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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE KING MOUNTAIN QUADRANGLE, POWDER RIVER AND ROSEBUD COUNTIES, MONTANA

[Report includes 43 plates]

By

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ILLUSTRATIONS

[Plates are in pocket]

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Conversion table

To convert	Multiply by	To obtain
feet	0.3048	meters (m)
miles	1.609	kilometers (km)
acres	0.40469	hectares (ha)
tons (short)	0.9072	metric tons (t)
short tons/acre-ft	7.36	metric tons/hectare-meter (t/ha-m)
Btu/lb	2.326	kilojoules/kilogram (kJ/kg)

INTRODUCTION

Purpose

This text is for use in conjunction with the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) maps of the King Mountain quadrangle, Powder River and Rosebud Counties, Montana, (43 plates; U.S. Geological Survey Open-File Report 79-092). This set of maps was compiled to support the land-use planning work of the Bureau of Land Management in response to the Federal Coal Leasing Amendments Act of 1976 and to provide a systematic inventory of coal resources on Federal coal lands in Known Recoverable Coal Resource Areas (KRCRAs) in the western United States. The inventory includes only those beds of subbituminous coal that are 5 feet (1.5 m) or more thick and under less than 3,000 feet (914 m) of overburden and those beds of lignite that are 5 feet (1.5 m) or more thick and under less than 1,000 feet (305 m) of overburden.

Location

The King Mountain quadrangle is in western Powder River and southeastern Rosebud Counties, Montana, about 7 miles (11.3 km) south-southeast of Ashland and about 38 miles (61 km) northeast of Decker, Montana. Ashland is on east-west U.S. Highway 212. The nearest railroads are spur lines of the Burlington Northern Railroad at the Big Sky coal mine in the Colstrip SE quadrangle about 27 miles (43.4 km) northwest of the quadrangle, and at the Decker coal mine about 36 miles (58 km) southwest of the quadrangle.

Accessibility

The King Mountain quadrangle is accessible from Ashland, Montana, by following U.S. Highway 212 southeastward about 4 miles (6.4 km) and then taking an improved, graveled road southward up Otter Creek about 5 miles (8 km) to the northern boundary of the quadrangle. This road extends south-southeastward through the quadrangle to Otter, Montana, and then continues south and southwestward to Decker. A number of local roads and trails intersect the Otter Creek road to provide access to most parts of the King Mountain quadrangle.

Physiography

The King Mountain quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The plateau is formed by nearly horizontal sedimentary strata and has been highly dissected by tributaries of the Tongue River which flows northeastward about 5 to 12 miles (8.0 to 19.3 km) west of the quadrangle. Otter Creek flows northward through the eastern half of the quadrangle in a flood plain which is about 0.5 mile (0.8 km) wide and continues north-northwestward about 8 miles (12.9 km) to empty into the Tongue River near Ashland. The eastern part of the quadrangle is moderately rugged grassland which is quite highly dissected by tributaries of Otter Creek. The western part of the quadrangle is a very rugged, forest-covered highland that forms the divide between Otter Creek and the Tongue River and is within the Custer National Forest. The crest of the divide is near the western border of the quadrangle so that only a small strip of the quadrangle is drained by King Creek and other northwestward-flowing tributaries of the Tongue River. King Mountain, elevation 4,161 feet (1,268 m), and a butte about 2 miles (3.2 km) to the south-southeast, elevation 4,175 feet (1,273 m), are the highest points in the quadrangle. The lowest elevation, about 3,020 feet (920 m), is on Otter Creek at the northern border of the quadrangle. Topographic relief in the quadrangle is about 1,155 feet (352 m).

Climate

The climate of Powder River and Rosebud Counties is characterized by pronounced variations in seasonal precipitation and temperature. Annual precipitation in the region varies from less than 12 inches (30 cm) to about 16 inches (41 cm). The heaviest precipitation is from April to August. The largest average monthly precipitation is during June. Temperatures in eastern Montana range from as low as -50°F (-46°C) to as high as 110°F (43°C). The highest temperatures occur in July and the lowest in January; the mean annual temperature is about 45°F (7°C) (Matson and Blumer, 1973, p. 6).

Land status

The Boundary and Coal Data Map (pl. 2) shows the land owndership status within the King Mountain quadrangle. Most of the quadrangle is within the Northern Powder River Basin Known Recoverable Coal Resource Area (KRCRA). Approximately the western half of the quadrangle is within the Custer National Forest. The Federal government owns most of the coal rights, but there is a considerable amount of non-Federal coal land in the eastern part of the quadrangle. In 1977 there were no Federal coal leases or prospecting permits.

GENERAL GEOLOGY

Previous work

Warren (1959, pl. 19) mapped the King Mountain quadrangle as part of the Birney-Broadus coal field. Matson, Dahl, Jr., and Blumer (1968, p. 24-33) mapped the strippable coal deposits on State land within the quadrangle. Matson and Blumer (1973, pl. 12) mapped the Knobloch coal bed in the quadrangle as part of the Otter Creek coal deposit. McKay (1976) made a preliminary geologic map and coal sections of the King Mountain quadrangle. In 1977 the U.S. Bureau of Land Management and the U.S. Bureau of Reclamation issued reports on resource and reclamation evaluation of the Dam Creek EMRIA study site, the Otter Creek East EMRIA study site, the Newell/28 EMRIA study site, and the Chromo/4 EMRIA study site: small areas in the central and eastern parts of the quadrangle.

Traces of coal bed outcrops shown by previous workers on planimetric maps which lack topographic control have been modified to fit the modern topographic map of the quadrangle.

Stratigraphy

A generalized columnar section of the coal-bearing rocks of the King Mountain quadrangle is shown on the Coal Data Sheet (pl. 3) of the CRO maps. The exposed bedrock units belong to the Tongue River Member, the uppermost member of the Fort Union Formation (Paleocene).

The Tongue River Member consists of interbedded lenticular beds of gray, fine- to dark-gray siltstone, gray shale and claystone, brown carbonaceous shale, and coal beds. The thicker coal beds have burned along the outcrops, baking the overlying sandstone and shale and forming thick, reddish-colored clinker beds. The upper part of the Tongue River Member has been removed from the quadrangle by erosion, but about 1,800 feet (549 m) of Tongue River strata remains.

