IC 8660

Bureau of Mines Information Circular/1974

Mineral Resources of the Black Hills Area, South Dakota and Wyoming

UNITED STATES DEPARTMENT OF THE INTERIOR

Information Circular 8660

Mineral Resources of the Black Hills Area, South Dakota and Wyoming

By John Paul Gries
Intermountain Field Operation Center–Mineral Supply, Denver, Colo.

UNITED STATES DEPARTMENT OF THE INTERIOR
Rogers C. B. Morton, Secretary

Jack W. Carlson, Assistant Secretary–Energy and Minerals

BUREAU OF MINES
Thomas V. Falkie, Director

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

This publication has been cataloged as follows:

Gries, John Paul

Mineral resources of the Black Hills area, South Dakota and Wyoming. [Washington] U.S. Bureau of Mines [1974]

61 p. illus., tables. (U.S. Bureau of Mines. Information circular 8660)

Includes bibliography.

1. Mines and mineral resources—South Dakota—Black Hills area. 2. Mines and mineral resources—Wyoming—Black Hills area. I. U.S. Bureau of Mines. II. Title. (Series)

TN23.U71 no. 8660 622.06173

U.S. Dept. of the Int. Library

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FOREWORD

A report entitled "Black Hills Area Resources Study," prepared jointly by the Departments of Agriculture and Interior, was published in February 1967. The publication presented the findings of an intensive investigation of resource development opportunities in the Black Hills area of South Dakota and Wyoming.

Participants in the study included representatives of 10 agencies within the Department of the Interior, 6 services of the Department of Agriculture, and numerous components of State government in South Dakota and Wyoming.

Space considerations for the final report necessitated drastic abridgments in the contributions of the several participants, including those on mineral resources by the Interior Department's Bureau of Mines.

Dr. John Paul Gries, professor of Geological Engineering and dean of the Graduate Division, South Dakota School of Mines and Technology, at Rapid City, represented the Bureau of Mines on a special task force that drafted the 1967 report. Since then, shortages of energy fuels and other mineral commodities have become more acute, and it now is evident to all that discovery and development of domestic mineral resources are not keeping up with demand.

Thus, Dr. Gries was asked to update and expand his original manuscript on the mineral resource capabilities and their development potentials in the Black Hills area. His timely and authoritative report is published herewith in its entirety.

Thomas V. Falkie

Director

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MINERAL RESOURCES OF THE BLACK HILLS AREA, SOUTH DAKOTA AND WYOMING

by

John Paul Gries[1]

ABSTRACT

This Bureau of Mines report reviews the mineral industry of the Black Hills area, including Butte, Custer, Fall River, Lawrence, Meade, and Pennington Counties, S. Dak.; and Crook, Niobrara, and Weston Counties, Wyo. It includes discussion of geological occurrence, processing, and potential of 27 commodities that have been produced from the nine-county area.

The value of mineral production exceeds $70 million annually. Gold and petroleum account for two-thirds of the total, followed by clays, cement, sand and gravel, and rock.

The combined mineral industries annually consume 268 million kilowatts of electrical energy, 933 million Mcf of gas, and 2 million barrels of fuel oil. Water consumption is about 10,000 gallons per minute. About 2,700 persons are employed on a year-round or significant part-time basis.

INTRODUCTION

Historical Sketch

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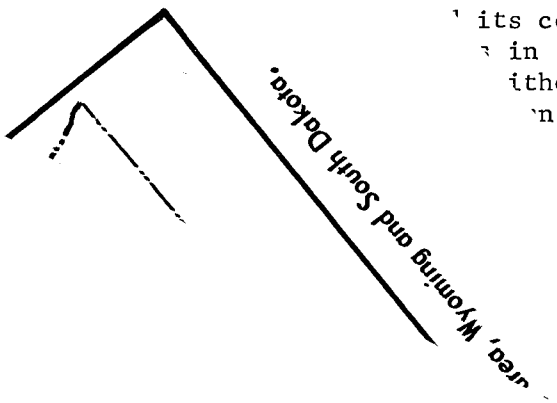

ls area (fig. 1) had its inception with the gold started soon afterward. In the early 1880's, Hills until litigation (1883) and a drop in its collapse. A tin boom developed in the in 1884-94, but the bubble burst when it ither so rich nor so abundant as at first n in the Cambria area north of Newcastle al petroleum industry had its start in eps and shallow wells in the Moor- nes of the northern Black Hills.

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[1] of the Graduate Division, South City, S. Dak. Consultant to

n the list of references

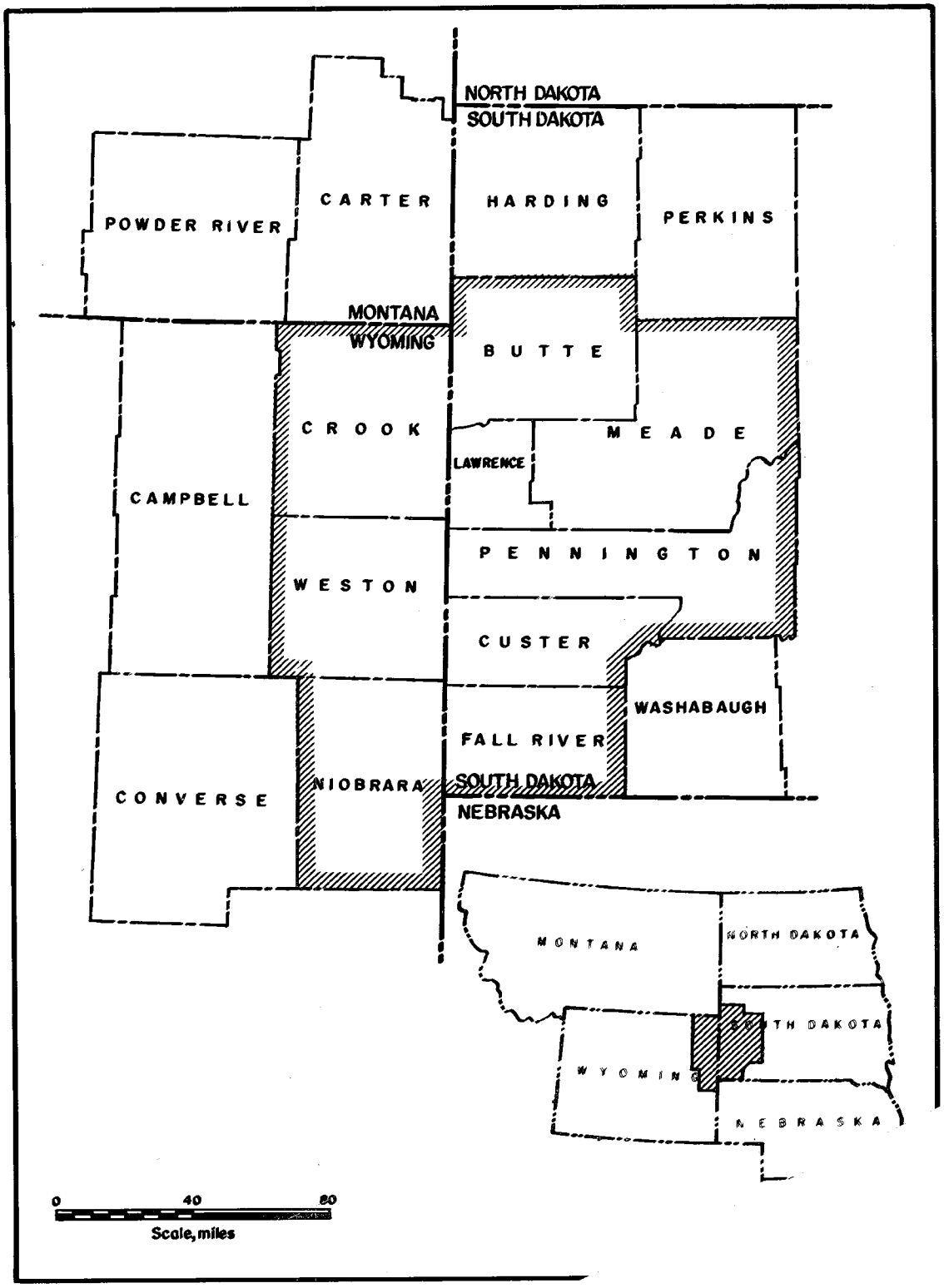

FIGURE 1. - Index map of nine-county

World War I stimulated the development of scattered tungsten deposits in the northern Hills and gave added impetus to the mining of sheet mica for the rapidly growing electrical industry. Bulky nonmetallics came into their own in the decade after the war, with rapid development of the feldspar and bentonite industries. Discovery of commercial oil accumulations at Mule Creek in Niobrara County and Osage in Weston County, Wyo., in 1919, marked the first real impact of that industry upon the local economy.

A major discovery of oil along Mush Creek in Weston County, Wyo., in 1944, started a period of exploration and development south and west from Newcastle and Osage that lasted for several years. It was followed by a deeper play which has worked its way north and west and now is centered in Campbell County, Wyo.

A new mining boom followed the discovery of uranium ores in the Cretaceous sandstones in 1951 and the completion of a processing plant at Edgemont in 1955. The present depressed price for uranium has brought both mining and milling to a virtual standstill in the Edgemont area.

Construction of major dams on the Missouri River, the interstate highway system, and the numerous defense installations in North and South Dakota and eastern Montana and Wyoming has greatly stimulated the production of sand and gravel, rock, and cement from the Black Hills area. With the completion of these projects, demand for such commodities may be expected to level off.

It is too early to predict whether the great increase in the price of gold will stimulate gold mining in the Black Hills.

Geology

Topography

The present Black Hills are the result of differential erosion of a large domal uplift formed at the same time as the rest of the Rocky Mountain System during Laramide time. The outline of the uplift is bean-shaped (fig. 2), with the western margin somewhat concave in the vicinity of Newcastle, Wyo. The main uplift, as outlined by hogbacks of Cretaceous sandstone, is about 120 miles long, and the long axis is oriented slightly west of north. The greatest east-west dimension is about 60 miles. Erosion has removed up to 7,500 feet of Mesozoic and Paleozoic sediments, and cut deeply into the Precambrian core. Topographic relief, from the plains on the east to the top of Harney Peak, is about 4,000 feet.

Precambrian Rocks

The Precambrian rocks are principally metasediments, strongly folded, and intruded by granitic masses such as those which now form Harney Peak and Mount Rushmore. The metasediments were originally shales, with lesser quantities of sandstone, carbonates, and cherts. Interspersed with the sediments are minor masses of amphibolite, which were originally dikes and sills of gabbro or diabase, massive basic flows, and pyroclastics.

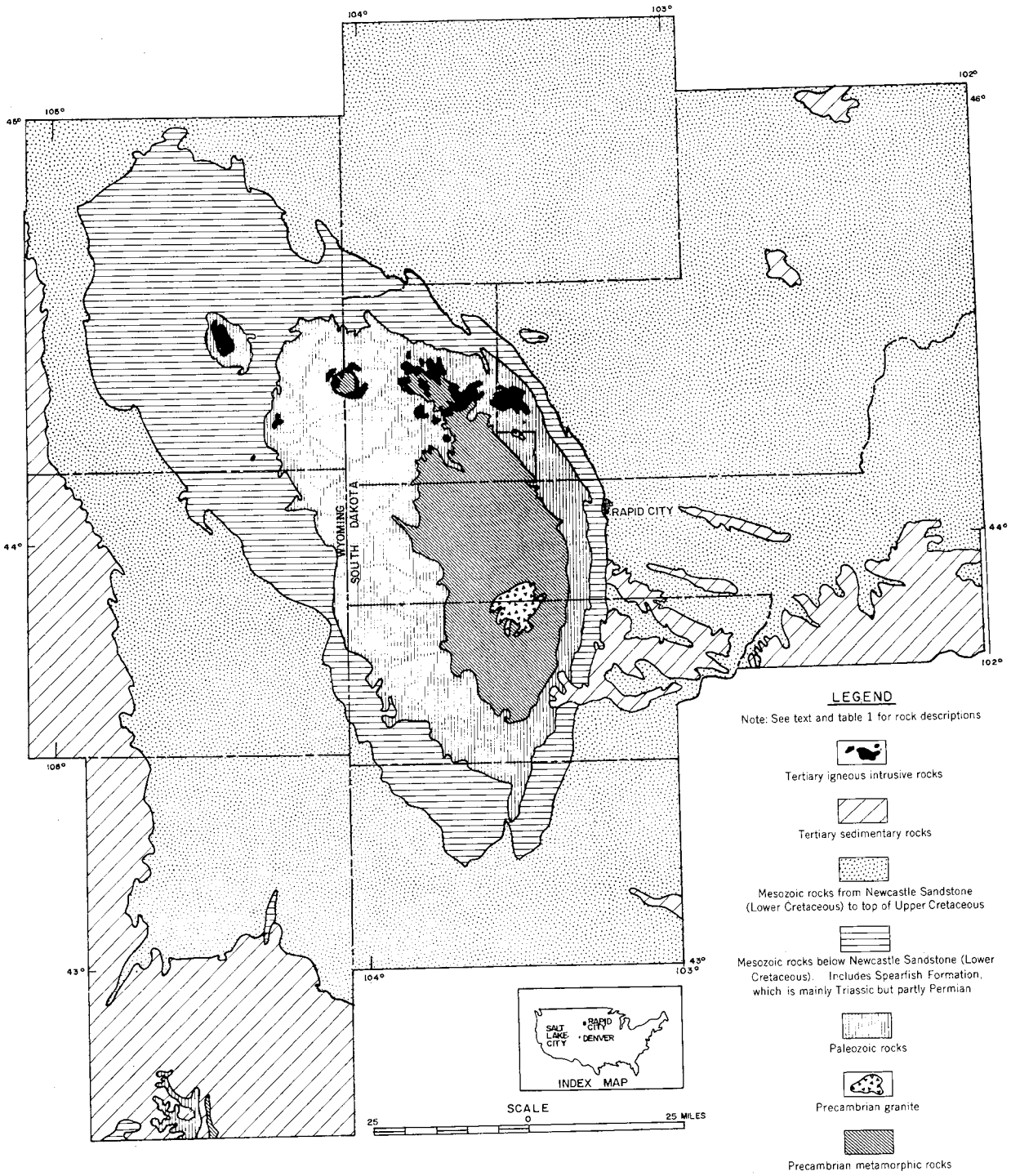

FIGURE 2. - Generalized geologic map of the Black Hills area.

In the northern Hills, detailed mapping has resulted in identification of five major stratigraphic units with a maximum thickness of 50,000 feet (22). In the southern Hills, a similar sequence, totaling 14,000 or more feet, also has been divided into five formations (27, p. 347). Correlation between northern and southern areas is complicated by great variations in thickness, and by different grades of metamorphism to which the rocks have been subjected. Until detailed mapping has been extended from one area to the other, correlations will remain uncertain. In both the northern and southern areas, mineralization in the Precambrian is usually associated with thin rock units which were originally rich in iron carbonates.

The metamorphic rocks in the central and southern Hills have been intruded by large sheets or sills of granite originally identified as the Harney Peak batholith. These large granitic masses are surrounded by a halo of many thousands of small granitic pegmatites. A very small percentage of the latter are zoned pegmatites (43, p. 10), which are the source of mica feldspar, lithia minerals, beryl, columbite-tantalite, and other minerals.

Paleozoic and Mesozoic Rocks

The sedimentary section is remarkably well represented (fig. 3). Because the site of the present Black Hills lay near the eastern shoreline of the great Paleozoic and Mesozoic seaway of the Rocky Mountain area, the individual strata are generally much thinner than their western counterparts, and in many instances, represent somewhat shorter periods of deposition.

Deadwood Formation

The Deadwood sequence consists of sandstone, greenish-gray shale, and carbonates. Limestone intraformational conglomerates are conspicuous in the middle part of the section, and glauconite is an abundant accessory mineral. The Deadwood represents near-shore deposition by a regressing sea which covered the area in Upper Cambrian and very early Ordovician time. The thickness ranges from as little as 5 feet in some exposures near Wind Cave to about 400 feet in the vicinity of Deadwood.

In the northern Hills, a thin carbonate zone just above the basal quartzite and conglomerate was called the "lower contact" by early day miners, and the term has continued in use. A similar carbonate a few feet below the Scolithus Sandstone at the top of the Deadwood is called the "upper contact." Ore-bearing solutions, rising along vertical fractures, locally replaced these carbonates, resulting in the formation of the gold, silver, lead, zinc, and tungsten deposits of the northern Black Hills. Bodies of coarse, clean sandstone, considered to be beach and bar deposits, have been mined for silica sand in the southern Hills, and are a modestly good aquifer downdip from the outcrops.

