SOUTH DAKOTA GEOLOGICAL SURVEY
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STATE OF SOUTH DAKOTA
RALPH HERSETH, GOVERNOR

# GEOLOGY
of the
# DALLAS QUADRANGLE
SOUTH DAKOTA

## EXPLANATION

**QUATERNARY**

**RECENT**

**Qal** — Alluvium
*(Floodplain deposits of silts, sands, and gravels in present stream valleys.)*

**PLEISTOCENE**

**Qts** — Alluvial Terrace Sand
*(Tan, locally greenish, fine- to medium-grained arkosic sand.)*

**Qt** — Terrace Deposits
*(Fluvial deposits of locally derived rubble in a coarse sand matrix. Maximum thickness 30 feet.)*

**Qh** — Herrick Formation
*(Light-colored coarse fluvial arkosic sands on upland surface. Maximum thickness about 35 feet.)*

**TERTIARY**

**PLIOCENE**

**Tb** — Bijou Formation
*(Green to white, medium- to fine-grained siliceous arkosic sandstone. Maximum thickness 4 feet.)*

**Tpa** — Ash Hollow Formation
*(Greenish-tan fine-grained calcareous arkosic sand and ledge-forming sandstone with small concretions of opaline silica and limestone. Maximum thickness 110 feet.)*

**Tpv** — Valentine Formation
*(Green to greenish tan, fine-grained arkosic sand, slightly clayey to slightly siliceous fine-grained arkosic sandstone with ashy and silty sand interbeds; locally coarse channel? sands with pebbles, vertebrate fossils. Maximum thickness 160 feet.)*

**OLIGOCENE**

**Tob** — Brule Formation
*(Upper: white ashy silts; Middle: white to green to tan waxy to silty clay with small white limestone concretions; Lower: greenish sand and clayey sand with local basel pebble conglomerate. Maximum thickness 53 feet.)*

**CRETACEOUS**

**UPPER CRETACEOUS**

**Pierre Formation**

**Kpe** — Elk Butte Member
*(Upper:- gray to olive-brown clay-shale; lower:- black to dark gray clay-shale; both with limonitic and limestone concretions; white bentonitic seam rare. The 30-40 feet underlying the Tertiary is orange to yellowish-tan clay with caliche spots. Discoscaphitid ammonites. Thickness 265-310 feet.)*

Contact
(dashed where approximately located)

X BM 2198
Bench Mark
(monument showing exact altitude above sea level)

△ THOMAS
Triangulation Station
(monument marking exact geographic location)

House, School, and Church

Geology by Robert E. Stevenson, 1957-58
Assisted by C.H. Skogstrom jr. and J.C. Harksen
Vertical and horizontal control surveyed from triangulation and level lines of Federal surveys
Drafted by C.F. Harris

Scale 1:62 500
0 1/2 1 2 3 4 Miles

Vermillion, South Dakota
1959

APPROXIMATE MEAN DECLINATION, 1958

Quadrangle Location

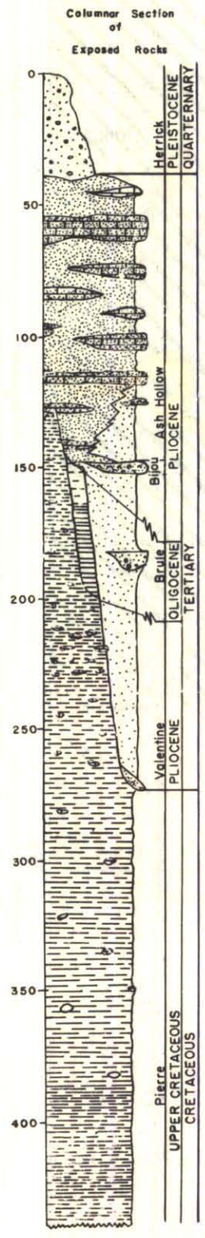
Tertiary Sediments

DALLAS QUADRANGLE

# GEOLOGY OF THE DALLAS QUADRANGLE

by

Robert E. Stevenson




## INTRODUCTION

The Dallas quadrangle includes about 218 square miles in the southeastern part of Tripp County and southwestern Gregory County, South Dakota, along the Nebraskan State line.

