70 million bbls. of recoverable shale oil within an area of three square miles.

Naval Oil-Shale Reserve No. 2 [13]

Established by Presidential Order of December 6, 1916, this reserve contains 132 square miles in T. 12 and 13 S., R. 18 and 19 E. Exposures of the oil-shale border the canyon of the Green River and tributary canyons, but most of the rich oil-shale beds are covered by overburden. The principal oil-shale zones are (1) the Mahogany bed and oil-shale beds in the basal Parachute Creek member and uppermost Douglas Creek member, ranging from 20 to 45 feet thick within the reserve, and (2) an upper oil-shale zone, 5 to 15 feet thick, present 30 to 80 feet above the main zone throughout most of the reserve. To the southwest the main zone decreases in thickness and richness and the upper zone disappears entirely.

Assuming that a minimum oil yield of 25 gallons per ton is necessary for development with present techniques, Cashion (1959) states that only a small area in the northeastern part of the reserve could be mined. This area comprises 16,757 acres and contains an estimated 1,417 million tons of oil-shale under overburden as thick as 950 feet. The deposit contains a potential yield of 843 million barrels of shale oil. Another small area in sections 1 and 2, T. 12 S., R. 18 E., was classified as suitable for strip mining. The oil-shale zone there averages 25 g.p.t. or 11 million barrels for the total estimated 18.5 million tons. Overburden is about 110 feet thick. Although thin to moderately thick overburden covers the oil-shale in many areas in the reserve, potential oil yield is too low for present economical mining throughout most of the oil-shale reserve.

Outcrop Area Between the Green River Canyons and Watson

The flat-lying to gently northward-dipping oil-shale strata are known to be exposed extensively near the headwaters of Hill, Willow, Bitter, and Asphalt Creeks, north of the Book Cliffs in southern Uintah County. Little published work has been done in this area, however, due, in part, to the fact that the oil-shale beds are presumed to represent a near shore facies, and shale exposures in this area are presumed to be low in oil content. The map of the oil-shale beds which accompanies this chapter is a modification of earlier small scale maps, previously published, drawn in conformance with recent topographic map coverage of the area (Winchester, 1923; Cashion and Brown, 1956; Cashion, 1957, 1959). (See Plate VI, page 52.)

Buried Oil Shale Beds Between the Uinta Basin

All evidence points to a gradual thickening of the richer oil-shale beds toward the axis of the Uinta Basin in an area north of the White River. Published reports of rich oil-shale encountered at depth by drilling are scarce, but Osmond (1957, p. 185-187) reports that an oil well in section 13, T. 7 S., R. 20 E., cut two oil-shale sections at 4100 to 6050 feet depths in the Green River formation. The upper zone, 4100 to 4950 feet deep, yielded an average of 18.5 g.p.t. of shale oil from the 850 foot thick zone, with the highest values below 4800 feet. The lower zone, 5750 to 6050 feet deep, yielded 1.0 to 12.7 g.p.t., with the highest values between 5870 to 5900 feet deep. He reports that other sections ran 3.0, 8.6, and up to 9.6 g.p.t.

13. Based on work by Cashion, 1959.

ECONOMIC SIGNIFICANCE OF THE OIL-SHALE DEPOSITS OF UINTAH COUNTY

The known oil-shale deposits in Utah, the richest of which are in Uintah County, are presently held in reserve pending a favorable conclusion to the experimental activities of the U. S. Bureau of Mines, the Shell Oil Company, the Sinclair Oil Company, and others, on the rich deposits of oil-shale in Garfield and Rio Blanco Counties Colorado. These Colorado deposits are estimated to contain up to 1,500,000,000,000 barrels of potential shale oil reserves (Nielson, 1958) and have received by far the greatest recognition and interest.

Mining and Retorting Oil-Shale

Although early efforts were made to mine and process oil-shale near Watson, Utah, all of the recent advances in oil-shale technology have come from the activities in nearby Colorado. The U. S. Bureau of Mines began in 1944 to experiment with mining and retorting methods, making comparative mining cost studies and improving shale oil recovery processes. Low-cost, underground "room and pillar" mining was successfully demonstrated by the Bureau of Mines. Another experiment presently in progress proposes to liberate shale oil directly from the oil-shale in place, by means of a controlled underground explosion of a thermo-nuclear device. It is hoped that the force of the explosion will shatter the surrounding rocks and that heat from the explosion will distill shale oil from the immediate blast area, causing it to collect as a liquid in the shattered peripheral zone where it can be recovered by conventional drilling and pumping equipment. The site of this experiment is near Rifle, Colorado, and the necessary tunnel for placing the atomic device underground has been completed. Presumably the only purpose for delaying the experiment is the current international moratorium against nuclear testing. The highly theoretical basis for this experiment makes the outcome speculative. Many considerations will have to be dealt with after the experiment is evaluated, but if it proves successful the vast, deeply buried reserves of oil-shale beneath the Uinta Basin will certainly take on added significance and value.

The more conventional methods of extracting shale oil from the rich oil-shale deposits are based on heat retorting, which is a crude form of distillation. Crushed raw oil-shale is fed into a closed vessel and heated to 400°-500° C. for a period of an hour or more. Oil and gas are formed and vaporize, along with volatile nitrogen and sulphur compounds. The vapors are condensed and collected for further refining to produce conventional petroleum products.

The standard retorting method in the oil-shale industry uses the Fischer retort. This device has been modified and improved upon over the years. A new shale retort built by Union Oil Company utilizes a unique "rock pump" which force-feeds the raw oil-shale into the bottom of the retort by a large ram-like piston (Hartley, 1958). As the shale is forced upward it is contacted by hot gases directed by blowers. Recovered oil and combustible gas are withdrawn from the bottom of the retort. Part of the gas recovered is utilized as fuel to retort additional shale. Spent shale ash is spilled over the top of the retort into a chute, allowing continuous operation.

Products of Oil-Shale

The Union Oil shale retort is reported to produce crude shale oil at a retorting cost of one dollar per barrel, at a rate of approximately 250 barrels per day. The retort has operated at a rate of 550 tons of oil-shale per day, yielding from one-half to two-thirds of a barrel of oil per ton. Hartley (1958) states that a retorting cost of fifty cents per barrel of oil is considered possible with increased output. These cost estimates do not include mining or transportation costs, however.

Shale oil can be further refined into high octane gasoline, solvents, kerosene and diesel fuels, lubricating oils, and combustible gas. Valuable by-products include electrode-grade carbon coke, ammonia, sulphur, and petroleum waxes. The waste "spent" shale represents a disposal problem, since it would accumulate in large quantities from any commercial operation.

Current Restriction on Oil-Shale Exploration and Mining

Oil-shale on the public domain is, in 1961, unavailable for leasing or any other form of acquisition. Prior to the Mineral Leasing Act of February 25, 1920, oil-shale could be acquired by placer mining location, and thousands of acres of valuable oil-shale lands were claimed under the mining laws. Many of these claims in the Dragon-Watson area were subsequently patented, so that many of the better surface deposits of oil-shale in Utah are today privately owned land. After 1920 oil-shale could no longer be acquired by mining claim, but mining leases were available on a rental-royalty basis through the U. S. General Land Office. Owners of oil-shale mining claims were granted a preference provided they relinquished their claims to the government. Undoubtedly many unpatented claims were extinguished in this manner. However, by Executive Order of April 19, 1930, all oil-shale lands owned by the United States, including outstanding unperfected mining claims, were "temporarily" withdrawn from all forms of disposal (except patent under the mining laws). The withdrawal remains to this day, effectively barring any private acquisition or development of federal owned oil-shale lands both in Utah or Colorado. Leases outstanding in 1930 were cancelled or allowed to expire, so that today oil-shale on public domain is unobtainable either by lease, purchase, or mining entry.

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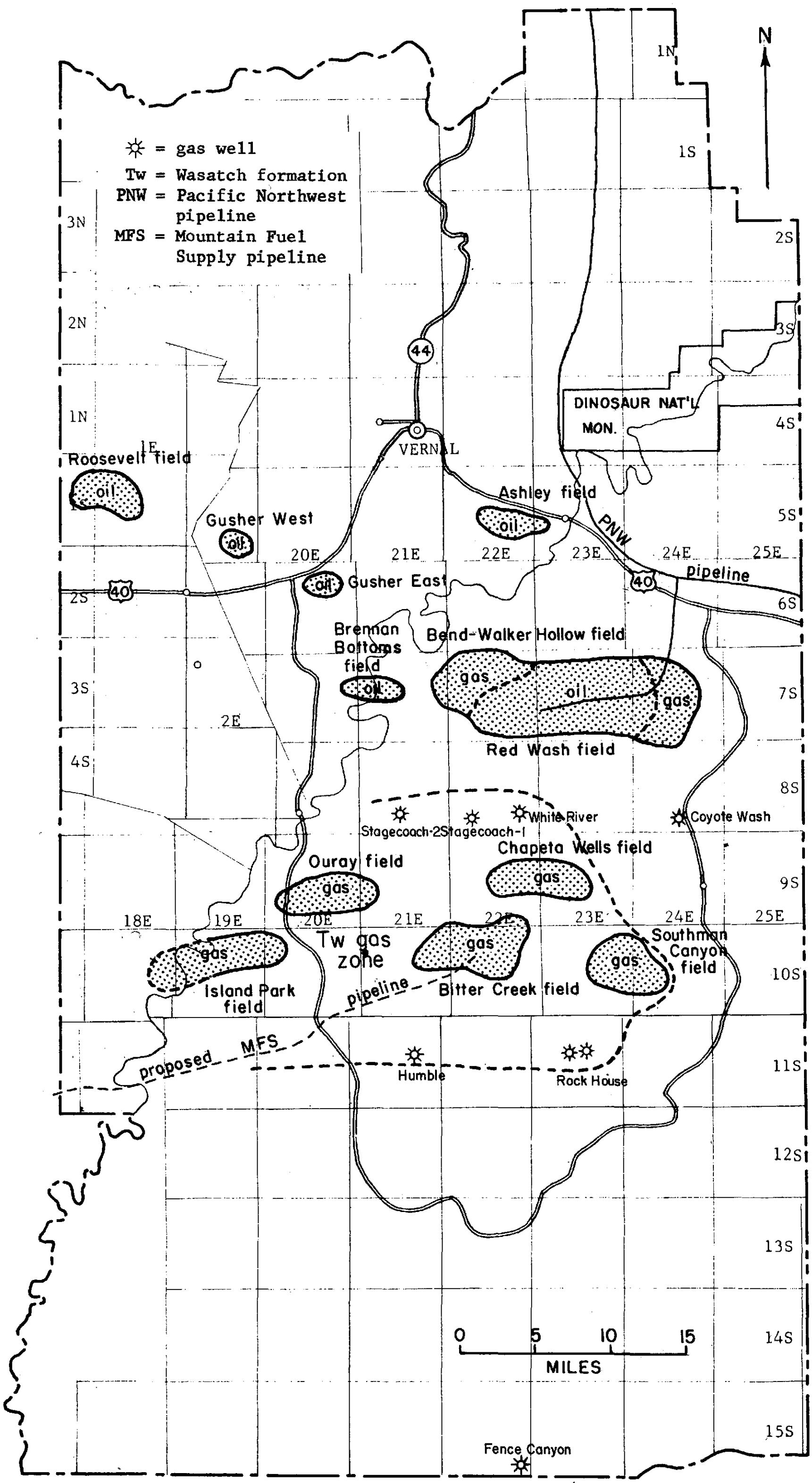

PLATE VII. MAP OF THE OIL AND GAS DEPOSITS OF UINTAH COUNTY.

CHAPTER V — OIL AND GAS

The Uinta Basin is fast becoming one of the major oil and gas provinces in the western United States, and is destined to grow even larger in the near future. Because of the intriguing surface occurrences of a great variety of petroleum substances in the basin, it was natural that there would be early investigations for oil and gas. The first commercial oil field in Utah, Ashley Valley, was discovered in Uintah County in 1948, and ushered in Utah's present booming petroleum industry.

Uintah County's first test was a dry hole drilled in 1900, above the Brown Cliffs, near the Grand County line. From 1900 to 1948 over 40 wells were drilled in the county, establishing some minor oil production in 1908-1910 (Utah Mining Association, 1955) and gas production in 1929-1941 (Kinney, 1955). Among the many test wells of the area were the wells drilled in 1911-1913 to tap the suspected liquid source of the asphalt deposits on Asphalt Ridge. But the tarry substance encountered in the holes was too viscous to be pumped, and the wells were abandoned.

In 1944 Carter Oil Company began serious oil exploration in the basin, using surface geologic reconnaissance and geophysical techniques. Several of the early discoveries were made on geophysical anomalies which later proved to have no significant relationship to the accumulations. Oil and gas in the Tertiary non-marine lacustrine and fluvial sediments occur mainly in stratigraphic traps, and subsurface geologic interpretation is probably the most reliable technique employed in the basin today.

In 1948 commercial quantities of oil were produced in Equity Oil Company's well at the Ashley field, near Jensen. This oil originated in the marine Park City formation and accumulated in the Paleozoic sediments of the Weber formation. It is noteworthy that other attempts to produce oil from Paleozoic sediments in the county have failed, although the Weber sandstone was found to constitute an ideal reservoir formation wherever it was tested.

The discovery of the Roosevelt field in 1949 launched the search for oil in the theretofore little explored Tertiary sediments of the Uinta Basin proper. The initial wells in the Roosevelt yielded prodigious quantities of high pourpoint, high paraffin oil, but attempts to enlarge the field yielded only water. In the search for oil in the basin many excellent shows of gas were recorded in the Tertiary sediments, but without a transmission pipeline these shows were, at least temporarily, disregarded. In time, however, the great gas reserves of the basin came to have greater significance than the oil. With the advent of transmission facilities now under construction into the basin, these gas reserves will at last be drawn upon. In early 1961 only the Red Wash-Walker Hollow oil and gas field had access to pipeline facilities.

The 1961-1962 season is expected to see the third largest exploration effort in the United States commenced in the Uinta Basin, much of it in anticipation of the new transmission facilities which will tap the great Wasatch formation gas production fields.

