STUDIES RELATED TO WILDERNESS
WILDLIFE REFUGES

BEAR RIVER MIGRATORY BIRD REFUGE, UTAH

GEOLOGICAL SURVEY BULLETIN 1260-C

Summary Report on the Geology and Mineral Resources of the Bear River Migratory Bird Refuge Box Elder County, Utah

By LOWELL S. HILPERT, U.S. GEOLOGICAL SURVEY

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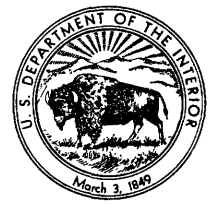
A compilation of available geologic information



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STUDIES RELATED TO WILDERNESS

WILDLIFE REFUGES

The Wilderness Act (Public Law 88–577, Sept. 3, 1964) directs the Secretary of the Interior to review roadless areas of 5,000 contiguous acres or more, and every roadless island, within the national wildlife refuges and game ranges under his jurisdiction and to report on the suitability or nonsuitability of each such area or island for preservation as wilderness. As one aspect of the suitability studies, existing published and unpublished data on the geology and the occurrence of minerals subject to leasing under the mineral leasing laws are assembled in brief reports on each area. This bulletin is one such report and is one of a series by the U.S. Geological Survey and the U.S. Bureau of Mines on lands under the jurisdiction of the U.S. Department of the Interior.

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By LOWELL S. HILPERT, U.S. Geological Survey

SUMMARY

The Bear River Migratory Bird Refuge comprises 64,895 contiguous acres in Box Elder County, Utah, at the outlet of the Bear River where it enters Bear River Bay, the northeastern arm of Great Salt Lake. Part of this refuge has been proposed for inclusion in the National Wilderness Preservation System.

Rocks under the refuge make up part of a downthrown, eastward-tilted structural block, the lower part of which is composed of complexly faulted rocks of Precambrian and Paleozoic ages, many thousands of feet thick; the upper part is unconsolidated sediments that range from a few hundred to several thousand feet in thickness. These sediments occupy a north-trending structural trough in the older rocks which passes beneath the eastern part of the refuge. Surficial rocks consist of mud, clay, silt, and fine sand.

The refuge contains no known mineral deposits of economic interest, and there is no record of mineral leasing or mining within its boundaries either before or after its establishment. A small amount of methane was obtained from a well drilled for water and was utilized for fuel at Refuge Headquarters during the early 1930's.

Of the leasable minerals, such as coal, oil, gas, phosphate, and potash and sodium compounds that might occur in the refuge, small pockets of methane gas may occur within a few hundred feet of the surface, but such pockets typically yield only small amounts of gas for short periods and are of little or no commercial importance. Brines of sodium, potassium, magnesium, and lithium salts may exist at depths of several hundred feet below the refuge, but they probably have been diluted by inflowing fresh water. Other parts of the lake basin are more favorable for the development of brine resources.

INTRODUCTION

This report reviews the geologic setting and mineral resources of the Bear River Migratory Bird Refuge, Box Elder County, Utah. A part of the refuge has been proposed for inclusion in the National Wilderness Preservation System.

In the absence of mineral production or deposits, the U.S. Bureau of Mines has not had occasion to examine the refuge, but the Bureau

is informed of the findings and conclusions of the U.S. Geological Survey.

LOCATION AND ACCESS

Bear River Migratory Bird Refuge is an arcuate area of 64,895 acres in parts of Ts. 8 and 9 N., Rs. 2–5 W., Box Elder County, Utah (fig. 1). It is roughly 20 miles long and 3–8 miles wide; the candidate area constitutes about 40,631 contiguous acres in the southern and western parts of the refuge.

The refuge is a lowland made up by a system of marshlands, embayments, and mudflats and by a system of drainage channels, principally in the delta of Bear River where it enters Bear River Bay, the northeastern arm of Great Salt Lake. Lake level in the bay in 1966 is about 4,195 feet above mean sea level, and the adjoining marshlands and mudflats rise gently northward to about 4,210 feet in altitude. The northwestern part of the candidate area is mostly a mudflat; the rest is mostly covered by waters of Bear River Bay and partly by marshlands and mudflats. Seasonal fluctuations in the level of Great Salt Lake cause the proportions of land and water to vary. The refuge is flanked by the Wasatch Mountains, which rise abruptly about 2 miles east of the refuge, and by the Promontory Mountains, about 1 mile west of the refuge.

