STATUS OF MINERAL RESOURCE INFORMATION FOR THE FORT BELKNAP INDIAN RESERVATION, MONTANA

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SUMMARY AND CONCLUSIONS

The Fort Belknap Indian Reservation is adjacent to the Zortman gold mining district and the Cleveland coal field, and within 40 miles from several oil and gas fields. Limestone, bentonite, clay, traprock, nepheline syenite, fluorite, zeolite mineral and sand and gravel have been found on or near the reservation. The only known mineral production from the reservation has consisted of traprock, limestone, and sand and gravel.

Formations which are coal-bearing elsewhere occur on the reservation. Little is known, however, about the coal potential within the reservation although the probability of future coal discoveries are fair to good.

Most of the gold and silver production from the Zortman mining district has come from deposits whose structural controls may extend into the reservation. Whether such extensions have been explored is not known but it is recommended that the possibility of finding them be investigated by field studies.

Geological and geophysical field work and subsurface information from new additional wells is necessary before any gas and oil resources can be postulated for the reservation.

INTRODUCTION

Purpose

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 and energy resources, and potential for economic development of certain Indian lands. Sources were published and unpublished reports as well as personal communication. No field work was done.

Location and Accessibility

The Fort Belknap Indian Reservation includes an area of 616,048 acres in north-central Montana (Figure 1). It is between long 108º 15' and 108º 45'W. and lat. 47º 50' and 48º 30'N., and includes the southeastern part of Blaine County and a narrow strip of southwestern Phillips County. The Milk River borders the reservation on the north, and the northern crest and flanks of the Little Rocky Mountains form its southern border. U. S. Highway 2, running east-west between Havre and Malta crosses the northern part of the reservation and Montana State Highway 376 extends southward through the western side of the reservation to U. S. Highway 191. Graveled all-weather roads are present along the Milk River Valley and also in the southern part of the reservation, interconnecting the towns of Lodgepole, Landusky, and Zortman. Elsewhere there are dirt roads which are passable only during dry weather.

The Burlington Northern Railway follows the Milk River Valley along the northern border of the reservation and the town of Harlem is the nearest rail shipping point.

Services and Communities

The largest community in the region is Havre, population 10,558, about 38 miles west of the northwest corner of the reservation. On the reservation, the largest communities are the unincorporated towns of Hays (pop. about 500), Lodgepole (pop. about 200), and Fort Belknap Agency (pop. about 200).

The town of Malta (pop. 2,195), about 18 miles from the northeast corner of the reservation, is serviced by a 6" natural gas pipeline from the Bowdoin gas field (Hoglund, 1975), and the town of Harlem (pop. 1,094), about 2 miles north of the northwest corner of the reservation, is serviced by a 4" gas pipeline from the Bowes gas field (Henderson, 1975), this same line also supplies gas to Fort Belknap Agency. The only other nearby natural gas pipeline is a north-south running 12" line located about 18 miles west of the western border of the reservation. It services the Tiger Ridge gas field (Bayliff, 1975).

Physiography

The Fort Belknap Indian Reservation lies within the Northern Great Plains physiographic province (Howard and Williams, 1972) and may be divided into three physiographic units: (1) the Milk River valley, (2) the central plain, (3) the Little Rocky Mountains and foothills.

The Milk River valley is a broad, flat flood plain bounded on the north and south by low bluffs of glacially deposited material. The valley was originally carved by the ancestral Missouri River prior to Pleistocene glaciation. Following the retreat of the ice, the Missouri River reestablished itself much further south and its original valley is now occupied by the Milk River (Alverson, 1965). The flood plain is the result of deposition by the meandering Milk River of fine-grained material onto glacial till which in turn overlies alluvium deposited by the ancestral Missouri River.

The central plain extends southward from the Milk River valley about 20-30 miles to the foothills of the Little Rocky Mountains. It is mostly mantled by as much as 80 feet of glacial till and glaciofluvial deposits. Drumlins, boulder trains, knob and kettle topography, and outwash plains, all features characteristic of glaciation, are locally well developed. Locally, meandering streams have cut through the glacial material and have now exposed the underlying Cretaceous rocks.

The central plain is broken by Snake Butte, Wild Horse Butte, and Twin Buttes, the summits of which are several hundred feet above the plain. The buttes are composed of resistant igneous rocks that were intruded during Tertiary time into less resistant sedimentary formations that later were eroded.

The Little Rocky Mountains are composed of a core of Precambrian metamorphic rocks and Tertiary intrusive rocks surrounded by uplifted and deformed sedimentary formations. The higher peaks rise about 1,500 - 2,000 feet above the central plain, reaching altitudes between 5,000 and 6,000 feet immediately south of the reservation.

The more resistant of the sedimentary formations commonly form hogbacks that dip away from the core of the mountains. Especially well developed is the hogback formed by the Mississippian Mission Canyon Limestone which nearly surrounds the base of the mountains. Other hogbacks are formed on resistant beds of the Kootenai Formation, the Mowry Shale, the Mosby Sandstone Member of the Warm Creek Shale, the Eagle Sandstone, and the Judith River Formation.

Flat gravelly terraces are well developed on the north flank of the Little Rocky Mountains and in places have buried the underlying sedimentary rocks. The terraces were formed by debris stripped from the higher parts of the mountains during Late Tertiary and early Quaternary time.

Previous Investigations

Hayden (1868) Weed and Pirsson (1896), and Emmons (1908) made the first geological studies in the area, concentrating mainly on mapping and describing the gold deposits and associated rocks in the Little Rocky Mountains. The mining districts were also studied by Corry (1933), Dyson (1939), and Bryant (1953). Pepperberg (1910, 1912) described the geology and coal deposits along the Milk River between Havre and Harlem and mapped portions of the northwest corner of the reservation.

The stratigraphy and possible oil and gas occurrences in and near the reservation have been studied by Collier and Cathcart (1922), Reeves (1924a, 1924b), and Knechtel (1944, 1959). Knechtel (1959) also made a detailed geological map of the Little Rocky Mountains and surrounding plains. Reeves (1924b, 1925, and 1946) mapped the extensive thrust fault system associated with the Bearpaw Mountains west of the reservation. Alverson (1965) studied the water resources and mapped the entire reservation geologically.

GEOLOGY

General

Geologically, the Fort Belknap Indian Reservation is situated on the extreme western edge of the Williston Basin. In a more local sense the reservation is bounded on the south by the Little Rocky Mountains uplift, on the west by the Bearpaw Arch, on the north by the Hogeland basin, and on the northeast by the Bowdoin dome (Figure 2) (Grose, 1972, fig. 1; Lumb, 1972, fig. 3). Glacial deposits and Quaternary alluvium are extensive on the reservation however, sedimentary, igneous, and metamorphic rocks ranging in age from Precambrian to Cretaceous, are exposed locally (Figure 3).

Stratigraphy

Table 1 summarizes the stratigraphic relationships of sedimentary rocks on the reservation. Subsurface data are limited in that only six exploratory holes have been drilled on the reservation for oil and gas. Figure 4 shows the location of these holes plus two additional holes drilled near the western edge of the reservation and the depths to various formation tops.

TABLE 1

Generalized Stratigraphic Section of Sedimentary Rocks, Fort Belknap Indian Reservation

(Descriptions taken from Knechtel (1959), Alverson (1965), and unpublished files of the U. S. Geological Survey; formations followed by an "*" have produced oil and gas elsewhere in Montana)

Quaternary System

Recent Series

Alluvium. Sand, silt, and clay, and some gravel; near the Little Rocky Mountains contains considerable limestone gravel. Thickness up to 90 feet.

Pleistocene Series

Glacial deposits. Boulders, cobbles, gravel, sand, silt and clay. Thickness up to 100 feet.

Tertiary System

Terrace deposits. Gravel, limestone pebbles and cobbles, some silt and sand. Thickness up to 50 feet.

Cretaceous System

Upper Cretaceous Series

Montana Group

Bearpaw Shale. Dark blue-gray marine shale, contains some bentonite zones up to 20 feet thick near base.[1]

Judith River Formation. Light gray, fine-grained, sandstone, siltstone and shale, contains some coal beds. Thickness about 380 feet.

Claggett Shale. Concretionary, brown to dark-gray, marine shales and siltstones, contains some bentonite. Thickness about 500 feet.

Eagle Sandstone.*Yellow sandstone and gray shale interbedded at base; upper part mostly shale; sandstone decreases to the east. Gas producer in nearby gas fields. Thickness about 270 feet.

Colorado Group

Warm Creek Shale. (Telegraph Creek, Niobrara, Carlile, Greenhorn, 3 Front, and Belle Fourche equivalents) Blue-gray shale, thin calcareous sandstones, some limestone lenses and some thin bentonite beds. Thickness about 1,050 feet.

Mowry Shale. Medium to dark gray, siliceous, shale. Thickness about 90 feet.

Thermopolis Shale. Shale, dark blue-gray; some sandstone lenses in lower half; some thin bentonite beds. Thickness 560 to 625 feet.

Lower Cretaceous Series

Dakota Sandstone.* (First Cat Creek) Coarse-grained, massive arkosic sandstone and siltstone. Thickness 40 to 95 feet.

Kootenai Formation.* Includes the Third Cat Creek (Lakota equivalent) and an upper argillaceous member (Fuson shale equivalent). Tan to buff, coarse-grained, arkosic sandstone; interbedded maroon and gray-green shale. Thickness 150 to 260 feet.

[1]Thickness 0 to 1,100 feet.

Jurassic System

Ellis Group

Morrison Formation.*Light gray mudstone, thin glauconitic sandstone beds, some coal seams in upper part. Thickness 60 to 75 feet.

