SOUTH DAKOTA GEOLOGICAL SURVEY

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GEOLOGY of the WITTEN QUADRANGLE SOUTH DAKOTA

EXPLANATION

QUATERNARY

RECENT

Qal — Alluvium

(Deposits of silt, sand, and gravel in present stream valleys)

PLEISTOCENE

Qt — Terrace Deposits

(Fluvial deposits of silt, sand, and gravel above present streams)

TERTIARY

PLIOCENE

Tpa — Ash Hollow Formation

(Calcareous, feldspathic sandstone)

Tb — Bijou Facies

(Light-green siliceous sandstone in Valentine Formation)

Tpv — Valentine Formation

(Clayey, feldspathic, loosely consolidated sand)

UNCONFORMITY

OLIGOCENE

Tow — White River Group

(Brule formation,--pink, silty, clay. Chadron formation,--light-green siliceous clay)

UNCONFORMITY

CRETACEOUS

UPPER CRETACEOUS

Kpu — Pierre Formation, Upper Unit

(Light- to dark-gray, calcareous to non-calcareous shale)

Contact

(dashed where approximately located)

Gravel Pit

x BM 1994

Bench Mark

(monument showing exact altitude above sea level)

▲ Witten

Triangulation Station

(monument marking exact geographic location)

House, school, and church

Geology by R. A. Schoon, 1957

Vertical and horizontal control surveyed from triangulation and level lines from Federal surveys

Drafted by Donald Jorgensen, 1958

APPROXIMATE MEAN DECLINATION, 1950

Scale 1:62 500

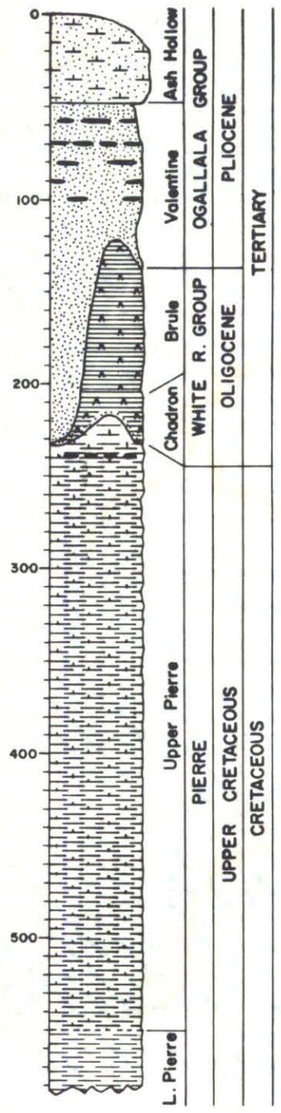
1 1/2 0 1 2 3 4 Miles

Tertiary Sediments

Quadrangle Location

WITTEN QUADRANGLE

Columnar Section of Exposed Rocks



Key to Columnar Section

- Calcareous Sandstone
- Sand
- Calcareous Shale
- Shale
- Siliceous Clay
- Bijou Facies "Quartzite"
- Limonitic Nodules

INTRODUCTION

The mapping of the Witten quadrangle was completed during the summer of 1957 as a thesis problem in partial fulfillment of the requirements for the degree of Master of Arts at the State University of South Dakota (Schoen, 1958). The writer thanks the State Geological Survey for its cooperation and for publishing the map. The Witten quadrangle is in Tripp county, in the south-central part of South Dakota and covers approximately 218 square miles. The area is in the Missouri Plateau and the High Plains subdivisions of the Great Plains physiographic province. The northern two-thirds of the quadrangle consists of low rolling plains whose monotony is broken locally by higher, fairly flat-crested hills that are capped with gravel. Near the northern boundary three such gravel-capped surfaces occur at different altitudes; to the south they become difficult to differentiate as they merge into one level.

The drainage in this area is well developed and the dendritic stream patterns show the horizontal attitude of the underlying strata. The two major drainages of the area, Cottonwood Creek and Oak Creek, have their headwaters at the base of the northward-facing escarpment produced by the Ash Hollow Formation; they flow in a northerly direction, and empty into the White River about 13 miles north of the quadrangle. The gradient of these streams is approximately 30 feet per mile.