Refuge Headquarters is accessible by hard-surfaced road from Brigham City, about 15 miles to the east. The city is on U.S. Highways 30S and 91. Access within the refuge is along a system of dikes that contain several artificial ponds and marsh areas.

ACKNOWLEDGMENTS

This report was compiled partly from well-log data obtained through the courtesy of the Utah State Oil and Gas Commission and the Utah State Engineer. Records of the only wells drilled within the refuge were provided through the courtesy of Mr. Lloyd Gunther, Refuge Manager. Special thanks are extended to Dr. Kenneth L. Cook, Department of Geophysics, University of Utah, for permission to abstract gravity data from an unpublished student thesis. Thanks also are extended to Dr. W. P. Hewitt, Director, Utah Geological and Mineralogical Survey, for assistance in the search for well data in the vicinity of the refuge.

GEOLOGY

Only a highly generalized description of the rocks under the Bear River Refuge can be given because they are deeply buried and structurally complex. Exposures in nearby mountains, some geophysical data, and limited drill-hole data indicate that the rocks consist of a basal consolidated sequence and an overlying unconsolidated sequence.

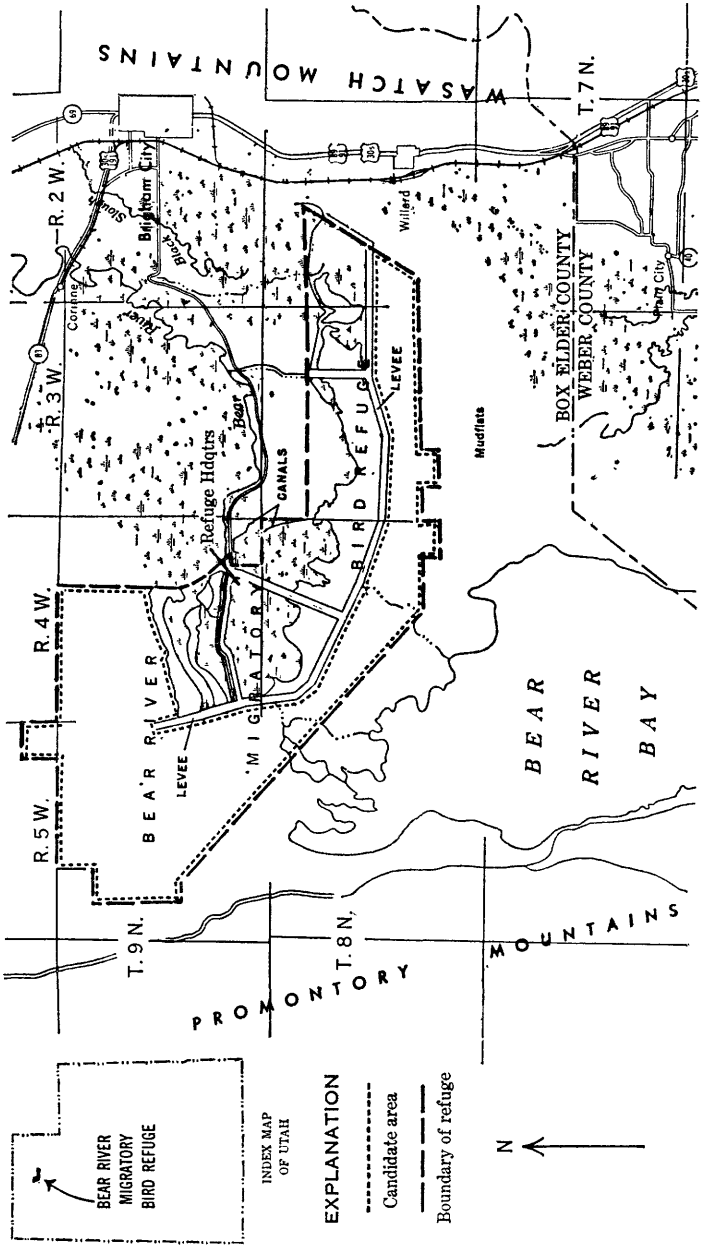

FIGURE 1.—Bear River Migratory Bird Refuge and adjacent areas, Box Elder County, Utah.