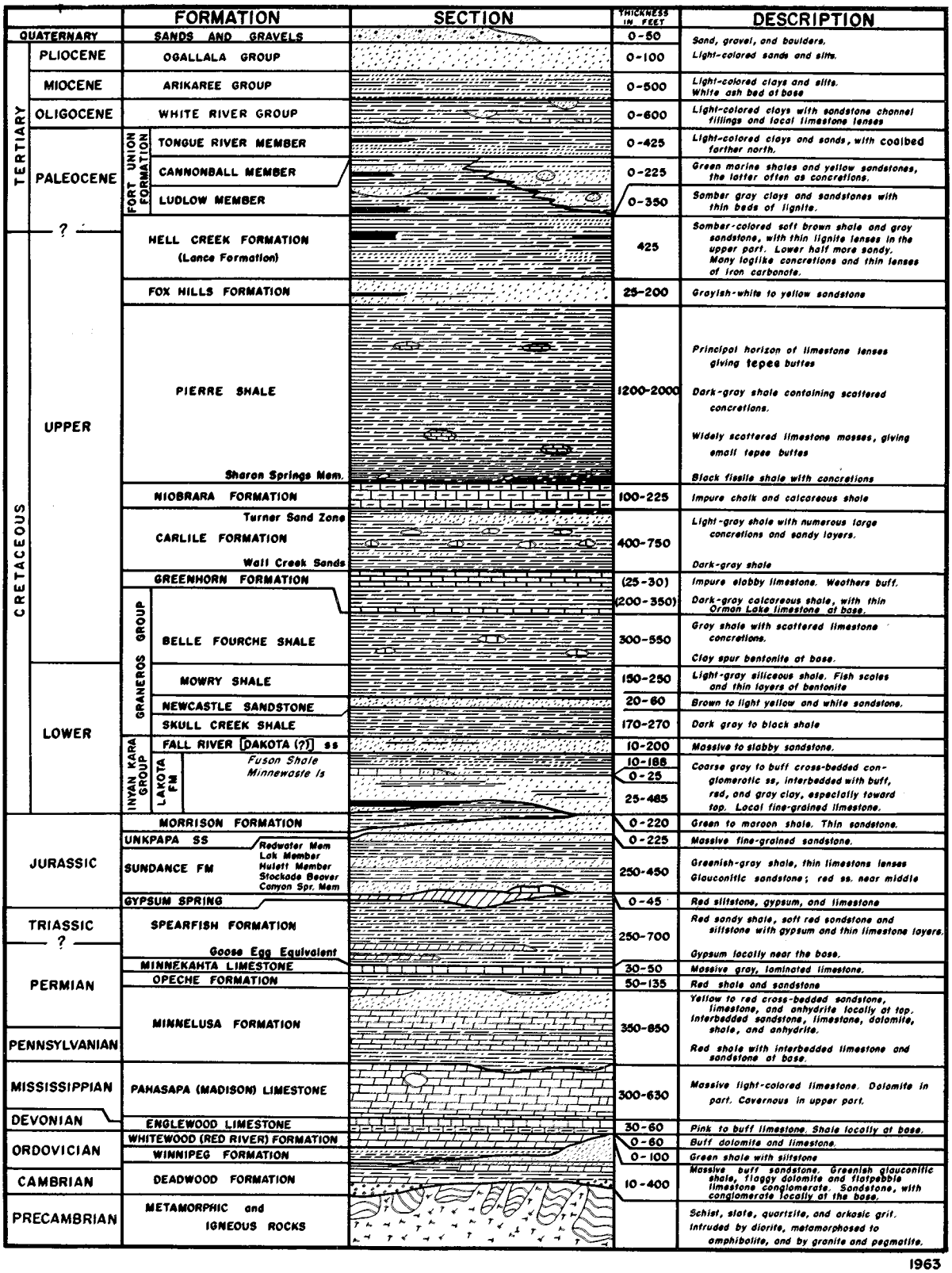

FIGURE 3. - General outcrop section of the Black Hills area. *(Courtesy, South Dakota School of Mines and Technology.)*

Winnipeg Formation

Ice Box Shale Member

Forty to sixty feet of fissile green shale overlying the Scolithus Sandstone formerly was included in the Deadwood, but was separated from it when fossils indicated a middle Ordovician age. It is present only in the northern third of the Hills, and is missing to the south either because of nondeposition or by pre-Mississippian erosion. The Ice Box is correlated with the Winnipeg Shale of the Williston Basin.

Roughlock Siltstone Member

Lying with very slight unconformity upon the Ice Box Member, and grading upward into the overlying Whitewood Dolomite, is 40 to 80 feet of clastic material which ranges laterally from a silty clay to a siltstone, and even to a clean white sandstone. It is a moot point whether the Roughlock should be considered a member of the Winnipeg Formation, or merely an introductory phase of Whitewood deposition.

Whitewood Dolomite

The Whitewood Dolomite, which crops out only in the northern Hills, represents the southeastern edge of a widespread blanket of Upper Ordovician dolomite known as the Bighorn Formation in Wyoming and Montana and the Red River Formation in the Williston Basin. It reaches a maximum thickness of 80 feet in the vicinity of Deadwood and Spearfish Canyon. Early settlers used the rock as a building stone and burned it for lime. It may be a potential source of commercial dolomite. Porous zones within the upper part of the formation yield commercial oil in Harding County, S. Dak. Encouraging, but thus far noncommercial, shows of gold are reported in the Carbonate area, Lawrence County (31, p. 100).

Englewood Formation

The Englewood is a red to lavender, argillaceous dolomite, ranging in thickness from 40 to 70 feet. Where the formation is thickest, as below the town of Deadwood, the basal 20 to 30 feet are gray to slightly purple shale. Fossils indicate that its age straddles the Devonian-Mississippian boundary. It rests on the Whitewood Dolomite in the northern Hills, and directly upon the Deadwood Formation in the southern Hills. The formation grades upward without discernible break into the overlying Pahasapa Dolomite.

Pahasapa Formation

Pahasapa is the local name for the Black Hills outcrops of the widespread Madison Carbonate of the northern Rocky Mountain-Great Plains area. The unit thins from 600 feet in Spearfish Canyon to less than 300 feet in some of the southern Hills outcrops, and it is entirely missing in drill holes a short distance southeast of the Hills.

It is mined for various rock products and is a potential source of both limestone and dolomite (45, p. 99). The dolomitic zones carried gold and silver adjacent to major vertical fractures in the Ragged Top and Carbonate Mining districts, Lawrence County (31, p. 99). The upper part of the formation especially is highly cavernous, and collapse zones are conspicuous. The formation is a good aquifer in western South Dakota and in Wyoming. It carries oil elsewhere in the northern Rocky Mountain and Great Plains area.

Minnelusa Formation

The Minnelusa Formation consists of alternating beds of sandstone and dolomite, with lesser amounts of red and black shale, and chert. The outcrop thickness ranges from 500 to 700 feet. Numerous beds of anhydrite, which thicken the formation in subsurface, are missing on the outcrop except in T 52 N, R 61 W, Crook County, Wyo. The formation is divided into upper and lower units by a red shale marker bed, probably a paleosol which marks an erosional break between Pennsylvanian and Permian time. A thick upper sandstone unit, called the Converse sand in Wyoming, is an important aquifer around the Black Hills, and produces oil in numerous fields in the Powder River Basin. The thin Leo Sandstones, associated with black radioactive shales below the "red marker," yield oil in Custer County, S. Dak., and Niobrara County, Wyo.

Opeche Formation

The Opeche consists of 85 to 125 feet of red silty shale, often with thin discontinuous beds of gypsum or anhydrite. The upper few feet of the formation are pale lavender, apparently the result of subaerial erosion prior to deposition of the overlying limestone.

Minnekahta Limestone

The Minnekahta consists of 35 to 40 feet of thin-bedded, gray to purple limestone. Because it lies between two red shale units, its typical topographic expression is a low tree-covered escarpment, cut by steep-walled box canyons. Four lithologic units can generally be identified. In ascending order, these are a lower brick-red shaly zone, with up to 60 percent silt and clay; a lower pure limestone zone, with very little insoluble residue; an upper shaly zone which weathers to thin slabs, and contains up to 10 percent insoluble clay and silt; and an upper unit of pure limestone. Selective mining of the top unit produces a particularly high-calcium rock.

The Minnekahta is the principal source of crushed rock, ballast, riprap, and building stone, and it is the most widely used raw material for manufacture of cement and lime.

Spearfish Formation

The Spearfish consists of red silty to sandy shales and siltstone, interbedded with thin, more or less continuous layers, of gypsum. The formation increases in thickness from about 275 feet in the southern Hills, to nearly

700 feet on the northwest side. Spearfish redbeds erode easily, so that they underlie the "Red Valley" or "Racetrack" which encircles the Hills just inside the Cretaceous sandstone hogbacks. The thicker beds of gypsum have been utilized in the past, and have some future potential.

Sundance Formation

The Sundance consists of 250 to 450 feet of alternating sandstone and gray-green shales. It has been subdivided into five members, as indicated on figure 3. The sandstones are minor aquifers close to the outcrop, and the same beds yield oil in adjacent parts of eastern Wyoming.

Unkpapa and Morrison Formations

Unkpapa and Morrison, two closely related formations, represent final continental deposition in this area after the retreat of the Sundance sea in late Jurassic time. The Unkpapa, confined largely to the southeastern flank of the Black Hills, consists of up to 300 feet of fine, argillaceous sandstone whose color ranges from dazzling white to red and yellow and lavender. Because of its homogeneity and ease of working, it was once quarried for building and ornamental stone (6, p. 292).

The Morrison consists of greenish-gray shale with one or more thin beds of sandstone and limestone. The total thickness ranges from 0 to 300 feet. In general, where one of these formations thins, the other thickens. The formation is unstable on steep slopes and has been the cause of some earthslide problems on highway cuts around the Black Hills. The sandstones are a very minor source of groundwater.

Lakota Formation

Prior to the time the Cretaceous sea invaded the area, a few hundred feet of sandstones, conglomerates, and clays were deposited by sluggish streams moving across a flood plain. These now comprise the Lakota Formation. The upper part of this unit, consisting primarily of gray to yellow and red clays, was formerly called the Fuson Shale. The Minnewaste is a thin, local lense of limestone at the top of the Fuson on the southeastern side of the Hills.

The sandstones are a most important aquifer; oil is found in the formation in a few fields on the west flank of the Black Hills uplift. Many of the uranium deposits on the southern and western sides of the Hills occur in Lakota Sandstone. The bituminous coal mined at Cambria, Weston County, Wyo., from 1881 to 1928 came from the Lakota Formation. The Fuson clays are used for manufacture of high-quality brick.

Fall River Formation

The Fall River represents the transgressive sandstone deposited as the Cretaceous sea spread eastward over the Black Hills area. The sandstones are fine grained and fairly well cemented. The formation generally averages about 100 feet in thickness. The sandstones were used as rough building stone in

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the early days of settlement, and quarries near Hot Springs produced dimension stone up until World War II. The formation is an important aquifer under the plains surrounding the Hills, and several small oilfields produce from it on the Wyoming side of the uplift. Uranium deposits occur within the formation on the northwestern and southwestern flanks.

Skull Creek Shale

The lowest of the four formations which comprise the Graneros Group consists of 225 to 275 feet of dark gray marine shale of lower Cretaceous age.

Newcastle Formation

Resting on Skull Creek Shale, and in part filling channels cut into it, are the shales, clays, and sandstones of the Newcastle Formation. This unit was laid down during a temporary shoaling of the sea. The thickness ranges from zero to about 60 feet. Channel sandstones on the west flank of the uplift form the reservoir rock for a succession of elongate oilfields in Weston County (fig. 4), and the nearly equivalent Muddy Sandstone carries oil in structurally formed traps throughout northeastern Wyoming. Lenses of bentonite, underlying the sandstone west of Belle Fourche, are of commercial importance (30, p. 45).

Mowry Shale

The Mowry consists of about 200 feet of hard, siliceous, marine shale. The outcrops weather to light gray ridges which support a stand of pine trees. The Clay Spur Bentonite, which is the most important commercial bed in the Black Hills region, lies at the top of the Mowry Formation.

Belle Fourche Shale

As originally named, the Belle Fourche unit consisted of about 600 feet of dark gray marine shale lying above the Mowry and below the Greenhorn Lime stone. A thin limestone named the Orman Lake bed, lying 150 to 200 feet below the principal Greenhorn ledge, forms a conspicuous topographic feature. Shales between the Orman Lake and Greenhorn Limestones carry a Greenhorn fauna, and are considered by the U.S. Geological Survey to belong to the Greenhorn rather than to the Belle Fourche Formation. A few feet below the Orman Lake Limestone there is a very persistent, 1- to 3-foot bentonite bed, called the Gray-red or F bed by the Geological Survey (30, p. 53).

Greenhorn Formation

The Greenhorn, as originally defined, consists of about 100 feet of calcareous shales, chalk, and thin limestone beds. It is a conspicuous ridge former around the Black Hills. When freshly broken, the limestone has a strong petroliferous odor, but no commercial oil has been recovered from it.

Carlile Shale

The Carlile consists of about 400 to 450 feet of gray marine shale, with conspicuous zones of very large septarian concretions. A thin sandstone near the base on the western side of the Hills, which forms a double hogback ridge with the Greenhorn Limestones, is correlated with one of the Wall Creek Sandstones of the Powder River Basin. Outcrops are often oil saturated, and several older oilfields west of the Hills have produced from this sandstone.

Niobrara Formation

The Niobrara consists of about 200 feet of impure chalk. The rock is bluish-gray when fresh, but weathers to buff and yellow. Soils developed on the Niobrara are high in selenium, and support such selenium-concentrating plants as Astragulus, Oonopsis, Stanleya, and Xylorrhiza. Elsewhere in the Great Plains region, the Niobrara has been used as a source of cement rock.

Pierre Formation

The Pierre consists of up to 2,700 feet of dark gray marine shale. A bentonite near its base in the Ardmore, S. Dak., area was once mined for use as a water softener (6, p. 327); other bentonites higher in the formation are too thin for commercial development in the foreseeable future. Weathered shale from the upper part of the Pierre is used at Rapid City as the raw material for portland cement, and for bloating to form Haydite lightweight aggregate.

Fox Hills Formation

The Fox Hills Sandstone, deposited along the shoreline of the retreating Cretaceous sea, forms a conspicuous escarpment on the west side of the Hills, but on the east it lies far out into eastern Meade and Pennington Counties. The sandstones are a minor aquifer; coal occurs in the Fox Hills Formation in eastern Meade County.

Lance and Hell Creek Formations

Several hundred feet of continental clays and sands of the Lance Formation overlie the Fox Hills in Niobrara, Weston, and Crook Counties. Thin sandstones within the formation serve locally as aquifers. In Butte, Meade, and Pennington Counties, beds of similar age, with minor coalbeds, are called the Hell Creek Formation.

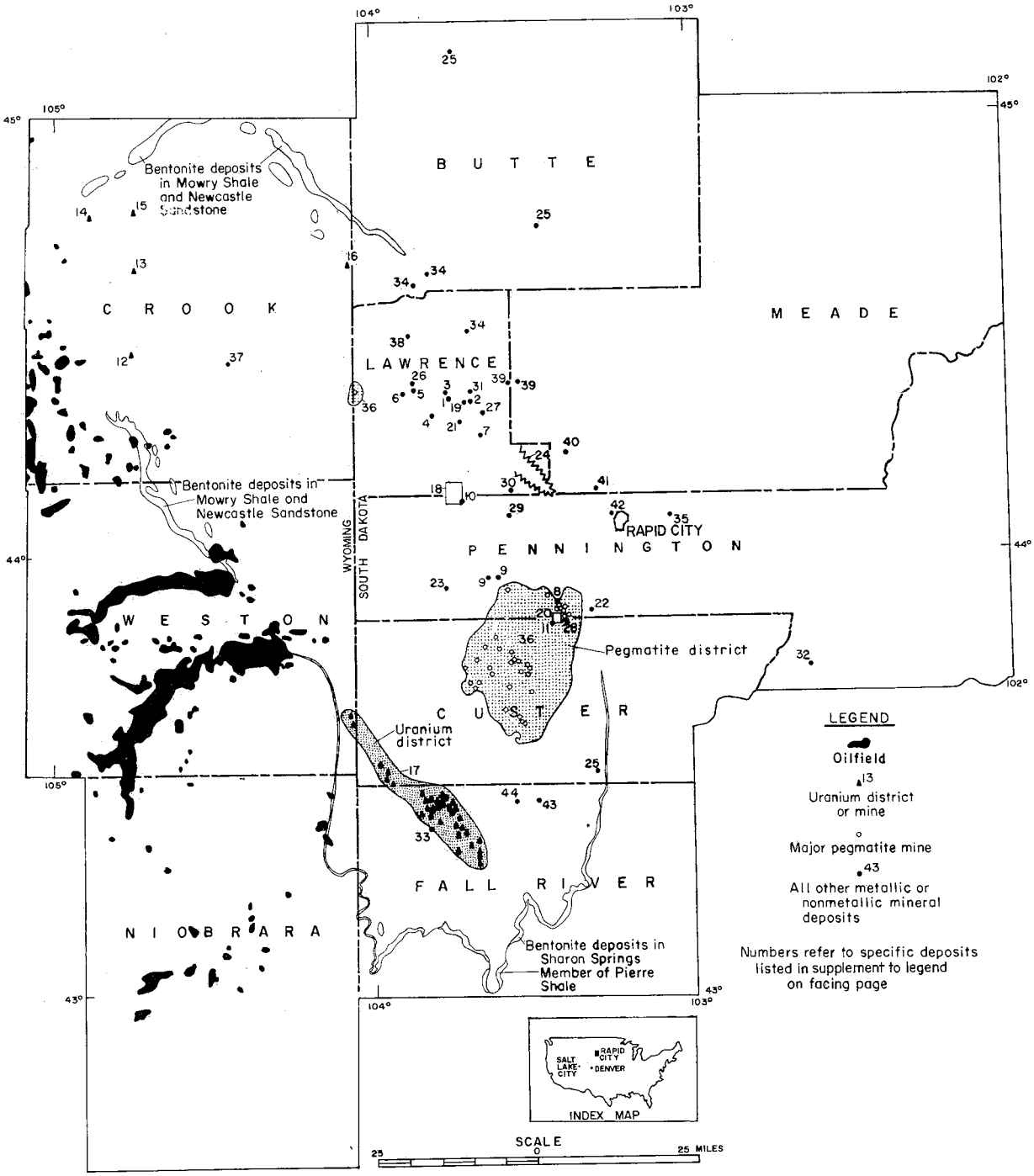

FIGURE 4. - Map of mineral resources.