Coal and other rocks comprising the Tongue River Member were deposited in a continental environment at elevations of perhaps a few tens of feet (a few meters) above sea level in a vast area of shifting rivers, flood plains, sloughs, swamps, and lakes that occupied the area of the Northern Great Plains in Paleocene (early Tertiary) time.

Representative samples of the sedimentary rocks overlying and interbedded with minable coal beds in the eastern and northern Powder River Basin have been analyzed for their content of trace elements by the U.S. Geological Survey, and the results have been summarized by the U.S. Department of Agriculture and others (1974) and by Swanson (in Mapel and others, 1977, pt. A, p. 42-44). The rocks contain no greater amounts of trace elements of environmental concern than do similar rocks found throughout other parts of the western United States.

Structure

The King Mountain quadrangle is in the north-central part of the Powder River structural basin. The strata dip regionally southward at an angle of less than 1 degree, but in the King Mountain quadrangle this dip is considerable modified by low-relief folding. Some of the nonuniformity in structure may be caused by differential compaction and to irregularities in deposition of the coals and other lenticular beds as a result of their continental origin.

COAL GEOLOGY

The coal beds in the King Mountain quadrangle are shown in outcrop on the Coal Data Map (pl. 1) and in section on the Coal Data Sheets (pls. 3A and 3B). All of the mapped coal beds occur in the middle and lower parts of the Tongue River Member of the Fort Union Formation (Paleocene). No commercial coals are known to exist below the Tongue River Member.

The lowermost recognized coal bed in the southwestern part of the quadrangle is the Terret coal bed which occurs about 60 to 170 feet (18-52 m) above the base of the Tongue River Member. The lowermost recognized coal bed in the eastern part of the quadrangle is the Broadus coal bed which occurs about 155 feet (47 m) above the base of the Tongue River Member. The Broadus coal bed is overlain successively by a noncoal interval of about 155 to 255 feet (47 to 78 m), the Flowers-Goodale coal bed, a noncoal interval of about 30 to 200 feet (9 to 61 m), the Nance coal bed, a noncoal interval of about 47 to 57 feet (14 to 17 m), the lower split of the Knobloch coal bed, a noncoal interval of 11 to 31 feet (3.4 to 9.5 m), the upper split of the Knobloch coal bed, a noncoal interval of 7 to 31 feet (2.1 to 9.4 m), a local coal bed above the Knobloch coal bed, a mainly noncoal interval of about 30 to 50 feet (9 to 46 m) containing local coal beds, the Lower Sawyer coal bed, a noncoal interval of 20 to 40 feet (6.1 to 12.2 m), the Upper Sawyer coal bed, a mainly noncoal interval of about 50 feet (15 m) containing a local coal bed, the C coal bed, a mainly noncoal interval of about 25 feet (7.6 m) containing a local coal bed, the D coal bed, a mainly noncoal interval of about 55 feet (16.8 m) containing local coal beds, the Cache

(Odell) coal bed, a mainly noncoal interval of about 160 to 280 feet (49 to 85 m) containing local coal beds, the Pawnee (Dunning) coal bed, a mainly noncoal interval of about 50 to 150 feet (15 to 46 m) containing local coal beds, the Wall coal bed, a noncoal interval of about 35 to 40 feet (10.7 to 12.2 m), the lower split of the Cook coal bed, a noncoal interval of about 120 to 180 feet (36.6 to 54.9 m), a mainly noncoal interval of about 75 to 100 feet (23 to 30 m) containing local coal beds, the Dietz coal bed, a noncoal interval of about 140 feet (42.7 m), the Anderson clinker bed.

The trace-element content of coals in this quadrangle has not been determined; however, coals in the Northern Great Plains, including those in the Fort Union Formation in Montana, have been found to contain, in general, appreciably lesser amounts of most elements of environmental concern than coals in other areas of the United States (Hatch and Swanson, 1977, p. 147).

Terret coal bed

The Terret coal bed was first described by Bass (1932, p. 51) from a small coal mine in sec. 16, T. 1 S., R. 45 E. on the Terret Ranch about 16.5 miles (26.5 km) north of the King Mountain quadrangle in the Cook Creek Reservoir quadrangle. The Terret coal bed does not crop out in the King Mountain quadrangle, nor is it recognized in test holes. However, it is projected into the subsurface of the southwestern part of the quadrangle from the Green Creek quadrangle to the west and from the Poker Jim Butte quadrangle to the southwest, where it has been recognized in test holes. In these quadrangles, the Terret coal bed occurs about 60 to 170 feet (18 to 52 m) above the base of the Tongue River Member. However, because of the meager information, the correlation of this coal bed with the Terret at its type locality is uncertain.

The isopach and structure contour map (pl. 39) shows that the Terret coal bed ranges from about 6 to 10 feet (1.8 to 3.0 m) in thickness and dips southward or southwestward at an angle of less than half a degree. Overburden on the Terret coal bed (pl. 40) ranges from about 680 to 1,400 feet (207 to 427 m) in thickness.

There is no known, publicly available chemical analysis of the Terret coal in the King Mountain quadrangle. A chemical analysis of the Terret coal from the Holt mine, sec. 20, T. 3 S., R. 44 E., about 5 miles (8.0 km) northwest of the King Mountain quadrangle in the Ashland quadrangle (Gilmour and Dahl, 1967, p. 18) shows ash 3.9 percent, sulfur 0.4 percent, and a heating value of 9,020 Btu per pound (20,980 kJ/kg) on an as-received basis. This heating value converts to about 9,386 Btu per pound (21,832 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Terret coal at that location is subbituminous C in rank. Because of the proximity of that location to the King Mountain quadrangle, it is assumed that the Terret coal in this quadrangle is similar and is also subbituminous C in rank.

Broadus coal bed

The Broadus coal bed was first described by Warren (1959, p. 570) from exposures of coal near the town of Broadus about 35 miles (56 km) east of the King Mountain quadrangle in the Birney-Broadus coal field. The Broadus coal bed does not crop out in the King Mountain quadrangle, but has been recognized in a test hole in the eastern part of the quadrangle. In this test hole, the Broadus coal bed occurs about 150 feet (46 m) above the base of the Tongue River Member. However, because of the sparse information, the correlation of the coal bed with the Broadus coal bed at its type locality is uncertain.

