

STATE OF SOUTH DAKOTA
Archie Gubbrud, Governor

STATE GEOLOGICAL SURVEY
Allen F. Agnew, State Geologist

Report of Investigations
No. 93

GEOLOGY OF SELECTED HIGHWAY STRIPS IN SOUTH DAKOTA

by
Earl J. Cox and others

Prepared cooperatively by the South Dakota State Geological Survey
and the State Highway Department

SCIENCE CENTER, UNIVERSITY
VERMILLION, SOUTH DAKOTA
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Earl J. Cox and others

FOREWORD

Part of the Flexible Pavement Research Program of the Research and Planning Division of the South Dakota Department of Highways is a study that began in August, 1957, with a proposal by Assistant Research Engineer Robert A. Crawford for geologic and soils mapping in 52 (later expanded to 53) test strips totaling approximately 750 lineal miles.

In April, 1959, an agreement was reached between C. P. Jorgensen, State Manager of the Research and Planning Division of the State Department of Highways, and Allen F. Agnew, State Geologist, whereby State Geological Survey personnel would be transferred to the Highway Department payroll for the performance of the geologic mapping. Field expenses were also provided by the Highway Department.

The State Geological Survey retained supervision of the technical phases of the work, and the State Highway Department assumed administrative responsibility.

The State Highway Department requested strip maps of the geology for half a mile on each side, along the full length of each test strip or project. In addition, the geologist was to make suggestions or recommendations where possible, regarding the effect of the geology on the cost, behavior, or performance of the highway strips. Specific locations along the highway were referred to by station numbers on the original prints of the strips that were transmitted to the State Highway Department; the station locations are omitted from the maps printed herein. The agreement provided that geologic samples be taken in order that engineering characteristics of the geological materials might be determined; the State Highway Department's auger drill was to do the sampling.

The geology was mapped on transparent strip foils in conjunction with air photos that were lent by the various Area Conservationists, Work Unit Conservationists, and Soil Scientists of the Soil Conservation Service of the U. S. Department of Agriculture. We especially wish to acknowledge this excellent aid provided through the courtesy of Ross S. Davies, State Conservationist.

In general, South Dakota was divided into West-River and East-River areas, where the geology was mapped by Earl J. Cox and Joel K. Montgomery, respectively. Cox was assisted by Donald Solmons, and Montgomery by Richard Von Holdt.

Cox mapped Strips 4, 5, 34-44, and 48-52. Montgomery mapped Strips 1-3, 8-12, 14-21, 24-31, and 53. In addition, the geology of Strips 6, 7, 13, 22, 23, 32, 33, and 46 was checked against already published detailed geologic quadrangle maps of the State Geological Survey by A. F. Agnew, B. C. Petsch, W. A. Pettyjohn, and F. V. Steece of the State Geological

Survey. The remaining two strips, 45 and 47, were mapped respectively by A. F. Agnew and W. D. Sevon, and by S. G. Collins, of the State Geological Survey.

All field mapping and most of the checking was completed during the summer and fall of 1959; the remainder was done in 1960. The geology was plotted on a transparent foil for each strip, and a text was prepared for each. Duplicate foils and edited texts were supplied to Robert A. Crawford between September, 1959, and September, 1960.

The highway strips are located in each of the major physiographic divisions of South Dakota, except the Black Hills, the High Plains, and the Minnesota Valley (fig. 1). Each physiographic province has different drainage problems, and several of them are underlain by rock types that are distinctly different from those under other strips.

The rock units and sediments of South Dakota are given in Table 1, together with the geologic symbol that is used on the map. The lithologic characteristics of the different formations are discussed in the descriptions of the test strips where they occur. The unconsolidated sediments are treated somewhat differently, and are described as both geomorphologic units of different ages and the materials that compose them.

The project has been a valuable one for the State Geological Survey, because it has enabled us to obtain detailed geologic strip maps of many areas of South Dakota which had previously had only the most reconnaissance type of mapping. We hope that the project is and will continue to be similarly valuable to the State Highway Department.*

Allen F. Agnew
State Geologist

November 1, 1962

*Owing to numerous requests for this information since 1960, the report is being published, in order to make it widely available.

The different authors of the strip reports emphasize different criteria in their writing; thus, a discussion of topography is not presented for some strips, and certain other features are not standardized. Discrepancies between the individual author and the Survey are noted where pertinent--AFA, November 15, 1962.

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Table 1.--Rock Units and Sediments Mapped along the Test Strips

Quaternary Units Listed According to Lithology

- Qal - alluvium, along present streams
- Qoal - older alluvium, generally as low terraces along streams
- Qalo - alluvium and outwash, undifferentiated
- Qc - colluvium, slope-wash material
- Qd - dune sand, windblown sand
- Qes - esker, sinuous raised gravel deposit of a glacial stream that flowed under the ice
- Qh - Herrick Sand, a pre-glacial western-derived Pleistocene sand
- Ql - loess, fine windblown silt mantling the upland
- Qlb - lake beds, fine clays in ancient or present lakes
- Qls - landslide material, along bluffs
- Qn - Newton Hills Sand, an eastern-derived sand probably deposited in front of the ice as it advanced, perhaps in a lake
- Qo - outwash deposit, sand and/or gravel laid down by melt-water streams in front of stagnating or retreating ice front
- Qtd - terrace deposits, sand and/or gravel laid down by older streams, at higher levels than the present valleys

Quaternary Units Listed According to Age (Youngest at Top)

	Mankato - Qwm	Letters added to denote geomorphic form as:
Wis- consin	Cary - Qwc	
	Tazewell - Qwt	
	Iowan - Qwi	
Illinoian	- Qi	Qwce = Cary end moraine Qwcg = Cary ground moraine Qwig = Iowan ground moraine

Pre-Quaternary Stratigraphic Units (Youngest at Top)