Swift Formation.* Light to dark gray gypsiferous shale, finegrained glauconitic sandstone, and impure limestone. Thickness 150 to 180 feet.

Rierdon Formation. Light to dark gray limestone. Thickness 80 to 150 feet.

Sawtooth Formation. (Piper, Bowes equivalent) Calcareous sandstone, siltstone, and shale with thin limestone beds. Thickness 200 to 230 feet.

Mississippian System

Madison Group

Mission Canyon Limestone.*Light gray to buff, coarse grained, massive limestone. Cavernous in upper parts. Thickness 325 to 500 feet.

Lodgepole limestone. Dark to light gray, thin bedded limestone; in places colored red from thin shale partings. Thickness 480 to 630 feet.

Devonian System

Three Forks Shale.*Light gray to green, calcareous shale and siltstone. Thickness 40 to 85 feet.

Jefferson Limestone.*Includes the Birdbear (Nisku equivalent) and Duperow. Thin-bedded, dark gray, fine grained limestone; red to green shale and siltstone; light gray, dolomitic, fine-grained limestone. Thickness 420 to 525 feet.

Maywood Formation. (Souris River equivalent) Thin bedded, calcareous siltstone and shale; impure limestone and dolomite. Thickness 175 feet.

Ordovician System

Bighorn Dolomite.*(Red River equivalent) Massive, gray dolomitic limestone and dolomite. Thickness 60 to 275 feet.

Ordovician and Cambrian Systems

Emerson Formation. Gray to green shale, interbedded limestone, dolomite, shale, and conglomerate. Thickness 950 to 1,100 feet.

Cambrian System

Flathead Sandstone. Light gray to buff to green sandstone and conglomerate. Thickness about 50 feet.

Explanation for Figure 4

Qt - glacial till	Kt - Thermopolis Shale
Tt - terrace gravel	Kk - Kootenai Formation
Tsp - syenite porphyry	Je - Ellis Group
Kb - Bearpaw Shale	Jm - Morrison Formation
Kjr - Judith River Formation	Js - Swift Formation
Kc - Claggett Shale	Jr - Rierdon Formation
Ke - Eagle Sandstone	Jsw - Sawtooth Formation
Kw - Warm Creek Shale	Mm - Mission Canyon Limestone
Km - Mowry Shale	Ml - Lodgepole Limestone
Kmd - Muddy Sandstone	Dj - Jefferson Limestone
Kd - Dakota Sandstone	C - Cambrian rocks
TD - Total Depth of hole	

Oil Test Hole Number	Name
1	Montana Gas Corp. - Pochler 1
2	Fred Munger - John Siert Farm 1
3	Mobil Producing F-11-151
4	Phillips Petroleum 1 Gros
5	Phillips Petroleum l-A Savoy
6	Phillips Petroleum 1 Fort Belknap "A"
7	Burlington Northern 8
8	Burlington Northern 9

Precambrian Metamorphic Rocks

Precambrian rocks are exposed in small outcrops in the core of the Little Rocky Mountains and include metasedimentary and metavolcanic rocks, all of which are more or less foliated. These rocks consist of fine-grained black amphibole schist, pink granitic gneiss, finely banded white gneiss, garnet schist, hornblende schist, and white quartzite. Nearly all these rocks contain biotite, muscovite, hornblende, chlorite, garnet, and kyanite as essential minerals. Accessory minerals are apatite, zircon, magnetite, and pyrite. A few mafic dikes, also of Precambrian age, have intruded the schist and gneiss locally.

Tertiary Intrusive Rocks

During the Tertiary Period, alkalic magmas intruded the Precambrian basement rocks and overlying sedimentary rocks and uplifted the Little Rocky Mountains area into a broad dome about 10 miles in diameter. Similar but smaller intrusions also occurred at this time at Twin Buttes, Wild Horse Butte, and Snake Butte (Figure 4). The most common rock type representing these magmas is syenite porphyry characterized by large phenocrysts of orthoclase and plagioclase set in a fine-grained, light to dark gray groundmass of feldspar and ferromagnesian minerals. The igneous rock that forms the laccolithic sill at Snake Butte is shonkinite a dark gray to black medium grained syenite containing feldspar and abundant augite (Knechtel, 1942).

The large bodies of syenite porphyry in the Little Rocky Mountains have been cut by dikes of syenite porphyry, monzonite porphyry, and trachyte porphyry. Most of the dike rocks are fresh in contrast to the main mass of older syenite porphyry which has been highly shattered and silicified by aqueous solutions, which are thought to have deposited the gold-silver ores that occur in the area (Emmons, 1908; Dyson, 1939).

Structure

The syenite porphyry intrusive forming the core of the Little Rocky Mountains was emplaced mainly between the sedimentary formations and the Precambrian metamorphic basement rocks. It is mostly concordant with the base of the sedimentary rocks but in places the intrusive cuts discordantly across Paleozoic and Mesozoic formations. As a result of the doming during the intrusive activity the sedimentary formations over much of the reservation have been tilted to various degrees. Adjacent to the dome the sedimentary rocks are steeply dipping, up to ninety degrees locally, forming the hogbacks common around the flanks of the mountains. The degree of tilting becomes progressively less away from the mountains so that a few miles away the sedimentary formations are dipping only a few degrees to the northeast and northwest (Figure 4).

In the southwest corner and also outside the reservation boundaries around the southern and southeastern flanks of the Little Rocky Mountains the intrusive activity created numerous trapdoor type structures. Knechtel (1944) described these features as follows: "The subordinate domes on the large subcircular dome of the Little Rocky Mountains were formed by bodies of igneous rock which were punched upward into the sedimentary rocks. They range in diameter from 1½ to 3½ miles. Each is typically subcircular or subelliptical in plan and normally includes a hinged block that is raised on a nearly vertical fault of curved trace. The rock strata in such a block are tilted up like a trapdoor which has opened along the fault and slopes down toward the opposite side of the block..... The faults within and at the margins of the trapdoor blocks have throws ranging from almost zero to several thousand feet."

On the central plain the gently dipping sedimentary rocks north of the Little Rocky Mountains have been slightly folded into a broad northeast trending anticline, and on the west side of the Little Rocky Mountains a broad syncline trends and plunges southwest from Twin Buttes (Figure 4).

The sedimentary rocks are also tilted up around Twin Buttes and Wild Horse Butte which are small laccolithic to stocklike intrusive masses. In contrast, the intrusive at Snake Butte is more sill like and overlies baked Bearpaw shale which shows little or no deformation.

Two areas of thrust faulting have been mapped on the reservation (Alverson, 1965, plate 1). One is in the southwest corner of the reservation (Figure 3) where several faults have displaced the Judith River Formation and the Claggett shale over and against the Bearpaw shale. Displacement on these faults is unknown but it is probably at least 400 feet (Alverson, 1965, p. 42). The other is in the northwest and northern parts of the reservation

(Figure 3) where low angle faults have displaced lower units of the Judith River and Bearpaw strata against higher units in the formations and also thrust Judith River rocks against the Bearpaw shale. Both of the areas of thrusting are part of the complex fault system surrounding the Bearpaw Mountains and are related to the formation of that uplift (Reeves, 1924a, 1946).

MINERAL RESOURCES

General

The only significant mineral production from the Fort Belknap Indian Reservation has been stone quarried from Snake Butte; it was used as crushed rock fill and riprap during the construction of the Fort Peck Dam.

A small amount (1,614 tons) of limestone was mined during 1944 and 1945 from a quarry in sections 3 and 4, T. 26 N., R. 24 E., on the reservation and was used in a sugar refinery that operated in Chinook, about 20 miles west of Harlem. No limestone is presently being quarried.

Oil and gas fields, and deposits of coal and bentonite have been developed in nearby areas west, north, and east of the reservation, (Figure 1 and Figure 2). Gold, totaling 380,000 ounces, has been produced from the central part of the Little Rocky Mountains adjacent to the southern edge of the reservation (Weissenborn, 1963, p. 75). Whether the mineralized structures extend northward into the reservation from the Zortman mining district is not known.

Energy Resources

Oil and Gas

General.--Limited exploration for oil and gas over the past 20 years has resulted in drilling of six wells within the reservation boundary. None of these wells have recorded shows of oil or gas accumulations. The location of these six wells and two other nearby wells and the depths to formation tops are shown in Figure 4. Although no oil or gas have been produced on the reservation the geological setting is favorable for their occurrence. In the following discussion, the completion and production data have been abstracted from annual reviews of the Montana Department of Natural Resources and Conservation, Oil and Gas Division. Several fields are adjacent or nearby (see Figure 2 and Figure 5). Tiger Ridge is a major gas field less than 25 miles west of the reservation, and Bowdoin gas field is 35 to 40 miles east of the north edge of the reservation. The Bowes gas field, the Bowes oil field, and the Rabbit Hills oil field are all located in an area 20 to 30 miles west and northwest of the reservation.

Tiger Ridge Gas Field.--Tiger Ridge is a huge gas field in T. 30 to 32 N., and R. 14 to 18 E. Gas production is given in Table 2.

One of the most important wells, the High Crest Oil Co. No. 1 O'Neil, in the SE¼NE¼, sec. 1, T. 31 N., R. 17 E., was completed in 1967 in the Eagle Formation, at a depth of 1,340 feet. Initial production was 3,100 M.C.F. gas per day.

In 1968 , the High Crest Oil Co., Morphey 31-1 well in the NE¼NE¼, sec. 31, T. 32 N., R. 18 E., was completed with an initial production of 50 barrels of oil per day. It penetrated the Sawtooth Formation to a depth of 4,113 feet.