The isopach and structure contour map (pl. 36) shows that the Broadus coal bed in this quadrangle ranges from about 5 to 10 feet (1.5 to 3 m) in thickness and dips westward at an angle of less than half a degree. Overburden on the Broadus coal bed (pl. 37) ranges from about 420 to 600 feet (128 to 183 m) in thickness. There is no known, publicly available chemical analysis of the Broadus coal in or close to the King Mountain quadrangle. It is assumed that the Broadus coal is similar in rank to other closely associated coals in the King Mountain quadrangle and is subbituminous C in rank.

Flowers-Goodale coal bed

The Flowers-Goodale coal bed was first described by Bass (1932, p. 53) from two small mines about 23 miles (37 km) north of the King Mountain quadrangle in the Brandenberg quadrangle. The Flowers-Goodale coal bed does not crop out in the King Mountain quadrangle but has been penetrated by test holes in the northern part of the quadrangle (pls. 1 and 3). The Flowers-Goodale coal bed occurs about 155 to 255 feet (47 to 78 m) above the Broadus coal bed. The isopach map (pl. 32) shows that the Flowers-Goodale coal bed ranges from about 1 to 22 feet (0.3 to 6.7 m) in thickness. The structure contour map (pl. 33) indicates a southwestward dip of about half a degree or less. Overburden on the Flowers-Goodale coal bed (pl. 34) ranges from about 140 to 1,200 feet (43 to 366 m) in thickness.

There is no known, publicly available chemical analysis of the Flowers-Goodale coal from the King Mountain quadrangle. However, a chemical analysis of this coal from a depth of 53 to 62 feet (16 to 19 m) in coal test hole SH-7076, sec. 14, T. 1 S., R. 45 E., in the Cook Creek Reservoir quadrangle about 17 miles (27 km) north of the King Mountain quadrangle (Matson and Blumer, 1973, p. 121) shows ash 8.144 percent, sulfur 0.961 percent, and heating value 8,102 Btu per pound (18,845 kJ/kg) on an as-received basis. This heating value converts to about 8,820 Btu per pound (20,515 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Flowers-Goodale coal at that location is subbituminous C in rank. Because the King Mountain quadrangle is deeper in the basin, the Flowers-Goodale in this quadrangle would be more compacted and higher in heating value and would be either subbituminous C or subbituminous B in rank.

Knobloch coal bed and its splits, including the Nance coal bed

The Knobloch coal bed was first described by Bass (1924) from exposures of coal along the Tongue River on the Knobloch Ranch in secs. 17 and 18, T. 5 S., R. 43 E. about 10 miles (16 km) west of the King Mountain quadrangle in the Birney Day School quadrangle. In the King Mountain quadrangle, the Knobloch coal bed splits into four coal beds, as shown by the composite columnar section on plate 3A.

The lowermost split of the Knobloch coal bed is the Nance coal bed which splits from the Knobloch coal bed in the northern part of the King Mountain quadrangle, as shown on the isopach and structure contour map of the Nance coal bed (pl. 29). The next higher coal bed is the lower split of the Knobloch coal bed, which splits from the Knobloch in the south-central part of the quadrangle (pl. 26). South of this split line the upper split of the Knobloch coal bed is also present as a separate coal bed (pl. 22). A thin local coal bed splits from the top of the Knobloch coal bed in the central part of the quadrangle (pl. 22). Only in the northernmost part of the quadrangle is the Knobloch coal a single, thick, unsplit coal bed (pl. 22).

Nance coal bed

The Nance coal bed is named for its occurrence at a depth of 242 feet (73.8 m) in the Nance and Hayes M11-2 drill hole, SE¼ SE¼, sec. 25, T. 5 S., R. 42 E., about 11.5 miles (18.5 km) west-southwest of the King Mountain quadrangle in the Browns Mountain quadrangle (Mapel and Martin, 1978, p. 21).

The Nance coal bed does not crop out in the King Mountain quadrangle, but has been penetrated by a member of the test holes (pl. 1). The Nance coal bed occurs about 30 to 200 feet (9 to 61 m) above the Flowers-Goodale coal bed. The isopach and structure contour map (pl. 29) shows that the Nance coal bed ranges from about 5 to 18 feet (1.5 to 5.5 m) in thickness. Regionally this bed is nearly flat but has been folded into a broad, low-relief, westward-plunging anticline across the central part of the quadrangle (pl. 29). Overburden on the Nance coal bed (pl. 30) ranges from about 80 to 1,100 feet (24 to 335 m) in thickness.

There is no known, publicly available chemical analysis of the Nance coal in the King Mountain quadrangle. However, an analysis of the upper, middle, and lower (Nance) benches of the Knobloch coal from a depth of 216 to 218 feet (65.8 to 66.4 m) in coal test hole SH-7055, sec. 6, T. 4 S., R. 45 E., about 0.6 mile (1.0 km) north of the King Mountain quadrangle in the Willow Crossing quadrangle (Matson and Blumer, 1973, p. 64) shows ash 6.381 percent, sulfur 0.154 percent, and heating value 8,558 Btu per pound (19,906 kJ/kg) on an as-received basis. This heating value converts to about 9,141 Btu per pound on a moist, mineral-matter-free basis, indicating that the Nance coal at that location is subbituminous C in rank. Because of the proximity of that location to the King Mountain quadrangle, it is assumed that the Nance coal in the King Mountain quadrangle is similar and is also subbituminous C in rank.

Lower split of the Knobloch coal bed

The lower split of the Knobloch coal bed splits from the Knobloch coal bed along a split line in the south-central part of the King Mountain quadrangle (pl. 26). This lower split of the Knobloch coal bed does not crop out in the King Mountain quadrangle, but has been penetrated by a number of test holes (pl. 1). In these test holes the lower split of the Knobloch coal bed occurs about 47 to 57 feet (14 to 17 m) above the Nance coal bed. The isopach and structure contour map (pl. 26) shows that the lower split of the Knobloch coal bed ranges from about 2 to 8 feet (0.6 to 2.4 m) in thickness and that the regional westward and southward dip of less than half a degree is modified by low-relief folding.

Overburden on the lower split of the Knobloch coal bed (pl. 27) ranges from almost 0 feet to about 300 feet (0-91 m) in thickness. The lower split of the Knobloch coal bed is assumed to be similar in rank to the other closely associated Knobloch coals and to be subbituminous C in rank.