A count of wells completed in Uintah County to the end of 1960 shows a total of 318 wells, including 179 oil wells, 52 gas wells, and at least three combined oil and gas wells. The remaining wells are either abandoned or suspended. But these statistics are not very meaningful since location and drilling activities are proceeding at a rapid pace, and any physical count of wells is quickly outdated. The following brief description is inadequate to fully treat the subject, but should serve to acquaint the reader with the basic factors involved in oil and gas exploration and production in Uintah County.

Oil Fields

Except for the Ashley field, which produces from Paleozoic sediments, all oil production in Uintah County is essentially from the lower unit of the Green River formation (Eocene), from non-marine lacustrine sediments. The Tertiary oil has a high wax content and a high pour point (Picard, 1956, 1957), is very black-green to yellow in color, with a gravity of 29°-33° A.P.I. The pour point is 85-90° F. and the oil from the Red Wash field is now blended with oil from the Rangely field for pipeline transportation.

The two distinct geologic environments from which oil is produced in Uintah County are: (1) Paleozoic sediments in the Weber sandstone (Pennsylvanian-Permian) and Park City formation (Permian), which are considered a common reservoir, and (2) Tertiary lacustrine sediments, mainly the lower unit of the Green River formation (Eocene). Some oil is produced as condensate from gas wells in the Mesaverde formation (Cretaceous). The Paleozoic oil is accumulated in structural traps, whereas the Tertiary oil is found in stratigraphic traps, only secondarily affected by structural controls.

The oil fields in Uintah County are, in order of importance: (See Plate VII, page 60).

Red Wash field: Total 161 wells, 139 oil producers, 15 gas. Production is from thin sandstone lenses in the Douglas Creek member of the Green River formation at depths of between 4700-6000 feet. Average production is currently 11,000 bbls. per day, and over 4,000,000 bbls. were produced in 1960. The discovery well in 1951 was drilled on a seismic anomaly, indicating a west-plunging anticlinal nose. Initial production was 12 to 392 bbls. per day and 784 to 4960 m.c.f. gas per day. Most wells in this field must be pumped. Standard Oil of California owns most of the field, which is the second largest in the Uinta-Piceance Basins (Picard, 1957). Oil reserves (including secondary recovery methods) are estimated at over 200,000,000 bbls., making it one of the major oil fields in the United States.

Ashley field: Total 36 wells, 28 oil producers, 1 gas. Production is from Weber sandstone (and Park City formation contact zone), which is an excellent reservoir, at depths of 4000-5000 feet. In 1960 this field produced 3000 bbls. per day for a total of 1,400,000 bbls. (Thomas, and Campbell, 1960). The discovery well in the Fall of 1948 was on a northwest-southeast trending faulted anticline, on a closure estimated to be 300 feet. Initial production was 260 bbls. per day with low gas-oil ratio. The field has a very strong water drive, with the water level 600-620 feet above sea level in 1957. The field is still a steady producer, indicating reserves of about 20,000,000 bbls.

Roosevelt field: Total 9 wells, 4 oil producers. Production is from fractures in a black shale zone of the Green River formation (Eocene), at depths of 9,000-10,000 feet. The discovery well in 1949 was drilled on gravity-seismograph anomaly, but production is from the fracture porosity in the sediments. Initial production from the discovery well was 1607 bbls. per day, with total production to 1961 of over 800,000 bbls. from this one well. The other three producing wells have yielded 300,000 to 400,000 bbls. each. Later wells flowed only water. The oil is very waxy and must be heated and shipped in insulated trucks (Current, 1953). The field is still a steady producer, producing 105,598 bbls. in 1959 and 88,916 bbls. in 1960 (Thomas and Campbell, 1960).

Brennan Bottoms field: Total 5 wells, 4 oil producers. Production is from stratigraphic traps in the lower Green River formation from depths of 7000-8000 feet. Discovery well in 1953 was drilled on seismic indications of northwest-plunging anticlinal nose, initially producing 213 bbls. per day, later (1957) 92 bbls. per day (Osmond, 1957).

Gusher fields (two small fields): Total 4 wells, 2 oil producers. Production is from fracture zone in lower Green River formation, from depths of 8500-9500 feet. The discovery well in the east field in 1950 produced 24 bbls. per day. Recompleted in 1958, it tested 45 bbls. per day, produced a total of 4,673 bbls. in 1959. The discovery in the west field in 1952 initially produced 23 bbls. per day. Total production from both fields was 4818 bbls. in 1959. Recent attempts to recomplete other wells in the area have been unsuccessful.

Gas

Commercial gas production is mainly from the Wasatch formation (Eocene), with minor production from the Mesaverde formation (Cretaceous), the Uinta formation (Eocene) and the Dakota formation (Cretaceous). The Mesaverde formation yields little present production but is considered an attractive objective. Since the initial exploration for oil in the Uinta Basin, the emphasis has shifted from oil to gas exploration, particularly with the advent of transmission pipelines into the Basin[14]. New pipeline facilities proposed and under construction will undoubtedly stimulate further gas exploration.

Gas production from the Tertiary sediments of the basin comes from stratigraphic traps, and the many separate fields in the Wasatch formation are probably genetically related throughout the basin. Current estimated gas reserves from the Uinta Basin exceed 2 trillion cubic feet of recoverable gas. (See Plate VII, page 60.)

Red Wash - Walker Hollow field: 12 gas producing wells, mainly on the eastern end of the field, produce from the Green River formation (Eocene). The oil wells in the field produce considerable associated gas. A few shallow gas wells produce from the Uinta formation in the Walker Hollow portion of this field.

Bend field: Total of 4 wells, 2 gas producers, producing from Uinta formation. The largest well, in section 8, T. 7 S., R. 22 E., tested 4,225,000 cu. feet in 1959 from a depth of about 3000 feet.

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14. In early 1961 only the Red Wash-Walker Hollow fields were connected to a pipeline. Another pipeline to the southern part of the gas producing area via Soldier Summit is under construction, and will connect the Uinta Basin directly with the Salt Lake City market area.

Ashley field: 1 gas well, produced only 536,336 cu. feet of gas during 1929-1941 from the lower Morrison formation (Jurassic), from depths of 1430-1475 feet and 1673-1680 feet. It was abandoned in 1941 when gas pressure decreased from 580 to 100 pounds per square inch (Kinney, 1955).

(The following fields are actually only units in a major production field in the Wasatch formation, producing from isolated stratigraphic traps.)

Bitter Creek field: Total 10 wells, 8 gas producers. Production is from the Wasatch formation at depths of 4800-5500. The early wells in 1957 produced 2,000,000 c.f. and 5,000,000 c.f. respectively from depths of 5000-5400 feet. A well completed in 1959 initially produced 17,500,000 c.f. from 4800-5200.

Chapita Wells field: Total 23 wells, 8 gas producers, 1 oil. Production is from the Wasatch formation at depths of about 5100 feet and the Mesaverde formation at depths of 8200-8300 feet. Some oil is also produced from Wasatch and Mesaverde formations with the gas. The discovery well, completed in 1952, had an initial flow of 30 bbls. of oil per day, 5% water, and 1000 m.c.f. gas per day from the Mesaverde formation. It was abandoned in 1955. The second well, completed in 1955, produced 4,618,000 c.f., and 50 bbls. oil from the Wasatch formation in four days (Miller, 1957). Additional wells are planned for this area.

Ouray field: Total 7 wells, 5 gas producers, 1 oil. The first wells were drilled in 1948, but all were dry. In 1956 gas was produced from the Wasatch formation at 1230 m.c.f. per day at a depth of 4854 feet. Later wells produced gas from depths as deep as 6345 feet, still in the Wasatch formation. Oil is produced from the Green River formation at 3560 feet. Gas wells in this field are shut in awaiting the new pipeline (Gillespie, 1957).

Southman Canyon field: Total 6 wells, 1 gas producer, 2 combined oil and gas producers. Gas is produced from both the Wasatch and Mesaverde formations with some oil production from the Mesaverde. The single gas producer is in the Wasatch formation. It yielded 1,300,000 c.f. per day from 4663-4888 feet depth (Picard, 1956). Another well produces gas from the Wasatch formation at 6700-6825 feet. One of the combined oil and gas wells produces from the Mesaverde formation at 5900-6000 feet, initially flowing 4,700,000 c.f. of gas and 121 bbls. per day of oil condensate.

Island Unit field: 3 wells, all gas producers. This is a new field, producing from the Wasatch formation at 5475-5575 feet. The three wells have a total capacity of 24,000,000 c.f. of gas per day.

Other wells capable of gas production are located in the Coyote Wash and Rock House units, and a single Humble well in T. 11 S., R. 21 E. Another interesting gas well is located far to the south of the known gas fields of Uintah County, in section 36, T. 15 S., R. 22 E., almost on the Grand County line. This well is especially interesting since it produced gas from the Dakota formation (Cretaceous). The well tests a total depth of 10,348 feet.

The unusual brevity of this chapter, particularly since it deals with the most important single mineral resource of Uintah County, requires a note of explanation. The complex relationship of stratigraphy, sedimentation, and sub-surface geologic projections which are integral to an understanding of the oil and gas reserves of the Uinta Basin are adequately treated in the companion bulletin to this work by the Untermanns, and in forthcoming publications on the oil and gas potentials of Utah, either planned or in the process of compilation by the Utah Geological and Mineralogical Survey and the Intermountain Association of Petroleum Geologists[15].

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15. The reader is referred specifically to the Intermountain Assoc. Petrol. Geologists "Oil Fields of Utah" to be released in the Fall of 1961, and Utah Geological and Mineralogical Survey Bulletin 54, "Oil and Gas Possibilities of Utah, Re-evaluated", and Bulletin 72, "Geologic Atlas of Utah--Uintah County."

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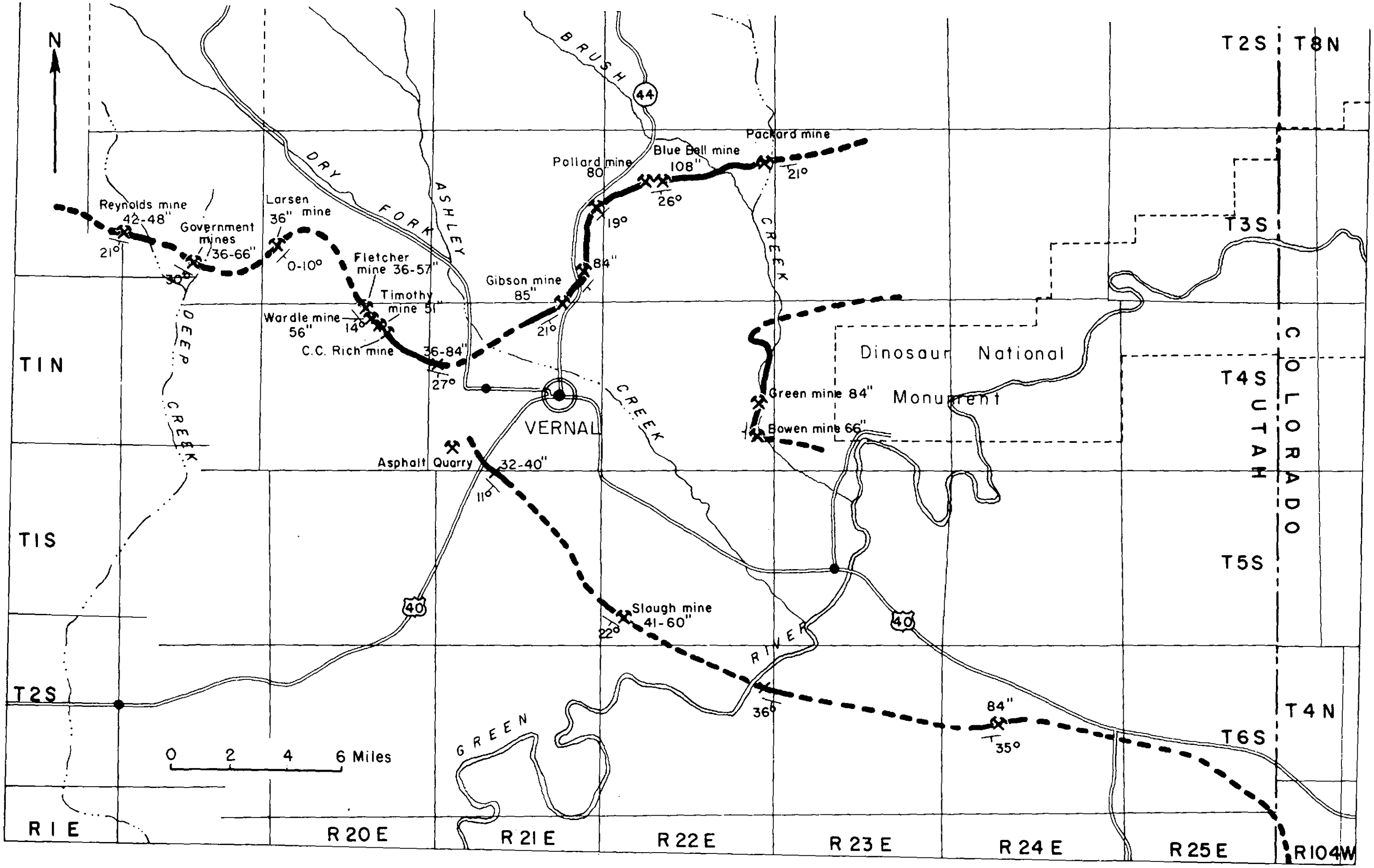

PLATE VIII. MAP OF THE COAL DEPOSITS OF UINTAH COUNTY.