The High Crest, State 16-2 well, is in the SW¼NE¼, sec. 16, T. 30 N., R. 18 E. It was completed in 1968 in the Judith River Formation at a depth of 2,042 feet. Initial production was 5,000 M.C.F. gas per day.

Production from the three formations has been from a structural stratigraphic trap. The Sawtooth reservoir has a natural water drive, and the Judith River and Eagle reservoirs probably have a depletion water drive.

TABLE 2

Gas Production from Tiger Ridge Field

Year	Judith River Formation Gas Wells		Eagle Formation Gas Wells		Production (M.C.F.)
	Producing	Shut-in	Producing	Shut-in	
1968	0	1	0	33	0
1969	0	1	2	55	225,948
1970	1	5	9	94	466,985
1971	1	5	13	126	1,578,194
1972	6	0	93	26	5,104,476
1973	6	0	123	37	29,130,011
1974	6	0	139	12	19,452,541

Note: One oil well in the Sawtooth Formation is shut-in.

Source: Department of Natural Resources and Conservation of the State of Montana, Oil and Gas Conservation Division, Annual Reviews.

Bowdoin Gas Field.--The Bowdoin, one of Montana's major producers, is in T. 31-33 N., R. 31-35 E., Phillips and Valley Counties, Montana. According to Perry (1960, p. 54-56):

> "The field is located on a circular dome, about 50 miles in diameter, with 700 feet or more of closure. Gas was discovered in 1913 on the east side of the dome in a shallow well drilled for water. A deeper test drilled in 1916 discovered gas on the west side of the dome. A drilling campaign got underway in 1929 when 25 750-foot gas wells were drilled. Most of the wells were small producers. Some of the better wells produced about 1 million cubic feet of gas per day. Within 5 years 45 wells had been drilled, 21 were producing gas, 11 were shut in, and 13 were abandoned."

The field's deepest test well in sec. 8, T. 32 N., R. 32 E., was drilled in 1947 by Texaco, and bottomed in Cambrian strata. No commercial production was found below the Phillips gas zone ±800 feet depth.

The Bowdoin gas zone is the more important producer. It ranges in thickness from 15 to 100 feet, but averages about 50 feet thick. The top of the zone is 670 feet deep and is a very fine-grained sandstone or siltstone with an average porosity of 10 percent or less. Initial open flows ranged from 250,000 to 1,210,000 cubic feet per day, averaging approximately 660,000 cubic feet. Initial reservoir pressure was about 217 pounds.

About one-sixth of the Bowdoin gas area is also productive in the Phillips gas zone. The Phillips gas zone ranges between 20 and 80 feet thick, and averages about 35 feet. Initial open flows were between 200,000 and 1,400,000 cubic feet of gas per day, averaging approximately 725,000 cubic feet. Initial reservoir pressures were between 265 and 438 pounds. A structural saddle on top of the dome divides the field into two parts, a western and an eastern field. Combined production from the Bowdoin and Phillips gas zones is shown in Table 3.

TABLE 3

Gas Production from Bowdoin Field

Combined Production from Bowdoin and Phillips Gas Zones

Year	Number of gas wells		Production
	Producing	Shut-in	(M.C.F.)
1960	364		5,075,532
1961	364		4,013,919
1962	364		2,711,954
1963	364		1,994,110
1964	364		2,021,246
1965	349		2,189,154
1966	349		2,148,063
1967	349		2,071,723
1968	346		1,988,908
1969	346		1,947,951
1970	281	65	2,637,040
1971	305	52	2,394,978
1972	327	19	2,624,413
1973	327	19	5,300,849
1974	307	39	4,925,075

Source: Department of Natural Resources and Conservation of the State of Montana, Oil and Gas Conservation Division, Annual Reviews.

Bowes Oil and Gas Field.--The following field history and well data are from Perry (1960, p. 53-54):

> "The Bowes oil and gas field lies 6 miles south of Chinook or 20 miles southeast of Havre on the glaciated upland plain of northern Montana. It is about 10 miles northeast of the foothills of the Bearpaw Mountains. The gas producing area covers about 5 square miles, and the oil-producing area, about one mile eastward, covers about 3 square miles. The gas and the oil come from different formations.
>
> "The first well in the field was drilled in 1924 to a depth of 4,700 feet, and although some gas was found, it was abandoned because of no pipeline. The development of the gas field began in 1926 when four wells were drilled, and by 1935, there had been nine wells successfully completed on the structure. Seven to 30 million cubic feet of gas per day per well flowed from the Eagle sandstone at depths from 653 to 1,078 feet, depending on structure. Initial pressures ranged from 250 to 300 pounds, the average being 260 pounds. A pipeline was laid to Chinook and Havre in 1926. The field then produced gas continuously, and the oil field remained unknown for 23 years. The gas is essentially methane.
>
> "In 1949 drilling of the Northern Ordinance-Guertzgen No. 1 well (sec. 2, T. 31 N., R. 19 E.) initiated the development of the oil-producing area, which spreads out broadly about 2 miles eastward. The well yielded asphaltic oil of 20º A.P.I. gravity amounting to about 200 barrels per day from the basal Ellis Sawtooth Formation at a depth of about 3,400 feet or about 2,600 feet beneath the Eagle sandstone. Development proceeded rapidly, and by the end of 1951 about 20 additional wells had been drilled with initial flows ranging from 100 to 400 barrels per day. An oil pipeline was laid to the railroad at Chinook. Peak oil production was reached in 1953 when 1,025,261 barrels of oil were produced, ranking this field fourth among Montana's oil fields at that time. By 1958 production had declined to 277,263 barrels of oil coming from 87 wells, an average of nearly nine barrels per well per day. Peak gas production of 1,350,000,000 cubic feet was reached in 1950. In 1958, gas production was 886,086,000 cubic feet from 19 wells, an average of nearly 130,000 cubic feet per well per day."

The Sawtooth Formation averages 37 feet of net pay zone, has a partial water drive, and an average porosity of 11.7 percent.

The deepest well in the field was drilled to a depth of 5,082 feet, but the Mississippian and Devonian strata were nonproductive.

Oil production from the Sawtooth Formation is shown in Table 4. Eagle Formation gas production is shown in Table 5.

TABLE 4

Oil Production from Bowes Oil Field

Year	Wells: Producing	Wells: Shut-in	Production (barrels)
1966	59	N/A	180,941
1967	57	N/A	175,427
1968	58	N/A	175,008
1969	52	N/A	152,802
1970	52	N/A	150,560
1971	43	33	137,902
1972	47	29	115,391
1973	41	29	85,798
1974	51	25	122,238

Cumulative production to 1-1-74 was 7,727,922 barrels.

Reserves as of 1-1-74 were 871,000 barrels.

N/A - (not available)

Waterflood started in 1961 using Madison water.

Source: Department of Natural Resources and Conservation of the State of Montana, Oil and Gas Conservation Division, Annual Reports 1966 to 1973, Inc.

TABLE 5

Gas Production from Bowes Field

Year	Producing Wells	Gas Production (M.C.F.)
1966	21	579,397
1967	21	569,069
1968	19	497,649
1969	20	427,417
1970	18	343,620
1971	18	293,312
1972	18	280,333
1973	26	472,642
1974	26	372,346

Source: Department of Natural Resources and Conservation of the State of Montana, Oil and Gas Conservation Division, Annual Reports 1966 to 1973 Inc.

Rabbit Hills Oil Field.--The Rabbit Hills oil field is in T. 34 N., R. 19 and 20 E., about 18 miles west of the reservation.

The following information on this oil field is from the Department of Natural Resources and Conservation of the State of Montana.

> "The Amoco No. 1 Sonneberg, in 1972, discovered oil in the Sawtooth Formation (Jurassic). The discovery well was located in the SE¼,NW¼, Sec. 24, T. 34 N., R. 19 E. It was completed at a total depth of 4,038 feet with an initial production of 114 barrels of oil per day. The pay section averages about 12 feet with an average porosity of about 18 percent. The field covers about 640 acres, and the gravity of the oil is 21° A.P.I. Oil production is shown in Table 6."

TABLE 6
Oil Production from Rabbit Hills Field
Producing Formation: Sawtooth (Jurassic)

Year	Number of Producing Wells	Production (Barrels)	Cumulative production (Barrels)
1972	1	6,592	6,592
1973	3	60,098	66,690
1974	3	73,410	140,100

Reserves as of 1-1-74 were 433,000 barrels.

Source: Department of Natural Resources and Conservation of the State of Montana, Oil and Gas Conservation Division.

Guinn Dome Gas Field.--The sub-commercial Guinn Dome gas field, on the south flank of the Little Rocky Mountains about 6 miles south of the reservation (Figure 2), represents a structural gas trap in a dome that was probably caused by a laccolithic intrusion. The productive horizon is the Eagle Sandstone (Knechtel, 1944).

Potential Oil and Gas

Hydrocarbon Bearing Formations and Stratigraphic Traps.--Rock formations that have produced oil and gas from the nearby fields are present in the reservation area, as are all formations that have produced anywhere in Montana with the exception of Upper Mississippian strata. Of particular importance are the upper Colorado shales and Eagle Sandstone of Cretaceous age. Stratigraphic traps caused by porosity changes possibly could occur anywhere in the reservation, however this type of trap may be more common in the east and northeast parts of the reservation due to a decrease in the content of sandy material in the Eagle Formation and a corresponding increase of shales in an eastward direction (Knechtel, 1959, p. 743). The search for stratigraphic traps requires a much higher density of exploratory wells than exists on the reservation and the wells must be carefully logged for porosity changes. The logging of any future wells drilled on the reservation would be enhanced by comparison of the porosity characteristics with the productive zones of the Bowdoin field.

