PRELIMINARY MINERAL RESOURCE STUDY OF THE UINTAH AND OURAY RESERVATION, UTAH

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SUMMARY AND CONCLUSIONS

Development of known mineral resources on the Uintah and Ouray Indian Reservation probably will be confined to expanded production of oil and gas by conventional methods and to extraction of modest amounts of sand and gravel.

Oil shale may have some development potential provided exploration can prove sufficient reserves in the Avintaguin Canyon-Indian Canyon area. If an adequate reserve is confirmed a successful commercial process for production must be developed. Therefore, under the most favorable conditions, any development of an oil shale industry on the reservation likely will be several decades away.

Although moderate coal resources exist on these Indian lands, the coal is low-Btu material that probably can be used only for conventional power generation. Because of the lack of a large resource, the absence of strippable reserves, the low-Btu value of the coal, the distance from adequate transportation facilities, and the large quantities of coal found in more accessible areas of Utah, it is doubtful that any significant development of coal on the reservation will occur in the near future.

Bituminous sandstones on the reservation contain large quantities of oil, but there has been no serious attempt to recover the oil in other than small amounts for use as a natural asphalt paving material. The problem is the same as with coal; larger, richer deposits occur off the reservation which probably will be developed first. Until exploration more accurately determines the size, saturation, and depth of the Indian owned deposits, it is impossible either to plan development of the oil impregnated deposits or to accurately assess their value.

Enough copper carbonate may exist on the reservation to sustain a small mining operation. An exploration program would be necessary to determine (1) the amount of resource present, (2) the location of the best material, and (3) the size of operation the resource would sustain. Recovery of the silver and uranium contained in the copper deposits probably is not economic at this time. Exploration to determine if minable gold placers exist on the reservation also would be useful for long-range planning.

Phosphate resources within the reservation do not appear large or rich enough to warrant exploration. The construction materials, stone and sand and gravel, are widespread over the area and will be developed as needs arise. Other nonmetals such as trona, dawsonite and the zeolites may be present.

INTRODUCTION

This report was prepared for the U. S. Bureau of Indian Affairs by the U. S. Geological Survey and the U. S Bureau of Mines under an agreement to compile and summarize available information on the geology, mineral resources, and potential for economic development of certain Indian lands. Source material was published and unpublished reports, as well as personal communication. There was no field work.

The Uintah and Ouray Indian Reservation includes parts of Duchesne, Grand, Uintah[1] and Wasatch Counties in northeastern Utah (Figure 1). The reservation is an irregular-shaped area of 1,008,152 acres, of which about 970,000 acres is tribally-owned, 24 acres is government-owned, and nearly 38,000 acres is allotted to individual Indians. In addition, the tribe controls subsurface rights on another 192,000 acres. Over the years, some tribal and allotted land has been sold to private interests. However, the Indians retained subsurface rights on most of the land sold. In addition to the main reservation, small areas of Indian land are scattered along White River and in the region south of White River, east of the reservation, and north of the Grand County line. Most of these small areas are leased for agricultural purposes.

The reservation, located within the Uinta Basin, is an area of relatively rough topography drained by the Duchesne, Uinta, White, and Green Rivers. U. S. Highway 40 passes through the area from east to west, and state roads and highways allow access to the north and south (Figure 1). Roads built by the Bureau of Indian Affairs also afford access to the southern part of the reservation.

[1]The National Board of Geographic Names applies the spelling "Uintah to political subdivisions, such as counties, reservations, etc., and the spelling "Uinta" to mountains, streams, and other geographic features. The word "Uintah" is believed to mean "That (country) at the foot of longleaf timber pines, clear stream flowing" (Unterman and Unterman, 1964).

Principal towns in the region are Vernal (population 3,908), Duchesne (population 1,094), and Roosevelt (population 2,005). Bureau of Indian Affairs and Tribal Council facilities are in the village of Ft. Duchesne.

GEOLOGIC SETTING

The Uinta Basin is a major sedimentary basin of the western-central Rocky. Mountain province. It is bounded by the Uinta Mountain uplift on the north and by the Wasatch Mountain uplift and the eastern faulted margin of the Wasatch Plateau on the west (Figure 2). On the southwest and south the basin is bounded by the San Rafael Swell and the Uncompampahgre uplift. The southern basin edge is usually considered to be the Book and Roan Cliffs, escarpments of Upper Cretaceous and Lower Tertiary Formations which dip northwest, north, and northeast into the basin. The northwest-southeast- trending salt folds of the northern Paradox basin plunge beneath the Book Cliffs in the southernmost part of the basin, and the two downwarps merge imperceptibly in this area. On the east the Uinta Basin is separated from the Piceance basin of northwest Colorado by the Douglas Creek arch which parallels the Utah Colorado boundary (Ritzma, 1972).

The Uinta Basin took shape in latest Cretaceous and Paleocene time when the then-dominant north-south tectonic and sedimentation patterns of Cretaceous time shifted to west-east in response to rapid uplift of the Uinta Mountains. The Uintahs impose a dominant west-east trend through most of the basin; however, structures in the southeast portion have a strong northwest grain reflecting the buried older Uncompahgre and Paradox trends of this area.

The basin is strongly asymmetric. Dips on the southwest and southeast flanks range from a few to 15º. The north flank is highly complex with major faulting, steep to overturned beds, and multiple unconformities which allow youngest Eocene rocks to lie unconformably on Precambrian. The basin axis is close to the mountain flank and migrates northward with depth.

The Uinta Basin is filled with 30,000 to 32,000 feet of sediments in its northern and deepest portion. These are subdivided as follows:

Tertiary (Eocene-Paleocene)	55%
Upper Cretaceous	25%
Triassic-Lower Cretaceous	10%
Paleozoic	10%

Although by far the greatest portion of the rocks exposed on the reservation are of Tertiary age, some pre-Tertiary age rocks are exposed on the northern and northwestern boundaries (Figure 3). There are reported occurrences of coal and phosphate-bearing material in the pre-Tertiary rocks, but the resource potential is somewhat limited because these rocks dip rather steeply to the south and thus become deeply buried toward the central part of the reservation.

Formation of the Uinta Basin began in Paleocene or Eocene time (55-65 million years ago) and has been sporadically active since then (Cashion, 1967, p. 1; Osmund, 1964). On the north flank of the basin, rocks of pre- and Early Tertiary age (65 million years and older) dip steeply to the south and are buried beneath younger rocks. On the south flank of the basin, the rocks dip gently to the north; these rocks are also buried by younger rocks lying over the central portion of the Uinta Basin.

During Eocene time (38-50 million years ago) large amounts of sediment from adjacent higher areas were deposited in various lacustrine and fluvial environments in the basin. These sediments, assigned to the Wasatch, Green River, and Uinta Formations (Figure 3) are perhaps more than 15,000 feet thick in the center of the basin, and contain important mineral resources (Cashion, 1967, p. 1).

Much of the area now occupied by the Uinta Basin was covered by a large lake named Lake Uinta by Bradley (1930) during Eocene time. Lacustrine marlstone, oil shale, limestone, siltstone, and sandstone of the Green River Formation were deposited in the lake. During the lake's expansionary periods, fluvial beds were deposited that are now beneath and peripheral to the lake deposits. The fluvial deposits form the shale, sandstone, and conglomerate of the Wasatch Formation. As the lake receded, fluvial beds were deposited peripheral to it, and finally covered the entire lake area. These beds form the Uinta Formation (Cashion, 1967, p. 5).

Stratigraphy

The stratigraphy of the Uinta Basin is given in Table 1 and the correlation of the various units are shown in Figure 4 (Untermann and Untermann, 1964, p. 15).

MINERAL RESOURCES

Energy Resources

Introduction

The Uinta Basin is a rich source of many energy-producing minerals. The greatest portion of the energy resources are hydrocarbons, in the forms of coal, oil and gas, oil shale, bituminous sandstone and limestone, and to a much smaller degree gilsonite.

Cretaceous and older rocks contain many productive oil and gas zones. However, the major portion of the energy production from the Uinta basin is from Tertiary rocks, and the distribution of the energy minerals is directly related to their depositional environment. The general distribution of hydrocarbons in Upper Cretaceous and Tertiary formations in the Uinta basin is shown on Figure 5.

Oil and Gas

Commercial production of oil and natural gas began in the Uinta Basin around 1948; since then production has steadily increased.

Three important fields are Cedar Rim, Bluebell and Altamont. All have had important discoveries made at the transition zone between the Green River and Wasatch Formations, both of Eocene age. Recent exploration and development strongly suggests that all of the fields are on the same trend, and further exploration might extend the trend to the west. Cedar Rim, Bluebell, and Altamont all produce from stratigraphic traps, and apparently from fractured clastic rocks, or in the case of Altamont, from dense carbonate or highly calcareous shale (Baker and Lucas, 1972). Entrapment at Altamont is at the transition between the Green River source rocks and the generally nonporous Wasatch red facies. The Altamont field lies on the south flank of the Uinta Basin, where a late Tertiary uplift produced a classical stratigraphic trap (Baker and Lucas, 1972).

The transition between typical Wasatch and typical Green River deposition was apparently the habitat for the formation of vast quantities of associated natural gas. The depositional environment during the waning stages of Lake Uinta was a less favorable habitat for the formation of crude oil and natural gas, and only small accumulations seem to be present in the transition from the Green River to the Uinta Formation (Ritzma, 1972).

The Cedar Rim and Bluebell fields are similar in detail, and are described by Peterson (1973a, 1973b). Earlier production from the Bluebell field was, from the lower Green River Formation, about 6,000 feet higher in the stratigraphic section than the transition zone which was discovered in late 1967.

The general distribution of the oil and gas producing fields on and near reservation lands is shown on Figure 6.

Table 2 lists oil and gas companies producing from the Uintah and Ouray Reservation in 1974. Table 3 lists companies and individuals holding nonproducing leases on the reservation.

Recent activity has centered around the Altamont-Bluebell area. In 1970, the Altamont field yielded 238,939 barrels of oil and 166,599 thousand cubic feet (Mcf) of gas. During 1973, the same field yielded 5,572,414 barrels of oil and 6,829,281 Mcf of gas.

In 1970, the Bluebell field yielded 1,439,179 barrels of oil, and 616,314 Mcf of gas, and in 1973, production increased to 7,350,889 barrels of oil and 6,257,542 Mcf of gas.

TABLE 2

1974 Oil and Gas Producers on the Uintah and Ouray Reservation.

Amoco Production Corp. Security Life Building Denver, Colorado 80202	Husky Oil Corp. 600 S. Cherry Street Denver, Colorado 80222
Belco Petroleum Corp. 630 Third Avenue New York, New York 10017	Koch Industries P.O. Box 2256 Wichita, Kansas 67201
Brinkerhoff Drilling Co. 600 Denver Club Building Denver, Colorado 80302	Mapco 900 Oil Center Building Tulsa, Oklahoma 74119
Chevron Oil Corp. P.O. Box 599 Denver, Colorado 94104	Mountain Fuel Supply Co. P.O. Box 11368 Salt Lake City, Utah 84139
Diamond Shamrock Corp. First National Bank Bldg. Box 631 Amarillo, Texas 79105	Phillips Petroleum Co. 7801 E. Belleview Englewood, Colorado 80110
Exxon Corp. of America P.O. Box 120 Denver, Colorado 80201	Shell Oil Corp. 1700 Broadway Denver, Colorado 80202
Flying Diamond Corp.* Suite 900, 1700 Broadway United Bank Center Denver, Colorado 80202	Sun Oil Co. 1720 S. Bellaire, Suite 300 Denver, Colorado 80222
Friar Oil Corp. 21 Felt Building Salt Lake City, Utah 84111	Texaco, Inc. 135 East 42nd Street New York, New York 10017
Gas Producing Enterprise 1050 17th Street, 21st Floor Denver, Colorado 80202	Union Oil Co. Union Oil Center 461 South Boylston Street Los Angeles, California 90017
Gulf Oil Corp. Gulf Building P.O. Box 1166 Pittsburgh, Pennsylvania 15230	

*May no longer produce from the reservation.