CHAPTER VI — COAL

NATURE OF THE DEPOSITS

Sub-bituminous coal of commercial value is found in Uintah County in the Mesaverde and Frontier formations (both upper Cretaceous). The Mesaverde coal beds are very important producers in the Yampa and White River coal fields of northwestern Colorado, but the coal beds thin rapidly toward the west due to an erosional unconformity at the upper contact. In Uintah County this coal bed is exposed on Raven Ridge and Asphalt Ridge, and thins to extinction approximately where U.S. Highway 40 crosses Asphalt Ridge. The Frontier coal bed is exposed along the northern edge of the Uinta Basin in Uintah County, and on the flanks of the Split Mountain anticline. This coal bed thins to extinction towards the east, ending near Jensen, Utah. (See plate VIII, page 66)

Early Discoveries and Production

The early settlers in the Uinta Basin probably noted the coal deposits at an early date, but the first published report was by Hague (1877), in the 40th Parallel Survey of the early Geological Survey. The earliest reported coal mining in the county occurred at the George A. Slaugh mine in section 31, T. 5 S., R. 22 E., from about 1893 to 1904 (Gale, 1909, 1910) and at the Bowen Mine, in section 25, T. 4 S., R. 22 E., which was opened in 1891 (Gale, 1910). Possibly the mines immediately north and northwest of Vernal were opened even earlier. The period 1903-1905 saw the maximum coal production in the basin, reaching 10,000 to 13,000 tons (Kinney, 1955). Substantial production continued until 1948 when oil became cheaply available from the refinery at Jensen, gas was produced from the Ashley Creek field and better roads made coal from Carbon County cheaply available. In 1947 the Reynolds mine and two others in T. 4 S., R. 20 E., were the only mines open (Kinney, 1947), and by 1955 only the Wardle mine was open, producing 1,000 tons in that year (Utah Mining Association, 1955). In 1961 all coal mines in Uintah County were idle.

The Mesa Verde Coal Deposits

The Mesaverde coal bed in Uintah County is of marginal quality, particularly when compared with the vast deposits within this formation in nearby northwestern Colorado. Much of the Mesaverde formation in Uintah County has been stripped by erosion, and then buried by the Tertiary sediments of the Wasatch, Green River, Uinta and Duchesne River formations.

The easternmost exposure of good coal in the Mesaverde formation of Uintah County is 2 miles south of Cocklebur, in the $S\frac{1}{2}$ section 17, T. 6 S., R. 24 E., S.L.M. (Gale, 1910). Here an old mine has produced considerable coal in the past from a bed at least 7 feet thick, dipping 35° south. Gale comments (at page 210) that the coal was of a very satisfactory grade, well suited for domestic use. The mine had been idle for some time prior to 1907. East of this mine the Mesaverde coal bed is concealed under soil and alluvium in a broad flat valley and only a few coaly beds can be seen in wash gulleys. The basal Mesaverde rocks in T. 6 S., R. 25 E., dip 60° to 70° to the southwest, and in places form a prominent hogback.

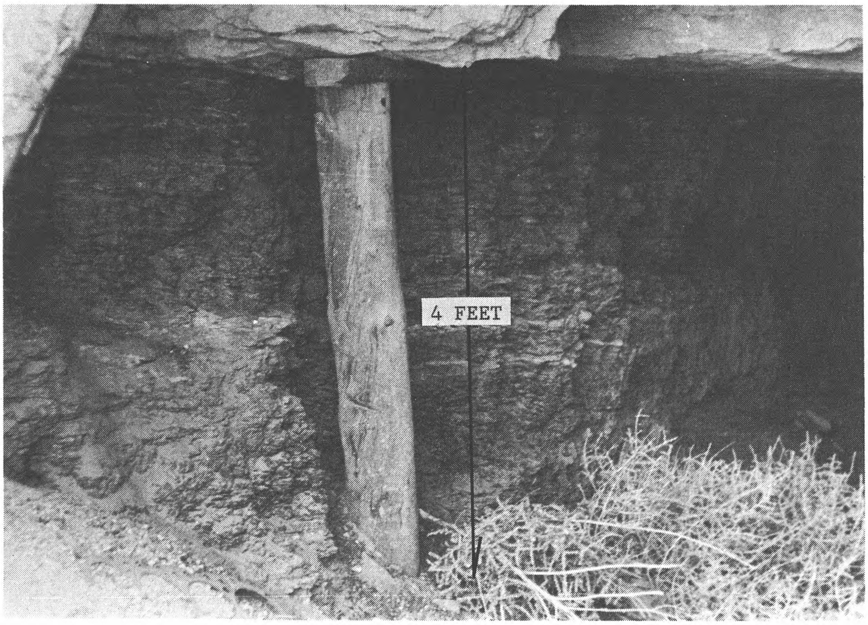

Figure 14. Coal seam at the Wardle mine, northwest of Vernal. The coal (here just inside the portal of the idle mine) is soft and broken by shaly partings. The bed is about 4 feet thick at the outcrop.

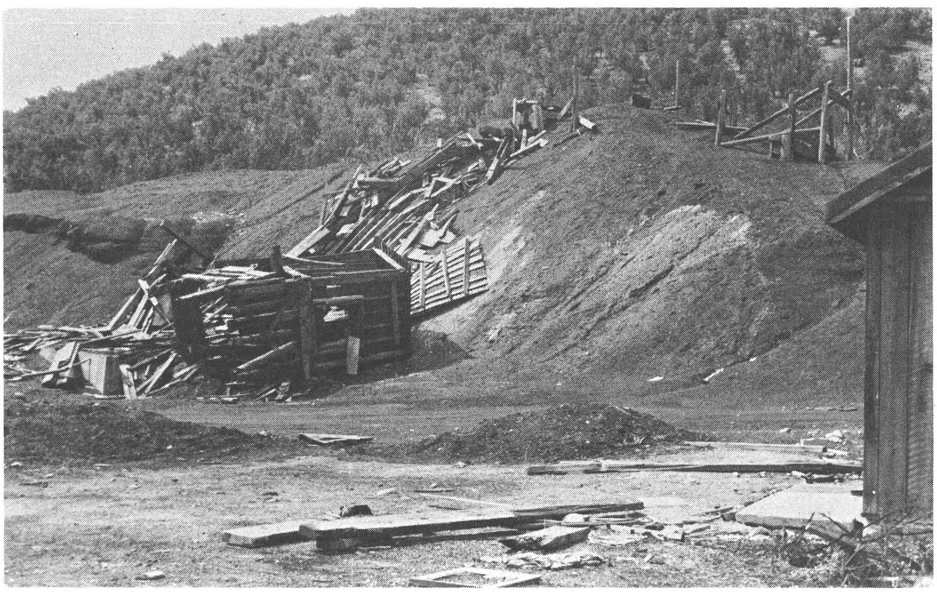

Figure 15. The idle Wardle mine, showing part of the large mine dump area. The portal of the mine is immediately behind the apex of the dump. This mine was the last to operate in the Vernal coal field and closed shortly after 1955.

The next coal exposure to the west is in a bluff on the east side of the Green River, in section 2, T. 6 S., R. 22 E. Between this exposure and the Cocklebur Mine there is little surface indication of coal in the formation. The bluffs on the west side of the Green River contain no coal, probably due to the erosional unconformity which lies at about the horizon of the coal bed (Gale, 1910, page 210).

The Slaugh mine, in section 31, T. 5 S., R. 22 E., was opened in 1893 and worked until 1904. A slope for mining was driven down dip for 100 feet or more, but was caved in 1907. The coal bed at this mine is 3 feet 5 inches thick at the surface and about 5 feet thick in the mine. The bed is said to have broken off abruptly, probably due to a local fault (Gale, 1910, p. 211). Outcrops of bituminous sandstone occur just above the coal bed at the mine, and the coal has a strong smell of petroleum. The coal is reported to slack rapidly when exposed to the air. The coal bed strikes N 42° W, and dips 22° SW. Immediately above the coal bed is a coarse conglomerate, thought to be the base of the Tertiary formation.

The most northwesterly exposure of Mesaverde coal is near the east quarter-corner of section 32, T. 4 S., R. 21 E., (Gale, 1910, p. 214). An old entry exposes a coal bed 2 feet 8 inches to 3 feet 4 inches thick, dipping westward. This is the end of the Mesaverde coal bed for all practical purposes, although several coal patents are found in sections 29, 30 and 31, T. 4 S., R. 21 E., atop rich bituminous sandstone deposits.

The Frontier Deposits

The Frontier formation contains two coal beds at many points, although only the lower bed is mined. The Frontier coal is thicker and of better quality than the Mesaverde coal in Uintah County, and has been mined more extensively. It is not exposed east of Brush Creek near Jensen, Utah. There is a great deal of bone debris in the Frontier coal at certain localities, which increases the ash content of the coal and seriously affects mining operations.

The Bowen mine, in the W½ section 25, T. 4 S., R. 22 E., on the west side of Brush Creek, is the best showing of the Frontier coal bed in the east part of the Vernal coal field (Gale, 1910). The coal bed is 5½ feet thick at the mine and badly weathered at the surface. Gale measured the bed as follows:

Bone........4 to 5 inches thick
Coal........2 to 2½ feet thick
Dirt........6 to 8 inches thick
Coal........about 3 feet thick

The Bowen mine was opened in 1891, and in 1907 had reached a depth of 175 feet.

The Green mine, in the N½ section 24, T. 4 S., R. 22 E., is probably the same bed mined at the Bowen mine. However, the coal here contains too much dirt to meet commercial requirements (Gale, 1910). Coal exposed just north of the Green mine is also very boney and of doubtful value, although 120 acres in section 13 were patented as coal lands in 1923-1924. The coal bed is traceable at least 3 miles to the northeast of Brush Creek along the northern flank of Split Mountain, but little is known about its quality or thickness in this area.

The Packard mine, in the N½ section 12, T. 3 S., R. 22 E., is an old entry near Little Brush Creek. The coal is said to be very bony (Gale, 1910). Nearby the NE¼NE¼ section 14 was patented as coal lands in 1932.

The Blue Bell mine (Massey Mine), in the NE¼SE¼ section 8, T. 3 S., R. 22 E., was operated for over 40 years and produced low grade bituminous coal. The coal bed is 9 feet thick and dips 27° south. In 1944 an inclined shaft reached 7 to 10 acres which have been mined out. In 1944 available production was 200 tons per month (Hendricks, 1944b). Hendricks reports the coal analyses for this bed is:

Moisture	11.3%
Volatiles	35.6%
Fixed Carbon	46.4%
Ash	6.7%
Sulphur	0.95%
B.T.U.	11,280

Nearby is the Pollard mine, situated on the Brush Creek side of a low divide. The coal bed here is 6 feet 8 inches thick and dips 24° southeast. In 1910 a single entry drift 200 feet long was observed at the mine (Gale, 1910).

An old unnamed entry is situated near the east edge of section 13, T. 3 S., R. 21 E. In 1907 a broad open entry 10 feet wide by 8½ feet high ran 100 feet or more down a 16° slope, but the coal at the surface did not appear workable (Gale, 1910). The coal bed measured 3 feet 4 inches, and dipped 19½° south. In 1930 a coal permit was issued for the W½ section 19, T. 3 S., R. 22 E., but the character of the coal mined under this permit is unknown.

Another unnamed mine is located in section 36, T. 3 S., R. 21 E., on a coal bed 4 feet 3 inches thick. The coal bed resembles the coal exposed at the Gibson mine, but does not appear suitable for commercial purposes (Gale, 1910).

The Gibson mine, a 40-acre coal patent in the NE¼NW¼ section 2, T. 4 S., R. 21 E., was a major mine in the area. The coal bed measures 7 feet 1½ inches thick and is capped by massive sandstone (Gale, 1910). In 1960 the U. S. Bureau of Reclamation constructed the Stanaker Draw earth-fill dam, and the west abutment buries the old shaft, effectively terminating the possibility of future production of coal from this property.

West of Ashley Creek Valley, in the NW¼ section 18, T. 4 S., R. 21 E., is another mine on the same coal bed as the Gibson mine. The upper 3 feet of the coal appears valuable, but the lower part contains too much bone debris. The bed strikes N80°E and dips 27°S (Gale, 1910 , p. 215).

Several important coal mines are located 7 to 8 miles northwest of Vernal, in what is called the Vernal coal field. The main coal bed here is apparently the same bed exposed in the Gibson mine, but a second upper bed is also exposed. Four mines in this field have operated for many years and constitute the main supply of coal for the Vernal area.

The Wardle mine, known also as the Old Joe Rich mine, is located in the W½SW¼ section 2, T. 4 S., R. 20 E., and has operated since about 1894 (Hendricks, 1944b). The main coal bed measures 4 feet 8 inches thick and dips 15° southwest. A small upper coal bed measures 8 to 10 inches thick, but is not mined (Gale, 1910). In 1907 the main inclined shaft was 1300 feet long, and by 1944 had been extended to 1500 feet long. This was the latest coal mine to operate in Uintah County, and was a sizable mine in its day. In 1961 the mine had been idle for several years, but appeared uncaved.

The Fletcher mine, known also as the Old George Gray mine, is immediately northeast of the Wardle mine, in the E½ section 3, T. 4 S., R. 24 E., on the east slope of the coal ridge. The mine was opened about 1919 and in 1924 produced 2,000 tons of coal. In 1944 the mine was idle except for a new entry 400 feet long (Hendricks, 1944b). Hendricks measured the main bed as 4 feet thick, but Gale (1910) measured the same bed at three places, obtaining measurements ranging from 3 to 4 feet thick. The coal bed strikes N80°E, and dips 14° south.

The Timothy mine is immediately southeast of the Wardle mine in lot 10, SW¼ section 1, T. 4 S., R. 20 E. The coal bed here measures 4 feet 3 inches thick and dips 11°. The same small upper coal bed is exposed at this mine also, but is not valuable (Gale, 1910).

The C. C. Rich mine (also known as the Pack Allan mine) is immediately southeast of the Timothy mine in lots 1 and 2, NW¼ section 11, T. 4 S., R. 20 E. The coal bed measures about 4 feet thick and dips slightly steeper than at the Timothy mine (Gale, 1910).

To the west, in the Deep Creek district of the Vernal coal field, the Larsen mine is located in the NW¼NE¼ section 30, T. 3 S., R. 20 E., on a coal bed 3 feet 1½ inches thick. The coal bed is flat to slightly southward dipping, and capped by massive sandstone 3 to 5 feet thick, but the coal is broken by partings of bone. Southwest and west of the mine, the coal bed is not exposed at the surface for a distance of three miles (Lupton, 1912).

