SOUTH DAKOTA GEOLOGICAL SURVEY
ALLEN F. AGNEW, STATE GEOLOGIST

STATE OF SOUTH DAKOTA
RALPH HERSETH, GOVERNOR

# GEOLOGY
of the
# DELL RAPIDS QUADRANGLE
SOUTH DAKOTA

(Rutland) (Flandreau) (Pipestone) (Chester) (Ihlen) (Hartford) (Sioux Falls) (Hills)

96°45' 40' R.49W. R.48W. 35' R.48W. R.47W. 96°30'
44°00' 55' 50' 43°45'
T.106N. T.105N. T.104N. T.103N.

Egan Trent Dell Rapids Baltic DELL TRENT BALTIC

Chicago, Milwaukee & St. Paul Pacific and Big Sioux River

CEMETERY

MOODY CO. MINNEHAHA CO.

Stone Creek

BM 1499

## EXPLANATION

RECENT

**Qal** — Alluvium
*(Floodplain deposits of silt and sand along the Big Sioux River and its larger tributaries)*

PLEISTOCENE — WISCONSIN

**Qwcvo** — Cary Valley Train Outwash
*(Stratified meltwater deposits of gravel, sand, and silt confined to narrow stream valleys; has flat topographic expression)*

**Qwco** — Cary Outwash Plain
*(Stratified meltwater deposits of gravel, sand, and silt unconfined; has flat topographic expression); also terrace deposits (Qwckt)*

**Qwce** — Cary End Moraine
*(Ridge-like accumulations of till; characterized by rough topography, undrained depressions, and boulder-strewn surface)*

**Qwtvo** — Tazewell Valley Train Outwash
*(Stratified meltwater deposits of gravel, sand, and silt confined to narrow stream valleys; has flat topographic expression)*

**Qwio** — Iowan Outwash Plain
*(Terrace, stratified meltwater deposits of gravel, sand, and silt; has flat topographic expression slightly modified by erosion)*

**Qwik** — Iowan Kame Deposits
*(Ice-contact deposits of gravel, sand, and silt forming short irregular ridges)*

**Qwig** — Iowan Ground Moraine
*(Relatively flat accumulations of till; characterized by well developed drainage, smooth slopes and no undrained depressions -- up to six feet of loess cover)*

**Qwie** — Iowan End Moraine
*(Ridge-like accumulations of till; characterized by high, smooth, well-drained topography -- up to six feet of loess cover)*

ILLINOIAN

**Qig** — Illinoian Ground Moraine
*(Accumulations of till; characterized by well developed drainage, deep dissection, steep slopes -- up to eight feet of loess cover)*

QUARTERNARY

PRECAMBRIAN

**Pcs** — Sioux Formation
*(Pink, blocky, well-jointed, quartzitic sandstone)*

Contact
(dashed where approximately located)

Gravel Pit

X BM 1737
Bench Mark
(monument showing exact altitude above sea level)

△ DELL
Triangulation Station
(monument marking exact geographic location)

House, School, and Church

Cemetery

Geology by Merlin J. Tipton, 1958

Assisted by H. D. Wong,

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

Drafted by C. F. Harris.

APPROXIMATE MEAN DECLINATION, 1958
TRUE NORTH — MAGNETIC NORTH — 9°30'

Scale 1:62500

1 1/2 0 1 2 3 4

Vermillion, South Dakota
1959

Quadrangle Location (104° 97° 46° 43°)

DELL RAPIDS QUADRANGLE

# GEOLOGY OF THE DELL RAPIDS QUADRANGLE

by

M.J.Tipton

## INTRODUCTION

The Dell Rapids quadrangle includes about 217 square miles in northeastern Minnehaha and southeastern Moody Counties. The southern border of the mapped area is 10 miles north of the city of Sioux Falls.