The presence of gilsonite (Knechtel, 1959, p. 735), a black solid hydrocarbon, in vugs in the Mississippian Mission Canyon limestone suggests that these rocks once contained liquid hydrocarbons. However, these rocks are strongly upturned around the Little Rocky Mountains creating a large hydrostatic head of water. Because of this large volume of water under artesian pressure it is likely that any liquid hydrocarbons would have been flushed from the area. To effectively trap these hydrocarbons would require a large structural anomaly in the Mississippian formations. There is no evidence that such a large trap exists at depth on the reservation.

Structural Traps.--Possible structural traps on the reservation may be of two types. The first type is one formed by shallow faults that are related to the uplift of the Bearpaw Mountains. These faults are confined to the Upper Cretaceous and Lower Tertiary formations and formed by gravity sliding of Cretaceous rocks down the flanks of the uplifted Bearpaw Arch (Reeves, 1946). They extend at least 30 miles from the Bearpaw Mountains and subsidiary normal faults and faulted anticlinal structures in the upper plate of the thrust have acted as gas traps in the Bowes, Havre, Boxelder, Tiger Ridge, Sherard, and Winnifred gas fields located around the Bearpaw Mountains (Figure 2). As previously mentioned thrust faults associated with the Bearpaw Arch have been mapped (Alverson, 1965, plate 1) and extend onto the southwestern and northwestern parts of the reservation (Figure 2). These structures together with the known occurrence of Upper Cretaceous rocks indicate that the entire western side of the reservation is a favorable area for possible gas accumulations.

The second possible type of structural trap is one formed by doming of sedimentary rocks by laccolithic igneous intrusions. The sedimentary formations have been tilted up by the emplacement of intrusive bodies at Twin Buttes and Wild Horse Butte. It is also possible that buried intrusives may have domed the sedimentary rocks but that the structures have not been recognized due to cover by soil, alluvium, and glacial debris. Limited evidence for such doming by a "blind" intrusive body is given by geophysical surveys (unpublished data, U. S. Geological Survey) conducted by the Pure Oil Company which suggest that a buried dome may exist in the northern part of the reservation approximately under T. 31 N., R. 24 E. The oil and gas possibilities in these structures on the reservation are unknown but the occurrence of subcommercial gas in the Guinn Dome, outside of the reservation, indicates that gas and possibly oil may have accumulated in similar structural situations elsewhere (Knechtel, 1944; Collier and Cathcart, 1922).

Forty-eight wells have been drilled on or adjacent to the reservation. None found oil and gas in commercial quantities. Most of them (41) are in an adjacent area west or north of the reservation. Two of the wells were abandoned before they penetrated the potentially productive formations. Forty-six wells found the Eagle Formation to be water-bearing, and 22 found the sands in the Colorado Group to be nonproductive (Table 7).

TABLE 7

Wells drilled on or adjacent to the Fort Belknap Indian Reservation and horizon tested

(As of 1-17-75 all wells were nonproductive)

Formation or System Tested	Total wells Drilled	Wells drilled on Reservation
Colorado Group	22	6
Kootenai Formation	19	6
Jurassic System	18	5
Mississippian System	14	5
Devonian System	2	2
Ordovician System	1	1
Cambrian System	1	1

Source: Department of Natural Resources and Conservation of the State of Montana, Oil and Gas Conservation Division.

Coal

General.--Recent trends in the national energy picture have focused attention on the development of the western coal resources. The reservation is, therefore, an area of interest because it contains formations that contain coal elsewhere.

No coal has been produced and no workable beds of coal are known to exist on the Fort Belknap Indian Reservation. However, some coal has been mined in the nearby Milk River coal field (Pepperberg, 1910, 1912) and the Cleveland coal field (Bowen, 1912) (Figure 1).

Nearby Coal Fields.--The Milk River coal field is along the Milk River to the north and west of the reservation between the towns of Harlem and Havre. The coal is subbituminous and occurs in lenticular beds ranging from a few inches to nine feet in thickness in the upper parts of the Judith River Formation. The coal beds are much thinner and of lower grade in the eastern part of the field near Harlem and production from this part of the field has been limited to that used for local consumption. Further west between the towns of Chinook and Havre the coal beds are thicker and production has been much greater. Analyses of coals from the Milk River field indicate that they are relatively low in sulphur and high in moisture and ash.

The Cleveland coal field is immediately to the west of the reservation about 10 to 15 miles south of the Milk River (Figure 1). The coal occurs in the upper parts of the Judith River Formation in thin beds generally less than two feet thick (Bowen, 1912, p. 350). Most of the beds contain shale partings and impurities that detract from the value of the coal. Because of surface cover and some faulting the beds can be traced laterally only short distances. The coal in the Cleveland field is subbituminous and is similar in quality to the Milk River coals (Bowen, 1912, p. 355). Other than local usage, the only mine with any recorded production is the Cook mine located in section 25, T. 30 N., R. 20 E. which during 1912 was producing about 600 tons per year from a coal bed about three feet thick (Bowen, 1912, p. 355). The thin beds and impurity of the coal make it unlikely that the field will ever have any major development.

Coal Characteristics.--The rank of the coal from the beds near the reservation is subbituminous. The coal contains high moisture, low heat, and a low sulfur content (Table 8). Coal of this rank typically disintegrates when exposed to the weather and cannot be stored in large piles for long periods of time because of possible spontaneous combustion. Subbituminous coal is suitable for domestic heating and as a fuel for light industry and power plants. Subbituminous coal gasifies readily and would be suitable for the synthetic natural gas industry.

Potential Resources.--The extent of the coal resources on the reservation is unknown, but the coal-bearing Judith River Formation may contain significant coal resources. It is now recognized that the coal beds in Montana were formed in many small, and often isolated, basins. As a consequence, the thickness and quality of the coal beds commonly change substantially over relatively short distances. Therefore, the lateral extent of the coal beds from nearby fields can be projected into the reservation with only a fair degree of confidence. The beds could be thin and even pinch out. On the other hand, they could thicken significantly so that minable beds of good quality could be present on the reservation even though beds near the reservation border are thin and often of poor quality.

A systematic examination of the Judith River Formation on the reservation might discover minable coal. However, glacial material covers much of the reservation and prevents the discovery of coal beds by ordinary ground and aerial surveys. Therefore, more elaborate, and thus more costly exploration methods, such as drilling or trenching would be required.

The Kootenai Formation, which also underlies nearly the entire reservation, might contain significant coal resources. However, except for a small area near the Little Rocky Mountains where minable coal is present in the Kootenai Formation, the coal beds would be too far below the surface to be of economic interest at this time.

Development of Coal Resources.--The possibility of developing coal resources on the reservation requires that the coal be competitive in price with that from large-scale surface mines now operating elsewhere in eastern Montana. Known coal resources on the reservation are not sufficient to support any large-scale surface mines, but this could change significantly if additional resources are discovered. Small scale surface mines that supply coal to local markets may be economically and technically feasible. The technical considerations would depend primarily on the thickness of the coal bed, thickness of overburden, and the quality of the coal. Consideration should be given to the rehabilitation of mined lands and to minimizing damage to shallow aquifers. Underground mining would not be economically feasible mainly because coal from an underground mine would cost three to four times as much as coal from surface mines such as those in eastern Montana (Katell and Hemingway, 1974a, p. 5, 1974b, p. 4).

Uranium

There has been prospecting for uranium on the reservation around the flanks of the Little Rocky Mountains. No anomalies or concentrations of uranium were found (unpublished data, U. S. Geological Survey). The prospecting may have resulted from the discovery of radioactive concretions contained in the lower 40 feet of the Warm Creek shale of Upper Cretaceous age which crops out around the Little Rocky Mountains (Alverson, 1965, plate 1). The concretions are a dark brownish black manganiferous siderite, 3-4 inches in diameter. They form a conspicuous rubble on weathered surfaces and according to Gries, (1953, p. 102), concentrations of this rubble are sufficiently radioactive to affect an airborne scintillometer.

Metallic Mineral Resources

Gold and Silver

No gold has been produced from the Fort Belknap Indian Reservation, however, significant amounts of gold and silver have been mined from the core of the Little Rocky Mountains a few miles south of the reservation (Hubbard and others, 1964, p. 10). Gold was first discovered in the Little Rocky Mountains in placer deposits along streams draining the higher parts of the range about 1884, and lode deposits were found a few years later.

The gold-silver mineralization is genetically related to the later stages of igneous activity that domed the Little Rocky Mountains and formed the main laccolithic intrusive and the numerous associated dikes and sills during Tertiary time. The intrusive rocks are mainly alkalic syenite porphyry. Lesser amounts of granite, monzonite porphyry, trachyte, phonolite, and granodiorite occur in smaller dikes and as local variations of the main laccolith.

The gold occurs mainly in small (less than 12") quartz veins that are concentrated in large fissure zones of shattered and altered rock. Some low-grade gold is also present in auriferous pyrite disseminated locally in the syenite and other intrusive rocks. In a few areas gold occurs in higher-grade replacement deposits in limestone. The most productive mines are near the towns of Landusky and Zortman (Figure 1). The deposits near Landusky are generally high-grade, but restricted, irregular veins that have an overall northeast trend, whereas the deposits near Zortman are more persistent, lower-grade veins located in northwestern trending, shattered fissure zones (Corry, 1933).