The mapped area, in the prairie lands of the Great Plains physiographic province, shows a variety of topographic features, each characterized by a rock type. At the southern edge of the quadrangle is the wide flat valley of the Keya Paha River (underlain by the Pierre shale). To the north, an east-west band of buttes and mesas and intervening valleys merges northward into a large upland flat and drainage divide (underlain by the Ash Hollow sandstone). In the central part of the quadrangle is a poorly drained grassed sandy plain with a few marshes and scattered groves of trees (developed on the Valentine sand), and farther north a rolling well-drained mature topography is present on the Pierre shale. Elevations range from 2400 feet on the upland to 1950 feet in the Keya Paha River valley.

Along the youthful tributaries of the Keya Paha River, are a series of terraces representing earlier levels of the streams. The Keya Paha River, which has cut about 420 feet below the upland plain, is characterized by two terrace levels. The upper, dominantly erosional, is 110-120 feet above the floodplain and merges with the terraces of the tributaries; the lower alluvial sand terrace, 60-65 feet above the flood plain, is widespread on the south side of the river. The headwaters of Ponca Creek drain the northern part of the quadrangle. The permanent water bodies, Roosevelt Lake and numerous stock reservoirs, are all artificial.

The Dallas quadrangle has a semi-arid climate characterized by a mean annual rainfall of 21 inches and an average temperature of 48.6° F. This fairly well populated agricultural area has one family per 0.9 square miles. Dallas (pop. 244) is the only major settlement, and there is a store, school, and church at Paxton. U. S. Highways 18 and 183 cross respectively the northern and northwestern parts of the quadrangle, and a branch line of the Chicago and Northwestern railroad parallels U. S. Highway 18.

The geology was mapped in 1957 and 1958 under the direction of Dr. Allen F. Agnew as part of the State Geological Survey's program of studying South Dakota's economic mineral resources. The writer was assisted in the field by H. C. Skogstrom and J. C. Harksen. The identification of vertebrate fossils by Dr. Morton Green and Dr. J. R. Macdonald of the South Dakota School of Mines and Technology is gratefully acknowledged. Thanks are extended to the many local residents who provided water well information.

## EXPOSED SEDIMENTARY ROCKS

Exposed bedrock sediments include Oligocene White River and Pliocene Ogallala sandy fluviatile and lacustrine deposits, and the underlying Late Cretaceous Pierre marine shales.

### Pierre Formation Meek & Hayden 1862

The Pierre was named from exposures at Ft. Pierre (90 miles northwest of the Dallas quadrangle). Later the Pierre along the Missouri River was divided into six members (Searight, 1937), of which only the uppermost is exposed in the Dallas area.

#### Elk Butte Member Searight 1937

The Elk Butte (Kpe) shale is poorly exposed in the gently rolling hills in the northern part of the quadrangle. The Elk Butte is overlain by a thick soil, but outcrops are abundant in the rough topography adjacent to the Keya Paha River and its tributaries in the southern third of the quadrangle, where the surface is locally covered by fragments of orange-brown Pierre concretions.

The Elk Butte Member in this quadrangle consists of an upper sequence, about 250 feet thick, of gray to olive-brown thinly laminated clay-shale, and a lower sequence, 50 feet thick of black to dark-gray clay-shale both with limonitic and calcareous concretions. Local thin seams of white to cream bentonite or bentonitic clay are present in the upper sequence, and large limestone concretions are concentrated in the upper half of the upper sequence.

A disconformity at the top of the Elk Butte is marked by at least 160 feet of relief, along with the partial development of 30 to 40 feet of orange and yellowish-tan clay and associated caliche patches which represent the Interior paleosol (Schultz and Stout, 1955).

The Elk Butte in this area is characterized by the presence of discoscaphitid ammonites, and in the basal part there is a zone of small undescribed scaphitid ammonites.