The basal sequence consists of quartzite, gneiss, tillite, and other metamorphic rocks of Precambrian age and limestone, dolomite, quartzite, shale, and sandstone of Paleozoic age. The thickness of this sequence is not known, but it must total many thousands of feet; in the adjacent Promontory Mountains rocks of Paleozoic age alone are about 30,000 feet thick (Olson, 1956, p. 41), and in the nearby Wasatch Mountains they are about 20,000 feet thick (Williams, 1962, p. 132).

The overlying unconsolidated sediments probably range in thickness from a few hundred to as much as 5,000 feet between the western and eastern parts of the refuge. These rocks are Tertiary and Quaternary in age and probably consist of the Wasatch Formation at the base, succeeded by the Salt Lake Formation and overlying sediments of Lake Bonneville and younger alluvium (Adamson and others, 1955; Heylmun, 1965). The lithology of only the upper part of this sequence is known from rather sparse drill-hole data. The deepest well of record was drilled to a depth of 1,027 feet at Refuge Headquarters. According to the driller's log, 30 feet of river sediments, 210 feet of clay, and about 790 feet of intercalated shale and fine sand were succesively penetrated. Several beds of organic matter and methane gas also were encountered in the hole. The log of this well, provided by courtesy of Mr. Lloyd F. Gunther, Refuge Manager, is as follows:

Driller's log of U.S. Biological Survey well 2

[Location, approximately sec. 35, T. 9 N., R. 4 W., SLM]

Depth below collar (feet)	*Material*
0–30	River fill, silt
30–50	Blue clay
50–53	Black organic matter, some gas
53–102	Blue clay
102–109	Streaks of shale or hard clay
109–124	Blue clay
124–131	Sand, gas
131–240	Blue clay
240–250	Black sand, organic matter
250–251	Hard sand
251–265	Fine quicksand
265–291	Clay
291–322	Shale
322–330	Shale and gas
330–340	Shale
340–350	Black sand, organic matter, and gas
350–357	Shale
357–361	Sand, gas
361–383	Shale
383–514	Blue shale streaked with lime
514–520	Brown shale

Driller's log of U.S. Biological Survey well 2—Continued

[Location, approximately sec. 35, T. 9 N., R. 4 W., SLM]

Depth below collar (feet)	*Material*
520–528	Brown sand and organic matter with artesian water and gas.
528–550	Shale
550–555	Fine sand
555–622	Shale
622–751	Shale, clay, and sand streaks
751–762	Shale
762–772	Fine sand
772–794	Sand and shale
794–816	Shale and hard lime
816–828	Shale
828–834	Hard fine sand
834–838	Shale
838–846	Hard lime and shale
846–860	Clay and sand streaks
860–1,000	Shale and clay streaks
Total 1,000–1,028	Clay and streaks of sand, with artesian water and gas.

The top 30-foot thickness of silt is deltaic material deposited by the distributaries of the Bear River. This material, saline clay, and mud are exposed above water in the refuge. Shoreward from the refuge, particularly toward the Wasatch Mountains, water-well records indicate that these surficial materials and the underlying clays and sands grade and intertongue with coarser materials, which become conglomeratic and bouldery near the mountains. For details on these relations and on the stratigraphy of the Wasatch Formation, Salt Lake Formation, and the lake sediments near the refuge, see Feth (1955, p. 46; fig. 12), Adamson and others (1955, p. 1–14), and Morrison (1966, p. 77–104).

The Bear River Refuge is near the eastern margin of the Basin and Range province, which is characterized by north-trending fault-block mountain ranges and intervening structural valleys. The refuge lies in a valley which is an arm of a broader basin that was occupied by ancient Lake Bonneville, of which Great Salt Lake is a remnant (Morrison, 1966).