LEGEND FOR FIGURE 4. - Minerals of the Black Hills and the districts, areas, and mines where they were produced

Map No.	District, area, or mine
	GOLD AND SILVER
1	Lead
2	Deadwood-Two Bit
3	Garden
4	Bald Mountain
5	Squaw Creek
6	Ragged Top
7	Cloverleaf
8	Keystone
9	Hill City
10	Rochford
11	Ivanhoe
	URANIUM
12	Carlile
13	Barlow Canyon
14	Hulett Creek
15	Elkhorn Creek
16	Aladdin
17	Southern District (includes 34 mines as well as several dozen not plotted)
	IRON
18	Rochford-Nahant
19	Two Bit Gulch
20	Iron Mountain
21	Strawberry Ridge
22	Hayward
23	Bobcat Gulch
24	Nemo
25	Siderite-hematite-limonite deposits
	LEAD AND ZINC (includes some silver)
26	Carbonate
27	Galena
28	Spokane
29	Silver City
30	Calabogia
31	Spruce Gulch
	MOLYBDENUM
32	Indian Creek
33	Runge
	CLAYS, BENTONITE, AND LIGHT-WEIGHT AGGREGATE
34	Clay and shale pits used for brick
35	Clay and shale pit used for light-weight aggregate and cement
	PEGMATITE
36	Area containing feldspar, lithium, mica, beryl, tantalite-columbite, and tin in pegmatites. Major mines are signified by °.
	GYPSUM
37	Sundance
38	Spearfish
39	Sturgis
40	Piedmont
41	Black Hawk
42	Rapid City
43	Hot Springs
44	Erskine

Tertiary and Quaternary Rocks

Igneous Intrusions

Early Tertiary igneous activity (30 to 40 million years ago) resulted in the intrusion of numerous dikes, sills, stocks, and laccoliths in a belt extending roughly S 70° E from the Missouri Buttes and Devils Tower in Crook County to Bear Butte in Meade County. The gold-silver, lead-zinc, and tungsten mineralization of the northern hills appears to be related to this intrusive episode, though the ores are generally in associated rocks rather than in the intrusives themselves.

White River Beds

Following uplift and erosion in very early Tertiary time, the Black Hills must have had a relief similar to that of the present time. During Oligocene time, debris from the Hills themselves, and from the area to the west, plus volcanic ash wafted in by prevailing westerly winds, buried all but the higher parts of the Hills. Erosion since Oligocene time has reexcavated most of the earlier topography, but remnants of the White River beds still cap terraces east of the Hills, fill old valleys coming out of the Hills, and are found at elevations exceeding 5,200 feet in the northern and central parts of the higher hills. The fine-grained clays were once considered possible sources of fuller's earth (6, p. 314). Traces of uranium and molybdenum mineralization have been found in some of the White River beds.

Terrace Deposits

Several generations of terrace deposits, found on upland surfaces and on benches adjacent to present-day stream valleys, are probably of Pliocene and Pleistocene age. They are widely exploited for sand and gravel.

Economic Potential

From the standpoint of potential utilization, the mineral resources of the Black Hills area fall into four categories. These are (1) commodities such as bentonite, rock, common clay and shale, iron, gypsum, and sand and gravel available in large or nearly limitless reserves for which expanded production awaits only the development of new uses or the expansion of existing markets; (2) minerals such as gold, the pegmatite minerals, uranium, and ceramic-grade clay of limited known reserves but for which experience has shown that exploration will yield new discoveries when economic conditions warrant, or when more efficient extraction methods are developed; (3) minerals such as silver, lead, zinc, tin, molybdenum, and vanadium, which have been produced in minor quantities and for which prospects for greatly increased production in the near future are not bright; and (4) the mineral fuels coal and petroleum, for which exploration is in full swing and the market is expanding at a phenomenal rate.

These observations are subject to the reservation that new developments in mineral exploration methods may lead to the discovery of deeply buried deposits, the search for which is not now feasible.

Major Enterprises and Industries

The outstanding single enterprise is the gold operation of the Homestake Mining Co. at Lead. It provides steady year-round employment for approximately 1,800 persons. In 1972, the mine produced 407,397 ounces of gold and 99,319 ounces of silver.

The uranium mill at Edgemont is capable of processing more than 500 tons of uranium ore per day. When in full operation, the mill employs approximately 60 persons and supports mining operations employing a similar number of miners. Because of the currently depressed price of uranium, all mines are closed, and the mill is operating on a limited scale processing old tailings for vanadium.

Seven bentonite mills, scattered around the north and west sides of the Hills from Osage, Wyo., to Belle Fourche, S. Dak., employ about 250 individuals. Mining and hauling operations are seasonal; milling is a reasonably steady year-round operation.

In 1972, approximately 24,600 tons of feldspar was produced in the area. Most of this was processed at the plant built by International Minerals and Chemicals Corp., but sold to the Pacer Corp. of Custer in November 1972. The plant employs approximately 20 persons.

The State cement plant at Rapid City shipped 2,668,273 barrels of cement, valued at $13,116,838, in 1972. It employed 160 persons on a year-round basis. A midwinter shutdown is generally utilized for maintenance, repair, and vacations.

Petroleum operations, conducted in 74 fields in the 9-county area in 1972, produced in excess of 8 million barrels of crude oil. The Tesoro refinery at Newcastle has a capacity of 8,000 barrels per day, and employs more than 50 persons. No effort has been made in this survey to determine the number of pumpers, service crews, and drilling crews used to maintain production.

Several quarry operators produced crushed rock valued at $2,123,124 in 1967.

Consolidation Coal Co. has constructed an experimental lignite gasification plant at Rapid City which employs about 120 persons. The plant is designed to use the CO_2 Acceptor Process for producing pipeline gas from northern Great Plains lignites.

Income and Trends

Despite fluctuations in the demand and production of individual commodities, the overall mineral industry has demonstrated a picture of steady

expansion and progress. By 1969, mineral production for the nine counties exceeded $70 million, compared with $67 million in 1960. Table 1 shows value of production by counties, and a listing, in decreasing order of importance, of the commodities contributing to the totals.

TABLE 1. - Value of mineral production, nine Black Hills counties

(Thousands)

State and county	1965	1970	Principal commodities in order of value
South Dakota:			
Butte.....	W	W	Clays, sand and gravel.
Custer.....	$465	$200	Feldspar, sand and gravel, lime, petroleum.
Fall River.....	250	W	Uranium, vanadium, sand and gravel.
Lawrence.....	22,381	21,499	Gold, silver, sand and gravel, stone.
Meade.....	186	W	Sand and gravel, gypsum.
Pennington.....	7,557	8,503	Cement, stone, lime, sand and gravel.
Wyoming:			
Crook.....	27,697	22,954	Petroleum, clay, sand and gravel, stone.
Niobrara.....	2,833	W	Petroleum, sand and gravel.
Weston.....	12,051	11,334	Petroleum, clay, sand and gravel, stone.

W Withheld to avoid disclosing individual company confidential data.

Source: Bureau of Mines Minerals Yearbook.

In this area, where active exploration and development are in progress, value of commodities does not tell the entire story of the benefits that accrue to owners of land or mineral rights, or to other residents of the area. Annual rentals are paid to land- or mineral-right owners for leases held for future development of sand and gravel, bentonite, petroleum and uranium. Expenditures on labor and supplies for annual assessment work on mining claims are usually made locally.

Production royalties, actually a part of the value of the commodities involved, are paid on uranium, oil and gas, sand and gravel, rock, and bentonite, on either a tonnage or ad valorem basis. These royalties accrue to the owner of the mineral rights, which may be the Federal Government, the State, or private individuals. In the entire State of Wyoming for the year 1972, 61.5 percent of all royalties on oil were paid to the Federal Government, 6.2 percent to the State government, and 32.2 percent to individuals (48). A percentage of lease and royalty monies paid to the Federal Government is returned to the counties in which the minerals were produced.

Employment and Trends

The mining and processing of metallics and nonmetallics in the 9-county area utilizes the services of about 2,400 persons (table 2), and the petroleum industry probably adds about 300 jobs to this total. Most are full-time positions, though some seasonal jobs exist because demands for the commodities are

related to construction or other seasonal industries. Some open pits shut down and others operate on a shortened schedule during the winter months, thus reducing the employment of miners and truckers.

TABLE 2. - Principal mining and processing operations, Black Hills area, 1971

Commodity and operator	Reported capacity	Average number of employees	First date of operation
Bentonite:			
American Colloid Co., Belle Fourche, S. Dak.	1,000 tpd	85-90	1935
American Colloid Co., Upton, Wyo.	1,000 tpd	30-35	1927
Federal Bentonite Co., Colony, Wyo.	20 tph	18	1958
Federal Bentonite Co., Upton, Wyo.	10 tph	14	1939
International Minerals & Chemical Corp., Colony, Wyo.	182,000 tpy	30	1967
National Lead Co., Baroid Div., Colony, Wyo.	1,000 tpd	43	1947
National Lead Co., Baroid Div., Osage, Wyo.	400 tpd	20	1924
Clay, other:			
Black Hills Clay Products Co., Belle Fourche, S. Dak.	7,200,000 bricks/yr	20	1927
Light Aggregates, Inc., Rapid City, S. Dak.	10 tph	9	1952
Cement: State Cement Plant, Rapid City, S. Dak.	3,500,000 bbl/yr	160	1924
Lime:			
Black Hills Lime Co., Pringle, S. Dak.	16 tpd	7	1899
Pete Lien & Sons, Rapid City, S. Dak.	400 tpd CaO	21	1964
Gold: Homestake Mining Co., Lead, S. Dak.	4,931 tpd	1,808	1877
Pegmatite minerals: International Chemical Corp., Custer, S. Dak.	26,000 tpy	20	1936
Petroleum refining:			
C & H Refinery, Lusk, Wyo.	65 bbl/day	5	NA
Tesoro Petroleum Corp., Newcastle, Wyo.	8,000 bbl/day	53	NA

NA Not available.

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TABLE 2. - Principal mining and processing operations, Black Hills area, 1971--Continued

Commodity and operator	Reported capacity	Average number of employees	First date of operation
Natural gas: True Oil Co., Coyote & Donkey Creeks fields, Wyoming	1,014,185,000 cf/yr	NA	1963
Rock:			
Hills Materials Co., Loring Siding, S. Dak.	300,000 tpy	NA	1963
Hills Materials Co., Rapid City, S. Dak.	400,000 tpy	20	NA
L. G. Everist, Rapid City, S. Dak.	2,500 tpd	20	1953
Lee Construction Co., Deadwood, S. Dak. (inactive)	-	-	-
Pete Lien & Sons, Argyle (Lien) Siding, S. Dak.	3,000 tpd	5	NA
Pete Lien & Sons, Rapid City, S. Dak.	2,000 tpd	20	1945
Reeves Quarry, Newcastle, Wyo.	-	-	-
Roberts Construction Co., Sundance, Wyo.	-	-	-
Sand and gravel: All operators at Wasta, Oral, Creston, Whitewood, and Belle Fourche	NA	30	NA
Uranium mining and milling: Mines Development, Inc., Edgemont, S. Dak.	650 tpd	60	NA

NA Not available.

Employment has not increased with production, primarily because of technological improvements on the part of the larger operators. Homestake, for instance, mined and milled essentially the same tonnage of ore in 1972 that it did prior to the shutdown in 1942, yet it did so with about 400 fewer men. Automation in the newer bentonite mills and the refinery at Newcastle also has permitted reduction of personnel coincident with increased production.

The number of small pegmatite mining operations is probably at a 40-year low, and the figure will remain small unless increased demands develop for feldspar, mica, beryl, and lithium minerals, or for one of the lesser minerals produced as byproducts.

Suspension of mining and milling operations in the Edgemont uranium industry already has been noted. As soon as problems associated with operation of atomic powerplants have been reconciled, and the market price of

uranium returns to a point of profit, the area should return to its former scale of activity.

COMMODITIES

A brief commodity analysis, with production potential and all known estimates of reserves, follows so that the reader may determine for himself the potential of individual minerals as demands and economic conditions change through the years.

References are given to more extensive publications dealing in detail with the geology, distribution, and development of the various commodities found in the Black Hills area. Particular attention is drawn to discussions of the potential of several of these minerals, written by specialists on the individual commodities, and included in the reports on mineral and water resources of South Dakota and Wyoming, prepared respectively for Senators McGovern and McGee (44-45).

Bentonite

(6, pp. 317-332; 7; 14; 17; 39; 45, pp. 105-109; 46)

Bentonite is a cream- to greenish-gray-colored clay consisting of the mineral montmorillonite. It occurs as widespread beds interstratified with the dark gray marine shales of the area. It is believed to have formed by alteration of ash that fell into the Cretaceous seas from volcanic explosions in the Northwestern United States. Four such beds have been exploited in the Black Hills area.

Most commercial production to date has come from the Clay Spur bed, which averages 3 to 4 feet in thickness, and directly overlies the siliceous Mowry Shale on the western and northern sides of the Black Hills. It lies at the contact between Lower and Upper Cretaceous formations. A lenticular bentonite bed in the Newcastle Formation (Bed B of the U.S. Geological Survey) has been extensively mined in Crook County, where it is also known as the Robinson bed. A persistent bentonite (Bed F) in the upper Belle Fourche Shale, a few feet below the Orman Lake Limestone, constitutes an important reserve in Crook and Butte Counties but has had little development to date. The "Ardmore bed" is a low-swelling clay occurring in the Sharon Springs Member of the Pierre Formation, especially well developed in Fall River and Weston Counties.

The bentonite industry first became an economic factor in the Black Hills area about 1927, when pioneer processing plants were established in Weston County, Wyo. The industry has expanded steadily, and the 1964 production from the nine-county area totaled 852,100 tons, valued at $9,322,000.

Uses

Because most of the clay is used as a binder for foundry sands, and as a mud additive in oil-well drilling, production has fluctuated with the activity of those particular industries. Recently, use of bentonite as a binder for pelletizing taconite has exceeded foundry use and added a third expanding outlet. Lesser quantities are used as a sealant for dams, canals, and

reservoirs, as a filler, as a bleaching and purifying agent, and as a vehicle for certain sprays. Bentonite slurry, dropped from airplanes, is effective in retarding forest fires. From 1917 to 1943, the Permutit Co. mined the Ardmore bed for use as a water conditioner. Total production during this interval was approximately 20,000 tons.

Reserves

Estimation of bentonite reserves depends upon the depth of overburden that can be economically removed at any given time, and upon whether only the yellow, swelling, near-surface clays are considered, or whether the more deeply buried, blue, low-swelling clays also are included.

The only published figures of reserves in the Black Hills area are those in the Clay Spur bed in the Clay Spur district, where the amount present was estimated by Davis (7, p. 4) to be "two million tons or less of commercial bentonite." Bentonite deposits in the northern Hills are much more extensive than those in the Clay Spur district. Probably the reserves in the northern district are 20 times the size of those in the Clay Spur district (S. H. Patterson, written communication, March 22, 1966).

Potential

Very large potential reserves of bentonite, which are of little present value, include (1) deposits in the Clay Spur and Newcastle (B) beds that lack the properties of bentonite now in demand, (2) deposits under excessive overburden, and (3) bentonite of substandard grade occurring in beds other than the Clay Spur and Newcastle beds. The potential resources of bentonite in the Black Hills area have not been inventoried adequately. The total amount present is certainly as much as 100 million tons (S. H. Patterson, written communication, March 22, 1966) and actually may be several times this figure. Large tonnages of this clay eventually may be used for purposes that are quite different from those for which most Black Hills bentonite is now sold.

A recent tendency has been noted among existing bentonite producers to increase their productive capacity by building new plants in other parts of Wyoming, where extensive reserves of bentonite are known. It seems unlikely in the foreseeable future that Black Hills output will exceed the present capacity of existing mills.