Upper split of the Knobloch coal bed

The upper split of the Knobloch coal bed crops out in the southern part of the King Mountain quadrangle (pl. 1) and has been penetrated by several test holes (pl. 3B). In these test holes, the upper split of the Knobloch coal bed occurs about 11 to 31 feet (3.4 to 9.5 m) above the lower split of the Knobloch (pl. 3B). The isopach map (pl. 22) shows that the upper split of the Knobloch coal bed ranges from about 17.6 to 30 feet (5.4 to 9.1 m) in thickness. The structure contour map (pl. 23) shows that this coal bed, in general, dips westward or southward at an angle of half a degree or less, although this dip is modified by low-relief folding. Overburden on the upper split of the Knobloch coal bed (pl. 24) ranges from 0 feet at the outcrops to about 1,000 feet (0-305 m) in thickness.

A chemical analysis of the upper split of the Knobloch coal bed from a depth of 106 to 116 feet in coal test hole SH-7052, sec. 27, T. 5 S., R. 45 E., in the southern part of the King Mountain quadrangle (Matson and Blumer, 1973, p. 68) shows ash 4.277 percent, sulfur 0.177 percent, and heating value 8,258 Btu per pound (19,208 kJ/kg) on an as-received basis. This heating value converts to about 8,627 Btu per pound (20,066 kJ/kg) on a moist, mineral-matter-free basis, indicating that the upper split of the Knobloch coal in the King Mountain quadrangle is subbituminous C in rank.

Knobloch coal bed

The Knobloch coal bed crops out in a few places in the valley of Otter Creek (pl. 1) in the King Mountain quadrangle. In most places the Knobloch coal has been burned near the land surface forming a thick clinker bed. The Knobloch coal bed is thickest in the northernmost part of the quadrangle where the Nance and other coal beds have not split from it. Here the Knobloch coal bed occurs about 30 to 80 feet (9 to 24.4 m) above the Flowers-Goodale coal bed (pls. 3A and 3B). The isopach map (pl. 22) shows that the Knobloch coal bed in this northernmost part of the quadrangle, in general, ranges from about 50 to 74 feet (15 to 22.6 m) in thickness, although in one test hole in the valley of Otter Creek the coal bed has been partially eroded and reduced to 22 feet (6.7 m) in thickness. South of the line where the Nance coal bed splits from the Knobloch (pl. 22), the Knobloch coal bed in most places ranges from 40 to 48 feet (12 to 14.6 m) in thickness, but in the valley of Otter Creek the thickness of the coal is reduced to 0 because of erosion and to burning of the coal in other places. South of the line where the local bed above the Knobloch coal bed splits from the Knobloch (pl. 22), the Knobloch coal bed ranges from 0 to 44 feet (0-13.4 m) in thickness. The structure contour map (pl. 23) shows that the Knobloch coal bed dips westward in the west-central part of the quadrangle at an angle of less than half a degree, but elsewhere it has been considerably affected by low-relief folding. Overburden on the Knobloch coal bed (pl. 24) ranges from 0 feet to about 1,000 feet (0-305 m) in thickness.

A chemical analysis of the Knobloch coal from a depth of 56 to 77 feet (17 to 23.5 m) in drill hole SS-5, sec. 36, T. 4 S., R. 45 E., about 0.5 miles (0.8 km) east of the King Mountain quadrangle in the Yager Butte quadrangle (Matson and Blumer, 1973, p. 69) shows ash 5.2 percent, sulfur 0.200 percent, and heating value 8,740 Btu per pound (20,329 kJ/kg) on an as-received basis. This heating value converts to about 9,219 Btu per pound (21,443 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Knobloch coal at that location is subbituminous C in rank. Because of the proximity of that location to the King Mountain quadrangle, it is assumed that the Knobloch coal in this quadrangle is similar and is also subbituminous C in rank.

Local coal bed above the Knobloch coal bed

The local coal bed which splits from the upper part of the Knobloch coal bed in the central part of the King Mountain quadrangle crops out only locally (pl. 1), but it has been penetrated by several coal test holes (pls. 2 and 3B). In these test holes the local bed occurs 7 to 31 feet (2.1 to 9.4 m) above the Knobloch coal bed or the upper split of the Knobloch coal bed. The isopach and structure contour map (pl. 19) shows that this local bed ranges from about 2 to 6 feet (0.6 to 1.8 m) in thickness and dips eastward or northward at an angle of half a degree or less, although this dip is somewhat modified by low-relief folding. Overburden on this local coal bed where it is more than 5 feet (1.5 m) thick (pl. 20) ranges from 0 feet at the outcrops to about 400 feet (0-122 m) in thickness. It is assumed that this local bed is similar in rank to the closely associated Knobloch coal bed and is subbituminous C in rank.

Sawyer coal bed

The Sawyer coal bed was first described by Dobbin (1930, p. 28) from exposures of coal in the foothills of the Little Wolf Mountains in the Forsyth coal field (Rough Draw and Black Springs quadrangles), about 35 miles (56 km) northwest of the King Mountain quadrangle. The Sawyer coal bed crops out in the northern part of the King Mountain quadrangle where it occurs about 30 to 150 feet (9 to 46 m) above the Knobloch coal bed. Close to the northern border of the quadrangle, the Sawyer coal bed is split into two beds about 20 to 40 feet

(6.1 to 12.2 m) apart. Because neither coal bed is more than 5 feet (1.5 m) thick, economic coal resources have not been assigned to them.

C and D coal beds

The C and D coal beds, named by Bass (1932, p. 55), are two closely spaced thin coal beds that occur in the northwestern part of the King Mountain quadrangle. The C coal bed is about 50 feet (15 m) above the Sawyer coal bed, and the D coal bed is about 25 feet (7.6 m) above the C coal bed. Because the C and D coal beds are both less than 5 feet (1.5 m) thick, they have not been assigned economic coal resources.