TABLE 3

1974 Nonproducing Oil-Gas Lease Holders on the Uintah and Ouray Reservation

Amerada Hess Corp.
51 W. 51st Street
New York, New York 10019

Atlantic Richfield
Security Life Bldg., Suite 1500
1616 Glenarm Place
Denver, Colorado 80202

Basin Petroleum Corp.
900 Fidelity Plaza
Oklahoma City, Oklahoma 71302

Champlin Oil and Refining Co.
P.O. Box 1257
Englewood, Colorado 80110

Continental Oil Co.
30 Rockefeller Plaza
New York, New York 10020

Cotton Petroleum Co.
2121 S. Columbia Street
Tulsa, Oklahoma 74114

A. R. Diller
1600 10th Street
Wichita Falls, Texas 76301

Gillman A. Hill
6200 Plateau Drive
Englewood, Colorado 80110

Home Petroleum Corp.
304 6th Avenue S.W.
Calgary, Alberta, Canada

Mesa Petroleum Co.
1660 Lincoln Street
Lincoln Center Bldg., Suite 2400
Denver, Colorado 80202

Mobil Oil Corp.
P.O. Box 5444
Denver, Colorado 80217

Palmer Cattle Co.
1600 10th Street
Wichita Falls, Texas 76301

Pennzoil Co.
P.O. Drawer 1139
Denver, Colorado 80202

Prudential Fund, Inc.
9601 Main Place
Dallas, Texas 75250

Sabine Exploration Corp.
2627 Tennaco Bldg.
Houston, Texas 77002

Shenandoah Oil Corp.
1612 Tremont Place
Denver, Colorado 80202

Toledo Mining Co.
322 Newhouse Bldg.
Salt Lake City, Utah 84111

Viersen Cochran
P.O. Box 280
Okmulgue, Oklahoma 74447

Zoller and Danneberg Exploration, Ltd.
Denver Plaza, Suite 2100
Denver, Colorado 80202

Table 4 lists cumulative production of oil and gas from those fields located on or near the reservation through 1973, the last year for which production figures are available.

TABLE 4
Cumulative Production of Oil and Gas Through 1973 from Fields on and Near the Uintah and Ouray Reservations

Field	Oil (barrels)	Gas (thousand cubic feet)*	
Altamont	9,556,077	11,340,233	
Bluebell	14,972,812	11,317,713	
Castle Peak	116,045	124,030	
Cedar Rim	811,315	965,796	
Cottonwood Wash	27,941	20,713	
Duchesne	537,383	188,826	**
Flat Mesa	511,215	355,995	
Flat Rock	23,279	159	
Gusher	62,949	-	
Gypsum Hills	165,521	22,319	
Indian Ridge	116,191	381,486	
Nutter Canyon	42,058	50,910	
Pariette	337,903	251,054	
Pleasant Valley	2,886	-	
Roosevelt	2,997,612	308,227	
Stagecoach	4,175	2,445,445	
Starr Flats	10,975	4,842	
Ute Trail	17,838	9,952,629	
Wonsits Valley	27,790,214	19,260,773	***

*Casinghead gas.
**Production figure from Oil and Gas Scouts, 1972, V. II.
***Wonsits Valley production figures have been combined with production from Red Wash field. Data are unavailable on the percentage that can be applied to Wonsits Valley field only.

Royalties paid to the Indians during fiscal year 1974 averaged about 16.5 percent for oil and about 22.0 percent for gas. Table 5 shows production value and royalty figures from oil and gas production on the reservation during fiscal years 1973 and 1974.

Income to the Tribe from royalties on oil and gas should show a large increase over the next few years from higher prices for oil and gas and from expanded production.

Bituminous Rocks

Bitumen is a generic term which is applied to native substances of variable color, hardness and volatility, composed principally of hydrocarbons, substantially free from oxygenated bodies, sometimes associated with mineral matter, the non--mineral constituents being fusable and largely soluble in carbon disulfide. Bituminous sandstone refers to sandstone which contains variable amounts of bitumen in its pore spaces (Kayser, 1966).

The location of the oil-impregnated rocks in and near the reservation is shown on Figure 7. The significant deposits of bituminous rocks are obviously within, or on the edges of, the Uinta Basin, and the most significant appear to be outside reservation boundaries. Within the Uinta Basin, most deposits and reserves occur in the Green River, Uinta, Duchesne River, and Wasatch Formations of Eocene age. The Asphalt Ridge deposit occurs in the Uinta and Duchesne River Formations (Eocene) and Mesaverde Formation (late Cretaceous) (Picard and High, 1970; Byrd, 1970). The White-rock deposit occurs in the Navajo Sandstone of Jurassic age (Ritzma, 1968). The Deep Creek Nose deposit, a potentially large deposit, occurs in the Duchesne River Formation, in sandstone and conglomerate overlying the Mancos shale and Duchesne River Formations. The Tabiona deposits are localized in the Current Creek (late Cretaceous and Paleocene age) and Eocene Uinta Formations; these sandstone units do not appear to be greater than 25 feet thick and are of very limited areal extent. The Myton Bench bituminous sandstones occur in highly lenticular units of the Uinta Formation and appear to have limited commercial value (Covington, 1963). The Hill Creek deposits appear to be an extension of the P.R. Spring deposits, but of a lower grade.

Physical properties of the bituminous rocks are a very important factor in the evaluation of the deposits. Porosity, permeability, grain size distribution, and cementing material have a direct bearing on the degree of bituminous saturation and probability of successful extraction of the bitumen (Kayser, 1966, p. 39). The degree of cementation influences not only migration of bitumen, but also cost of mining and crushing. Oil migration may have taken place laterally along bedding planes, through permeable sandstone or limestone formations, or along lateral or vertical passages formed by faults, fractures, or joints. Fractures and joints associated with faulting are often very important migration routes. In addition, faults frequently form barriers to migration and may cause entrapment. Usually, however, stratigraphic factors, principally porosity and permeability, appear to be more important than structure (Ritzma, 1968).

Although the potential resource contained in the bituminous rocks may be large, several problems may limit successful exploitation in the foreseeable future. Large-scale operations are apt to be restricted by a limited water supply. Surface deposits, if sufficiently large, may be amenable to strip mining. The bitumen-bearing rocks dip towards the interior of the basin, and development of the more deeply buried deposits will depend on in situ thermal processes, which are not yet economically feasible.

The largest bituminous sandstone deposit, known as the Hill Creek deposit, contains an estimated 1.2 billion bbls of oil, of which 350 million bbls is in measured reserves. The remainder falls in the indicated and inferred categories (Ritzma, 1974). The Hill Creek deposit probably does not belong to the Tribe. Part of it is in Naval Shale Oil Reserve No. 2 and the remaining part on the reservation probably belongs to the Federal Government, but ownership needs clarification. It would be worthwhile to determine if oil contained in the bituminous sandstone inside the Naval Oil Shale reserve is reserved in the same manner as oil contained in the oil shale. No known development has occurred on the Hill Creek deposit.

The second largest bituminous sandstone deposit is in the White Rocks area. Only a small part of the deposit is believed to extend onto the reservation. According to Ritzma (1974), past development on the White Rocks deposit has consisted of "Experimental mining and extraction of oil (pilot plants operated successfully for short period), in-situ experiments (steam flood and thermal), and core drilling."

The third largest oil sand occurrence at least partly on Indian land is the Willow Creek deposit. The Utah Geological and Mineral Survey estimates the deposit contains 20 to 25 million barrels of oil in place (Ritzma, 1974). According to Hurlbut, Kersich, and McCullough (1974) oil saturation of the sands is poor, 2 to 8 gallons per ton, and the deposit occurs under several hundred feet of overburden. However, they estimated the deposit contains about 44.0 million barrels of oil in two zones on Indian lands. This figure is nearly twice as much as the Utah Geological and Mineral Survey estimated for the entire deposit.

The fourth largest oil sand, now known as the Pariette deposit and formerly called Myton Bench or Myton area, actually consists of several small deposits. The entire area contains an estimated 10 to 12 million barrels of oil (Ritzma, 1974). Most of the deposit, however, is not controlled by the Tribe, and the extent of their ownership is unknown. There has been no, known development on the deposit.

A smaller deposit on Indian lands is the Littlewater Hills occurrence, formerly known as Deep Creek Nose. The oil content is estimated to be 10-12 million barrels (Ritzma, 1974). Overburden ranges from 0 to about 500 feet, and there are one or two pay zones. There has been no known development.

Another oil impregnated sandstone, wholly on Indian-controlled land, is the Lake Fork deposit. Estimates of oil-in-place are 6.5 to 10 million barrels by the Utah Geological and Mineral Survey (Ritzma, 1974) and 9.5 million barrels by Hurlbut, Kersich, and McCullough (1974). Overburden thickness has been placed at 0 to 450 feet and total thickness of the pay zone at 10 feet by the consultants and 5 to 70 feet by the Utah Survey. At least two authorities agree that this deposit has little economic significance. Covington (1963) states that the sands ate not rich enough to use as asphalt paving material, indicating that saturation is poor, and Hurlburt, Kersich, and McCullough (1974) state that "the deposit cannot be strip mined and reserves are too small to make the deposit economic for underground mining." However, the Garner Construction Co. reportedly is interested in using the deposit for asphalt paving material. Because of the disagreement concerning the thickness of the pay zone, exploration would be desirable to better define both the pay zones or zones and degree of saturation.

The Chapita Wells occurrence has been designated as a medium small (7.5 to 8 million barrels) deposit (Ritzma, 1974). The deposit, actually a group of small individual occurrences, is in the Hill Creek Extension of the Reservation. Some land in and near the deposits is not owned by the Tribe, and they do not control the mineral rights. No development has been recorded at this location, and the economic possibilities are unknown.

The Tabiona deposit, estimated to contain about 4.6 million barrels of oil, is entirely on Indian land (Ritzma, 1974). There is no development and the commercial possibilities are unknown.

The Spring Branch deposit is estimated by the Utah Geological and Mineral Survey to contain only 1.5 to 2.0 million-barrels of oil (Ritzma, 1974). Hurlbut, Kersich, and McCullough (1974) estimate the deposits contains as much as 3.7 million barrels, but state that the deposit is uneconomic at present because the saturation is only 9.4 barrels per ton. Still, they believe the deposit may be strippable. There has been no development on the deposit to date. An examination to determine the size, thickness, and degree of saturation of this deposit would be useful.

Solid Hydrocarbons

Solid hydrocarbons of the Uinta basin occur only to a minor extent on the Uintah and Ouray Reservation. All current mining is for gilsonite and is centered around the community of Bonanza several miles east of the reservation. The other hydrocarbons, wurtzilite, tabbyite, ingramite, albertite, and ozokerite (ozocerite), have not been mined for several years. According to Nackowski, Fisher, and Beer (1963), reserves of wurtzilite, ozokerite, and tabbyite combined do not exceed 3,000 tons. Ozokerite is not known to occur on the reservation.