Land Restoration

Some bentonite strip-mining pits have been reclaimed by leveling and reseeding. A major problem, common to other strip mine areas, is the difficulty of establishing any vegetative cover on the very poor soil that remains after stripping operations. Topsoil has been stockpiled prior to mining in recent instances, and redistributed over the back-filled area before seeding. Costs of land restoration have not yet been determined.

Beryl

(6, pp. 253-255; 28, pp. 36-39; 32, p. 38; 38, pp. 49-52; 40; 45, pp. 125-126)

Although beryl has been produced as a minor byproduct of pegmatite mining since 1914, new uses developed during and subsequent to World War II greatly stimulated world demand. Government purchasing programs during the war, and between 1952 and 1962, raised production from Pennington and Custer Counties to a peak of 392 tons in 1953. With the termination of all purchasing programs, production from the Black Hills virtually ceased. Small lots are being stockpiled by individual operators. In 1969, production totaled 46 tons (41). A very small quantity was produced from Niobrara County, Wyo., in 1960 and 1961.

Beryl is generally hand-cobbed from other pegmatite minerals and shipped as beryl concentrates to reduction plants in the East. In recent years some has been recovered by flotation methods.

Uses

Beryllium is used with various other metals in electrical equipment. It formerly was used as a phosphor in fluorescent lighting. Because the metal is transparent to X-rays, limited quantities are used as windows in X-ray equipment.

Reserves

Twenty-six deposits are known that contain more than 100 tons each of beryl and have a grade exceeding 0.2 percent. These are estimated to contain 17,400 tons of beryl. Applying the cutoff of 1 percent, below which pegmatites cannot be mined for beryl alone, this figure is reduced to 3,500 tons of beryl (45, p. 129).

Potential

Beryl production can be stimulated by guaranteed high prices in time of national emergency. Because of the low beryl content of most pegmatites, beryl normally can be produced only in conjunction with feldspar, mica, or the lithium minerals. Traditionally, beryl has been recovered by hand-cobbing methods. Experiments have shown that beryl can also be recovered by flotation techniques, but the small content of beryl in known Black Hills pegmatites discourages attempts at application of this method at present prices.

Cement

(6, pp. 271-277; 18, pp. 18-19; 34, pp. 30-36; 45, pp. 100, 102)

Portland cement has been produced at the State-owned plant in Rapid City since 1924.

Basic materials are Minnekahta Limestone from a quarry at the plant site, Pierre Shale from a pit 8 miles east of the plant, and lesser quantities of locally mined gypsum, sand, and iron ore. In 1971, the plant used 420,601 tons of limestone, 101,004 tons of shale, 15,037 tons of gypsum, 24,410 tons of sand, and 5,638 tons of iron ore.

Sales have increased from 338,000 barrels in 1925 to a record 2,668,273 barrels in 1972. Most of the product is marketed in North and South Dakota, Nebraska, eastern Wyoming and Montana, and northwestern Iowa. During 1971, 65 percent of all sales was to 34 consumers, and 12.4 percent was sold in North Dakota.

Clays

(6, pp. 305-317; 45, pp. 105-112)

Black Hills Clay Products obtains buff- and red-burning clays from the Fuson Member of the Lakota Formation for the manufacture of brick and other ceramic products. The original pit is 2 miles south of Belle Fourche, along U.S. Highway 85, in NE¼ sec 34, T 8 N, R 2 E. The newer Donato pit is southwest of town along the south edge of sec 25 and the north edge of sec 36, T 8 N, R 1 E. A small amount of clay used for a grog is obtained from a pit near Whitewood, south of the center of sec 1, T 6 N, R 3 E.

Limited quantities of Fuson clay also have been mined near Rapid City for local pottery manufacture.

The State Cement Commission maintains a quarry in the Pierre Shale 8 miles east of Rapid City to produce clay used in manufacturing portland cement. Nearby, Light Aggregates, Inc., operates a smaller pit in weathered Pierre Shale which is bloated to form lightweight aggregate (Haydite). Both operators truck the shale to their plants on the west side of Rapid City.

Coal

Coal mining was an important part of the Weston County economy between 1889 and 1928. Bituminous coal of coking quality was mined at Cambria, 5 miles north of Newcastle on a spur of the Burlington Railroad. The coalbed averaged 5 feet in thickness within the Lakota Formation of Lower Cretaceous age. Much of the coal was used directly by the railroad, and coke was supplied to smelters in the northern Black Hills and elsewhere between 1891 and 1903 (6, pp. 380-386).

Small quantities of the same bituminous coal were mined at Aladdin, Crook County, for domestic use and for the Chicago and Northwestern Railway, and near Edgemont for domestic uses. There has been no recorded production in any of these areas since 1935. Some lignite has been produced from wagon mines in the Stoneville area of eastern Meade County. This coal occurs in the Fox Hills Formation of late Cretaceous age.

Present Source

Simultaneously with the phasing out of the mines at Cambria, open pit mines were developed in the subbituminous coal adjacent to the Burlington right-of-way at Wyodak, Campbell County, Wyo., only 15 miles west of the Crook County line. Essentially all of the coal currently consumed in the Black Hills area is mined at Wyodak, where a bed of high-grade subbituminous coal of early Tertiary age attains a thickness of 75 to 110 feet. The overburden thickness is generally less than one-half that of the underlying coal. In 1971, Wyodak Resources Development Corp., a subsidiary of Black Hills Power and Light Co., produced 446,590 tons of coal, employed 35 people, and had a payroll of $304,600. Ninety-seven percent of the coal was burned in company powerplants at Wyodak, Osage, Kirk, and Rapid City; 3 percent was sold for commercial and domestic heating.

Reserves

Coalbeds remaining in the nine-county area are generally less than 5 feet in thickness, and have a high ratio of overburden to coal thickness. Total original reserves, as calculated by the U.S. Geological Survey, total 352 million tons (3-4). Although this figure appears large, it represents only one-half of 1 percent of the reserves in adjacent Campbell County (62,219 million tons), where beds of subbituminous coal locally exceed 100 feet in thickness, and where overburden-to-coal ratios may be less than 1 to 1.

The only conceivable potential lies in the bituminous coking coal remaining in the abandoned Cambria area. The Cambria field once produced at a rate exceeding 500,000 tons per year. Berryhill (3, p. 29) states that "..most of the easily recoverable coal, especially that of coking quality, has been removed from the Cambria field, and it is doubtful if any appreciable tonnage of coking coal can now be recovered from the area" (table 3).

TABLE 3. - Original coal reserves in beds 2½ to 5 feet thick, unless otherwise noted

(Thousand short tons)

State and county	Area	Location	Coal		
			Lignite	Subbituminous	Bituminous
South Dakota:					
Meade.....	Stoneville.....	T 9 N, R 12 E	1,380	-	-
Fall River....	Edgemont.....	T 7 S, R 2 E	-	-	6.8
Do.....	.....do.....	T 9 S, R 3 E	-	-	4.1
Wyoming:					
Weston.....	15 townships total	-	-	[1]285,370	[2]39,940
Niobrara.....	Dull Center.....	T 40 N, R 66 W	-	560	-
Do.....	Shawnee.....	T 34 N, R 67 W	-	12,530	-
Do.....	Dull Center.....	T 41 N, R 67 W	-	1,220	-
Crook.....	Aladdin.....	T 54 N, R 61 W	-	-	590
Do.....	Sundance.....	T 51 N, R 64 W	-	-	560
Do.....	Moorcroft.....	T 49 N, R 68 W	-	8,640	-
Total (all coals)...	-	-	1,380	308,320	42,100.9

[1] Including 36,310,000 tons in beds 5 to 10 feet thick.
[2] Bituminous coal in 6 townships only.

Sources: 3; 4; 6, pp. 379-399; 18; 24; 35; 45, pp. 147-151.

Columbite-Tantalite

(6, pp. 255-257; 15; 18, pp. 30-31; 28, pp. 66-68; 38, pp. 53-56; 45, p. 126)

The mineral series columbite-tantalite is found in very minor quantities in many pegmatites, both in the southern Hills and in the Tinton area. It contains tantalum and niobium (colubium), both of which are used in limited quantities in manufacturing special corrosion-resistant alloys.

The mineral is hand-picked incidental to other mining, stockpiled, and marketed when prices are high. The annual production from the Black Hills has been less than 1 ton per year. The peak year was 1954, when 12½ tons was shipped. A Federal buying program between 1952 and 1958 did little to stimulate production in this area.

Copper

(6, 208-211; 18, p. 36)

Traces of copper occur in some of the black graphitic schists in the Precambrian core of the Black Hills. Despite very extensive prospecting and developmental work, particularly just prior to and during World War I, no commercial ore bodies have been discovered. Small lots of hand-sorted ore have been shipped to a smelter from time to time, resulting in small production figures credited to South Dakota.

Feldspar

(6, pp. 248-250; 12; 18, pp. 34-35; 38, pp. 20-35; 45, pp. 120-121, 127-133)

Feldspar is the only pegmatite mineral occurring in sufficient abundance and purity to permit mining for that commodity alone under normal market conditions. Minable deposits run at least 30 percent feldspar, in crystals generally ranging from 1 foot to 10 feet in diameter. Potash spar and a little soda spar are obtained from numerous pegmatites in Pennington and Custer Counties.

Feldspar mining has been a relatively steady industry in the Black Hills since an initial adjustment of railroad freight rates in 1923 permitted it to enter eastern markets at competitive prices. In the peak year of 1946, the Hills shipped 75,000 tons; current production is roughly 24,600 tons per year. The drop can be attributed to the development in the mid-1950's of milling methods that permitted recovery of feldspar from fine-grained, feldspar-rich, igneous rocks such as occur in abundance in North Carolina.

Uses

Feldspar is used primarily in the ceramic, porcelain, and glass industries, and small quantities are used as a mild abrasive in scouring powders.

Reserves

The U.S. Geological Survey has estimated that pegmatites containing 30 to 50 percent potash spar probably have a reserve equal to past production (1.4 million long tons) (45, p. 131).

Potential

Because transportation costs to distant markets seem to be the controlling factor limiting production, development of a local demand for feldspar seems to be the best means of stimulating production. The principal producers, North Carolina, California, Connecticut, Georgia, and South Carolina, are appreciably closer to the principal feldspar consuming States of Ohio, California, New Jersey, Illinois, and Pennsylvania. New, small-scale, milling methods are needed to help the Black Hills area compete with other feldspar-producing States.

Gem Stones

(6, pp. 341-346; 28, pp. 20-23, 32-35, 51, 91-93, 152-153, 167-172, 205-208; 38, p. 57; 45, pp. 140-141)

Materials sought by collectors in the Black Hills area include the pegmatite minerals, rose quartz, spodumene, beryl, apatite, tourmaline, feldspar, and the rare phosphate minerals; and such silica minerals as jasper, agate, chalcedony, petrified wood, and cycads. Golden barite, garnet, specularite, andalusite, and alabaster are also found. Much of the material is kept in its natural form for display specimens; the remainder is cut and polished, tumbled, or carved.

Because the collecting and sale of gem stones is largely a part-time hobby of amateurs, production figures are not available. The Bureau of Mines estimates production from the Hills area at about $42,000 per year. It is probable that money spent by "rockhounds" and other collectors visiting the area far exceeds the intrinsic value of the material collected.

Gold

(1; 6, pp. 71-182; 16; 18, pp. 11-17; 27, pp. 400-402; 45, pp. 41-49)

Gold has been a stong contributor to Black Hills economy since 1876. Production reached a peak of 628,259 ounces in 1965; 513,494 ounces was produced in 1971. The highly productive mines, active and inactive, are in Lawrence County; gold has come either from Precambrian rocks or from the overlying sedimentary rocks. Since World War I, Homestake Mining Co. at Lead has been the only large operator, and except for some very small intermittent operations, it has been the only producer since the Bald Mountain mines were shut down in July 1959. Homestake produced 36 percent of the gold mined in the continental United States during the decade 1963 through 1972.

Reserves

Gold reserves are imperfectly known because it is impractical to determine deep or remote reserves until mining of existing ores makes them accessible. Traditionally, under relatively stable conditions, and at a fixed price of gold, Homestake maintained a 10- or 11-year reserve of proved ore. With inflation and a rising price for gold operating in opposite directions, ore estimates vary from day to day. The 1972 Annual Report of the Homestake Mining Co. indicates a measured ore reserve for between 4 and 5 years at the present rate of mining. Measured, indicated, and inferred ore above the 6,800-foot level total 13.6 million tons, or reserves for approximately 9 years' operation at the present rate of mining.

Judging from the value of ores mined from the Deadwood Formation prior to the Federal shutdown order in 1942, there are also large but undetermined tonnages of gold-bearing rocks in the Maitland and Trojan areas that average between $5 and $8 per ton at the old $35 price.

Gypsum

(6, pp. 277-284; 18, p. 26; 28, pp. 102-104; 34, pp. 37-57; 45, pp. 133-137)

Occurrence and Use

Gypsum beds 10 to 30 feet thick occur in the Spearfish Formation. In the past, short-lived plaster mills have been operated in several Black Hills towns. At present, production is limited to approximately 29,000 tons per year, mined near Rapid City and used as a retarder in portland cement manufactured by the State Cement Commission.

Reserves

Discontinuous beds of gypsum in and just above the Spearfish Formation crop out almost continuously around the Black Hills. These beds or lenses are generally less than 10 feet in thickness, though local thicknesses of from 30 to 40 feet have been reported. Outcrops are narrow, and the beds soon dip beneath overlying strata. Cox and Bowles (45, p. 135) conclude that "the Spearfish and Gypsum Springs Formations contain large reserves of gypsum that are adaptable to exploitation by surface mining," but they give no tonnage estimates.

Gypsum in beds 25 to 40 feet thick occur in the Minnelusa Formation in T 52 N, R 61 W, Crook County, Wyo. This huge reserve has been mined only for fabrication into art objects.

Potential

Ample raw materials and fuel are available in the Black Hills area to support the manufacture of gypsum products. So long as the local market remains limited, it appears that this market will continue to be supplied from Heath, Mont., and Fort Dodge, Iowa.

Iron

(6, pp. 212-218; 13; 19, p. 36; 45, pp. 56-59)

Types and Distribution

Five types of iron deposits have been exploited on a small scale in the past. These are (1) recent bog iron deposits in the Rochford-Nahant area, Lawrence and Pennington Counties; (2) hematite ores of the basal Deadwood Formation in the Strawberry Hill-Two Bit area, Lawrence County; (3) pyritic deposits of the Precambrian and Cambrian rocks in Lawrence County; (4) Precambrian specularite-martite-magnetite-taconite deposits of the Nemo area, Lawrence County; and (5) a large hematitic mass associated with Precambrian quartzite at Iron Mountain on the Pennington-Custer County line.

Uses

Types 1, 2, and 5 have shown some merit as paint pigment, but efforts to exploit them invariably have failed. Type 3 was widely used as a flux for smelting refractory gold ores of the Deadwood formation prior to 1914. Types 1, 2, and 4 have been used as additives in manufacturing portland cement. In recent years, the only consumer has been the State cement plant, which uses about 5,600 tons annually. Because several years' supply was stockpiled in 1962, no production has been reported since that date.

Potential

Extensive iron ore deposits in the Black Hills await development when economic conditions are favorable. The figures in table 4 show inferred reserves based on preliminary studies by the Bureau of Mines (13), and an analysis made of the potential of the taconite reserves of the area. It has been stated that adequate limestone, dolomite, bentonite, fuel, and power are available to support a mining, beneficiating, and pelletizing facility. Estimated initial cost of a minimal 1-million-ton operation is given as $26 million. Harrer (13) anticipates that pellets would be shipped to blast furnaces outside the State and concludes that "Activation of a taconite enterprise in South Dakota is a long-range venture dependent upon the answers to many exploration, beneficiation, economic, and financial problems. Public problems involved will include the acquisition of Federal mineral land patents or some other form of agreement, water pollution control and conservation, and the location of the taconite in the general forest and recreation area of the Black Hills."

TABLE 4. - Black Hills iron reserves

County and area	Type of ore	Inferred reserves	
		Short tons	Iron content (percent)
Lawrance:			
Nemo district.....	Taconite (specularite-martite-magnetite).	500,000,000	20-43
Two Bit Gulch.....	Hematite-limonite.....	100,000	20-40
Custer-Pennington:			
Iron Mountain.....	.....do.....	750,000	30-60
Strawberry Ridge, Hayward, Bobcat Gulch.	.....do.....	100,000	35-45
Lawrence-Pennington: Rochford-Nahant.	Bog iron (limonite-goethite-turgite).	500,000	25-56
Total tonnage (all iron ores).	-	501,450,000	-

Source: Harrer (13, p. 11).

Lead and Zinc

(6, pp. 183-199; 8; 25, p. 126; 31; 45,pp. 60-64)

Although zinc minerals are noted in most of the lead-silver ores, the Spruce Gulch area east of Deadwood, Lawrence County, is the only place where commerical zinc mining has been feasible. The Belle Eldridge mine yielded 530,000 pounds of zinc, valued at $45,406, between 1942 and 1948. The concentrate was shipped to western Montana for smelting. The ore occurs as a replacement in the Deadwood Formation.