The area is in the Dissected Till Plain section (fig. 1) of

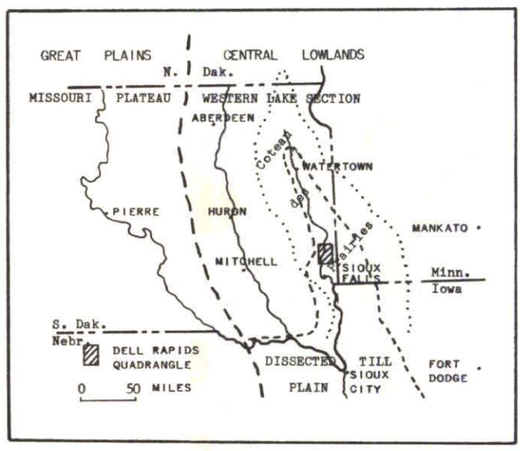


Fig. 1. Map showing physical divisions of eastern South Dakota and adjoining area. (after Rothrock, 1943; Fenneman, 1938; and Carman, 1915).

the Central Lowlands physiographic province (Fenneman, 1938, map), and is on the Coteau des Prairies (Rothrock, 1943, map), a relatively high plateau-like feature of eastern South Dakota, southwestern Minnesota, and northwestern Iowa (Carman, 1915, p. 243). The Big Sioux River crosses the western part of the quadrangle from north to south, and Pipestone Creek enters and leaves the quadrangle along the eastern border. Elevations range from 1475 to 1650 feet above sea level. The maximum relief of the mapped area is thus approximately 175 feet, and the local relief ranges up to 100 feet.

U. S. Highway 77 and State Route 34 cross the western and northern parts of the quadrangle, and the Chicago, Milwaukee, St. Paul and Pacific Railroad crosses the western part. Dell Rapids (pop. 1650), Egan (pop. 347), Baltic (pop. 255) and Trent (pop. 213) are the only towns in the mapped area. Gravel roads make almost any part of the quadrangle easily accessible. The climate is characterized by a wide temperature range and an average precipitation of 23 inches per year.

The geology was mapped on air photos during the summer of 1958 under the supervision of Dr. A. F. Agnew, State Geologist. The writer is grateful to Fred V. Steece, who mapped the adjacent quadrangle to the south, for his advice and cooperation in the field work.

## SURFICIAL DEPOSITS

The quadrangle is covered by unconsolidated material that can be separated into three main groups: (1) glacial deposits, (2) stream deposits, and (3) wind deposits.

### Glacial Deposits

The first ice sheet to cover the upper Middle West was the Nebraskan, and it was followed by the Kansan, Illinoian, and Wisconsin sheets. The Wisconsin ice advanced at five separate times; from oldest to youngest, the Iowan, Tazewell, Cary, Mankato, and Valders. A sixth subdivision of the Wisconsin called the Farmdale, is said to be present in Illinois and Iowa, below the Iowan (Leighton, 1958, p. 299-302). Although the Nebraskan, Kansan, and Illinoian deposits are present in eastern South Dakota, some of the Wisconsin ice advances may not have reached this area.

The ice sheets deposited drift consisting of clays, silts, sands, gravels, and boulders reworked from bedrock and from older surficial deposits. In the Dell Rapids quadrangle the drift ranges in thickness from zero, near Dell Rapids where the bedrock crops out (see Precambrian Rocks), to 410 feet in the Colman city well, eight miles west of Egan (see Subsurface Sedimentary Rocks).

The drift is divisible into two lithologic groups: till and outwash. Till consists of unsorted and unstratified material that ranges in size from boulders to clay. The till was produced through abrasion by the ice sheet against the land surface. Outwash consists of stratified sand, gravel, and silt reworked from the drift and deposited by the meltwater streams of the ice sheet.

#### Till

The till exposed at the surface in the Dell Rapids quadrangle is of Illinoian (?), Iowan (?), and Cary age. The till in the northwestern part of the quadrangle is Cary in age, that in the southern part is Illinoian (?) in age, and the remainder is Iowan (?) in age. The age of the latter tills is questioned pending the results of a more regional study (Steece, Tipton, and Agnew, In Preparation).