Tertiary			
Pliocene	Tpa	Ash Hollow - silt, ash	} Ogallala, un- differentiated Tpo } Tpb = Bijou quartzite facies)
	Tpv	Valentine - silty, ash	
Miocene	Tmmc	Monroe Creek - silt, ashy	} Arikaree, un- differentiated Tma } (Tmm = Mellette limestone facies)
	Tms	Sharps - silt, ashy	

x

Table 1.--Rock Units and Sediments Mapped along the Test Strips--
continued

Oligocene	Tob	Brule - silt	} Tow	White River un- differentiated
	Toc	Chadron - clay, sand, bentonite		
Paleocene	Tpt	Tongue River - sand, clay	(Tpt1 = Lodgepole coal facies)	
	Tpl	Ludlow - clay, sand	} Tplg = Giannonatti coal facies Tplh = Hillen coal facies Tpls = Shadehill coal facies	
Cretaceous				
Kh	Hell Creek - clay, sand, manganese nodules			} Khu = upper Khl = lower
Kfc	Colgate - sandstone	} Kf Fox Hills, undifferentiated		
Kfb	Bullhead - shale			
Kft	Timber Lake - sand, silt			
Kftc	Trail City - clay, silt			
Kpe	Elk Butte - shale	} Kp Pierre, undifferentiated (Kpu = upper, Kpmi = middle, Kpl = lower)		
Kpm	Mobridge - calcareous shale			
Kpvc	Virgin Creek - shale			
Kpv	Verendrye - shale			
Kpd	DeGrey - shale, manganese nodules			
Kpg	Gregory - shale, calcareous sand			
Kpss	Sharon Springs - bituminous shale			
Kn	Niobrara - marl			
Kc	Carlile - shale			
Kg	Greenhorn - limestone			
Khf	Belle Fourche - shale	} Kgn Graneros - shale		
Kmr	Mowry - shale			
Knc	Newcastle - sandstone			
Ksc	Skull Creek - shale			

Table 1.--Rock Units and Sediments Mapped along the Test Strips--
continued

Kfr	Fall River - sandstone
Kf	Fuson - shale
Kl	Lakota - sandstone

Jurassic	
Jm	Morrison- shale, sandstone

Js	Sundance - sandstone, shale
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Triassic	
TRs	Spearfish - shale, gypsum

Precambrian	
PEs	Sioux - quartzite
PEd	diabase

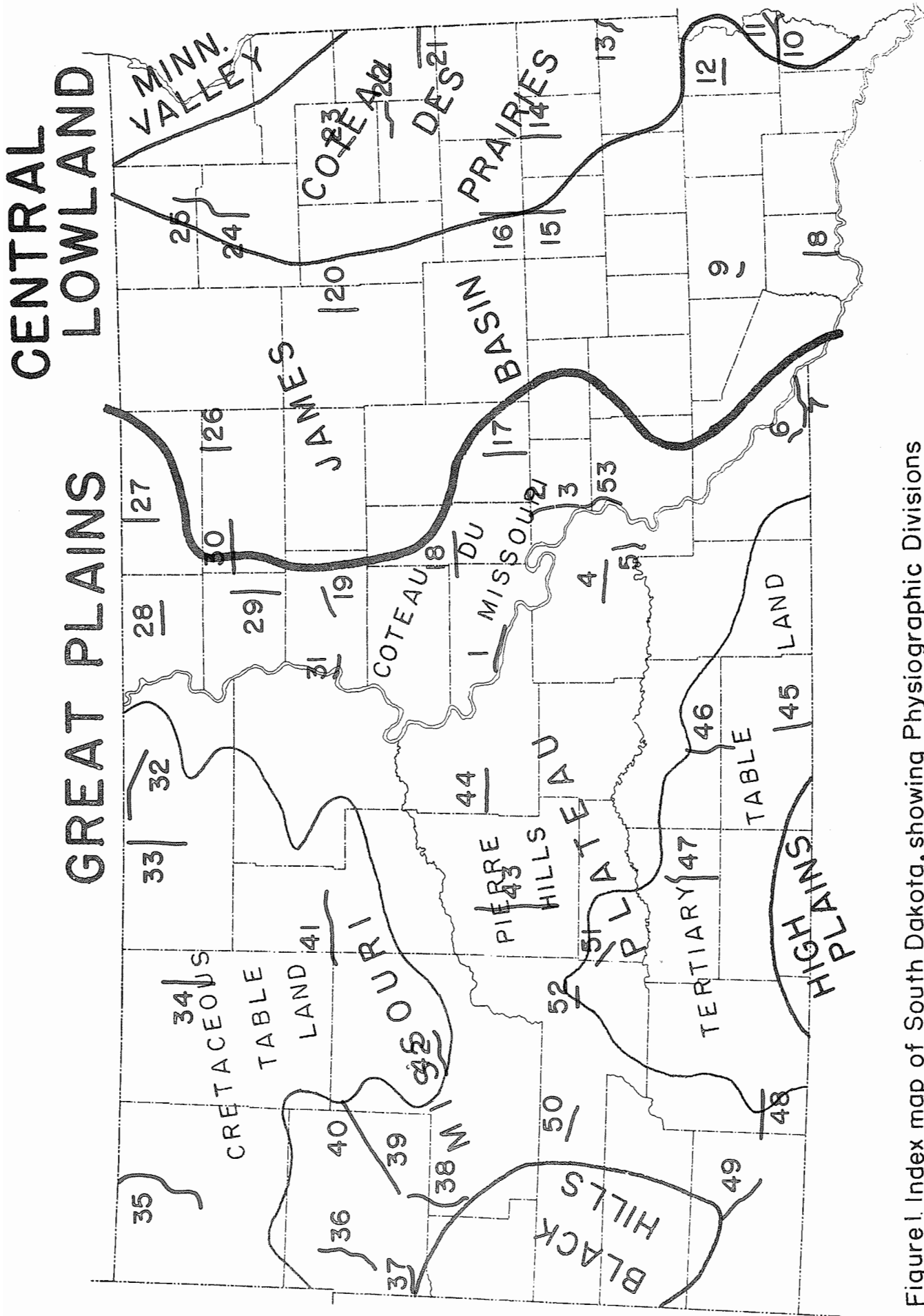
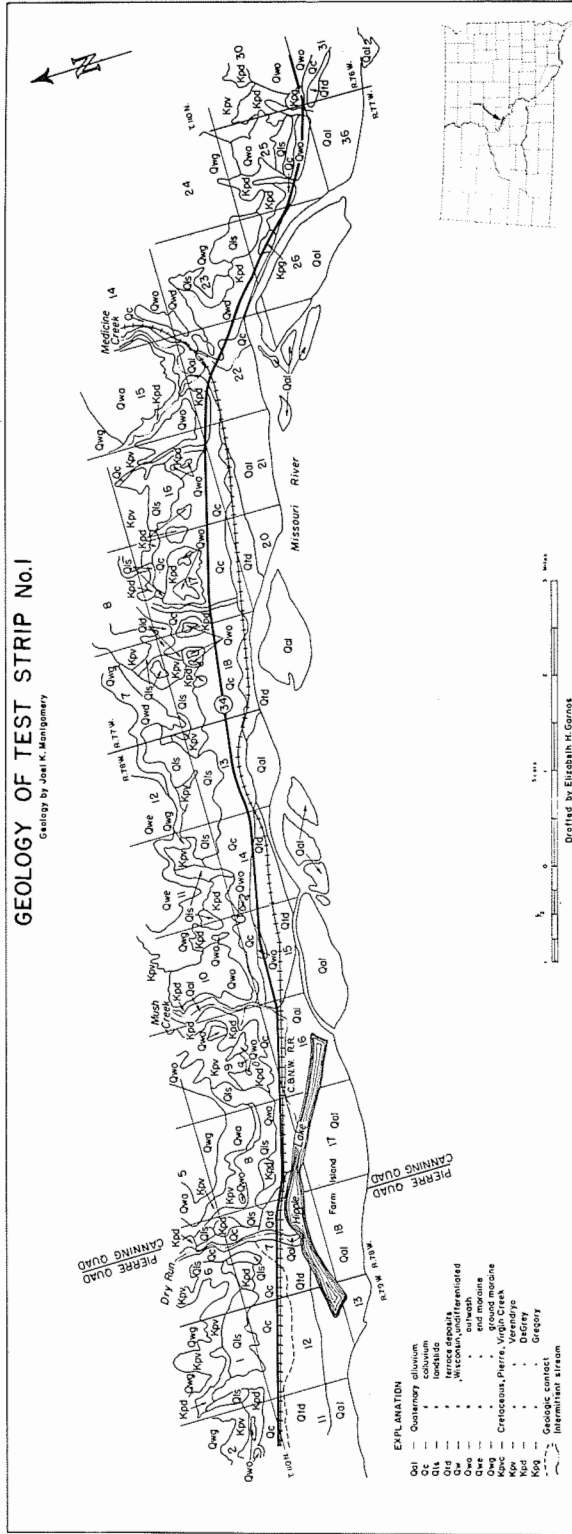


