SOUTH DAKOTA GEOLOGICAL SURVEY

ALLEN F AGNEW, STATE GEOLOGIST

STATE OF SOUTH DAKOTA

JOE FOSS, GOVERNOR

GEOLOGY of the GREGORY QUADRANGLE SOUTH DAKOTA

EXPLANATION

RECENT

Qal — Alluvium

(Floodplain deposits of silts, sands, and gravel in present stream valleys)

PLEISTOCENE

Qt — Terrace Deposits

(Terrace deposits of locally derived fluvial rubble in a coarse to fine sand matrix)

Qtl — Lower Terrace Deposits

(Alluvial sands with interbedded silts and gravels. Mostly local material. 35 feet above stream level. 5 to 45 feet thick)

Qtm — Middle Terrace Deposits

(Coarse to fine alluvial sands of local derivation. 55 feet above stream level. About 10 feet thick)

Qtu — Upper Terrace Deposits

(Isolated high terrace deposits of sands and gravels. A few contain abundant locally derived carbonate rubble. About 70–100 feet above stream level. 5–30 feet thick)

Qh — Herrick Formation

(Light-colored coarse fluvial arkosic sands lying on the upland surface. Vertebrate fossils. Up to 54 feet thick)

QUATERNARY

UNCONFORMITY

PLIOCENE

Tb — Bijou Facies

(Greenish to white, medium to fine grained, siliceous arkosic sandstone ("quartzite") facies of Pliocene strata with associated partly cemented sands. Locally crossbedded with clay–pebble conglomerates. Up to 5 feet thick)

Tpa — Ash Hollow Formation

(Tan partly calcareous fine arkosic sand and calcareous ledge-forming sandstone, characterized by small concretions of opaline silica and local limestone concretions. Local bed of greenish opaline silica. Vertebrate fossils. 10–70 feet)

Tpv — Valentine Formation

(Greenish-tan fine-grained partly clayey and tuffaceous arkosic sand. Local white dense sandy limestone concretions and interbedded green clay, basal conglomerate, and an impure discontinuous ash. Vertebrate fossils. Up to 71 feet)

TERTIARY

UNCONFORMITY

?OLIGOCENE

Tob — ?Brule Formation

(Pinkish-tan waxey clay, sandy tuffaceous silt, and silt with small irregular white limestone concretions. Interbedded greenish and reddish-tan waxey clay. Maximum exposed thickness 20 feet)

UNCONFORMITY

UPPER CRETACEOUS — Pierre Formation

Kpe — Elk Butte Member

(Gray to olive-brown clay-shale with orange brown limonitic concretions and streaks. Limestone concretions, locally with cone-in-cone structure, are abundant. The 20 feet underlying the Tertiary is a paleosol, yellowish-brown clay with caliche. Maximum thickness 176 feet)

CRETACEOUS

Contact (dashed where approximately located)

Gravel Pit

x BM 2213 — Bench Mark (monument showing exact altitude above sea level)

Dickens — Triangulation Station (monument marking exact geographic location)

House, school, and church

Cemetery

Airport

Geology by R.E. Stevenson, 1956–57

Assisted by R.L. Hale and H.C. Skogstrom, Jr.

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

Drafted by F.J. Buckmeier, 1958

APPROXIMATE MEAN DECLINATION, 1952

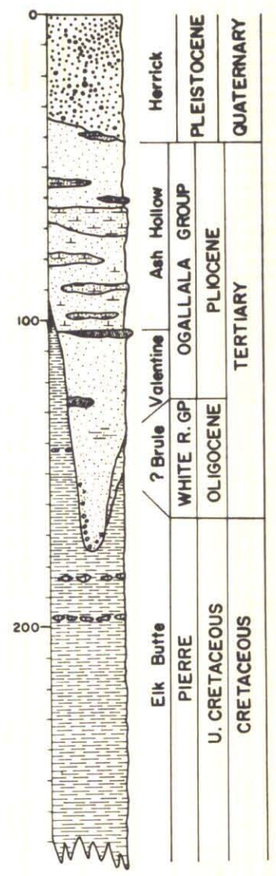
Scale 1:62 500

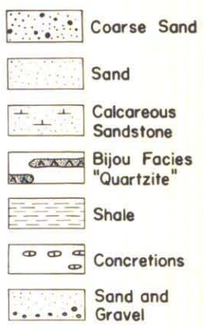
Vermillion, South Dakota
1958

Tertiary Sediments

Quadrangle Location

GREGORY QUADRANGLE





INTRODUCTION

The Gregory quadrangle includes about 218 square miles in the southwestern corner of Gregory county, South Dakota, along the Nebraska state line.