Lead ores are reported from six districts in the Black Hills, but lead has been produced only as a byproduct of mining for silver, gold, or zinc. The only recent production has been from the Silver Queen mine at Galena, Lawrence County, where 10,500 pounds, valued at $1,484, was produced between 1961 and 1963. Lead valued at $253 was produced, along with a small amount of silver, from the same property in 1969.

Reserves

Areas where lead and zinc mineralization occurs include the Spruce Gulch, Galena, Carbonate, and Calabooga districts in Lawrence County, the Silver City district in Pennington County, and the Spokane district in Custer County. Traces of lead and zinc mineralization are also reported from the Black Buttes, Crook County, Wyo. Although known high-grade deposits in these old camps have been worked out, undetermined reserves of low-grade ore remain, and particularly at Galena, it is reasonable to believe that substantial ore bodies remain to be found by systematic prospecting.

Lime

(6, pp. 285-288; 18, p. 25; 34, pp. 58-71; 45, pp. 99-100)

Although records of lime production extend back only to 1896, it is evident from the remains of crude kilns that limited quantities of lime were burned at several points in the Hills prior to that time. Raw materials have included the dolomitic Whitewood Formation, both the limestone and dolomitic members of the Pahasapa Formation, and the high-calcium Minnekahta Limestone.

Uses

Prior to 1964, most of the lime produced in the Black Hills was consumed by the local mining, construction, and sugar beet industries. Some is used in water treatment and sewerage treatment plants. Discovery that lime is useful for stabilizing bentonitic soils to control seasonal expansion and contraction has opened up a large market in highway and airport construction. Recently expanded facilities at Rapid City made it possible to extend the marketing area to several adjacent States.

Reserves

Reserves of suitable limestone are nearly limitless. Reserves of Minnekahta Limestone alone have been estimated to be adequate for all present uses for the next 12,000 years (45, p. 101).

Lithia

(6, pp. 236-248; 18, pp. 33-34; 38, pp. 36-48; 45, pp. 124-125, 130)

The Black Hills area was the principal source of the world's lithia from 1898 to 1952. Spodumene, amblygonite, and lepidolite were obtained from numerous pegmatites by hand sorting, and later by milling operations. Production has been limited to Custer, Pennington, and Lawrence Counties.

Traditional uses for lithia have been in pharmaceuticals and in the glass and ceramics industries. New uses developed during and after World War II created a greatly increased demand, which in turn encouraged development and milling of large-scale, low-grade deposits in Canada and in the southern Appalachian States, and imports from Rhodesia. Black Hills operations have lost their competitive advantage. The spodumene flotation mill of the Lithium Corp. of American at Hill City was closed in 1956. The Etta mine at Keystone, which had produced hand-cobbed spodumene since 1898, closed in 1960. Since then, Black Hills production has been negligible.

Potential

A national emergency, or increased demand for other pegmatite minerals, would encourage production of limited quantities of lithium minerals from the Black Hills. The abundance of known deposits of lithium-rich brines in Nevada and California precludes any possibility of intensive search for deeply buried lithium-rich pegmatites.

Reserves

Fifteen deposits are known that contain more than 0.4 percent lithium oxide (LiO_2), with an estimated total of 21,000 tons of LiO_2. One percent is the approximate cutoff point below which pegmatites cannot be mined for lithium alone. Some 12,000 tons of LiO_2 is estimated to occur in deposits of this concentration (45, p. 130).

Manganese

(6, pp. 339-340; 25, pp. 129-131; 45, pp. 64-66)

Small pockets of impure manganese oxides have been reported in the Precambrian rocks, in the Deadwood, Whitewood, Pahasapa, and Minnelusa carbonates, and in the Tertiary intrusive rocks of the northern Black Hills and Bear Lodge Mountains.

Noncommercial amounts of manganese oxides have been reported in the Cambrian (Deadwood) sediments at Galena, Spruce Gulch, Strawberry Hill, and Two Bit. Small pockets are also reported in the Mississippian Pahasapa Limestone at Galena, Carbonate Camp, and Ragged Top. All of the above occurrences are in Lawrence County. Small layers of manganese oxides have been noted in cave fillings in the Pahasapa Limestone in the southern Black Hills.

Production History

Nineteen tons was shipped from a pocket in the Minnelusa Formation near Argyle, Custer County, in 1892. Under a Government purchasing program during World War II, two carloads of manganese ore was produced from the North Star mine near Deadwood, and at least one small shipment was made from the Bearlodge Mountains in Crook County, Wyo.

Potential

Reserves are unknown, and presumably very small. Experience during World War II indicates that small tonnages can be produced when buying standards are lowered to about 30 percent MnO_2.

Mica

(6, pp. 250-253; 18, pp. 31-33; 20; 21; 28, pp. 47-49; 38, pp. 10-19; 45, pp. 121-124)

Occurrence and Uses

Mica occurs primarily in the outer or wall zone of some pegmatites. Except for small quantities of scrap from Lawrence and Niobrara Counties, all mica has been mined in Pennington and Custer Counties.

Pegmatites in the southern Black Hills have yielded high-grade sheet mica since 1879. Sheet, originally prized for its heat-resistant properties, is

widely used by the electrical industry because of its special dielectric and insulating properties. Because of limited domestic sources, and the excessive handwork in splitting, grading, and sorting, most sheet mica is imported.

Scrap mica has been recovered as a byproduct of other pegmatite mining since 1899. Black Hills mica is generally shipped elsewhere for grinding by either the wet- or dry-grinding process. Wet-ground mica is used primarily by the paint industry, and as a filler, and for surfacing molds in the rubber industry. Dry-ground mica is used extensively for surfacing asphalt roofing, and as a lost-circulation remedy in oil well drilling.

Production History

The first period of organized mica mining was between 1906 and 1911 when Westinghouse Electric and Manufacturing Co. bought and operated several mines in the Custer-Pringle area. Under a Government purchase program, between 1942 and 1945, sheet and punch mica valued at $1,174 was mined in the Black Hills. A second, lower support program between 1952 and 1962 encouraged production for a Government-sponsored, mica-rifting plant at Custer. With the closing of the plant and the termination of the program in the latter year, sheet mica production in the Black Hills has dropped to virtually nothing.

Potential and Reserves

The experience of the two World Wars has demonstrated that the Black Hills pegmatites can produce vital quantities of high-grade sheet mica under the stimulus of artificially high, guaranteed prices. During normal times, imports provide necessary supplies at a price with which local producers cannot compete. Large but unestimated reserves of scrap mica are present in known pegmatites. No appreciable reserves of sheet mica are known; future production depends upon additional discoveries.

Petroleum and Natural Gas

(6, pp. 368-379; 47; 48)

Occurrence and Development

Petroleum is a strong but irregular factor in the economy of counties west and south of the Black Hills uplift. Periods of boom have followed new discoveries and the introduction of secondary recovery methods to older fields. Nearly all fields produce from sandstone reservoirs. Prior to 1944, most of the discoveries, Osage excepted, were from anticlinal traps clearly discernible at the surface. Since that time, most accumulations have been found in stratigraphic traps related to channels, bars, and unconformities, or in more subtle structures discovered by geophysical exploration. Although the major discoveries in recent years have been in the Newcastle (Muddy), Fall River, Lakota, and Minnelusa Sandstones, Lance Creek field, discovered in 1918, has produced from 10 different pay zones ranging in age from Pennsylvanian to Upper Cretaceous.

As of January 1, 1973, there were 31 fields in Crook County, 1 in Custer County, 13 in Niobrara County, and 30 in Weston County, still actively producing oil and/or gas. Cumulative production for the four counties totals 274 million barrels of oil and 188 million Mcf of gas.

Reserves

Reserves available by primary and secondary recovery methods are fairly well known to the individual operators.

Potential

A greater potential may lie in discoveries yet to be made. Geological indications are that individual fields will continue to be small, and that discoveries will more or less offset production. The petroleum industry may thus continue at about its present pace for many years. The center of the Powder River Basin oil play has shifted westward to Campbell County, but small discoveries will continue to be made in Crook, Weston, and Niobrara Counties.

It is not anticipated that large gas reserves will be encountered. The area will continue to be dependent upon outside sources for a major share of its industrial and domestic gas requirements.

Sand and Gravel

(6, pp. 299-305; 38, p. 17; 45, pp. 93-96)

Occurrence and Uses

All Black Hills counties have produced sand and gravel suitable for highway construction. The gravels are of local origin, found on high terraces surrounding the Black Hills or associated with the present-day streams. Most of this gravel is dirty and alkali reactive. Production comes from local pits opened for specific contracts.

Masonry-grade sand and gravel is obtained from terraces and flood-plain deposits of the Cheyenne and Belle Fourche Rivers, and Battle Creek. Disintegrated sandstone from the Lakota Formation, 2 miles west of Bear Butte, has been used locally for masonry and plaster sand. The Homestake Mining Co. has utilized a fine white sand from the top of the Minnelusa Formation in sec 15, T 5 N, R 4 E, as a molding sand. Weathered Unkpapa Sandstone has been extensively used in highway base preparation between Rapid City and Sturgis. The State cement plant has opened a sand pit in this same formation to supply a high-silica sand for manufacture of portland cement in the NE¼ sec 34, T 2 N, R 7 E. Sandstone from coarse clean units within the Deadwood Formation has been crushed, sized, and shipped as silica sand from pits north of Hill City and near Pringle (5). Much of this sand was used in "hydrofracing" oil well reservoir rocks.

The total value of sand and gravel produced annually varies widely with local construction activity. Sand and gravel produced from the nine-county area was valued at $1,877,000 in 1969.

Potential and Reserves

Huge reserves of sand and gravel suitable for road construction and similar uses are available. The largest deposits are found outside the Hills proper, in the broad valleys of present-day streams and on high, interstream divides. A generalized map showing the distribution of gravels within South Dakota has been published (45). Most of these gravels are alkali reactive.

Sands suitable for masonry use are distributed extensively along the Cheyenne River. As available sources are exhausted, new, less accessible deposits will be developed. Experience has shown that some deposits located in the present stream channel are replenished during times of flood.

Silica sand, which in the past has been used as a fracture-propping medium in stimulating oil wells, is available from the Deadwood Formation in the southern Black Hills (5). Reserves are believed to be large.

Sands suitable for glass manufacture and as molding sand are present in the Minnelusa Formation in virtually limitless quantities.

Silver

(6, pp. 183-199; 11; 18, p. 36; 31; 45, pp. 41-49, 60-63)

Early-day production of silver came from such camps as Carbonate, Galena, Spokane, and Silver City. In the first three, the ore was argentiferous galena and associated secondary minerals occurring as replacements in the Deadwood Formation. At Silver City, the ores were arsenical and antimonial lead sulfides occurring as veins within the Precambrian metamorphic rocks. The most productive properties at Galena were shut down by litigation in 1883. Most remaining silver properties closed when the price of silver dropped in 1891. Periodic efforts to reopen some of these mines have not been successful, but a substantial rise in the price of silver would certainly prompt further exploratory work at Galena and Carbonate.

In recent years, the only appreciable production of silver has come as a byproduct of gold mining. Homestake recovered 99,319 ounces of silver incidental to gold production in 1972.

Stone

(6, pp. 288-299; 10, pp. 109-118; 18, pp. 21-23; 45, pp. 96-105)

All but three of the regularly operating quarries in the Black Hills area utilize the Minnekahta Limestone. This is a dense, thin-bedded, high-calcium, pink to gray limestone whose outcrop forms a distinctive ridge that completely encircles the Black Hills uplift. Other rocks used include the Pahasapa

(Madison) Limestone and Dolomite, the Tertiary intrusive rocks of the northern Hills, and the quartzites and similar tough rocks in the Precambrian core of the Hills.

Uses

Except for minor amounts used for riprap, and rough and ornamental construction stone, all rock is crushed. Major uses include road metal, aggregate for concrete and asphalt, ballast, and manufacture of portland cement and lime. Fines are used as a subcourse under concrete slabs, and as agricultural rock. Carbonate rocks from the Black Hills may be used in large quantities if a lignite gasification plant using the CO_2 Acceptor Process is built within the market area.

Production fluctuates with heavy construction. Rock produced in the nine-county area had an estimated value of $2,123,124 in 1967, and only $1,345,542 in 1969. Because of the lack of other good rock, and the scarcity of non-alkali-reactive gravels in the surrounding area, the limestone is shipped by rail or truck for distances exceeding 200 miles.

Reserves

Among the nine counties under consideration, the Minnekahta Limestone fails to crop out only in Niobrara. The Pahasapa crops out in each of the six counties in South Dakota, and a rock of similar age crops out in southwestern Niobrara County.

The outcrop of the Minnekahta Formation ranges in width from 200 feet to nearly 3 miles, and the formation averages 40 feet in thickness. Assuming an outcrop width of 1,000 feet, the formation contains 3-1/3 billion tons of limestone free of appreciable overburden and lying generally above the water table. This is a 1,200- to 1,500-year supply at the recent rate of consumption, including its use in manufacture of lime and cement.

The Pahasapa Formation has an outcrop area within the Black Hills of about 580 square miles. Total thickness of the formation ranges from 300 feet in the southern Hills to 650 feet in Spearfish Canyon. Assuming for simplicity of calculation that the average thickness of outcrop is 264 feet (1/20th mile), there is a volume of 29 cubic miles of Pahasapa under the outcrop area. However, the potential of the Pahasapa formation may not be so much for the limestone as in the rather considerable thicknesses of dolomite and highly dolomitic limestone within the formation. Individual dolomite beds over 100 feet in thickness are known (10).

In addition to limestone and dolomite, there are huge resources of quartzite, porphyry, and other abrasion-resistant rocks suitable for road metal, ballast, riprap, etc.

Talc

(2; 28, pp. 200-201)

Large deposits of low-grade talc have been reported in secs 1 and 12, T 2 N, R 5 E, and in sec 29, T 3 N, R 5 E, Lawrence County. At present, these are not competitive with beds of higher grade that are closer to markets. The deposit in sections 1 and 12 is nearly vertical, strikes slightly west of north, and extends for a length of 12 miles. Two measurements on the width of the deposit are 390 and 440 feet (2, p. 7).

Tin

(6, pp. 262-263; 9; 15; 18, p. 30; 25, p. 193; 28, pp. 51-55; 33; 36; 45, pp. 68-71)

Minor quantities of the tin mineral cassiterite occur as small isolated grains in quartz veins in the Hill City district, and in the border zones of pegmatites in the Hill City, Keystone, and Tinton areas. In the form of stream tin, it has been found in placer deposits in the same areas, particularly in the Tinton-Nigger Hill district astride the Wyoming-South Dakota border in Lawrence and Crook Counties.

Production

Total production since the first tin was marketed from the area in 1884 is less than 200 tons (45, p. 68). Milling of pegmatite rock by the Northwest Beryllium Corp. at Keystone resulted in production of small quantities of tin concentrate in 1966-69.

Reserves

Studies by the U.S. Geological Survey indicate that no known lode deposit in the Black Hills averages more than 1 percent tin. These lode deposits are small and the tin is erratically distributed. The total tin reserve is estimated at less than 1,000 tons, mostly in pegmatites and quartz veins with a grade of one-half to 1 percent (45, pp. 70-71).

Tungsten

(6, pp. 199-207; 15; 18, p. 35; 28, pp. 110-111, 176-178, 219-223; 37; 45, pp. 71-74)

The tungsten mineral wolframite occurs in the vicinity of Lead and Two Bit, Lawrence County, as a replacement in Deadwood Dolomite a few feet above the Precambrian surface. In the southern Hills, Precambrian quartz veins and pegmatites carry huebnerite and wolframite in the Hill City and Spokane areas. Deposits are numerous, but most are small and of low grade.

Production History

Deposits near Lead were exploited during World War I; the peak year was 1917 when 270 tons valued at $299,644 was produced. There has been only small, scattered production from the Hills since that time, and it is doubtful if the operations have been economic.

Potential

It appears that most of the deposits that can be found by surface exploration were exploited during the World War I boom (45, p. 74). High prices offered during the Government stockpiling program of 1950-56 failed to stimulate local production. However, a small production of tungsten would be expected from the Deadwood, Lead, Hill City, and Spokane areas in case of a national emergency, although known deposits are not of the size or concentration necessary for normal market conditions.

Uranium

(25, pp. 206-207; 28, pp. 49-51; 29; 30, pp. 121-123; 45, pp. 50-54)

All uranium in the nine-county area has come from Lower Cretaceous sandstone ore bodies. The principal minerals are carnotite, tyuyamunite, corvusite, rauvite, and coffinite. The discovery of uranium ores in the Black Hills area was made in the fall of 1951, and the first ore was shipped to Rifle, Colo., in January 1952. An AEC buying station was established at Edgemont in 1955. The most productive areas have been in western Fall River County, north of Edgemont, and on the northwestern flank of the Black Hills in Crook County, Wyo. Lesser quantities have been mined in Butte, Custer, Lawrence, Niobrara, Pennington, and Weston Counties. More than 60 properties in Fall River County have contributed ore; perhaps one-fourth that many have shipped from Crook County. The largest operation in the latter area was the Hauber mine of Homestake Mining Co., which employed an average of 40 persons. The mine was shut down in August 1966 after producing 574,544 tons of ore yielding 2,606,223 pounds of U_3O_8.

