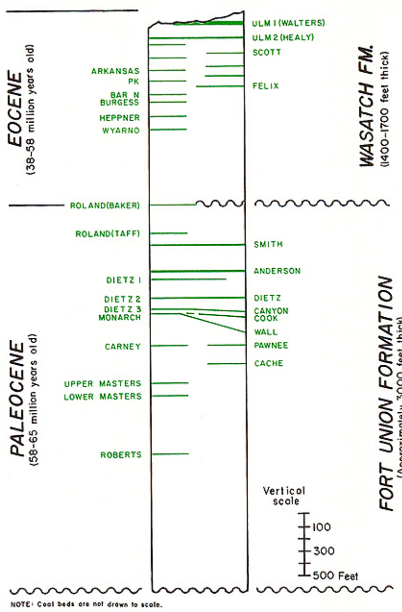
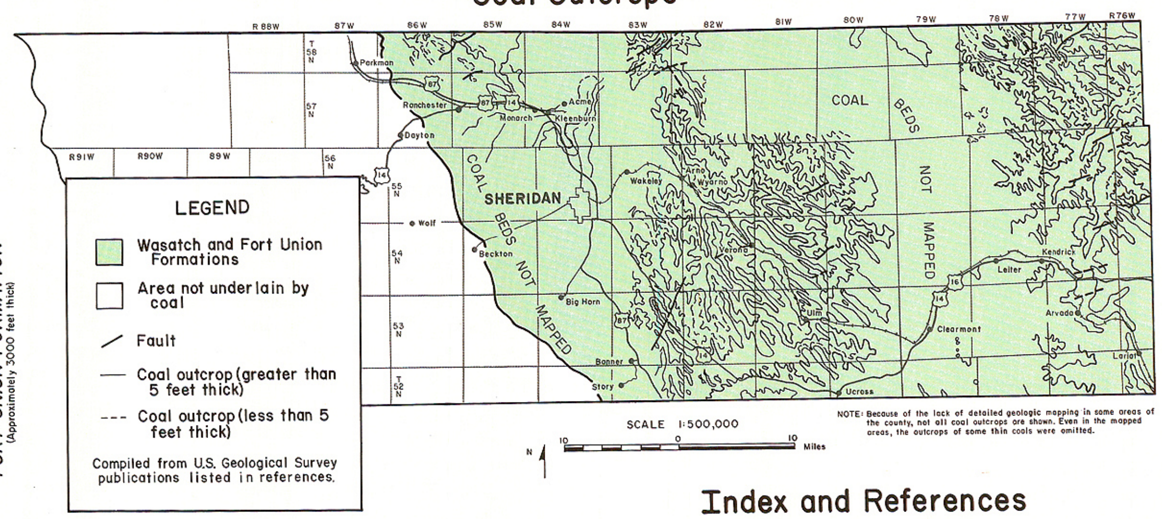


Coal Outcrops



Coal Resources

Between 38 and 65 million years ago, densely vegetated swamps frequently covered what is now Sheridan County. Beneath the waters of these swamps, dying trees, reeds and grasses accumulated as thick layers of dead plant material. As thousands of years passed, sediment was intermittently deposited atop these accumulations, converting them into peat beds. Pressure resulting from the weight of these added sediments compressed the peat, and heat associated with the increasing depth of burial transformed the peat into subbituminous coal. As a result of uplift and subsequent erosion, these coals now crop out over most of the eastern two-thirds of the county. The western third of Sheridan County, however, contains no coal-bearing rocks, partly because of nondeposition and partly because the same erosion that exposed coals in the east completely removed the coal-bearing rocks in the west.

While coal beds are flat-lying or dip very gently westward on the east side of Sheridan County, coals dip eastward in the west central part of the county. Many coals are mapped for more than thirty miles along their outcrops. The lack of detailed mapping, not the lack of coal, accounts for the apparent absence of coal outcrops in some portions of eastern Sheridan County.

The Tertiary Fort Union and Wasatch Formations contain all of the thick and persistent coals that crop out in Sheridan County. In fact, these two formations are two of the most prolific coal-bearing formations in Wyoming. In Sheridan County, the Wasatch Formation contains six to ten persistent subbituminous beds or coal zones. The Ulm No. 1 and the Ulm No. 2 beds are up to 52 and 30 feet thick, respectively, but most minable coal beds in the Wasatch Formation are between five and fifteen feet thick.

The upper half of the older Fort Union Formation contains up to twelve persistent subbituminous coals, which are a few feet to 45 feet thick. Coals occur in the lower half of the Fort Union Formation as well, but these coals are thinner and much less persistent than those in the upper part of the formation.

Although the Cretaceous Lance and Mesaverde Formations exhibit some minable low rank coals on the southern and eastern edges of the Powder River Basin, there is no evidence that any but very thin, discontinuous coals occur in these formations in Sheridan County.

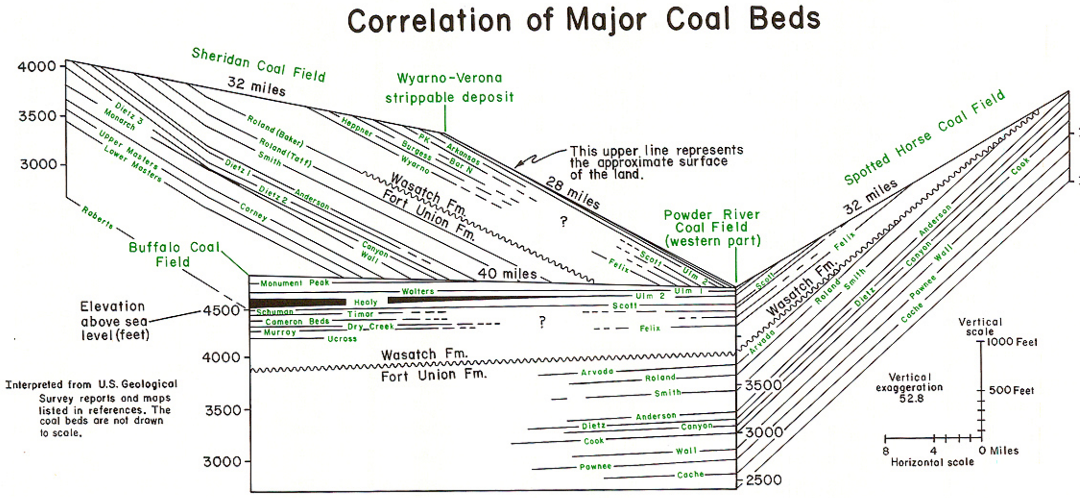
Many outcropping coals have been burned through natural causes over large areas of the county. In particular, the thicker coal beds are extensively burned along their outcrops. The heat from these fires has baked and fused overlying rock into distinguishable red "clinker" beds, characteristic of this and many other coal-bearing areas of Wyoming. Despite this burning, more than 26 billion tons of coal still underlie Sheridan County at depths up to 3,000 feet. Of an estimated 7.1 billion tons of coal that occur under less than 1,000 feet of overburden, 5.2 billion tons are believed minable by underground methods.[1] Another 1.9 billion tons that lie under less than 200 feet of rock are potentially recoverable by strip mining.[2]

Twenty-one percent of Wyoming's remaining identified coal resources and seven percent of its known strippable reserves are in Sheridan County.

[1] Hamilton, P.A., White, D.H., Jr., and Matson, T.K., 1975, The reserve base of U.S. coals by sulfur content, Part 2, The western states: U.S. Bur. Mines IC 8693, p. 267.

[2] Culbertson and Mapel, 1976, and Smith and others, 1972: see Index and References.

Correlation of Major Coal Beds



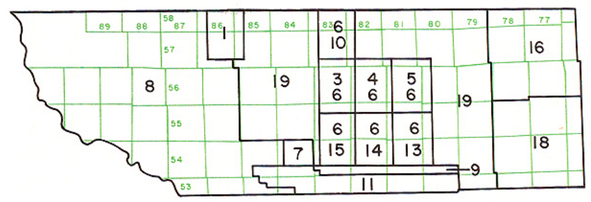
Coal Analyses

	FORT UNION FORMATION																		
	CARNEY			DIETZ NO. 1	DIETZ NO. 2			DIETZ NO. 3			MASTERS'[1]			MONARCH			ROLAND[2]	SMITH
AS RECEIVED	RANGE	AVER.	AVER.		RANGE	AVER.	AVER.	RANGE	AVER.	AVER.	RANGE	AVER.	AVER.	RANGE	AVER.	AVER.		
NUMBER OF ANALYSES	46[3] (13)[4]	46	13	1	14[3] (4)[4]	14	4	11[3] (2)[4]	11	2	6[3] (2)[4]	6	2	76[3] (18)[4]	76	18	1	1
PROXIMATE: MOISTURE (%)	21.2-25.8	24.1	23.6	24.7	21.3-23.6	22.4	22.4	19.1-25.7	23.8	21.8	22.7-25.8	24.0	23.3	19.8-25.0	23.0	22.8	23.5	23.9
PROXIMATE: VOLATILE MATTER (%)	29.5-35.8	32.0	32.3	37.6	31.3-34.1	33.2	32.8	30.0-34.8	31.6	33.0	32.4-34.8	33.9	34.5	31.2-38.3	33.9	33.4	34.5	35.8
PROXIMATE: FIXED CARBON (%)	34.9-43.7	40.3	40.3	33.0	35.5-40.2	37.8	38.1	33.9-41.7	39.5	40.7	36.6-38.2	37.5	37.4	33.1-42.1	38.8	39.2	37.2	34.3
PROXIMATE: ASH (%)	2.6-8.6	3.7	3.8	4.7	5.0-8.5	6.7	6.8	3.5-8.6	5.2	4.6	3.8-5.9	4.7	4.9	2.8-11.2	4.4	4.6	4.8	6.1
ULTIMATE: HYDROGEN (%)	5.8-6.5		6.3	6.2	6.1-6.4		6.3	6.1-6.3		6.2	6.1-6.3		6.2	5.8-6.9		6.4		6.5
ULTIMATE: CARBON (%)	52.3-55.3		53.8	51.5	50.6-53.6		52.2	52.6-56.6		54.5	52.7-53.7		53.1	49.2-55.3		53.9		51.0
ULTIMATE: NITROGEN (%)	0.9-1.2		1.1	1.1	1.2-1.3		1.2	1.1-1.4		1.3	1.0-1.2		1.1	1.0-1.3		1.1		1.1
ULTIMATE: OXYGEN (%)	32.5-36.1		34.7	36.1	31.7-33.1		32.5	31.3-34.7		33.0	34.1-34.8		34.5	30.4-35.0		33.3		34.6
ULTIMATE: SULFUR (%)	0.3-0.8	0.4	0.4	0.4	0.7-1.3	1.0	1.1	0.3-0.6	0.5	0.5	0.3-0.7	0.5	0.3	0.2-1.2	0.5	0.6	1.4	0.8
HEAT VALUE BTU/POUND	8910-9720	9240	9260	8903	9000-9430	9200	9200	8730-9710	9060	9360	9010-9360	9230	9250	8450-9820	9350	9410	9010	8820

[1] Undifferentiated Upper and Lower Masters [2] Roland of Taft [3] Number of analyses used to determine range for proximate analysis, sulfur, and heat value
[4] Number of analyses used to determine range for hydrogen, carbon, nitrogen, and oxygen

(Table compiled from channel, tipple, or delivered samples analyzed by the U.S. Bureau of Mines. Only a few analyses represent the full thickness of a given bed. Noncoaly partings and dirty (bony) coal were removed from channel samples).

Index and References



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2.* Berryhill, H.L., Jr., and others, 1950, Coal resources of Wyoming: U.S. Geol. Survey Circular 81, 78 p.

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4. Culbertson, W.C., and Klett, M.C., 1975, Preliminary geologic map and coal sections of the Jones Draw quadrangle, Sheridan County, Wyoming: U.S. Geol. Survey Misc. Field Studies Map MF-726, 2 sheets.

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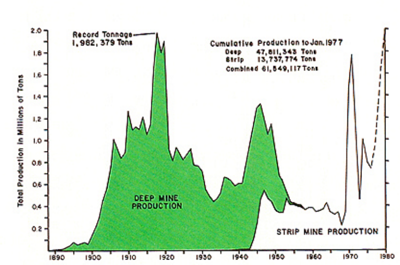
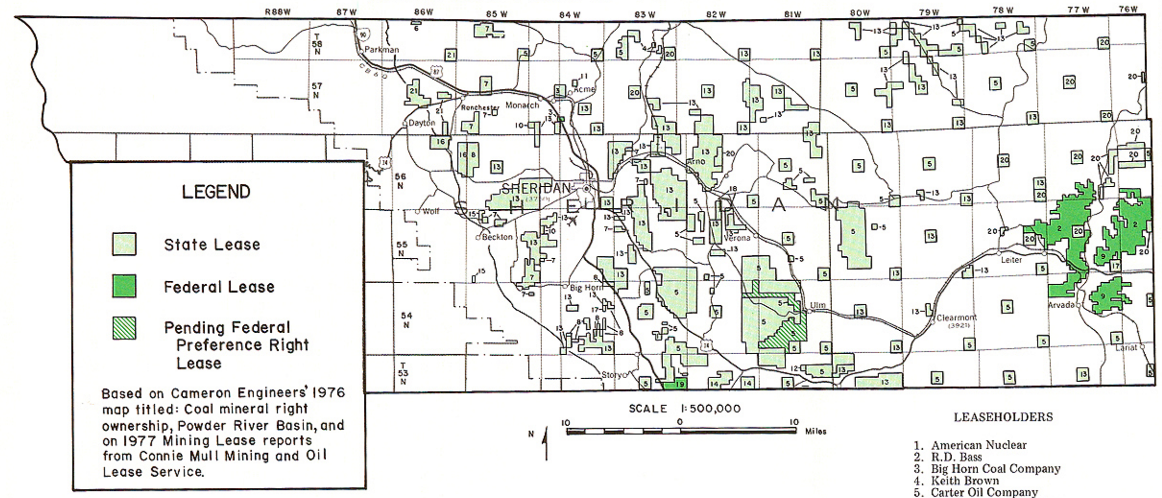
* Not included on index map.

Annual Coal Production



State and Federal Coal Leases



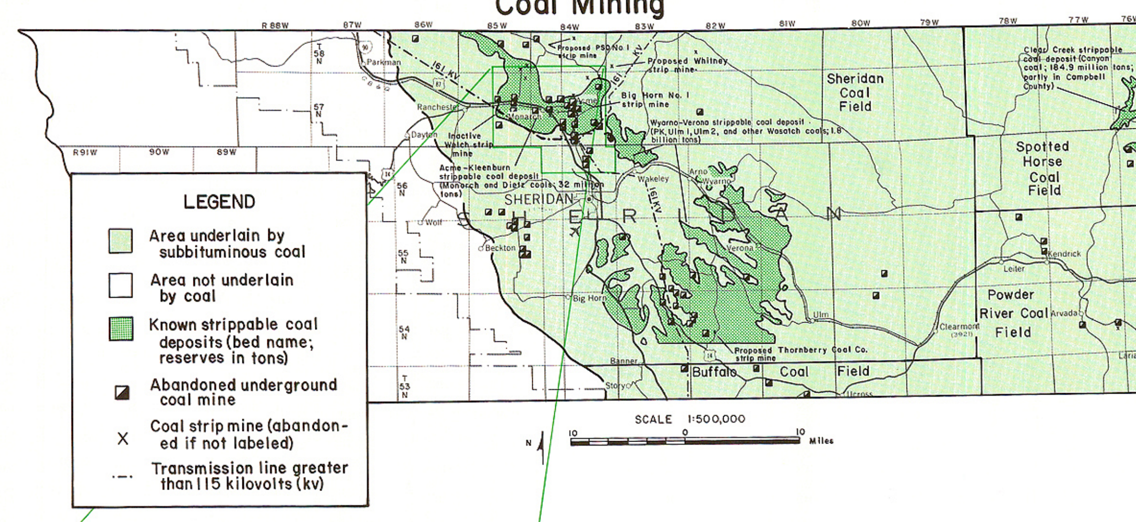
LEASEHOLDERS

1. American Nuclear
2. R.D. Bass
3. Big Horn Coal Company
4. Keith Brown
5. Carter Oil Company
6. Champion Ventures, Inc.
7. P.C. Development
8. GKM & Company
9. Gulf Oil Corporation
10. P.T. Jenkins
11. Kerr-McGee Corporation
12. D.J. Leeman & J.M. Beard
13. Mapco, Inc.
14. Mobil Oil Corporation
15. R.L. Peterson
16. North American Nuclear
17. C.J. Sherman
18. W.H. Haas, Trustee
19. Texaco, Inc.
20. Tipperary Resources
21. Wyoming Coal Corporation

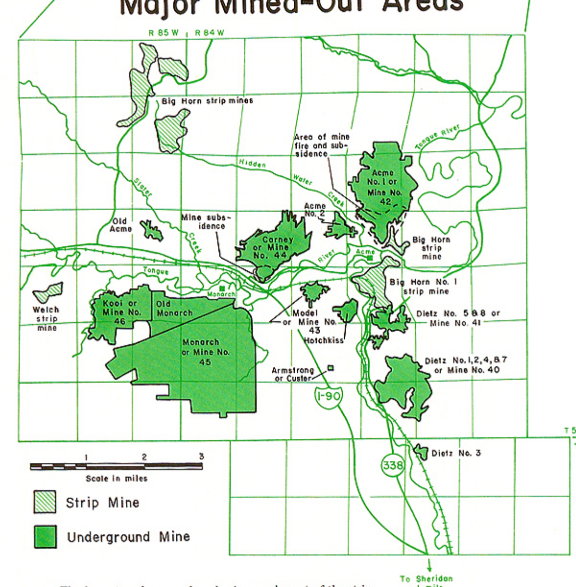
COAL OWNERSHIP

Although demand for coal from Sheridan County is not matching that from several other Powder River Basin counties in Montana and Wyoming, the number of large state and federal coal leases in the county indicates significant interest. In 1975, 218 state coal leases on almost 168,000 acres were held by 19 lessees. Four of these lessees controlled 90 percent of the leases. Six federal leases held by four lessees add 26,670 acres, to give a total of more than 194,000 acres under government lease. Additionally, Carter Oil holds a federal preference right lease application for almost 6,000 acres.

Coal Mining



Major Mined-Out Areas



The largest underground coal mines and most of the strip mines in Sheridan County occur in the Acme area. All these mines were developed on the Monarch, Carney, or various Dietz coals of the Fort Union Formation. Only the Big Horn No. 1 strip mine, however, is still active.

Large circular craters and open cracks in the area north of the Tongue River between Monarch and Acme are caused by subsidence above abandoned underground coal mines. An underground mine fire, which has burned for tens of years, also continues to accentuate and extend ground subsidence features in this area.

Although some subsidence occurs above all underground coal mines, the ground surface is not always affected. Surface subsidence depends on many factors which include the depth of the mine, the type of rock above the mine, the coal thickness, and the mining technique.

History and Forecast for Coal Mining

Although documented coal mining in Sheridan County dates back to 1887, significant production was not attained until the early 1900's. In 1918 the county's record annual production was set at 1.98 million tons. Production remained above 400,000 tons a year until a steep decline began in the late 1950's. Annual production bottomed at 217,790 tons in 1968. Despite fluctuations in production since that date, annual production has gradually risen. By 1980, production should set a new record for the county.