The tills are differentiated by topographic differences and to some extent by the amount of loess cover (wind-blown silts and clays). The Cary till surface is poorly drained, containing many undrained depressions, and has steep slopes which in places are strewn with boulders. The Iowan (?) till surface is well drained, having no undrained depressions, and has smooth slopes and a relatively low relief that gives the surface a flat appearance. The Illinoian (?) till surface is very well drained, having no undrained depressions, and is deeply dissected. In general, the Cary till has a thin and sporadic loess cover, whereas the Iowan (?) and Illinoian (?) tills have a more extensive and thicker loess cover; however, the Cary till is locally covered with thick loess (see Wind Deposits).

The geomorphic expression of the Cary till in the Dell Rapids quadrangle is mapped as end moraine, which is till left as linear ridge-like accumulations along the margins of the ice sheet by lodgement and conveyor-belt or snowplow action of the moving ice. On the other hand Lee (1959) has mapped the extension of this end moraine into the Flandreau quadrangle to the north as ground moraine, which is till that was carried forward in, on, or beneath the ice and deposited from its under surface or let down from the upper surface, forming a topography of low relief, which is devoid of transverse linear elements. This disparity shows the different interpretations that can result from emphasizing certain criteria rather than others.

The Cary end moraine in the Dell Rapids quadrangle marks the easternmost advance of the Cary ice sheet in the James River lobe. This end moraine is not as rough and rugged, and does not have as much local relief as the Cary end moraines farther north near Watertown, South Dakota (Steece, 1958). This can be explained either (1) by a thinning of the ice in the Dell Rapids area which would result in more subdued moraines, or (2) by the possibility that the end moraines in this area may be lodgement-type, and the moraines farther north being snowplow-type.

The Iowan (?) drift in the Dell Rapids quadrangle formed ground moraine except along the southern border where a broad, ridge-like high may be the erosional remnant of an end moraine. The crest of this high is marked by a line of nearly continuous hills that can be traced across the quadrangle and into the adjacent Chester quadrangle (Tipton, 1959, map and text). The tops of the hills stand nearly 50 feet above the surrounding drift, and are probably not held up by bedrock highs, as scattered data show the drift to be thickest beneath the hills. Stratified drift of Iowan (?) age forms gravel knolls (kames) adjacent to the ridge in sec. 2, T. 104 N., R. 48 W. and in the northeast part of the Sioux Falls quadrangle to the south (Steece, 1959, map). These are the only kames known on the Iowan (?) drift of the Coteau des Prairies in South Dakota. The occurrence of these gravel knolls near the high ridges helps show that the ridges are end moraines, as stratified drift is commonly associated with end moraines. Similar remnant end moraines, also associated with kames, were found along the Iowan drift border in northeastern Iowa by Alden and Leighton (1917, p. 171-181).

The Illinoian(?) and Iowan (?) drifts in the Dell Rapids area were both mapped as Iowan by Flint (1955, pl. 1). The topographic difference between the two drifts is visible in the field, and is strikingly apparent on air photos and topographic maps. The change in topography between the two drifts roughly parallels the area where the bedrock of the Sioux Formation crops out (see Precambrian); thus the nearness of this bedrock to the surface in the Illinoian (?) drift area might cause the difference in the drift topography. If this is the case, the drift mapped as Illinoian (?) could be Iowan(?) in age. Another possible explanation is that the Sioux Formation formed an obstacle that halted the advance of the Iowan (?) ice in this area, thus the earlier Illinoian (?) drift was not covered by Iowan (?) to the southeast. It is believed that the latter is the best explanation, (1) because of the presence of Iowan (?) end moraine remnants, and (2) because several areas of Sioux Formation exposures just east of the quadrangle in Minnesota do not show any change in the topography of the Iowan (?) drift. This problem will be discussed in more detail by Steece, Tipton, and Agnew (In Preparation).