Potential

Discoveries and investigations to date indicate that ores in the Black Hills area are associated with channel deposits in the Fall River and Lakota Sandstones. With few exceptions individual ore bodies have been relatively small. Results of test drilling in 1966-70 suggest that when drilling is coupled with sufficient geological interpretation, additional small deposits may be located. Until environmental problems associated with the completion and operation of atomic powerplants have been solved, low demand and reduced prices for uranium will not encourage exploration in the Black Hills area.

Reserves

When the Atomic Energy Commission announced on November 24, 1958, that it would purchase uranium from ores discovered only prior to that date,

exploration for new deposits virtually ceased in the Black Hills area. The reserves discovered between 1951 and 1958 were fairly well mined out by the end of 1966, the anticipated date for closing the mill of Mines Development, Inc., at Edgemont. Further extension of the AEC purchasing program through 1968, and changes in regulations to permit private purchase of radioactive materials, encouraged extensive test drilling in the Black Hills vicinity between 1966 and 1970, with the subsequent discovery of substantial but undisclosed reserves.

Vanadium and Molybdenum

(45, pp. 74-77, 80-81)

Vanadium and molybdenum have been recovered to date only as byproducts of uranium milling at Edgemont, S. Dak. The sandstone uranium ores of South Dakota are reported to contain an average of 0.153 percent V_2O_5, or 3.1 pounds per ton. The molybdenum, recovered at the Mines Development, Inc., mill, was derived from uraniferous lignite ores mined in Harding County in the northwestern corner of the State. Small showings of molybdenite have been reported from Tertiary porphyries of Lawrence County, but the occurrences are not believed to be in sufficient quantity or of high enough tenor to be of commercial interest.

Channel sandstones in basal Chadron (White River) beds on Indian Creek, west of Scenic, Pennington County, contain the molybdenum mineral ferrimolybdite. Prospect areas were mapped and drilled during 1964-65. Grades ranging from a few hundredths of 1 percent to as high as 10 percent were reported, with the high values concentrated at the outcrop face. There has been no further activity reported in the area since 1965.

PRODUCTION

Mineral production from the days of the first records in 1879 to the present has grown consistently, responding favorably to each period of increased demand. In South Dakota, during this period, gold accounted for nearly two-thirds of the total value of the mineral production. The nonmetallic commodities of sand, gravel, stone, cement, and clay account for nearly one-third. The remaining minor minerals account for about 5 percent of the total.

Table 5 gives detailed production statistics for each commodity for 1965-69. Initial year of production, peak years, and final year of production are indicated. Table 6 breaks down the petroleum figures to show production by county and field. Table 7 summarizes oil and gas production by counties.

The only commodities produced in the Black Hills area, but not consumed largely within South Dakota and adjacent States, are bentonite, gold, pegmatite minerals, and uranium. In 1970, the Homestake mine contributed 33 percent of U.S. gold production. In 1964, the last year for which detailed figures are available, the Black Hills area produced 49 percent of the Wyoming-type bentonite, 4 percent of the feldspar, and 3 percent of the uranium.

TABLE 5. - Mineral production in Butte, Custer, Fall River, Lawrence, Meade, and Pennington Counties, S. Dak.; and Crook, Niobrara, and Weston Counties, Wyo., - 1968-72

Commodity	First year of production	Peak years	Last year of production	1968		1969		1970		1971		1972	
				Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Bentonite:													
South Dakota.....thousand short tons..	1915	1951	1969	W	W	W	W	NA	NA	W	W	W	W
Wyoming.....do....	1924	NA	1969	W	W	W	W	W	W	891	$9,446	950	$10,111
Beryl.....do....	1914	1953	1969	75	$35	W	W	W	W	W	W	W	W
Columbium-tantalum.....pounds..	1905	1928	1969	NA	NA	W	W	NA	NA	NA	NA	NA	NA
Cement (shipments)....thousand 376-pound barrels..	1925	1961	1969	1,866	6,407	1,593	$5,896	W	W	W	W	W	W
Clays (other)[1].....thousand short tons..	NA	NA	1969	868	9,300	989	10,835	165	$946	150	128	185	156
Coal:													
South Dakota.....do....	NA	NA	1935	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wyoming.....do....	1889	NA	1924	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper.....short tons..	1889	NA	1963	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Feldspar.....long tons..	1923	1946	1969	W	W	W	W	17,211	114	22,000	539	W	W
Gem stones[2].....	1906	NA	1969	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gold.....troy ounces..	1876	1965	1969	593,052	23,283	593,146	24,621	578,716	21,059	513,427	21,179	407,430	23,875
Gypsum.....thousand short tons..	1884	1956	1969	16	65	11	46	15	61	21	83	24	43
Iron ore.....thousand long tons..	1893	1956	1962	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead.....short tons..	1889	NA	1969	NA	NA	NA	([3])	3	1	NA	NA	NA	NA
Lime.....thousand short tons..	1888	NA	1969	W	W	W	W	W	W	W	W	W	W
Lithium minerals.....short tons..	1898	1951	1969	W	W	W	W	W	W	NA	NA	NA	NA
Manganese ore.....do....	1897	1892	1942	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mica:													
Scrap.....thousand short tons..	1899	1946	1969	W	W	W	W	W	W	W	W	W	W
Sheet.....pounds..	1879	1941-43	1963	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Natural gas.....million cubic feet..	NA	NA	1969	3,793	554	3,715	546	1,278	188	14,216	474	2,028	328
Natural gas liquids:													
LP gases.....thousand 42-gallon barrels..	NA	NA	1969	284	514	323	516	NA	NA	NA	NA	NA	NA
Natural gasoline.....do....	NA	NA	1969	225	627	245	685	NA	NA	NA	NA	NA	NA
Petroleum (crude):													
South Dakota.....do....	1955	NA	1969	12	26	8	19	5	12	9	25	6	16
Wyoming.....do....	1887	NA	1969	7,735	20,408	7,456	20,876	8,115	23,777	8,308	25,751	7,907	24,596
Sand and gravel:													
South Dakota.....thousand short tons..	NA	NA	1969	2,700	2,444	1,524	1,526	953	886	1,924	2,298	1,941	2,285
Wyoming.....do....	NA	NA	1969	355	384	388	351	445	398	W	W	W	W
Silver.....thousand troy ounces..	1876	NA	1969	138	295	124	223	120	212	107	165	100	168
Stone:													
South Dakota.....thousand short tons..	NA	NA	1969	1,160	1,809	997	1,228	1,058	1,133	1,427	1,142	1,687	1,976
Wyoming.....do....	NA	NA	1969	3	7	77	117	W	W	54	W	W	W
Tin.....long tons..	1884	1884-93	1969	NA	NA	W	W	NA	NA	NA	NA	NA	NA
Tungsten.....short tons..	1898	1917	1954	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Uranium:													
South Dakota.....thousand pounds..	1952	NA	1969	W	W	W	W	W	W	W	W	W	W
Wyoming.....do....	1952	NA	1969	W	W	W	W	W	W	NA	NA	NA	NA
Vanadium:													
South Dakota.....short tons..	1960	NA	1967	NA	NA	NA	NA	NA	NA	NA	NA	W	W
Wyoming.....do....	1960	NA	1967	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc.....do....	1889	1942-48	1948	NA	NA	NA	NA	1	([3])	NA	NA	NA	NA
Undistributed (values indicated by symbol W).....					3,673		2,832		NA		NA		NA
Total mineral value.....				NAp	69,831	NAp	70,318	NAp	NA	NAp	NA	NAp	NA

NA Not available. NAp Not applicable. W Withheld to avoid disclosing individual company confidential data.
[1]Wyoming only, including bentonite. South Dakota withheld.
[2]No breakdown by county available.
[3]Less than ½ unit.

TABLE 6. - Petroleum fields and production, nine-county Black Hills area

State, county, and field	Location		Discovery date	Producing formation	1972 production		Cumulative production	
	Township	Range			Oil (barrels)	Gas (thousand cubic feet)	Oil (barrels)	Gas (thousand cubic feet)
South Dakota:								
Custer								
Barker Dome	6 S	2 E	1955	Leo	5,935	NA	193,220	NA
Wyoming:								
Crook:								
Ammo	52 N	68 W	1965	Muddy	1,435	NA	57,009	NA
Barton	50 N	65 W	1956	Lakota	NA	NA	7,874	NA
Black Bank	57 N	68 W	1966	Muddy	24,369	NA	383,371	NA
Butler Ranch	49 N	68 W	1958	Newcastle	NA	NA	3,082	438
Cabin Creek	52 N	67 W	1958	...do	NA	NA	354	NA
Corral Creek	55 N	68 W	1962	Minnelusa	17,472	NA	312,972	NA
Coyote Creek (see Weston County)								
Cyclone Canyon	NA	NA	1972	Newcastle	17	NA	17	NA
Donkey Creek	49 N	68 W	1953	Dakota, Muddy, Parkman	211,171	86,275	4,893,853	2,018,433
	50 N	68 W						
Donkey Creek, North	50 N	68 W	1960	Dakota	1,012	NA	321,494	NA
Donkey Creek, South	49 N	68 W	1957	...do	NA	NA	582,546	NA
Foster	49 N	65 W	1957	Lakota, Dakota	NA	NA	2,236	NA
Crasshopper Butte	50 N	66 W	1953	Newcastle, Minnelusa	NA	NA	9,561	NA
	50 N	67 W						
Guthery	51 N	68 W	1963	Minnelusa	214,440	40,537	1,528,630	244,535
Jewel	54 N	67 W	1960	...do	23,860	NA	391,813	NA
Kara	50 N	66 W	1955	Wall Creek	2,033	NA	30,844	NA
Keyhole	50 N	66 W	1967	Morrison	236	NA	2,497	NA
Kiehl	53 N	67 W	1972	Minnelusa	96,433	NA	96,433	NA
Kummerfeld	50 N	67 W	1960	Newcastle, Dakota	272,614	24,953	6,008,158	638,128
	51 N	67 W						
Lad	54 N	68 W	1971	Minnelusa	2,548	NA	14,391	NA
Little Mo	53 N	68 W	1965	...do	23,112	1,154	289,639	14,197
Mellott Ranch	52 N	68 W	1960	...do	292,411	NA	2,566,943	NA
Miller Creek	51 N	68 W	1959	Dakota	99,301	182,721	5,278,629	3,387,707
Miller Creek, East	51 N	68 W	1963	...do	NA	11,792	NA	17,436
Moorcroft	52 N	67 W	1887	Newcastle, Minnelusa	207,093	NA	6,484,323	6,282,986
Oshoto	53 N	68 W	1965	Muddy	NA	NA	12,766	1,368
Pine Ridge	50 N	66 W	1960	Lakota	1,672	NA	23,595	NA
Prairie Creek	53 N	68 W	1960	Newcastle	32,040	44,843	770,654	266,694
	53 N	69 W						
Prong Creek	50 N	67 W	1959	Minnelusa	144,966	NA	2,378,351	NA
	51 N	68 W						
Reynolds Ranch	52 N	68 W	1972	...do	91,095	NA	91,095	NA
Robinson Ranch	50 N	67 W	1958	...do	146,171	NA	6,181,653	NA
Robinson Ranch, East	50 N	67 W	1961	...do	73,561	NA	1,330,925	NA
Robinson Ranch, South	49 N	67 W	1964	Lakota, Minnelusa	44,147	NA	1,160,808	135,815
Rocky Ford	52 N	62 W	1909	Minnelusa	(1)	(1)	(1)	(1)
R. T.	50 N	68 W	1967	...do	NA	NA	16,597	834
Semlek	52 N	68 W	1962	...do	505,341	NA	4,256,187	31,792
Slattery	48 N	68 W	1957	Muddy, Minnelusa	231,734	6,458	4,039,930	55,142
	49 N	69 W						
Soap Hole	50 N	65 W	1966	Fall River	807	NA	7,226	NA
Tomcat Creek	49 N	65 W	1959	Lakota	19,241	NA	91,514	NA
Wakeman Flats	49 N	66 W	1919	Newcastle	1,367	NA	986,065	NA
War Bonnet	49 N	67 W	1966	Muddy	(1)	(1)	(1)	(1)
Wind Creek	49 N	66 W	1958	Butler, Lakota	25,225	NA	231,125	NA
Wind Creek, North	49 N	66 W	1971	Dakota	(1)	(1)	(1)	(1)
Wood	51 N	68 W	1962	Lakota, Butler	374,148	2,135	2,705,135	25,582
Niobrara:								
Ant Hills	37 N	63 W	1927	Dakota	16,395	NA	644,387	20,211
Ant Hills, North	37 N	63 W	1947	...do	9,338	NA	287,605	644,914
Boggy Creek	40 N	64 W	1971	Muddy, Turner	9,888	96,444	34,019	144,924
Bridge Creek	39 N	61 W	1948	Dakota	NA	NA	49,923	NA
Buck Creek	36 N	63 W	1952	Dakota, Leo	NA	NA	3,497	NA
Cheyenne River	41 N	66 W	1953	Newcastle	12,809	135,757	339,045	1,520,333
Cow Gulch	36 N	62 W	1947	Leo, Bell	NA	NA	35,410	NA
Dogie	40 N	65 W	1954	Newcastle	NA	NA	7,763	NA
Hat Creek	34 N	66 W	1971	Canyon Springs, Muddy	38,955	676	48,976	1,309
Jiggs Thompson	41 N	64 W	1961	Dakota, Muddy	NA	NA	10,794	NA
Krejci	37 N	64 W	1960	Mowry	NA	NA	56,738	780
Krejci, North	37 N	64 W	1964	Morrison	NA	NA	9,164	NA
Lance Creek	35 N	65 W	1918	Muddy, Morrison, Sundance, Leo, Dakota.	263,489	443,048	104,072,221	135,940,359
	36 N	65 W						

TABLE 6. - Petroleum fields and production, nine-county Black Hills area--Continued

State, county, and field	Location		Discovery date	Producing formation	1972 production		Cumulative production	
	Township	Range			Oil (barrels)	Gas (thousand cubic feet)	Oil (barrels)	Gas, (thousand cubic feet)
Wyoming--continued								
Niobrara--continued								
Lance Creek, East	36 N	64 W	1919	Dakota, Muddy	16,300	15,892	6,370,634	1,695,382
Leimser	36 N	63 W	1965	Dakota	3,760	NA	43,293	NA
Leverett	38 N	65 W	1954	Newcastle	NA	NA	6,222	NA
Lightning Creek	34 N	65 W	1949	Muddy	29,883	296,303	1,822,849	332,219
	35 N	66 W						
Little Buck Creek	35 N	63 W	1944	Dakota, Leo	7,314	1,884	7,812,719	3,175,815
	36 N	64 W						
Long Green	38 N	65 W	1954	Newcastle	(1)	(1)	(1)	(1)
Lost Springs	34 N	67 W	1971	Teapot	(1)	(1)	(1)	(1)
Mule Creek and Mule Creek, West.	39 N	60 W	1919	Dakota, Minnelusa	38,145	NA	3,109,606	87,301
	40 N	61 W						
Pine Lodge	35 N	63 W	1960	Leo	6,381	NA	94,087	NA
Red Bird	38 N	62 W	1964	...do	10,291	NA	300,091	18,070
Red Bird, Northeast	38 N	61 W	1967	...do	NA	NA	526	NA
Rankin	39 N	65 W	1954	Newcastle	(1)	(1)	(1)	(1)
Snyder Creek	40 N	66 W	1954	...do	NA	NA	14,195	NA
Wagonhammer	40 N	67 W	1954	...do	(1)	(1)	(1)	(1)
Weston:								
Black Thunder	42 N	66 W	1953	...do	51,027	NA	914,091	NA
Cheyenne River	41 N	66 W	1953	...do	(2)	(2)	(2)	(2)
Clareton	43 N	65 W	1950	...do	123,834	NA	525,948	NA
Clareton, Southwest	41 N	67 W	1969	...do	1,938	NA	13,444	NA
Coyote Creek	48 N	68 W	1958	Dakota	400,784	949,600	19,104,938	22,711,935
	49 N	68 W						
Coyote Creek, South	48 N	67 W	1963	Turner, Dakota	204,192	15,575	2,723,403	1,195,353
	48 N	68 W						
Dewey Dome	41 N	60 W	1936	Sundance	66	NA	11,044	NA
	42 N	61 W						
Fiddler Creek	45 N	64 W	1948	Newcastle	81,844	NA	3,056,416	NA
	46 N	66 W						
Fiddler Creek, Southeast	46 N	64 W	NA	Muddy	2,711	NA	99,684	NA
Fiddler Creek, East	46 N	64 W	NA	...do	178,702	NA	10,366,174	NA
Fiddler Creek, West	46 N	65 W	NA	Newcastle	260,483	NA	6,164,593	NA
Finn	42 N	64 W	1965	Newcastle, Wall Creek, Muddy.	40,505	NA	383,609	17,945
	43 N	64 W						
Four T	43 N	65 W	NA	Newcastle	(3)	(3)	(3)	(3)
Frog Creek	41 N	67 W	1972	Muddy	124,690	13,246	124,690	13,246
George Ranch	45 N	65 W	1961	...do	NA	NA	3,990	NA
Hampshire	42 N	65 W	1953	Newcastle	NA	NA	20,079	NA
Hay Creek	45 N	66 W	1949	...do	16,135	NA	1,379,971	660
	46 N	67 W						
Kummerle	45 N	65 W	1948	Dakota	NA	NA	3,269	NA
Lodgepole Creek	44 N	66 W	1949	Newcastle, Dakota	14,299	7,913	632,894	269,100
	44 N	67 W						
Lonetree Creek	45 N	67 W	1949	Turner, Dakota, Newcastle	36,771	120,425	1,532,750	2,303,941
Mat	45 N	67 W	1970	Dakota	1,141	56	9,446	471
Mush Creek	44 N	62 W	1943	Newcastle	174,905	4,574	11,200,862	1,913,428
	44 N	63 W						
Mush Creek, North	44 N	63 W	NA	...do	8,675	NA	79,954	101,999
Mush Creek, West	44 N	65 W	1949	...do	116,669	NA	3,091,194	NA
Newcastle	44 N	61 W	1941	...do	211	NA	5,376	NA
	45 N	61 W						
Osage	46 N	63 W	1919	...do	1,563,341	NA	18,347,725	5,866
	47 N	64 W						
Pedro	45 N	62 W	1922	...do	NA	NA	2,404	NA
	46 N	63 W						
Rochelle	41 N	67 W	1954	...do	(1)	(1)	(1)	(1)
Sherwin	41 N	67 W	1954	...do	55,747	90,375	760,203	275,137
Shurley	42 N	64 W	1963	Wall Creek	23,509	NA	282,616	NA
	42 N	65 W						
Skull Creek	44 N	62 W	1946	Newcastle	425,246	1,627	9,058,265	1,285,114
	45 N	62 W						
Skull Creek, North	45 N	62 W	1946	...do	51,084	191,631	1,109,915	1,090,720
Slattery	48 N	68 W	1957	Muddy, Minnelusa	231,724	6,458	4,039,930	55,142
	49 N	69 W						
Thompson	NA	NA	1972	Newcastle	1,495	NA	1,495	NA
Thornton	49 N	66 W	1915	Turner	756	NA	36,995	NA
Turner	48 N	68 W	1966	...do	3,739	NA	28,490	NA
Wildcat Creek	41 N	64 W	1964	Turner, Muddy	1,495	NA	8,847	NA