As in many of the state's early coal-producing counties, most tonnage from Sheridan County has come from underground mines, rather than strip mines. Of the county's cumulative coal production of 61.5 million tons, underground mining has accounted for 78 percent, or 47.8 million tons. This tonnage has come from 69 or more deep mines, most of which are located in the Acme area north of Sheridan. Strip mining began in 1939, accounted for more annual production than underground mines by 1952, and completely replaced deep mining by 1959. Today, one strip mine produces all the coal mined in Sheridan County.

This one active mine, the Big Horn No. 1 strip mine, is owned by Big Horn Coal Company, a subsidiary of Peter Kiewit Sons, Inc. The mine is located near Acme, Wyoming, about six miles north of Sheridan. Most of Big Horn's coal is sold to power plants in Illinois, Missouri and South Dakota.[1] Last year Big Horn applied for, and subsequently withdrew, a mining application for a second strip mine (Whitney mine) northeast of Big Horn No. 1. The status of the Whitney mine property is unknown at this time.

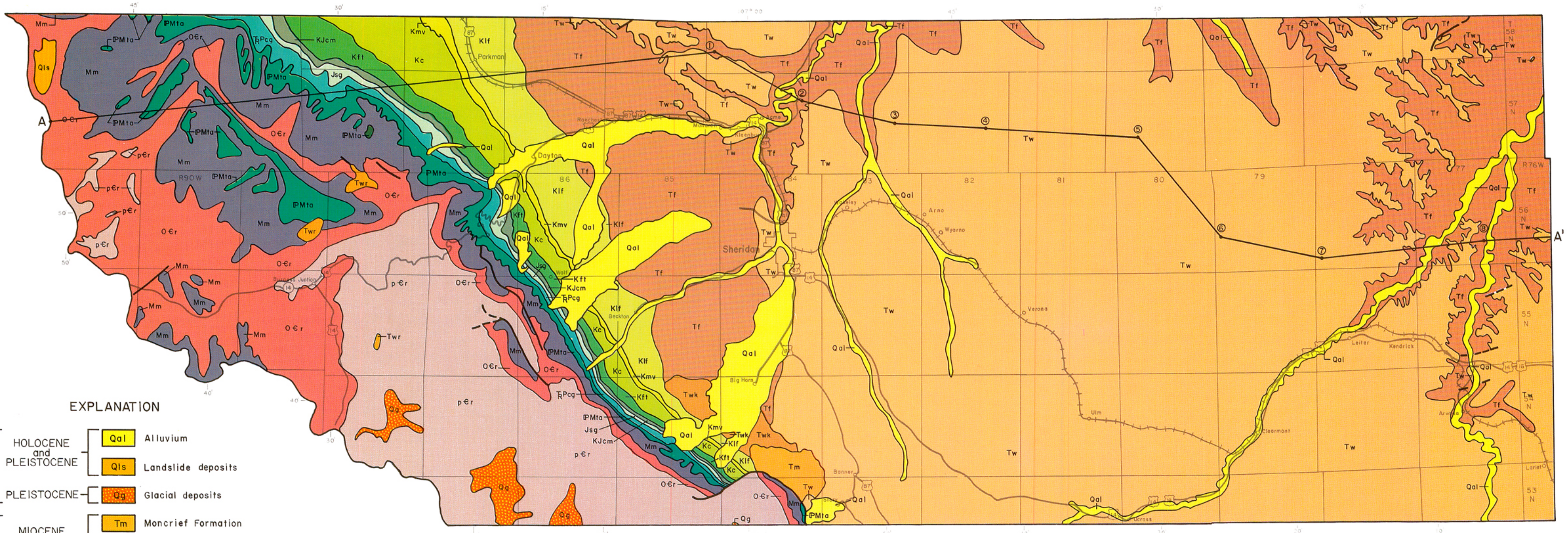
By 1980, Public Service Company of Oklahoma plans to have a 500,000 ton per year strip mine on line near the Montana border.[1] Thornberry Coal Company has announced its intention to open a strip mine in the southern part of the county, although a firm timetable is not available. Also the Welch strip mine near Ranchester is expected to reopen in the near future. Combined production from these active and proposed mines could exceed two million tons per year by 1980.

In other coal-related developments, two power plants have been proposed for Sheridan County. Pacific Power and Light Company is considering the Sheridan area as a possible site for a new coal-fired power plant. Apparently, coal for this plant would be shipped into Wyoming from Montana. Several years ago, Tipperary Resources also investigated a power plant site in southern Sheridan County. With no announced siting or construction plans, the status of these plants is uncertain.

Thin coal, excessive depth of cover, and low quality are significant problems to the development of many Sheridan County coals. For example, while the quality of coals in the Fort Union Formation is frequently adequate for current markets, these coals are not mined because they are much thinner than coals north and east of the county. Also, these coals lie below strippable limits over a vast area in the central portion of the county. Consequently, the majority of the shallow coals that crop out in Sheridan County belong to the younger Wasatch Formation. Analyses from adjacent areas show that the quality of many Wasatch coals, in particular their heat values, is too low to warrant economic development at this time.

[1] Glass, G.B., 1976, Wyoming coal directory: Wyoming Geol. Survey Public Information Circular 5, 21 p.

The Geological Survey of Wyoming, 1977.



Geology from U.S. Geological Survey Hydrologic Investigations Atlas HA-465, 1973

Base from U.S. Geological Survey SHERIDAN 1°X2° Quadrangle, 1955-62

N

SCALE 1:250,000

5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

EXPLANATION

QUATERNARY	HOLOCENE and PLEISTOCENE	Qal	Alluvium
		Qls	Landslide deposits
	PLEISTOCENE	Qg	Glacial deposits
TERTIARY	MIOCENE and OLIGOCENE	Tm	Moncrief Formation
		Twr	White River Formation
	EOCENE	Tw	Wasatch Formation
		Twk	Kingsbury Conglomerate Member
	PALEOCENE	Tf	Fort Union Formation
CRETACEOUS		Klf	Lance Formation & Fox Hills Sandstone
		Kmv	Mesaverde Formation
		Kc	Cody Shale
		Kft	Frontier, Mowry, & Thermopolis Formations
JURASSIC		KJcm	Cloverly & Morrison Formations
		Jsg	Sundance & Gypsum Spring Formations
TRIASSIC and PERMIAN		ŦPcg	Chugwater & Goose Egg Formations & equivalent rocks
PENNSYLVANIAN and MISSISSIPPIAN		IPMta	Tensleep Sandstone & Amsden Formation
		Mm	Madison Limestone
ORDOVICIAN		O€r	Bighorn, Gallatin, Gros Ventre & Flathead Formations
PRECAMBRIAN		p€r	Igneous and metamorphic rocks, undifferentiated

Contact—Dashed where approximately located

Fault—Dashed where approximately located

STRUCTURAL GEOLOGY

Sheridan County is dominated by two major structural features, the Powder River Basin and the Bighorn Mountains. The Powder River Basin is a structural trough, or syncline, which occupies most of northeastern Wyoming. The basin is asymmetric, with its deepest part (axis) lying just east of, and running parallel to, the Bighorn Mountain front. The Bighorn Mountains, a part of which lie in western Sheridan County, are part of a larger, arcuate mountain complex which includes the Pryor, Bighorn, Bridger, and Owl Creek ranges. Structurally, the Bighorns may be described as an asymmetric anticline. As shown on the cross section below, sedimentary rocks lying above the Precambrian gneisses and granites (basement rocks) dip gently or are nearly flat-lying over the top of the range, but dip steeply northeast over the eastern flank of the range where major faulting has occurred.

Five structural elements may be distinguished in the greater Bighorn Mountain region (Hoppin and Jennings, 1971, p. 39). These are northwest trending folds in adjacent basins, the Pryor-Bighorn-Bridger-Owl Creek uplift, east-west trending lineaments, high angle faults and associated monoclinal folds, and flank thrusts along the margins of the uplifts. These elements are considered to have developed in the order given, although considerable overlap exists. For example, many of the northwest trending folds undoubtedly developed contemporaneously with uplift of the adjacent Bighorn Mountains, approximately 55 million years ago.

Lineaments, which are defined as straight or slightly curved features at the earth's surface (faults, breccia zones, etc.), traverse the Bighorn Mountains and adjacent basins at many localities. The Tongue River and Shell lineaments are of interest in Sheridan County (see adjacent photo). The Shell lineament is the surface expression of a Cenozoic mineralized fracture zone, a part of which may be the northern tear fault of the Piney Creek thrust (NW¼, T.53N., R.84W.) The Tongue River lineament, trending northeast across the Bighorns in alignment with the Tongue River, is characterized by faulting and mineralized fracture zones. Faulting of a segment of the lineament along the north end of the Precambrian core in Sheridan County has resulted in at least 600 feet of stratigraphic displacement. A northeast extension of the Tongue River lineament has been recognized in the subsurface of the Powder River Basin.

Flank thrusts are locally exposed along the eastern margin of the Bighorns, as shown on the geologic map (e.g., T.53N., R.84W.). These are loosely called thrusts, but seismic evidence suggests that these flank faults steepen at depth and have only a minor component of horizontal displacement at the surface. Foster and others (1968, p. 100) have postulated a near-vertical subsurface fault extending from the Casper Arch in Natrona County north to Sheridan, with a maximum throw (vertical displacement) of 4000 feet at Buffalo. A similar subsurface fault along the west flank of the Bighorns (near Basin) suggests vertical movement of the Bighorn Mountain block(s).

The Sheridan County region has been subjected many times to tectonic activity (mountain building, basin subsidence, etc.), but Cenozoic tectonism is responsible for most of the present large-scale structural features. The distribution and ages of Cenozoic gravels along the Bighorn Mountain front are important clues to unraveling the tectonic history of the area. The oldest Cenozoic gravel deposit, the Kingsbury Conglomerate Member of the Wasatch Formation, contains pebbles and cobbles of Paleozoic and Mesozoic rocks. Hoppin and Jennings (1971, p. 43) believe that the Kingsbury represents the first significant and widespread uplift of the range.

Tectonic movement of the Piney Creek thrust (T.53N., R.84W.) during the Miocene is indicated by fanglomerates of the Moncrief Formation. The Moncrief, containing cobbles and boulders of Precambrian rocks, is distributed along the front of the Piney Creek thrust. Pliocene uplift of the Bighorns is indicated by Oligocene strata lying unconformably on Paleozoic strata high in the Bighorn Mountains (T.56N., R.88 and 89W.) These Oligocene outcrops have been vertically displaced several thousand feet above equivalent strata in the adjacent Powder River Basin in latest Tertiary time. Possible Quaternary uplift of the Bighorns is indicated by gravel-capped pediments and terraces adjacent to the east flank of the Bighorns; many of these increase in gradient directly adjacent to the mountain front, suggesting very recent vertical movement. However, the possibility of climatic control on the origin of these terraces must be considered.

For additional stratigraphic and geological information, see the Stratigraphy Plate.

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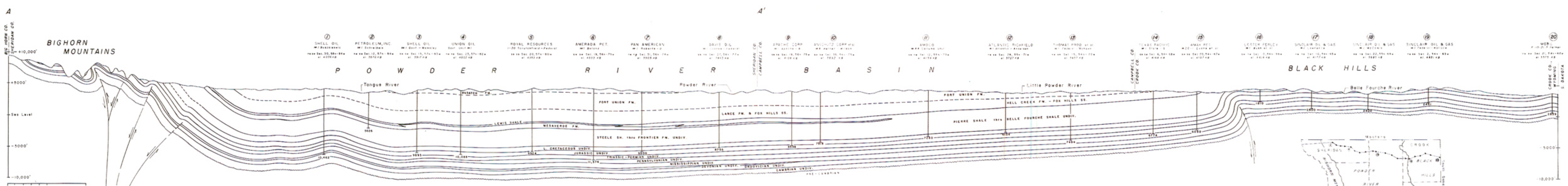
BIGHORN MOUNTAINS. The satellite photograph shows the Bighorn Mountain uplift, flanked to the west by the Bighorn Basin, and to the east by the Powder River Basin. Dark areas of the photograph represent vegetation. The western part of Sheridan County is outlined by a dashed line. Sedimentary rocks dipping steeply into the Powder River Basin are clearly shown along the east flank of the mountains. On the west side of the mountains, these same strata dip gently into the Bighorn Basin.

Several structural features are visible on the photograph. The Pryor Mountains are the less uplifted northern part of the Bighorn Mountains which extend into Montana. The Tongue River lineament is clearly shown as a northeast trending zone which transects the range. The Shell lineament transects the range in the southern part of Sheridan County, and, according to Hoppin and Jennings (1971, p. 42), is partly indicated by the linearity and landslide topography of Shell Canyon. The Piney Creek thrust is shown as a dramatic eastward bulge along the east margin of the Bighorn Mountains. According to Hudson (1969, p. 283), the thrust has moved a wedge of Precambrian and Phanerozoic rock 2.5 miles eastward from the main mountain front, resulting in a stratigraphic displacement of 10,000 feet.

Many drainages and other physiographic features show up well on the photograph. The interested reader may correlate features shown on the photograph with those on the geologic map. EROS Data Center photo.



DIAGRAMMATIC CROSS-SECTION OF THE NORTHERN POWDER RIVER BASIN, WYOMING

The Geological Survey of Wyoming, 1977.

FHP

LAND USE—CRS 5, Sheridan County, Wyoming

A land-use map depicts the prevailing uses of natural and man-altered land, including both urban and rural uses. It does not reflect the optimum or potential use of a given area.

A map of an area as large as Sheridan County, compiled and checked within the span of one year, cannot be free of error. This map represents a "best estimate" of predominant land use in the summer of 1976.

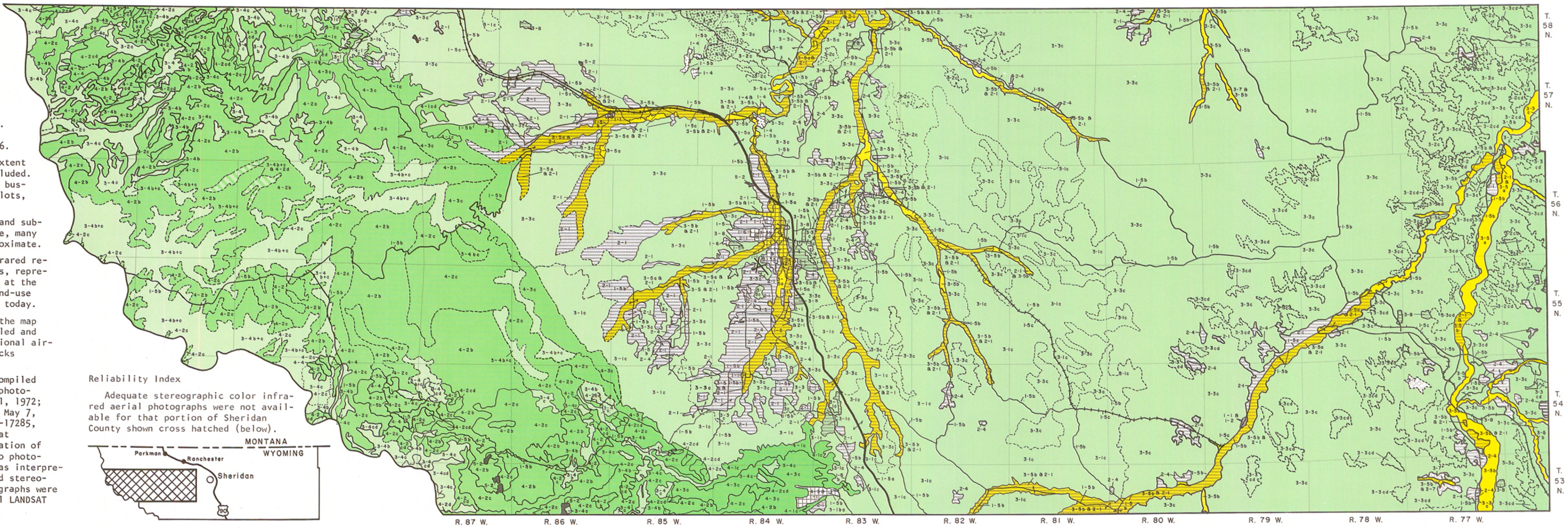
Only those land-use classes of areal extent appropriate to the map scale could be included. Excluded are isolated urban dwellings and businesses, ranch houses and buildings, feedlots, small stockponds, and the like.

Many land-use units (especially grassland subclasses) grade into one another; therefore, many of the mapped boundary locations are approximate.

Land-use identifications, based on infrared reflectance of vegetation and other features, represent the conditions of the ground surface at the time of overflight. In areas of rapid land-use change, such identifications may not hold today.

Most of the airphotos used to compile the map were obtained in 1973. The map was compiled and revised in 1976-77, on the basis of additional airphotos obtained in May 1975 and field checks carried out during the summer of 1976.

The Sheridan County Land-Use Map was compiled from high-altitude color infrared aerial photographs (NASA flights no. 72-138, August 11, 1972; no. 73-147, August 30, 1973; and no. 310, May 7, 1975) and from LANDSAT band 7, scene 1409-17285, September 5, 1973. The map was compiled at 1:100,000-scale by stereo-photo interpretation of 1:120,000-scale photographs. Where stereo photographs were unavailable, LANDSAT band 7 was interpreted at 1:250,000-scale. Areas not covered stereographically by high-altitude aerial photographs were transferred directly from the more general LANDSAT interpretations.



Reliability Index

Adequate stereographic color infrared aerial photographs were not available for that portion of Sheridan County shown cross hatched (below).

MONTANA
WYOMING
Parkman
Ranchester
Sheridan

Land use map compiled by: D.R. Gaylord, Department of Geology, University of Wyoming.

Work supported by: U.S. Geological Survey, Grant #14-08-0001-G-163.

Scale 1:250,000

5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

MAP KEY

N

URBAN AND BUILT UP LAND:

1-1 Subclass Residential: High-density, extensive areas of habitation, such as Sheridan and Ranchester. Individual ranch and farm sites not mapped.

1-2 Subclass Commercial: High-density, extensive areas of commercial structures, places of business and small industry.

1-4 Subclass Extractive: All extractive enterprises such as open pit coal mines and oil and gas wells. Open pit coal mines are designated by solid lines. Oil and gas production areas, rather than being mapped as individual wells, were mapped as "fields".

1-5 Subclass Transportation: Major maintained county, state and federal highways; 1-5a four-lane interstate highways; 1-5b all two-lane highways; 1-5c railroad tracks.

1-6 Subclass Recreation: Recreation areas including golf courses, athletic fields, picnic and camping areas, and fairgrounds.

AGRICULTURAL LAND:

2-1 Subclass Irrigated and Sub-irrigated Cropland Pastureland: Agricultural land (harvest and/or pastureland) which has been periodically maintained or improved by artificially supplying water or by using naturally high groundwater supplies in flood plains to grow native hay, alfalfa, etc. Dual use of irrigated land and flood plain is common.

2-4 Subclass Dryland Crop: Crops dependent on rain and/or snowfall for their water needs. These croplands quite often can be identified by the parallel strips of fallow and cultivated land.

RANGELAND:

3-1 Subclass Moist Shrub Grassland: Areas of lush shrubs and deciduous trees which predominate in the low spots and valleys. The suffixes b and c (good and fair, respectively) which are based on near-infrared reflectivity indicate the quality of range.

3-2 Subclass Semiarid Shrub Grassland: Most common in areas of drier range where dry shrubs, coniferous trees and bushes are interspersed with range flora. The suffixes b and c (good and fair, respectively) which are based on near-infrared reflectivity indicate the quality of range.