Mineralogically the gold occurs in auriferous pyrite, as free gold in quartz veins and in oxidized limonitic ores; and in the telluride mineral sylvanite. Silver almost always occurs with the gold and probably also is present in telluride minerals. In some ores the silver-gold ratio is as high as 100 to 1 (Bryant, 1953, p. 163).

Gangue minerals are mainly pyrite, quartz, secondary orthoclase feldspar, kaolinite, sericite, fluorite, sparse calcite, and limonite. Purple fluorite is present in almost all of the ores and is usually associated with the higher grade deposits; however, in the porphyries it may be almost colorless. Limonite is abundant in the oxidized ores, cementing and coating fragments in shattered zones. Sericite and kaolin are widely disseminated both within and outside of the mineralized zones.

Over the past few decades there has been only limited mining activity in the Little Rocky Mountains. The current gold price and new mining and processing techniques have renewed interest in developing large-tonnage, low-grade disseminated gold occurrences.

Although no gold or silver has been produced from within the reservation, several factors suggest that the area of the Little Rocky Mountains included in the reservation boundaries may contain gold-silver deposits that should be further evaluated. These include: 1) small amounts of placer gold have been recovered in the past from alluvium along Peoples Creek within the reservation; 2) low-grade gold deposits (0.3 ounces/ton) have been reported by prospectors in the 1950's to be present somewhere within the area covered by T. 25 N., R. 25 E.; T. 25 N., R. 26 E,: T. 26 N., R. 26 E.(exact locations were not given) (unpublished data, U. S. Geological Survey); 3) relatively large areas of favorable intrusive host rocks lie within the reservation boundaries; 4) the extent of altered and mineralized rocks and possible extensions of known mineralized districts have not been delineated by modern methods of prospecting and geological study; 5) higher gold prices and newer mining methods have made mineralized areas once thought to be worthless into economic ore deposits; and 6) the tendency of some of the gold in the Little Rocky Mountains to occur as disseminated grains in ill defined zones within the porphyritic rocks indicate that similar deposits could easily have been overlooked elsewhere within the range.

Tellurium

Tellurium has been reported in ore from several mines in the Zortman district (Dyson, 1939, p. 201). It occurs with gold in the Gold Bug, Ruby, Hawkeye, Little Ben, and August mines. There is no record of tellurium being recovered from the ore.

Tellurium is used chiefly in the primary metals industries. It is important in the manufacture of iron and steel to reduce the absorption of nitrogen. It is also used in the rubber industry to increase the heat and abrasion resistance of synthetic and natural rubbers, to decrease vulcanization time, and improve aging resistance properties (Davidson and Lakin, 1973, p. 627-630). It is doubtful that the tellurium occurrences in the Little Rocky Mountains will be of economic significance as sources of tellurium.

Tungsten

No tungsten has been reported from the Little Rocky Mountains area. However, Corry (1933, p. 35) mentions a garnetized limestone replacement (tactite) zone at the Beaver mine on Beaver Creek, in approximately sec. 5, T. 25 N., R. 25 E. The tactite occurrence should be examined with a mineral light to determine if scheelite (fluorescent ore mineral of tungsten) is present.

Nonmetallic Minerals

General

Numerous nonmetallic materials with possible present or future economic potential are found on or near the reservation. These are limestone, bentonite, clay, traprock, nepheline syenite, fluorspar, zeolites, and sand and gravel.

Limestone

Limestone beds of the Madison group form extensive ridges and cliffs around the margin of the Little Rocky Mountains uplift and some outlying domes (Figure 4). Limestone crops out as bluffs and ridges almost continuously from the Hays-Fort Belknap road east to beyond Lodgepole, a distance of about 15 miles. The road to Lodgepole parallels the outcrop about 1 mile to the north, and access roads lead to the limestone bluffs at several places (Hubbard, Roby, and Henkes, 1964, p. 6).

Madison Limestone forms steep cliffs along the walls of Mission Canyon where Peoples Creek cuts through the formation (Hubbard and others, 1964, p. 7). Potential quarry sites lie on or close to the Hays-Landusky road near the lower end of Mission Canyon.

Limestone is widely used. Limestone and dolomite are rocks composed respectively of calcite, $CaCO_3$, and dolomite, $CaMg(CO_3)_2$. Both are commonly called limestone by the industry, and intermediate varieties are not usually distinguished.

The value and use of carbonate rocks are determined by their composition. High calcium limestone has a great variety of uses in the chemical and metallurgical industries. As defined in the industry, high calcium limestone contains at least 95 to 97 percent $CaCO_3$ by weight.

Limestone for Portland cement may contain a considerable amount of clastic impurities, if they are uniformly distributed throughout the rock, but cannot contain more than 6.5 percent dolomite.

Carbonate rocks containing more than 25 percent fine clastic material are suitable only for fill on construction projects. Chert in crushed stone that is used as concrete aggregate is undesirable because the chert may react with the cement; the resulting chemical compounds weaken the concrete and cause spalling (Hubbard and Erickson, 1973, p. 358).

A small quarry in sec. 3, T. 26 N., R. 24 E. produced limestone from the Madison Limestone for a sugar refinery formerly operated at Chinook Montana (Hubbard and others, 1964, p. 7). Chip samples from the face of the quarry gave the following analysis:

	Percent
$CaCO_3$	90.20
$MgCO_3$	0.86
SiO_2	8.69
FeO_3	.259
$A1_2O_3$	0.045

Analyses of collected samples in the vicinity of the quarry and analyzed in the sugar refinery laboratory gave the following results:

Sample No.	Fe Al	CaO	MgO	Ign. Loss	Acid Insoluble
1	0.32	54.64	0.47	43.60	1.00
2	.28	54.98	.49	43.81	.49
3	.58	53.68	.58	43.11	2.09
4	.40	44.66	7.88	43.80	3.30
5	.32	54.34	.94	43.76	.70
6	.32	55.44	.62	43.39	.22
7	.20	54.99	.55	43.85	.47

Among the many other limestone deposits on the reservation, one at Matador Dome, deserves serious consideration provided a market should develop within a reasonable distance (Hubbard, 1964, p. 7). This deposit is in secs. 3 and 4, T. 25 N., R. 26 E., Phillips County. Limestone bluffs rise abruptly about 100 feet from the level plain and occupy about 60 acres. The base of the bluffs are about 2½ miles from paved Highway 191 over level terrain. Distance to the rail shipping point at Malta is approximately 40 miles.

A grab sample of limestone from Matador Dome assayed as follows:

	Percent
$CaCO_3$	97.600
$MgCO_3$	.920
SiO_2	.890
Fe_2O_3	.105
Al_2O_3	.041

The analyses, on the basis of CaO, MgO, and SiO_2 content, indicate that this limestone is suitable for the production of high calcium lime, or of metallurgical grade lime used in fluxes, sugar refining, and oil refining.

Limestone near Lodgepole, however, is variable in composition (Hubbard and others, 1964, p. 8). Some beds are high in calcium while others, similar in appearance, contain an objectionable amount of silica. Most of the limestone seems suitable for cement rock, agricultural lime, or building materials.

The average price of crushed limestone in the United States was $1.46 per ton in 1969. Freight costs often exceed the cost of the rock. Because of this, limestone of relatively poor quality may be used even though better quality limestone is available at a greater distance (Hubbard and Erickson, 1973, p. 357-363).

The limestone outcrops in the Hays-Lodgepole area are roughly 35 to 40 miles south of Harlem, by State Highway 376, a black-topped all-weather road. Harlem is a shipping point on the Burlington Northern and is centrally located in the Milk River Valley. The limestone at Matador Dome is about 42 miles by U. S. Highway 191 from Malta, Montana. Malta is 47 miles east of Harlem on U. S. Highway 2 and is also situated on the railroad (Hubbard and others, 1964, p. 8).

Four out of five major operating limestone quarries in Montana are producing from the Madison Limestone (Hubbard and others, 1964, p. 8). Because outcrops of limestone are rare and widely spaced in north-central Montana, the limestone on the Fort Belknap Reservation could be economically important if local limestone-using industries are developed.

Economic development of the Milk River Valley could create a future demand for industrial and agricultural limestone.

Bentonite

Bentonite is generally regarded as a rock formed by alteration of volcanic ash to clay minerals of the montmorillonite group (Berg, 1969, p. 2). Deposits of bentonite in Cretaceous beds are extensive in eastern Montana, but their physical properties are not uniform. Industrial users of the material require high gel strength, high viscosity, and high green and dry strength.

The three principal uses for bentonite are: oil well drilling mud, foundry molding sand binder, and a binder for taconite iron ore pellets. According to the Bureau of Mines Yearbook (1973, p. 295) the production of bentonite in the United States was 3,072,542 short tons valued at $11.34 per ton. Production from Montana was 176,586 tons valued at $6.98 per ton.

There is no record of commercial production of bentonite from the reservation. Lawson (1975, p. 29) lists two bentonite operations in Phillips County as: American Colloid Co., location unknown, and Hallett Minerals Co., Brazil Creek pit, sec. 21, T. 28 N., R. 27 E. (about 5 miles east of the reservation).

Knechtel (1959, p. 739-741, p. 744-745), describes several thin beds of bentonite in the Upper Cretaceous Thermopolis shale, Mowry shale, Warm Creek shale, Claggett shale, and Bearpaw shale. These beds are in the southern part of the Little Rocky Mountains south of the reservation. These shales cover extensive areas on the reservation along the east, north, and west flanks of the mountains, and may contain bentonite.