The Elk Butte Member ranges in thickness from 265 to 310+ feet.

### White River Group Meek & Hayden 1858

#### Brule? Formation Darton 1899

The upper part of the White River Group was named for the Brule Indians in southern South Dakota. Strata in the Dallas quadrangle have been tentatively assigned to the Brule Formation on the basis of lithologic similarity to rocks in quadrangles to the west (Collins, 1958a, 1958b; Schoon, 1958; Schoon and Sevon, 1958) in the interval between Dallas and the Brule of the White River quadrangle (Agnew, 1957).

Scattered exposures of the questionable Brule strata (Tob) are restricted to seven small areas in T. 96 N., R. 75 W. and other small areas along the northern edge of the quadrangle. The questionable Brule strata consist of a lower series of lensing pebble conglomerate (limonite, limestone, quartz, chert and granite pebbles) with pinkish-tan and greenish fine-grained sand and clayey sand; a middle series of tan-gray to brown (weathering pink) waxey vesicular clay, white to greenish-gray waxey clay and silty clay, both with dense irregular limestone concretions; and an upper series of thinly laminated and cross-bedded pinkish and greenish ashy silts. The base of the questionable Brule is characterized by a layer of dull-black iron-manganese oxide-like material, half an inch to two inches thick; the oxide cements the pebbles in the basal conglomerate. The maximum exposed thickness of the questionable Brule Formation is 53 feet.

### Ogallala Group Darton, 1899

#### Valentine Formation, Barbour & Cook, 1917

The Valentine Formation was named from exposures near Valentine, Nebraska (50 miles southwest of the Dallas quadrangle ). Exposures of the Valentine Formation (Tpv) are present in much of the southern third of the mapped area, and in the north-central part of the Dallas quadrangle a wide band of Valentine is present. In the latter area the distinction between bedrock Valentine sand and reworked sand (blow sand) is most difficult to discern.

The Valentine Formation is dominantly a greenish-tan to tan, fine-grained, arkosic sand and slightly clayey to slightly siliceous, fine-grained arkosic sandstone, with interbeds of greenish-tan to tan, fine-grained ashy arkosic sand, pinkish-tan ashy silt, and buff to tan fine-grained arkosic sand and silty sand. In sec. 20, T. 95 N., R. 75 W., the Valentine Formation contains a fairly resistant bed, about 25 feet thick, of coarse- to fine-grained, poorly sorted, locally ferruginous or slightly clayey, arkosic sand with scattered small pebbles of quartz, chert, granite, and clay. This deposit might represent channel sedimentation. Locally a thin layer of light-buff, very finely crystalline limestone lies about 10 feet below the principal siliceous sandstone layer of the Bijou facies (see below).

The Valentine is characterized by a fauna dominated by grazing animals, and in the Dallas quadrangle contains fragmentary teeth and bones representing equids, camelids, and antilocaprids. Green (1959) has identified Cynomys (prairie dog) from the sands cropping out at Roosevelt Lake. The formation ranges up to about 160 feet thick.

#### Ash Hollow Formation Engelmann 1876

This formation was named for exposures in Ash Hollow Canyon, Nebraska (170 miles southwest of the Dallas quadrangle). In the Dallas quadrangle, the characteristic ledges ("mortar beds") of the Ash Hollow Formation (Tpa) are present in the uplands, and as butte and mesa caps.

The bulk of the formation consists of interbedded buff to greenish-tan fine-grained arkosic sand, partially cemented ("nodular") fine-grained arkosic sand, and ledge-forming vuggy calcareous arkosic sandstone. Beds of greenish-tan fine-grained clayey and silty arkosic sand are locally present. Some of the strata are ashy, and some contain white dense limestone concretions. The calcareous sandstone, which may contain small irregular and roof-like concretions of grayish opaline silica, shows some replacement of the quartz grains by calcite (Taft, 1958). Above the main ledges, a 1-2 foot bed of white to tan porous crystalline limestone with occasional sand grains and a fauna of undetermined gastropod species, is locally exposed. The maximum thickness of the Ash Hollow Formation is 110 feet, and the ledges range in thickness from a few inches to 10 feet.