The valley overlies a deformed and faulted structural block that is tilted eastward and bounded on the eastern side by the high-angle Wasatch fault along which the block has dropped several thousand feet. The block also has been dropped along the western side along similar faults, but less so. Internally, the block is probably broken and folded in the Paleozoic and older rocks, along thrust faults of Late Cretaceous to early Tertiary age, and by younger high angle

faults, principally of late Tertiary and Quaternary age, similar to those in the nearby mountains (Stokes, 1963).

A gravity survey of the refuge (Lum, 1957, fig. 2) and a similar survey of the adjoining area to the south (McDonald and Wantland, 1960, fig. 3) show a structural trough on the consolidated rock sequence that trends northward along the eastern side of the valley under the eastern end of the refuge, and a structural ridge along the western flank of the trough that trends northward and northwestward under the central part of the refuge. This ridge is exposed in South Little Mountain. It extends northward under the refuge, probably within a few hundred feet of the surface.

MINERAL RESOURCES

No mineral deposits of economic interest are known within the Bear River Migratory Bird Refuge, and there is no record of mineral leasing or mining within the refuge area before or after it was established.

In areas near the refuge, some of the minerals subject to leasing in the Public Domain, including oil and gas, phosphate, salines, sand and gravel, common stone, and clay, have been mined and marketed. Small deposits of copper, lead, zinc, gold, silver, and antimony also have been mined.

LEASABLE MINERALS

OIL AND GAS

About 80 wells have been drilled for oil and gas in the Basin and Range province of Utah, most of them concentrated around the eastern and northern flanks of the Great Salt Lake, or Bonneville Basin (Hansen and Scoville, 1955; Heylmun, 1963, fig. 95; Heylmun and others, 1965). Many wells had shows of oil or gas, but none have tapped substantial reserves or have yielded any substantial amount of petroleum.

The productive wells are principally in a small field west of Farmington, Davis County, where between 1891 and 1897, several shallow wells, originally drilled for water, yielded methane gas from a zone 400–700 feet below the surface. In 1896–97, gas was delivered by pipeline to Salt Lake City, but only about 150,000,000 cubic feet was marketed before the wells were depleted and abandoned (Richardson, 1905). Similarly, a well drilled for water in the Bear River Refuge (see log, p. C4) in the early 1930's yielded methane gas, which was utilized for fuel at Refuge Headquarters for several years until the gas was depleted (V. T. Wilson, oral commun., November 1966). A nearby water well, 341 feet deep, also yielded some gas, as have numerous shallow-water wells in the general area east and south of the refuge.

At Rozel Point, west of the Promontory Mountains, and about 10 miles west of the refuge, oil seeps were known before 1900. The area has been prospected by 20–30 wells, most of them a few hundred feet deep and one of them about 2,700 feet deep. From time to time a few barrels of oil—a viscous black material generally referred to as asphalt—have been produced. Most of the oil shows and production are from a zone of jointed vesicular basalt 130–300 feet below the surface, and some are from a zone 1,240–1,375 feet below the surface (Boutwell, 1904; Heylmun, 1963, p. 298). The basalt is interbedded with lacustrine limestone of the Salt Lake Formation.

Source of the petroleum at Rozel Point is speculative, but the oil generally is thought to have migrated from organic-rich material within the Salt Lake Formation or possibly from deeper beds along a fault (Slentz and Eardley, 1956; Eardley, 1963).

Source of the gas in the Farmington field, in the wells at Refuge Headquarters, and in numerous other water wells and a few oil tests north of the refuge apparently is mostly the organic material in the lake sediments of Quaternary age. The productive zones are within a few hundred feet of the surface and are generally associated with organically rich layers. The productive gas pockets are small and not commercially attractive.

Few shows of oil and gas have been encountered in the pre-Tertiary rocks, and though these rocks have been recognized by petroleum geologists as potential source rocks, they have not been attractive for prospecting in recent years because of high exploration costs and the poor risk for making a discovery. The rocks are highly faulted and folded, making structural targets difficult to define. They also probably permitted escape and loss of the petroleum at the surface.