In the southern third of the quadrangle the topography developed on the White River sediments is very similar to that developed on the Pierre Formation to the north. An abrupt low escarpment is present where the siliceous claystone layer of the White River remains. The present erosion surface rises toward the south, where it intersects the scarp produced by the Ash Hollow Formation. The Ash Hollow sediments are characterized by a flat upland surface. To the south of this upland this slope is toward the south, and a topography nearly identical with that immediately north of the upland is developed on the White River sediments there.

As in the northern part of the quadrangle, the drainage in the southern part is dendritic, but owing to the sandy nature of the soil, the streams are not as well developed. The upland of the Ash Hollow Formation acts as a drainage divide. Thus the streams on the south empty into the Keyapaha River.

Natural lakes are non-existent in the quadrangle; however, artificial lakes are numerous and almost all are used for stock watering.

The climate is semi-arid and is characterized by a wide temperature range, an average annual rainfall of 18 inches, and by strong winds.

Witten (pop. 117), the only town in the area, lies in the north-central part of the quadrangle. The village of Carter is along U. S. Highway 18 at the western extremity of the quadrangle. The two primary roads, U. S. Highways 18 and 183, are supplemented by a network of secondary roads which are virtually impassable during periods of wet weather.

SURFICIAL DEPOSITS

The surficial deposits in the Witten quadrangle may be classified into two groups: (1) alluvium in present stream valleys, and (2) terrace deposits adjacent to these valleys.

Alluvium

Alluvium consists of quartz silt and sand derived from local bedrock, and is confined to the present stream valleys.

Terrace Deposits

Terrace deposits consist of quartz silts and sands and argillaceous materials. The coarser fractions are composed of fragments derived from the Ash Hollow and the Pierre Formations and the Bijou facies. All terraces in the Witten quadrangle have a high carbonate content.

EXPOSED ROCKS

Five formations are exposed in the Witten quadrangle, in ascending order, the Pierre Formation of Cretaceous age, the Chadron and Brule Formations of Oligocene age, and the Valentine and Ash Hollow Formations of Pliocene age. For want of good exposures the contact between the Chadron and Brule Formations could not be accurately determined, and these formations were accordingly mapped together as the White River Group. For similar reasons the Pierre was not divided into members, but was mapped as the Upper Pierre unit (Agnew, 1957).

Cretaceous System

Pierre Formation. Meek and Hayden, 1862

This formation, named for exposures near Fort Pierre 70 miles to the north, crops out in the northern two-thirds of the quadrangle and is present in the subsurface elsewhere in the quadrangle. A composite section indicates that the upper 360 feet of the formation is exposed in the quadrangle. In general, the Pierre in the Witten quadrangle is light- to medium bluish-gray calcareous to slightly calcareous, fine-textured shale. Upon weathering the shale produces buff to light-gray gumbo at some stratigraphic zones, and thin flat polygonal chips with a submetallic sheen at others. Thin placers of limonite plates, weathered from limonitic concretions, are common at the base of exposures of the Pierre. The lowest stratigraphic exposure of the Pierre occurs where Cottonwood Creek intersects the northern boundary of the quadrangle. At the base of this exposure the shale is dark-gray, blocky, non-calcareous, and non-fossiliferous. This lithology possibly represents the Virgin Creek Member of the Pierre (Searight, 1937).

The top of the Pierre Formation is marked in the Witten quadrangle by an erosional unconformity which has a local relief of 15 to 20 feet.

Tertiary System

Oligocene Series. White River Group. Meek and Hayden, 1858

The White River Group embodies two formations, the Chadron (lower) and Brule. Where these formations are not easily differentiated, they are commonly mapped as the White River Group. This procedure was followed in mapping the Witten quadrangle.

The White River Group was named for exposures along the White River in the Big Badlands of South Dakota, 150 miles to the west. In the Witten quadrangle this group crops out as an irregular band of sediments from Carter southeasterly across the quadrangle. The thickness of the group ranges up to 85 feet within the mapped area.