Three Government mines are located in section 33, T. 2 N., R. 2 E., U.S.M. The eastern mine is in the NW¼SW¼ section 33, on a 3-foot thick bed of coal with partings of bone. The largest mine is in the W½ section 33, on a 5 foot 6½ inch thick coal bed which is separated into three benches by 3½-inch and 5-inch bone layers. There are extensive caved workings in this area, but the grade of the coal is not reported. The coal beds strike N60-70°E and dip 30° south at the main mine. To the west for 2 miles the coal bed is buried by alluvium. To the east, in the SW¼SW¼ section 27, T. 3 S., R. 19 E., S.L.M., is an exposure of a coal bed only 1 foot 9 inches thick, but with no partings of bone. This bed strikes N80-90°E and dips 19° south. A second lower coal bed, 4 or 5 feet below the main bed, is exposed at the same locality, but is not considered important. In the SW¼SE¼ section 27 is another exposure of the main bed, again about 2 feet thick (Lupton, 1912).

ECONOMIC SIGNIFICANCE

The combined coal resources of Uintah County, while not great when compared with the larger coal fields of Utah and Colorado, are still significant from the standpoint of local markets and future industrial demand in the Uinta Basin. Lupton (1912) estimated 44,461,000 tons of coal in the Deep Creek district alone. This estimate was based on coal beds 14 or more inches thick under a maximum overburden of 3,000 feet. Lupton believed that 60 to 75 percent of this amount could be recovered by careful mining practices.

TABLE A

COAL PRODUCTION FROM UINTAH COUNTY, UTAH
1896-1948

Year	Short tons	Year	Short tons	Year	Short tons
1896	300*	1914	4,879	1932	2,581
1897	1,000*	1915	4,341	1933	2,422
1898	5,000	1916	3,785	1934	2,500*
1899	6,450	1917	3,500*	1935	2,500*
1900	6,500	1918	6,100	1936	2,500*
1901	7,750	1919	9,929	1937	2,500*
1902	3,540	1920	9,228	1938	2,500*
1903	10,300	1921	3,814	1939	2,500*
1904	12,200	1922	3,015	1940	2,500*
1905	12,945*	1923	3,500*	1941	2,500*
1906	3,887	1924	4,184	1942	2,880
1907	4,000*	1925	5,214	1943	2,000*
1908	5,150	1926	5,510	1944	1,140
1909	4,480	1927	6,000*	1945	1,000*
1910	8,590	1928	7,484	1946	599
1911	4,700	1929	5,860	1947	2,496
1912	6,800	1930	3,544	1948	2,950
1913	5,595	1931	2,500*	TOTAL	239,642

* Starred items are estimated. (After Kinney, 1955, p. 143)

TABLE B

COAL ANALYSES FROM 12 MINES IN THE VERNAL DISTRICT

Mine (locality)	Proximate (percent)		Ultimate (percent)						
	Volatile matter	Fixed carbon	Ash	Sulfur	Hydro-gen	Carbon	Nitro-gen	Oxygen	B.T.U.
Rasmussen Bros. mine, just off slope 300 feet from surface, cover 50 feet.................	37.0	46.4	6.8	0.9	....	....	....	....	11,674
F. A. Gross mine..............	36.8	44.3	10.1	2.4	5.5	63.0	1.1	17.9	11,140
Reynolds mine..................	35.6	46.4	6.7	.95	....	....	....	....	11,380
Fletcher mine (Gray mine) 46½ inch cut......................	34.3	47.1	10.1	1.6	5.3	62.8	1.0	19.2	11,250
Fletcher mine (Gray mine) 42 inch cut......................	36.4	47.7	7.3	1.3	5.6	65.6	1.1	19.1	11,880
Wardle mine (Joseph Rich mine)	38.2	44.9	8.1	1.5	5.6	65.7	1.1	18.0	11,640
Timothy mine, 2 lower benches, 17½ inch cut..................	35.7	45.8	10.3	1.3	5.5	63.5	1.0	18.4	11,420
Timothy mine, 2 upper benches, 33½ inch cut..................	36.7	46.7	8.0	2.1	5.8	65.7	1.0	17.4	11,770
C.C. Rich mine (Pack Allan Coal Co. Mine)................	38.6	42.9	9.9	1.8	5.6	63.2	1.1	18.4	11,350
Gibson mine, lower 24 inches of 22-inch top bench..........	32.8	44.9	12.9	1.9	5.1	57.8	0.9	21.4	10,370
Gibson mine, middle bench, 42½ inch cut......................	34.4	44.5	9.4	1.9	5.6	59.2	0.9	23.0	10,580
Gibson mine, lower bench, 21 inch cut......................	32.7	44.8	12.3	0.8	5.3	60.0	1.0	20.6	10,600
Blue Bell (Massey) mine, 225 feet on main entry...........	37.2	43.5	9.5	1.5	....	....	....	....	....
Green mine....................	38.8	44.2	8.2	2.4	....	....	....	....	....
Joseph Dudley mine............	38.3	43.8	9.5	1.5	5.5	64.7	1.1	17.7	11,320
Collier mine..................	39.6	43.8	8.7	2.4	5.6	64.8	1.2	17.3	11.550

(after Kinney, 1955)

Kinney (1955) states that coal production from the Frontier formation in Uintah County totals 240,000 tons (to 1953), and that indicated coal reserves total 60,000,000 tons under less than 1,000 feet of overburden, 54,000,000 additional tons under 1,000 to 2,000 feet of overburden, and 29,000,000 additional tons under 2,000 to 3,000 feet of overburden. The highest rate of production from coal deposits in the county was an estimated 10,000 to 13,000 tons annually during the period 1903 to 1905.

At the present the coal mines in the county are essentially idle. In 1955 only the Wardle mine near Vernal was working, employing only one man and producing approximately 1000 tons of sub-bituminous coal during that year (Utah Mining Assoc., 1955). By about 1958 this last mine had closed also. An increased local demand, such as an incoming industry, could look to these deposits to supply ordinary demands, but the likelihood of shipping coal from these mines to compete in distant markets is insignificant.

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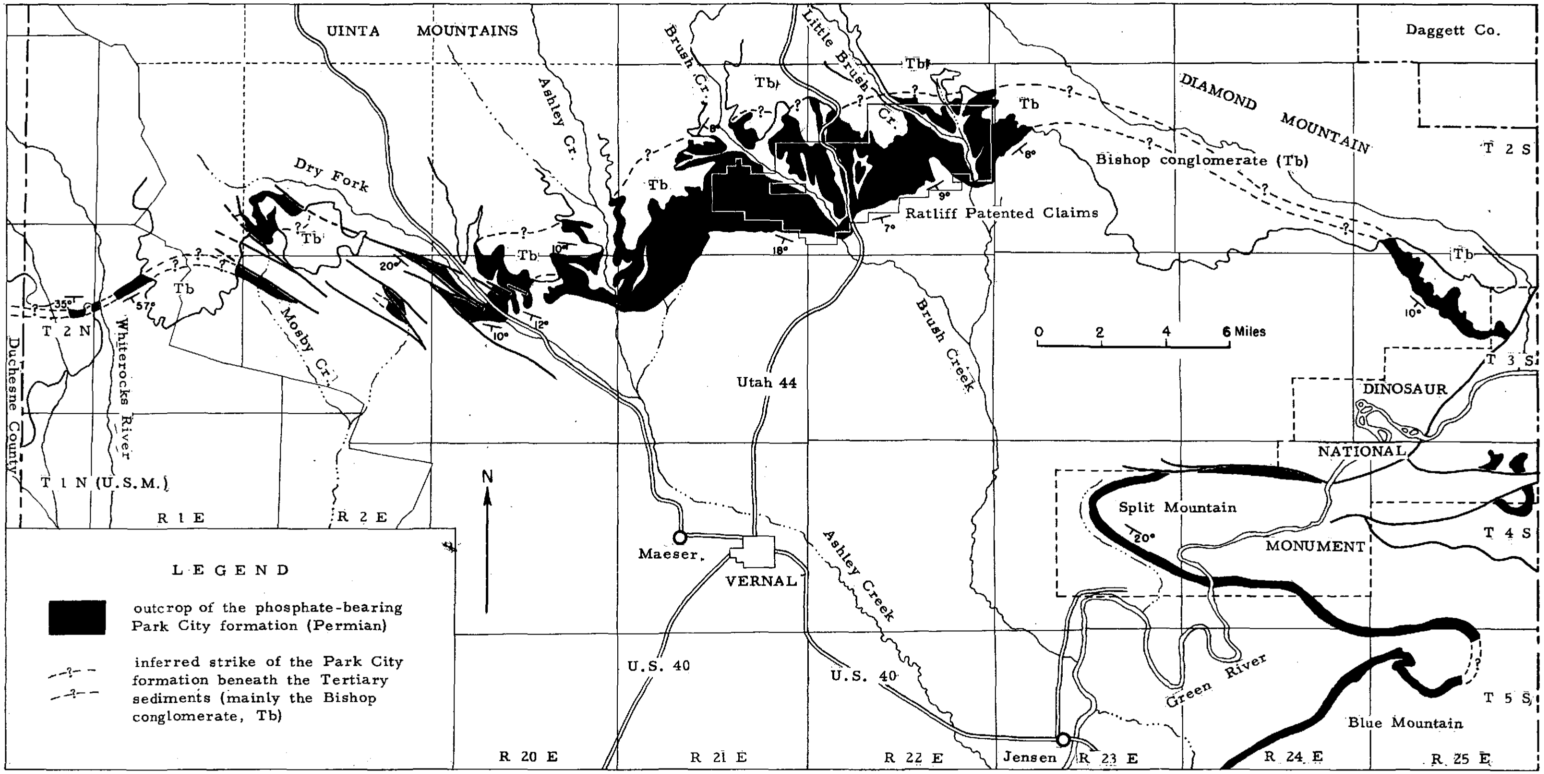

PLATE IX. MAP OF THE PHOSPHATE-BEARING PARK CITY FORMATION IN UINTAH COUNTY.

CHAPTER VII — PHOSPHATE

"Phosphate" in the mining industry is a sedimentary rock containing significant quantities of apatite, $3\ Ca_3(PO_4)_2 \cdot Ca(F,Cl_2)_2$, in a matrix of silt, sand, or lime. In the western United States phosphatic rocks are found mainly in the Phosphoria formation of Permian age (known in Utah as the upper Park City formation). This formation is exposed as narrow bands running from southwestern Montana, through southeastern Idaho and western Wyoming, into northeastern Utah, ending in Uintah County. The formation is remarkably consistent and the phosphate deposits in Montana, Idaho, Wyoming, and Utah are similar in most respects.

In the trade "phosphate" ore is classified according to the phosphorous or "bone phosphate of lime"[16] content. The usual catagories are (Cheney, 1957):

(1) Acid-grade ore, over 31% P_2O_5 (+ 80% apatite).
(2) Furnace-grade ore, 24-31% P_2O_5.
(3) Low-grade rock, less than 24% P_2O_5.

Increased demand and advances in beneficiation have revised the above percentages downward, so that ore containing as low as 6% P_2O_5 may be classed as low-grade rock (Duncan King, personal communication 1960). In describing deposits the ore is called <u>phosphate rock</u> if it contains over 50% B.P.L., and <u>phosphatic</u> rock if it contains 20-50% B.P.L. (Kinney, 1955). The deposits of Uintah County, described below, fall into the furnace-grade, phosphatic rock classification.

DESCRIPTION AND OCCURRENCE

The phosphatic rock of the Uinta Mountains is a shale ranging in color from dark brown to brownish-gray to black, sometimes with a greenish cast. The principal phosphate mineral is collophane, occurring as structureless pellets and nodules, replacements of fossils, and as oolites and pisolites. In the richer beds the cementing material is also collophane (Cheney, 1957). The phosphatic rock is easily recognized by its physical appearance, resembling a dark coarse granular limestone, noticeably heavier than the other sedimentary rocks of the area, and by its strong fetid odor when freshly broken. Phosphatic rock weathers to a bluish-white coating on surfaces, but since it occurs in soft shale, it is often concealed in the soil as pieces of distinctive float material (Schultz, 1918).

The host rock of the phosphatic material in the Uinta Mountains is the Meade Peak shale member of the Park City formation. This tongue of shale ranges up to 122 feet thick in the western Uinta Mountains, and thins to extinction eastward in the vicinity of Split Mountain in eastern Uintah County, Utah. It is underlain by the Weber sandstone (Pennsylvanian), and overlain by the Franson member "red beds" of the upper Park City formation. The Meade Peak shale is 20 to 40 feet thick in the vicinity of Brush Creek, north of Ver-

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16. Since an early commercial source of phosphate was from animal bones, "bone phosphate of lime" became the measure of phosphate in rocks. The percentage of B.P.L. is equivalent to the $Ca_3(PO_4)_2$ content. Today a commonly used measure of phosphorous content is phosphorous pentoxide, P_2O_5. Both terms are found in the literature, and a convenient conversion factor from B.P.L. to P_2O_5 is 2.19:1.