The Ash Hollow flora and fauna resemble that of the Valentine, but the only identifiable fossils found in the Dallas quadrangle other than many Celtis (hackberry) seeds, were teeth of Nannippus (horse), and turtle shells.

The contact between the Ash Hollow and Valentine is irregular and ranges over a vertical distance of about 50 feet.

#### Bijou facies Stevenson 1953

This facies, which takes its name from the Bijou Hills where it forms the caprock, is now considered a facies of the Late Tertiary strata (Stevenson, 1958a). The Bijou facies (Tb) is exposed in scattered patches in a northeast-trending band across the northern half of the quadrangle, and as butte and mesa caps in the southeastern part.

The most persistent stratigraphic position for the Bijou facies in this quadrangle is in the upper ten feet of the Valentine. Another less persistent zone is at the base of the Valentine, and the facies also occurs as thin local lenses in the Ash Hollow and elsewhere in the Valentine Formations.

The Bijou facies is a green to white, medium- to fine-grained, siliceous arkosic sandstone ("quartzite"), and partly cemented arkosic sand with local cross-bedding. The facies ranges from a few inches to four feet thick. The silica cement is thought to have been deposited during Late Pliocene time (Agnew, 1958). A tooth of Nannippus (horse) represents the only fossil found in the Bijou facies in the Dallas quadrangle.

## SURFICIAL DEPOSITS

The unconsolidated surficial deposits include the upland sands of the Pleistocene Herrick Formation, and the Recent alluvial materials along stream valleys.

### Herrick Formation Stevenson and Carlson, 1951

The Herrick Formation was described in detail in the adjacent Gregory quadrangle, to the east (Stevenson, 1958b). In its westernmost extent this formation mantles a small part of the upland along the eastern edge of the Dallas quadrangle (sec. 8, T. 95 N., R. 73 W.). The Herrick Formation (Qh) consists of lensing, cross-bedded, very coarse- to medium-grained arkosic sands with local lenses of pebble conglomerate (granite, quartz, feldspar, schist, and petrified wood). The sands are well-sorted and show an eastward-sloping cross-lamination. The maximum thickness is about 35 feet. At the present time, the age is considered to be Early Pleistocene (Stevenson, 1958b).

### Alluvial Deposits

The alluvial deposits have been divided into three units: terrace deposits, alluvial terrace sands, and alluvium.

Terrace deposits (Qt) are accumulations of rubble adjacent to the Keya Paha River and its tributaries. The terrace lies 105-120 feet above the Keya Paha floodplain, but in the tributaries the interval diminishes to about 20 feet near the headwaters. The rubble deposits consist of angular and semi-angular blocks of Ash Hollow calcareous sandstone (85 percent), Pierre limonitic concretions (12 percent), and Pierre limestone concretions (3 percent), imbedded in a coarse sand matrix (the sand contains reworked Herrick Formation). Locally the rubble may be rich in fragments of Bijou siliceous sandstone. There are interbeds of greenish fine-grained reworked Ogallala sand. The only fossils found were bond fragments and a poorly preserved horse tooth. The deposits range up to 36 feet in thickness.

Alluvial terrace sand deposits (Qts) are extensive low terraces along the Keya Paha River. Although the terrace lies 55-65 feet above the Keya Paha floodplain, the sands generally cover the entire slope from terrace to river. The deposits are fine- to medium-grained arkosic sands (reworked Herrick Formation and Ogallala Group) with occasional angular chunks of Bijou siliceous sandstone, Ash Hollow calcareous sandstone, and Pierre limonite fragments. The thickness ranges from a few feet to more than 20 feet.

Alluvium (Qal) is sands and sandy clay along the floodplains of the present major streams.

## SUBSURFACE ROCKS

Rocks not exposed at the surface in the Dallas quadrangle, but probably present in the subsurface are shown in Table 1.