In the Witten quadrangle the White River Group exhibits four distinct types of lithology. (1) Moderately rounded, clayey, fine to very coarse-grained sand occurs at the base. Disseminated throughout this sand are smooth siliceous pebbles which, when released by weathering, form a gravel placer at the White River-Pierre contact, and leave pits in the sand. Also found in this sand are balls of limonite-cemented sand grains. Nowhere in the Witten quadrangle does this sand exceed a thickness of two feet. (2) Overlying the basal sand is a light-greenish silty bentonitic clay which weathers very light-buff. (3) Above the silty clay is highly fractured silica-cemented claystone which contains smooth siliceous pebbles and local "peaballs" of silica-cemented clay disseminated throughout. The fractures are commonly stained reddish, probably due to iron oxide. (4) Overlying the claystone layer is a series of pale-pink and green silty to sandy clays. These clays become progressively more sandy upward, exhibit a waxey luster on fresh surfaces, and weather light-buff. It is probable that the lower two lithologies probably represent the Chadron Formation, and the upper two the Brule Formation.

Pliocene Series. Ogallala Group. Darton, 1889

The Ogallala Group, named for exposures near Ogallala, Nebraska (about 130 miles southwest of the quadrangle), is represented in the Witten quadrangle by the Valentine and Ash Hollow Formations.

Valentine Formation Barbour and Cook, 1917.--The Valentine Formation, named for exposures near Valentine, Nebraska, about 30 miles southwest of the Witten quadrangle, crops out in the southern quarter of the quadrangle except where it is overlain by the Ash Hollow Formation.

In this quadrangle the Valentine Formation is composed of massive loosely consolidated clayey silts and sands which possess a high percentage of quartz and feldspars and low percentages of olivine, and calcite (Taft, W. H., personal communication, February, 1958).

As a result of the erosional unconformity at the top of the White River Group, the thickness of the Valentine Formation varies between 75 and 185 feet in the Witten quadrangle.

Bijou facies (Stevenson, 1958).--The Bijou quartzitic sandstone is present in scattered areas in southern and south-central South Dakota and adjacent areas in Nebraska (Agnew, 1958). In the Witten quadrangle the Bijou occurs as a facies of the Valentine Formation; it forms the caprock of the Red Hill Buttes, and is mapped separately where possible.

The Bijou is a homogeneous, medium to fine-grained quartzose sandstone which has been consolidated by the addition of a greenish silica cement. Intercalacted between the quartzitic strata are lenses of homogeneous clayey medium to fine-grained unconsolidated quartz and feldspar sand. Light-green clay balls, moderately to well-cemented with silica, are common at the base of the lowest silicified stratum. The thickness of this facies is variable, and the thickest exposed was eight feet.

Ash Hollow Formation Englemann, 1876.--This unit, named for exposures at Ash Hollow Canyon in western Nebraska, 170 miles to the southwest, caps outliers of the High Plains in the southern part of the Witten quadrangle. Although its areal extent in the quadrangle is restricted to five or six square miles, exposures are abundant.

In the Witten quadrangle the Ash Hollow consists of carbonate- and silica-cemented quartzose sand which is generally more consolidated toward the top. The characteristic boxwork structure appears to be a result of differential weathering of the two types of cement. This formation is nearly white, but lichens give the weathered surface a medium-gray color. Fossil vertebrates and hackberry seeds are common.

The Ash Hollow Formation conformably overlies the Valentine Formation, and the contact is commonly marked by small caves which have been carved in the Valentine sands by wind action.

SUBSURFACE ROCKS

Formations not exposed in the Witten quadrangle, but believed to be present because of nearby oil tests are tabulated below:

TABLE 1.--Summary Log of Tests in Witten Quadrangle

Formation	General Crude #1 Assman sec. 22, T. 98 N., R. 78 W. Tripp County	General Crude #1 Vogt sec. 25, T. 99 N., R. 79 W. Tripp County
	Thickness, feet	Thickness, feet
Pierre--shale	1125	945
Niobrara--chalk	170	180
Carlile--shale	250	270
Greenhorn--limestone	45	60
Belle Fourche-Mowry--shale	140	135
Newcastle--sandstone	125	155
Skull Creek--shale	90	100
"Dakota"--sandstone	680	645
Morrison (?)--shale	125	120
Sundance (?)--sandstone	80	90
Minnelusa (?)--sandstone	185	185
Precambrian--granite	-	-