NA Not available.
[1]No production reported.
[2]See Niobrara County.
[3]Included in Clareton field.

TABLE 7. - Summary of oil and gas production, by counties

State and county	1972		Cumulative	
	Oil (barrels)	Gas (thousand cubic feet)	Oil (barrels)	Gas (thousand cubic feet)
South Dakota: Custer.....	5,935	-	193,220	-
Wyoming:				
Crook.....	3,491,055	400,068	53,540,278	13,121,087
Niobrara.....	462,954	988,120	13,203,588	3,613,405
Weston.....	4,197,728	1,401,480	95,124,704	31,240,057
Total.....	8,157,672	2,789,668	162,061,890	47,974,549

Coal and gypsum are the only two mineral commodities present in the nine-county area in near commercial quantities that are imported rather than produced from local supplies. As noted elsewhere in this report, coal for the Black Hills area is mined only 15 miles west of Crook County under ideal conditions that cannot be duplicated closer to the Hills. Historically, local sources of gypsum have supported small plaster mills at Spearfish, Sturgis, Piedmont, Black Hawk, Rapid City, and Hot Springs. Repeated surveys within the last few years have shown that it is more economical to mine and process gypsum for plaster-of-paris, sheetrock, and other gypsum products in adjacent Montana and Iowa than to attempt to operate a small-scale mining and processing operation in the Black Hills area.

MARKETS

The Black Hills mineral industry is dependent upon the availability of national, regional, and local markets for its various mineral products. Bentonite and the pegmatite minerals, and more recently gold and uranium, enter the national market directly. Such commodities as petroleum and natural gas, cement, lime, brick, and lightweight aggregate enter the local and regional markets. Rock, sand, and gravel are fairly well confined to markets within a 200-mile radius.

Rock

Local and regional demand is easily met by existing quarries and preparation facilities. The market for crushed rock, riprap, flagstone, and other rough forms is limited to a practical shipping distance of 200 miles beyond the perimeter of the Hills; additional markets may be generated by increased construction demands within this limit. Quarries are well located with regard to shipping facilities, both rail and truck, and production could be greatly increased if conditions warranted.

Rock quarries in the Mitchell-to-Sioux Falls area produce crushed Sioux Quartzite at points on the Chicago and Northwestern, and the Milwaukee Railroads, thus sharply limiting shipments of Black Hills rock eastward on those same railroads.

Petroleum and Natural Gas

Production of crude oil in the nine-county area exceeds present refining capacity; much crude leaves the area by pipeline, and finished products enter the area from outside refineries. Active exploration for oil and gas is in progress in Weston and Crook Counties and small discoveries are made yearly in each. Wyoming has no prorationing law, but production may be limited by pipeline capacity. Pipelines are built as reserves justify their construction. The present shortage of crude oil, both locally and nationally, assures a ready market for any oil or gas discovered.

The nine-county area does not produce sufficient gas for its own needs. Towns on the north and east side, from Colony, Wyo., to Rapid City and Ellsworth Airforce Base, S. Dak., are supplied with natural gas from Wyoming and North Dakota by Montana-Dakota Utilities.

Cement

The Black Hills area is self-sufficient in portland and masonry cement, and has a surplus available for regional distribution. The marketing area is fairly well prescribed by shipping costs, so production and sales are largely dependent upon the demand of the construction industries within that area. In 1972, the State cement plant at Rapid City operated at about 77 percent of its rated capacity, marketing nearly 2.7 million barrels during the year. The Cement Commission owns reserves of limestone that are adequate for many years' operation at the current rate, and supplies of shale, gypsum, sandstone, and iron ore are essentially limitless.

Brick and Other Ceramics

The market for common brick is definitely limited by shipping costs and the location of competing plants in surrounding States. Production is entirely dependent upon demand within the prescribed area. But because architects and builders will pay a premium for particularly pleasing colors and textures of face brick, the latter may be sold throughout a much larger area. The local brick industry, having a variety of clays to draw upon, modern facilities, and production capacity well beyond present market demands, is in an excellent position to compete in adjacent market areas.

Lime

The market for high-quality lime products is limited both by the competition of other plants located on good sources of raw material, and by shipping costs to intermediate points. The Black Hills lime industry is ideally located in this respect, and with increased demand for lime (particularly for highway stabilization) in the area, it has been possible to support a new and rapidly expanding industry. The current marketing radius is approximately 500 miles, although shipments have gone as far south and west as Arizona.

Adequate reserves of high-calcium limestone make even further expansion practical.

Lightweight Aggregate

The lightweight aggregate plant at Rapid City serves most of South Dakota, and adjacent parts of Wyoming, Montana, and Nebraska. About one-half of the product is manufactured into Haydite block at the Rapid City plant; the remaining fraction is shipped as aggregate for manufacture of block and tile in other centers of construction, or for use as bulk aggregate. The present facility at Rapid City has access to unlimited reserves of high-grade bloating shale, and has been operating at roughly one-half its rated capacity.

NEEDS OF THE MINING INDUSTRY

Land

Land devoted principally or exclusively to mining operations represents less than one-half of 1 percent of the total land area under study. In regular mining, land so classified would include only the area devoted to excavations, stock and waste piles, access roads, and milling activities. On petroleum leases, it is estimated that between 2 and 5 percent of the area under production is occupied by pump installations, treaters, tank batteries, and access roads.

In mining operations where extensive stripping is required, waste piles may occupy one to five times the area of the excavation. In pegmatite mining, stripping is at a minimum, but waste rock piles generally occupy at least twice the area of the original excavation. In bentonite and uranium mining, where there may be a very high ratio of overburden to ore, waste piles and abandoned pits cover significant areas, but even here it is unusual for the entire mining operation to occupy 50 percent of the land area of the individual mining claim or lease.

In local sand and gravel operations, overburden is generally thin; when a pit is abandoned, strippings and oversize material are usually left within the boundary of the excavation. Virtually no stripping is necessary when mining Minnekahta Limestone, so operations are restricted to the outlines of the excavation. Crushing, sizing, stockpiling, and loading operations are often confined to the mined-out area.

Some areas from which bog iron and bentonite have been removed have been regraded by the operators and restored to their original contours.

As an example of land utilization, Homestake Mining Co. in 1965 owned 93,400 acres in the Black Hills nine-county area. Of the total, 7,500 acres was patented mining claims, 300 acres was unpatented mining claims, 52,200 acres was timberland, 26,200 acres was farmland, and 7,200 acres was classified as miscellaneous uses. Gold and uranium operations of the company were estimated to require the exclusive use of less than 1 percent of the total acreage; water gathering and active timber cutting accounted for less than an additional 1 percent.

At the present rate of consumption, it is estimated that the limestone under 20 acres of Minnekahta Limestone outcrop is depleted each year, and that bentonite is mined out from under 210 acres per year. It is not easy to estimate the area affected by sand and gravel operations; perhaps a total of 25 acres is stripped, mined out, and abandoned each year. The annual increment lost from smaller surface operations and from underground mining operations is very small.

Water

Most water use figures are estimates. The following discussion and tables are based on data collected by the Bureau of Mines in a 1962 water canvass of the Black Hills data on public file at the School of Mines and Technology at Rapid City, and figures collected especially for this report.

Mining, processing, and refining operations in the nine-county area probably require 10,000 gallons per minute of new water. About one-half the water is derived from surface sources; the rest comes from groundwater. Groundwater includes both fresh and saline well water and mine water. About one-half the water is consumed; the remainder is discharged into surface streams or ponds after use. Over 90 percent of all individual operations depend entirely upon wells for their water requirements.

In 1972, 52 waterflood operations were underway in 18 oilfields in the three Wyoming counties of Crook, Weston, and Niobrara. Some of the water is saltwater produced along with the oil, but most is new water derived from wells into the late Cretaceous and early Tertiary sandstones, or from the Madison Limestone. No reliable estimate of the total water consumed by these projects is available.

Table 8 represents an updating of a water-use inventory conducted in the Black Hills area in 1962. It has been possible to secure recent figures from all large users except the scattered waterflood operators.

Little change is anticipated in total demand for water by the mineral industry. Gold milling, currently the largest single consumer, will continue at approximately its present rate of consumption, insofar as the Homestake mine is concerned. Opening of other properties following the recent drastic raise in the price of gold would, of course, create additional demands which would be met from mine water and surface water supplies.

The second most important user, the oil industry, uses water primarily for refining and for waterflooding of producing fields. Overall demand for water for these purposes will increase in the Powder River basin for several years. However, within the three counties under consideration, the demand probably will not exceed the present rate of withdrawal within the foreseeable future.

The volume of water used for washing sand and gravel and rock are small. Much of it is reused or ultimately returned to circulation, and even an

appreciable increase in the demand for these commodities would not strain available sources of water supply.

TABLE 8. - Sources and estimated requirements of new water used by mineral industries of Black Hills nine-county area, on annual basis

Type of operation	Year[1]	Requirements (gallons per minute)	Sources	Remarks
Mining and milling:				
Homestake Mining Co.....	1972	6,000	3/4 surface; 1/4 mine.	1/4 consumed; 3/4 discharged.
Susquehanna-Western.....	1965	1,740	Wells.....	3/4 consumed; 1/4 discharged.
State cement plant.....	1972	220	.....do.....	Consumed.
Bentonite and feldspar mills.	1965	40	.....do.....	Do.
All others.....	1972	10	.....do.....	Do.
Rock sand, and gravel: Washing, etc.	1962	75	Wells and surface.	Mostly discharged.
Petroleum:				
Drilling.....	1962	38	.....do.....	Consumed.
Waterflooding, fresh and saline.	-	1,506	Water and oil wells.	-
Refining.....	1971	175	Well.....	Consumed (evaporated).

[1] Date of basic information.

The volumes of water used for washing sand and gravel and rock are small. Much of it is reused or ultimately returned to circulation, and even an appreciable increase in the demand for these commodities would not strain available sources of water supply.

Energy

Power consumption of the Black Hills mineral industry in 1971 is shown in table 9. Other sources of energy utilized by the mineral industries include natural gas, fuel oil, coal, diesel fuel, and sawdust. Table 10 estimates gas and fuel oil consumed during 1971 by the principal users. Homestake Mining Co. burned 4,508 tons of Wyodak coal during the year. Nearly all operators used diesel-powered equipment; a conservative estimate would be between 150,000 and 225,000 gallons of that fuel consumed. Gas and oil used by the petroleum industry in pumping, refining, and other operations have not been included.

TABLE 9. - Power consumption of Black Hills mineral industry, 1971

Category	Kilowatt-hours	Sources
Homestake Mining Co. (gold)....	121,729,537	70 percent Black Hills Power and Light Co.; remainder is hydroelectric generation by Homestake Mining Co.
Other metal mining and metallurgical operations.	6,544,000	Black Hills Power and Light Co.
State cement plant.....	37,519,000	Bureau of Reclamation (Missouri River).
Bentonite mills.....	28,151,420	Black Hills Power and Light Co.
Other stone and clay products..	3,208,886	Do.
Petroleum refining.....	23,821,152	Black Hills Power and Light Co. Less than 1 percent other sources.
Petroleum, pipeline, and pumping.	12,658,496	Black Hills Power and Light Co.
Do.....	[1]34,000,000	Tri-County Electric Association
Total.....	267,632,491	-

[1]Estimated with assistance of Manager, Tri-County Electric Association. A parallel estimate for 1972 is 47 million kilowatt-hours.

Sources: Black Hills Power and Light Co., Rapid City, S. Dak.; Tri-County Electric Association, Sundance, Wyo.

TABLE 10. - Major mineral industry users of gas and oil, 1971

Industry	Gas (thousand cubic feet)	Fuel oil (gallons)
Bentonite industry.....	930,409,000 (4 plants)	[1]2,000,000 (3 plants)
Gold mining.....	196,984	14,000
Cement, other clays.....	2,424,987	14,000
Total (estimated in part)....	933,030,971	2,028,000

[1]Estimated.

PROCESSING AND PROCESSING PLANTS

Bentonite

Bentonite occurs in beds 3 to 5 or more feet thick which dip gently away from the Black Hills at 3° to 10°. Overburden consists of medium hard, fissile, dark gray, marine shale. Because the bentonite overlies the resistant Mowry Shale, it generally crops out on the flanks of a well-drained topographic ridge.

Overburden is stripped with a variety of heavy equipment, and the clay is turned over and remains in place for several weeks or months in advance of

mining to permit natural reduction of moisture content. Then the crude bentonite is loaded into trucks and hauled to stockpiles at one of the strategically located processing plants. If necessary, clays are blended to produce a uniform feed to the mills, which dry, grind, and size it. The finished clay is either sacked or shipped in bulk.

Three plants in Weston County are located on the Burlington Northern Railroad running from Omaha to the west coast via Billings, Mont. One in Butte County and three in Crook County are situated on a spur of the Northwestern Railway, which extends from Belle Fourche, S. Dak., to Colony, Wyo. Some clay is shipped by truck.

Drying is done in rotary kilns fired with gas or fuel oil. Capacity and other data on each of the seven operating plants are given in table 2. All plants rely on wells to supply their small water requirements.

Clay Products

Black Hills Clay Products Co. established a brick plant at Belle Fourche in 1927. Through successive modernization and expansion, the plant now has two modern, downdraft, gas-fired kilns, each capable of producing 14,000 bricks each 36 hours. Common and face brick in several styles are produced. Until recently, tile was fired in one of the old beehive kilns at the plant. The company is able to produce several colors of fired products by selective mining and blending of clays from two quarries developed in the Fuson Member of the Lakota Formation. The company employs an average of 20 men throughout the year.

Light Aggregates, Inc., has produced a lightweight aggregate at Rapid City since 1952. Most of the aggregate is used at the site for manufacture of lightweight concrete or Haydite blocks. Shale is bloated in a gas-fired kiln having an hourly capacity of 10 tons. A shale pit is located in the Pierre Shale 8 miles east of town, and the shale is trucked to the kiln west of Rapid City. Electricity is supplied by Black Hills Power and Light Co., gas comes from Montana-Dakota Utilities, and water is obtained from a 200-foot well into the Minnelusa Sandstone. An average of nine employees was reported in 1971.