<u>Gilsonite</u>.--Gilsonite is a solid amorphous asphaltic bitumen which occurs in distinct veins and veinlets in the Tertiary nonmarine sediments of the gently downwarped Uinta Basin. These veins continue unbroken for miles and maintain relatively constant thickness. Most of the veins are vertical and are filled with massive gilsonite, showing clean contacts with little or no impregnation or saturation of the vein walls. The veins fill vertical tensional cracks in the competent sedimentary beds, and generally extend downward until they reach the incompetent mudstone of the Uinta Formation and the oil shales of the Green River Formation (Crawford and Pruitt, 1963). Hunt and others (1954) concluded that the gilsonite is derived from the upper Green River Formation oil shales, and flowed upward into the open tensional cracks.

Three systems of gilsonite veins cross the reservation. Two veins of the Fort Duchesne system mark the northern extent of gilsonite veins in the Uinta Basin. One or the other of these veins, which are as much as 4 feet thick and 3 miles long, were mined from the late 1880's until 1946. The Pariette system south of Myton in Duchesne County is the western extremity of known gilsonite deposits in Utah. This system has a total length of 9 miles, with veins approximately 18 inches wide at the surface and increasing to approximately 40 inches at a depth of 1,500 feet. The Willow Creek and Ouray systems, south of Chapita Wells, are in relatively unexplored areas, but are known to contain at least five moderate-sized gilsonite veins, and a number of other veins whose dimensions and quality are not well known (Crawford and Pruitt, 1963).

Except for minor quantities near Fort Duchesne and some small uneconomic veins near Ouray, the area resources are not Indian-owned.

Hurlbut, Kersich, and McCullough (1974) suggest that a geophysical investigation using electrical resistivity methods might lead to discovery of gilsonite veins that have no surface expression.

Oil Shale

Oil shale which may be a significant economic resource, is neither oil nor shale. The host rock is usually a magnesian marlstone with a high organic content and inorganic constituents such as dolomite, calcite, and clay minerals. The rock was formed by compression of abundant plant and animal life deposited in Lake Uinta during Eocene time (Cashion, 1967; Quigley and Price, 1963). When oil shale is heated under the proper conditions, oil is released.

The oil shale of interest in the Uinta basin is restricted to the Green River Formation. Rich oil shales of the Piceance Creek basin of northwestern Colorado also occur in the Green River Formation. Depositional conditions differed between the two basins, however, leading to more rapid changes in quality and quantity of oil shale across the Uinta Basin. Many rich areas have been found, but these appear to be more erratic in areal extent and more subject to vertical variation than the Colorado deposits (Smith and Stanfield, 1964).

Oil shale prospects in the eastern Uinta Basin have been more extensively investigated because outcrop information is more abundant and depths to subsurface deposits are shallower, and more drilling has been done on the Naval Oil Shale Reserve. The oil shale is more deeply buried in the western and central parts of the Uinta Basin.

Although oil shale occurs over a large portion of the reservation, much of it is too low in grade or is too deep to be considered economic (Figure 8). Also, large areas of known oil shale occurring on the reservation are not controlled by the Indians. For example, in the southern part of the reservation, the U. S. Government owns most of the shale; some of the area is within Naval Oil Shale Reserve No. 2. Nevertheless, some shale under Indian control on the reservation may have commercial possibilities. The study by Hurlbut and others (1974) indicates that at least one 20-foot bed of oil shale in the Avintaguin Canyon area in the southwestern corner of the reservation may approach commercial grade, and the lowermost of three oil shale beds averaged 35 gallons of crude shale oil to the ton. This bed may contain between 100 and 185 million barrels of oil. The study also recommends further exploration. An exploratory drilling program would provide the necessary information to evaluate the area and determine its commercial possibilities.

The Tribal Council and employees of the Ute Research Laboratories state that Paradox Production Co. is interested in leasing the Avintaguin Canyon oil shale. The company, which owns oil shale claims in the canyon adjacent to the reservation (Figure 8) reports that shale on its property contains about 50,000 bbls of oil per acre. Recent work by the Laramie Energy Research Center at Laramie, Wyo., indicates that the 50,000-bbl figure is not unrealistic. Two cores taken by the company on land adjacent to the reservation were recently analyzed by the Laramie facility. Both cores showed an average of about 31 bbls per ton through an 18-foot section or about 40,000 bbls per acre. The company has indicated that a 50,000-bbl-per-day plant might be feasible, provided enough shale is available.

Coal

Minable beds of coal are found in the Frontier Sandstone Member of the Mancos Shale and in the Mesaverde Group, both of Late Cretaceous age (Schell, 1964). These beds are described by Huddle and McCann (1947) and Huddle, Mapel, and McCann (1951), and crop out in the northwestern portion of the reservation. Essentially the entire reservation is underlain by coal-bearing rocks, but readily available coal occurs only near areas of outcrop. Because the coal-bearing strata dip toward the center of the Uinta Basin, the coal may be 3,000 feet below the land surface only a few miles from the outcrop, and may be as much as 20,000 feet below the surface in the center of the basin (Averitt, 1972). Near-surface coal on the reservation is in two fields, the eastern or Vernal field and the western or Tabby Mountain (Blacktail Mountain) field. Development in those portions of the fields on Indian-controlled lands has been slight, but there are small, abandoned mines in both areas. Production probably has not exceeded a few thousand tons from either field. One existing coal lease on 200 acres of reservation land (Figure 9) is held by the Red Creek Coal Corp. The property contains the abandoned Redden mine, which was opened in a coalbed about 27 feet thick that dips to the south about 50º. Production probably did not exceed a thousand tons from both the strip and underground operations.

Coal owned by the tribe in the northeastern corner of the reservation is part of the Vernal field. All of the coal is in the Frontier Formation and the only significant coal is a single steeply dipping bed 3 to 6 feet thick (Hurlbut, et al., 1974).

All coal in the northwest part of the reservation is in the Tabby Mountain (Blacktail Mountain) field. According to Doelling and Graham (1972), the entire field, including both the Frontier and Mesaverde beds, contains about 231.1 million tons of coal.

Hurlbut, Kersich, and McCullough (1974) report that lands held by the Indians contain about 62.0 million tons of "semi-proven" coal resources plus 97.0 million tons of "possible" coal reserves in five beds, each 5 feet thick or more, and at a depth of less than 3,000 feet. This coal is in an area between Red Creek and Currant Creek, the only area on the reservation that contains worthwhile quantities of minable coal.

The coal on the reservation is ranked as high volatile C bituminous. Analyzed samples contain 7500 to 12,000 Btu value. The coal is noncoking, and cannot be used for metallurgical purposes. About the only use for reservation coal would be for power generation.

Recent work by A. E. Lindquist, USBM, indicates that coal owned by the Tribe may be insufficient to warrant a coal-gasification plant. To amortize the capital investment, the life of a coal--

gasification plant necessarily would be about 35 years. A plant using 7,500 Btu coal requires about 9.2 million tons of coal per year, and a plant using 12,000-Btu coal requires about 5.8 million tons per year. Therefore, a gasification plant using reservation coal would require between 203 million and 322 million tons of reserves. The Tribe probably does not have 200 million tons of minable coal. Moreover, coal beds on the reservation are steeply dipping (about 50º) making it impossible to strip mine to any great depth. U.S. Bureau of Mines (1971) does not list any reserves in Duchesne or Uintah Counties.

Overall, it is deemed unlikely that a large mine or mines will be developed on the reservation in the foreseeable future. However, the tribe has indicated that it has been approached by interested companies.

Uranium

Small, non-commercial, low-grade uranium deposits occur within the reservation (Figure 10) (Cohenour, 1969).

The most common type of uranium occurrence in the Uinta Formation is a copper-uranium-carbon association found in a zone centered near Ouray (Figure 10). The highest grade mineralization occurs in carbonized wood, bones, turtle shells, and logs. The logs are generally found on the flanks of paleochannels; each log is surrounded by a halo of azurite and malachite. Only secondary uranium minerals have been identified and copper is generally more abundant than uranium. Some uranium has also been noted in carbonaceous shales, but there is essentially no uranium in noncarbonaceous sediments (Noble and Annes, 1957, p. 17). Locally uraniferous opal in a caliche--like material coats fracture surfaces and bedding planes in the Uinta Formation (Cohenour, 1969). The Green River Formation has a high potential tonnage of weakly mineralized rock (Noble and Annes, 1957), but it contains no known uranium deposits of ore grade. There are no obvious guides to uranium in the Green River Formation, although deposition was probably controlled by finely divided carbon trash disseminated in calcareous siltstone and calcareous clayey mudstone.

A uranium occurrence has been reported in fresh water limestone of unknown age ten miles south of Highway 40 (Beroni and McKeown, 1952, P. 13).

Metallic Mineral Resources

Copper

Copper mineral occurrences have been known in the Uinta sandstone for many years (Butler and others, 1920; Roberts, 1964) and although sporadic prospecting has been done, there appears to have been no commercial production. The most significant mineralization appears to be near the junction of the Green and Duchesne Rivers, although the weak uranium mineralization usually occurs with copper mineralization (Figure 10).

The copper typically occurs in the sandstone in close association with plant remains. Portions of the plant remains have been replaced by copper minerals, primarily chalcocite. Near the surface the copper minerals have all been oxidized and now are primarily malachite, a copper carbonate. If a large proportion of plant fragments has been replaced, the copper mineralization may be of high grade. The copperbearing rock is confined to lenses containing abundant plant remains; however, the mineralization, extending through a thickness of about 10 feet, is not limited to concentrations around carbonized material.

Copper content of the ore varies, but a mine near the reservation southwest of Ouray has proven reserves of about 100,000 tons averaging 1.17 percent copper and minor quantities of gold, silver, and uranium. The mine, owned by Lloyd Ash of Pleasant Grove, is being developed and work to date has consisted of upgrading access to the mine and clearing and leveling about 3 acres to be used as leach pads. Several small dams have been constructed, and about 1 mile of pipeline has been installed to pump water from Pariette Draw to fiberglass tanks installed at the mine site. Mining at a rate of about 10,000 tons per year is scheduled to begin in the late spring of 1975. Processing will consist of leaching with sulfuric acid supplied by Kennecott Corp. of Bingham.

Another copper deposit on the reservation occurs east of Green River north of Ouray. The Tribe does not own the minerals but two claims have been staked by Lawrence Jenks, a tribe member. Mineralization on these two claims is in the Uinta Formation and is of the same type described for deposits west of the river.

Gold

Accumulations of gold in river gravels probably occur on Indian land along the Green River in Uintah and Grand Counties. Attempts to mine placer deposits upstream (Figure 10) from the reservation between 1905 and 1942 resulted, however, in only a small annual recovery. The highest production was in 1941 when a combined total of 334 ounces of gold was recovered from all placers along the Green River (Johnson, 1973).

The gold is reported to be in a fine, flourlike form that is very difficult to recover. Source of the gold probably was the Precambrian rocks of northwestern Colorado. Dredging operations were attempted at Horseshoe Bend, Jensen, and below Split Mountain gorge, about 25 to 35 air-miles above the reservation boundary, but they were unsuccessful. Gravels dredged in 1910 reportedly averaged \$0.60 to \$1.75 per cubic yard. Percent recovery is unknown. Gold also is known to occur in placers along the Green River in Grand County, but the grade has not been determined.

Total reserves of gold contained in placer gravels along the Green River on Indian land are unknown but could be substantial. However, the average content is low, and the gold is difficult to recover because of its finely divided form. Nevertheless, field reconnaissance and sampling to determine the extent and grade of the placers would clarify the uncertainties.

Minor Metals

Minor occurrences of several other metals are reported on and near the reservation. Ilsemannite, an amorphous, water-soluble molybdenum salt (Mo_30_8 nH_20), is reported to occur in the Bridger formation on the south side of the Duchesne River valley in Uintah County. An attempt was made to market the mineral as a dye, but was unsuccessful (Pruitt, 1961). Little else is known of the deposit.