STRUCTURE

The Witten quadrangle is near the southeastern margin of the Dakota (Williston) Basin, possibly overlying a Precambrian topographic high which separates that basin from the Central Nebraska Basin. Subsurface data indicate generally horizontal beds which dip from 1½ to 10 feet per mile toward the northwest. No local structure was mapped in the quadrangle. Structures, if present, are effectively masked by the Pierre shale which slumps easily.

ECONOMIC GEOLOGY

Ground Water

Ground water may be obtained in all parts of the quadrangle. The relatively permeable Valentine sands yield excellent quality water (see table) from depths of 15 to 150 feet. Water is also obtained from the base of the White River Group, but is hard and contains excessive solids, and locally excessive nitrogen. Water in the Pierre shale is of poor quality and is generally unfit for human consumption. Water in the lower stream terraces is seldom used by the local inhabitants; no samples of this water were collected but, owing to the high carbonate content of the gravels, the water is probably hard. The Newcastle and "Dakota" sandstones, important aquifers in large areas of South Dakota, are not used as a water source in this area.

TABLE 2.--Chemical Analysis of Shallow Ground Water

Water Source	Parts Per Million									
	Fe	Mg	Na	K	Ca	SO_4	Cl	NO_3	Total Dissolved Solids	Hardness as $CaCO_3$
1	0	142	300	18	564	2150	90	8	2651	1909
2	0.0	17	71	22	80	65	35	16	567	226
3	0.0	12	12	13	40	15	5	1-	239	126
4	0.3	125	-	-	-	250	250	10	500	120

Analysis by Dr. Oscar Olson, Head, Station Biochemistry, South Dakota Agricultural Experiment Station, State College, Brookings, South Dakota, 1957.

1 Pierre Formation, McCullums Market, Carter, South Dakota.
2 White River Formation, Bartleson farm, SE corner sec. 9, T. 98 N., R. 79 W.
3 Valentine Formation, Lyons farm, center sec. 36, T. 96 N., R. 79 W. (10 miles south of the Witten quadrangle).
4 Standard Limits, U. S. Bureau of Public Health (1946).

Gravels

Gravels suitable for use as road metal are found in terrace deposits mainly in the northern two-thirds of the quadrangle. The high clay content of these gravels eliminates the need of adding a clay filler for road material. The soluble nature of many constituents of these gravels prohibits their use as concrete aggregate, as analyses show the soluble material in the higher gravels to be as great as 35.5 percent, and that of the lower gravels, 28 percent. It is estimated that 8,000,000 cu. yd. of gravel are available for exploitation in the Witten quadrangle.

Clays

The silicified White River claystone layer has been crushed and used locally as road surfacing material, but this rock breaks down rapidly and for this reason is not used extensively.

Sandstone

The Bijou "quartzite" which caps the Red Hill Buttes, is a hard durable material which, when crushed and screened, is very desirable for concrete aggregate and road metal. The oversize material can be used for rip-rap. Approximately 6,200,000 cu. yd. of this material is available in the Witten quadrangle.

Oil and Gas

From surface observations it seems doubtful that structures favorable for oil and gas accumulation exist in the quadrangle. Stratigraphic traps, on the other hand, possibly exist at depth. Between the deeper part of the Williston Basin of northwestern South Dakota and the Witten quadrangle, 6400 feet of pre-Tertiary sediments have been wedged out because of onlap against the Precambrian surface, and/or pre-Cretaceous truncation. Possible oil zones in the Witten quadrangle which bear investigation are (1) the eastward-thinned Minnelusa Formation, which produces oil in eastern Wyoming and the southern Black Hills, and (2) stratigraphic traps in tongues of the Newcastle and "Dakota" sandstones. Gas occurrence is possible in the Niobrara Formation. Gas has been produced from the "Dakota" sandstone near Pierre, and deep oil tests west and south of Pierre gave gas shows from that formation.

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