Cement

The State-owned cement plant at Rapid City has been expanded from a rated capacity of 2,000 barrels per day in 1925 to the present capacity of 10,000 barrels per day or 3.5 million barrels per year. Sales in 1972 totaled 2,668,278 barrels valued at $13,116,938. The plant is served by a siding of the Chicago and Northwestern Railway, but an increasing percentage of the cement, both sacked and bulk, is shipped by truck.

Two rotary kilns and three grinding circuits may be operated simultaneously. The kilns are normally fired with gas, but fuel oil must be used during cold periods when extra gas is needed for domestic heating. Gas is supplied by Montana-Dakota Utilities, and fuel oil is purchased on the open market. Electric power is obtained from the Bureau of Reclamation. In 1971,

18.7 kilowatt-hours of electricity and 1.115 Mcf of gas were consumed for each barrel of cement produced. Water is obtained from three 200-foot artesian wells in the Minnelusa Sandstone.

An average of 185 persons was employed during 1971.

Lime

The Black Hills Lime Co. has operated a lime kiln at Pringle, Custer County, intermittently since 1899. A high-grade metallurgical lime is produced. Two vertical kilns, having a total capacity of approximately 16 tons per day, use sawdust as fuel. The company operates a quarry in the Pahasapa Limestone adjacent to the plant. The average number of employees in 1971 was seven.

Utah-Idaho Sugar Co. at Belle Fourche for many years purchased high-calcium limestone and produced its own quicklime, but the plant was permanently closed at the end of the 1964-65 season.

A new lime plant, adjacent to quarries in the Minnekahta Limestone west of Rapid City, was opened by Pete Lien & Sons late in 1964 (fig. 5). It has a gas-fired rotary kiln capable of producing 160 tons per day of calcium oxide and a vertical kiln with a daily capacity of 180 tons of CaO per day.

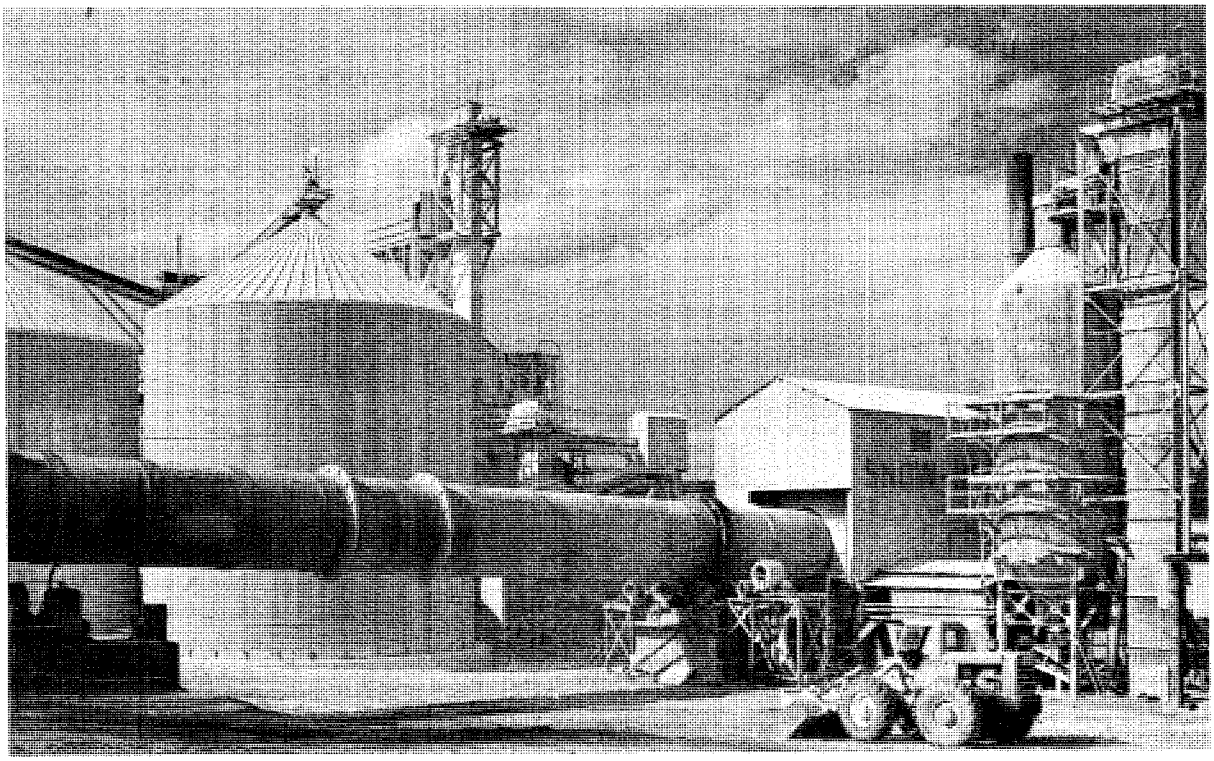

FIGURE 5. - Lime-processing plant of Pete Lien & Sons, Rapid City, S. Dak. Note a traditional horizontal rotary kiln at left and a newer vertical design at right.

The vertical kiln was added in 1966. Gas is supplied by Montana-Dakota Utilities and electric power by Black Hills Power and Light Co. The company has its own water well. Both quicklime and hydrate are produced. The products are shipped by truck and by rail all over South Dakota and into adjacent States within a 500-mile radius. Lime is used for water treatment, for masonry and plaster, and for highway stabilization in areas of bentonitic shales. An average of 21 employees is required for the 24-hour operation.

Gold

The Homestake mine and mills at Lead and Deadwood have been gradually increased in capacity, and in 1971 treated an average of 4,930 tons of ore per day (fig. 6). Until 1970, gold was recovered by amalgamation and classifying;

FIGURE 6. - Aerial view of Homestake Mining Co. surface plant at Lead, Lawrence County, S. Dak. Major units are (1) Yates shaft and hoisting plant, (2) company offices, (3) Ross shaft and hoisting plant, (4) compressor building, (5) south mill, (6) east cyanide plant, (7) west cyanide plant, (8) gold refinery.

(Photo courtesy Homestake Mining Co.)

after final grinding, the sands and slimes were separately leached by cyanide solutions, and the gold was recovered from solution by precipitation with zinc dust. Under this process, gold recovery averaged between 95 and 96 percent. The use of mercury for amalgamation was phased out between August and December 1970, and an appreciable drop in recovery was experienced. A new carbon-in-pulp cyanidation plant will replace the old slime treatment plant in mid-1973, and gold recovery is expected to return to near its former level.

Bullion formerly was shipped by express to the United States Mint in Denver, but since 1968 the gold has been sold directly on the open market.

The gold operations of the Homestake Mining Co. employed an average of 1,808 employees in 1971.

Pegmatite Minerals

The only feldspar-grinding plant currently operating in the Black Hills is located at Custer, on a branch line of the Burlington Northern Railroad. Originally started in 1936, the plant was largely rebuilt and enlarged after a fire in 1958, and is now capable of processing 44,000 tons of feldspar per year. The present owner of the mill is the Pacer Corp. of Custer, S. Dak. (fig. 7). About 25 men are employed.

Two grinding plants have operated at Keystone. A pioneer mill was built in 1929, subsequently enlarged, and finally destroyed by fire in 1957. A small grinding mill, built in the 1960's, was destroyed by the flood of June 1972.

Attempts at more sophisticated milling of pegmatite rock in the Black Hills have been short lived. Prior to and during World War II, a flotation mill at Tinton, Lawrence County, separated fine-grained amblygonite from quartz. In 1952, Lithium Corp. of America built a 160-ton flotation mill at Hill City for separation of spodumene from the Matteen and other lithia pegmatites. Competition from eastern lithium-producing areas, coupled with a limited supply of water and lithia-bearing rock, caused the plant to shut down in 1956. Northwest Beryllium Corp. operated a 175-ton mill at Keystone from 1963 through 1969. It was designed to recover feldspar, mica, columbite-tantalite, cassiterite, beryl, and quartz from old pegmatite dumps or from freshly mined pegmatite rock.

Petroleum and Natural Gas

The various processing facilities maintained by the petroleum industry extend from wellhead to the refinery. They include pumping, treating, and gathering facilities, pipeline and pumping stations, plants for recovering natural gasoline and liquefied petroleum products from gas, and pumping facilities for injecting gas or water back into the reservoirs for repressuring or pressure maintenance. These scattered facilities, even though important in the aggregate, have not been inventoried for this survey.

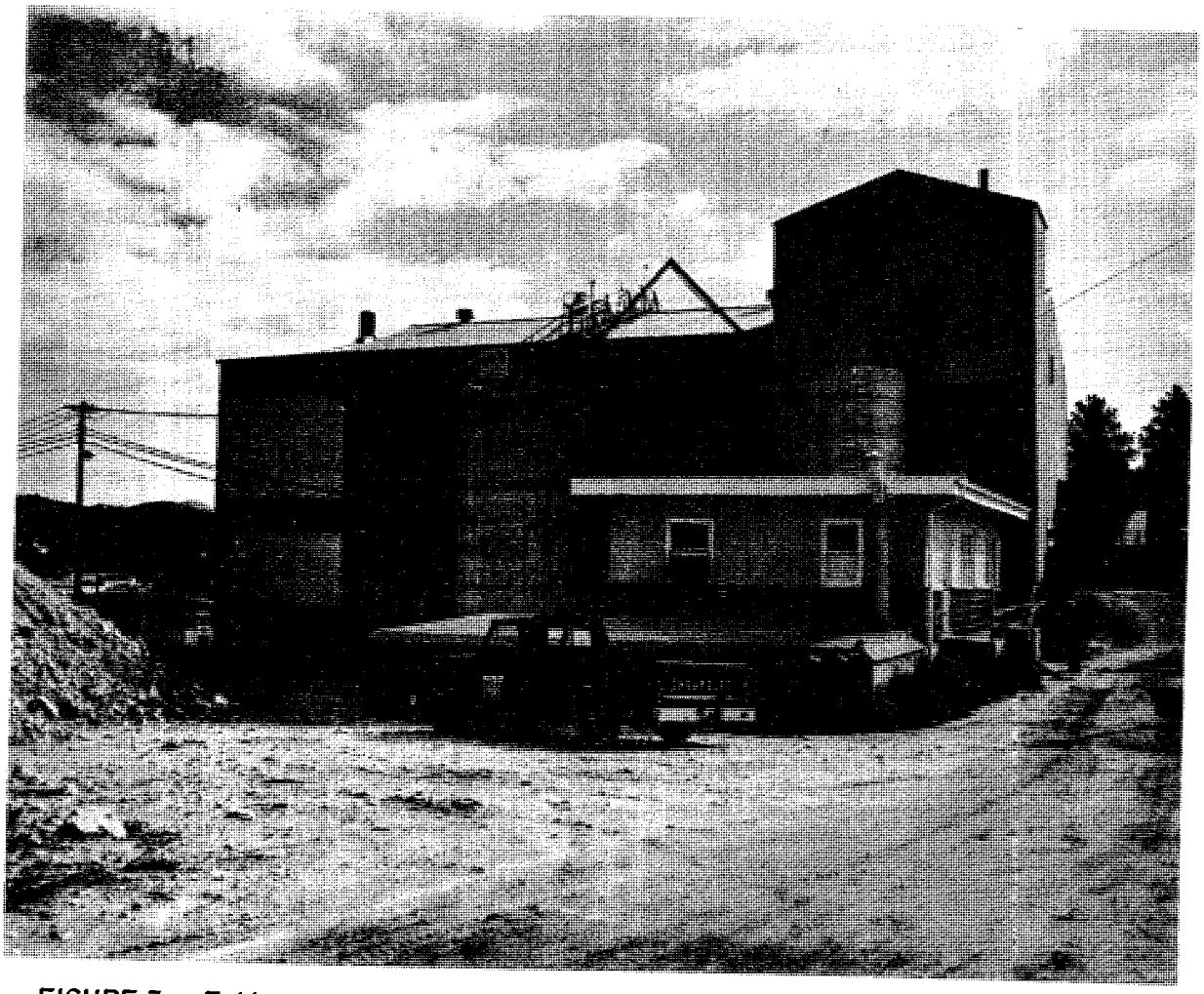

FIGURE 7. - Feldspar-processing plant at Custer, S. Dak. Sold to Pacer Corp., Custer, by International Minerals and Chemical Corp. in 1972.

Tesoro Petroleum Corp. operates a refinery at Newcastle, Wyo., capable of processing 8,000 barrels of crude oil per day. Products include gasoline, diesel fuel, jet fuel, lubricants, and heating oils, most of which are marketed within 100 miles of the refinery. During 1971, the plant consumed 252,000 gallons of water per day from its own 3,465-foot well into the Madison Limestone. Fifty-three persons were employed during 1971.

One product line in the area delivers from Newcastle to a distribution terminal at Rapid City.

The C. & H. Refinery at Lusk is a small skimming plant that employs about five people.

True Oil Co. operates a small gas plant in the Coyote-Donkey Creek area of Crook and Weston Counties, Wyo. In 1972, the plant processed 1,014,185 Mcf of gas, and recovered 5,440,649 gallons of liquid petroleum products.

Sand and Gravel

Most masonry-grade sand and gravel is produced from deposits along the Cheyenne River. The product is washed and sized. Most of it is moved by truck, although railroad facilities are available near each of the major operations. At the peak of the construction season, probably between 30 and 35 men are employed in scattered operations. The operations shown in table 11 are presently active, or have contributed appreciable tonnages in the recent past.

TABLE 11. - Sources of sand and gravel, 1973

Company	Location	Source
Birdsall Sand & Gravel Co., Rapid City.	Cheyenne River above Wasta, Pennington County.	Sand and gravel from beneath present flood plain, and from channel.
Do.....	Cheyenne River at Oral, Pennington County.	Sand from terraces above present flood plain.
L. G. Everist, Inc., Sioux Falls and Rapid City.	Cheyenne River near old Highway 16 bridge. Operation closed down at Wasta.	Sand and gravel from flood plain and present river channel.
Do.....	Cheyenne River near Creston, Pennington County.	Sand and gravel from beneath present flood plain.
Hills Materials, Inc. (formerly Flyte), Rapid City.	Cheyenne River near highway at Oral, Pennington County.	Sand from stream terraces above present flood plain.

Small quantities of sand for use in local concrete products plants are obtained from along the Belle Fourche River at Belle Fourche, and along Whitewood Creek near Whitewood.

A plant for mining, crushing, and sizing silica sand operated intermittently at Pringle between 1964 and 1970. The plant was dismantled in early 1973. An earlier plant at Redfern, Pennington County, became inactive in 1962.

Stone

Several quarries, favorably situated with regard to market and transportation, have operated continuously for many years. Others, some of large size, have been opened only for specific jobs, and have become inactive once the project was completed.

At a typical rock quarry, the stone is drilled, blasted, hauled to the crusher, crushed, sized, and either loaded directly or placed in stockpiles. Some of the operators have facilities for supplying washed stone on demand. The following operators supply stone to the trade:

Hills Materials Co., Rapid City.--Quarries at Rapid City and Loring Siding, Pennington and Custer Counties, respectively.

Pete Lien & Sons, Rapid City.--Quarries at Rapid City and Argyle Siding, Pennington and Custer Counties, respectively.

L. G. Everist, Sioux Falls and Rapid City.--Quarry north of Rapid City near Blackhawk, Pennington County.

Lee's Quarry, Spearfish, inactive.--Quarry between Spearfish and Deadwood, Lawrence County.

Flyte Sand and Gravel Co., Hot Springs.--Quarry on north side of Hot Springs, Fall River County.

Roberts Construction Co., Sundance, Wyo.--Quarry near Sundance, Crook County.

Reeves Quarry, Newcastle (leased on royalty basis from Bureau of Land Management).--Quarry 7 miles southeast of Newcastle, Weston County.

The State cement plant processes from 400,000 to 450,000 tons a year but uses it all in its own operation. Black Hills Lime Co. supplies a small amount of crushed rock to the trade, but uses most of its production in its own kilns. Pete Lien & Sons supplies both the trade and its lime operation from the Rapid City quarry.

Small quarries are operated intermittently by the city of Lead, the U.S. Forest Service, several county highway departments, and the Wyoming Highway Department.

In 1969, the total rock produced within the nine-county area was reported to be 1,345,542 tons.

Uranium

A uranium mill at Edgemont was completed in late 1955 by Mines Development, Inc., a subsidiary of Susquehanna-Western, Inc. Originally built to process 250 tons per day by the acid-leaching, resin-in-pulp process, its capacity has been gradually increased to a rated 650 tons per day. A vanadium recovery circuit was added in 1960, and a molybdenum recovery unit was added in 1963 to recover molybdenum from uraniferous lignite ash from the Buffalo area, Harding County, S. Dak. Processing of the lignite ores ceased in 1966. Water is obtained from deep wells in the Madison Limestone. When the plant is running near capacity, water consumption approximates 2.5 million gallons per day. The final product is yellow cake (U_3O_8 concentrate), which is barreled and shipped elsewhere for further processing. In full operation, the plant employs approximately 60 persons. In mid-1974, the plant was on a standby basis until the market price of uranium improved.

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U.S. GOVERNMENT PRINTING OFFICE : 1974 O - 563-972

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