3-3 Subclass Grassland: Encompasses vast areas of land use on the semiarid prairie lands. In rating the quality of range an arbitrary classification was employed based on near-infrared reflectivity of the soils; the higher the reflectivity,

(Rangeland - continued):

the lower the range classification. The highest reflectivities were found in areas of active and near-active erosion. The smoother, more rolling plains received higher classifications. Those with the least dissection and sufficient water received the highest rating.

3-3b Good rangeland.

3-3bc Good to fair rangeland.

3-3c Fair rangeland.

3-3cd Fair to poor rangeland.

3-3d Poor rangeland.

NOTE: In most cases the boundaries between grassland types can only be approximately located.

3-4 Subclass Mountain Meadows: Rangeland at higher elevations bordered on three or more sides by dense coniferous growth. This range is predominantly used for summer pasture of sheep and cattle brought up from the warmer, drier lowland range. Subclasses are based on reflectivity, topography and lushness of growth. The areas with substantial sagebrush growth received a lower rating.

3-4b Good mountain meadow, low relief, low erosion with a substantial supply of moisture.

3-4c Fair mountain meadow, high relief predominating, higher erosion with numerous exposed barren areas and a lesser supply of moisture. This rangetype may have up to 10% coniferous cover over a total area. The conifers may occur in small dense growths or as separately spaced trees.

3-4cd Fair to poor mountain meadow--a mixed classification with small areas of 3-4c and 3-4d intermingled.

3-4d Poor mountain meadow, barren rock and talus in many places with sparse lichen growth, grasses and small shrubs. This type generally occurs above the tree line in a zone next to barren rock.

3-5 Subclass Natural Flood Plain: The flood plain is defined as the area periodically inundated under high water conditions. However, the area denoted as flood plain on this map includes more infrequent high water marks also.

3-5a Flood plain with greater than 25% deciduous cover.

3-5b Flood plain with less than 25% deciduous cover.

NOTE: The flood plain may also support a variety of shrubs; but, differences in shrub types are not denoted in the classification.

(Rangeland - continued):

3-7 Subclass Naturally Disturbed Vegetation: Vegetated land which has been subjected to changes in ground and/or surface waters. These areas contain numerous barren soils which often are the result of adverse alkalinity or too great an influx of recent sediment. Consequently this range subclass often exists as a mixed land-use type with flood plain and near flood plain areas.

3-8 Subclass Previously Cultivated: Land which was formerly under cultivation, showing no signs of recent agricultural activity. It is apparently being allowed to return to a natural state.

FOREST LAND:

4-1 Subclass Deciduous: Denotes the densest growths of deciduous trees which primarily occur in and along the flood plains and within urban districts.

4-2 Subclass Coniferous: Coniferous forest areas which have been subdivided on the basis of crown density. Without specific ground-truth statistics this cannot be expected to accurately depict the health and/or productivity of the forest.

4-2b Densest conifer cover (greater than 90%) with few open meadow spaces or barren rock exposures.

4-2c Moderately dense conifer cover (greater than 60%). The remainder is open meadow and/or barren rock with limited use as rangeland.

4-2cd Mixed areas of 4-2c and 4-2d.

4-2d Least dense conifer cover (10-30%). This forest type is often found along steep-sided, talus-strewn valleys. These areas may have limited use as rangeland.

4-3 Subclass Mixed: Areas of greater than 10% deciduous cover coexisting with conifers.

4-3c Moderately dense mixed forest (greater than 60% crown density). This subclass has limited use as rangeland.

4-3cd Mixed forest (30-60% combined crown density).

4-4 Subclass Clear-cut: All areas cleared of timber in the recent past for lumbering purposes. A dual use at this time is as mountain meadow because of the abundance of range flora at many of the clear-cut sites.

WATER:

5-2 Subclass Lakes and Reservoirs: Large natural lakes, man made lakes and reservoirs.

NONVEGETATED LAND:

7-3 Subclass Barren Rock: Includes exposed crystalline or sedimentary bedrock, talus fields, or other exposed modern sediments. These barren rocks have less than 5% organic cover including grasses, shrubs or trees. The most extensive areas of barren rock occur above the tree line.

KEY TO OTHER MAP SYMBOLS:

Boundary of land-use unit

Airstrip

Oil or gas field boundary

A clear-cut area (4-4) with abundant wood debris and new seedling growth lies in the foreground. Fair conifer forest (4-2c) is visible at the far clear-cut boundary. Poor conifer cover (4-2d) and fair-to-poor mountain meadow (3-4cd) cap the barren, rocky ridge on the horizon. The picture was taken looking NE from NW ¼ sec. 25, T.54N., R.88W. →

Fair rangeland (both 3-3c and 3-1c) can be seen in the foreground with deciduous trees (4-1) growing on the low sloping flanks of the mountains. Poor and fair conifer cover (4-2c and 4-2d, respectively) as well as fair mixed deciduous and conifer forests (4-3c) are visible on the steep face of the mountain. The picture was taken looking SW from NW ¼ sec. 23, T.54N., R.85W. →

← *A mountain lake (5-2) is set amongst moderately dense (4-2c) and dense (4-2b) conifer forest. The barren rock outcrops (7-3) seen above the lake are not large enough to be included on the map. The photo was taken looking NE from NE ¼ sec. 35, T.54N., R. 87W.*

Fair rangeland (3-3c) in the foreground gives way to a dryland field (2-4) on the level ground immediately below the butte. Fair to poor rangeland (3-3cd) occupies the upper levels of the butte with fair rangeland (3-3c) covering the flanks. This picture was taken looking N from NW ¼ sec. 4, T.54N., R.76W. →

← *An open pit coal mine (1-4) is surrounded by fair rangeland (3-3c). The Bighorn Mountains are visible on the horizon. The photo was taken looking S from NW ¼ sec. 36, T.58N., R.85W.*

Irrigated cropland (2-1) and flood plain (3-5b) are seen in foreground and center. Fair to poor rangeland (3-3cd) covers the slopes of the uplands in the background. The picture was taken looking SE from SE ¼ sec. 30, T.54N., R.79W. →

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Marrs, R.W., 1975, Special report: Land-use in the Moorcroft and Keyhole Reservoir areas, Crook County, Wyoming: University of Wyoming, Department of Geology, August, 1975, 17 p.

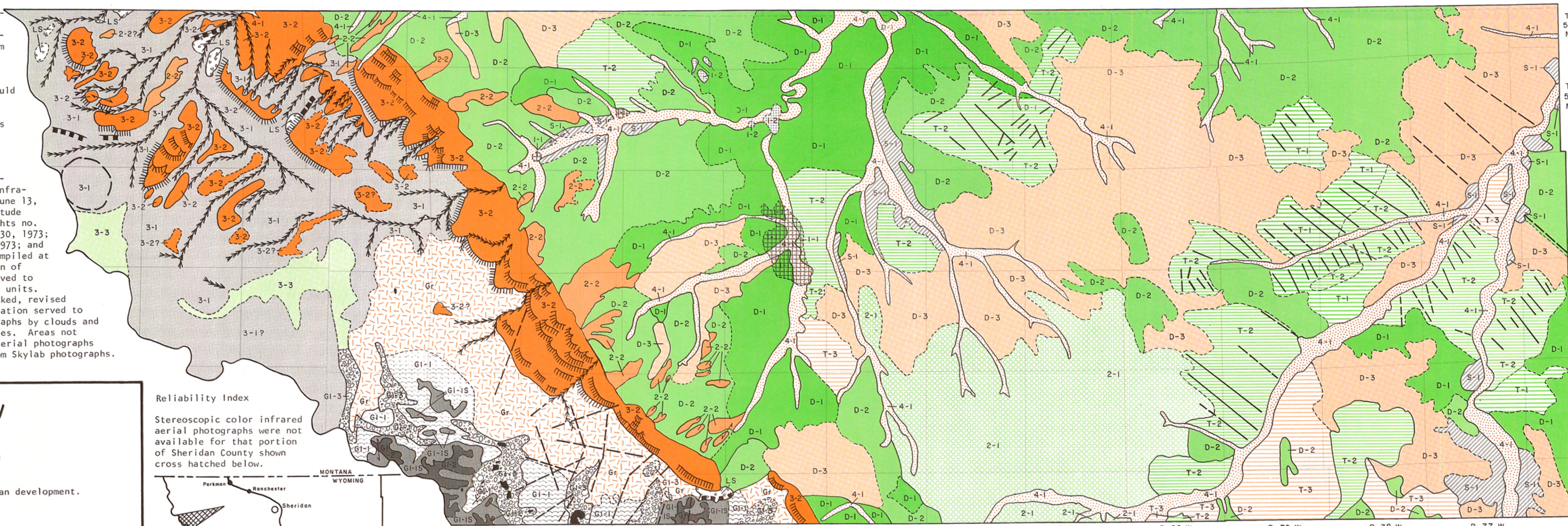
Wyoming Geological Survey, 1976, Johnson County, Wyoming—geologic map atlas and summary of land, water and mineral resources: Wyoming Geological Survey, County Resource Series No. 4, 9 maps.

The Geological Survey of Wyoming, 1977.

LANDFORMS—CRS 5, Sheridan County, Wyoming

The landforms map represents a classification of the land surface of Sheridan County. Each area is classified according to its dominant geomorphic characteristics. A landform unit is defined on the basis of regional and local topography, pattern, texture, and the geomorphic processes that control its formation. Boundaries between landform units should represent the lines of sharpest contrast between landform types; however, because some boundaries are not abrupt, their placement is uncertain, as indicated on the map by dashed lines.

The Sheridan County landforms map was compiled from interpretations of Skylab color infrared photographs (S-190A, track 5, pass 10, June 13, 1973, roll 15, frames 229-231) and high-altitude color infrared aerial photographs (NASA flights no. 72-138, August 11, 1972; no. 73-147, August 30, 1973; no. 239, June 20, 1973; no. 248, August 7, 1973; and no. 310, May 7, 1975). The map was first compiled at 1:120,000-scale by stereo photointerpretation of aerial photographs. This interpretation served to define general landform classes and mappable units. The photo interpretation was then field checked, revised as necessary, and recompiled. This recompilation served to fill in areas obscured on the aerial photographs by clouds and to improve the accuracy of map-unit boundaries. Areas not covered stereographically by high-altitude aerial photographs (see reliability index) were interpreted from Skylab photographs.



Landforms map of Sheridan County compiled by:
R.W. Marrs, D.R. Gaylord, and J.K. King
Department of Geology; University of Wyoming

Work supported by:
The U.S. Geological Survey
Grant 14-07-0001-G-163

Reliability Index

Stereoscopic color infrared aerial photographs were not available for that portion of Sheridan County shown cross hatched below.

MONTANA
WYOMING
Parkman
Ranchester
Sheridan
90

N

Scale 1:250,000

5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

Map Key

Landforms Modified by Man:

- Surface modified for urban development.
- I-2 Surface modified by mining activities.

Erosional Landforms (forms created by the destructive action of denuding factors):

Landforms of fluvial origin:

- **D-1** Widely-spaced dendritic drainage with large, flat interstream areas; interstream divides indefinite.
- **D-2** Dendritic drainage with intermediate spacing; interstream areas steeper and narrower than D-1; interstream divides readily defined.
- **D-3** Closely-spaced dendritic drainage with many small, steep interstream areas; interstream divides readily defined.
- **T-1** Widely-spaced trellis drainage with large, flat interstream areas; interstream areas indefinite.
- **T-2** Trellis drainage with intermediate spacing; interstream areas steeper and narrower than T-1; interstream divides readily defined.
- **T-3** Closely-spaced trellis drainage with many small, steep interstream areas; interstream divides readily defined. Smaller drainage enters larger drainage at right angles.
- **2-1** Knobby topography showing high degree of irregular dissection and dominated by small buttes.
- **2-2** Surfaces near base of slopes currently reworked by fluvial processes.
- **3-1** Steep slopes and irregular topography cut by steep-sided stream valleys.
- **3-2** Dip-slopes. Sloping surface conforms closely to the dip of the supporting rock layers.
- **3-3** Broad, sloping mountain valleys; valley floors composed of alluvial and colluvial material.
- **Gr** Granitic terrain; irregular, rounded topography with some bare rock summits.

Landforms of fluvio-glacial origin:

- **Gl-1** Rounded glacial topography with rounded valleys, ridges, and knolls marginal to steeper glacial topography; some bedrock exposed.
- **Gl-lS** Glacier-scoured topography with bedrock exposed in U-shaped valleys, on steep valley walls, and on broad divides.
- **Gl-2** Steep, glacial topography with bedrock exposed in aretes, horns, cols, and steep-sided glacial valleys.

Depositional Landforms (forms created by the aggradational action of water, wind, ice, or mass movement):

Deposition by water:

- **4-1** Flood plains of major streams and rivers; level bottom-land where alluvium has accumulated.
- **S-1** Smooth, gentle slopes flanking major streams and rivers.

Deposition by ice:

- **Gl-3** Moraines and glacial outwash material forming hummocky, low-dipping topography that extends outward from regions of glacial erosion; currently being reworked by fluvial processes.

Deposition by mass wasting:

- **LS** Large-scale landslides, earth-slumps, and mud-flows resulting in hummocky terrain beneath steep, breakaway scarps.

Key to Map Symbols:

- Boundary of landform unit; dashed where uncertain
- Narrow, steep-walled canyon; arrows point downstream
- Abrupt change in slope; hachures on steeper slope
- Cliff or near-vertical slope; blocks on cliff side
- Large-scale linear feature; dashed where less obvious
- Body of water

View looking southeast from SE ¼ NE ¼ sec.27, T.58N., R.88W. A typical flood-plain area flanked by rangeland occupies the central portion of the scene. Outcrops of older sedimentary rocks form eastward-dipping dipslopes in the right background.

View looking northeast from U.S. Highway 14 toward Dayton (center) which lies along the Tongue River flood plain. Large, flat pediment surfaces slope eastward away from the mountain front (left center).

View of a large slump area, shown looking west-southwest from the southwest corner of sec.6, T.54N., R.84W. THe hummocky ground at the base of the escarpment is typically unstable.

View of a broad mountain valley in western Sheridan County, sec.14, T.55N., R.90W. This rolling topography is typical of much of the area along the crest of the northern Bighorn Mountains.

An area of recent surface collapse caused by the burning-out of coal from beneath the surface. This underground coal fire is near Acme.

View of Sawmill Lakes, looking northeast from NW ¼ sec.35, T.54N., R.87W. This area is an excellent example of glacial terrain with lakes formed on a hollow which was "carved-out" by moving ice and surrounded by moraines left as the glaciers melted.

SOURCES OF DATA

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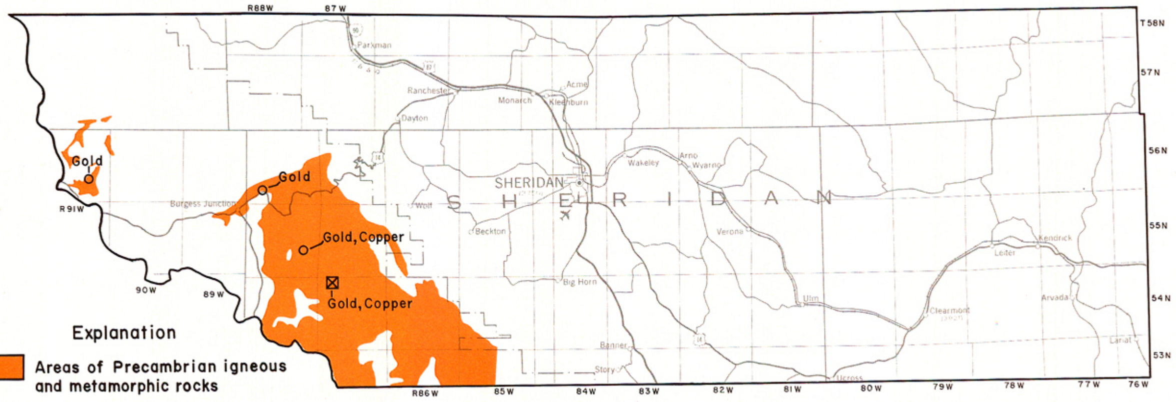
Curran, H.A., Justus, P.S., Perdew, E.L., and Prothero, M.B., 1965, Atlas of landforms (2nd. ed.): John Wiley and Sons, New York, 140 p.

The Geological Survey of Wyoming, 1977.

Minor Minerals



Explanation

- Areas of Precambrian igneous and metamorphic rocks
- ○ Mineral occurrence
- ⊠ Underground mine (abandoned)

Minor Minerals

Copper

Copper mineralization occurs at a number of small prospecting pits and abandoned mines on the east flank of the Bighorn Mountains. The most common copper minerals in this region are malachite, which occurs primarily as apple-green staining in fractures in diabasic and granitic rocks, and chalcocite, which occurs as massive, metallic, lead-gray crystals in fractures. Some minor amounts of galena, a metallic, lead-bearing mineral, and chrysocolla, a blue-green hydrous copper silicate, occur in association with some of the copper veins.

Gold

Placer gold deposits have been found near the headwaters of the Little Bighorn River (Beeler, 1907). The gold was reported to occur as fine flat grains with sharp jagged edges, suggesting little abrasion during stream transport.

Gold, in lode deposits, is generally associated with some silver in quartz veins in granitic and diabasic rocks along shear zones and at contacts between dikes and the intruded granitic masses.

The basal sandstone of the Flathead Formation is known to contain gold at several sites in the Bighorn Mountains. However, attempts to mine the gold have proven unprofitable.

The interested reader is referred to Osterwald and others (1966) for additional information on gold prospects in Sheridan County.

Iron

Iron mineralization is very minor in Sheridan County. The common iron-bearing minerals magnetite, hematite, pyrrhotite, pyrite, and limonite are generally associated with copper mineralization and occur as massive and disseminated minerals in shear and fracture zones.

At the old "Leopard Rock" quarry south of Twin Buttes, stringers of disseminated bronze-colored pyrrhotite and massive pyrite occur in diabasic dikes and on the old mine dumps.

Sheridanite

Sheridanite is a talc-like variety of chlorite. It was named after Sheridan County, where it was first found and identified (Osterwald and others, 1966). Sheridanite has no economic significance.

Tungsten

Scheelite has been reported in granite in prospect pits and shallow shafts about 25 miles southwest of Sheridan, where microscopic tungstite and wolframite are reported to occur in the quartz-rich rocks.

Vermiculite

Vermiculite is a soft micaceous magnesium-aluminum-iron silicate which has the unique property of expanding to up to 30 times its orginal volume when heated or acid treated. Because of this property, vermiculite is commonly used for insulating purposes.

Vermiculite occurs about 30 miles southwest of Sheridan in a number of prospecting pits; however, no production has been realized (Hagner, 1944).