The mapped area lies in the prairie lands of the Great Plains physiographic province, and is characterized by remnants of an upland depositional plain, covered with coarse fluvial sand, slopes 11 feet per mile eastward and has a very low relief.

The broad mature valleys of Ponca Creek and its tributaries have cut about 300 feet below this upland. The present floodplain of Ponca Creek, one quarter of a mile wide, has a gradient of 14 feet per mile. An earlier stage, represented by the 35-foot terrace level which shows an average valley width of about three quarters of a mile and the same gradient as the present floodplain, first cut the valley to a depth slightly below the present valley floor. A still earlier stage, represented intermittently by terraces about 20 feet above the 35-foot terrace level, indicates a former valley two to four miles wide, with a gradient of 13 feet per mile. Between the river valley and the uplands the surface is gently rolling. Altitudes in the quadrangle range from 1930 feet in the Ponca Valley to 2300 feet on the uplands.

Ponca Creek meanders across its floodplain with a gradient of eight feet per mile in the northern part of the quadrangle. The permanent water bodies, stock reservoirs, Lake Burke and Star Lake, are artificial.

The climate of the Gregory quadrangle is semi-arid, with a mean annual rainfall of 21 inches and a mean annual temperature of 48.6° F. (extremes are 104° and -19° F.). This agricultural area is well populated, with 1 family per 0.6 square mile. Gregory (pop. 1376) and Burke (pop. 829), the county seat, are the only settlements. U. S. Highway 18 and State Route 47 cross respectively the northern and eastern parts of the quadrangle, and a branch line of the Chicago and North Western railroad crosses the northern part of the area.

The geology was mapped in 1956 and 1957 under the supervision of Dr. A. F. Agnew as part of the South Dakota Geological Survey's program of studying the State's mineral resources. The geology was mapped on air photos, supplemented by plane table surveys with the assistance of R. L. Hale and H. C. Skogstrom, Jr. J. C. Harksen and P. D. Lidel drilled several holes with the State Geological Survey's jeep-mounted auger, for stratigraphic and economic information. The writer thanks William Cahill of the Burke Stone and Sand Company for donating fossils, Jesse Roberts of the U. S. Soil Conservation Service, A. G. Siverling, and the many local residents who provided water well data. The identification of vertebrate fossils by Drs. C. W. Hibbar, J. T. Gregory, C. B. Schultz, J. R. MacDonald, and Morton Green is gratefully acknowledged.

EXPOSED SEDIMENTARY ROCKS

Exposed bedrock includes the marine Pierre Formation of Late Cretaceous age, which is overlain by sandy fluviatile and lacustrine deposits of Oligocene and Pliocene age.

Cretaceous System

Pierre Formation Meek and Hayden, 1862

The Pierre was named from exposures at Ft. Pierre (100 miles north of the Gregory quadrangle). It has been subdivided into six members along the Missouri River, but only the uppermost member crops out in the Gregory area.

Elk Butte Member Searight, 1937.--The Elk Butte (Kpe) shales are poorly exposed in the broad valleys of Ponca Creek and its major tributaries, in the southwestern corner of the quadrangle where the surface is covered by scattered orange-brown fragments of limonitic concretions, and in the northeastern corner of the quadrangle where it is overlain by a very thick soil cover. This member consists of a thick sequence of gray to olive-brown thinly laminated clay-shale with some brown-orange laminae and many concretions. Five types of concretions are recognized: (1) very abundant orange-brown to red-brown limonitic claystone, (2) abundant very light-gray dense to silty limestone, (3) light-gray to gray cone-in-cone limestone, (4) light-gray dense limestone with orange-brown limonitic claystone cores, and (5) silty septarian limestone. Where it is overlain by the Tertiary deposits, the uppermost part of the Pierre is represented by a weathered zone of about 20 feet of yellowish-brown clay and clay-shale with local limonitic patches and many small concentrations of caliche, which has been called the Interior paleosol (Schultz and others, 1955).