Table 1. Subsurface Formations

| | | | |
|---|---|---|---|
| Upper Cretaceous | Pierre Formation | 750' | Gray to black shale with local silty and marly zones; limonitic, dolomitic and limestone concretions. |
| | Niobrara Formation | 185' | White-speckled gray marl with minor beds of gray granular limestone. |
| | Carlile Formation | 200' | Dark-gray clay and clay-shale with sideritic and limestone concretions; medium-grained sandstone in upper part. |
| | Greenhorn Formation | 45' | Light-gray chalky limestone and calcarenite with abundant Inoceramus prisms. |
| | Belle Fourche and Mowry Formations | 70' | Gray shale and siltstone with a few stringers of quartzose sandstone; upper part slightly calcareous. |
| Lower Cretaceous | Newcastle ("Dakota") Formation | 110' | Light-gray, medium- to fine-grained quartzose sandstone. |
| | Skull Creek Formation | 120' | Gray shale with much interbedded quartzose sandstone in upper 60 feet. |
| | Inyan Kara Group | 140' | Light-gray, medium- to coarse-grained massive quartzose sandstone and interbedded light clays. |
| | UNCONFORMITY | | |
| Jurrassic and older | Sundance? and older Formations | 490-530' | White medium- to coarse-grained quartzose sand and sandstone, locally glauconitic; tan to pink, fine- to medium-grained quartzose sandstone; red to red-brown shale with sideritic pellets, and light-gray shale; about 350 feet below the top is a 30 foot layer of quartzose grit; variegated to maroon shale near base (Spearfish Formation?) |
| | UNCONFORMITY | | |
| Pennsylvanian | Minnelusa Formation | 70-120' | Pale red to grayish-pink dolomite, sandy dolomite, medium- to coarse-grained sandstone; interbeds of white to pink limestone, and gray dolomitic limestone; basal lateritic zone. |
| Ordovician | Red River Formation | 0-150' | Light-buff finely crystalline dolomite; local limey horizons. |
| | UNCONFORMITY | | |
| Precambrian | Ortonville? Granite | | Red medium-grained granite with biotite schlieren. |

This information was obtained from oil tests and deep water wells in the Dallas and adjacent quadrangles (see Fig. 1 ). Lack of available detailed subsurface information in the southern part of the Dakota (Williston) Basin has made it impossible to subdivide stratigraphically the post-Minnelusa, pre-Inyan Kara interval.

## STRUCTURAL GEOLOGY

The Dallas quadrangle lies on a saddle which separates the Dakota (Williston) and Central Nebraska basins; thus the Cretaceous and older strata are essentially horizontal.

## ECONOMIC GEOLOGY

Ground water, available at varying depths below the surface in all parts of the Dallas quadrangle, is the principal mineral resource of this semi-arid area. Sandstone was being commercially quarried in 1958, and sand and gravel have been produced in the mapped area. Several other potentially economic mineral resources are present in this region.

### Ground Water

The best source of subsurface water in the Dallas quadrangle is the permeable sands of the Valentine Formation, which yield water under low artesian pressure at depths of 16 to 75 feet on the sandy plain. Water from these sands is of excellent chemical quality except for excessive hardness, and is suitable for nearly all common uses (Table 2).

On the uplands, where the Valentine is deeper, water is obtained from permeable zones in the shallower Ash Hollow Formation, at depths of 30 to 45 feet. The Ash Hollow water is similar to Valentine water in general character, but harder and higher in calcium, magnesium and chloride ions (see Table 2).

In the northern and southern parts of the quadrangle where the Valentine is missing, water is obtained from the jointed and weathered upper part of the Pierre clay-shale. The capacity of these shale wells varies greatly, but is not large. Water from the Pierre shale (Table 2) is very high in sulfate, sodium, calcium, and total solids, making it unsuitable for most domestic uses. It can, however, be used without treatment, for stock.

Some farms on the floodplains of larger streams obtain their water from alluvial sands and gravels. This water is suitable for most uses, but is locally hard and slightly above the standard limit for total dissolved solids. One well in the Dallas quadrangle obtains suitable water from the Brule? Formation.