Bentonite beds near the base of the Bearpaw shale have been reported in several locations near the reservation and a few on the reservation. Two samples reported from the reservation (Berg, 1962, p. 20, Nos. 70 and 71) were in the SE¼ sec. 23, T. 28 N., R. 26 E. and the SW¼ sec. 15, T. 28 N., R. 26 E. Both are in Phillips County. The beds were 2 and 2½ feet thick, respectively, but neither met drilling specifications. Berg also reports on a sample (No. 69) taken from the base of the Bearpaw shale in T. 33 N., R. 22 E., Blaine County, about 5 miles north of the reservation. Although the sample did not meet drilling mud specifications, it did contain zeolite as a major constituent. Berg also reported that bentonite deposits were being developed in the area.

The contact between the Bearpaw shale and the underlying Judith River Formation extends for many miles in the northern part of the reservation. This area is only about 10 miles from the railroad. It would be well to examine the area carefully for bentonite deposits.

Since bentonite is a relatively low-priced product, transportation costs are critical. Raw bentonite from the Reservation must be shipped from 10 to 80 miles by railroad to processing plants from producing areas. The 1975 price for the pelletizing grade was $9.75 per ton F.O.B. northeastern Wyoming. The freight rate to the northern Minnesota Iron Range was $17.35 per ton for carload lots of 140,000 pounds (Nigro and Leak, 1975, personal commun.).

There was an 11 percent increase in tonnage and a 19 percent increase in value of bentonite produced in the United States in 1973 over that produced in 1972. There was a 24 percent decrease in the production of bentonite in Montana in 1973, with an attendant price increase of $0.58 per short ton (Bur. Mines, Minerals Yearbook, 1973, p. 295).

Kaolin

Kaolin, sometimes called "China clay", is white and can be fired at high temperatures without warping or changing color. Its primary use is for coating and as a paper filler. Minor uses include pottery, dinnerware, stoneware, and white cement.

Pure white kaolin was reported by Sahinen (1958, p. 23) at the crest of Morrison dome in sec. 12, T. 24 N., R. 24 E. A sample from a bed ranging in thickness from 2 to 12 inches in the lower part of the Upper Jurassic Ellis Formation, yielded the following chemical analysis:

	Percent
SiO_2	63.0
Al_2O_3	27.4
Fe	.7
CaO	.6
MgO	Nil
Na_2O	.4
K_2O	.4
TiO_2	.2

The material was reported to be high refractory clay. The available alumina was not given but the total alumina was relatively high as compared to other Montana clays.

Although the sampled bed was not on the reservation, Upper Jurassic rocks crop out extensively on the reservation. Field studies should include a search for similar clay deposits.

Traprock

Traprock is a general term that includes all mafic igneous rocks suitable for road metal, riprap, or other commercial purposes (Bowles 1963, p. 2-3). Rocks of this nature are found in the northwest corner of the reservation in secs. 2, 3, 10, and 11, T. 30 N., R. 22 E., where an intrusive shonkinite sill underlies the relatively flat-topped Snake Butte (Figure 1), (Hauptman, 1953 p. 156). The rock is medium to fine-grained and exhibits conspicuous augite and biotite phenocrysts. Average mineral composition of several specimens follows:

	Percent
Augite	40
Feldspar(Orthoclase)	20
Olivine	15
Biotite	10
Zeolites	10
Nepheline	5

A large quarry has been opened on the southeast side of Snake Butte (N½ sec. 10) along two benches that are about three-fourths mile in length. The upper bench exposes a vertical face 57 to 75 feet high that, in places, exhibits conspicuous columnar jointing. The rock breaks easily along joint planes into large, irregularly-shaped boulders of several tons each.

The Corps of Engineers report that 882,582 cubic yards of riprap was used in the construction of Fort Peck dam. Most of the rock was produced in 1933-37, but a minor amount was quarried more recently for repair and improvements at the dam. The rock was transported about 150 miles from quarry to damsite.

The Snake Butte traprock quarry provides a readily accessible source for crushed rock and riprap. The deposit contains significant reserves and is located only 4 miles from State Highway 376 and about 12 miles south of Harlem (Hubbard and others, 1964, p. 9).

Nepheline Syenite

Nepheline syenite is a silica-deficient igneous rock that can be used in the ceramic industry as a flux permitting lower firing temperatures in the manufacture of sanitary ware, tile, electrical porcelain, vitreous bodies, and glass (Deeth, p. 1241). A sample of shonkinite from Snake Butte contained nepheline. Other nepheline-bearing rocks (nepheline syenite) may occur in the Little Rocky Mountain area. In general, the nepheline syenite used by the ceramic industry in the United States contains more than 20 percent nepheline.

Fluorite

Sahinen (1962, p. 33) mentions fluorite occurrences at Antone Peak in NW¼SE¼ sec. 12, T. 25 N., R. 24 E. near the center of the Little Rocky Mountains (Figure 4). The fluorite is sparsely disseminated in porphyritic syenite. Samples collected averaged between 2 and 3 percent CaF_2, contained traces of gold and silver, and had a lead content of 0.5 to 0.8 percent.

In Montana all the commercial fluorspar deposits occur in metasedimentary rocks of Pre-cambrian age along the margin of the Idaho batholith. The disseminated fluorite in deposits such as those in the Little Rockies are a peculiar occurrence associated with the potassic rocks of central Montana's isolated mountain groups. These occurrences have not produced commercial fluorspar, but have served as a prospecting indicator for gold (Sahinen, 1962, p. 26).

At the present time the United States produces only about 20 percent of its required fluorspar (Worl and others, 1973, p. 223). The other 80 percent is imported mainly from Mexico, Spain, and Italy. In 1973, U. S. fluorspar reserves totaled about 25 million tons of ore containing about 35 percent CaF_2 (Bur. Mines, Mineral Yearbook, 1973, p. 527).

Zeolites

Traprock mentioned previously contains 10 percent zeolites and 5 percent nepheline. Nepheline is a common parent mineral of zeolites (Clarke, 1929, p. 420).

One of the many important uses of natural zeolites is in antipollution processes; one of which is the removal of ammonia from sewage effluent and carbon dioxide from methane gas. Both uses consume large tonnages of zeolites (Eyde, 1974, p. 1-2).

The sample of the traprock from Snake Butte was probably collected without consideration of the possible zeolite content. It may be advisable to re-examine Snake Butte to determine if it contains economic concentrations of zeolites.

Sand and Gravel

Sand and gravel deposits occur primarily as alluvial deposits at the base of the Little Rocky Mountains in the southern part of the reservation. The most extensive deposits occur in T. 25 and 26 N., R. 23 E., south and southwest of Hays. Gravel from this area has been used locally on roads, but none has been shipped beyond the immediate vicinity (Hubbard and others, 1964, p. 8).

Although sand and gravel will continue to be used locally for road surfacing, it is doubtful that a large commercial sand and gravel operation will be developed on the reservation in the near future. Very large gravel deposits are located north of the Milk River a few miles from Harlem (Larrabee and Shride, 1946). Because of the extent of these deposits and their proximity to the railroad, they will probably be developed in preference to the more remote deposits on the Fort Belknap Reservation.

RECOMMENDATIONS FOR FURTHER WORK

The largest known mineral resources on the Fort Belknap Indian Reservation are the deposits of sand and gravel, stone, and limestone. Little additional work on these deposits is necessary and their development depends solely on the growth of future markets in the area.

Natural gas is probably present in significant quantities under the reservation. Its development depends in large part on favorable costs and terms for leasing arrangements. Geologically, detailed stratigraphic and structural field studies should be conducted of exposed surface rocks to determine any subtle structural anomalies and possible facies changes that may be indicative of gas traps. Close spaced seismic and possibly other geophysical methods (i. e. magnetic and gravity) surveys may better delineate the shallow fault blocks on the western side of the reservation and thus act to guide future drilling. Any additional oil and gas wells drilled on the eastern side of the reservation should closely compare their porosity logs with those from wells in the Bowdoin field particularly in the section of upper Colorado shales for possible stratigraphic changes and traps.

The potential resources of gold and silver on the reservation are strictly speculative. To adequately assess their potential it is recommended that a field survey and sampling program be undertaken.

Nonmetallic minerals with economic potential should be given appropriate analyses and tests to check conformance with established industrial specifications.

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TABLE 8.--Analyses of coal from mines near the Fort Belknap Indian Reservation

(Bowen, 1912, p. 354, Fieldner and others, 1932, p. 36)

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Mine	Location	Formation	Sample thickness (feet)	Sample thickness (inch)	Moisture[1/] percent	Volatile matter percent	Fixed carbon (percent)	Ash percent	Sulfur percent	Heat content (Btu/lb.)
Government	Sec. 1, T. 32 N., R. 23 E.	Judith River	2	6	11.1	33.8	42.0	13.1	0.8	8845
Indian Reservation	Sec. 22, T. 25 N., R. 25 W.	Kootenai			11.9	33.3	42.0	12.8	.7	
Cook	SW¼ Sec. 35, T. 30 N., R. 20 E.	Judith River	3	1	12.5	33.9	43.5	10.1	.8	9830
Bryson McSharry	Sec. 12, T. 27 N., R. 20 E.	Judith River	3	0	5.7	31.7	45.8	16.8	.9	10438

1/ Analyses are from air dried samples that contained only inherent moisture except analysis for Indian Reservation mine which is from an "as received" sample that contained inherent moisture plus surface moisture.