Figure 1. Index map of South Dakota, showing Physiographic Divisions and location of test strips (red)

GEOLOGY OF TEST STRIP No.1

Geology by Joel K. Montgomery



EXPLANATION

Oai	Quaternary alluvium
Oc	Quaternary caliche
Qd	Terrace deposits
Qw	Wisconsin, undifferentiated
Qee	end moraine
Ong	ground moraine
Qoc	Cretaceous, Pierre, Verendrye
Kp	DeGrey
Kd	Gregory
(---)	Geologic contact
(---)	intermittent stream

Defined by Elizabeth H. Gornok

GEOLOGY OF TEST STRIP 1

by

Joel K. Montgomery

Location

Test Strip 1 is located east of Pierre on South Dakota State Route 34 in Hughes County. It is 14.7 miles long, extending from Farm Island State Park to Rousseau. Both the highway strip and the Chicago & Northwestern Railroad parallel the Missouri River on its north side.

Previous Work

Previous detailed geologic work in the area includes two U. S. Geological Survey geologic quadrangle maps by Crandell (1954a, b). He added the name DeGrey Member to the Pierre Formation.

Topography and Drainage

The strip lies in the northern part of the Coteau du Missouri division of the Great Plains physiographic province (fig. 1). The topography of the test strip area is nearly level in the western part along the Missouri River floodplain, whereas the eastern part has steeply undulating topography above dissected bluffs along the Missouri River Trench. Maximum relief in the mapped area amounts to 330 feet, with a maximum elevation of 1752 feet above sea level.

Mush Creek, Medicine Creek, and several other intermittent streams flow southward from the bluffs into the Missouri River.

Geology

Bedrock consists of Upper Cretaceous Pierre Shale, of which a thickness of about 500 feet is present along Test Strip 1. The members of the Pierre Shale, in ascending order, are the Gregory (including Crow Creek), DeGrey, Verendrye, and the Virgin Creek.

The Gregory and Crow Creek (Kpg) Members were mapped together because of the thinness of the units and the small exposures. Both Gregory and Crow Creek strata crop out along the highway in the eastern part of the project. The Gregory Member is composed of noncalcareous claystone and shale and is overlain by the basal, brown calcareous siltstone of the Crow Creek Member. Above the 10-foot siltstone bed is eight feet of light-gray marl which weathers grayish-orange.

The DeGrey (Kpd) Member overlies the Crow Creek and is widely exposed in bluffs north of the highway. This member thins eastward from 150 feet to 100 feet; it consists of light-gray siliceous claystone and shale having many bentonite beds, especially in the upper part. It is equivalent to the Oacoma manganese facies farther south, although it is thicker and lighter colored than the Oacoma beds. The DeGrey weathers to a stair-step profile. A concretionary bed of white limestone $\frac{1}{2}$ - to 1-foot thick crops out near the top of the member; small iron or manganese concretions occur below the limestone bed, and are progressively

more abundant toward the eastern margin of the test strip area. Iron-manganese, carbonate-replaced pelecypods are present. The Agency facies, which forms steep slopes, is the lower part of this unit and is a highly siliceous shale. Joints are abundant in the lower part of the DeGrey Member. The beds dip slightly to the northwest. Extensive slumping has taken place.

Exposures of the Verendrye (Kpv) and Virgin Creek (Kpvc) Members are present farther north at the mouths of the canyons near the top of the Missouri River bluffs. The Verendrye is a gray to olive-gray mudstone and claystone, which weathers to gumbo. The Virgin Creek is a dark-gray shale, and contains numerous thin bentonite beds in the lower part.