Small reservoirs of gas and possibly oil occur in the refuge in the rocks of Tertiary and Quaternary ages, and possibly also in the rocks of pre-Tertiary age. The small size of the targets and the costs of discovery and development make these resources commercially unattractive.

PHOSPHATE

The potential for phosphate resources in the refuge is judged to be poor, though specific data are lacking. Phosphorites in Utah occur principally in the Park City Formation of Permian age and partly in shale of Mississippian age (Gere, 1964, p. 196–197). The Park City Formation, however, is missing in parts of the mountains and in wells near the refuge; it may have been removed by erosion during the Laramide orogeny (Eardley, 1963, p. 23–26). If so, it probably is missing under the refuge. Occurrences of low-grade phosphatic shale of Mississippian age are known in Utah (Gere, 1964, p. 195–196), but

if any such shale is under the refuge, it is deeply buried and probably not of economic value.

SALINE MINERALS

Saline minerals occur in the brines of Great Salt Lake, in sedimentary deposits under the lake basin, and as crusts on the mudflats. Substantial quantities of common salt and potash have been recovered from the brines by solar evaporation, and the recovery of magnesium, lithium, and other salts is being investigated. Large beds of sodium sulfate (glauber salt) are known under the lake bottom, but they have not been exploited (Hite, 1964).

All the important salt production has come from brines, largely from along the southern and western shores of the lake. The refuge is at the mouth of the Bear River, the principal supplier of fresh water to the lake basin, where the brines in the lake waters are diluted by the inflowing fresh water. Because of the location of the refuge, the brines beneath it probably also are dilute. Bedded salines within the sediments under the refuge are unlikely because the hydrologic conditions during early periods of desiccation probably were similar to those at present. During such periods the salts are concentrated and precipated in the central and lower parts of the lake basin, and salines that are present in the surficial crusts of the marginal areas are dissolved and carried basinward. Consequently, it is likely that the saline resources beneath the refuge are less important than in other parts of the lake basin.

SAND, GRAVEL, AND COMMON STONE

Tongues and lenses of sand and gravel occur under the refuge to depths of at least several hundred feet below the surface, as indicated in water-well log records. Because of the thinness of the individual beds, their limited lateral extent, and their tendency to be interbedded with clay and mud, they are not considered to be of commercial importance. High-quality sand and gravel occur along nearby Pleistocene lake terraces in amounts that are more than ample to meet local needs within the foreseeable future.

Common stone in the refuge is deeply buried and is not considered of commercial significance because adequate supplies of such material are readily available along the Wasatch Mountains.

CLAY

Clay deposited in Pleistocene Lake Bonneville composes most of the material in the upper few hundred feet of unconsolidated rocks under the refuge (see log, p. C4). Similar clays from other areas have been used for making brick, tile, and other heavy structural clay prod-

ucts, but much of it contains a high percentage of alkalies and alkaline earths and is of little value for ceramic products (Greaves-Walker, 1911). Enormous tonnages of this type of clay are available and more accessible in many other parts of the Bonneville basin.

METALLIC MINERALS

In the general region around the refuge are scattered small lode deposits in rocks of Precambrian and Paleozoic age that contain copper, lead, zinc, gold, silver (Butler and others, 1920, p. 219–223, 226–227, and 502–503), and antimony (White, 1951, p. 22). A few of them have yielded some ore. No deposits of metallic minerals are known in the refuge, however, and no data are available to indicate the presence of commercial deposits of such minerals in the subsurface.

CONCLUSIONS

Mineral-resource potential of the Bear River Migratory Bird Refuge appears to be low. Small pockets of methane gas may occur within a few hundred feet of the surface, but such pockets typically yield only limited amounts of gas for short periods and are of little or no commercial significance. Brines probably exist at depths of several hundred feet below the surface, but as compared with brines elsewhere in the Great Salt Lake basin, they probably are diluted as a result of inflow of fresh water from the Bear River. Neither the gas nor brine resources are likely to be of economic importance. Clays, sand, and gravel are known in the area, but they are of low value.

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