References

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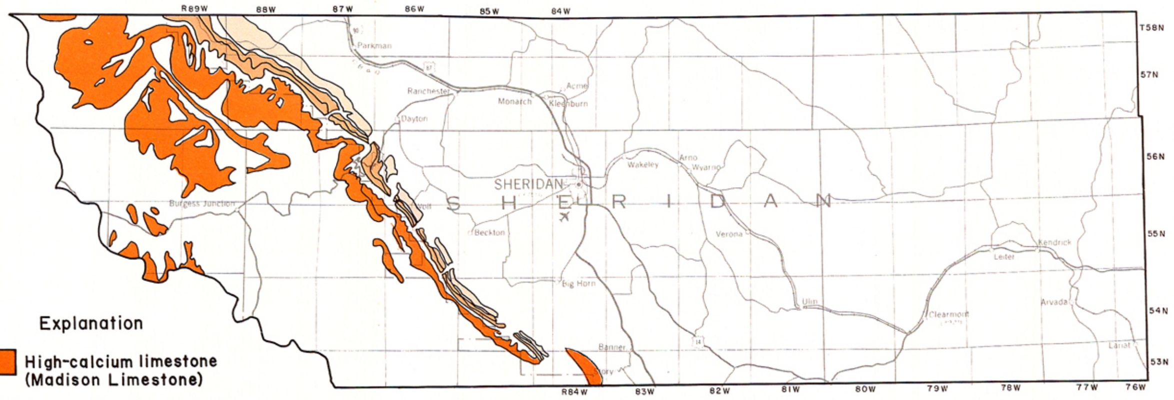
Hagner, A.F., 1944, Wyoming vermiculite deposits: Geological Survey of Wyoming Bulletin 34, 47 pp.

Osterwald, F.W., Osterwald, D.B., Long, J.S., Jr., and Wilson, W.H., 1966, Mineral resources of Wyoming: Geological Survey of Wyoming Bulletin 50, 287 pp.

Industrial Minerals



Explanation

- High-calcium limestone (Madison Limestone)
- Gypsum-bearing formations (Goose Egg, Chugwater & Gypsum Springs Formations)
- Bentonite-bearing formations (Frontier & Thermopolis Formations)

Industrial Minerals

Bentonite

The term, bentonite, was first used by Wilbur C. Knight (1898) for clayey material in the Cretaceous Benton Formation of eastern Wyoming. Since that time, bentonite has been recognized for its unique property of increasing in volume from 15 to 20 times when wetted (Hosterman, 1973, p. 127.)

Two kinds of bentonite are recognized, the sodium-rich clay, or swelling variety, which is known as "western" or "Wyoming" bentonite, and the nonswelling calcium-rich bentonite known as "southern" bentonite. (Gillson, 1960).

Bentonite typically forms by devitrification and chemical alteration of glassy igneous rock such as tuff and volcanic ash. Cretaceous formations containing bentonite beds today were deposited from airborne volcanic ash in Wyoming during a time of extensive volcanism in northern Idaho and western Montana. Bentonite is typically light green on fresh fractures and alters to a cream or white color when exposed to the air, and has a greasy or soaplike feel.

Bentonite beds in Sheridan County occur in the Cretaceous Thermopolis, Mowry and Frontier Formations, which are exposed along the east flank of the Bighorn Mountains. Commercial deposits of bentonite have been identified in northern Sheridan County (T.58N., R.88W.) by Knechtel and Patterson (1956, p. 99). These deposits have been named the Clay Spur, Bed J, and Soap Creek beds. The Clay Spur lies within the Mowry Shale, while Bed J and Soap Creek lie within the lower Frontier Formation. The Clay Spur bed has been measured at 5½ feet thick, and is well suited for use as foundary and drilling mud clay. Bed J, 3½ to 6½ feet thick, is equally well suited for commercial use. The Soap Creek bentonite is up to 20½ feet thick and was commercially stripmined in sec. 17 and 18, T.58N., R. 88W., by the Wyotana Bentonite Mining Comapny in the late 1940's. However, thick overburden has precluded extensive bentonite mining in this area.

In order to have commercial production of bentonite, the following criteria must be met: the bentonite seam must be nearly horizontal to gently dipping (less than 5 degrees), the overburden cover must be thin, the bentonite seam must be of a minable thickness and of good quality, and there must be adequate means of transportation to the market to help minimize costs.

Bentonite is used in foundries for heavy duty casting, and as a binder for the pelletization of powdered iron-ore concentrate in the taconite industry. The petroleum industry uses bentonite in drilling muds and as a catalyst in petroleum refining. It is also used as a carrier for insecticides and fungicides and as a seal and waterproofing material for irrigation canals and reservoirs (Hosterman, 1973).

The processing of bentonite includes the following steps, weathering, drying, grinding, sizing, granulation, and the addition of additives for cation exchange (see Hosterman, 1973).

Gypsum

Gypsum is a naturally occurring sulfate mineral. It is typically deposited in evaporitic sedimentary environments in association with limestone, salt, marl, and clay. Gypsum, $CaSO_4 \cdot 2H_2O$, contains 79 percent calcium sulfate and 21 percent water, by weight. The transparent variety of gypsum is called selenite, while the white or lightly colored massive variety is called alabaster. Other varieties of gypsum include satin spar and gypsite.

The Goose Egg, Chugwater and Gypsum Spring Formations contain significant deposits of gypsum. In Sheridan County, these formations form a northwest-trending outcrop band on the east flank of the Bighorn Mountains. Gypsum is continuously exposed at the base of the Chugwater Formation from the Wyoming-Montana border south to Little Goose Creek (Stone, 1920, p. 299).

Gypsum is a common building material. It is used in wallboard and plaster. Crude gypsum is used in portland cement to retard setting, and in agriculture to neutralize alkaline soils and provide sulfur. Calcined gypsum ($CaSO_4 \cdot ½H_2O$) is marketed as plaster and used in wallboard (Reed, 1975).

The location of gypsum mines with respect to markets is a critical factor affecting their economic feasibility. Wyoming gypsum deposits are well situated with respect to markets in the Pacific Northwest, an area deficient in gypsum deposits. However, the steep dips of gypsum-bearing formations in Sheridan County may preclude extensive development of gypsum mining there.

High-Calcium Limestone

A third industrial mineral of potential economic value in Sheridan County is high-calcium limestone. High-calcium limestone is already in demand in Wyoming for use in refining sugar from sugar beets and in lime scrubber systems for air pollution control of coal-fired power plants. In these power plants, the high-calcium limestone is used to remove sulfur from stack gases.

The Madison Limestone (Mississippian) is the best potential source of high-calcium limestone in Sheridan County. The Madison is variable in thickness, up to 800 feet thick at the Little Tongue River (Sando, 1976, p. 47). The Madison is underlain disconformably by the Jefferson Dolomite (upper Devonian) and is overlain disconformably by the Amsden Formation (Late Mississippian and Pennsylvanian), which lies on a karst surface formed on the Madison in Late Mississippian time.

The Madison has been divided into six members (Sando, 1976) on the basis of rock type and faunal content. These are the Cottonwood Canyon Member (basal member consisting of silty and sandy dolomite with subordinate shale and quartz sandstone), a lower dolomite member (fine- to medium-grained dolomite), the Woodhurst Member (limestone, dolomitic limestone, and dolomite), a cherty dolomite member (poorly fossiliferous, fine-grained cherty dolomite), a cliffy limestone member (medium- to thick-bedded, cherty, crinoidal limestone), and the Bull Ridge Member (cherty, coarse-grained, fossiliferous limestone). Of these members, parts of the Woodhurst, cliffy limestone, and Bull Ridge may contain beds of high-calcium limestone.

A mine was proposed for the Madison Limestone west of Story in Sheridan County, approximately one mile north of the Johnson County Line. However, environmental considerations have curtailed development. The limestones at the Story outcrops are very pure, ranging up to 98.7 percent pure calcium carbonate. A potential obstacle to limestone mining in Sheridan County is the relatively steep dip (averaging 30 degrees east) of the Madison Limestone along the flank of the Bighorn Mountains. Steep dips generally require underground mining for economic feasibility.

In the event of large-scale construction of new coal-fired electrical generating plants in the Powder River Basin, it is likely that high-calcium limestones will be used for scrubbers. As a rough approximation, about 100,000 tons of limestone would have to be mined each year to supply a 1000 MW generating plant, depending on variables such as heat value of the coal and purity of the limestone. High-calcium limestone beds in Sheridan County are an important resource in this regard.

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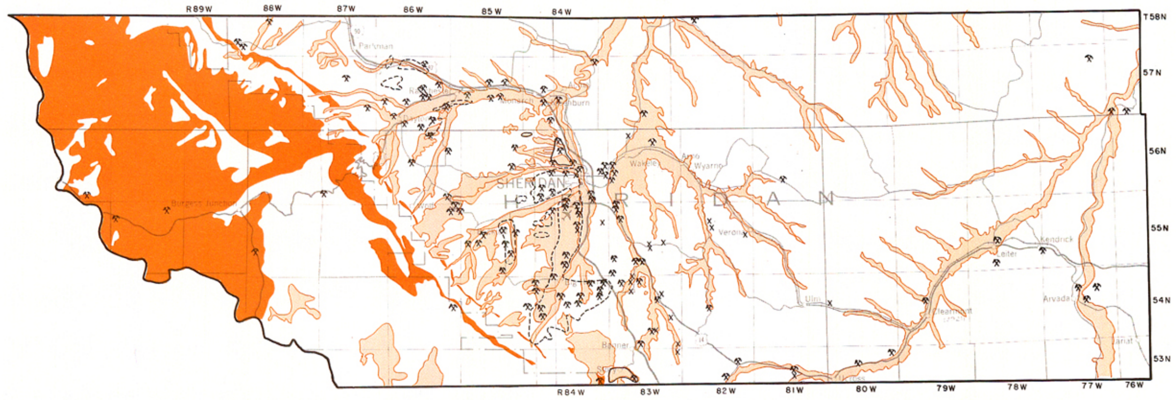
Construction Materials



Explanation

- Gravel pits
- Scoria pits
- Excellent gravel area delineated by sampling and testing.
- Good to fair gravel deposits.
- Unconsolidated surficial deposits, includes alluvium, terrace, pediment and glacial deposits.
- Potential sources of crushable ledge rock material.

Compiled from Wyoming Highway Department Construction Materials Survey and listing of known sand and gravel pits.

The photograph shows Peter Kiewit's scoria pit near Acme, Sheridan County, Wyoming.

Sheridan County Construction Materials Summary

SYSTEM	SERIES	FORMATION	THICKNESS	CHARACTER	CONSTRUCTION MATERIAL POTENTIAL
QUATERNARY	Recent	ALLUVIUM-COLLUVIUM	0-60'	Sand, silt, clay, and gravel; sediments are finer grained away from the Big Horns Mtns; also includes landslide and lake deposits.	Near the mountains gravel can be found in these deposits. In most cases, however, the water table is at or near the ground surface.
	Recent and Pleistocene	TERRACE DEPOSITS	0-50+'	Clay, silt, sand and gravel. Gravel consists of well-rounded pebbles, cobbles and subrounded boulders of limestone, sandstone, quartzite, chert and igneous rocks. In southern part of county may have 0-5' of silt, sand and clay overburden.	Best source of highway construction material in this county. Gravel is often clean, quite hard and well-graded.
		PEDIMENT DEPOSITS	0-100'	Heterogeneous mixture of Paleozoic and igneous rocks, grading related to distance from mountains.	Not a good source of construction material. Contains large boulders, as well as interstitial clay. An extensive screening and crushing program would be required.
TERTIARY	Pliocene	MONCRIEF CONGL.	10-1200'	Lower one-third interbedded greenish siltstone, silty sandstone, thin beds of conglomerates grading upward to boulder beds.	Conglomerates may be coarse but should yield large quantities of good construction material.
	Oligocene	WHITE RIVER FORMATION	10-300'	Light brown bentonitic claystone interbedded with calcium carbonate and light gray tuffaceous cemented conglomerate.	Could be a source of highway construction material but contains some bentonitic material.
	Eocene	WASATCH	500-2400'	Shale, sandstone, bentonite, and lignite layers having an overall drab brownish-gray appearance in upper part. Some white sandstone and conglomerate in lower part.	This formation generally will not provide any construction material due to interlayering of shales causing high plasticity. Only the scoria beds are recommended for use in highway construction.
		KINGSBURY CONGL.	10-600'	Predominantly conglomerate, some sandstone and claystone, consists mainly of hard Paleozoic rocks.	Conglomerates may yield good quality gravel or crushed ledge rock depending on degree of cementation. Sandstone in the conglomerate causes wear grade in the forties. Slopewash overburden may be thick in some areas.
	Paleocene	FORT UNION	2500-4000'	Interbedded clay, shale, sandy shale, and coal in lower and upper parts; middle part consists of massive sandstone beds.	Sandstone beds would yield non-plastic sand and sandstone.
CRETACEOUS		LANCE	1900-3000'	Brownish sandstone, gray shale, and carbonaceous shale; some lignite in upper part. Typically sandstone is a cross-bedded channel deposit.	May have some sand and sandstone, but generally formation is mostly shale and not recommended for use.
		FOX HILLS SANDSTONE	100-600'	Salt and pepper sandstone; contains gray shale at top and massive, cliff-forming reddish-brown sandstone at bottom.	A satisfactory source of sand and sandstone, but not hard enough for crushable ledge rock.
		BEARPAW SHALE	200	Sandy carbonaceous shale that weathers buff and blue.	No construction materials located within this formation.
		MESAVERDE	600-700'	Upper and middle parts consist of carbaneous shale shale and slabby sandstone. Parkman Sandstone Member (lower part) is massive, cross-bedded, and medium grained.	Parkman Sandstone Member could supply unlimited quantities of sand and sandstone, but not hard enough to provide crushed rock.
		CODY SHALE	3100-3600'	Medium to dark gray marine shale; contains sandstone lens in upper part.	Although parts of this formation are sandy, the formation should be avoided since interlayered shales tend to cause high plasticity.
		FRONTIER SANDSTONE	400-800'	Interbedded sandstone and shale at the top form the Wall Creek Sandstone Member, consisting of three sands; bentonite lies at the base of the formation.	The two top Wall Creek Sandstone Members could provide non-plastic sand and sandstone, but the Lower Wall Creek Member is not recommended, nor is any part of the lower Frontier Formation recommended for any use due to its bentonite content and high plasticity.
		MOWRY SHALE	200-350'	Dark brownish gray siliceous shale that weathers to silvery gray; contains thin beds of bentonite.	This formation is hard, brittle, and shatters in plate-like fragments along bedding planes; unconfined, the material tends to slip and is only recommended as "gravel surfacing" of non-paved roads.
		THERMOPOLIS SHALE	150-250'	The upper part consists of gray shale and beds of bentonite. Lower part consists of thin-bedded black shale. The Muddy Sandstone Member is a well-indurated drab buff to brown, medium-grained sandstone.	No construction material deposits located within this formation.
		CLOVERLY	80-100'	Massive white to light-creme medium-grained sandstone containing lenses of small pebble conglomerate (10-30') with 100' of grayish-black shale.	The sandstone member could provide non-plastic sand and soft sandstone, but is not hard enough to provide crushed rock.
JURASSIC		MORRISON	200-300'	Lenticular beds of fine to medium-grained sandstone and shale; weathers to variegated colors.	No construction material deposits located within this formation.
		SUNDANCE	250-300'	Interbedded greenish-gray glauconitic shale and light-gray and yellow sandstone with 5-10' lenticular limestone layers at top, middle and bottom.	The lenticular limestone is an excellent crushable hard ledge rock. It will have dip slopes exposed with several hundred thousand cubic yards available.
TRIASSIC		CHUGWATER	750-1000'	Bright red, fine to medium-grained sandstone, shale, and siltstone containing gypsum beds as much as 2 feet thick.	No construction material deposits located within this formation.
PERMIAN		GOOSE EGG	200-250'	Soft, reddish-brown, silty clay and siltstone, interbedded gypsum and red siltstone.	No construction material deposits located within this formation.
PENNSYLVANIAN		TENSLEEP SANDSTONE	300-400'	Massive, light-gray, white, yellow, or pinkish-white fine to medium-grained cross-bedded sandstone.	This formation is an unlimited source of non-plastic sand and sandstone, but has only a few lenticular ledges hard enough to provide crushable ledge rock.
		AMSDEN	250'	Red sandstone and claystone and tan massive dolomite.	The sandstone and clay are not a source of construction material, but the dolomite layers may provide a crushable hard ledge rock.
MISSISSIPPIAN		MADISON LIMESTONE	500'	Thin-bedded to massive resistant limy dolomite and limestone; unit forms prominent cliffs.	This formation has an unlimited supply of limestone with qualities meeting the most rigid demands of high quality materials specifications.
ORDOVICIAN		BIGHORN DOLOMITE	150-300'	Basal gray to red sandstone overlain by resistant pitted gray dolomite. Top layer is lenticular, slabby dolomite.	The dolomite is recommended as an excellent source of crushable ledge rock. It would be clean and hard and would meet high quality specifications.
CAMBRIAN		GALLATIN LIMESTONE	50'	Greyish-red, slabby, silty limestone, with some flat pebble conglomerate.	This formation is not recommended because it is often obscured by overburden; overlying units have better quality material in open exposures.
		GROS VENTRE	500'	Soft non-resistant medium to coarse-grained green to red sandstone overlain by soft grayish-green shale.	This formation is often covered by overburden and vegetation. It is not recommended for use as a construction material.
		FLATHEAD SANDSTONE	260'	Tan to brown, medium to coarse-grained quartz sandstone with some conglomerate at base.	Could provide non-plastic sand and sandstone, but no hard ledge rock is available.
PRECAMBRIAN		GRANITE		Pink, pinkish-gray and gray, fine to coarse-grained granite; intrusive rocks of varying composition and metamorphic rocks.	Could provide crushable hard rock as construction material; may also have zones of disintegrated granite which might be used without blasting.

Compiled from Wyoming Highway Department Construction Materials Survey

Construction Materials

Sheridan County has a number of geologic units suitable for construction materials, particularly in the western part. Most often the location of a deposit with respect to its use area determines whether it is economic. Energy related development of coal, uranium, and oil in the Powder River Basin will increase the demand for construction materials in Sheridan County.

The best sources of sand and gravel in the county are terrace deposits, most of which are located near the Bighorn Mountains or along the major stream drainages. Alluvial stream deposits become progressively finer away from the mountains and are generally too fine for construction uses.

Crushable aggregate sources are large and include Precambrian, Ordovician, Mississippian and lower Jurassic rock units. Most of the Upper Cretaceous and Tertiary units are too soft for such use.

Clinker, or baked rock formed from natural underground coal fires, is found in abundance where the Fort Union and Wasatch formations are exposed. Clinker is used for ballast and subsurfacing or surfacing on secondary roads: it is generally brittle and has a high absorption rate.

Location of known, tested, and potential sand and gravel deposits, as well as sources for crushable ledge rock, are shown on the map. The chart summarizes the characteristics of all the rock units found in Sheridan County.

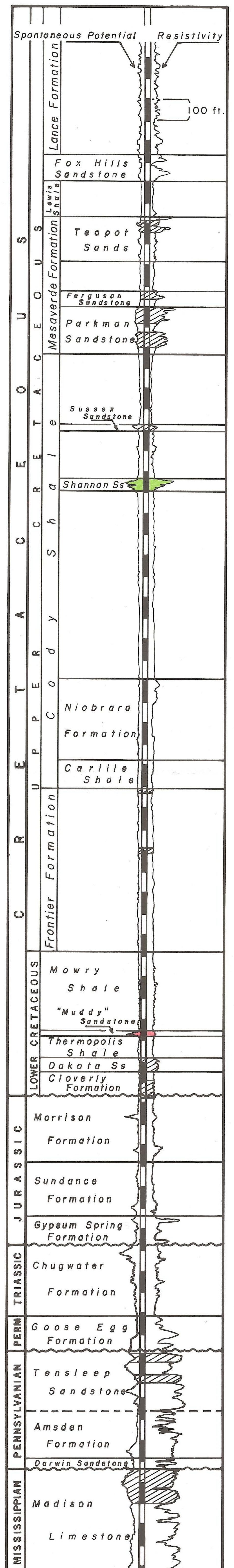
Sources

Wyoming State Highway Department, 1965, Construction materials survey I-90, Sheridan County, 185 p.