Glacial drift, 10-20 feet thick, covers the highlands and is of Iowan and Iazewell age (Crandell, 1954b). An end moraine (Qwe) is surrounded by ground moraine (Qwg). Large erratics, one to six feet in diameter, are presently (summer, 1959) being removed and hauled to the Oahe Dam site and used in its construction.

Small terrace deposits (Qtd) stand 20-30 feet above the floodplain and are composed mainly of reworked glacial drift and Pierre Shale detritus.

Extensive landslides (Qls) and slumping have taken place.

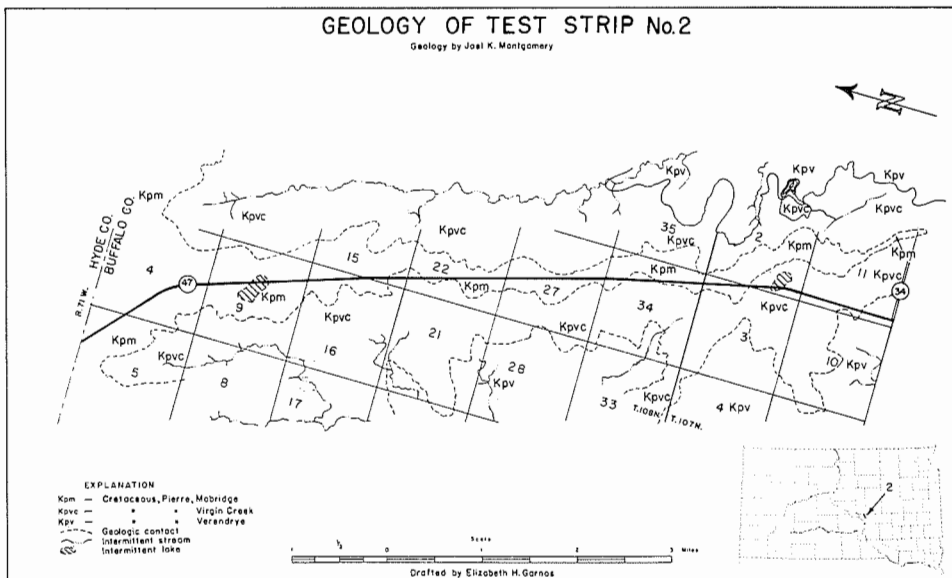
Alluvial fans extend out on the terraces and to the floodplain of the Missouri River. They are made up mostly of tributary alluvium (Qal) and colluvium (Qc), and range up to 30 feet in thickness. The floodplain of the Missouri River is covered with fine sand.

Effect of Geology on Highway

Most of the road repairs occur in cuts of the Pierre Shale; however, a few occur in areas of fill. Several road repairs are present in the DeGrey Shale in Sections 22 and 23, T. 110 N., R. 77 W. Road failures are more abundant in the shale than in the till, outwash, or alluvium because of higher plasticity, greater shrinkage, and more water content in the bentonitic shale.

GEOLOGY OF TEST STRIP No.2

Geology by Joel K. Montgomery



- EXPLANATION**
- Kpm — Cretaceous, Pierre, Moberg
 - Kpvc — Verendrye
 - Kpv — Virgin Creek
 - Geologic contact
 - - - - - Intermittent stream
 - ((())) Intermittent lake

Drafted by Elizabeth H. Garros

GEOLOGY OF TEST STRIP 2

by

Joel K. Montgomery

Location

Test Strip 2 is situated in the northern part of Buffalo County along State Route 47, extending 14.143 miles northward from the intersection with State Route 34 to the Hyde-Buffalo County line. It is in the Crow Creek Indian Reservation.

Previous Work

Curtiss (1950) of the State Geological Survey mapped the Stephan Quadrangle; it includes this strip. The geology is slightly modified from his original work, as the writer had the advantage of soil maps and a row of recently dug telephone-pole holes along the strip. Searight (1937) described the stratigraphy of the Pierre in this region, and Gries and Rothrock (1941) and Wing and Gries (1941) mapped the manganese-bearing beds and the structure, respectively, for the State Geological Survey.

Topography and Drainage

The area is nearly level, with small rolling hills. It lies in the Coteau du Missouri (fig. 1).

The drainage system is dendritic; the small intermittent streams drain the entire area southward into the Missouri River.

Geology

The few bedrock exposures in the area are very poor, owing to extensive erosion and weathering. The following stratigraphic units of the Pierre Shale, in ascending order, were recognized in the area.

The Verendrye (Kpv) Member consists of light-gray bentonitic clay with concretions; it weathers to gumbo. This member is exposed in the southern part of the area.

The Virgin Creek (Kpvc) Member is a medium-gray bentonitic clay which weathers to gumbo. The shale in the lower part weathers dark gray to purple and contains several 2-inch bentonite beds. It is exposed in two road cuts near the middle of the strip.

The Mobridge (Kpm) Member is predominantly a blue-gray limey foraminiferal bentonitic clay with many concretions; it also contains light-gray calcareous shale. Exposures of the Mobridge Member occurred in the northern part of the area in the telephone-pole holes.

No glacial till or lake deposits are present. Most of the soil is a dark clayey loam, a residual weathering product derived from the underlying shales.

The attitude of the strata is essentially horizontal, with possibly a very slight dip to the northwest. In Section 11, T. 107 N., R. 71 W.