In general, the topography of the Cary drift in this area is rough and rugged, that of the Iowan (?) drift is smooth and undulating, and that of the Illinoian (?) is well dissected. These three types of topography may reflect different characteristics of the individual ice sheets, but more probably are the result of the difference in age and thus the effect of post-depositional erosion. This is best shown in the upper Middle West by the scarcity of pre-Wisconsin end moraines, as contrasted with the numerous rough and rugged end moraines on the young drift sheets. Either the pre-Wisconsin ice sheets did not build extensive end moraines, or a more reasonable explanation is that the earlier end moraines were built and then destroyed by erosion.

The lithology and degree of weathering of the tills in the Dell Rapids quadrangle were not used as criteria for age differentiation because of the scarcity of outcrops.

#### Outwash

Outwash deposits in this area are recognized topographically by their level surfaces, as contrasted with the undulating surfaces of till deposits. Cary outwash deposits are present in a channel which includes the Big Sioux River, Tazewell (?) outwash deposits are present along Pipestone Creek and Iowan (?) deposits are adjacent to the Tazewell (?) outwash. The age of the Cary and Tazewell (?) outwash deposits was determined by tracing them to their respective end moraines; the age of the Iowan (?) deposits was inferred from its position as a terrace above the Tazewell (?) deposits.

The composition of the Cary sands and gravels varies locally, but in general averages about 50 percent soft carbonates and argillaceous rocks, and 50 percent hard igneous and metamorphic rocks. The composition of the Iowan (?) sand and gravels averages about 40 percent soft carbonates and argillaceous rocks, and 60 percent hard igneous and metamorphic rocks. The Tazewell (?) sands and gravels were not collected owing to a thick cover of alluvial deposits.

The texture of the Cary outwash deposits varies locally but generally ranges from silts to coarse gravels with one percent in the silt fraction, 60 percent in the sand fraction, and 39 percent in the gravel fraction. The texture of the Iowan (?) outwash deposits also ranges from silts to coarse gravels but contain three percent in the silt fraction, 26 percent in the sand fraction, and 71 percent in the gravel fraction.

The Cary outwash channel along the Big Sioux River covers about 25 square miles and averages about 20 feet thick. The thickness ranges up to a maximum of 52 feet in sec. 20, T. 104 N., R. 49 W. The Tazewell (?) outwash channel along Pipestone Creek covers about five square miles and averages 19 feet thick. The thickness ranges up to a maximum of 45 feet in sec. 8, T. 105 N., R. 47 W. The Iowan (?) outwash covers about one square mile and averages 17 feet thick. The thickness ranges up to a maximum of 24 feet in sec. 19, T. 105 N., R. 47 W. The above mentioned thicknesses of the sands and gravels were determined by 42 drill holes and six resistivity stations.

### Stream Deposits

Recent alluvial deposits consist of silt and sand reworked by present streams from bedrock and older surficial deposits. The alluvium in the Dell Rapids quadrangle is confined to the Big Sioux River, Pipestone Creek, and a few of their tributaries. The alluvium along the Big Sioux River averages one-fourth mile wide and about six feet thick, and along Pipestone Creek it is about half a mile wide and 3½ feet thick.

### Wind Deposits

Loess is a wind deposit of silt, clay, and a few sand particles derived mainly from outwash plains. In the Dell Rapids quadrangle, loess is present sporadically on the Cary drift; it is spread more uniformly on the Iowan (?) and Illinoian (?) drifts, averaging about four feet thick on the former and about six feet on the latter. The loess is usually unleached where covered by soil; otherwise, it may be leached as much as three feet deep. The color of the loess varies from a light buff where unoxidized, to orange.

An unusual northwest-southeast lineation is visible on air photos of the Illinoian (?) drift area. This lineation may be the result of a prevailing wind during the deposition of the loess; however, as this lineation is not apparent on the ground and because some of the linear elements are not loess-covered, they may be due to some other cause. Some of the linear elements are as much as five miles long and very straight; thus they may be drumlins or drumlinoids. A drumlin is a streamlined hill or ridge of glacial drift with its long axis parallel to the direction of flow of a former glacier, and a drumlinoid is a rock structure modified by ice movement so as to look like a drumlin. These drumlins or drumlinoids contain no stratified material where drilled.