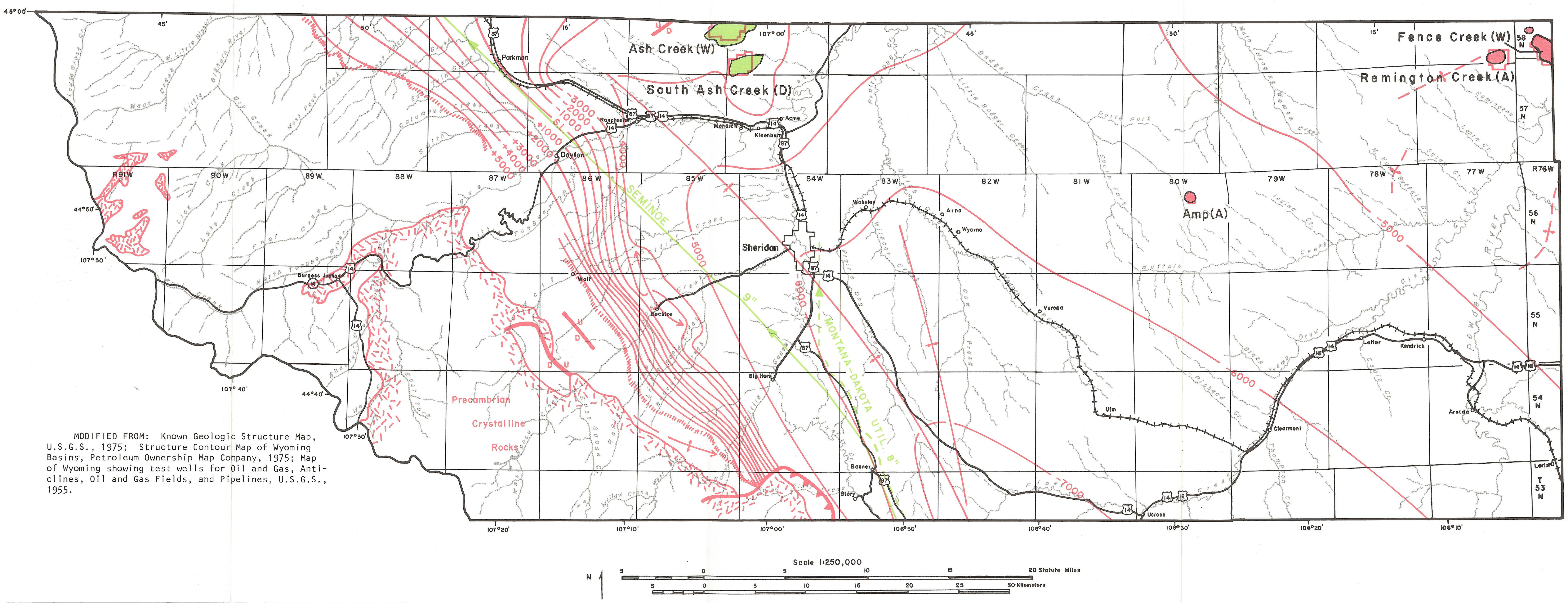
Wyoming State Highway Department, open file reports and maps.

The Geological Survey of Wyoming, 1977.

Composite Electric Log

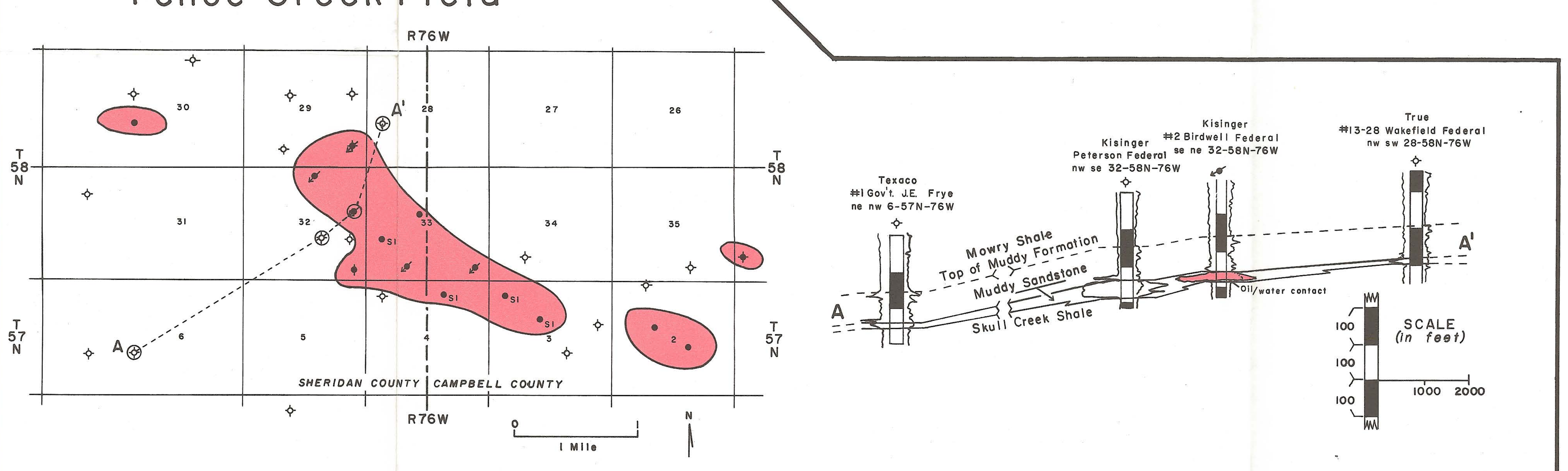


Producing zones color coded the same as on the oil and gas fields map.

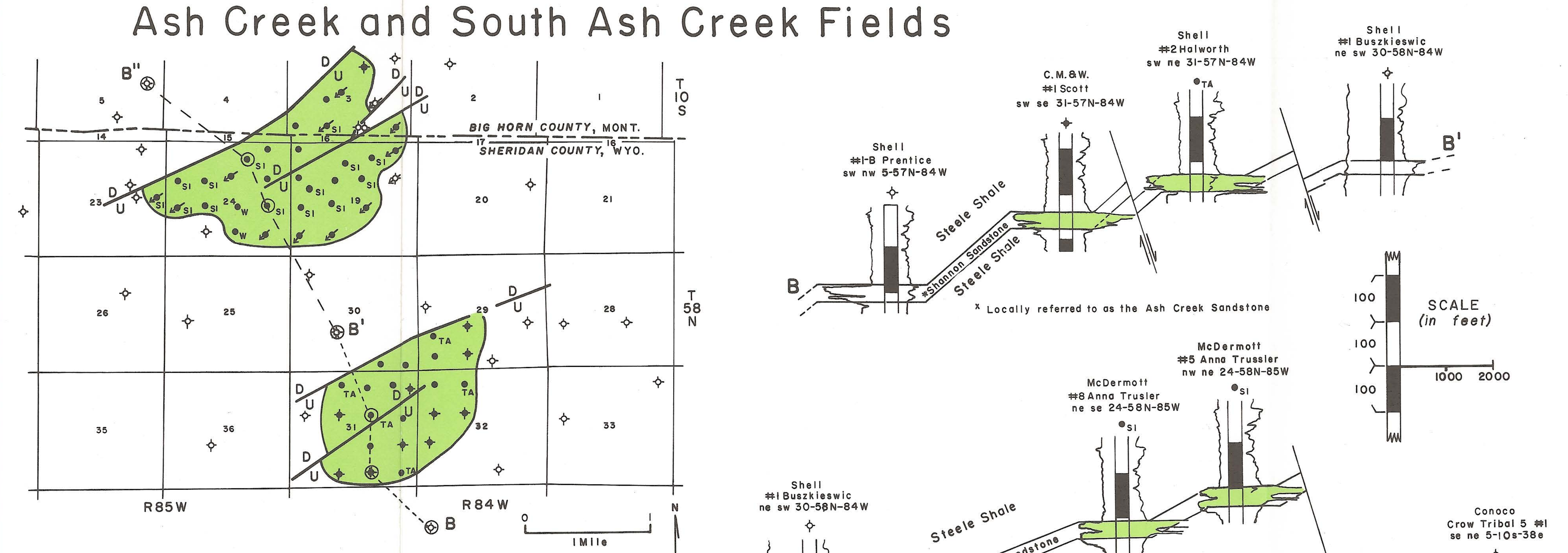


MODIFIED FROM: Known Geologic Structure Map, U.S.G.S., 1975; Structure Contour Map of Wyoming Basins, Petroleum Ownership Map Company, 1975; Map of Wyoming showing test wells for Oil and Gas, Anticlines, Oil and Gas Fields, and Pipelines, U.S.G.S., 1955.

Fence Creek Field



Ash Creek and South Ash Creek Fields



Well Symbols

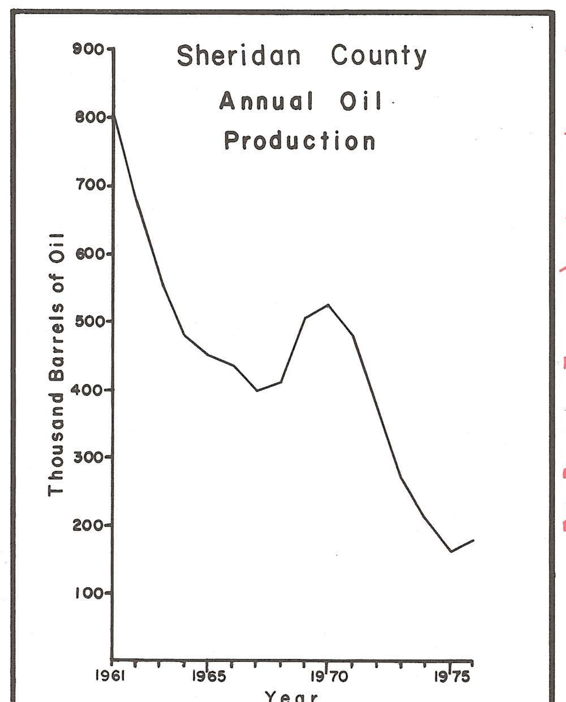
- Oil well
- Abandoned, dry hole
- Abandoned oil well
- Water injection well
- Water supply well
- Shut-in oil well
- Temporarily abandoned oil well
- A—A' Line of section

Oil and Gas Field Symbols

- Upper Cretaceous Age
- Lower Cretaceous Age
- Potential Productive Zones
- Known Geologic Structures
- (A) Abandoned Fields
- (D) Water Disposal Project
- (W) Waterflood Project

Geologic Symbols

- Anticline with surface & subsurface expression
- Anticline with only surface expression
- Syncline
- 5000 Structure contours on top of Dakota Ss.
- Dakota Ss. outcrop or subcrop beneath Tertiary rocks
- Normal fault
- Reverse or thrust fault



DATA SOURCE: State Board of Equalization Ad Valorem Tax Department and the Wyoming Oil and Gas Conservation Commission.

Pipelines

(owner, size, & direction of flow)

Oil — Seminoe 9"

Products — Mont.-Dak. Util. 8"

Oil and Gas Production

Field Name and Discovery Date	Location	Producing Formation	Average Producing Depth	No. Prod. Wells	Cumulative Production to Dec.31, 1975 Oil(BBL)	Gas(MCF)	Field Status
Amp (1970)	56N-80W	Muddy	9470'	0	980	545	Abnd.
Ash Creek (1952)	58N-84W, 85W	Shannon (Ash Creek)	4410'	7	5,384,722	0	Prod.(W)
Ash Creek (1954) -South-	58N-84W	Shannon (Ash Creek)	4730'	8	7,993,306	0	Prod.(D)
■Fence Cr.(1968)	58N-76W	Muddy	7710'	3	1,256,705	308,208	Prod.(W)
Remington Cr. (1968)	58N-76W	Muddy	8120'	0	72,051	8,917	Abnd.
Total of 5 Fields —				18	14,707,692	317,670	

■ Cumulative Production figures given for Fence Creek Field include that portion in Campbell County.

(W) Waterflood Project (D) Water Disposal Project

DATA SOURCE: Wyoming Oil and Gas Conservation Commission.

PETROLEUM IN SHERIDAN COUNTY

Introduction

The first significant oil discovery in Sheridan County, made in 1952 approximately 15 miles north of Sheridan, was Ash Creek Field. It and South Ash Creek Field (discovered in 1954) are structural traps situated on a large, faulted anticlinal nose. Production is from the Upper Cretaceous Shannon Sandstone (locally referred to as the Ash Creek Sandstone) at an average depth of 4600 feet. Originally, 50 producing oil wells were drilled in the two fields, of which 15 are still producing.

Exploration continued without success through the 1950's and 1960's until 1968, when Fence Creek Field (partially in Campbell County) and Remington Creek Field were discovered in the northeastern part of the county. Both fields are stratigraphic traps producing from Lower Cretaceous Muddy Sandstone at average depths of 7710 and 8120 feet, respectively. Amp Field, a one well field discovered in 1970, produces from Muddy Sandstone at a depth of 9470 feet. These discoveries initially sparked active exploration for stratigraphic traps in the northern and eastern portions of the county. More recently, drilling activity has dropped off significantly and no new discoveries have been made since 1970.

Current oil production in the county is restricted to Ash Creek, South Ash Creek, and Fence Creek Fields. Of these, Ash Creek and Fence Creek Fields have active secondary (water flood) recovery programs underway. South Ash Creek Field, in addition to its oil production, serves as a water disposal project, allowing disposal of water produced with the oil in Ash Creek Field and South Ash Creek Field. Remington Creek and Amp Fields both produced for a short time, but are now abandoned.

As shown on the accompanying production graph, overall production has steadily declined except for the brief resurgence indicated for the late 1960's and early 1970's, resulting from the discovery of Fence Creek and Remington Creek Fields and the initiation of water flooding in Ash Creek Field. Recent initiation of water flooding in French Creek Field is probably responsible for the slight resurgence in production shown for 1976.

Sources of Production

Production to date within the county has been restricted to Cretaceous strata. The nonmarine post-Cretaceous strata appear to lack favorable source rock and trapping mechanisms, and tests of pre-Cretaceous strata have thus far encountered either non-porous reservoir rock or poor source beds.

There are two types of traps present within the county, structural traps in the more highly deformed margin of the Powder River Basin and stratigraphic traps in the relatively stable interior portion of the Basin.

Cross-section B-B'-B" illustrates the faulted anticlinal or structural trap forming Ash Creek and South Ash Creek Fields. Early exploration techniques centered around the search for surface expression of anticlinal structures, usually carried out by surface mapping. Ash Creek and South Ash Creek Fields are in this catagory of discoveries. The anticlinal nose upon which they are situated was located by photogeology, and subsequently confirmed by surface mapping and seismic work. The majority of structural traps in Wyoming have been discovered, and as a result newer, more sophisticated seismic techniques are now used to explore for the subtle, deep structural traps that remain to be found.

The stratigraphic trap, characteristic of the central Powder River Basin, is illustrated by cross-section A-A' through Fence Creek Field in the northeastern portion of Sheridan County. Most Muddy Sandstone reservoirs in the basin are stratigraphic traps consisting of thin beach sands or offshore bar sands that trend NW-SE, and thin discontinuous channel sands which are usually subperpendicular to beach and bar sands. The reservoir sandstones in Fence Creek Field are an example of NW-SE trending offshore bars that pinch out both updip and downdip as shown on cross-section A-A'. Much of the present exploration in the Powder River Basin is for this type of stratigraphic trap.

Future Developments

When compared in oil and gas production to other, highly productive counties within the Powder River Basin, Sheridan County seems quite insignificant. Past drilling within the county has met with very limited success, and exploratory drilling has dropped off to the degree that, today, only one or two rigs are active at any given time. However, there are new discoveries in neighboring Campbell County that may be indicative of future success.

The best potential for future exploratory success probably lies in the search for new Cretaceous stratigraphic traps in the eastern and northern portions of the county. Judging from the numerous discoveries in adjacent northwestern Campbell County, the Muddy Sandstone still seems to hold potential. Improved seismic techniques could aid in exploration for deep structural traps along the western margin of the basin, on the flanks of the Bighorn Mountains.

Today, increasing oil and gas prices are fostering deep tests (greater than 20,000 feet) in other Wyoming basins, and it seems reasonable to expect deep drilling to become feasible in the Powder River Basin in the near future. In Sheridan County, areas near the axis of the basin and near the flanks of the Bighorn Mountains would probably be most affected by an increase in deep drilling, allowing for testing of potential Pennsylvanian Tensleep and Mississippian Madison reservoirs. Potential accumulations in Lower Paleozoic pinch-outs and deep Cambrian Flathead reservoirs could also be tested. To date, the deepest drilling near the axis of the basin in Sheridan County has penetrated Lower Cretaceous strata.

Although the declining production trend could be reversed by one or two discoveries of the type just discussed, the county does not appear to have the potential for production that adjacent counties are exhibiting.

Selected References

Rocky Mountain Association of Geologists, 1972, Geologic atlas of the Rocky Mountain Region, 331 p.

Wyoming Geological Association, 1958, Thirteenth Annual Field Conference Guidebook: Powder River Basin, 341 p.

Wyoming Geological Association, 1962, Seventeenth Annual Field Conference Guidebook: Symposium on Early Cretaceous rocks of Wyoming, 339 p.

Wyoming Geological Association, 1976, Twenty-eighth Annual Field Conference Guidebook: Geology and energy resources of the Powder River Basin, 328 p.

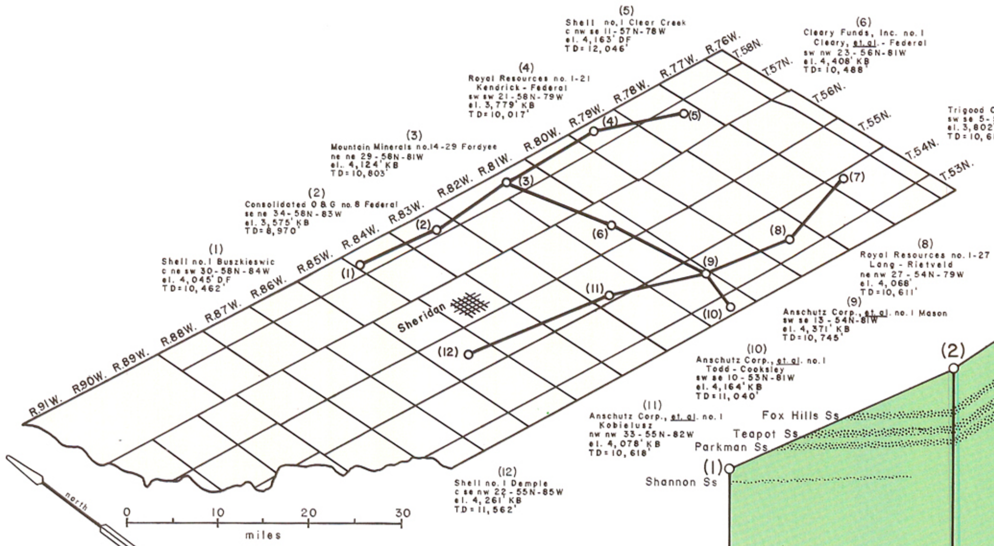
Wyoming Geological Association and Billings Geological Society, 1963, First Joint Field Conference Guidebook: Northern Powder River Basin, Wyoming and Montana, 204 p.

Wyoming Oil and Gas Conservation Commission, 1977, Wyoming oil and gas statistics 1976, 125 p.