Cache (Odell) coal bed

The Cache coal bed was named by Warren (1959, p. 572) for exposures along Cache Creek about 25 miles (40 km) east-southeast of the King Mountain quadrangle in the Yarger Butte and Lonesome Peak quadrangles. The Odell coal bed was first described by Warren (1959, p. 572), presumably from exposures of coal along O'Dell Creek in the Green Creek quadrangle just west of the King Mountain quadrangle. Warren (1959, pl. 19) also mapped the Odell coal bed in the King Mountain quadrangle. McKay (1976) mapped the Cache coal bed at the same stratigraphic position in the King Mountain quadrangle. Preliminary regional mapping indicates that the Cache and Odell coal beds are equivalent.

The Cache coal bed crops out in the western and northeastern parts of the King Mountain quadrangle. It occurs about 55 feet (16.8 m) above the D coal bed. The isopach and structure contour map (pl. 16) shows that the Cache (Odell) coal bed ranges from about 3.2 to 6 feet (1.0 to 1.8 m) in thickness, and generally dips westward at an angle of half a degree or less, but this dip is modified by low-relief folding. Overburden on the Cache (Odell) coal bed where it is more than 5 feet (1.5 m) thick (pl. 17) ranges from 0 feet at the outcrops to about 500 feet (0-152 m) in thickness.

There is no known, publicly available chemical analysis of the Cache (Odell) coal in, or close to, the King Mountain quadrangle. It is assumed that this coal is similar in rank to other closely associated coals in the King Mountain quadrangle and is subbituminous C in rank.

Pawnee (Dunning) coal bed

The Pawnee coal bed was first described by Warren (1959, p. 572) from outcrops in the Birney-Broadus coal field which includes the King Mountain quadrangle. This coal bed crops out in the western part of the quadrangle and occurs about 160 to 280 feet (49 to 85 m) above the Cache (Odell) coal bed. The isopach and structure contour map (pl. 13) shows that the Pawnee (Dunning) coal bed ranges from about 1.6 to 8 feet (0.5 to 2.4 m) in thickness and generally dips westward or southwestward at an angle of less than half a degree, but this dip is modified by low-relief folding. Overburden on the Pawnee (Dunning) coal bed (pl. 14) ranges from 0 feet at the outcrops to about 500 feet (0-152 m) in thickness.

There is no known, publicly available chemical analysis of the Pawnee (Dunning) coal in, or close to, the King Mountain quadrangle. It is assumed that the Pawnee coal is similar to other closely associated coals in the King Mountain quadrangle and is subbituminous C in rank.

Wall coal bed

The Wall coal bed was first described by Baker (1929, p. 37) from exposures in the northward extension of the Sheridan coal field, probably from outcrops along Wall Creek about 20 miles (32 km) west-southwest of the King Mountain quadrangle in the southwestern part of the Birney quadrangle. The Wall coal bed was mapped by Warren (1959, pl. 19) and by McKay (1976) in the western part of the King Mountain quadrangle. This coal bed occurs about 50 to 150 feet (15 to 46 m) above the Pawnee coal bed. The isopach and structure contour map (pl. 10) shows that the Wall coal bed ranges from 2.1 to 12 feet (0.6 to 3.7 m) in thickness and dips southwesterly at an angle of 1 degree or less, although this dip is modified by low-relief folding. Overburden on the Wall coal bed (pl. 11) ranges from 0 feet at the outcrop to about 500 feet (0-152 m) in thickness.

There is no known, publicly available chemical analysis of the Wall coal in the King Mountain quadrangle. A chemical analysis of the Wall coal (Matson and Blumer, 1973, p. 39) from a depth of 150 to 159 feet (45.7 to 48.5 m) in coal test hole SH-110, sec. 33, T. 5 S., R. 41 E., about 21 miles (34 km) west-southwest of the King Mountain quadrangle in the Birney SW quadrangle shows ash 5.790 percent, sulfur 0.380 percent, and heating value 8,972 Btu per pound (20,869 kJ/kg) on an as-received basis. This heating value converts to about 9,523 Btu per pound (22,150 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Wall coal in that location is subbituminous B in rank but close to subbituminous C in rank. It is assumed that the Wall coal in the King Mountain quadrangle is similar and is subbituminous C in rank.

Lower split of the Cook coal bed

The Cook coal bed was first described by Bass (1932, p. 59-60) from exposures of coal in the Cook Creek Reservoir quadrangle about 10 miles (16 km) north of the King Mountain quadrangle. Preliminary regional mapping indicates that the Cook coal bed in places splits into two coal beds, and that this bed in the King Mountain quadrangle correlates with the lower split of the Cook coal bed. This coal bed does not crop out in the King Mountain quadrangle, but it has been projected into the subsurface of the quadrangle from the quadrangles to the west and south. It occurs about 35 to 40 feet (10.7 to 12.2 m) above the Wall coal bed. The isopach and structure contour map (pl. 7) shows that the lower split of the Cook coal bed ranges from about 5 to 9 feet (1.5 to 2.7 m) in thickness and dips southwestward at an angle of less than half a degree. Overburden on this coal bed (pl. 8) ranges from 0 feet at the outcrops to about 400 feet (0-122 m) in thickness.

There is no known, publicly available chemical analysis of coal of the lower Cook split in, or close to, the King Mountain quadrangle. It is assumed that the lower split of the Cook coal is similar to other closely associated coals in this quadrangle and is subbituminous C in rank.

Canyon coal bed

The Canyon coal bed was first described by Baker (1929, p. 36) from exposures in the northward extension of the Sheridan coal field. Although a type locality was not given, it may be along Canyon Creek in northern Spring Gulch quadrangle, about 24 miles (39 km) southwest of the King Mountain quadrangle. Warren (1959, pl. 19) and McKay (1976) mapped the Canyon coal bed in the western part of the King Mountain quadrangle. The Canyon coal bed occurs about 120 to 180 feet (36.6 to 54.9 m) above the lower split of the Cook coal bed. The isopach and structure contour map (pl. 4) shows that the Canyon coal bed ranges from 2 to 5.5 feet (0.6 to 1.7 m) in thickness and dips eastward at an angle of less than half a degree, although this dip is somewhat modified by low-relief folding. Overburden on the Canyon coal bed (pl. 5) ranges from 0 feet at the outcrops to about 300 feet (0-91 m) in thickness.