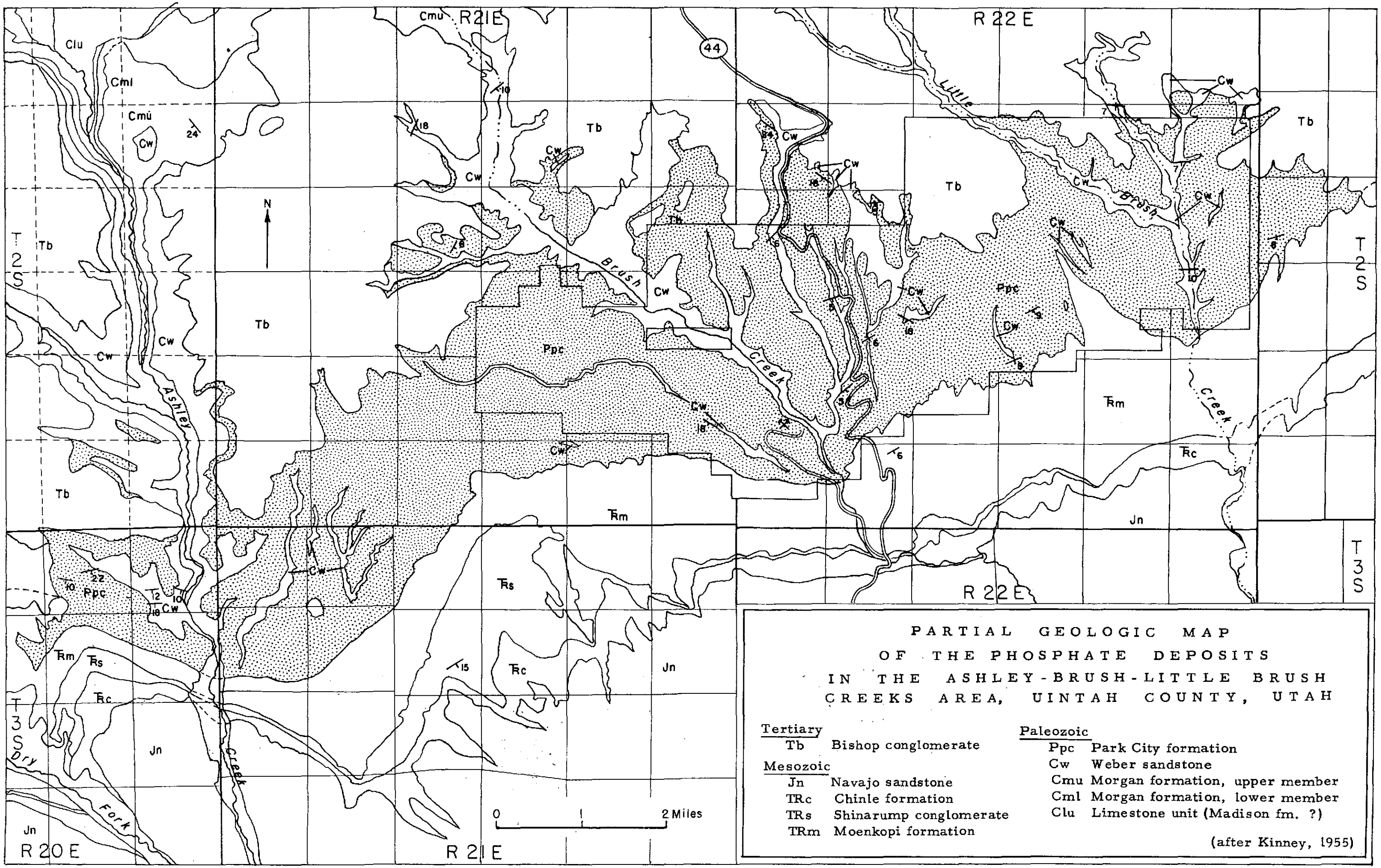

PLATE X. MAP OF THE PHOSPHATE DEPOSITS NORTH OF VERNAL, UTAH.

nal. The richest phosphate is concentrated in two units each approximately 5 feet thick, separated by 2 to 6 feet of low-grade rock (Cheney, 1957).

The phosphatic shale beds are exposed along the southern flanks of the eastern Uinta Mountains at about 7000 to 8000 feet elevation, dipping moderately to the south. In many areas the phosphatic shale occupies sloping benches atop the resistant Weber sandstone under a relatively thin mantle of soil or limestone. West of the Whiterocks River the Park City formation is buried beneath the Tertiary sediments for a distance of over 25 miles. In the area between the Whiterocks River and Ashley Creek, the formation is broken by faulting and partially covered by the Tertiary Bishop conglomerate. Mining in this area presents many difficulties, although the grade of the phosphatic rock is good. The area from Ashley Creek to Little Brush Creek, a distance of almost twelve miles, contains the richest beds in the formation in Uintah County, and is amenable to open pit mining. It is this area that is presently being mined by the San Francisco Chemical Company, near Brush Creek. Less than 2 miles east of Little Brush Creek, the Park City formation is again buried by the Bishop conglomerate for a distance of almost 15 miles on Diamond Mountain. The Park City formation is exposed again in T. 3 S., R. 25 E., north of Dinosaur National Monument, in Red Wash. It outcrops as steeply dipping beds along the nose of the Split Mountain anticline within the Monument, but the phosphatic shale member is very thin or absent in this area. The Park City formation can be traced along the base of Blue Mountain, and into Colorado, but it contains no phosphate east of Split Mountain (Cheney, 1957).

Early Discoveries of Phosphate

Phosphate rock was known as early as the 1890's in southeastern Idaho and northern Utah (Wideman, 1958), but the presence of commercial grade deposits on the south slopes of the Uinta Mountains was not suspected until about 1914. During August 11 to September 11, 1914, A. R. Schultz of the U. S. Geological Survey made a reconnaissance along the Uinta Mountains to confirm suspected occurrences of phosphate in the region. As a direct result of his survey, 224,558 acres of phosphate-bearing lands were withdrawn by the federal government on May 11, 1915[17]. According to Schultz's own account (Schultz, 1918), he was the first man to discover phosphate deposits in Uintah and Duchesne Counties. He found no signs of prospecting on the phosphate beds except on the West Fork of Lake Fork (Duchesne County) and along Little Brush Creek where the dark phosphatic beds had been examined for coal or oil shale. Schultz reports that a local rancher, Frank V. Goodman, had tunneled into a rich phosphate bed on the west side of Little Brush Creek and was apparently the first to explore the phosphate deposits of Uintah County, although Goodman thought the beds were oil shale.

The man locally credited as being the first to recognize the value of the phosphate deposits of Uintah County was T. H. (Harry) Ratliff of Vernal. Probably acting on information of the discoveries made by the Schultz reconnaissance a year earlier, and possibly aware of the purpose of the Schultz survey, Ratliff located 136 160-acre placer claims on the richest and most accessable deposits in the

17. Phosphate Reserve No. 24, effective May 11, 1915 (as authorized by the Acts of August 24, 1912, 37 Stat. 497, and July 17, 1914, 38 Stat. 509.) This withdrawal was recently lifted, so that phosphate is presently available to mineral leasing from the Federal Government.

Brush Creek-Little Brush Creek area. The Ratliff claims were located and recorded during the period March 20 to May 5, 1915, the last three claims being recorded just ten days before the withdrawal became effective on May 11, 1915. A search of the Uintah County mining records disclosed that no other claims have ever been located on phosphate in the county. Considering the immense deposits which are today so valuable, this is a remarkable circumstance, and a tribute to Ratliff's vision and conviction which, 45 years later, is at last becoming a reality.

In 1917-1930 Harry Ratliff, in association with the Humphrey Phosphate Company, patented 91 placer claims totaling 18,144 acres on the richest deposits. In view of the requirements of the Act of January 11, 1915 (44 Land Decisions 46), that the owner of placer claims on phosphate deposits faithfully demonstrate that assessment work was done on the claims for every year, most, if not all, of the remaining unpatented claims located in 1915 are probably no longer in force today.

LOCATION OF THE PHOSPHATE DEPOSITS

The Park City formation outcrops along the southern flank of the Uinta Mountains and around the Split Mountain anticline. Because of faulting and broad areas which are buried beneath Tertiary sediments, the formation has been divided into three segments for the description below: (1) the area west of Ashley Creek, extending to the Uintah County line near the Whiterocks River, (2) the Brush Creek-Little Brush Creek deposit north of Vernal, and (3) the Diamond Mountain-Split Mountain area, extending eastward to the Colorado state line.

Area West of Ashley Creek

This segment of the Park City formation is characterized by numerous faults and extensive Tertiary cover, resulting in many isolated exposures of the phosphatic shale beds. Immediately west of the Whiterocks River, the formation is buried under the Tertiary Duchesne River formation for a distance of over 25 miles. At the Whiterocks River, the Meade Peak phosphatic shale tongue is 20 feet thick (Cheney, 1957) and dips 70° south (Williams, 1939). Samples of two 3-foot thick phosphatic beds were cut at this locality by Schultz (1918, p. 92) in the NE$\frac{1}{4}$ section 18, T. 2 N., R. 1 E., U.S.M. (see Table F, items 1 and 2). Assays of 51.42 and 57.79% $Ca_3(PO_4)_2$ were obtained, but the beds are concealed beneath the Tertiary Bishop conglomerate a short distance to the east (Schultz, 1918). This locality has been considered as possibly of future value (Williams, 1939, p. 9).

The following excerpt from Williams (1939) describes the exposures at the Whiterocks River:

> "The outcrop of the Phosphoria formation crosses Whiterocks River just inside the mouth of the canyon about 7 miles due north of Whiterocks Indian School. It trends north 65 degrees east and extends about a mile and a half each way from the river. The beds dip steeply (73°) toward the southeast.
>
> "Following is a detailed description of the Phosphatic shale member measured on the east side of the river. Those

beds that were obviously too lean or too thin to be worthwhile were not sampled for analysis.

TABLE C

SECTION OF THE PHOSPHATIC SHALE MEMBER OF THE PHOSPHORIA FORMATION, EAST SIDE WHITEROCKS RIVER, NE¼ SEC. 18, T. 2 N., R. 1 E., U.B.&M.
Strike S65°W, Dip 73°S

Designation of bed	Description	Thickness ft.	in.	P_2O_5 (Moisture-free basis)	$Ca_3(PO_4)_2$	Minable depth feet
	Light greenish gray thin-bedded sandstone, with much nodularly bedded chert.					
N	Medium to light gray oolite	1	9	(Compare bed I)		
M	Greenish medium gray clay shale	4	0			
L	Medium gray shale		9			
K-1	Medium gray oolite		10			
K	Medium gray shale		9			
J	Brownish medium gray siliceous rock	1	0			
I	Black oolite grading upward into yellowish medium gray medium grained sandstone	1	6	26.68	58.27	270
H	Black to medium gray paper shales weathering with brownish tinge interrupted by thin seams of chert and one thin (1") stringer of oolite	1	6			
G	Thin bedded medium gray oolite weathering greenish light gray, interrupted by two 8" beds of greenish gray paper shale that are not included in the analysis	6 (4	0 8)	19.95	43.6	1250
B-F	Greenish to brownish medium gray siliceous to slightly calcareous shales interrupted by two 3" beds of chert	6	0			
A	Coarse grained sandstone		3			
A-2	Thin bedded light gray sandstone	1	3			
A-1	Light yellowish gray calcareous sandstone	1	6			
	TOTAL	27				

Weber sandstone.

"It will be noted that there are only three beds of phosphate rock in this section, and none is high grade. Bed N was not analyzed, but megascopic examination indicates that it probably is no richer than bed I. Bed G includes a net thickness of 4 feet 8 inches of oolite after deduction is made for the two shale seams.

"According to the . . . standards in use by the U. S. Geological Survey, beds N and I would be minable to a depth of about 300 feet and bed G to a depth of 1,250. The former, however, are barely over the limit of minimum thickness; they are not of high grade, and may be eliminated.

"The line of outcrop in this area is approximately three miles long. The density of the oolite is nearly 180 pounds per cubic foot. On this basis the area contains 7,430,000 long tons of 44 percent (B.L.P.) rock.

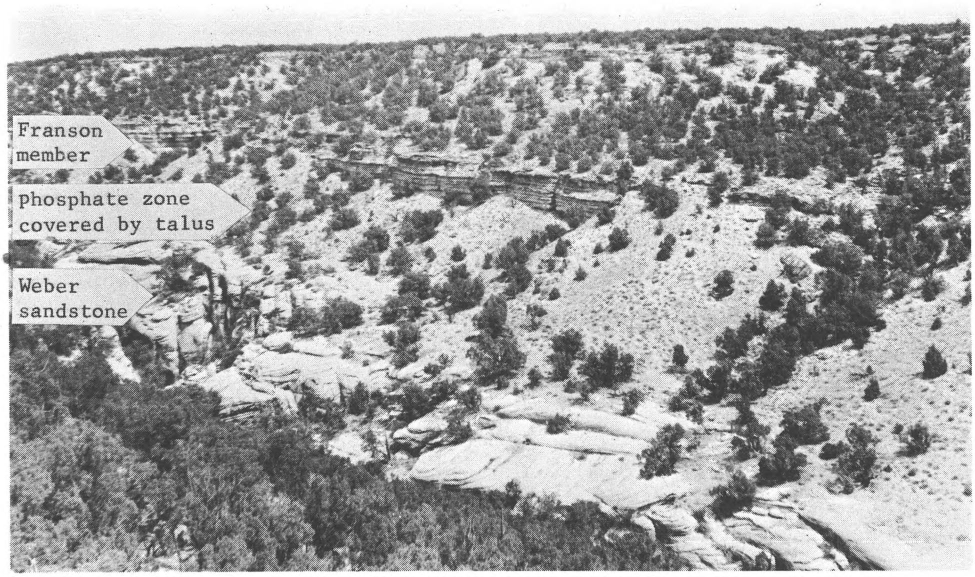

Figure 16. View of the Park City formation underlain by the massive white Weber sandstone. The phosphatic shale immediately overlies the Weber, and is covered in many places by talus. The overlying Park City limestone beds tend to preserve the softer phosphate beds on the gently inclined dip slopes.

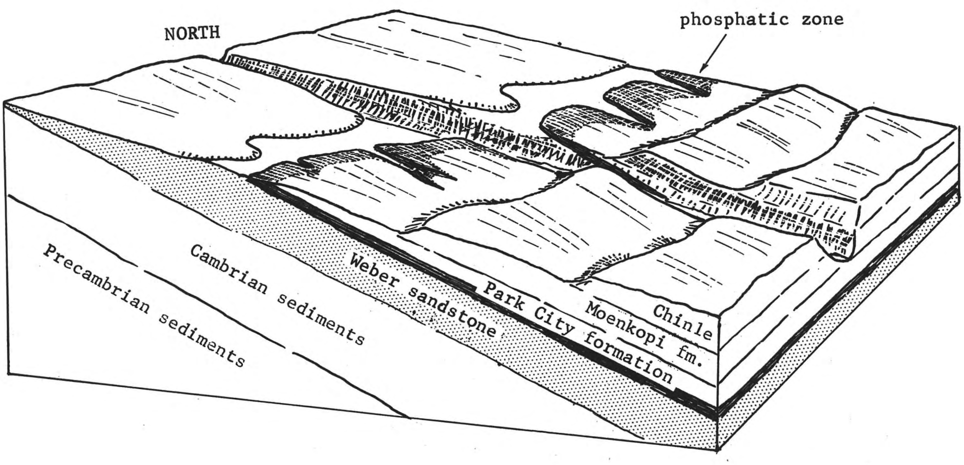

Figure 17. Generalized block diagram of the phosphate deposits on the dip-slope of the Uinta Mountains near Brush Creek.