DNG

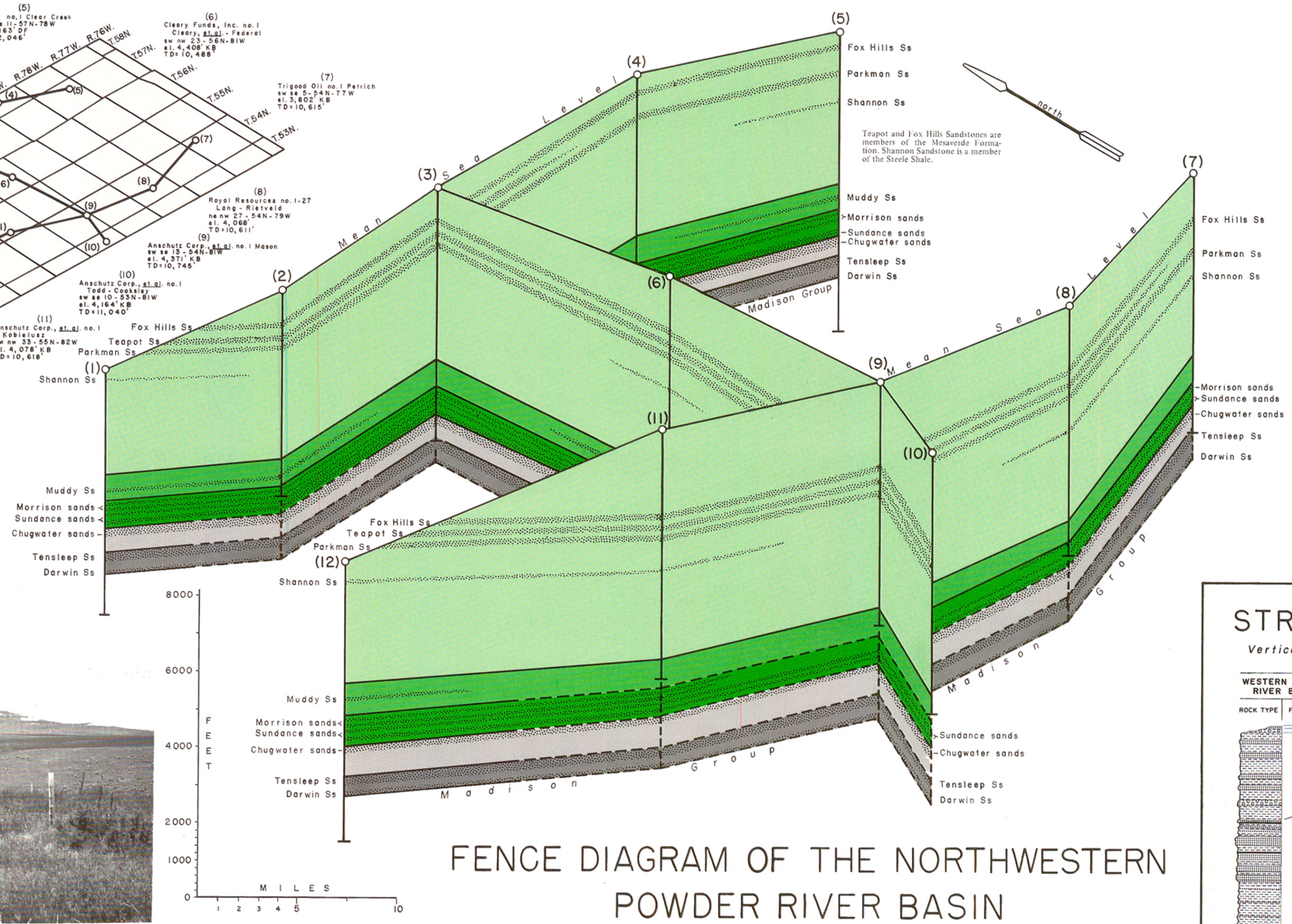
The Geological Survey of Wyoming, 1977.

STRATIGRAPHY—CRS 5, Sheridan County, Wyoming



FENCE DIAGRAM OF THE NORTHWESTERN POWDER RIVER BASIN

(MEAN SEA LEVEL TO TOP OF MADISON GROUP)



LEGEND

Geologic Time Expressed in "Millions of Years Before Present"

Source: GEOLOGIC TIME TABLE (1975), Elsevier Scientific Publishing Co.

- Upper Cretaceous Rocks 65 - 100 M.Y.B.P.
- Lower Cretaceous Rocks 100 - 141 M.Y.B.P.
- Jurassic Rocks 141 - 195 M.Y.B.P.
- Triassic - Permian Rocks 195 - 280 M.Y.B.P.
- Pennsylvanian Rocks 280 - 310 M.Y.B.P.
- Significant Sandstone Units (thicknesses diagrammatic)

These dramatic cliffs of (Mississippian) Madison Limestone are exposed south of U.S. Highway 14, west of Dayton, Wyoming. The limestone strata dip northeast into the Power River Basin off the east flank of the Bighorn Mountains. The prominant treeless scar at the base of the cliff is the result of landslide activity occurring along bedding planes.

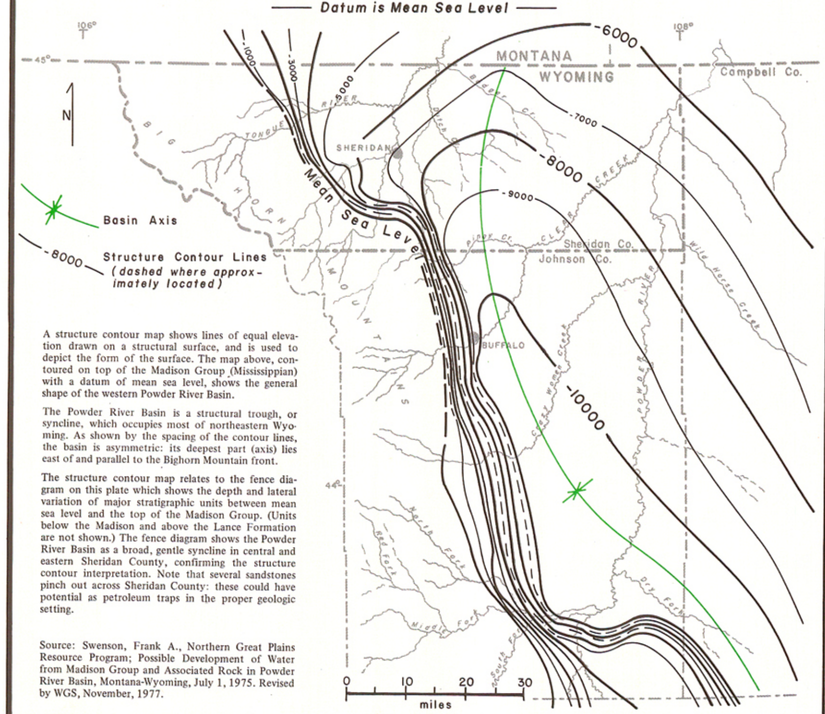
Sandstones, siltstones, and claystones of the Wasatch Formation (Eocene) are exposed in this butte in eastern Sheridan County. Wasatch strata are nearly flat-lying, and cover most of Sheridan County east of the Bighorn Mountains. The formation is approximately 1700 feet thick and contains at least 18 coal beds of significant thickness (Culbertson and Mapel, 1976, p. 196). Thus, the Wasatch is a valuable resource for Sheridan County.

Photographs courtesy of David Gaylord, Remote Sensing Laboratory, University of Wyoming, Laramie.

Structural Contour Map of the top of the Madison Group

(Contour Interval = 1,000 Feet)

Datum is Mean Sea Level



A structure contour map shows lines of equal elevation drawn on a structural surface, and is used to depict the form of the surface. The map above, contoured on top of the Madison Group (Mississippian) with a datum of mean sea level, shows the general shape of the western Powder River Basin.

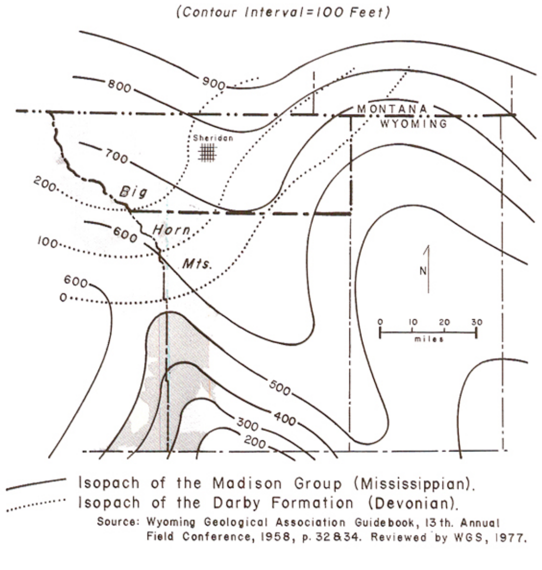
The Powder River Basin is a structural trough, or syncline, which occupies most of northeastern Wyoming. As shown by the spacing of the contour lines, the basin is asymmetric: its deepest part (axis) lies east of and parallel to the Bighorn Mountain front.

The structure contour map relates to the fence diagram on this plate which shows the depth and lateral variation of major stratigraphic units between mean sea level and the top of the Madison Group. (Units below the Madison and above the Lance Formation are not shown.) The fence diagram shows the Powder River Basin as a broad, gentle syncline in central and eastern Sheridan County, confirming the structure contour interpretation. Note that several sandstones pinch out across Sheridan County: these could have potential as petroleum traps in the proper geologic setting.

Source: Swenson, Frank A., Northern Great Plains Resource Program; Possible Development of Water from Madison Group and Associated Rock in Powder River Basin, Montana-Wyoming, July 1, 1975. Revised by WGS, November, 1977.

Isopach Map of the Madison Group and Darby Formation

(Contour Interval = 100 Feet)



Isopach of the Madison Group (Mississippian).
Isopach of the Darby Formation (Devonian).

Source: Wyoming Geological Association Guidebook, 13th. Annual Field Conference, 1958, p. 32 & 34. Reviewed by WGS, 1977.

Devonian rock units of northern Wyoming thin southward to a zero edge which trends across southeastern Sheridan County, as shown by the dotted pattern on the isopach (thickness) map above. These rocks consist predominately of marine carbonates which were deposited on a broad, shallow cratonic shelf bordering deeper waters to the west. In late Devonian or early Mississippian time, crustal movement caused uplift and erosion of parts of the cratonic shelf, and Devonian strata were completely eroded from central and southern Wyoming. Mississippian limestones were then deposited with regional unconformity on Devonian and older rocks across Wyoming. Subsequent periods of deformation have affected the regional thickness of Mississippian strata. Stratigraphic "pinch-outs," such as the southward thinning of Devonian strata, have potential as petroleum traps.

STRATIGRAPHY OF SHERIDAN COUNTY, WYOMING

Sedimentary rocks, Cambrian to Recent in age, are exposed along the eastern and northern flanks of the Precambrian crystalline core of the Bighorn Mountains. These sedimentary rocks have been divided into 23 formations of 17,500 feet in aggregate thickness (Mapel, 1959, p. 9).

Core rocks are disconformably overlain by the Middle Cambrian Flathead Sandstone, 345 feet thick, a cross-bedded sandstone with interbedded micaceous shale and siltstone (Mapel, 1959, p. 10). The ratio of sand to shale may vary greatly between outcrops. The basal part of the Flathead is a pebbly sandstone, 10 to 40 feet thick.

The Flathead Sandstone is overlain by 645 feet of the Middle and Upper Cambrian Gros Ventre and Gallatin Formations. The Gros Ventre consists of thin-bedded calcareous, glauconitic sandstone, overlain by micaceous silty shales and thin-bedded, flat-pebble limestone conglomerate beds. The Gallatin is a cliff-forming, finely crystalline limestone containing pink, green, and red shale partings.

Cambrian strata are unconformably overlain by the Ordovician Bighorn Dolomite, up to 395 feet thick, a white, friable, cross-bedded basal sandstone overlain by 230 feet of massively bedded sugary dolomite characterized by a rough pitted weathered surface (Mapel, 1959, p. 13). Outcrops of the Bighorn generally form west-facing cliffs with east-facing gentle dipslopes.

The Bighorn Dolomite is overlain throughout most of Sheridan County by the Devonian Jefferson (or Darby) Formation, a limestone with thin interbedded shales and sandstones. Pinchout of Devonian strata in the Powder River Basin could result in petroleum entrapment.

Mississippian strata overlie the Bighorn in southern parts of the county, due to Late Devonian/Early Mississippian erosion and truncation. The Madison Limestone (Devonian and Mississippian) consists of carbonate rocks, up to 805 feet thick in the northern Bighorn Mountains. The Madison has been divided into six members (Sando, 1976), on the basis of rock type and faunal content. The Madison Limestone is of current interest as an aquifer in the Powder River Basin.

The Madison Limestone is disconformably overlain by the Darwin Sandstone Member of the Amsden Formation at most localities, but locally by the Horseshoe Shale Member, or, rarely, the Ranchester Limestone Member, of the Amsden (Sando, 1976, p. 45). The disconformity between Madison and Amsden rocks is a karst surface formed on the Madison in Late Mississippian time. The Darwin is a cross-bedded conglomeratic sandstone, the lower part of which may be fluvial in origin. The Darwin is overlain by Amsden strata consisting of 240 feet of interbedded dolomite, red shale, finely crystalline limestone, calcareous sandstone, and siltstone (Mapel, 1959, p. 20).

Amsden strata are overlain by the Pennsylvanian Tensleep Sandstone, 275 feet thick, a well-sorted quartz sandstone. Large-scale cross-bedding is characteristic of the Tensleep. Pink to yellow dolomite with chert nodules is commonly interbedded with the sandstone.

Interbedded gypsum, red shale and siltstone, and light gray limestone overlie the Tensleep Sandstone. These beds, probably correlative with the Permain Goose Egg Formation, form a narrow outcrop band 180 feet thick at the bases of Tensleep dipslopes.

Permian strata are overlain by 800 feet of the Triassic Chugwater Formation. The lower 700 feet of shale, siltstone, and poorly sorted sandstone has been designated the Red Peak Member (Love, 1945): cross-bedding and ripple marks are common. The Alcova Limestone, the middle member of the Chugwater Formation, is a slabby, thin-bedded limestone characterized by wavy bedding. The upper member of the Chugwater, the Crow Mountain Sandstone Member, is 70 feet of cross-bedded friable sandstone.

Triassic strata are disconformably overlain by the Middle Jurassic Gypsum Spring Formation, 180 feet thick, consisting of red shale and thin-bedded limestone. Prominant limestone beds, which occur near the middle and top of the formation, stand out as sharp white ledges in contrast to the intervening red strata (Mapel, 1959, p. 28).

Upper Jurassic strata include the Sundance and Morrison Formations. The Sundance is 280 feet of shale and sandy shale interbedded with sandstone and fossiliferous limestone. The Morrison Formation is 180 feet of claystone and shale interbedded with lenticular sandstone beds. Most sandstone beds are cross-bedded and contain chert pebbles, clay partings, and bone fragments (Mapel, 1959, p. 34).

Lower Cretaceous strata include the Cloverly Formation, Skull Creek Shale, Newcastle Sandstone, and Mowry Shale. The Cloverly consists of 150 feet of massive, cross-bedded sandstone, carbonaceous shale, and thin-bedded siltstone. Globular dahllite concretions are characteristic of the upper Cloverly. The Skull Creek Shale is 175 feet of nonresistant black shale interlaminated with siltstone. The Newcastle Sandstone, 50 feet thick, is fine-grained sandstone with thin black shale partings. The Mowry Shale consists of a lower nonresistant black shale member, 200 feet thick, and an upper resistant light gray siliceous shale member, 325 feet thick.

Lower Cretaceous Strata are overlain by the Upper Cretaceous Frontier Formation, Cody Shale, Parkman Sandstone member of the Mesaverde, Lewis Shale, and Lance Formation. The Frontier is 500 feet of interbedded shale and sandstone. A conglomeratic chert-pebble sandstone occurs at the top of the Frontier. The Cody Shale contains several members totaling 3570 feet in thickness (Mapel, 1959, p. 47), consisting of shale and sandstone beds. The Parkman Sandstone is 770 feet of massive sandstone overlain by gray shale and sandstone. The Lewis Shale, 700 feet thick, is a dark gray marine shale. The Lance Formation is 1960 feet of massive channeled sandstone and shale.

The Paleocene Fort Union Formation overlies Mesozoic strata. The Fort Union, 3900 feet thick, consists of 1500 feet of thin-bedded ferruginous sandstone, claystone, siltstone and fine-grained sandstone, overlain by 1500 feet of rock of much the same lithology with the addition of several thick carbonaceous shales, and 900 feet of poorly consolidated sandstone lenses, shale, and conglomerate (Mapel, 1959, p. 61).

The Eocene Wasatch Formation, which overlies the Fort Union unconformably, consists of sandstone, carbonaceous shale, and coal which interfingers to the west with conglomerate. The Kingsburg Conglomerate Member contains pebbles and cobbles of Paleozoic limestone and dolomite (Mapel, 1959, p. 63). The Kingsburg member represents coarse sediment eroded from the Rocky Mountain highlands during the Laramide Orogeny.

Oligocene and Miocene strata, the Arikaree, White River, and Moncrief Formations, represent a period of highland erosion and deposition in adjacent basins, which nearly buried the Rockies prior to late Cenozoic regional uplift. They consist mostly of conglomerate, sandstone, and volcanic ash.

Pleistocene and Quaternary strata record episodes of glaciation, pedimentation and alluviation in, and adjacent to, the Bighorn Mountains.

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Sando, W.J., 1976, Madison Limestone (Devonian and Mississippian), east flank of Bighorn Mountains, Wyoming: Wyoming Geol. Assoc., 28th Annual Field Conference Guidebook, p. 45-52.

Wyoming Geological Association, 1958, 13th Annual Field Conference Guidebook, Power River Basin, 341 p.