No fossils were found in the Pierre in the Gregory quadrangle, but elsewhere in this area the Elk Butte Member contains a fauna dominated by the ammonite cephalopod Discoscaphites. The maximum thickness of the Elk Butte in the Gregory quadrangle is 176 feet. The upper surface of the Pierre Formation was extensively eroded before the deposition of the Tertiary sediments, resulting in a relief of more than 100 feet at the disconformable contact.

Tertiary System, Oligocene Series

? Brule Formation Darton, 1899

The strata described below have been tentively assigned to the Brule Formation (Tob) of the White River Group. In the absence of fossils, this correlation is based on lithologic similarity and stratigraphic position to White River sediments in nearby quadrangles to the west; (Collins, 1958; Schoon and Sevon, 1958; Agnew, 1957).

The questionable Brule strata are found in eight small isolated exposures mostly in the east-central part of the quadrangle. The Brule (?) strata consist of pinkish-tan clay with a waxey appearance, tuffaceous feldspathic silt, and sandy silt with irregular pebble-size concretions of dense white limestone, which are locally very abundant. Interbedded greenish-tan and reddish-brown waxey clay, and pinkish-tan fine-grained feldspathic sand are locally present. The maximum exposed thickness is 20 feet.

Pliocene Series

Valentine Formation Barbour and Cook, 1917

The Valentine Formation was named from exposures near Valentine, Nebraska (60 miles southwest of the Gregory quadrangle). Exposures are present in most of the mapped area between the valleys and the uplands.

The Valentine Formation (Tpv) is dominantly a greenish-tan to tan, partly clayey and/or tuffaceous, fine to very fine arkosic sand and sandstone, with local interbeds of greenish-tan tuffaceous arkosic silt and clayey silt, and light-green clay. A thin sandy basal conglomerate containing pebbles of limestone concretions (34 percent), feldspar (20 percent), quartz (18 percent), and granite (14 percent) crops out in the SE¼SE¼SW¼ sec. 14, T. 96 N., R. 72 W. Two miles north of Burke an irregular bed of white volcanic ash up to 7⅛-inches thick, with lenses and pockets of sand, is exposed. The shards of this ash are similar to those of the Calvert ash bed of the Valentine Formation in Nebraska and Kansas (Swineford, Frye, Leonard, 1955, p. 251).

The Valentine, which was deposited in the low areas of the pre-Pliocene erosion surface, consequently varies in thickness, ranging up to 71 feet in this quadrangle.

The Valentine Formation contains a vertebrate fauna dominated by grazing animals. According to J. T. Gregory the assemblage indicates an early Clarendonian age (Early Pliocene).

Ash Hollow Formation Engelmann, 1876

This formation was named for exposures in Ash Hollow Canyon (180 miles southwest of the Gregory quadrangle). In the Gregory quadrangle the characteristic ledges or "mortar beds" and cemented areas of the Ash Hollow Formation (Tpa) are present on the edges of the uplands.

Interbedded greenish-tan fine-grained arkosic sand, partially cemented ("nodular") calcareous fine-grained arkosic sand, and ledge-forming fine-grained vuggy calcareous arkosic sandstone ("mortar beds", "caprock") make up the bulk of the formation. Beds of greenish-tan clayey fine-grained arkosic sand and sandstone are locally present. Many beds contain small irregular and root-like concretions of grayish opaline silica (chert?), and at one locality (near S¼-corner sec. 30, T. 95 N., R. 72 W.) a two- to three-foot bed of greenish opaline silica with internal areas of concentrically laminated structure is present in the upper part of the formation. Locally, the formation contains white, light-gray or brown sandy to dense limestone concretions (some containing poorly developed septaria). Some strata show a definite cross-lamination that indicates derivation of the sands from the west. The formation averages about 70 feet thick in the west, but thins toward the east to about 10 feet.

The calcareous sandstone ledges that are so diagnostic of the Ash Hollow Formation elsewhere in the Great Plains are developed only locally in the Gregory quadrangle, where the ledges range from 1 to 10 feet thick and appear generally at different stratigraphic levels. Where the ledges are absent, there are zones of lenticular calcareous cemented nodules in a sand matrix.

The Ash Hollow vertebrate fauna closely resembles that of the Valentine, but the only fossils found in the mapped area, other than many hackberry seeds were bones of a rhinoceras.