An uneconomic manganese deposit is reported in an area several miles east of the reservation. Manganese is not known to occur on the reservation (Pruitt, 1961).

Nonmetallic Mineral Resources

Nonmetallic resources of the Uintah and Ouray Reservation and environs are widespread, but, except for sand and gravel and possibly minor quantities of stone, they have not been developed. Resources on or near the reservation include phosphate, sand and gravel, stone, gypsum, dawsonite, and possibly zeolites and trona.

Phosphate

Phosphate of potential economic importance on the reservation is found in the Meade Peak phosphatic shale member of the Phosphoria Formation of Permian age (Figure 9). This member contains large resources of low-grade rock amenable to strip mining, but these resources are found primarily off the reservation, near Vernal (Cheney, 1957a, p. 7). Phosphate rock is produced by the Stauffer Chemical Co. from its Cherokee mine north of Vernal.

Most phosphate rock occurring in Duchesne or Uintah Counties is outside reservation boundaries. No phosphate rock occurs near Indian lands in Wasatch County, and Grand County has no known phosphate rock deposits. A known deposit on Indian land occurs along the northern border of the reservation near the community of Hanna. Also, an 80-acre area of phosphate rock is in the northeast corner of the reservation at White Rocks Canyon in Uintah County. According to Pruitt (1961) and consultants Hurlbut, Kersich and McCullough (1974), the latter deposit probably is not economic. It consists of three phosphate beds 1.75 feet thick, 1.5 feet thick, and 4.7 feet thick. The first two beds contain about 27 percent P_20_5 and the third about 20 percent P_20_5. The two richer beds probably are too thin to be mined. The thicker bed possibly could be exploited, but it contains only ab out 700,000 tons to a depth of 1,250 feet, the limit to which it could be mined. The entire deposit is estimated to contain some 2.2 million tons of resources.

The deposit along the northern boundary of the reservation near Hanna is in two parts, one on each side of the North fork of the Duchesne River. Analytical data on samples taken from these deposits is reported by Nackowski and others (1963). All were low in grade, and the richest was only 18.75 percent P_20_5. Williams (1942) confirms the low grade of the phosphate rock, reporting an analysis of a sample from about the same area to be only 2.95 percent P_20_5. He states "Mining of phosphate in Duchesne County at the present time would be marginal or not feasible due to the narrow widths, low grade, and steep dip of the phosphate beds."

Although Gere (1964, p. 201) reports rather large low-grade phosphate reserves for Duchesne County, his estimates include some resources off the reservation, and may be optimistic. The two areas discussed by Coffman and Service (1967, p. 138) total about 300 acres of above-drainage level Meade Peak. The Mackentire Draw area contributes about 35 acres, and the remaining 265 acres is found in the Rock Creek area. In an 11.5-foot zone in the Mackentire Draw area there could be 11 million tons of at least 14 percent P_20_5" The Rock Creek area, using a 4.8-foot zone of 18 percent or greater, P_20_5, should contain roughly 5.5 million tons above drainage level and 1.8 million tons for each 100 feet below drainage level (Coffman and Service, 1967, p. 138).

Overall, it appears unlikely that phosphate deposits on reservation lands could be exploited economically in the foreseeable future. It is equally doubtful that further exploration would significantly change that outlook.

Saline Minerals

Nahcolite.--Nahcolite ($NaHCO_3$) occurs in the Uinta and Green River Formations of Eocene age (Hite, 1964). It was first reported from a Sun Oil Co. well in the NE¼NE¼ sec. 22, T. 9 S., R. 20 E., where it occurred in a zone approximately 525 feet thick, the top of which is 1,745 feet below the surface. The best mineralized interval was 5 feet thick and averaged 60 percent nahcolite. A well drilled by Continental Oil Co. in the NE¼SW¼NE¼ sec. 17, T. 4 S., R. 4 W., Uinta Special Meridian, may also have penetrated bedded deposits of sodium minerals between depths of 2,902 and 3,582 feet (Hite, 1964). Dane (1955) reported the occurrence of nahcolite and shortite [$Na_2Ca_2(C0_3)_2$] in the Carter Oil Co. Joseph Smith No. 1 well located in the SE¼ SE¼ sec. 16, T. 3 S., R. 5 W., Uinta Special Meridian, a few miles north of Duchesne. The nahcolite was observed in a section 20 feet thick at a depth of 3,600 feet.

Nahcolite is a potential source of soda ash, but any development on reservation lands would face serious competition from the nearby established Wyoming trona fields. Nielson (1969) reported that nahcolite is effective as an air pollution control agent in removing sulfur compounds from stack gases. If this use becomes economically feasible, there is a possibility of development of the nahcolite underlying reservation lands.

Gypsum

Gypsum ($CaS0_4$ $2H_20$) has been noted in the northeastern corner of the reservation in the Carmel Formation. Except for local use as a plaster, it has not been mined (Pruitt, 1961). It is unlikely that gypsum deposits in the area can be developed, owing to the distance from railroads and lack of a significant local market.

Zeolites

Zeolites have been reported to occur in the Green River Formation east of the reservation (Pruitt, 1961), indicating they possibly may be present in the same formation on the reservation. No such discoveries have yet been noted, however.

Stone

Stone resources are widespread over the reservation. However, no high-value stone, such as marble or slate, occurs in the area. The available resources of low-value sandstone and limestone probably will be in only small demand within the foreseeable future.

Sand and Gravel

Sand and gravel deposits are widespread on the reservation, both as alluvium in existing streams and as older terrace deposits adjacent to such streams. Deposits related to ancient streams also are found in many areas of the reservation. Sand and gravel owned by the Indians is currently being produced from only one deposit. The Uinta Basin Concrete Products Co. of Roosevelt has a permit to extract sand and gravel from 100 acres in the eastern part of the reservation. During 1973, 20,158 cubic yards of sand and gravel was mined for which the Indians received $1,924 in royalty. In 1974, the company removed 55,275 cubic yards and paid the Indians $0.06 per yard for a total of $3,316. The importance of a sand and gravel resource in an area of low population density, such as the reservation, is negligible.

MINERAL LEASING

Federal regulations require established royalty and rental fees for mineral leases on the Uintah and Ouray Indian Reservation in Utah. Also, bonds must be posted by the lessee for each lease. The bonds are as follows, except as noted.

For less than 80 acres	$1,000
For 80 acres and less than 120 acres	1,500
For 120 acres and not more than 160 acres	2,000
For each additional 40 acres, or part thereof, above 160 acres	500

The bond for minerals other than oil and gas may be less, provided the Secretary of the Interior, with consent of the Tribe, agrees; or a lessee may file a bond of $15,000 for all leases in one state if the total acreage does not exceed 10,240. A lessee may also file a bond of $75,000 for nationwide coverage.

Lessees may acquire more than one lease, but a single lease may not exceed 2,560 acres for minerals other than coal. Ordinarily, coal leases also are limited to 2,560 acres, but upon application, leases can be combined. Leases may be made for any specified term not to exceed 10 years. A diagram of the procedure for obtaining leases and mining permits is shown in Figure 11.

Royalties and rentals for oil and gas leases are set by the Secretary of the Interior. The law provides that $1.25 per acre per annum be paid by the lessee in advance and that the royalty shall be at least 12.5 percent. For minerals other than oil and gas, rental payments are set at $1.00 per acre and a development expenditure of not less than $10.00 per acre per year.

Unless otherwise authorized by the Commissioner of Indian Affairs, the minimum rates for minerals other than oil and gas shall be as follows:

> "(a) For substances other than gold, silver, copper, lead, zinc, tungsten, coal, asphaltum and allied substances, oil, and gas, the lessee shall pay quarterly or as otherwise provided in the lease, a royalty of not less than 10 percent of the value, at the nearest shipping point, of all ores, metals, or minerals marketed."

"(b) For gold and silver the lessee shall pay quarterly or as otherwise provided in the lease, a royalty of not less than 10 percent to be computed on the value of bullion as shown by mint returns after deducting forwarding charges to the point of sale; and for copper, lead, zinc, and tungsten, a royalty of not less than 10 percent to be computed on the values of ores and concentrates as shown by reduction returns after deducting freight charges to the point of sale."

"(c)For coal the lessee shall pay quarterly or as otherwise provided in the lease, a royalty of not less than 10 cents per ton of 2,000 pounds of mine run, or coal as taken from the mine, including what is commonly called 'slack'."

"(d) For asphaltum and allied substances the lessee shall pay quarterly or as otherwise provided in the lease, a royalty of not less than 10 cents per ton of 2,000 pounds on crude material or not less than 60 cents per ton on refined substances."

In addition to the Federal regulations, the tribe requires that some Indians be hired by any firm extracting minerals from reservation lands.

The Tribe presently owns only the surface rights in the easternmost part of the reservation and over most of its southern extension. The Tribal Council is currently preparing legislation to be presented to the present congress (94th Congress, First Session) for restoration of mineral rights in the area. Part of Naval Oil Shale Reserve No. 2 is in the area.

MARKETS

Markets exist for most mineral commodities found within the reservation. Sand and gravel and stone however have a limited local market. Petroleum and natural gas reserves are being developed at a rapid rate, but most of the production is exported. A limited national market exists for gilsonite, but because substitutes exist for most uses of this material competition is strong.

Bituminous sandstones have found a limited local use as road asphalt, but their greatest promise is as a source of petroleum products.

Only sand and gravel, crushed stone, and minor quantities of bituminous sandstones could be used locally. All other mineral commodities occurring on the reservation must find their way into the national market.

RECOMMENDATION FOR FUTURE WORK

1) Determine the status of mineral rights on reservation land to determine which land can offer economic benefits to the Tribe.

2) Encourage commercial oil companies to continue exploration, especially on the Altamont trend.

3) Continue mapping of near-surface coal deposits exposed in the northwest portion of the reservation.

4) Initiate exploration for near-surface, secondary copper mineralization. Although it appears that these deposits are scattered and probably of low tonnage, the copper present should be amenable to low cost extraction by heap leaching methods.

5) Define extent and grade of oil shale by examination of existing well log data, extended field mapping, and perhaps drilling 2 to 4 core holes in the west-central portion of the reservation.

6) Determine ownership, extent, and oil content of bituminous sandstones to evaluate their potential and plan for development.

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Table 1.--Generalized stratigraphy of the Uintah and Ouray Indian Reservation and adjacent area

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System	Series	Formation	Thickness (feet)	Lithologic character and distribution
Quaternary	Holocene and Pleistocene	Alluvium and outwash gravel	1-200	Gravel, sand, and silt; generally unconsolidated. Outwash gravel generally prominent along Uinta River drainage. Recent alluvium occurs in most stream valleys
Tertiary	Miocene(?)	Bishop conglomerate	1-800	Conglomerate of rounded to subangular boulders in sandstone matrix. Occurs on south slope of Uinta Mountains, dipping gently away from mountains.
	Oligocene or Eocene	Duchesne River Formation	50-300	Mudstone, siltstone, sandstone in beds 2 to 6 feet thick, commonly separated by unconsolidated beds of similar material. Underlies surface over northern and eastern parts of basin. Normally flat lying; maximum dips 2°-4°.
	Upper Eocene	Uinta Formation	1,500	Green to reddish shale capped in places by 30 to 50 feet of sandstone in beds a few inches to a few feet thick. Underlies surface over southern half of basin; underlies Duchesne River Formation elsewhere. Normally flat lying; maximum dips 2°-4°.
Tertiary	Eocene	Green River Formation (divided into Evacuation Creek, Parachute Creek, Garden Gulch, and Douglas Creek Members)	About 1,500 where exposed; as much as 4,000 feet in subsurface	Black shale, sandstone, and oolitic limestone. Oil- and gas-producing sandstone and shale. Underlies entire basin but is several thousand feet below surface along axis of of basin.