There is no known, publicly available chemical analysis of the Canyon coal in the King Mountain quadrangle. A chemical analysis of the Canyon coal (Matson and Blumer, 1973, p. 47) from a depth of 43 to 53 feet (13.1 to 16.2 m) in coal test hole SH-7038, sec. 9, T. 7 S., R. 44 E., about 12.5 miles (19 km) south-southwest of the King Mountain quadrangle in the Hamilton Draw quadrangle shows ash 3.761 percent, sulfur 0.165 percent, and heating value 8,801 Btu per pound (20,471 kJ/kg) on an as-received basis. This heating value converts to about

9,145 Btu per pound (21,271 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Canyon coal at that location is subbituminous C in rank. Because of the proximity of that location to the King Mountain quadrangle, it is assumed that the Canyon coal in this quadrangle is similar and is also subbituminous C in rank.

Dietz coal bed

The Dietz coal bed was named by Taff (1909, p. 139-140) from exposures of coal about 50 miles (80 km) southwest of the King Mountain quadrangle near the old coal-mining town of Dietz in the Sheridan coal field, Wyoming. McKay (1976) mapped the Dietz coal bed in the King Mountain quadrangle. The Dietz coal bed occurs about 75 to 100 feet (23 to 30 m) above the Canyon coal bed. The Dietz coal bed is less than 5 feet (1.5 m) thick in the King Mountain quadrangle, and consequently, economic coal resources have not been assigned to it.

Anderson clinker bed

A thick clinker bed formed by the burning of the Anderson coal bed caps the highest hills in the western part of the King Mountain quadrangle about 140 feet (42.7 m) above the Dietz coal bed. The Anderson coal has been entirely burned.

Local coal beds

Local coal beds occur in the King Mountain quadrangle above the following coal beds: the Knobloch, Upper Sawyer, C, D, Cache (Odell), Pawnee, and Canyon coal beds. These local coal beds are thin and of limited known areal extent. Except for the local coal bed that splits from the upper part of the Knobloch coal bed, these local coal beds have not been assigned economic coal resources.

COAL RESOURCES

Data from all publicly available drill holes and from surface mapping by others (see list of references) were used to construct outcrop, isopach, and structure contour maps of the coal beds in this quadrangle.

A coal resource classification system has been established by the U.S. Bureau of Mines and the U.S. Geological Survey and published in U.S. Geological Survey Bulletin 1450-B (1976). Coal resource is the estimated gross quantity of coal in the ground that is now economically extractable or that may become so. Resources are classified as either Identified or Undiscovered. Identified Resources are specific bodies of coal whose location, rank, quality, and quantity are known from geologic evidence supported by specific measurements. Undiscovered Resources are bodies of coal which are surmised to exist on the basis of broad geologic knowledge and theory.

Identified Resources are further subdivided into three categories of reliability of occurrence: namely Measured, Indicated, and Inferred, according to their distance from a known point of coal-bed measurement. Measured coal is coal located within 0.25 mile (0.4 km) of a measurement point, Indicated coal extends 0.5 mile (0.8 km) beyond Measured coal to a distance of 0.75 mile (1.2 km) from the measurement point, and Inferred coal extends 2.25 miles (3.6 km) beyond Indicated coal to a distance of 3 miles (4.8 km) from the measurement point.

Undiscovered Resources are classified as either Hypothetical or Speculative. Hypothetical Resources are those undiscovered coal resources in beds that may reasonably be expected to exist in known coal fields under known geologic conditions. In general, Hypothetical Resources are located in broad areas of coal fields where the coal bed has not been observed and the evidence of coal's existence is from distant outcrops, drill holes, or wells that are more than 3 miles (4.8 km) away. Hypothetical Resources are located beyond the outer boundary of the Inferred part of Identified Resources in areas where the assumption of continuity of the coal bed is supported only by extrapolation of geologic evidence. Speculative Resources are undiscovered resources that may occur in favorable areas where no discoveries have been made. Speculative Resources have not been estimated in this report.

For purposes of this report, Hypothetical Resources of subbituminous coal are in coal beds which are 5 feet (1.5 m) or more thick, under less than 3,000 feet (914 m) of overburden, but occur 3 miles (4.8 km) or more from a coal-bed measurement.

Reserve Base coal is that economically minable part of Identified Resources from which Reserves are calculated. In this report, Reserve Base coal is the gross amount of Identified Resources that occurs in beds 5 feet (1.5 m) or more thick and under less than 3,000 feet (914 m) of overburden for subbituminous coal.

Reserve Base coal may be either surface-minable coal or underground-minable coal. In this report, surface-minable Reserve Base coal is subbituminous coal that is under less than 500 feet (152 m) of overburden. In this report, underground-minable Reserve Base coal is subbituminous coal that is under more than 500 feet (152 m), but less than 3,000 feet (914 m) of overburden.

Reserves are the recoverable part of Reserve Base coal. In this area, 85 percent of the surface-minable Reserve Base coal is considered to be recoverable (a recovery factor of 85 percent). Thus, these Reserves amount to 85 percent of the surface-minable Reserve Base coal. For economic reasons coal is not presently being mined by underground methods in the Northern Powder River Basin. Therefore, the underground-mining recovery factor is unknown and Reserves have not been calculated for the underground-minable Reserve Base coal.

Tonnages of coal resources were estimated using coal-bed thicknesses obtained from the coal isopach map for each coal bed (see list of illustrations). The coal resources, in short tons, for each isopached coal bed are the product of the acreage of coal (measured by planimeter), the average thickness in feet of the coal bed, and a conversion factor of 1,770 short tons of subbituminous coal per acre-foot (13,018 metric tons per hectare-meter). Tonnages of coal in Reserve Base, Reserves, and Hypothetical categories, rounded to the nearest one-hundredth of a million short tons, for each coal bed are shown on the Areal Distribution and Tonnage maps (see list of illustrations).

As shown by table 1, the total tonnage of federally owned, surface-minable Reserve Base coal in this quadrangle is estimated to be 1,386.71 million short tons (1,258.02 million t). The total tonnage of federally owned, surface-minable Hypothetical coal is estimated to be 23.38 million short tons (21.21 million t). As shown by table 2, the total federally owned, underground-minable Reserve Base coal is estimated to be 691.82 million short tons (627.62 million t). The total federally owned, underground-minable Hypothetical coal is estimated to be 180.13 million short tons (163.41 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 2,078.53 million short tons (1,885.64 million t), and the total of surface- and underground-minable Hypothetical coal is 203.51 million short tons (184.62 million t).