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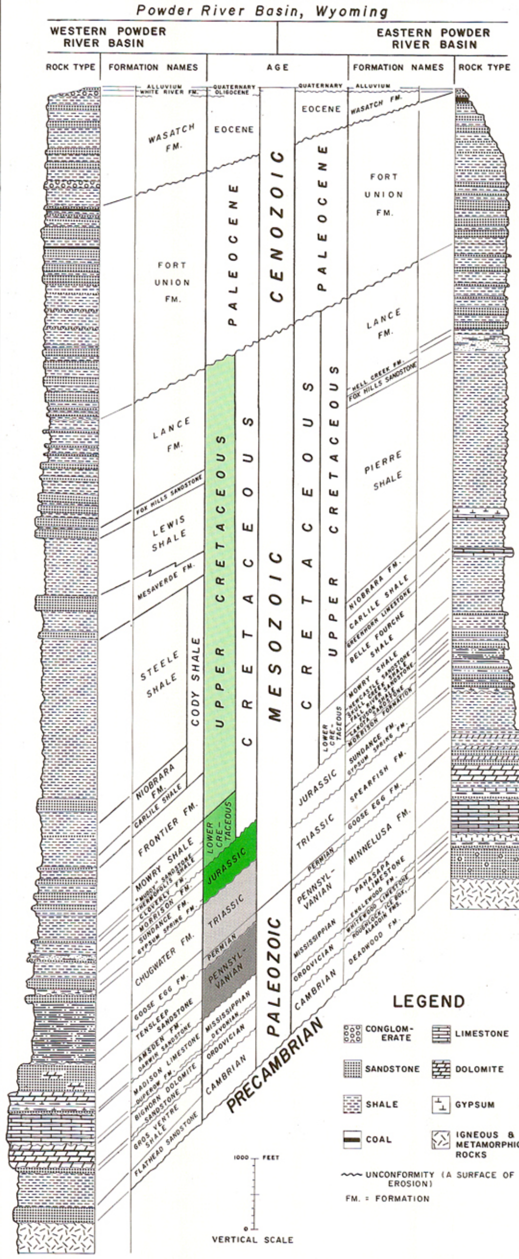
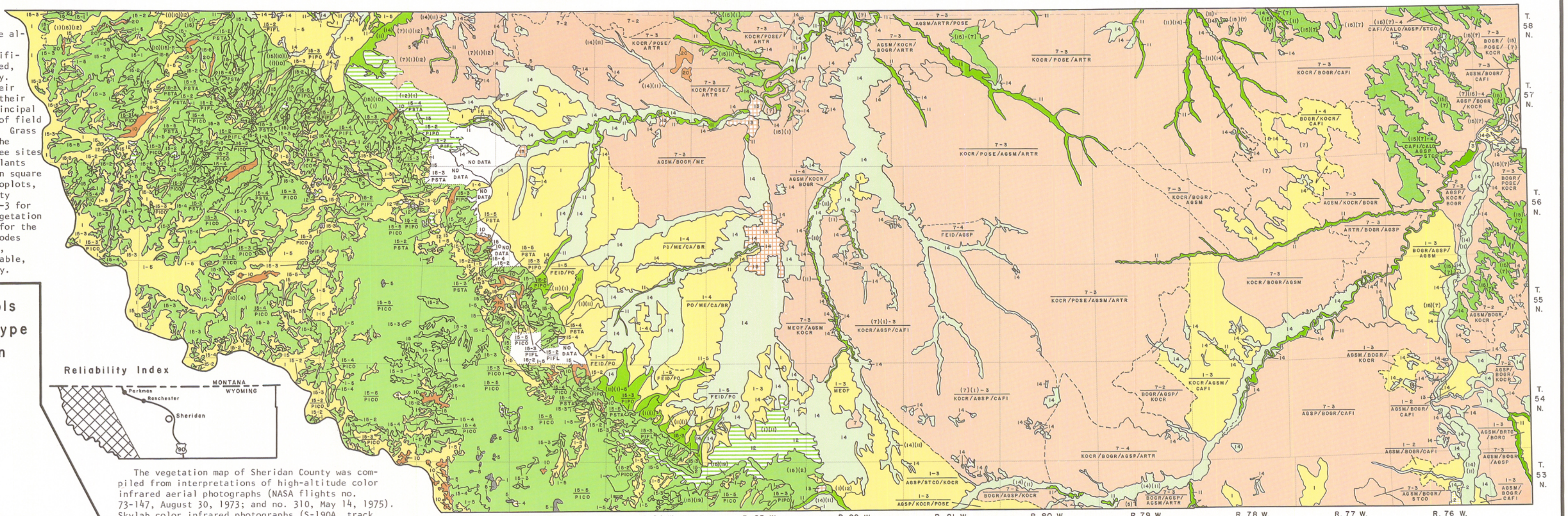
STRATIGRAPHIC COLUMN

Vertical Sequence Of Rock Formations Within The Powder River Basin, Wyoming



VEGETATION—CRS 5, Sheridan County, Wyoming

This map shows the major vegetation types in Sheridan County. The vegetation varies from the grasslands and widespread sagebrush-grasslands of the plains, to the alpine grasslands, meadows, and coniferous stands of the Bighorn Mountains. A classification scheme of twenty classes is employed, of which fourteen occur in Sheridan County. Vegetation types were distinguished by their appearance on aerial photographs (called their "visual aspect"). Density classes and principal plant species were derived from analysis of field data collected during the summer of 1976. Grass and herbaceous sites were sampled using the square-foot density method. Shrub and tree sites were sampled by recording the number of plants found within a sequence of randomly chosen square meter plots and 10 x 10 meter-square macroplots, respectively. Vegetation types and density classes are represented by two numbers, 7-3 for example, which refer to entries in the Vegetation Class and Density Class tables. Symbols for the principal plant species are four-letter codes representing the plants' scientific names, AGSM/BOGR for example, as listed in the table, Principal Plant Species of Sheridan County.



Reliability Index

The vegetation map of Sheridan County was compiled from interpretations of high-altitude color infrared aerial photographs (NASA flights no. 73-147, August 30, 1973; and no. 310, May 14, 1975). Skylab color infrared photographs (S-190A, track 19, pass 6, June 6, 1973, frames 117-118) were used to cross check some areas in the northeastern portion of the county. Areas not adequately covered stereographically by high-altitude aerial photographs (cross hatched area on Reliability Index, above) were generalized from 1:24,000-scale U.S. Forest Service "forest-type" maps.

N

Scale 1:250,000

5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

Vegetation map compiled by:
Alvin L. Medina
Department of Range Management
University of Wyoming

Work supported by:
U.S. Geological Survey
Grant 14-08-0001-G-163

Explanation of Map Symbols Used For "Vegetation Type Designation" in Sheridan County, Wyoming.

SYMBOL ORDER

VEGETATION CLASS - DENSITY CLASS

PRINCIPAL PLANT SPECIES

DENSITY CLASSES**

CLASS	DEFINITION	GROUND COVER
1	trace/none	less than 5%
2	rare	5 - 25%
3	parklike	26 - 50%
4	interrupted	51 - 75%
5	continuous	76 - 100%

** Density classes refer to the percentage of ground covered by the total vegetation within a vegetation type.

VEGETATION CLASSES

1 Grassland and associated herbaceous plants, not under cultivation. Perennial grasses predominate and determine the aspect. Ex.: Bouteloua gracilis, Agropyron smithii

2 Alluvial areas; drainage from nearby highland (erosion usually heavy; sometimes saline).

3 Areas dominated by grasses rather than sedges. Generally moist, meadow-like areas in open timber or flood-plain areas, becoming moderately dry by midsummer. Ex.: Festuca idahoensis, Poa spp.

4 Areas characterized principally by sedges, and by very poorly drained and/or partially submerged soils. Ex.: Carex spp.

5 Lakes, reservoirs, and other major water impoundments.

*6 Areas characterized by annual grasses or weeds. Also includes areas in transitory stages and semi-permanent conditions. Ex.: Bromus tectorum

7 Areas where sagebrush predominates.

*8 Areas where the various salt desert shrubs of the Atriplex family form the predominant vegetation and visual aspect. Ex.: Atriplex nuttalli

*9 Areas where greasewood (Sarcobatus) is the predominant vegetation and visual aspect. Includes valley floors subject to overflow during flood periods or areas underlain with ground water at shallow depths and having saline soil. Ex.: Sarcobatus vermiculatus

10 Areas where browse, except sagebrush or subtypes, gives the main aspect or is the predominant vegetation. Shrubs occupy the transition zone of lower mountain slopes, foothills, and plateau areas. Ex.: Cercocarpus ledifolius

11 Areas characterized by poplars (cottonwoods), willows, and other vegetation supported by stream water.

12 Areas characteristic of Populus spp. and other deciduous trees not including riparian.

13 Residential, business, and industrial areas (mines and mills included).

14 Areas where the land is cultivated for farmcrops, natural haylands, irrigated pastures, and fallow fields.

15 Areas characterized by coniferous species.

*16 Areas where timber has been logged.

*17 Areas of timberland, brushland or woodland that have been burned over, and a woody vegetation has not been established.

*18 Areas where vegetation is absent as a result of disturbance. Litter-covered ground is included.

*19 Areas of solid rock or land that is very rocky. Vegetation is essentially absent.

20 Areas where almost no vegetation exists and which have not been disturbed by man. Ex.: Intermittent lakebeds, rockslides, heavily eroded soils.

No data; areas where stereo-coverage was unavailable or area was inaccessible.

*NOTE: Vegetation classes, identified by asterisks (above), do not occur in Sheridan County singularly or as primary classes, but may occur as subordinate vegetation classes where other classes dominate.

SOURCES OF DATA

Beetle, A.A., 1970, Recommended plant names: Res. Journal No. 31, Agricultural Experiment Station, University of Wyoming.

Inter-Agency Range Survey Comm., 1937, Instructions for range surveys.

Kuchler, A.W., 1976, Vegetation mapping: The Ronald Press Company, New York.

Thilenius, J.F., (Plant Ecologist), Personal communication, 1975: Rocky Mountain Forest and Range Experimental Station, Laramie, Wyoming.

PRINCIPAL PLANT SPECIES OF SHERIDAN COUNTY

SYMBOL	SCIENTIFIC NAME	COMMON NAME
ABLA	*Abies lasiocarpa*	Alpine fir (subalpine f.)
ACNE	*Acer negundo*	Boxelder maple
ACLA	*Achillea lanulosa*	Western yarrow
ACMI	*Achillea millefolium*	Common yarrow
AGGL	*Agoseris glauca*	Pale agoseris
AG	*Agropyron* (spp.)	Wheatgrass, quackgrass
AGCR	*Agropyron cristatum*	Crested wheatgrass
AGDA	*Agropyron dasystachyum*	Thickspike wheatgrass
AGRE	*Agropyron repens*	Common quackgrass
AGSM	*Agropyron smithii*	Western wheatgrass
AGSP	*Agropyron spicatum*	Bluebunch wheatgrass
AGAL	*Agrostis alba*	Redtop bent
ALCE	*Allium cernuum*	Nodding onion
AMAL	*Amelanchier alnifolia*	Saskatoon serviceberry
ANGE	*Andropogon gerardi*	Big bluestem
ANHA	*Andropogon hallii*	Sand bluestem
ANSC	*Andropogon scoparius*	Little bluestem
ANRO	*Antennaria rosea*	Rose pussytoes
ARLO	*Aristida longiseta*	Red threeawn
ARCO	*Arnica cordifolia*	Heartleaf arnica
ARCA	*Artemisia cana*	Silver sagebrush
ARFI	*Artemisia filifolia*	Sand sagebrush
ARFR	*Artemisia frigida*	Fringed sagewort
ARNO	*Artemisia nova*	Black sagebrush
ARPE	*Artemisia pedatifida*	Birdfoot sagewort
ARSP	*Artemisia spinescens*	Bud sagewort
ARTR	*Artemisia tridentata*	Basin big sagebrush
AS	*Astragalus* (spp.)	Milkvetch
ATCO	*Atriplex confertifolia*	Shadscale saltbush
ATNU	*Atriplex nuttailli (gardneri)*	Nuttail saltbush
BASA	*Balsamorhiza sagittata*	Arrowleaf balsamroot
BEOC	*Betula occidentalis*	Water birch
BOCU	*Bouteloua curtipendula*	Sideoats grama
BOGR	*Bouteloua gracilis*	Blue grama
BR	*Bromus* (spp.)	Brome
BRAN	*Bromus anomalus*	Nodding brome
BRIN	*Bromus inermis*	Smooth brome
BRJA	*Bromus japonicus*	Japanese brome
BRMA	*Bromus marginatus*	Mountain brome
BRTE	*Bromus tectorum*	Cheatgrass brome
CACA	*Calamagrostis canadensis*	Bluejoint reedgrass
CAIN	*Calamagrostis inexpansa*	Northern reedgrass
CALO	*Calamovilfa longifolia*	Prairie sandreed
CANU	*Calochortus nuttalli*	Sego mariposalily
CA	*Carex* (spp.)	Sedge
CAFI	*Carex filifolia*	Threadleaf sedge
CAGE	*Carex geyeri*	Elk sedge
CAHE	*Carex heliophila*	Sun sedge
CACO	*Castilleja coccinea*	Common indianpaintbrush
CELE	*Cercocarpus ledifolius*	Curlleaf mountainmahogany
CEMO	*Cercocarpus montanus*	True mountainmahogany
CHAL	*Chenopodium album*	Lambsquarters goosefoot
CHLA	*Chrysothamnus lanceolatus*	Lanceleaf rabbitbrush
CHNA	*Chrysothamnus nauseosus*	Rubber rabbitbrush
CIAR	*Cirsium arvense*	Canada thistle
CR	*Crataegus* (spp.)	Hawthorn
DEBI	*Delphinium bicolor*	Little larkspur
DISP	*Distichlis spicata stricta*	Inland saltgrass
ELCA	*Elymus canadensis*	Canada wildrye
ER	*Eriogonum* (spp.)	Wildbuckwheat
EULA	*Eurotia lanata*	Common winterflat
FEID	*Festuca idagoensis*	Idaho fescue
GRSQ	*Grindelia squarrosa*	Curlycup gumweed
GUSA	*Gutierrezia sarothrae*	Broom snakeweed
HA	*Halogeton* (spp.)	Halogeton

SYMBOL	SCIENTIFIC NAME	COMMON NAME (con't.)
HOBR	*Hordeum brachyantherum*	Meadow barley
HOJU	*Hordeum jubatum*	Foxtail barley
JU	*Juncus* (spp.)	Rush
JUCO	*Juniperus communis*	Common juniper
JUSC	*Juniperus scopulorum*	Rockymountain juniper
KOCR	*Koeleria cristata*	Prairie junegrass
LE	*Lepidium* (spp.)	Pepperweed
LU	*Lupinus* (spp.)	Lupine
MEBU	*Melica bulbosa*	Onion melic
ME	*Melilotus* (spp.)	Sweetclover
MEAL	*Melilotus alba*	White sweetclover
MEOF	*Melilotus officinalis*	Yellow sweetclover
MECI	*Mertensia ciliata*	Mountain bluebells
OPPO	*Opuntia polyacantha*	Plains pricklypear
ORHY	*Oryzopsis hymenoides*	Indian ricegrass
PE	*Penstemon* (spp.)	Penstemon
PHAL	*Phleum* (spp.)	Alpine timothy
PH	*Phlox* (spp.)	Phlox
PIEN	*Picea engelmanni*	Engelmann spruce
PICO	*Pinus contorta*	Lodgepole pine
PIFL	*Pinus flexilis*	Limber pine
PIPO	*Pinus ponderosa*	Ponderosa pine
PO	*Poa* (spp.)	Bluegrass
POCA	*Poa canbyi*	Canby bluegrass
POIN	*Poa interior*	Inland bluegrass
POPR	*Poa pratensis*	Kentucky bluegrass
POSE	*Poa secunda*	Sandberg bluegrass
POAN	*Populus angustifolia*	Narrowleaf poplar
PODE	*Populus deltoides*	Eastern poplar
POTR	*Populus tremuloides*	Quaking aspen
POFR	*Potentilla fruticosa*	Shrubby cinquefoil
PR	*Prunus* (spp.)	Cherry, plum, etc.
PSME	*Pseudotsuga menziesii*	Common douglasfir
QU	*Quercus* (spp.)	Oak
RO	*Rosa* (spp.)	Rose
SA	*Salix* (spp.)	Willow
SATE	*Salsola tenuifolia*	Tumbleweed russianthistle
SAVE	*Sarcobatus vermiculatus*	Black greasewood
SE	*Sedum* (spp.)	Stonecrop
SHCA	*Shepherdia canadensis*	Russet buffaloberry
SIHY	*Sitanion hystrix*	Bottlebrush squirreltail
SO	*Solidago* (spp.)	Goldenrod
SOAM	*Sorbus americana*	American mountainash
STCO	*Stipa comata*	Needle and thread
STVI	*Stipa viridula*	Green needlegrass
SYAL	*Symphoricarpos albus*	Common snowberry
TAOF	*Taraxacum officinale*	Common dandelion
ZIVE	*Zigadenus venenosus*	Meadow deathcamus

Picture # 1

Picture # 2

Picture # 3

Picture #1
Riparian site of the Powder River flood plain south of Arvada. The area is comprised of cottonwoods, willows, and assorted perennial and annual grasses and forbs (Class 11).

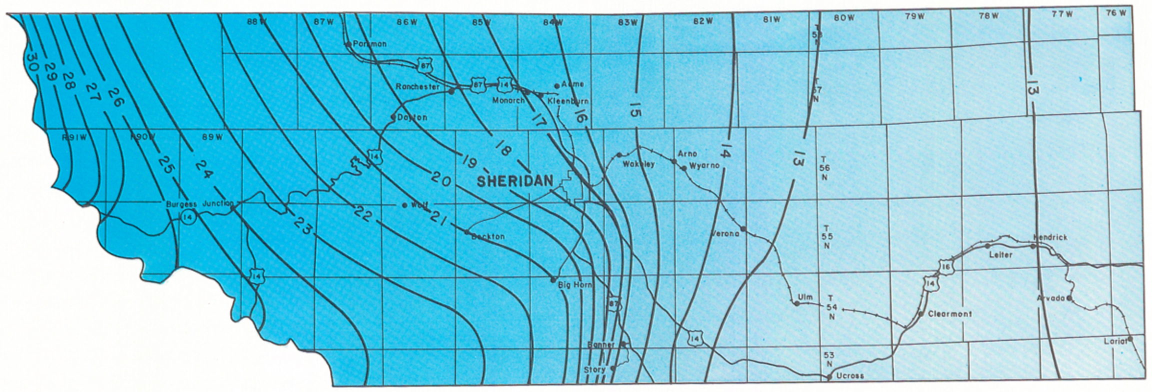
Picture #2
Ponderosa pine--juniper--sagebrush association found on isolated breaks in the northeastern portion of the county and on the east side of the Powder River.

Picture #3
Mountain scene showing four major vegetation classes (grassland, riparian, sagebrush-grassland, and coniferous), commonly found on the Bighorn Mountains (Classes 1, 11, 7, 15).

DNG

The Geological Survey of Wyoming, 1977.

Climate & Precipitation



Average annual precipitation (inches)

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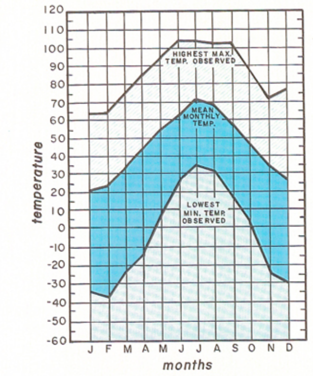
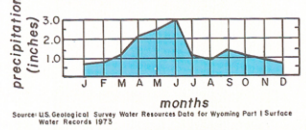
Annual temperatures, Sheridan field station



Aveage monthly precipitation (Sheridan AP weather station)



Source: U.S. Geological Survey Water Resources Data for Wyoming Part I Surface Water Records 1973

Climate and Precipitation

The climate of Sheridan County is strongly influenced by its physiography. The western quarter of the county includes the crest of the Bighorn Mountains, and the eastern three-quarters is in the semi-arid Powder River Basin. Both temperature and precipitation (as shown on the map) vary directly with elevation. Annual precipitation ranges from more than 30 inches at the crest of the Bighorns to less than 13 inches at Clearmont in the rainshadow of the mountains.

Sheridan, the major population center of the county, is located in the foothills of the Bighorn Mountains and receives about 17 inches of precipitation annually. The average temperature in Sheridan is 45°F. Although Sheridan receives 65 inches of snow and sleet each year, most of it is low in moisture. Over half the annual precipitation occurs between April and July, and the winter months are the driest.

Prevailing winds are generally northwesterly. Sheridan, as well as most of the eastern three-quarters of the county, is in the lee of the Bighorn Mountains and benefits from the warming effect of downslope winds. Snow cover is generally short lived.