The water-bearing "Dakota" sandstone lies at depths of 1100-1500 feet in the Dallas quadrangle, but it is not used because the Valentine water is of better quality and lies at much shallower depths.

Table 2. Chemical Analyses of Representative Waters

| Water Source | Parts per Million: Iron | Magnesium | Sodium | Potassium | Calcium | Sulfate | Chloride | Nitrate | Total dissolved solids | Hardness as $CaCO_3$ | Specific Conduc. Micromohs at 5° C. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Valentine sand* (1) | - | 2 | 5 | - | 142 | 97 | 27 | - | 794 | 363 | |
| Pierre shale**(2) | 0.02 | 117 | 79 | 20 | 272 | 1000 | 20 | 0 | | 1160 | 2200 |
| Ash Hollow sand (3) | - | 1060 | 62 | - | 322 | 44 | 227 | - | 1484 | 845 | |
| Standard Limits (4) | 0.3 | 125 | | | | 250 | 250 | 45 | 500 | 120 | |

*

**Analysis by Dr. O. E. Olson, Station Biochemistry, S. Dak. Agric. Experiment Station, Brookings, South Dakota.
(1) Bill farm, NE¼NE¼ sec. 30, T. 96 N., R. 74 W.
(2) Shattuck farm, SE¼ sec. 34, T. 95 N., R. 74 W.
(3) Flakus farm, SW¼ sec. 22, T. 96 N., R. 74 W.
(4) U. S. Public Health Service Repts., v. 61, p. 371-89, 1946.

### Sandstone

The Bijou facies is a hard siliceous sandstone (quartzite), which makes a very good crushed aggregate for concrete and bituminous paving, as well as road surfacing. Two quarries, producing crushed aggregate were operating in 1958. This sandstone could also be used for dimension stone, foundation stone, and rip-rap for surfacing earthen dams.

The softer calcareous sandstone ("magnesia") of the Ash Hollow Formation may be crushed and used in surfacing farm to market roads

### Sand

The Valentine Formation and the alluvial sand deposits could provide a good source of fine sand for finish cement and fine plaster. Coarse sand suitable for cement blocks, tile, mortar, and plaster is found in the Herrick Formation on the eastern edge of the quadrangle.

### Gravel

Sandy gravels suitable for surfacing secondary roads are found in the terrace deposits along the tributary streams to the Keya Paha river. They contain a high percentage of ironstone, preventing their use as concrete aggregate.

### Oil and Gas

The Dallas quadrangle lies on the southern edge of the Williston Basin, a major oil and gas producing area. Although most of the basin's production comes from tectonic upwarps in the center and along the western edge, some oil production comes from sedimentary traps along the northeastern flank. There is no evidence for subsurface tectonic structures in the Dallas area, but sedimentary traps are possible. Lenticular sands in the Minnelusa Formation (productive of oil in the southern Black Hills), at depths of 2000 to 2500 feet, are favorable zones for oil prospecting. It is possible that the Red River (=Whitewood) limestone, which is productive in northwestern South Dakota's Buffalo field,might contain oil at depths of 2100 to 2700 feet.

In 1956 the General Crude Oil Company drilled four oil tests in Tripp County, the #1 Shippy being in the Dallas quadrangle (NW¼ sec. 5, T. 96 N., R. 75 W.). These borings, which reached the Precambrian basement rocks, were abandoned as dry holes with no reported oil shows.

### Shale

Some of the shale from the Pierre Formation in the Dallas quadrangle could be used for the manufacture of bricks. This shale might also be used in the manufacture of light-weight aggregate, which is a very important structural building material because of its thermal acoustical, refractory and chemically inert properties.

### Uranium

Uranium and other rare-earth metals are present in minute quantities in the Pierre Formation. The weathered zone at the top of the formation has a higher concentration of radioactive minerals. However, the Dallas quadrangle has no concentrations of commercial value.

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Figure 1