About 11 percent of the surface-minable Reserve Base tonnage is classed as Measured, 32 percent as Indicated, and 57 percent as Inferred. All of the underground-minable Reserve Base tonnage is Inferred.

The total tonnages per section for both Reserve Base and Hypothetical coal, including both surface- and underground-minable coal are shown in the northwest corner of the Federal coal lands in each section on plate 2. All numbers on plate 2 are rounded to the nearest one-hundredth of a million short tons.

COAL DEVELOPMENT POTENTIAL

There is a potential for surface-mining in the Northern Powder River Basin in areas where subbituminous coal beds 5 feet (1.5 m) or more thick are overlain by less than 500 feet (152 m) of overburden (the stripping limit). This thickness of overburden is the assigned stripping limit for surface mining of multiple beds of subbituminous coal in this area. Areas having a potential for surface mining were assigned a high, moderate, or low development potential based on their mining-ratio values (cubic yards of overburden per short ton of recoverable coal).

The formula used to calculate mining-ratio values for subbituminous coal is:

$$MR = \frac{t_o \, (cf)}{t_c \, (rf)}$$

where MR = mining ratio

t_o = thickness of overburden, in feet

t_c = thickness of coal, in feet

rf = recovery factor = 0.85 in this area

cf = conversion factor = 0.911 cu. yds./short ton for subbituminous coal

The mining-ratio values are used to rate the degree of potential that areas within the stripping limit have for surface-mining development. Areas having mining-ratio values of 0 to 10, 10 to 15, and greater than 15 are considered to have <u>high</u>, <u>moderate</u>, and <u>low development potential</u>, respectively. This grouping of mining-ratio values was provided by the U.S. Geological Survey and is based on economic and technological criteria. Mining-ratio contours and the stripping-limit overburden isopach, which serve as boundaries for the development-potential areas, are shown on the overburden isopach and mining-ratio contour plates. Estimated tonnages of surface-minable Reserve Base and Hypothetical coal resources in each development-potential category (high, moderate, and low) are shown in table 1.

Estimated tonnages of underground-minable coal resources are shown in table 2. Because coal is not presently being mined by underground mining in the

Northern Powder River Basin for economic reasons, for purposes of this report all of the underground-minable coal resources are considered to have low development potential.

Development potential for surface-mining methods

The Coal Development Potential (CDP) map included in this series of maps pertains only to surface mining. It depicts the highest coal development-potential category which occurs within each smallest legal subdivision of land (normally about 40 acres or 16.2 ha). For example, if such a 40-acre (16.2-ha) tract of land contains areas of high, moderate, and low development potential, the entire tract is assigned to the high development-potential category for CDP mapping purposes. Alternatively, if such a 40-acre (16.2-ha) tract of land contains areas of moderate, low, and no development potential, the entire tract is assigned to the moderate development-potential category for CDP mapping purposes. For practical reasons, the development-potential categories of areas of coal smaller than 1 acre (0.4 ha) have been disregarded in assigning a development potential to the entire 40-acre (16.2-ha) tract.

In areas of moderate or high topographic relief, the area of moderate development potential for surface mining of a coal bed (area having mining-ratio values of 10 to 15) is often restricted to a narrow band between the high and low development-potential areas. In fact, because of the 40-acre (16.2-ha) minimum size of coal development-potential tracts, the narrow band of moderate development-potential area often does not appear on the CDP map because it falls within the 40-acre (16.2-ha) tracts that also include areas of high development potential. The Coal Development Potential (CDP) map then shows areas of high development potential abutting against areas of low development potential.

The coal development potential for surface-mining methods in the Federal coal lands is shown on the Coal Development Potential map (pl. 42). Most of the Federal lands have a high development potential for surface mining.

The Canyon coal bed (pl. 5) has narrow bands of high development potential for surface mining (mining-ratio values less than 10) and narrow bands of moderate development potential (mining-ratio values 10-15) near the top of the highland in the west-central part of the quadrangle. There is a quite large area of low development potential extending from the 15 mining-ratio contour to the crest of the highland.

The lower split of the Cook coal bed (pl. 8) has narrow bands of high development potential for surface mining (mining-ratio values less than 10) and even narrower bands of moderate development potential (mining-ratio values 10-15) on high slopes in the southwestern part of the quadrangle. Wider areas of low development potential extend from the 15 mining-ratio contour to the crests of the hills.

The Wall coal bed (pl. 11) has narrow bands of high development potential (mining-ratio values less than 10), and even narrow bands of moderate development potential (mining-ratio values 10-15) on hill slopes in the western part of the quadrangle. There are wider areas of low development potential for surface mining extending from the 15 mining-ratio contour to the crests of the hills.

The Pawnee (Dunning) coal bed (pl. 14) has narrow bands of high development potential for surface mining (mining-ratio values less than 10) and narrow bands of moderate development potential (mining-ratio values 10-15) on hill slopes in the northwestern part of the quadrangle. There are wider areas of low development potential for surface mining extending from the 15 mining-ratio contour to the crests of the hills or to the 500-foot (152 m) overburden isopach (the stripping limit).

The Cache (Odell) coal bed (pl. 17) has narrow to fairly wide areas of high development potential for surface mining (mining-ratio values less than 10) on hill slopes in the northeastern, southwestern, and west-central parts of the quadrangle. There are adjacent, narrow bands of moderate development potential (mining-ratio values 10-15). Quite wide areas of low development potential for surface mining extend from the 15 mining-ratio contour to the crests of the hills or to the 500-foot (152 m) overburden isopach (the stripping limit).

The local coal bed above the Knobloch coal bed (pl. 20) has a limited area of development potential for surface mining in the central part of the quadrangle. There are small areas of high development potential (mining-ratio values less than 10) and of moderate development potential (mining-ratio values 10-15). Most of the area is of low development potential for surface mining (mining-ratio values greater than 15).

The Knobloch coal bed and the upper split of the Knobloch coal bed (pl. 24) have a wide area of high development potential for surface mining (mining-ratio values less than 10) in the valley of Otter Creek and on the lower hill slopes. There are narrow to quite wide areas of moderate development potential between the 10 mining-ratio contour and the 500-foot (152 m) overburden isopach (the stripping limit). In the southwestern part of the quadrangle, there is a fairly wide band of low development potential for surface mining extending from the 15 mining-ratio contour to the 500-foot (152 m) overburden isopach (the stripping limit). The Knobloch coal under the highland in the western part of the quadrangle has no potential for surface mining, as it is beyond the assigned stripping limit of 500 feet (152 m) of overburden.