The length of the growing season is about 127 days at Sheridan, and decreases substantially toward the mountains. The frost-free period is from mid-May to mid-September. Although temperatures in the basin are generally higher than those in the mountains, they have greater seasonal variation. Irrigated agriculture is common along the major water courses in the county. Dryland farming is common along the foothills and in the basin where precipitation allows.

Sources of Information

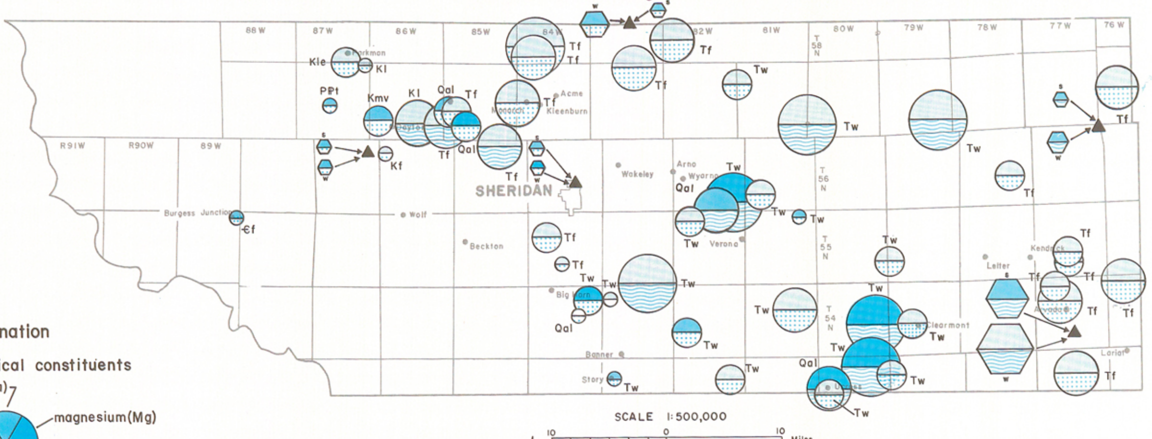
Becker, C.F., and Alyea, J.D., 1964, Temperature probabilities in Wyoming: University of Wyoming Agriculture Experiment Station Bulletin 415, p. 81.

_______________, 1964, Precipitation probabilities in Wyoming: University of Wyoming Agricultural Experiment Station Bulletin 416, p. 79-82.

Natural Resources Research Institute, 1966, Wyoming weather facts: Wyoming Natural Resource Board, Cheyenne, p. 20-21.

This view looking southwest up Little Goose Creek Valley shows the physiography of the Bighorn Mountains, foothills belt, and Powder River Basin. The town of Big Horn is at right center. (Photo: Wyoming Travel Commission.)

Water Quality



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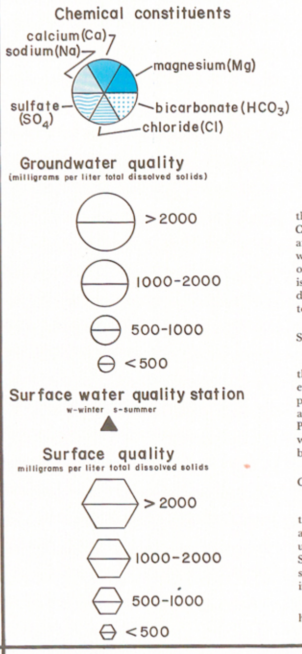
Explanation



Water Quality

Water quality is often a more important consideration than quantity for domestic, agricultural, and industrial uses. Chemical, bacteriological, and suspended constituents are affected by man's activities, but the "natural" quality of water is primarily determined by the rocks and soil units over and through which it flows. Chemical quality of water is usually expressed in parts per million (ppm) for major dissolved constituents (anions and cations) as well as for total dissolved solids (the sum of all dissolved constituents).

Surface Water Quality

Surface water quality usually varies with seasonal flow; that is, during high surface runoff, streams have lower mineral content than during periods of low runoff. Most streams pick up higher loads of suspended sediment as they flow across the soft and easily eroded rocks and soils in the Powder River Basin. The chemical composition of surface water in major streams is shown in the octagons on the map by a color code, and total dissolved solids by their sizes.

Ground Water Quality

The chemical quality of ground water is a function of the aquifer's geochemistry. Water analyses for pre-Tertiary aquifers are sparse. Waters suitable for domestic or stock use can be produced from the Lance Formation, Bearpaw Shale, Parkman Sandstone, and Tensleep Sandstone. Tensleep, Amsden, and Flathead Formation waters are of good irrigation quality.

Domestic water from the Fort Union Formation may have high iron and total dissolved solids. While Fort Union water may be used for stock use, its high sodium and bicarbonate contents make it poor for irrigation. Domestic water from the Wasatch Formation usually exceeds the standard for total dissolved solids. Agricultural water from the Wasatch is variable in suitability. Both of these major Tertiary aquifers may contain objectionable levels of hydrogen sulfide.

Ground water in the Quaternary deposits is unconfined and interacts directly with surface waters, and therefore is variable in water quality. The chemical composition of groundwater in major aquifers is shown in the circles on the map by a color code, and total dissolved solids by their sizes. Geologic symbols indicate the producing aquifer:

Geologic Source Symbols

Qal	Alluvium
Tw	Wasatch Formation
Tf	Fort Union Formation
Kle	Lewis Shale
Kmv	Mesaverde Formation
Kf	Frontier Formation
€f	Flathead Sandstone

Standards

Drinking water standards of the U.S. Public Health Service recommend less than 500 mg/1 (milligrams per liter, nearly the same as ppm) dissolved solids for human consumption. Stock water can be used up to 5000 mg/1, but good stock water is less than 1000 mg/1. Standards for the most common chemical constituents in Sheridan County water are shown in the chart. Both "hard" and "soft" waters occur in Sheridan County. The most common water types are sulfate and bicarbonate waters with calcium and sodium the dominant cations.

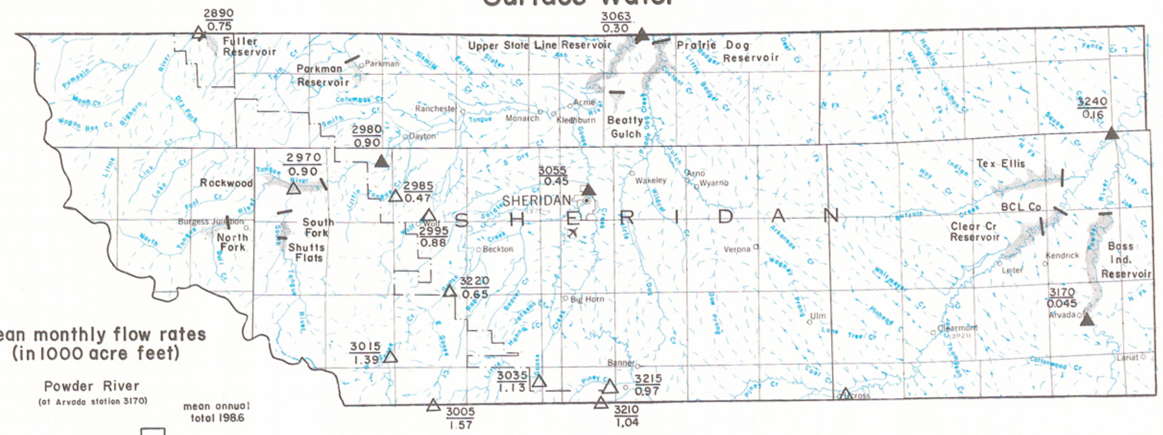
Constituent	Maximum mg/1 for drinking water (U.S.P.H.S.)	"Hardness"
Cations		
Calcium, Ca; Magnesium, Mg	250 total	"hard"
Sodium, Na; Potassium, K		"soft"
Anions		
Carbonate, CO_3; Bicarbonate, HCO_3	undetermined	With Ca and Mg, temporary (treatable)
Sulfate, SO_4	250	With Ca and Mg, permanent
Chloride, Cl	250	
Total dissolved solids	500	

Sources of Information

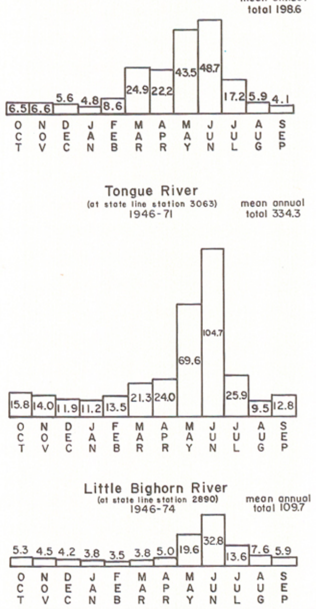
Hodson, W.G., Pearl, R.H., and Druse, S.A., 1973, Water resources of the Powder River Basin and adjacent areas, northeastern Wyoming: U.S. Geological Survey Hydrologic Investigations Atlas HA-465, 4 maps.

Lowry, M.E., and Cummings, R.T., 1966, Ground-water resources of Sheridan County, Wyoming: U.S. Geological Survey Water-Supply Paper 1807, 77 p.

Surface Water



Mean monthly flow rates (in 1000 acre feet)



Proposed or potential reservoir site and storage in acre feet

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3170 / 0.045 △ Active stream gauging station

Upper number identifies station; the lower number is average annual runoff, at the station, expressed in cubic feet per second per square mile of drainage area.

3170 / 0.045 △ Active stream gauging station and chemical-quality sampling site

(see water quality map for data)

Surface Water

The major streams draining Sheridan County are the Tongue, Powder, and Little Bighorn Rivers and their tributaries. All ultimately join the Yellowstone River.

Surface water use is controlled by a Compact governing the division of Yellowstone River waters among Wyoming, Montana, and North Dakota. Although the Tongue and Powder Rivers normally have unappropriated and unused waters available for divison, no Compact water is available during drought years. Storage would be required to develop Compact water.

Streamflow is mainly from precipitation in the Bighorn Mountains, and is highest during runoff in May and June. Streams draining the basin areas generally have low flows and high sediment loads. Locations of potential reservoirs shown on the map are based on information from the State Engineer's office.

Use of surface water in Sheridan County is primarily for irrigation. Its second major use is for stock water: hundreds of stock ponds store water for livestock. Its third major use is for municipal water supplies in Sheridan, Dayton, and Ranchester. Energy development will require large amounts of water and constitutes a major part of predicted future water needs.

Competition for existing surface water supplies and for water from new sources will increase. New storage projects, transbasin diversions, and groundwater development have been considered for new supplies.

Sources of Information

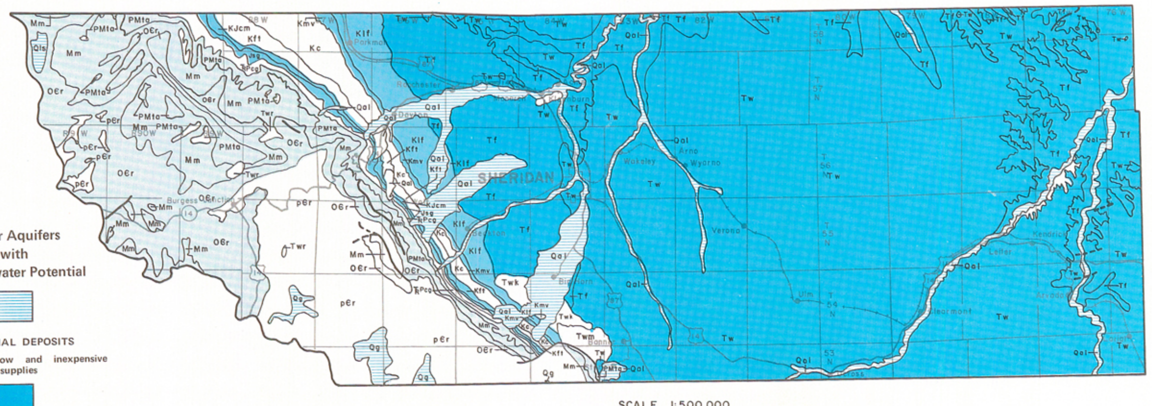
Hodson, W.G., Pearl, R.H., and Druse, S.A., 1973, Water resources of the Powder River Basin and adjacent areas, northeastern Wyoming: U.S. Geological Survey Hydrologic Investigations Atlas HA-465, 4 maps.

Wyoming State Engineer, 1965, Water resources inventory for Water Division Number 2, State of Wyoming (prepared by R.L. Streeter), 57 p.

Wyoming State Engineer, 1973, The Wyoming framework water plan: Wyoming Water Planning Program, 243 p.

This photograph shows the Tongue River during high spring snowmelt runoff.

Ground Water



Major Aquifers with Groundwater Potential

SURFICIAL DEPOSITS

Common shallow and inexpensive source for small supplies

TERTIARY SANDSTONES

Major source for moderate to small yields of domestic and agricultural uses

MESOZOIC SANDSTONES

Interbedded sandstones with variable groundwater potential

PALEOZOIC UNITS

Largely undeveloped and unevaluated aquifers with large potential and large development costs

Ground Water

Ground water supplies in Sheridan County are as diverse in quality and quantity as the source rocks are. A number of aquifers yield adequate supplies for stock and domestic use, but larger supplies for industrial use are only available from a few of the deep formations.

Recharge is from precipitation (see Climate and Precipitation) and infiltration where streams cross rock outcrops in the Bighorn Mountains. Crystalline rocks of Precambrian age are exposed in the central part of the Bighorns and, although in the main recharge area, provide only fair to poor aquifer characteristics. The foothills belt of the mountains contains rocks from Precambrian to Tertiary ages, including several good aquifers; however, these rocks dip steeply into the Powder River Basin and are deeply buried within a few miles of their outcrops. The three-quarters of the county in the Powder River Basin is underlain by Tertiary sediments which contain lenticular aquifers of moderate ground water potential.

Pre-Tertiary aquifers with large ground water potential are the Bighorn Dolomite, the Madison Limestone, the Amsden Formation, and the Tensleep Sandstone. Moderate to small supplies should be available from the Flathead Sandstone, Sundance Formation, Morrison Formation, Cloverly Formation, Muddy Sandstone (Thermopolis Formation), Frontier Formation, Mesaverde Formation, and Lance Formation.

Most stock and domestic water wells are developed in the Tertiary Fort Union and Wasatch Formations. These wells are relatively shallow and do not produce large quantities of water. Quaternary deposits along the major streams and rivers provide good supplies of unconfined water.

The adjacent chart shows the ground water available in the geologic units: their distribution is shown on the map. Logs and records of specific wells are available for inspection at the Wyoming State Engineer's Office, Barrett Building, Cheyenne, Wyoming 82001.

Sources of Information

Hodson, W.G., Pearl, R.H., and Druse, S.A., 1973, Water resources of the Powder River Basin and adjacent areas, northeastern Wyoming: U.S. Geological Survey Hydrologic Investigations Atlas HA-465, 4 maps.

Lowry, M.E., and Cummings, R.T., 1966, Ground-water resources of Sheridan County, Wyoming: U.S. Geological Survey Water-Supply Paper 1807, 77 p.

SCALE 1:500,000

GEOLOGIC FORMATIONS AND POTENTIAL WATER SUPPLY

Map Sym	Unit / Thickness	Lithology	Groundwater Possibilities	Water Quality (dissolved solids in milligrams per liter)
Qal	Alluvium 0-100	Unconsolidated silt, sand and gravel underlies floodplains and terraces; landslides include loose blocks and fine matrix; tills are bouldery and cobbly	Qal yields small to moderate supplies for domestic, stock, and irrigation uses; Qls and Qg usually yield small supplies restricted to mountains	No dominant type usually good — but variable
Qls	Landslide 50±			
Qg	Glacial 0-48			
Tm	Moncrief Formation 0-400	Coarse grained sandstone and siltstone grading upward into boulder beds	Moderate to large supplies could be obtained from coarser facies	
Tow Twr	Arikaree and White River Formations 0-30	Tuffaceous claystone, siltsone and sandstone with local conglomeratic lenses	Limited due to small outcrop area	Mostly sodium and calcium bicarbonate
Tw	Wasatch Formation 1200±	Fine to coarse-grained sandstone with interbedded shale and coal; grades westward into conglomeratic zones.	Usually adequate supplies (10-15 gpm) but may produce up to several hundred gpm for domestic and stock use; gas (H_2S) associated with water in many wells	Sodium sulfate and bicarbonate are the dominant types, ranging from 500 to 1500 mg/l
Twk	Kingsbury Conglomerate Member 0-800			
Tf	Fort Union Formation 2000±	Fine-grained sandstone and interbedded carbonaceous shale and coal	Yields water from fine-grained sandstone, jointed coal and clinker beds; maximum yields 150 gal/min	Sodium bicarbonate and sulfate, 500 to 1500 mg/l, common sodium irrigation hazard
Klf	Lance and Fox Hills Formations 1900±	Sandstones and interbedded sandy shale	Yields small supplies of water suitable for domestic and stock	200 to 2000 mg/l, but usually less than 1000; no type dominant
Kmv	Mesaverde Formation 500-1000	Sandstones massive to thin-bedded, with shale and coal	Small to moderate supplies in larger fractured sandstones such as Parkman	300 to 2000 mg/l, mostly sodium sulfate
Kc	Cody Shale 3750	Gray and black shale with some fine sandstone; few bentonite beds	Poor; only the Shannon sandstone may produce small quantities of water	Greater than 1000 mg/l, mostly sodium sulfate
Kft	Frontier Formation 515; Mowry and Thermopolis Shales 525 200±	Predominantly shales with some siltstone and sandstone	Maximum yields minor and restricted to sandstones, most of section not water bearing	Greater than 1000 mg/l, sodium sulfate and bicarbonate
KJcm	Cloverly and 281-306	Sandstones, siltstones and interbedded shales	Sandstones yield small quantities in Sheridan Co: 20 ga/m	Mostly sodium sulfate, 300 to 3000 mg/l
	Morrison Formations 139-235	Variegated shale and siltstone	A few sands may yield as much as 10 gal/min	No dominant type; 500 to 2000 mg/l
Jsg	Sundance and 327-452	Green calcareous shale with glauconitic sandstone		500 to 2000 mg/l, no dominant type
	Gypsum Springs Formations 205	Massive white gypsum, red claystone and gray limestone	Not considered a good source for water	Greater than 1000 mg/l, calcium sulfate
ҞPcg	Goose Egg Chugwater Formations and Equivalent Rocks 600-700	Red beds of sandstone, siltstone and shale, with ledge forming limestone 70' from top	Small yields, not considered a good source for water	Calcium sulfate dominant, locally sodium chloride
PMta	Tensleep and 50-250	Massive to cross-bedded sandstone with minor dolomite	Moderate to high yields, often artesian flow	Mostly calcium bicarbonate, quality varies with depth, in oil fields is sodium sulfate
	Amsden Formations 150-300	Shale, sandstone and dolomite	Small to large (greater than 1000 gpm) supplies especially in fractured pr cavernous areas	
Mm	Madison Limestone 1100	Limestone and dolomitic limestone, sandy at base		
O€r	Bighorn Dolomite 400-500	Massive dolomite with limestone in upper part and sandstone at base		
	Gallatin and Gros Ventre Formations 645±	Flatpebble conglomerate; shaly and sandy limestone; and sandstone	Not considered a good source in this county	Variable
	Flathead Sandstone 345	Sandstone with some interbedded shale and siltstone with basal conglomerate	Small yields from sandstone and conglomerate in mountains	
p€r	Igneous and metamorphic Precambrian	Crystalline rocks	As much as 20 gpm from joints but mostly small yield to none	Usually less than 1000

Sources of Information

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