Continued

Table 1.--Generalized stratigraphy of the Uintah and Ouray Indian Reservation and adjacent area--Cont.

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System	Series	Formation	Thickness (feet)	Lithologic character and distribution
Tertiary	Lower Eocene	Wasatch Formation	1,500-5,000	Mudstone, sandstone, conglomerate, and minor amounts of limestone; predominantly fluviatile red beds. Underlies entire basin--is more than 10,000 feet below surface at deepest part. May include older rocks.
Tertiary and Cretaceous	Paleocene and Upper Cretaceous	North Horn Formation	500-1,600	Interbedded sandstone, conglomerate, shale, and limestone. Probably does not crop out in the area of the report; may occur in subsurface.
	Upper Cretaceous	Mesaverde Formation	400-1,200	Fine- to medium-grained sandstone, dark-gray shale, lignitic shale and lignite. Sandstone predominates in lower half of formation, and lignitic shale and lignite are present only in upper part. Crops out at eastern end of basin; probably underlies entire basin.
		Mancos shale (includes rocks equivalent to Emery and Ferron Sandstone Members and Frontier Sandstone Member, and intertonguing sandstone lenses of Mesaverde Formation	3,500-5,000	Gray marine mudstone with eastward-thinning sandstone lenses. Crops out northeast of basin; probably underlies entire basin.

Continued

Table 1.--Generalized stratigraphy of the Uintah and Ouray Indian Reservation and adjacent area--Cont.

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System	Series	Formation	Thickness (feet)	Lithologic character and distribution
Cretaceous	Upper Cretaceous	Dakota Sandstone (included with Mancos shale on generalized map)	50-90	Conglomeratic sandstone that represents advance of Cretaceous time lines. Crops out north and northeast of basin; probably underlies entire basin.
	Lower Cretaceous	Cedar Mountain Formation (includes Buckhorn conglomerate member)	120-200	Green, purple, and maroon mudstone with discontinuous conglomerate and conglomeratic sandstone at base. Probably underlies entire basin; thickens to southwest.
Jurassic	Upper Jurassic	Morrison Formation (probably mostly equivalent to the Brushy Basin shale member of southeastern Utah)	800-1,000	Varicolored mudstone and claystone. Crops out north and northeast of basin; probably underlies entire basin.
		Curtis Formation	250-300	Fossiliferous, glauconitic sandstone, shale, and sandy limestone. Crops out north and northeast of basin; probably underlies entire basin.
		Entrada Sandstone	100-175	Principally crossbedded eolian sandstone. Crops out north and northeast of basin; Probably underlies entire basin.
	Upper and Middle Jurassic	Carmel Formation	125-170	Red sandstone, shale, and siltstone. Crops out north and northeast of basin; probably underlies entire basin.
		Navajo Sandstone	700-900	Crossbedded calcareous sandstone. Crops out north and northeast of basin; probably underlies entire basin.

Continued

Table 1.--Generalized stratigraphy of the Uintah and Ouray Indian Reservation and adjacent area--Cont.

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System	Series	Formation	Thickness (feet)	Lithologic character and distribution
Triassic(?)	Upper Triassic	Chinle Formation (includes Shinarump Member)	250	Basal sandstone or conglomerate overlain by red-orange, purple, or green claystone to conglomerate. Conglomerate of Shinarump Member fills channels in Moenkopi Formation. Crops out north and northeast of basin; probably underlies entire basin.
Triassic	Middle(?) and Lower Triassic	Moenkopi Formation (included with Chinle Formation on map)	700-800	Red beds of unfossiliferous sandstone, siltstone, and claystone both above and below a middle fossiliferous limestone member.
Permian		Park City Formation	200±	Thick limestone with intercalated quartzite and sandstone. Crops out north and northeast of basin; probably underlies entire basin.
		Phosphoria Formation (included with Park City Formation on map)	40-60	Phosphatic shale with thin limestone beds.
Pennsylvanian		Weber Sandstone	1,000-1,200	Massive, crossbedded, fine- to coarse-grained sandstone. Crops out north and northeast of basin; probably underlies entire basin.
		Morgan Formation (included with Weber sandstone on map)	1,100-1,300	Thick bedded, cherty, fossiliferous limestone in lower member and red sandy shale, buff and red crossbedded sandstone, and thin beds of gray to pink cherty limestone in upper member. Occurrence is similar to the Weber.

Continued

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Table 1.--Generalized stratigraphy of the Uintah and Ouray Indian Reservation and adjacent area--Cont.

System	Series	Formation	Thickness (feet)	Lithologic character and distribution
Pennsylvanian and Mississippian		Pennsylvanian and Mississippian rocks undivided. Probably includes rocks equivalent to Mannin Canyon shale, Humbug Formation, Deseret and Madison limestone.	1,000±	Principally massive limestone with a black fissile shale unit at top. Occurrence is similar to Weber.
Cambrian	Upper Cambrian	Lodore Formation	100-1,200	Thickbedded, coarse-grained, arkosic sandstone and arenaceous shale. Occurrence is similar to Weber.
Precambrian		Uinta Mountain	12,000-15,000	Red, pink, or white quartzitic sandstone with thin shale partings, and thin bedded sericitic and sandy shale interbedded with slabby sandstone. Forms core of Uinta arch in eastern part of Uinta Mountains.

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Table 5.--Total oil and gas production and value, and royalty production and value from Uintah and Ouray Reservation during fiscal years 1973 and 1974

	Oil (barrels)							
	1973				1974			
	Total	Value	Royalty	Value	Total	Value	Royalty	Value
Allotted lands ...	263,354	$740,833	41,335	$117,405	673,572	$4,134,416	112,127	$688.940
Tribal lands	1,453,091	4,052,117	246,779	607,257	3,245,415	20,450,399	534,345	3,390,837
Total	1,716,445	$4,792,950	288,114	$804,662	3,918,987	$24,584,815	646,472	$4,079,777

	Gas (thousand cubic feet)							
	1973				1974			
	Total	Value	Royalty	Value	Total	Value	Royalty	Value
Allotted lands ..	77,515	$18,163	11,756	$2,748	20,791	$63,937	33,614	$10,427
Tribal lands	170,405	41,603	28,332	6,743	551,391	228,859	91,898	38,143
Total	247,920	$59,766	40,088	$9,491	572,182	$292,796	125,512	$48,570
Grand total				$814,153				$4,128,347

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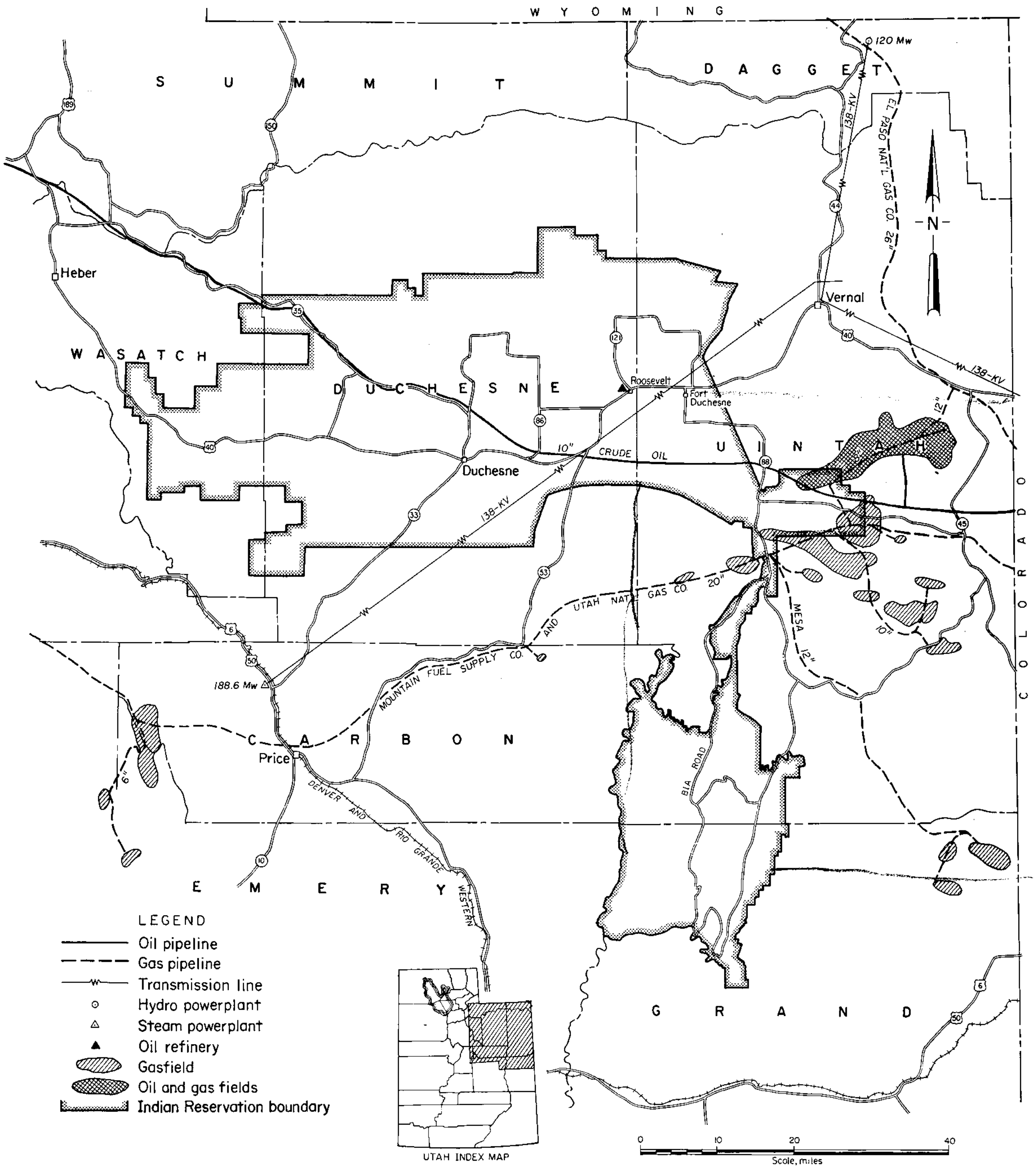

Figure 1. Index map showing infrastructure of Uintah and Ouray Indian Reservation, Utah.