The lower split of the Knobloch coal bed (pl. 27) has two small areas of development potential for surface mining in the east-central part of the quadrangle. There are small areas of high development potential (mining-ratio values less than 10), and very narrow bands of moderate development potential (mining-ratio values 10-15). Most of the coal is of low development potential (mining-ratio values greater than 15).

The Nance coal bed (pl. 30) has a wide area of high development potential for surface mining (mining-ratio values less than 10) in the eastern part of the King Mountain quadrangle. Most of this area of high development potential is under the flood plain of Otter Creek. Only a minor part of it is on the adjacent hill slopes. There are narrow to quite wide bands of moderate development potential (mining-ratio values 10-15) on the low hill slopes. There are wide areas of low development potential for surface mining extending from the 15 mining-ratio contour to the 500-foot (152 m) overburden isopach (the stripping limit). The Nance coal bed in the westernmost part of the quadrangle has no potential for surface mining, as it is beyond the assigned stripping limit of 500 feet (152 m) of overburden.

The Flowers-Goodale coal bed (pl. 34) has no areas of high or moderate development potential for surface mining, as all of this coal has mining-ratio values greater than 15. There is a wide area of low development potential for surface mining extending from the boundary of the coal to the 500-foot (152-m) overburden isopach (the stripping limit). The Flowers-Goodale coal bed in the westernmost part of the King Mountain quadragle has no development potential for surface mining, as it is beyond the assigned stripping limit of 500 feet (152 m) of overburden.

The Broadus coal bed (pl. 37) has no areas of high or moderate development potential for surface mining, as all of the Broadus coal has mining-ratio values greater than 15. There is a wide area of low development potential for surface mining under the flood plain of Otter Creek in the eastern part of the quadrangle extending from the boundary of the coal to the 500-foot (152-m) overburden isopach (the stripping limit). Most of the Broadus coal has no development potential for surface mining because it is beyond the assigned stripping limit of 500 feet (152 m) of overburden.

The Terret coal bed (pl. 40) has no development potential for surface mining in the King Mountain quadrangle because all of the Terret coal is beyond the assigned stripping limit of 500 feet (152 m) of overburden.

About 82 percent of the Federal coal lands in the King Mountain quadrangle has a high development potential for surface mining, 7 percent has a moderate development potential, and 11 percent has a low development potential for surface mining.

Development potential for underground mining and in-situ gasification

Subbituminous coal beds 5 feet (1.5 m) or more in thickness lying more than 500 feet (152 m) but less than 3,000 feet (914 m) below the surface are considered to have development potential for underground mining. Estimates of the tonnage of underground-minable coal are listed in table 2 by development-potential category for each coal bed. Coal is not currently being mined by underground methods in the Northern Powder River Basin because of poor economics. Therefore, the coal development potential for underground mining of these resources for purposes of this report is rated as low, and a Coal Development Potential map for underground mining was not made.

In-situ gasification of coal on a commercial scale has not been done in the United States. Therefore, the development potential for in-situ gasification of coal found below the surface-mining limit in this area is rated as low, and a Coal Development Potential map for in-situ gasification of coal was not made.

Table 1.--Surface-minable coal resource tonnage (in short tons) by development-potential category for Federal coal lands in the King Mountain quadrangle, Powder River and Rosebud Counties, Montana

[Development potentials are based on mining ratios (cubic yards of overburden/short ton of recoverable coal). To convert short tons to metric tons, multiply by 0.9072]

Coal bed	High development potential (0-10 mining ratio)	Moderate development potential (10-15 mining ratio)	Low development potential (>15 mining ratio)	Total
Reserve Base tonnage				
Canyon	1,230,000	860,000	8,370,000	10,460,000
Lower Cook	3,990,000	2,690,000	13,590,000	20,270,000
Wall	14,260,000	6,800,000	36,650,000	57,710,000
Pawnee (Dunning)	3,510,000	2,790,000	21,890,000	28,190,000
Cache (Odell)	11,910,000	4,770,000	20,700,000	37,380,000
Local above Knobloch	610,000	930,000	12,580,000	14,120,000
Upper Knobloch	739,990,000	134,420,000	60,580,000	934,990,000
Lower Knobloch	1,600,000	1,390,000	1,710,000	4,700,000
Nance	17,800,000	30,500,000	127,210,000	175,510,000
Flowers-Goodale	0	0	101,890,000	101,890,000
Broadus	0	0	1,490,000	1,490,000
Total	794,900,000	185,150,000	406,660,000	1,386,710,000
Hypothetical Resource tonnage				
Nance	0	0	1,630,000	1,630,000
Flowers-Goodale	0	0	16,930,000	16,930,000
Broadus	0	0	4,820,000	4,820,000
Total	0	0	23,380,000	23,380,000
Grand Total	794,900,000	185,150,000	430,040,000	1,410,090,000

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the King Mountain quadrangle, Powder River and Rosebud Counties, Montana

[To convert short tons to metric tons, multiply by 0.9072]

Coal bed	High Development potential	Moderate development potential	Low development potential	Total
Reserve Base tonnage				
Wall	0	0	80,000	80,000
Pawnee (Dunning)	0	0	630,000	630,000
Cache (Odell)	0	0	230,000	230,000
Upper Knobloch	0	0	438,490,000	438,490,000
Nance	0	0	85,820,000	85,820,000
Flowers-Goodale	0	0	121,470,000	121,470,000
Broadus	0	0	2,970,000	2,970,000
Terret	0	0	42,130,000	42,130,000
Total	0	0	691,820,000	691,820,000
Hypothetical Resource tonnage				
Upper Knobloch	0	0	590,000	590,000
Nance	0	0	14,780,000	14,780,000
Flowers-Goodale	0	0	131,530,000	131,530,000
Broadus	0	0	10,410,000	10,410,000
Terret	0	0	22,820,000	22,820,000
Total	0	0	180,013,000	180,130,000
Grand Total	0	0	871,950,000	871,950,000

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