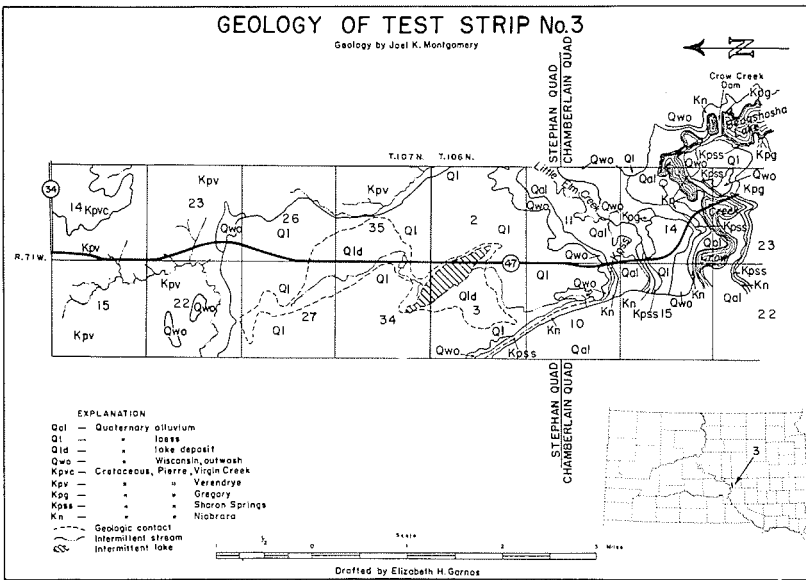
the strata (Virgin Creek Member) appear to dip as much as 10° to the north, but it is probably a slump feature since elsewhere most of the beds appear horizontal or nearly so.

Effect of Geology on Highway

Two small areas of repairs occur in depressions in the Moberge Member near the northern end of the strip. The highway has subsided slightly, owing to compaction of the recent alluvial sediments beneath it in the depressions.

GEOLOGY OF TEST STRIP No.3

Geology by Joel K. Montgomery



GEOLOGY OF TEST STRIP 3

by

Joel K. Montgomery

Location

This test strip is located in western Buffalo County, and extends from the Crow Creek Dam northward to the intersection of State Routes 34 and 47.

Previous Work

Petsch (1952) mapped the Chamberlain Quadrangle, which includes the southern part of the test strip. The northern part of the area has been mapped by Curtiss (1950). Searight (1937) described the stratigraphy of the Pierre Shale in this area, and Gries and Rothrock (1941) and Wing and Gries (1941) mapped the manganese-bearing beds and the structure, respectively, all for the State Geological Survey.

Topography and Drainage

The strip lies in the Coteau du Missouri division of the Great Plains physiographic province (fig. 1). The Missouri River Trench is 400-500 feet deep. The elevation of the river is 1320 feet above sea level, and the upland has an elevation of 1770 feet. The area consists of steeply rolling hills especially in the southern half. The Crow Creek Valley has steep bluffs 50-200 feet high, which extend from the Missouri River to the Crow Creek Dam.

A dendritic drainage system prevails in the area. Crow Creek and Little Elm Creek are the largest streams in the area, and all of the streams are intermittent and drain into the Missouri River. At the southern end of the strip is the Crow Creek Reservoir, also called Bedashosha Lake.

Geology

Strata of the Niobrara and Pierre Formations are exposed in the area, and good exposures occur along Crow Creek. The Niobrara (Kn) Marl is the oldest geologic unit present, and consists of light-gray foraminiferal chalk.

The Sharon Springs (Kpss) Member of the Pierre is a black carbonaceous shale, which contains abundant fish scales throughout. A one-inch cream-colored bentonite bed is present at the base, and a six-inch ash bed is present near the top. The member is approximately 20 feet thick.

Above the Sharon Springs is the Gregory (Kpg) Member, a brown to dark-gray bentonitic clay containing brown concretions. The member contains both calcareous and noncalcareous blocky shale. A good exposure of this member occurs on a side road east of State Route 47, north of Crow Creek.

There is no DeGrey exposed along the strip.

The Verendrye (Kpv) Member is well exposed near the north end of the strip in a road cut of a hill which is capped with a thin mantle of glacial outwash. The Verendrye Member is composed of gray to brownish-bentonitic shales which weather to gumbo. Ferruginous concretions are abundant, along with some bentonite layers.

The Virgin Creek (Kpvc) Member is a medium-gray bentonitic clay which weathers to gumbo.

Forty feet above Crow Creek along the sides of the valley are remnant terraces of outwash (Qwo) which were deposited by glacial meltwaters of the Wisconsin ice, probably Iowan in age (Flint, 1955). Sand mixed with gravels is present in poorly sorted beds, with a total thickness of 10-30 feet. A few thin deposits of outwash occur in the northern part of the area.

Alluvium (Qal) and valley fill occupy the present stream floodplains. The material consists mainly of gravel, sand, silt, and soil and was derived from the bluffs and Crow Creek tributary areas.

Two large depressions in the center of the area contain a mixture of clay and loess. They are believed to be of lacustrine (Qld) and eolian origin.

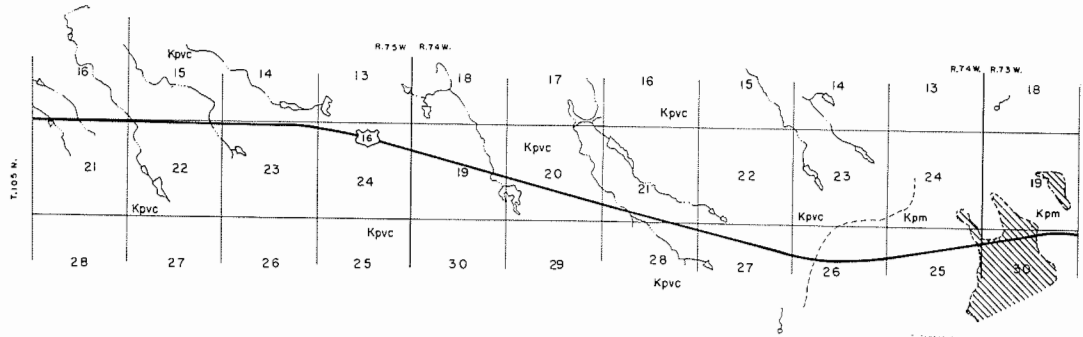
Loess (Ql) is widespread on the upland areas overlying bedrock and outwash gravels and sand, and is as much as 20 feet thick.

Effect of Geology on Highway

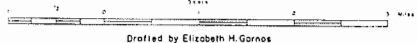
There are no road repairs along the test strip.