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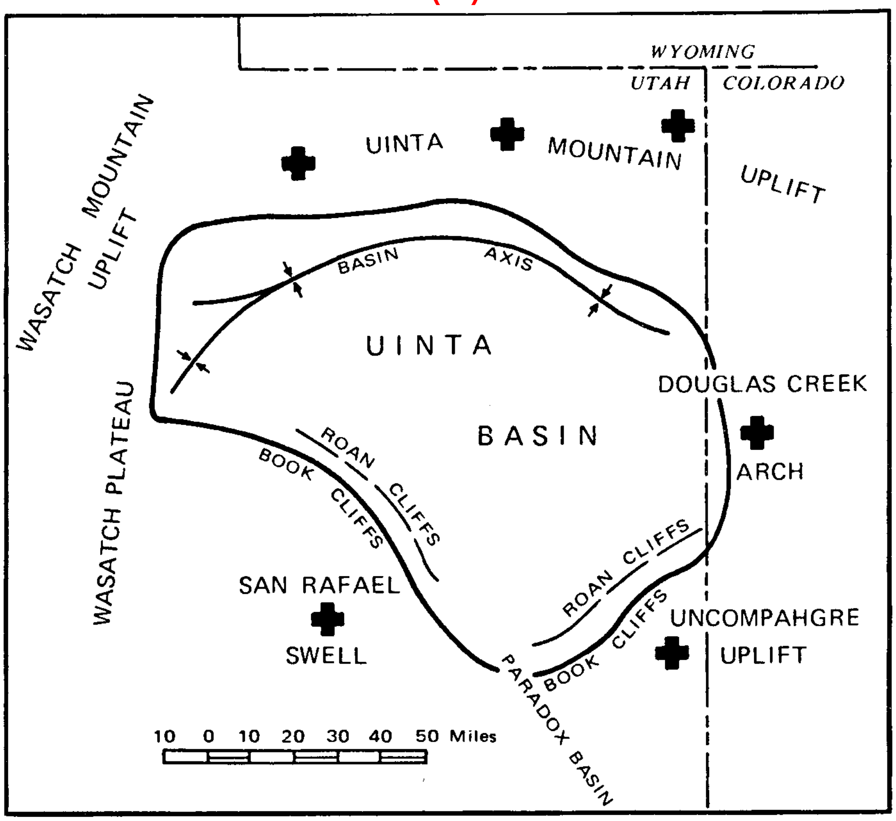

Figure 2. Generalized structural pattern of the Uinta basin and vicinity (Ritzma, 1972, p. 276).

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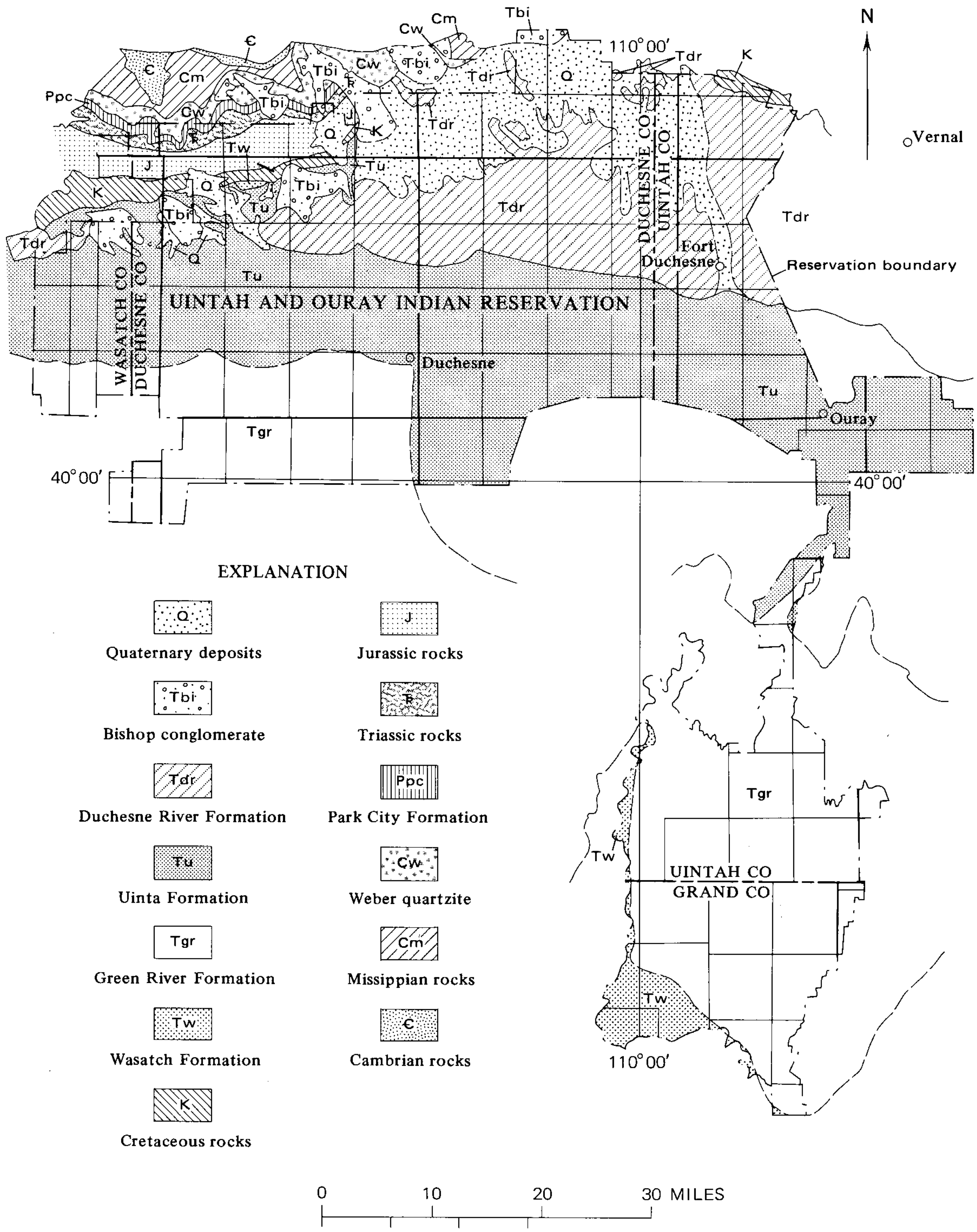

Figure 3. Generalized geologic map of Uintah and Ouray Reservation.

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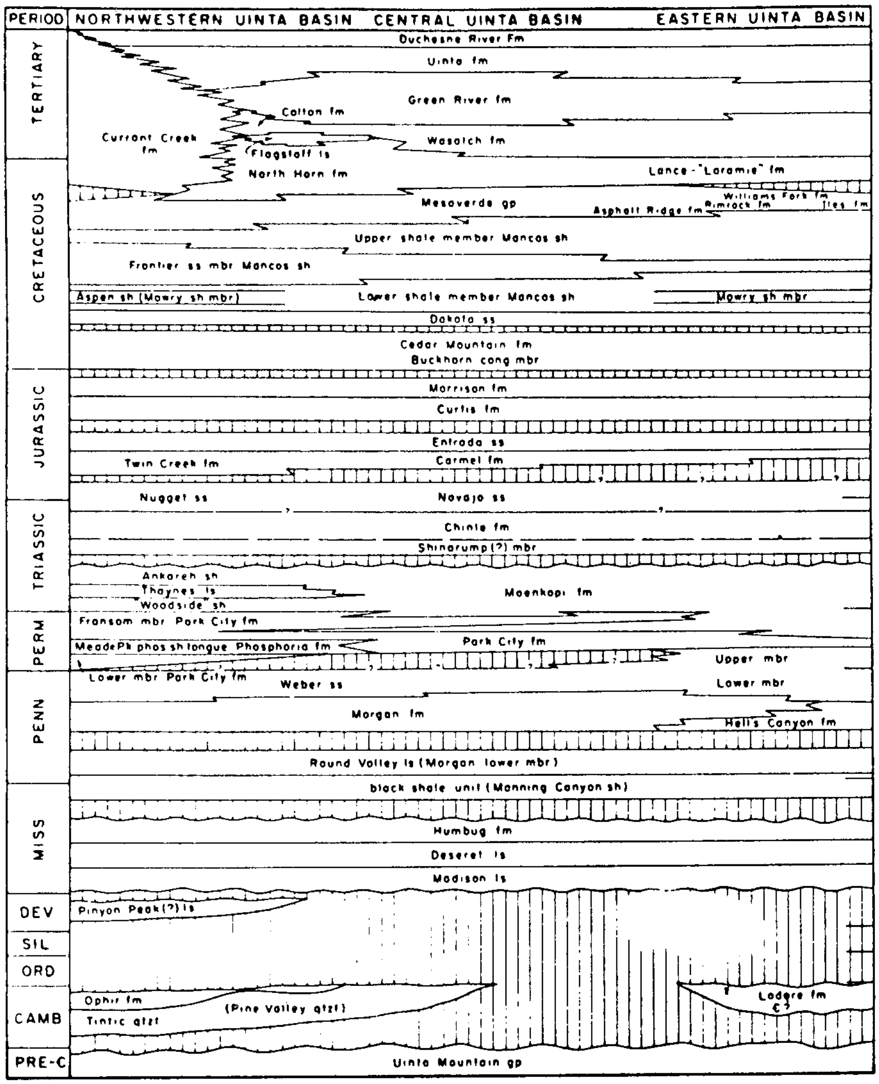

Figure 4. Correlation chart of the Uinta Basin area. (Untermann and Untermann, 1964).

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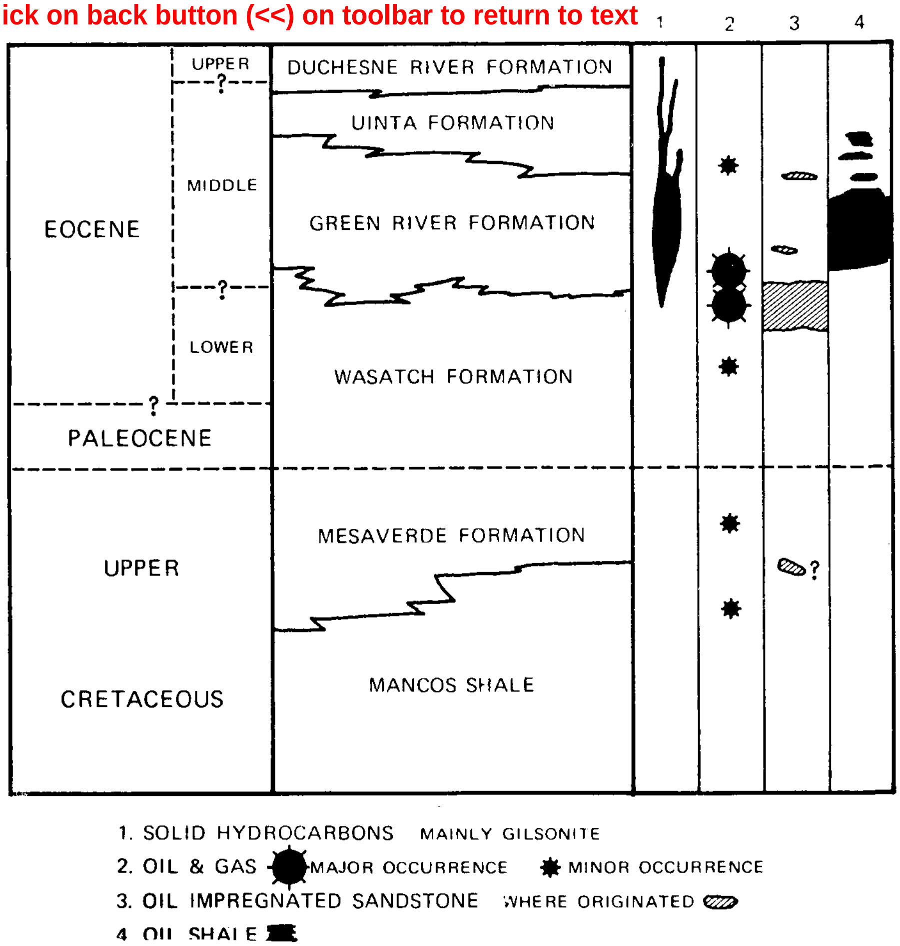

Figure 5. Occurrence of hydrocarbons in Upper Cretaceous and Tertiary formations of the Uinta Basin (Ritzma, 1972, p. 276).