The Bishop conglomerate covers most of the Mosby and Lake Mountains, and the next exposures of the phosphate to the east are found in Mosby Creek, where the beds dip 20° south. Schultz (1918) sampled an upper 1 foot bed and a lower 3 foot bed in the NE¼ section 8, T. 3 S., R. 19 E., S.L.M. (see Table F, items 3 and 4). East of Mosby Creek numerous faults cut the Park City formation, and on the divide between Dry Fork and Ashley Creek the phosphatic beds are partially concealed beneath the Bishop conglomerate. The following description is from Williams (1939, p. 15):

TABLE D

SECTION OF PHOSPHATIC SHALE MEMBER OF THE PHOSPHORIA FORMATION
EAST SIDE MOUTH OF ASHLEY CREEK GORGE
NE¼ SEC. 12, T. 3 S., R. 20 E., S.L.B. & M.
Strike N65°W Dip 27°S

Designation of bed	Description	Thickness ft.	Thickness in.	P_2O_5 (Moisture-free basis)	$Ca_3(PO_4)_2$ (Moisture-free basis)	Minable depth feet
	Thick bedded yellowish light gray calcareous sandstone. Green paper shales grading upward into nodular chert.					
E	Green shale, some oolite	7	6	14.28	31.2	150
D	Oolite and green shale	5	1	20.98	45.9	1400
C	Lower 20" or more green siliceous shale; toward top considerable oolite	3	5	14.52	31.7	100
B	Oolite with some green paper shale	2	9	19.96	43.6	600
	Gray sandstone		5			
A	Oolite and green paper shale	2	0	11.39		
	TOTAL	21				
	Weber sandstone.					

"It may be noted that through nearly 19 feet of this section the rock contains over 30 percent tricalcium phosphate. In this interval can be recognized 2 richer beds, alternating with 3 leaner ones. If the richer beds B and D are considered alone, there are 7 feet 10 inches of 44 percent (B.L.P.) rock. The weighted average for the 19 feet is 36.5 percent. The figures for minable depth are of little significance in this area because the beds are nearly horizontal and the overlying formations have been stripped off a wide area. The overburden varies from 0 to 75 feet, but if the minable depth is measured perpendicular to the ground surface, rather than parallel to the bedding, all the phosphate rock under the area covered by the outcrop of the formation is well within the limit of depth for the leanest of the beds, that is 100 feet."

Brush Creek-Little Brush Creek Deposit

The area between Ashley Creek and Diamond Mountain contains broad, gently southward-dipping beds of phosphatic rock, undisturbed by faulting and beneath little or no overburden. The beds are uniform in thickness and phosphate content, and well exposed on broad benches. Much of the area is ideally suited to open pit mining methods. The Ratliff patented claims cover a large area on both sides of Brush and Little Brush Creeks, and these claims are the site of San Francisco Chemical Co.'s recently opened phosphate mine. Schultz (1918) recognized this area as the most valuable deposit in the county, and remarked at the uniformity of the phosphatic beds from exposure to exposure. Two beds were recognized and sampled by Schultz: an upper bed averaging 3 feet 2 inches thick (SW¼ section

7, T. 3 S., R. 21 E.) containing 49.78% B.P.L., and a lower bed averaging 3 feet 4 inches thick (NW¼ section 4, T. 3 S., R. 21 E.), containing 52.88% B.P.L. Cheney (1957) recognized the same two phosphatic beds, each about 3 feet thick and each containing 26% P_2O_5, separated by 2½ to 7 feet of lower grade beds.

Kinney (1955) mapped the region in detail, and noted that the phosphatic rocks in the Ashley Creek-Brush Creek area average 20% P_2O_5 for a total thickness of 18 feet. He estimated 250 million tons of phosphatic rock under less than 43 feet of overburden, 650 million tons under less than 78 feet, 1,800 million tons above the stream level, and 2,450 million tons above a depth of 1000 feet below the stream level.

Williams (1939, p. 15) published estimates and analyses of the deposit on the Ratliff claims, released by the Humphrey's Phosphate Company:

Estimate of Overburden on Ratliff Patented Claims

Overburden thickness, feet	Acreage	Phosphate tonnage
Very slight	300	16,000,000
0-10	1,200	96,000,000
10-12 (20?)	1,500	120,000,000
20-50	3,500	280,000,000
greater than 50	6,200	496,000,000

TABLE E

SECTION OF PHOSPHATIC SHALE MEMBER NEAR LITTLE BRUSH CREEK ON CREASON CLAIM NO. 33 OF HUMPHREY'S PHOSPHATE COMPANY

(Beds numbered from top to bottom of section.)

Bed no.	Description	Thickness		Strata analysis: Percent Ins	Percent SiO_2	Percent P_2O_5	$Ca_3(PO_4)_2$	Percent Fe_2O_3	Percent CaO	Percent MgO
	Limestone cap layer									
	Streaks phosphate rock									
1.	Limestone	5'	0	27.11	25.75	1.40	3.05	2.52	24.00	1.00
2.	Shaly phosphate	2'	0	72.62	65.44	1.33	2.90	5.72	8.10	0.52
3.	Foliated shales and plates of sandstone	1'	0	51.37	48.36	3.26	7.05	2.34	15.47	2.26
4.	Coarsely oolitic rock	3'	0	13.08	11.90	17.88	60.88	1.14	43.77	1.29
5.	Lumpy phosphate	1'	0	25.40	21.22	20.07	43.83	1.90	34.65	1.07
6.	Yellow waste in hard streaks	0	9"	69.82	65.98	4.17	9.11	5.58	10.90	0.77
7.	Lumpy shale	2'	0	52.68	49.92	12.37	27.01	3.42	19.80	1.57
8.	Fine grained phosphate	5'	0	12.18	11.00	28.64	62.55	1.40	43.75	0.56
9.	Cherry lime rock	0	6"	74.33	69.67	2.25	4.92	6.35	8.00	0.47
10.	Phosphate shale	1'	0	29.07	24.35	20.53	44.83	2.95	32.10	1.12
11.	Iron streak	0	1"	18.23	16.96	22.68	46.20	17.26	34.90	0.59
12.	Soft phosphate brown and loose	1'	4"	8.50	7.83	29.51	64.45	2.18	47.00	0.39
13.	Limy slate	0	10"	57.12	50.62	9.70	21.32	3.83	15.05	1.07
14.	Massive phosphate rock, hard brown, gray	3'	0	15.36	13.66	22.42	49.07	1.89	41.75	0.34
15.	Clay	0	6"	51.75	26.50	10.54	23.02	5.15	1.77	1.61
	TOTAL	27'	0							
16.	Weber sandstone			94.00	91.36	0.61	1.32	2.77	trace	000

The Park City formation dips generally 8° southward in the area between Ashley and Brush Creek, but abruptly changes dip to about 15° S. along Brush Creek in T. 2 N., R. 21 E. (Schultz, 1918). The Park City formation outcrop is as much as 4 miles wide on the divides between the canyons west of Little Brush Creek (Williams, 1939). There are over 400 test pits on the Ratliff claims, exposing an estimated 705,000,000 tons of phosphate rock[18]. Mining on this deposit began late in 1960, and reserves for the next 100 years are in sight. The commercial significance of this deposit is discussed in a subsequent part of this chapter.

Diamond Mountain-Split Mountain Area

Within 2 miles of Little Brush Creek, the Park City formation and its rich phosphate beds are buried by the Bishop conglomerate of Miocene age, a poorly consolidated bed existing mainly as erosional remnants capping higher elevations in the foothills of the eastern Uinta Range. The Bishop conglomerate is only a few hundred feet thick and presumably the phosphate beds continue to outcrop on the buried landscape beneath it, a fact which may have significance if the demand for phosphate from this region increases.

Schultz (1918) mapped and sampled the phosphate beds where they again appeared from beneath the Bishop conglomerate near the east end of the Island Park Syncline (see Table F, items 14 and 15), and again on the flanks of the Split Mountain anticline. Schultz speculated that the phosphate beds continued eastward across the Colorado State line, but Williams (1939, p. 17) had little hope that the Split Mountain area and eastward contained any valuable phosphate. He remarks (at page 17) that the thinning of the Park City formation is "due not only to an alternation of all its members, but in part to non-deposition of the lower part of the Phosphatic shale member." Cheney (1957) states flatly that the Meade Peak tongue is absent at Split Mountain, so that there is no interest in the Split Mountain area as a potential supply of phosphate.

Information and even speculation concerning the phosphate beds as they pass beneath the Bishop conglomerate in T. 2 S., R. 23 E., is absent, but they could be expected to be potentially valuable, though more difficultly minable than the nearby Little Brush Creek deposits.

ECONOMIC SIGNIFICANCE OF THE PHOSPHATE DEPOSITS

With the recent developments in phosphate mining in the area, and the interest in phosphate leasing elsewhere along the Park City formation, there can be little doubt as to the current and potential significance of these deposits. However, it should be pointed out that all areas along the formation are not equally valuable. Undoubtably the patented Ratliff claims near Brush and Little Brush Creeks are the most significant economically. The vast deposits on public lands between Ashley and Brush Creeks are probably next in significance lying as they do under slightly greater overburden. The area west of Ashley Creek is broken by faulting and would be moderately difficult to mine on large scale. The Whiterocks River exposures are more limited in quantity and dip almost vertically downward. The Red Canyon deposits east of Diamond Mountain are in a remote area and probably do not contain beds as rich as the other deposits, and the buried deposits on Diamond Mountain are a great unknown.

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18. From an address by D. L. King, San Francisco Chemical Co., given October 6, 1961, before the A. I. M. E. in Salt Lake City, Utah.

Figure 18. Mining face at the Ratliff Mine.

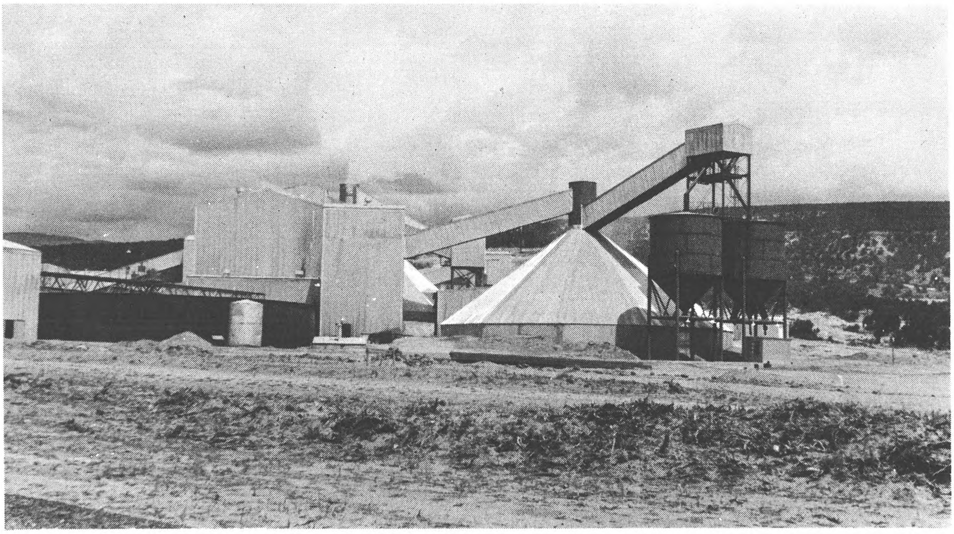

Figure 19. View of the Harry Ratliff phosphate concentrator of the San Francisco Chemical Company, located on the company's patented mining claims near Brush Creek. Here the 20% P_2O_5 phosphatic ore is upgraded to 31% P_2O_5. The tent-shaped structure is a covered storage pile of phosphate concentrate.

The current mining method in use on the Uintah County deposits is low cost open pit stripping. However, underground mining is employed in steeply-dipping phosphate beds in Rich County, northern Utah (Wideman, 1958). Whether underground methods are possible in the Uintah County deposits is purely a matter of economics and technique.

The San Francisco Company's open pit mine on Brush Creek began operation in 1960, feeding a 250-ton per hour plant in which the ore is concentrated by flotation to 31% P_2O_5 from an ore averaging 20% P_2O_5. The concentrate is trucked 200 miles to the Western Phosphates, Inc. plant at Garfield, Utah, for production of wet process phosphoric acid, ammonium phosphates and treble super phosphates. Annual maximum capacity of the initial plant is 200,000 tons of concentrate. Both San Francisco and Western Phosphate are 50% owned by Stauffer Chemical Company. (Mining World, May 1960) .

Commercial Application of Phosphate Ores

The major use for phosphatic rock and its many products is agricultural fertilizer, although phosphatic rock is commonly used to produce phosphoric acid, elemental phosphorous, phosphorous compounds and a host of valuable by-products.

Phosphatic fertilizers (superphosphates) are a mixture of monocalcium phosphate and calcium sulfate, containing 18 to 22% available P_2O_5. To make basic superphosphates, phosphate rock containing 31% P_2O_5 is finely ground and mixed with sulfuric acid (100 parts of rock to 85 parts of acid) and digested for a period of hours. The liquor, high in phosphoric acid, reacts with additional phosphate rock. The cake is then removed and allowed to cure for several weeks. The product is then disintegrated, screened, and mixed with potash and nitrogenous compounds to make a complete commercial fertilizer. During the acidulation process, hydrofluoric acid is formed and reacts with silica in the rock to form silicon tetrafluoride gas. Spray towers absorb this gas in the form of fluosilicic acid, a valuable by-product used in ceramics and insecticides.