Bijou Facies (Stevenson, 1958)

These strata, though named in 1951 (Stevenson, Carlson, 1951), were not formally described until two years later (Stevenson, 1953), as a series of Mio-Pliocene sediments. The formation was recently redefined (Stevenson, 1958) as a lithofacies within the Ash Hollow and Valentine Formations, characterized by greenish color and siliceous cement.

Scattered exposures of the Bijou Facies (Tb) are present on flat-topped hills and terraces southward from T. 96 N. The Bijou is present as lenses and discontinuous strata at a number of stratigraphic positions. Some of the lenses are persistent, especially the one at the top of the Valentine Formation.

Whereas most of the lenses of the Bijou Facies are in the Valentine, including the basal part of that formation (sec. 9, T. 95 N., R. 73 W.), they are also present in the Ash Hollow Formation (sec. 17, T. 95 N., R. 72 W.).

The Bijou is a greenish to white medium- to fine-grained siliceous arkosic sandstone ("quartzite") and partly cemented arkosic sand, with local crossbedding and a basal silicified-clay pebble zone. The Bijou ranges in thickness up to five feet. This silica-cemented facies of Pliocene sediments probably originated by shallow ground water action during late Pliocene time (Agnew, 1958, p. 132-133).

SURFICIAL DEPOSITS

The surficial deposits include the Pleistocene Herrick Formation, whose sands mantle the uplands, and the alluvial materials along present stream valleys.

Herrick Formation

This name was first used by Stevenson and Carlson (1951) in the legend of the geologic map of the Bonesteel quadrangle, but no type locality or description was published. The name was taken from the town of Herrick (7 mi. SE of Burke), near where it is well exposed.

The Herrick Formation (Qh) covers the uplands of the southern and northeastern parts of the Gregory quadrangle. The formation is a series of lensing crossbedded very coarse- to medium-grained arkosic sands with local streaks of small pebbles of granite, quartz, schist, and petrified wood. Individual lenses and layers are well sorted, and the torrential crossbedding slopes generally eastward. Rounded cobbles of greenish fine-grained clayey arkosic sand, and irregular fragments of greenish siliceous arkosic sandstone are locally embedded in the upper sands. The Herrick lies on a nearly flat erosion surface developed on the Ash Hollow Formation, and ranges up to 54 feet thick.

A paratype section, measured in the Burke Stone and Sand Company pit, 1½ miles west of Burke, shows:

	Thickness, feet
Recent--soil, tan, very sandy	0.3-0.9
Pleistocene, Herrick Formation--sand, light-colored, very coarse- to medium-grained, arkosic; cross-bedded and interfingered with gravel lenses. Plesippus (horse), mastodon	35-40
Pliocene, Ash Hollow Formation--sandstone, greenish-white, fine-grained, calcareous, arkosic	3.0+

Similar sands in Nebraska, 15 miles to the south, and in South Dakota, 45 miles to the east, were assigned to the Kansan or Nebraskan stages of the early Pleistocene by Condra and Reed (1950 p. 59), and by Schultz and Frankforter (in Flint, 1955, p. 48).

Teeth and bone fragments identified from the Herrick area indicate a Kansan or Nebraskan age.

Alluvial Deposits

The alluvial deposits have been divided into five types--undifferentiated terrace deposits; upper, middle, and lower terrace deposits, and alluvium, The threefold subdivision of terrace material is recognizable along Ponca Creek and its tributaries.

Terrace deposits (Qt) are subangular sands and rubble along the short southward-flowing streams in sections 25 and 36, T. 95 N., R. 73 W. The sandy part of these deposits is identical with the sands of the Herrick Formation, but the rubble fraction contains 80 percent subangular fragments of Ash Hollow calcareous sandstone, 16 percent angular fragments of Pierre limonitic and limestone concretions, 2 percent angular fragments of Bijou siliceous sandstone, and 2 percent well-rounded pebbles from the Herrick Formation. These deposits are about 5 feet thick.

Upper terrace deposits (Qtu), found in six isolated localities, consist of coarse sands and local gravel lenses at varying levels (approximately 70-100 feet) above the nearest streams. The material is mainly reworked Herrick Formation with a little Pliocene calcareous sandstone. The thickness ranges from about 5 feet to 30 feet.