GEOLOGY OF TEST STRIP No.4

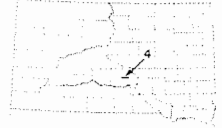
Geology by Earl J. Cox



EXPLANATION
Kpm — Cretaceous, Pierre, Moberidge
Kpvc — " " " Virgin Creek
--- Geologic contact
--- Intermittent lake



Drafted by Elizabeth H. Gornos



GEOLOGY OF TEST STRIP 4

by

Earl J. Cox

Location and Topography

U. S. Highway 16 between Kennebec and Reliance in Lyman County, is the site of Test Strip 4. The total length of the project, which is in the Pierre Hills of the Missouri Plateau division of the Great Plains physiographic province (fig. 1), is 11.179 miles.

Geological Formations Present

The Virgin Creek Member and the Mobridge Member of the Pierre Shale were identified on the project. The contact occurs near Station 440 + 00 (Sec. 26, T. 105 N., R. 74 W.).

Virgin Creek Member (Kpvc)

The Virgin Creek Member is divisible into lower and upper zones. The lower zone consists of hard-medium gray shale which weathers to small silvery flakes. A large number of bentonite beds are present in this lower zone. The upper zone is composed of gray shale which weathers to gumbo. It is characterized by several types of concretions which weather nearly white and are perforated by many small holes which give them a worm-eaten appearance. The thickness of the Virgin Creek ranges from 100 to 140 feet.

Mobridge Member (Kpm)

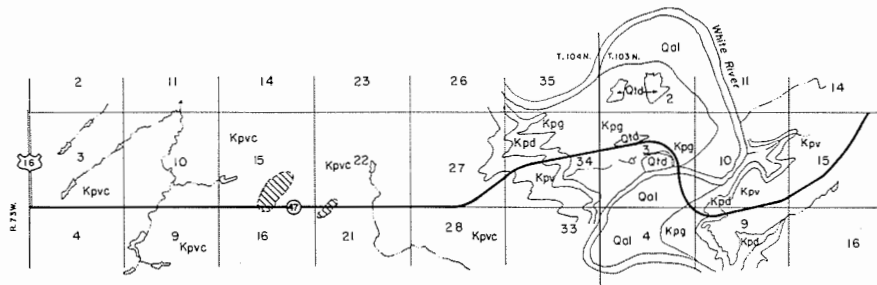
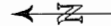
The Mobridge Member is highly calcareous and more or less chalky shale. It is made up of medium-gray and medium bluish-gray to dark-gray shale and chalk. Upon weathering these beds become buff-colored, ranging from almost white to a brownish-buff. Concretions and limestone lenses are common in the member, but bentonite beds are rare. The thickness of the Mobridge is about 200 feet.

Road Condition

The surface of the road has many patched areas. From Station 0 + 00 (west end of strip) to Station 470 + 00 (Sec. 26, T. 105 N., R. 74 W.) the road has been almost entirely resurfaced. Eastward from Station 470 + 00 to the end of the project, only scattered patching has been done. Nearly all the patching has been confined to the bentonitic Virgin Creek Member of the Pierre Shale. That portion of the road overlying the Mobridge Member is in relatively good condition and for the most part still has its original surface.

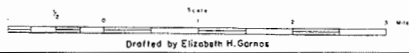
GEOLOGY OF TEST STRIP No. 5

Geology by Eorl J. Cox

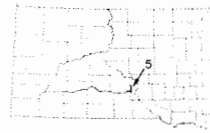


EXPLANATION

- Qal — Quaternary alluvium
- Qtd — terrace deposits
- Kpc — Cretaceous, Pierre, Virgin Creek
- Kpv — Verendrye
- Kpd — DeGrey
- Kpg — Gregory
- Intermittent stream
- Intermittent lake



Drafted by Elizabeth H. Ganos



GEOLOGY OF TEST STRIP 5

by

Earl J. Cox

Location and Topography

Test Strip 5 begins at the junction of U. S. Highway 16 and State Route 47 in Lyman County, and extends southward along Route 47 for a distance of 9.898 miles. The strip is in the Pierre Hills of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geological Formations Present

The Gregory, DeGrey, Verendrye, and Virgin Creek Members of the Pierre are exposed on the subject. The DeGrey is subdivided in ascending order into the Crow Creek and the Oacoma-Agency facies. Gravel terraces and stream alluvium are also present.

Gregory Member (Kpg)

The Gregory Member is made up of alternate beds of light-buff and gray shale; the light bands are calcareous. Scattered within the shale are many brown concretions of various sizes. The member is 120 feet thick in the area studied.

DeGrey Member (Kpd)

The DeGrey is basically a light-gray shale. The upper or Oacoma facies contains many iron-manganese nodules which make the unit appear as a black band in the breaks of the valley. It carries many thin layers of bentonite and ranges in thickness from 40 feet in Brule County to eight feet in Potter County. In some areas there is a "barren zone" of dark-gray shale completely devoid of the iron-manganese concretions, which is called the Agency facies. In fresh exposures it is a blocky shale but on weathering breaks down to thin flakes and chips which do not make gumbo when wet.

The Crow Creek is composed of sandstone about one foot or less in thickness, above which is a marl bed that is 4-10 feet thick. The marl is a smooth and very calcareous clay. The sandstone is partly unconsolidated, but usually appears as paper-like flakes on a weathered surface. This zone is too thin to show on the map, so it is included in the DeGrey.

Verendrye Member (Kpv)

The Verendrye is a light to dark shale, making the outcrop appear banded. The Verendrye has no calcareous layers but contains many large flat iron-manganese carbonate concretions. The upper part of the Verendrye

is dark shale and has layers of rusty concretions that seem to form large steps. Thickness of the Verendrye in the area studied is about 150 feet.

Virgin Creek Member (Kpvc)

The Virgin Creek Member is divisible into a lower and an upper zone. The lower zone consists of hard-medium gray shale which weathers to small silvery flakes. A large number of bentonite beds are present in this lower zone. The upper zone is composed of gray shale which weathers to gumbo. It is characterized by several types of concretions which weather nearly white and are perforated by many small holes which give them a worm-eaten appearance. The thickness of the Virgin Creek ranges from 100 to 140 feet.

Terrace Gravels (Qtd)

Terrace sand, gravel, and silt were deposited by the White River at an earlier stage, and lie approximately 60 and 120 feet above the present valley.

Alluvium (Qal)

Recent flood-plain deposits of the White River consist of clay, silt, and sand.