Elemental phosphorous is produced in furnaces (usually in electric furnaces where low-cost power is available) from a charge of phosphate rock, silica and carbon[20]. Silica is introduced either as coarse gravel or low-grade siliceous phosphate ores. The furnace feed is coarse lumps or granules which, when heated, evolve phosphorous vapor and carbon monoxide (up to 90% by volume) which is precipitated and condensed under a water layer. The elemental phosphorous is then used to manufacture phosphoric acid, incendiaries, poisons, alloys, and matches.

Phosphoric acid (H_3PO_4) may be produced directly from phosphate rock by decomposition with sulfuric acid and filtration of the phosphoric acid from the insoluable residue. Medium-grade phosphate rock (30 to 32% P_2O_5) is required in this process, and hydrosilicic acid is produced as a valuable by-product, along with calcium sulfate, fluorine compounds, vanadium and uranium. In addition, each ton of phosphate rock used in this process produces over one ton of gypsum which, though containing silica and silicate impurities, ought to be valuable for some use, such as for wall board or land plaster. In

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19. Based mainly on Waggamand and Ruhlman, 1958.
20. Suitable carbon should be cheaply available as a by-product from gilsonite mined in the Uinta Basin.

TABLE F

ANALYSIS OF PHOSPHATIC SAMPLES FROM UINTAH COUNTY, UTAH[19]

Location	Thickness	P_2O_5%	$Ca_3(PO_4)_2$%	Description
(Whiterocks River)				
1. NE¼ Sec. 18, T. 2 N., R. 1 E., U.S.M.	3'	23.48	51.42	Phosphatic limestone(upper)
2. NE¼ Sec. 18, T. 2 N., R. 1 E., U.S.M.	3'	26.39	57.79	Phosphate bed (lower).
(Mosby Creek)				
3. NE¼ Sec. 8, T. 3 S., R. 19 E., S.L.M.	1'	26.47	57.97	Fossiliferous phosphate bed (upper).
4. NE¼ Sec. 8, T. 3 S., R. 19 E., S.L.M.	3'	26.40	57.82	Phosphate bed (lower).
(Dry Fork)				
5. NW¼ Sec. 8, T. 3 S., R. 20 E.	2'	25.75	56.39	Fossiliferous phosphate bed
(Ashley Creek area)				
6. SW¼ Sec. 7, T. 3 S., R. 21 E.	3'2"	22.73	49.78	Phosphatic shale and limestone.
7. NW¼ Sec. 4, T. 3 S., R. 21 E.	3'4"	23.69	52.88	Phosphate bed.
(Brush Creek area)				
8. NW¼ Sec. 31, T. 2 S., R. 22 E.	2'	26.62	58.30	Phosphatic shale near base of series.
9. SW¼ Sec. 28, T. 2 S., R. 22 E.	2'	25.54	55.93	Part of phosphate bed.
(Little Brush Creek)				
10. SE¼SE¼ Sec. 14, T. 2 S., R. 22 E.	3'	21.82	46.70	Part of Phosphate bed.
11. SE¼SE¼ Sec. 14, T. 2 S., R. 22 E.	4'	19.85	43.47	Part of Phosphate bed.
12. SE¼SE¼ Sec. 14, T. 2 S., R. 22 E.	4'	22.70	49.71	Part of Phosphate bed.
13. SW¼ Sec. 24, T. 2 S., R. 22 E.	6'	24.45	53.55	Phosphate bed.
(Split Mountain)				
14. NE¼ Sec. 11, T. 4 S., R. 23 E.	Float	27.86	61.01	Phosphate rock.
15. NE¼ Sec. 10, T. 4 S., R. 24 E.	2'	30.11	65.94	Part of phosphate bed.

19. After Schultz, 1918, page 92.

the latter use it would serve as a source of calcium and of the sulfate radical (for counteracting "black" alkali) and phosphate impurities should have value as a fertilizer.

Future Development

Undoubtedly the success of the San Francisco Chemical Company in mining, upgrading, and marketing phosphate rock from their patented claims in the Brush Creek area will encourage varying degrees of competition and interest by others. The remaining phosphate deposits in Uintah County are mainly on federal or state-owned lands. Phosphate on federal lands is leaseable under 43 C.F.R., part 196 (1960 Supplement), as authorized by the Mineral Leasing Act of 1920 (41 Stat. 440; 441; 30 U.S.C. 211-214). Phosphate on state-owned lands is similarly leaseable on a rental-royalty basis.

Continued growth in the fertilizer industry and other applications of phosphorous is virtually assured and increased interest in mining and marketing phosphate rock will result in exploitation of many presently sub-marginal deposits. One intriguing scheme for "mining" phosphates in situ, by fluid injection and solution, is described by Pirson (1959). This technique involves fluid extraction by means of a drill hole or system of wells, similar to water flooding operations employed in oil fields. An aqueous solution of sulfur dioxide (SO_2) is pumped into the deposit at 77°F., and the phosphate is acid-leached to yield various water soluable compounds. The solution is then recovered through a net system of wells and the phosphate precipitated by neutralizing the solution with a small amount of sodium, potassium or ammonium hydroxide. The neutral solution allows the phosphate to precipitate as tricalcium and dicalcium phosphate and calcium sulfite. When the precipitate is treated with phosphoric acid and heated, the sulfur dioxide gas is recovered for further reuse and monocalcium phosphate, $Ca(H_2PO_4)_2$, is produced.

This method has been tried successfully on shallow phosphate deposits in Florida, and the author remarks (at page 3) that the Phosphoria formation appears suitable to fluid mining due to its pre-existing porosity and permeability, and its high susceptibility to hydraulic fracturing or "hydrafrac", demonstrated by countless oil well tests. This technique suggested by Pirson. or some equally novel technique, may open heretofore unaccessable deposits to commercial recovery and increase phospaate reserved many fold..

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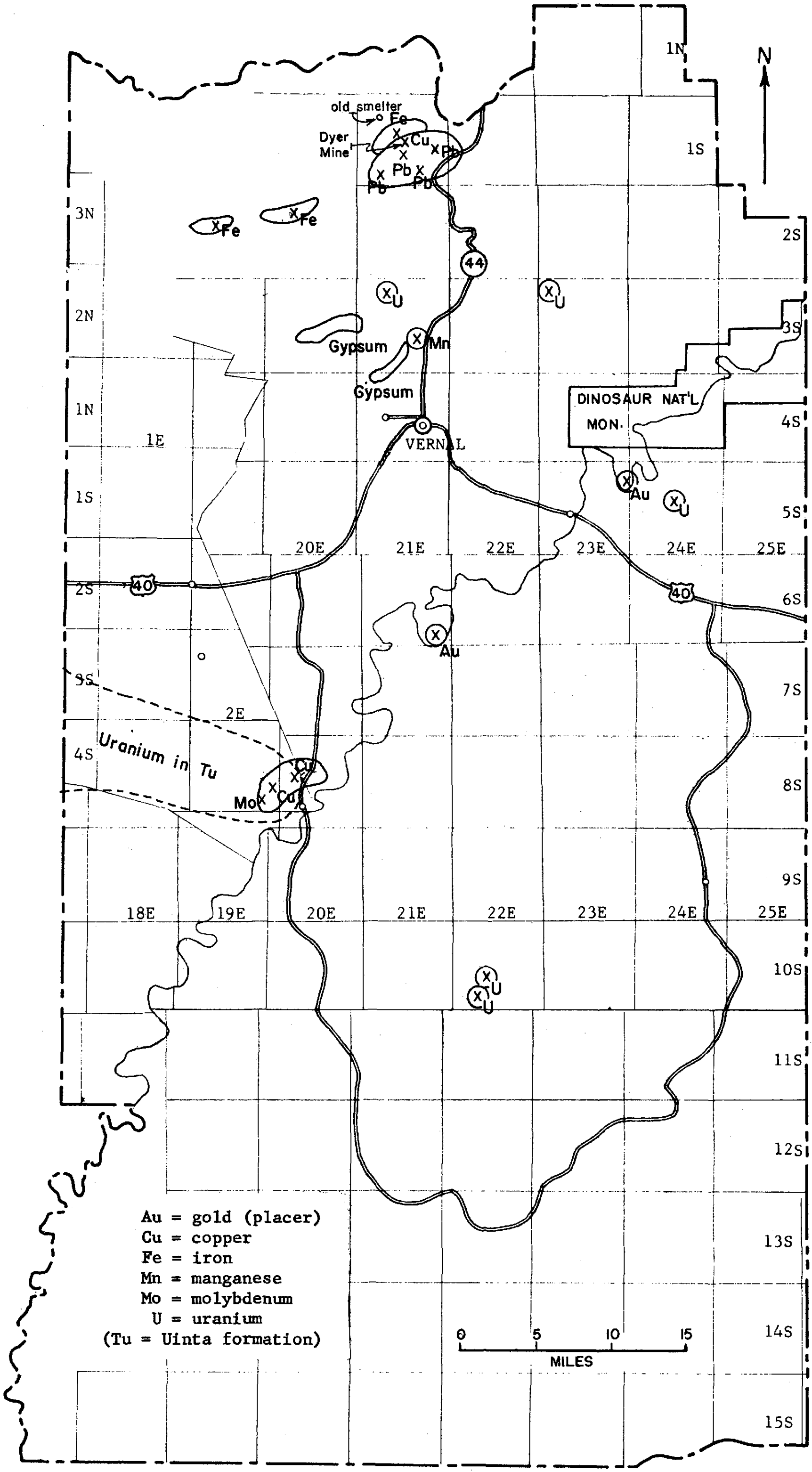

PLATE XI. METALLIC AND MINOR NON-METALLIC DEPOSITS OF UINTAH COUNTY.

CHAPTER VIII — METALLICS AND MINOR NON-METALLIC MINERALS

METALLIC MINERAL DEPOSITS

Deposits containing commercially valuable metallic minerals are rather scarce in Uintah County. Of the few known deposits in the county, most are merely in the prospect stage, and the remaining deposits which have been mined are currently idle. At the time of this writing there are no plans to produce minerals from any metal mine in the county. However, this is not to imply that many of the deposits do not possess commercial potential and that the reserves still in the ground are valueless.

A few of the deposits noted below are scientific curiosities in addition to their past or potential value in mining, such as the molybdenum deposits and fossil-replacing copper deposits near Ouray, Utah. Other deposits have excited interest in the past, but have faded into insignificance with the passage of time, such as the fine flaky placer gold deposits on the Green River. The description which follows has been subdivided according to the principal metals in the deposits, with a brief comment on each deposit.

Copper-Lead-Zinc-Silver

The Dyer mine, in the NW¼ section 16, T. 1 S., R. 21 E., is one of the most important metal mines in the county. It lies at an elevation of over 9,000 feet on the south slopes of the Uinta Mountains in the Carbonate mining district. The mine produced copper carbonate ore mixed with chalcocite and copper oxides from a replacement deposit in Mississippian limestone. The Dyer mine was opened in 1887 and old records show the shipment of about 400 tons of copper glance (chalcocite) assaying 49.47% copper, 26 ounces of silver, and $6 (0.266 oz.) per ton of gold (Butler, 1920, p. 602). A carload shipment in 1897 assayed 51.5% copper, and in the following two years about 200 tons of similar ore was shipped. The old smelter treated ore averaging 33.5% copper, and both ore and bullion were shipped to Price, Utah, and Carter, Wyoming (Butler, 1920)[21]. During the period 1898 to 1901 the mine shipped ore averaging 50% copper from two irregular ore bodies (Kinney, 1955, p. 159). In 1899-1901 a small blast furnace was operated to treat these ores, but the smelter was abandoned when production fell off in 1904, and mining continued only at intervals until 1941 when mining activity in the Carbonate district ceased altogether.

The Silver King mine, located about 1¼ mile south of the Dyer mine, in section 21, T. 1 S., R. 21 E., contains high-grade lead carbonate minerals in Mississippian limestone, apparently as replacement deposits since no structural controls are evident (Kinney, 1955). In 1947 some churn drilling was done on the property, but no results are available. In that same year 34 tons of lead-zinc ore were shipped. Prior to 1947 the only shipment from this property was 12 tons of hand-sorted ore assaying 25% lead, 17% zinc, 1.5% copper, 2 ounces of silver and 0.02 ounces of gold per ton (Volin, 1947). The min-

21. According to Crawford (1948, p. 155), copper ore from the Dyer mine was used in the few trial runs of the experimental smelter near the Charcoal Ovens, on the Union Pacific Railroad at Hilliard, Wyoming.

erals in this deposit are galena, oxidized sphalerite and minor amounts of malachite as scattered irregular replacements along fractures and bedding planes in the limestone. Development work on these patented claims is limited to shallow shafts and bulldozer cuts.

Several other lead prospects are located in the vicinity of the Dyer mine. One such prospect lies upstream from Brush Creek Cave near the quarter corner of sections 20 and 32 (20 and 29?), T. 1 S., R. 21 E. Limited amounts of lead ore were observed in an enlarged natural cave in the fractures gray cherty limestone on a joint plane (Kinney, 1955).

Lead prospects on Little Brush Creek, in the S½ section 13 and N½ section 24, T. 1 S., R. 21 E., lie on the crest of a southeast plunging anticlinal nose in Mississippian limestone (Kinney, 1955). The four patented claims in 1907 boasted a 135-foot tunnel and drifts totaling 111 feet[22].

The Commonwealth patented placer claim, in the SE¼ section 7 and the SW¼ section 8, T. 1 S., R. 21 E., is the site of the old Dyer smelter on Anderson Creek. In 1908 this claim boasted flumes, a mill, smelter, bunkhouse, scale house, and mining pits, but everything is idle now. It is not known what the placer mineral on the claim was, or if any mineral remains today.

Copper was discovered in 1896 in the Little Split Mountain area near where the Green River crosses the Utah-Colorado state line. In 1899 five tons of hand-sorted ore assaying 56% copper and 69 ounces of silver were shipped to Park City, Utah. The minerals in this area are copper carbonate and chalcocite in Carboniferous sandstones, about 8 inches above two 6 to 8 inch thick coal beds. The copper minerals replace plant remains and bones. The beds at this point dip 45° or more, and gold has been reported from the base of the copper bearing sandstone (Butler, 1920).