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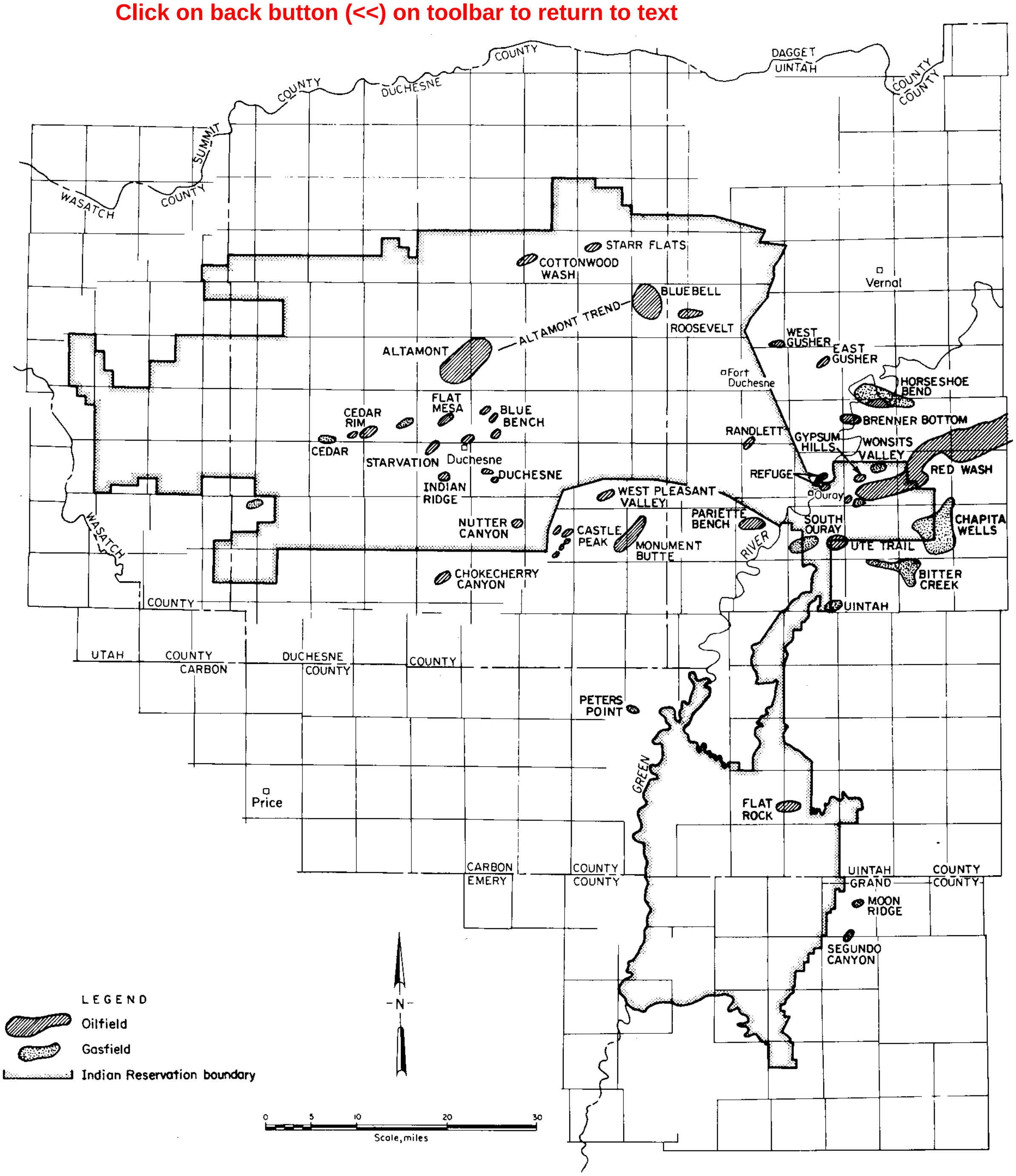

Figure 6. Oil and gas fields of the Uinta Basin.

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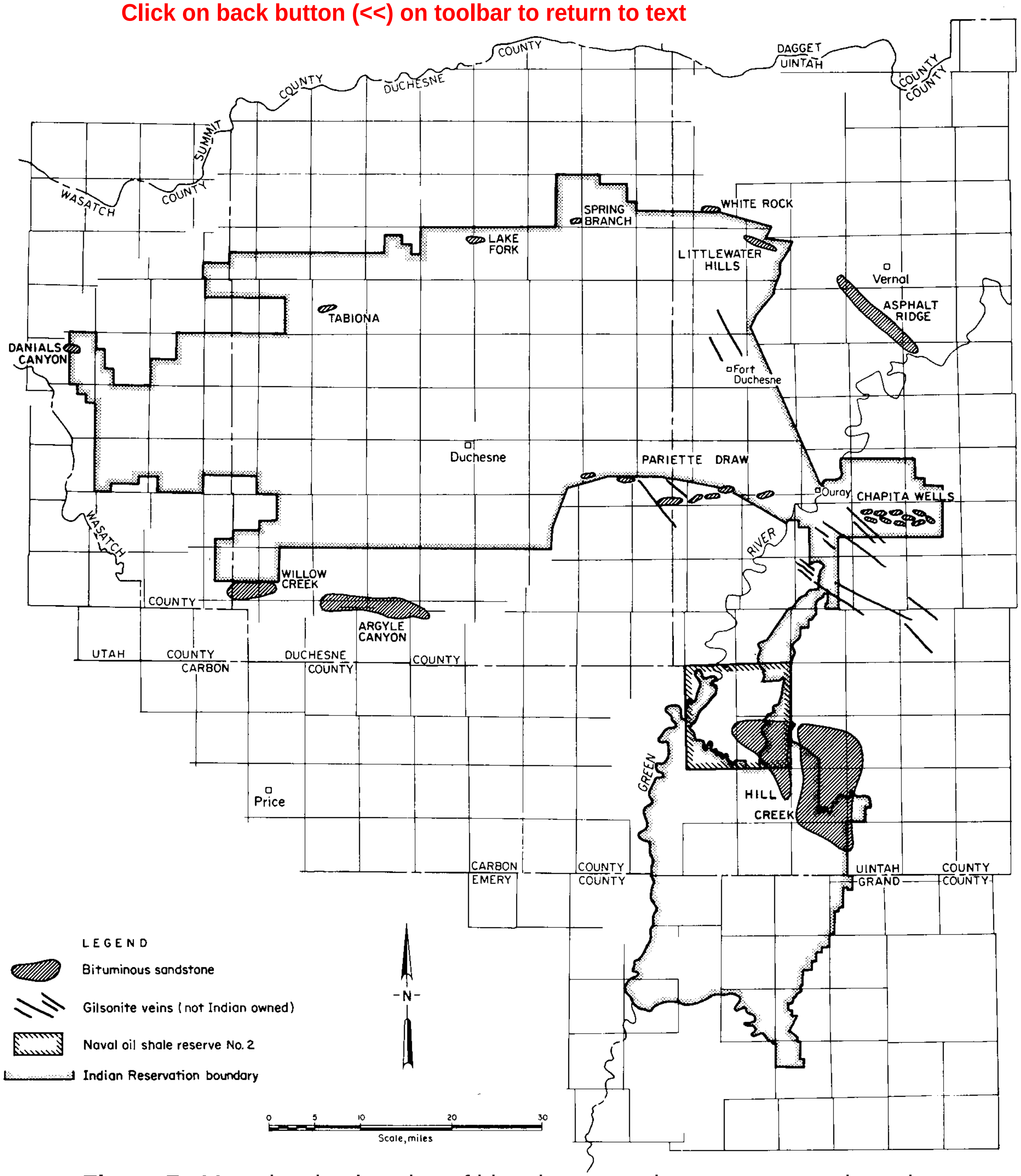

Figure 7. Map showing location of bituminous sandstone resources in and near the Uintah and Ouray Reservation.

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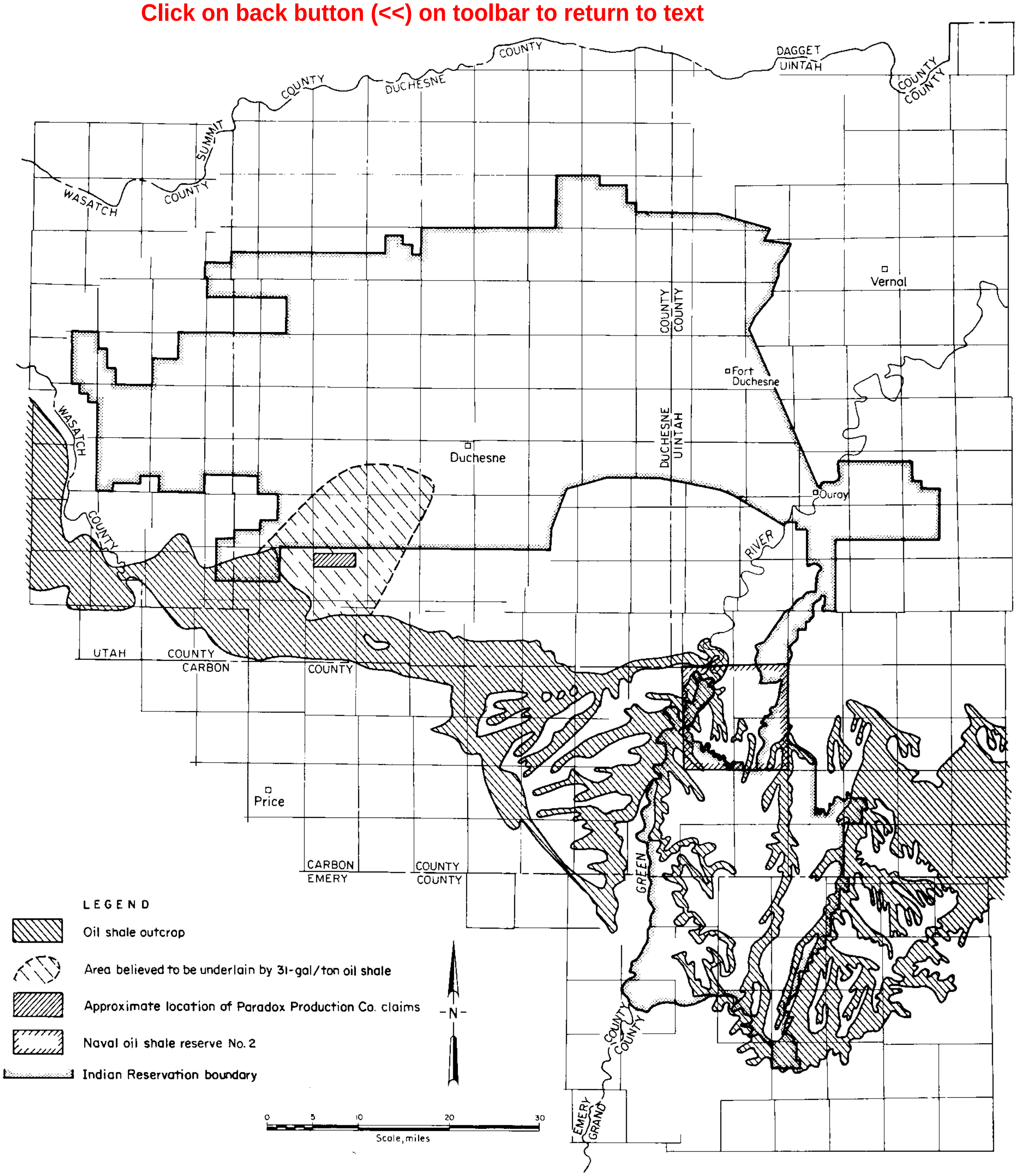

Figure 8. Map showing location of oil shale outcrop in and near the Uintah and Ouray Reservation.