Middle terrace deposits (Qtm) were found in only one area (along Ponca Creek, SE corner sec. 25, T. 96 N., R. 72 W.). The deposits lie about 55 feet above the main stream and consist of coarse to fine sand about 10 feet thick, composed of reworked Valentine and Herrick Formations.

Lower terrace deposits (Qtl) are the alluvial sands and associated coarse clastics along Ponca Creek and its major tributaries, about 35 feet above the stream level. The materials consist of reworked Herrick and Valentine sands augmented by a few interbeds of subangular gravel and rubble containing 70 percent Ash Hollow calcareous sandstone, 25 percent Pierre limonitic and limestone concretions, 3 percent Tertiary limestone concretions, and 2 percent Bijou siliceous sandstone. The deposit contains abundant clay and silt as a matrix for the coarser materials, and as interbedded lenses and layers. The thickness ranges from 5 to 45 feet.

Alluvium (Qal) is the floodplain deposit of clay, sandy clay, and sand along the present major streams.

SUBSURFACE ROCKS

Rocks not exposed at the surface in the Gregory quadrangle, but probably present in the subsurface are shown in Table 1. This information was obtained from oil tests (Gen. Crude #1 Shippy, 15 miles to the west; Palensky #1 Wagner, 45 miles to the east) and deep water wells (Ray Williams farm well, 5 miles to the east).

TABLE 1.--Subsurface Rocks of the Gregory Quadrangle

Upper Cretaceous	Pierre Formation	700'	Gray to black shale and siltstone with local marly zones; limonitic and calcareous concretions.
	Niobrara Formation	160'	White-speckled gray marl with minor gray granular dolomitic limestone.
	Carlile Formation	275'	Dark-gray clay and clay-shale with sideritic concretions; medium-grained sand in upper part.
	Greenhorn Formation	55'	Light-gray limestone and calcareous sandstone with abundant Inoceramus fragments.
---?---?---	Belle Fourche and Mowry Formations	105'	Gray shale and siltstone with a few stringers of quartzose sandstone; upper part slightly calcareous.
Lower Cretaceous	Newcastle (Dakota?) Formation	140'	Light-gray medium-to fine-grained quartzose sandstone.
	Skull Creek Formation	155'	Gray shale with interbeds of quartzose sandstone.
	Inyan Kara Group	110'	Light-gray medium-to coarse-grained massive quartzose sandstone with shale interbeds.
Jurassic and Older	Sundance? and Older Formations	530'	White medium- to coarse-grained quartzose sandstone, locally glauconitic, partly cemented; tan to pink fine- to medium-grained quartzose sandstone; red to red-brown shale with sideritic pellets; about 350 feet below the top is a 30-foot zone of quartzose grit; variegated to maroon shale near the base.
Pennsylvanian	Minnelusa Formation	0-50'	Pale-red to grayish-pink dolomite and sandy dolomite; interbeds of white to pink limestone and thin sandstone; basal lateritic zone.
Precambrian	Ortonville Granite		Red medium coarse-grained granite with biotite schlieren.

STRUCTURAL GEOLOGY

The quadrangle lies on a saddle separating the Dakota (Williston) and Central Nebraska basins; thus the Cretaceous and older rocks are essentially horizontal. Pliocene and later strata have an eastward dip of 0.9-foot per mile, which is thought to be depositional.

ECONOMIC GEOLOGY

The principal mineral resources in the semi-arid climate of the Gregory quadrangle is ground water, available at varying depth below the surface in all parts of the area. Sands were commercially quarried in 1957, and gravels were formerly produced in the mapped area. There are several other potentially economic mineral resources in this region.

Ground Water

The best source of ground (subsurface) water in the Gregory quadrangle is the fine-grained sands of the Valentine Formation. Permeable sand layers yield artesian water at depths of 100-160 feet in the upland areas, and about 45 feet at lower elevations. Generally the water from the Valentine sands is of excellent chemical quality and is suitable for all purposes. A typical analysis (table 2) shows that the principal constituents are well within the limits of the U. S. Bureau of Public Health.

Where the Valentine Formation is missing or has low permability, water is obtained from the jointed and weathered upper part of the underlying Pierre clay-shale. Wells in the shale average 50 feet in depth, and are generally in areas adjacent to major stream valleys. 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, with carbonate hardness of 755 ppm, making it unsuitable for most domestic and irrigation uses. However, it can be used without treatment for stock.