Road Condition

Patched areas and trouble spots were noted at the following locations:

Station 130 + 00 to 140 + 00 (Sec. 15, T. 104 N., R. 73 W.)

Dry lake bed with poor drainage.

Station 164 + 00 to 173 + 00 (Sec. 22, T. 104 N., R. 73 W.)

Dry lake bed with poor drainage.

Station 234 + 00 (Sec. 27, T. 104 N., R. 73 W.)

Patched in cut area; shoulders heaving.

Station 294 + 50 to 297 + 00 (Sec. 34, T. 104 N., R. 73 W.)

Patched in fill area.

Station 302 + 00 to 305 + 00 (Sec. 34, T. 104 N., R. 73 W.)

Resurfaced.

Station 307 + 00 to 318 + 00 (Sec. 34, T. 104 N., R. 73 W.)

Patched intermittently.

Station 275 + 00 to 280 + 50 (Sec. 34, T. 104 N., R. 73 W.) is an area in which major slumping has occurred. The road appears to have been entirely resurfaced between these stations. Cracks up to half an inch wide are present near the shoulders and running parallel to them.

Station 280 + 50 to 293 + 50 (Sec. 34, T. 104 N., R. 73 W.) has no apparent slumps at present but it is very likely that at least minor slumping will occur in the future because of thin bentonite beds underlying the area.

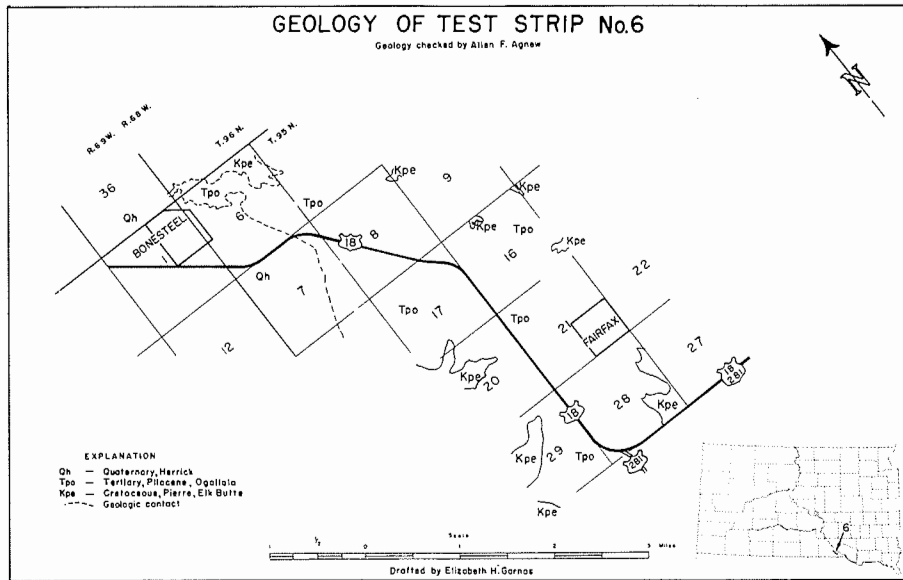
Station 298 + 00 to 303 + 00 (Sec. 34, T. 104 N., R. 73 W.) shows evidence of large-scale slumping. The presence of several thin bentonite beds in the area is probably a contributing factor to the slumping and consequent cracking of the road surface. Patching of the surface has been done on the east side of the road between the stations.

Recommendation

Where proposed roads are to be routed down steep inclines over the Pierre Shale, an early examination should be made to determine if slumping has occurred. If slumping is present, it can be assumed that it will continue and a more stable area should be chosen for the road, instead of the sharp ridges or topographic noses normally used.

GEOLOGY OF TEST STRIP No.6

Geology checked by Allan F. Agnew



GEOLOGY OF TEST STRIP 6

by

Allen F. Agnew

Introduction

Test Strip 6, which is 9.017 miles long, follows U. S. Highway 18 from Bonesteel to the junction with U. S. Highway 281, one mile south of Fairfax.

Topography and Drainage

The area including this highway strip, in the Pierre Hills of the Missouri Plateau division of the Great Plains physiographic province (fig. 1), is well dissected by intermittent tributaries of Ponca Creek, which lies a few miles to the southwest. The topography is slightly rolling along the upland that the highway traverses, with a relief of 50-60 feet.

Geologic Formations

General Statement

The strip is underlain by relatively flat-lying sand, silt and quartzitic sandstone, and shale. It lies in the Bonesteel Quadrangle, the geology of which was mapped by R. E. Stevenson and L. A. Carlson (1950) for the State Geological Survey.

Pierre Shale

The Elk Butte (Kpe) Member of the Cretaceous Pierre Shale is present at the extreme eastern end of the strip. It is brownish-gray bentonitic clay-shale with abundant small yellowish-brown ferruginous concretions that are calcareous. The Elk Butte is as much as 100 feet thick in this area.

Ogallala Group (Tpo)

The Pliocene Ogallala Group is represented by grayish-olive silt and fine sand, which weathers whitish. It is moderately well-cemented with calcareous material, impressions of rootlets are common, and silt is somewhat ashy. In places a greenish quartzite is present as lenses and beds. The Ogallala is as much as 20 feet thick in this area, and was mapped as "Bijou Formation" by Stevenson and Carlson (1950).