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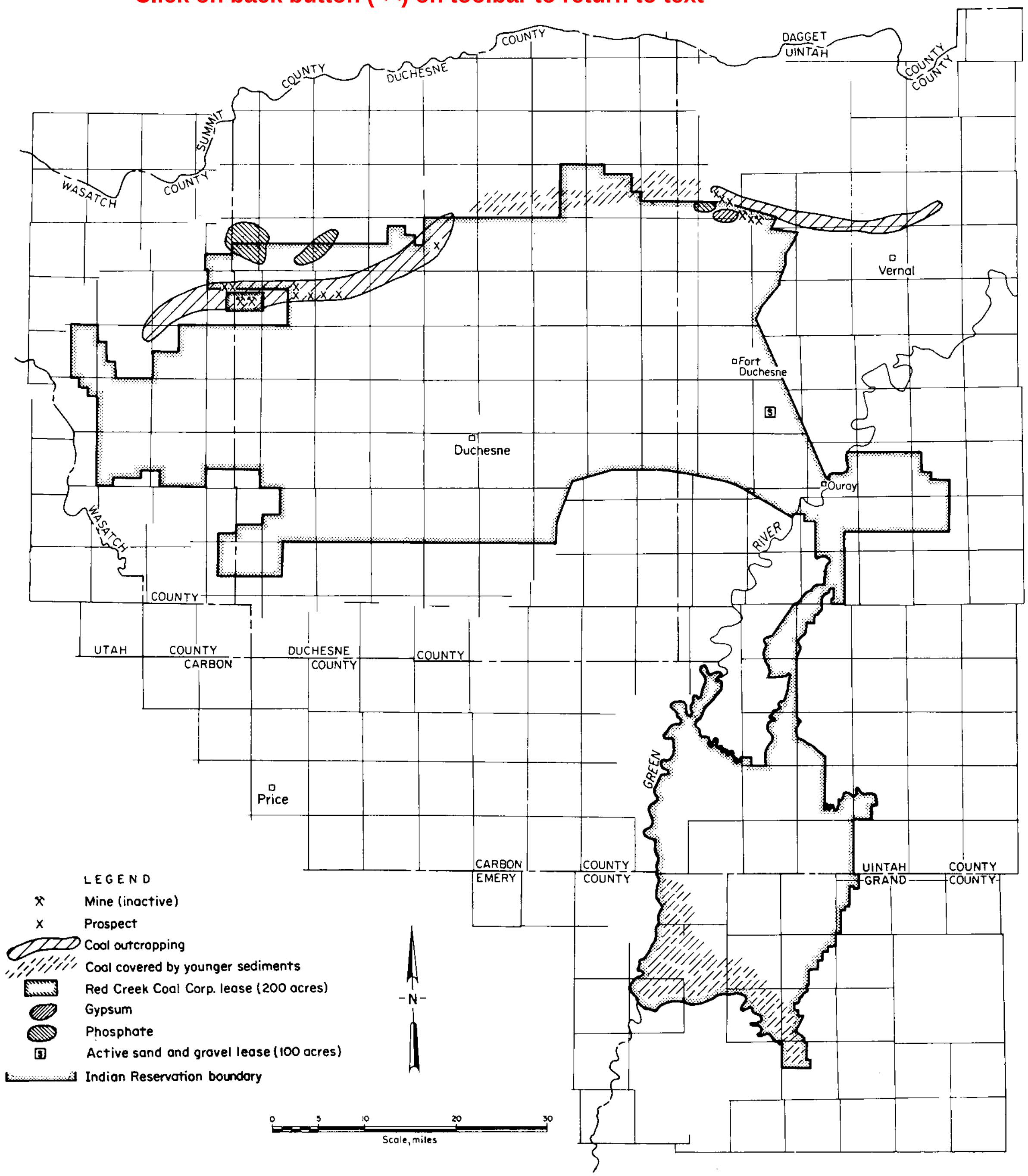

Figure 9. Map showing location of coal and nonmetallic mineral occurrences in and near the Uintah and Ouray Reservation.

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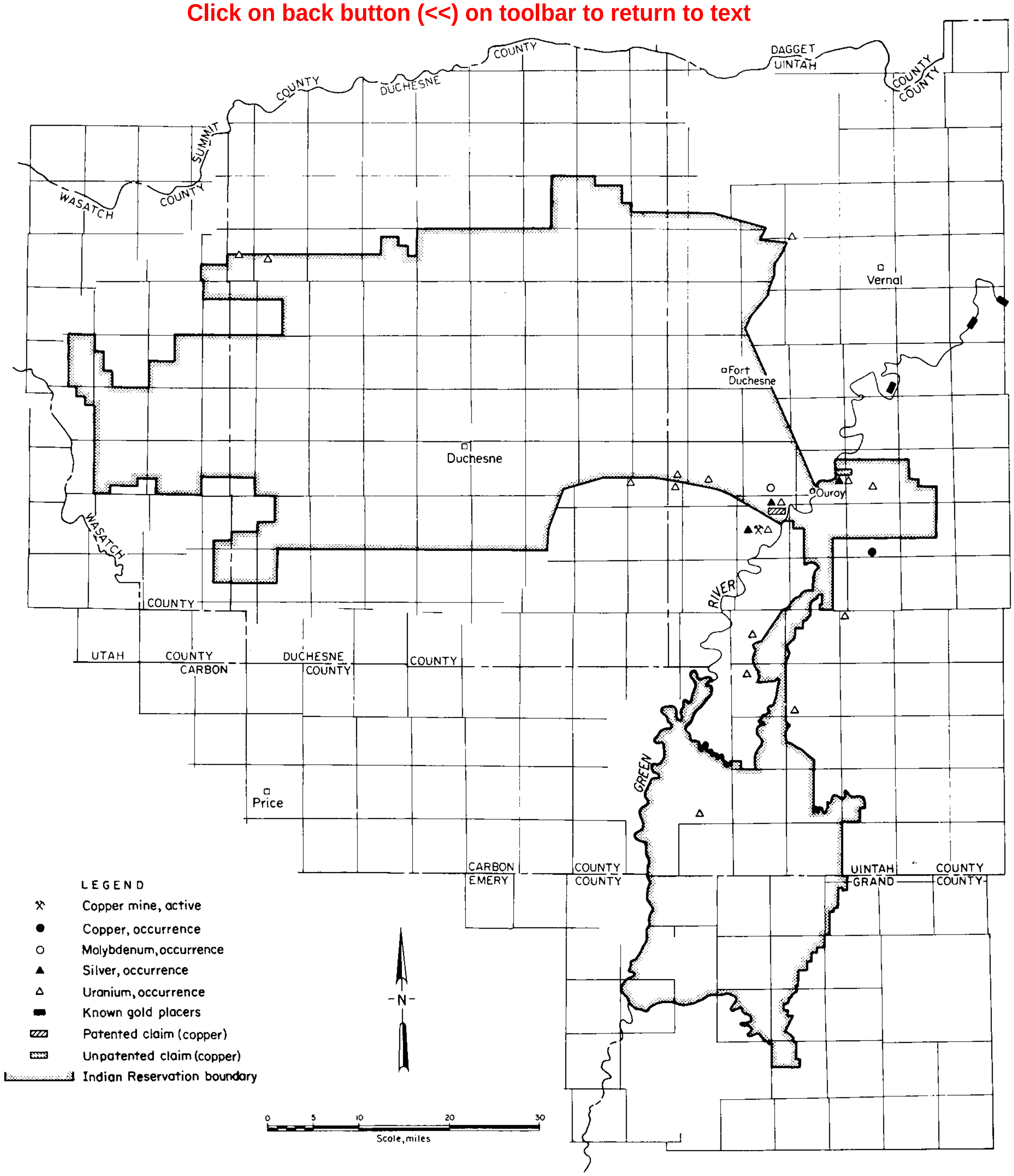

Figure 10. Map showing location of uranium and metallic mineral occurrences in and near the Uintah and Ouray Reservation.

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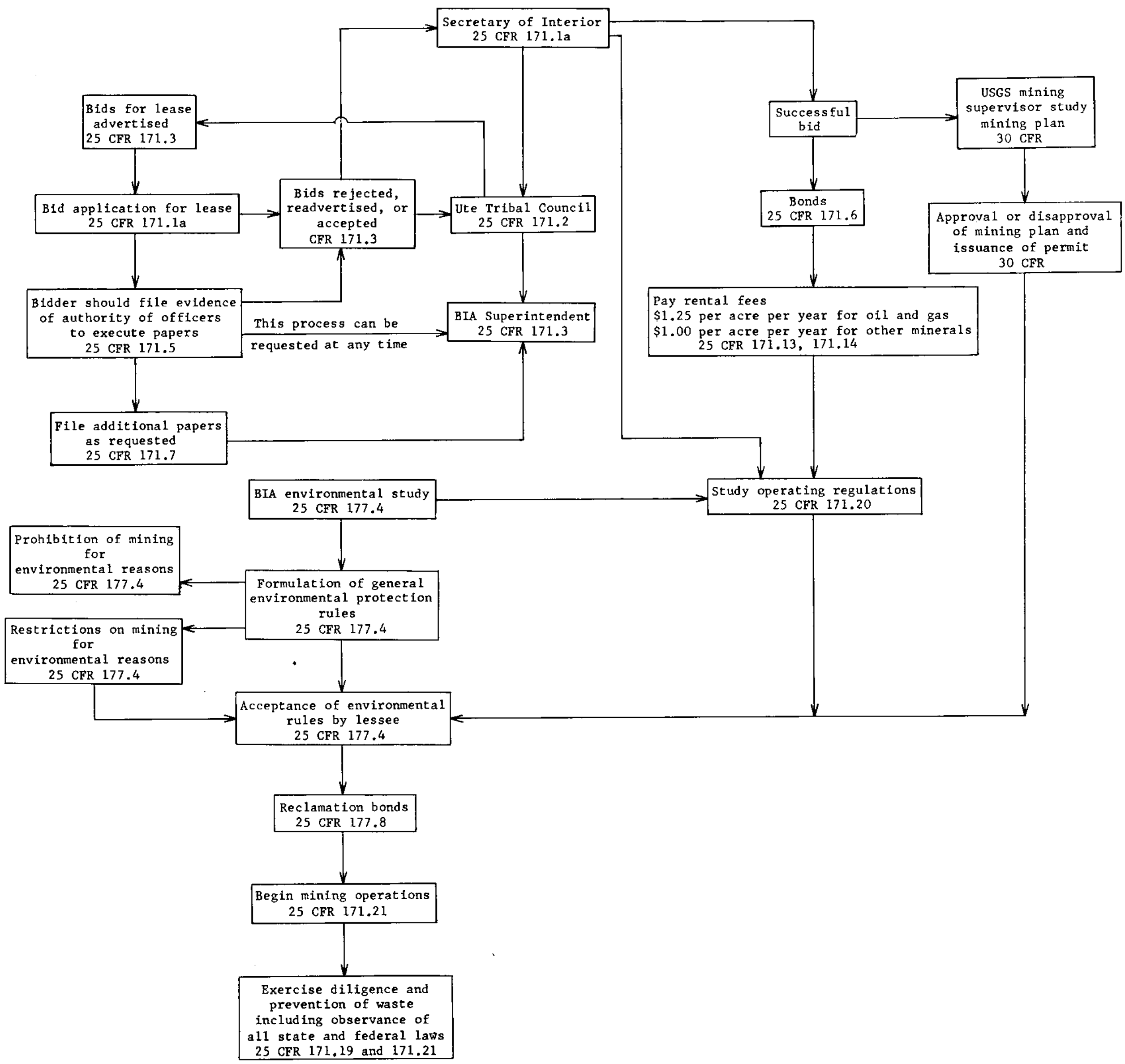

Figure 11. Diagram outlining procedure for obtaining leases and mining permits for the Uintah and Ouray Reservation.