Some of the farms on terraces or on the floodplain of Ponca Creek obtain their water from the alluvial sands and gravels at depths of 20-30 feet. The water is suitable for most uses, but it is very hard and slightly above the standard limit for total dissolved solids (table 2).

East of the Gregory quadrangle where the coarse sands of the Herrick Formation are most extensive, they locally provide water, but in the mapped area they are not productive.

South Dakota's well known artesian aquifer, the Dakota or Newcastle sandstone, lies at depths of 1300-1500 feet in the Gregory 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 in the Gregory Quadrangle

Source	In parts per million										Micromhos at 5° C
	Ca	Mg	Na	K	SO_4	NO_3	Cl	Fe	Hardness $CaCO_3$	Total Dissolved Solids	Specific Conductance
Valentine Sand (1)	46	10	12	8	5	71	7½	0	155	266	390
Pierre Shale (2)	204	60	216	10	880	0	10	7.1	755	1470	2200
Alluvial Deposits (3)	72	33	34	11	105	3	15	0.03	315	581	830
Standard Limits (4)	-	125	-	-	250	10	250	0.3	120	500	-

Analyses by Dr. Oscar Olson, Station Biochemistry, S. D. Agricultural Experiment Station, State College, Brookings, South Dakota, 1957.

(1) Richardson farm, sec. 34, T. 95 N., R. 72 W.
(2) Gerken farm, sec. 16, T. 97 N., R. 73 W.
(3) Steffen farm, sec. 10, T. 96 N., R. 72 W.
(4) U. S. Bureau of Public Health (1946) and others.

Sand

Large volumes of coarse sand suitable for cement block, tile, mortar, and plaster are present in the Herrick Formation. The sand is clean and contains little or no material deleterious to the manufacture of concrete. Pebble content is less than 5 percent, and can easily be screened out. The sand pits west of Burke have been producing since about 1908. The Burke Stone and Sand Company produces 10,000 tons annually, of which about 9 percent is used in the manufacture of cement block and tile. Farther west (sec. 21, T. 97 N., R. 72 W.), a sand pit operated by Pat Opperman produces intermittently. In addition to these operating pits, others are used from time to time for road surfacing. The Valentine Formation could provide fine sand suitable for finish cement and fine plaster.

Gravel

Gravels suitable for surfacing secondary roads are present in small quantities in the low terrace deposits along Ponca Creek, and in the terrace deposits in sections 25 and 36, T. 95 N., R. 73 W. These gravels contain a high percentage of undesirable carbonate and argillaceous material, however, which prevents their use as concrete aggregate. Some of the upper terrace deposits have enough pebbles and cobbles to qualify as gravels. They also have less carbonate and argillaceous material than the low terrace gravels.

Oil and Gas

The Gregory quadrangle lies on the southern edge of the Williston (Dakota) basin, a major oil and gas producing area. Although the basin's production comes mainly from tectonic upwarps in the center and along the western edge, some oil pools are in sedimentary traps along the northeastern flank. At the present time there is no evidence of tectonic structures in the Gregory area but sedimentary traps are possible. The eastward-thinned Minnelusa Formation (productive in eastern Wyoming), occurring at depths of 2200-2500 feet, is a favorable zone for prospecting. The General Crude Oil Company drilled four tests in Tripp county to the west, the nearest being the #1 Shippy, 15 miles west of the Gregory quadrangle. These tests were abandoned as dry holes with no reported oil shows.

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 for road surfacing. This rock can 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.

Shale

Some of the shales of the Pierre Formation in the Gregory quadrangle could be used for brick-making. Some could possibly be used in the manufacture of lightweight aggregate.

Volcanic Ash

An intermittent and impure bed of volcanic ash is present just north of Burke, and could be used as a fine abrasive material. Other, purer beds of volcanic ash of commercial thickness are possibly present in the Tertiary deposits of the Gregory area.

Uranium

Uranium and other rare-earth metals are present in very minute quanities in the Pierre Formation. Generally the weathered zone at the top of the formation has a higher concentration of radioactive minerals. However, in the Gregory quadrangle there are no concentrations approaching commercial value.

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