## SUBSURFACE SEDIMENTARY ROCKS

Sedimentary rocks are not exposed in the Dell Rapids quadrangle, and deep well borings are so sparse that little is known of the bedrock in this area. A well drilled at Colman, three miles west of the northwestern corner of the quadrangle, revealed 410 feet of glacial drift resting on 226 feet of Cretaceous sedimentary rocks. The latter consisted of 136 feet of Graneros (?) shale, 50 feet of Dakota (?) sandstone, 19 feet of Fuson (?) shale, and 21 feet of Lakota (?) sand, in descending order. Near Dell Rapids no subsurface Cretaceous rocks occur, as the Precambrian Sioux Formation is exposed at the surface (see Precambrian Rocks).

## PRECAMBRIAN ROCKS

The Sioux Formation is exposed in and around the town of Dell Rapids, and in the southeastern corner of the quadrangle. In this area the Sioux Formation is a quartzite consisting of fine grains of iron-coated quartz sand, cemented with silica. The rock has a greasy luster because it breaks through the quartz grains rather than around them. The iron coating on the quartz grains imparts a pinkish or reddish color to the formation.

The Sioux quartzite is blocky because of a well-developed joint pattern, and the bedding of the rock in this area dips slightly to the south and southwest (Baldwin, 1949, p. 13).

The Sioux Formation forms an east-west ridge, the axis of which passes through Mitchell and Sioux Falls (fig. 1); the Dell Rapids quadrangle lies on the north slope of this ridge.

## STRUCTURE

The structure of the bedrock sediments in this quadrangle is very difficult to determine, as the sediments are not exposed and well records are very few. Petsch (1953a) showed a slight northwesterly dip on the Greenhorn Formation in this area; this probably reflects the topographic surface of the Precambrian (Petsch, 1953b).

## ECONOMIC GEOLOGY

The most valuable geologic products of this quadrangle are ground water, sand and gravel, and stone. Clay and silt could become economically important, but at present are not used. Oil and gas might possibly have been trapped in the Cretaceous rocks where they pinch out against the Sioux Formation, but the possibility of any significant quantity is very slight because of the thin section of sedimentary strata in this area (see Subsurface Sedimentary Rocks).

### Ground Water

Ground water in quantity adequate to supply farm wells is available in most parts of the quadrangle. Ground water in larger amounts is present in some parts of the outwash channels, and possibly in buried channels of streams that drained this area before the last ice advance. Ground water is also present in sand lenses in the till, but these lenses are commonly small and are recharged with water very slowly; however, they generally contain enough water to supply domestic wells. No deep artesian wells are present in this area (Barkley, 1953, map), but a shallow artesian sand is present south of Trent (see buried channels at end of this section).

The largest areas of available shallow ground water in the Dell Rapids quadrangle are in the Cary and Tazewell (?) outwash channels.

The Cary outwash channel contains an average of 20 feet of sand and gravel, nine feet of which is water-saturated. The channel covers 16,000 acres and, assuming a porosity of 30 percent for the gravels, contains about 43,000 acre-feet of water. This is not a relatively large amount of water but the channel should be able to provide water for several irrigation wells, because of a large recharge area upstream, and because the texture of the deposits is coarse grained. The largest supply of water in the Big Sioux outwash channel is south of Dell Rapids, where the gravels average 32 feet in thickness and contain an average of 18 feet of water.

The Tazewell (?) and Iowan (?) outwash channels contain an average of 19 feet of sand and gravel, eight feet of which is water-saturated. These channels cover 3,200 acres in the Dell Rapids quadrangle and, assuming a porosity of 30 percent for the gravels, contains about 7,500 acre-feet of water. This is not as much water as desirable for irrigation purposes; however the channels should support a limited number of irrigation wells.