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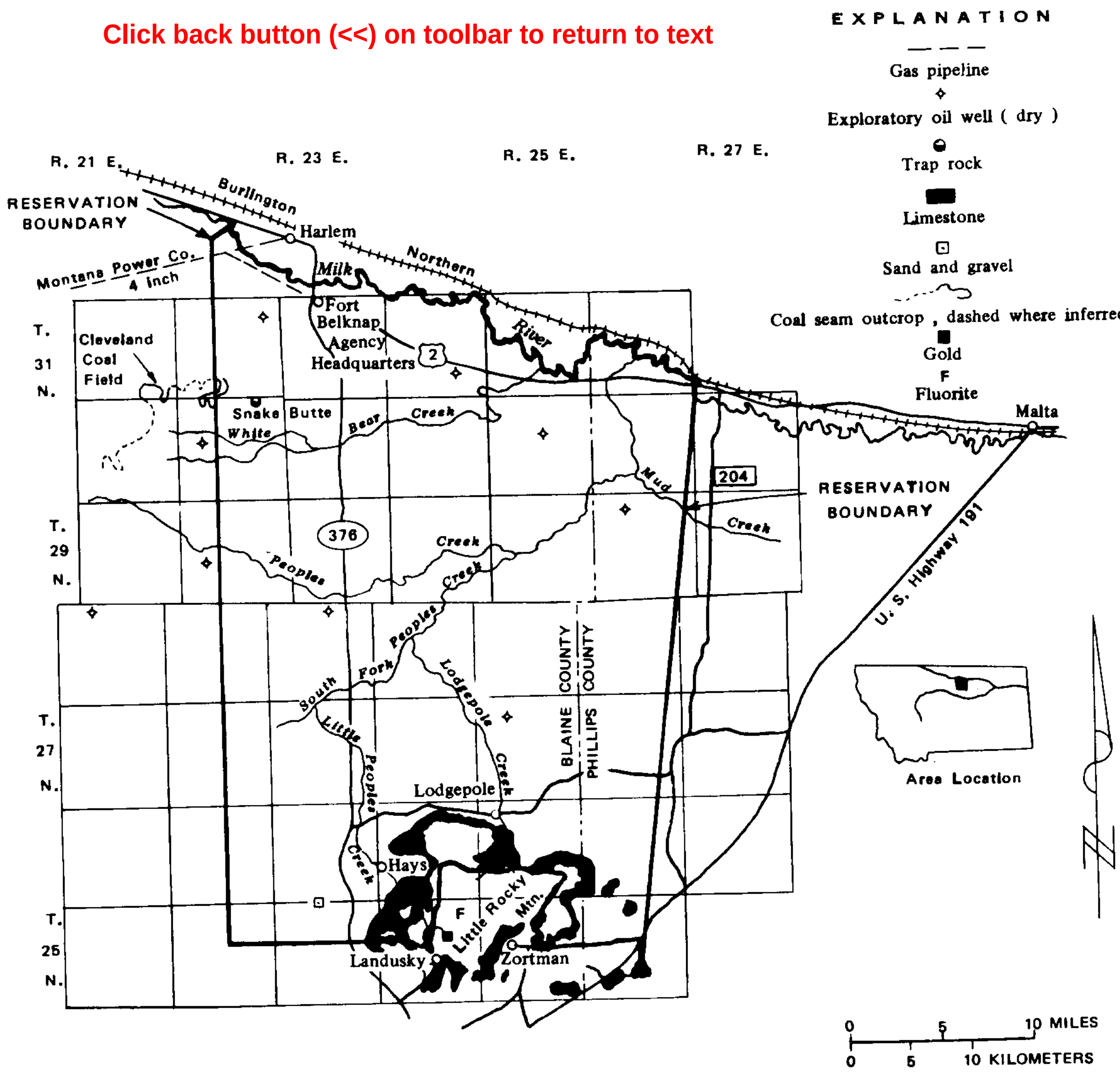

Figure 1. Index map showing limestone, traprock, gold, fluorite, sand and gravel deposits and exploratory gas and oil wells on and adjacent to the Fort Belknap Indian Reservation, Montana.

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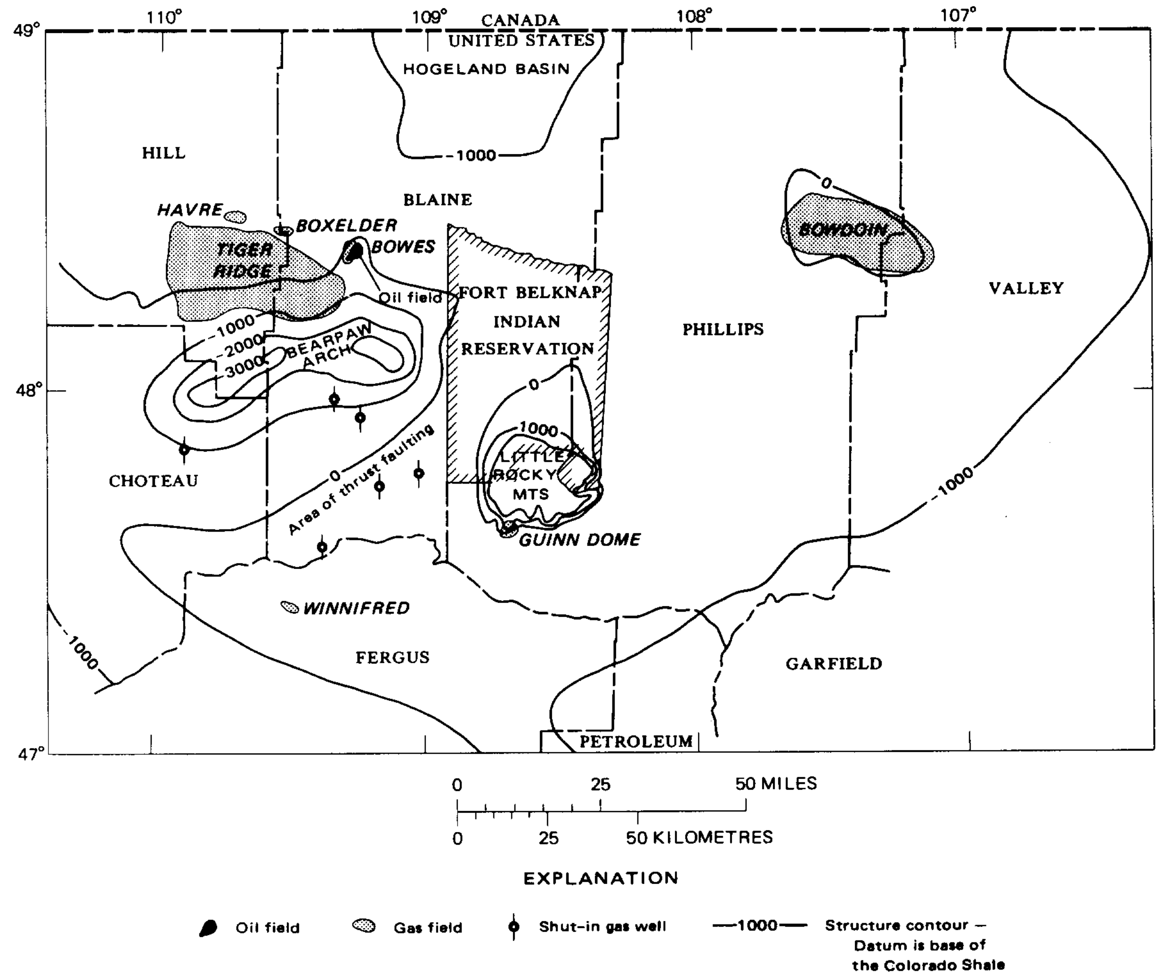

Figure 2. Map showing regional structural settings of the Fort Belknap Indian Reservation and nearby oil and gas fields.

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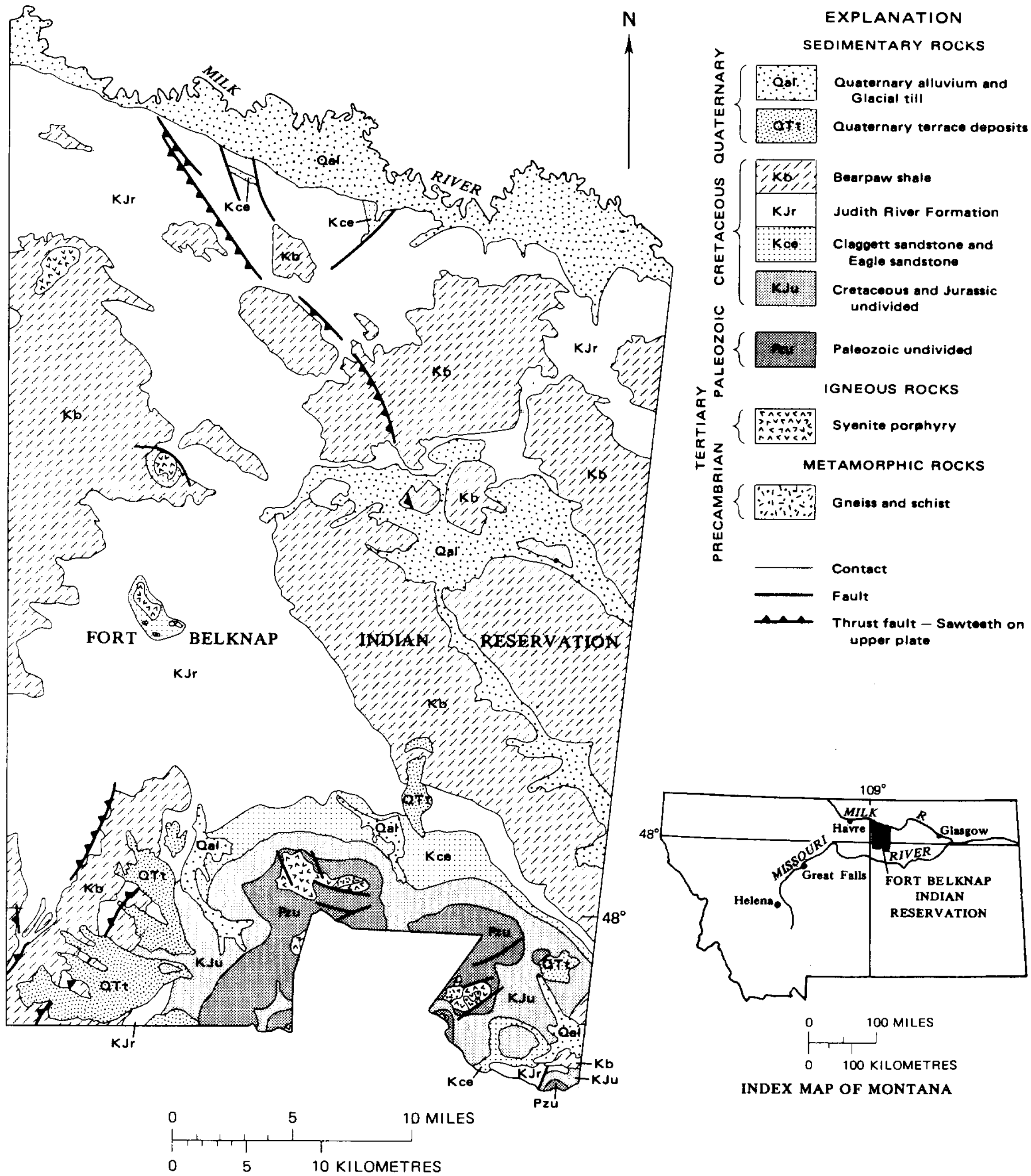