A similar unusual copper deposit is located near Ouray, on the Green River at the mouth of the Duchesne River. Numerous exposures of malachite and other secondary copper minerals are found in Tertiary sandstone associated with partly silicified and carbonized fossil plant remains. Where the plant remains are concentrated, copper values are high, but, as most plant remains are scattered, the deposit is mainly low grade. The copper bearing bodies crop out as narrow bands in the sandstone cliffs and have been mined in the past (Kinney, 1955). In 1905 the Uteland Mill was built to treat these ores, but never operated (Charlie Neal, personal communication, 1960). Most of the copper deposits in the vicinity are in an area 4 to 5 miles north and 3 to 4 miles northwest of the Uteland Mill. Several small gilsonite veins, molybdenum and uranium deposits are located in the same area. The remains of the old mill are located about 5 miles below Ouray.

Iron

The upperpart of the Uinta Mountain group (Precambrian) contains a brown-weathering ferruginous shale which has been prospected for iron in the Uinta River-Brush Creek area. Mississippian limestones and breccias in the South Flank fault zone also contain iron

22. Information on these claims is from official mineral survey notes on file in the Federal Land Office, Salt Lake City, Utah.

deposits. The <u>Pope deposit</u> contains high-grade red hematite in limited quantities in the Uinta Mountain group (Precambrian). The Pope deposit is separated by a large unconformity only 100 feet stratigraphically below the Dyer copper deposits northwest of the Dyer mine, but no genetic relationship between the two deposits can be discovered. The copper is notably low in iron and no copper is found in the iron deposits. Some iron is also reported as replacements in Mississippian limestone (Butler, 1920).

In the South Flank Fault area Kinney (1955) reports a small iron prospect in brown iron ore cementing a fault breccia, in section 10, T. 2 S., R. 19 E.

The Woodside deposit is located on the east side of Black Canyon in section 8, T. 2 S., R. 20 E. Brown iron oxide cements a limestone breccia on a branch fault (Kinney, 1955; Butler, 1920). Another gossan-like brown iron ore deposit on a fault zone in limestone is located in the NW$\frac{1}{4}$ section 33, T. 3 N., R. 1 W., U.S.M. , on the west side of Farm Creek, and is reported to contain gold. There was a short adit at the deposit being developed in 1955 (Kinney, 1955).

Crawford and Buranek (1943, page 4) report finding siderite as nodules in shale and replacements in Paleozoic limestone along the south flank of the Uinta Mountains in Duchesne County, but whether similar deposits occur in Uintah County is not known.

Manganese

A single claim on a small manganese deposit is located on the east side of Steinaker Draw, in sections 23 and 24, T. 3 S., R. 21 E. Nodules of manganese, mainly pyrolusite, are found in small discontinuous pods in red shale. Small samples assayed 9.0% and 8.7% manganese, and 0.03% phosphorous, but the deposit is considered too small and too low grade to mine (Heim, 1941).

Gold

Fine placer gold is found on the Green River in Uintah County at several localities. A bucket gold dredge was operated in 1910 or 1912 on the second bend below Split Mountain Gorge, dredging bench placer deposits from a floating barge. One sand bed is reported to have yielded $1.50 in gold per cubic yard (Charlie Neal, personal communication, 1960). Kinney (1955, p. 162) reports that high bench terraces on the Green River south of the Dinosaur National Monument are pockmarked with prospect holes in the gravels. He reports another gold dredge operated near the Horseshoe Bend on the Green River near Cub Creek (Utah Mining Association, 1955). However, none of the placer deposits on the Green River are considered valuable for their gold, since the fine gold is difficult to recover and mining costs exceed the value of the gold in most deposits. Trace amounts of platinum and chromite are also reported from these placer deposits, but are not economically recoverable (Butler, 1920).

Molybdenum

An unusual and interesting occurrence of molybdenum is reported by Hess (1923) near Ouray, Utah. Ilsemannite, an amorphous, water soluable molybdenum salt, is found in sandstone lenses of the Bridger formation (Tertiary) on the south side of the Duchesne River valley.

The deposits were discovered in 1916 by E. B. Curtis who thought the ocherous coatings on the outcrop might be carnotite. The fresh rock dug from the outcrop was black but turned dark blue when exposed to the air. Noting that the mineral dissolved in water and formed a permanent deep blue dye, Curtis tried to market the mineral as a dye substance and learned it was a molybdenum salt. The Ilsemannite is indistinguishable in the black sandstone lenses, which are 8 to 20 inches thick, and is not everywhere present, making visual identification difficult. Since the sediments in the vicinity contain no insoluble or primary molybdenum minerals, Hess theorized that the concentrated salts, assaying as high as 1% to 4% molybdenum, must be derived from a source within a radius of 20 miles from a deposit which was eroding in Eocene time. Hess believed that concentrated molybdenum solutions were trapped in the sandstone lenses, where they were encased in shale and have remained preserved. The original source might have been eroded away or its remnants may rest nearby, capped by later sediments.

Uranium

Despite much exploration and some development, Uintah County has not yet produced commercial uranium ores. An area south of Myton, Utah, very close to the Uintah County line, has accounted for several trial shipments of uraniferous-copper-carbonaceous rock totaling about 140 tons (Noble, 1957). Uranium in trace amounts is present in several formations in the basin, and several localities were thought to be promising at the height of the exploration period. The Gartra Grit member of the Chinle formation contains sub-ore in section 15, T. 5 S., R. 24 E., as carbon trash. The Curtis formation just over the state line in Colorado has yielded limited copper-uranium-vanadium ores from the Blue Mountains, but none in Uintah County. The upper Morrison formation contains uranium in bentonitic mudstones, as at Jensen Draw in section 6, T. 3 S., R. 23 E., where uranium-carbon flecks in a mudstone average 0.25% U_3O_8. The Mesaverde formation is considered the most promising source of potential production in the basin (Noble, 1957). Uranium occurs in the Rim Rock horizon of this formation near Vernal. Carnotite, autunite and phosphuranylite have been tentatively identified in sub-ores which are out of equilibrium, the true uranium content running higher than the radioactivity indicates. The Green River formation contains uranium up to 0.05% U_3O_8 in many places. The Uinta formation contains many small ore bodies in a belt from Myton to Ouray, Utah, as replacements of logs, bones, and carbon trash in the rocks. Frequently uranium is associated with copper carbonate in the trash. An occurrence in sections 33 and 34, T. 10 S., R. 22 E., contains uranium in bedding and fracture planes in a silty sandstone in this formation. One mile to the northwest is a limonitic sandstone containing caliche-like uranium coatings. The Park City formation phosphate beds are highly radioactive, but assay only 0.01% or less in uranium. The Moenkopi formation is weakly mineralized in section 4, T. 3 S., R. 21 E., near the base of a channel in the Chinle formation.

Summary of Metallic Mineral Deposits

From the foregoing it is clear that metal deposits in Uintah County are far less significant than are some of the promising nonmetallic mineral deposits. Some indication of the extent of metal mining in the county is revealed in a remark by Remington (1959, at page 260) that in 1915 over 3,400 pounds of copper ore were shipped from Uintah County to the Garfield Refinery in Salt Lake City via parcel post. However, parcel post at that time was the cheapest way to ship from the Uinta Basin. All of the bricks in the Vernal Bank were mailed to Vernal via parcel post.

NON-METALLIC MINERALS

Several occurrences of possibly valuable non-metallic minerals or rock are described in this brief chapter. These deposits lack present significance, but with continued industrial development of the Uinta Basin, they may take on added value.

Zeolites, mainly analcite, occur as lenses or beds at five levels in the Green River formation (Tertiary) in section 27, T. 9 S., R. 25 E. The largest lens is 40 feet long and 3 feet 3 inches thick at its maximum, and lies about 700 feet above the base of the formation. At 13, 35, and 130 feet above this lens are other lenses. The oil shale bed at this same locality contains equant crystals of analcite. In section 27, T. 10 S., R. 25 E., the same general bed can be seen. The well known "marker bed" just above the Mahogany oil-shale ledge in the Green River formation is an analcitized tuff. A thin asphalt-saturated ash bed in section 27 contains 65.84% analcite by weight (Bradley, 1929).

Gypsum occurs in the Carmel formation (upper Jurassic) as beds and lenses in Steinaker Draw, on the Taylor Mountain road and westward toward the Whiterocks River. Emmons (1877, at pages 292-293) describes a 30 foot thick pure white gypsum bed containing 79.014% $CaSO_4$, west of the mouth of Geode Canyon on the divide between the two forks of Ashley Creek, at the base of red clay cliffs. Another bed 25 feet thick, containing 76.736% $CaSO_4$ is reported to form a low ridge in clayey valleys to the south. Except for local use as plaster, none of these deposits have been mined. They are not thought to be of present economic value.

Salt deposits are reported to occur in the southwest part of Uintah County (Utah Mining Association, 1955), but they are undeveloped. A 1957 potash permit was issued for the S½ of section 4, T. 8 S., R. 21 E., but the extent of any deposit in the area is not known.

Bentonite is reported in the Mowrey shale and the Browns Park formation in the northern part of the county, but is not known to be valuable (Untermann, personal communication, 1960; I.A.P.G.,1957). The Morgan formation (Pennsylvanian) is reported to contain beds which have been used locally as abrasive siltstone.

Trona (a hydrous sodium carbonate) has been found in the Uinta Basin in the south Ouray No. 1 oil well in section 22, T. 9 S., R. 20 E. The minerals shortite and Naheolite were identified by Erikson (1952) and reported by Crawford (1952) from a well core between depths of 1975-2056 feet, and raises the possibility that trona deposits similar to those found near Green River, Wyoming, may also exist beneath the Uinta Basin. While many geological elements in the two basins are similar, there is no present knowledge of valuable trona deposits in the Uinta Basin.

Sand and gravel, local "flagstone" and other common rock deposits occur in Uintah County, but their importance as mineral resources is negligible.

One final comment, not properly a geological subject, ought to be included in this chapter. Local stories declare that Uintah County was the site of the famous Diamond Fraud of 1872, a landmark in the lore of early mining in this country. However, that episode took place in northwestern Moffat County, Colorado, between branches of the west fork of Vermillion Creek, east of Ruby Gulch, on outcrops of a coarse iron-stained sandstone mesa at the foot of Diamond Peak (Hague, 1877). The "Diamond Mountain" of Uintah County, Utah, was known in 1873 as "Summit Valley" (Powell, 1876). The name was probably changed to Diamond Mountain in deference to the old Diamond brand cattle ranch which grazed livestock in the area (Untermann, personal communication, 1960).

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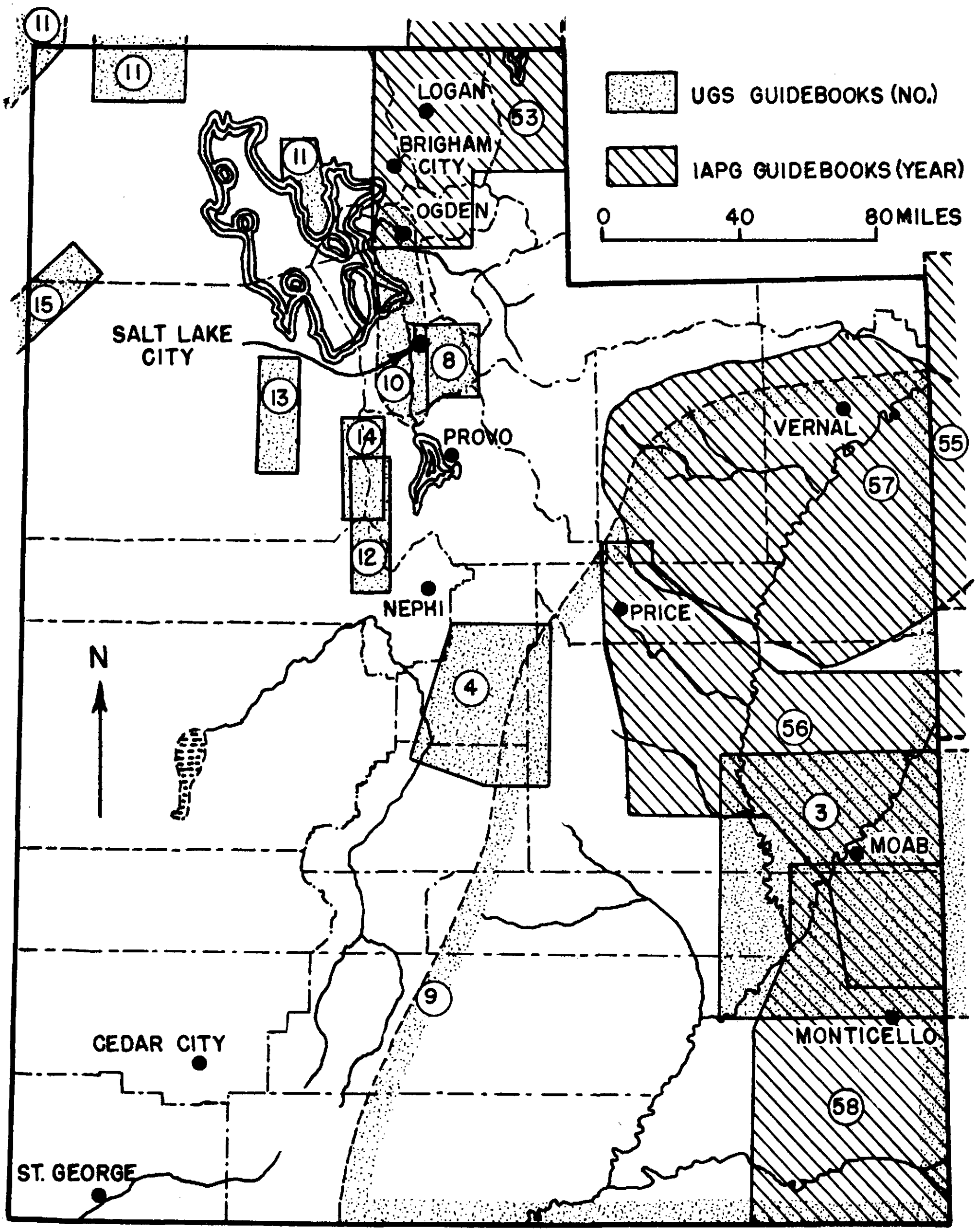

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