The quality of the water in the outwash channels varies greatly in short distances (table 1); it probably varies seasonally

Table 1. Analyses* of Water Samples in Dell Rapids Quadrangle

| SAMPLE (No. in parens denotes source; 1 - outwash, 2 - shallow artesian sand) | Parts Per Million | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ca | Na | Mg | N | Fe | Cl | $SO_4$ | Hardness $CaCO_3$ | Total Solids | Irrigation Class ** |
| Public Health Drinking Water Standards*** | -- | -- | 125 | 10 | 0.3 | 250 | 250 | -- | 1000 | |
| Dale Kittelson sec. 35-106-49 (1) | 100 | 11 | 25 | 24 | 0 | 5 | 114 | 351 | 578 | I |
| Clayton Sandro sec. 2-105-49 (1) | 177 | 400 | 37 | 1.4 | 0.7 | 27 | 1108 | 594 | 2120 | III |
| Ed E. Smidt sec. 3-105-49 (1) | 111 | 26 | 43 | 0 | Tr | 34 | 67 | 453 | 634 | I |
| Gust Carlson sec. 26-105-49 (1) | 205 | 243 | 120 | -- | -- | 20 | 1260 | 1004 | 2230 | III |
| George Christensen sec. 29-105-48 (1) | 127 | 14 | 33 | 34 | Tr | 6 | 193 | 454 | 712 | II |
| Albert Lampson sec. 30-105-48 (1) | 269 | 142 | 42 | -- | -- | 29 | 879 | 943 | 1892 | III |
| Myron Joneson sec. 31-105-48 (2) | 286 | 152 | 86 | -- | -- | 27 | 1095 | 1070 | 2038 | III |
| Myrtle Jaycox sec. 4-105-47 (1) | 127 | 19 | 34 | 12 | 0 | 0 | 233 | 459 | 690 | I |

* Analyses by South Dakota State Chemical Laboratory, Vermillion
** Class I - excellent to good, Class II - good to injurious, Class III - injurious to unsatisfactory
*** not to exceed

as well, so that periodic analyses should be made before and during the time that the water is being used.

Another possible source of water is the buried channels of former streams, which drained this area before the last ice advance. The locations of the valleys of these former streams (fig. 2) is inferred from linear topographically low areas. They contain deposits of sand and gravel which may be saturated with water.

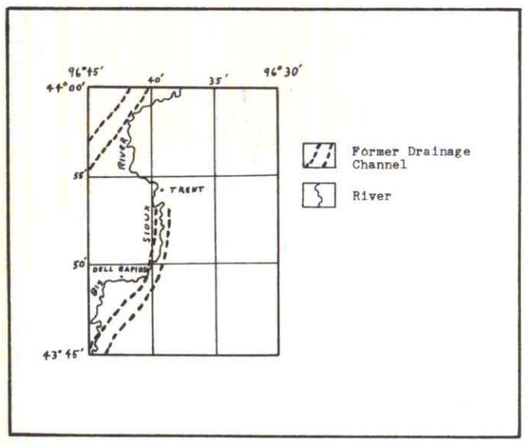


Fig. 2. Map of Dell Rapids quadrangle showing inferred former drainage channels (modified from Flint, 1955, pl. 7).

The several wells producing from artesian sands just below the outwash deposits, south of Trent, may be in buried channels. If the amount of water in these buried channels is great enough, and the physical character of the deposits is suitable, the channels may provide an additional source of water for irrigation.

### Sand and Gravel

The Cary outwash channel along the Big Sioux River covers about 25 square miles and contains about 500,000,000 cubic yards of sand and gravel. The Tazewell (?) and Iowan (?) outwash channel along Pipestone Creek covers about five square miles and contains about 95,000,000 cubic yards of sand and gravel. These gravels are suitable for subgrade materials in road building, and if the high percentage of soft material were removed, could possibly be used for bituminous or concrete aggregate.

### Stone

The Sioux quartzite is quarried east of Dell Rapids for building stone, paving blocks, monumental stone, tube-mill liners, grinding pebbles, rip-rap, crushed stone, filter beds, engine sand, abrasives, poultry grit, foundry sand, filler, silica brick, glass sand, and in the manufacture of ferro-silicon.

### Clay and Silt

The tills and loesses of the Dell Rapids quadrangle contain a large amount of clay and silt, which might possibly be used in the manufacture of brick and tile.

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