Figure 3. Geologic map of the Fort Belknap Indian Reservation.

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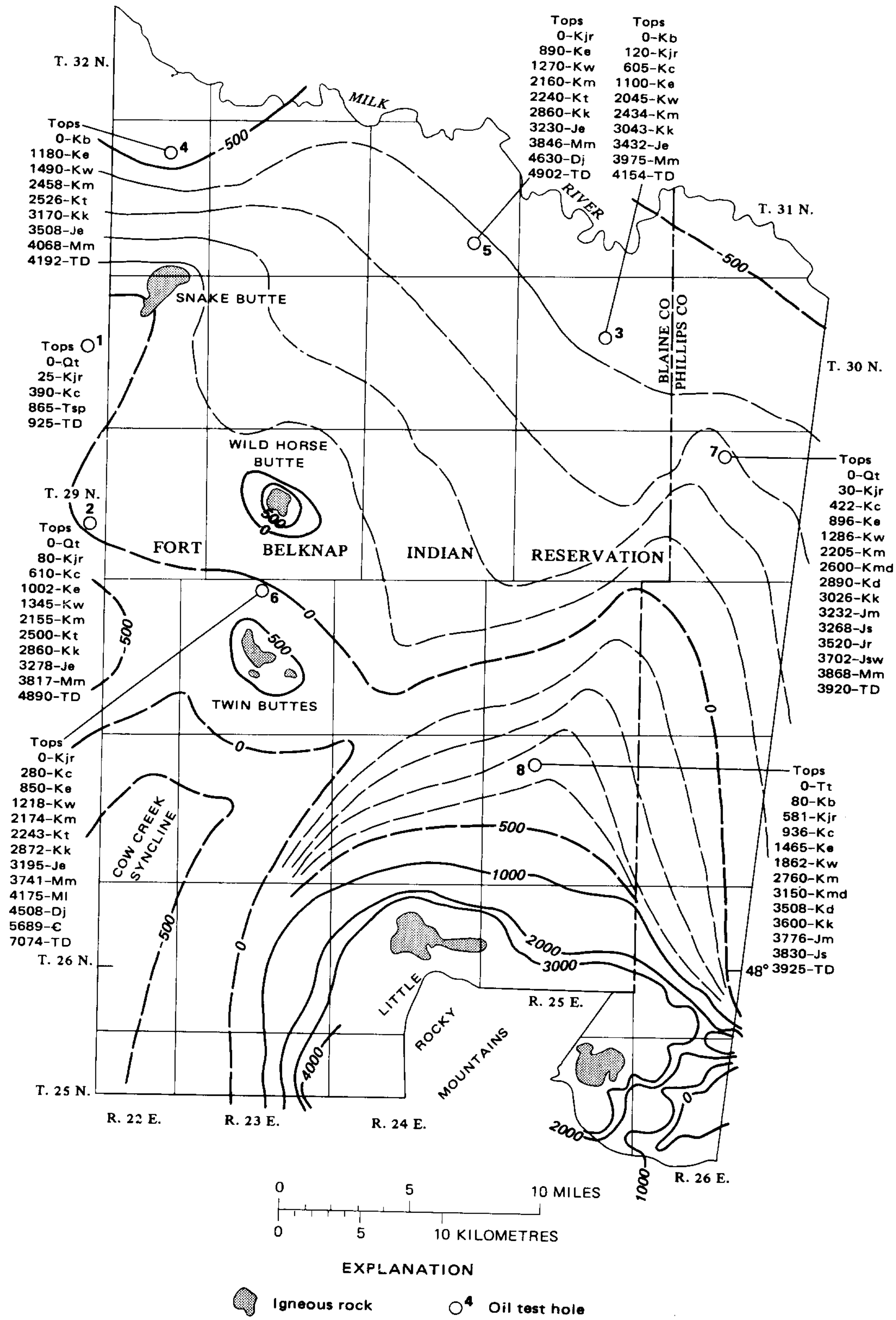

Figure 4. Structure-contour map of the Fort Belknap Indian Reservation. Contours are drawn at the base of the Thermopolis Shale; they are dashed where control is less accurate. Contour interval is 100 feet; datum is mean sea level. (Modified after Alverson, 1965, fig. 3).

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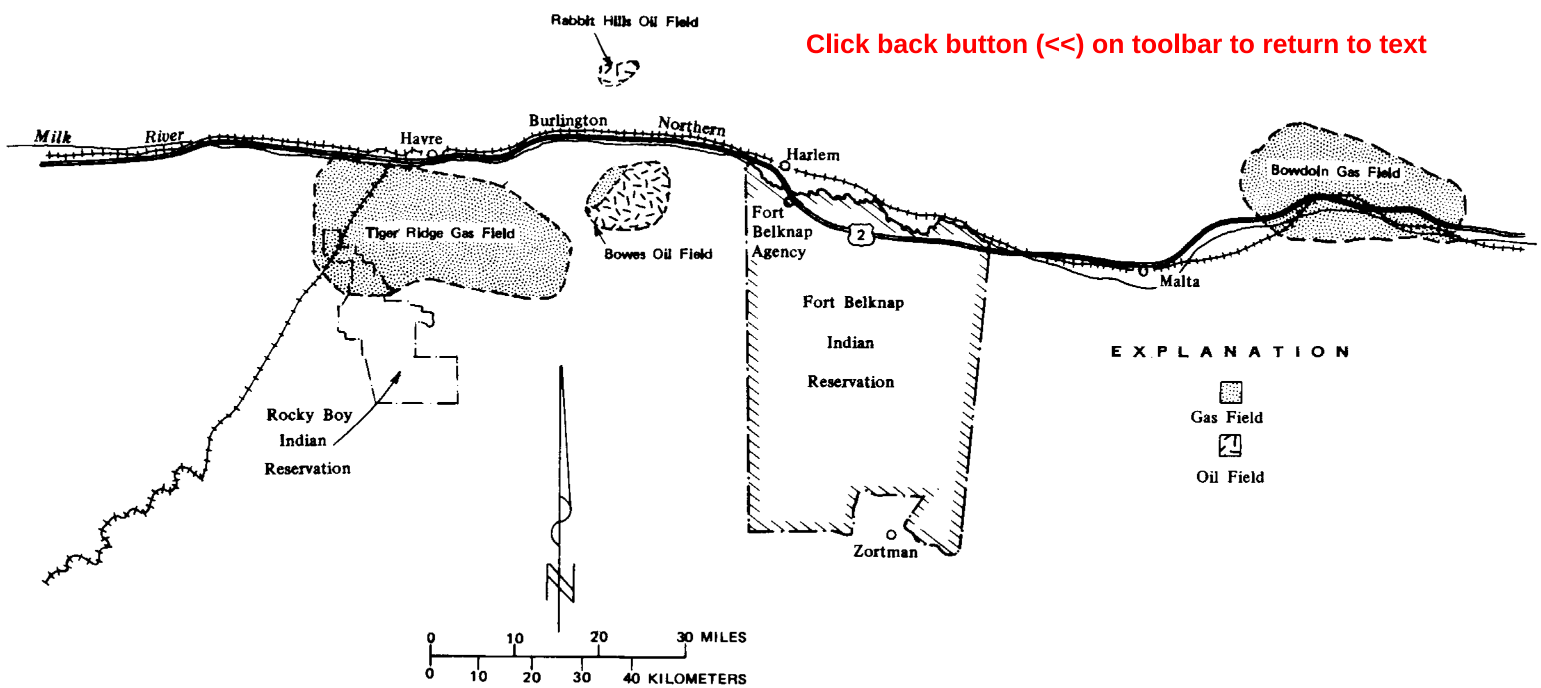

Figure 5. Map showing oil and gas fields near the Fort Belknap Indian Reservation.