Herrick Formation (Qh)

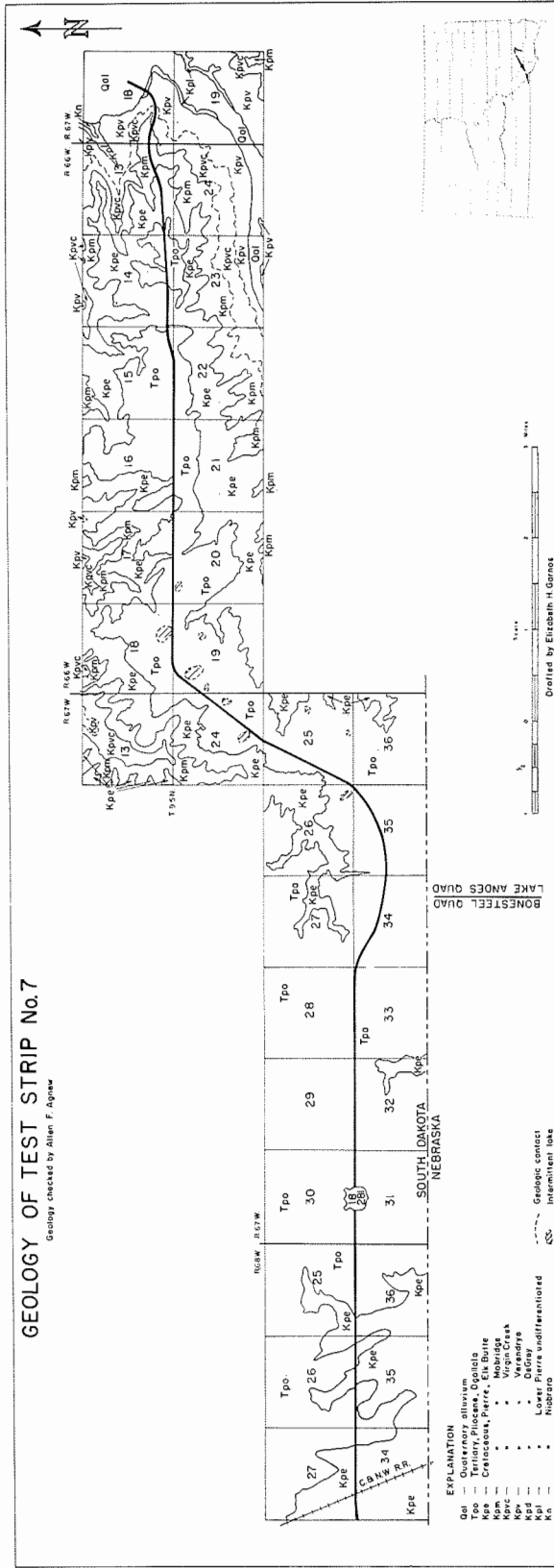
The Herrick sand and gravel is of western derivation, and is Pleistocene in age. This stream-deposited material is composed mainly of quartz and feldspar. The Herrick is 15-25 feet thick.

Effect of Geologic Conditions on Highway

The road, which is about five years old, is in excellent condition (summer, 1960). It is rough only between Stations 180 and 185 (Sec. 28, T. 95 N., R. 68 W.) on the steeply banked curve at the intersection.

GEOLOGY OF TEST STRIP No.7

Geology checked by Allen F. Agnew



- EXPLANATION**
- Qal --- Quaternary alluvium
 - Tpo --- Tertiary Pliocene, Ogallala
 - Kpe --- Cretaceous, Pierre, Elk Butte
 - Kpm --- Niobrara
 - Kpv --- Niobrara
 - Dal --- Niobrara
 - Geologic contact
 - Intermittent lake

Drafted by Elizabeth H. Ganoos

GEOLOGY OF TEST STRIP 7

by

Allen F. Agnew

Introduction

Test Strip 7, which is 17.179 miles long, extends along U. S. Highway 18 from a mile east of the junction with U. S. Highway 281, eastward to the southwest edge of Ft. Randall Dam.

Topography and Drainage

The area traversed by this highway strip, in the Pierre Hills of the Missouri Plateau division of the Great Plains physiographic province (fig. 1), is well dissected by intermittent tributaries of the Missouri River, which drain to the northeast. The topography of the upland is slightly rolling, and the rough breaks of the Missouri River show relief of 500 feet or more.

Geologic Formations

General Statement

The strip is underlain by relatively flat-lying sand, silt, quartzitic sandstone, and shale. It lies in the Bonesteel and Lake Andes Quadrangles, the geology of which was mapped in 1950 and 1951 by R. E. Stevenson and L. A. Carlson, for the State Geological Survey.

Niobrara Marl

The Niobrara (Kn) Marl is the oldest geologic unit present, and consists of light-gray foraminiferal chalk.

Pierre Shale

(Lower Pierre Undifferentiated, Kpl)

The lower part of the Cretaceous Pierre Shale consists of three stratigraphic units of different lithology, which are not differentiated on the map.

The basal member of the Cretaceous Pierre Shale is the Sharon Springs, a black to brown bituminous shale with many bentonite beds. It is 35 feet thick.

The Gregory Member is dark to light-gray clay with bentonite beds. The Gregory is 27 feet thick and underlies the Crow Creek. The Gregory in this area contains an eight-foot marly zone at its base, similar to the Crow Creek.

The Crow Creek marly zone, a calcareous siltstone that contains microfossils and shark teeth, is three feet thick (Gries, Rothrock, 1941).

(Oacoma Facies of DeGrey Member, Kpd)

The Oacoma facies is black to gray highly bentonitic clay with abundant manganiferous concretions; the concretions range in size from pebbles to cobbles three or four inches across. The thickness of the Oacoma in this area is 25 feet.

(Verendrye Member, Kpv)

The Verendrye is tan to olive-gray bentonitic clay with numerous brown ferruginous concretions, and is 95 feet thick.

(Virgin Creek Member, Kpvc)

The Virgin Creek is black carbonaceous clay-shale, with numerous bentonite beds and zones of gray calcareous concretions. The Virgin Creek is 40 feet thick.

(Mobridge Member, Kpm)

The Mobridge is gray calcareous claystone or marly shale, which weathers buff and contains an abundance of microscopic foraminifera. The Mobridge is 95 feet thick.

(Elk Butte Member, Kpe)

The Elk Butte Member of the Pierre is present at the western and eastern ends of the strip. It is brownish-gray bentonitic clay-shale with abundant small yellowish-brown ferruginous concretions that are calcareous. The Elk Butte is as much as 100 feet thick in this area.

Ogallala Group (Tpo)

The Pliocene Ogallala Group is represented by grayish-olive silt and fine sand, which weather white. It is moderately well cemented with calcareous material, impressions of rootlets are common, and the silt is somewhat ashy. In places a greenish quartzite is present as lenses and beds. The Ogallala is as much as 20 feet thick in this area, and was mapped as "Bijou Formation" by Stevenson and Carlson (1950, 1951). Near the eastern end of the strip, the deposits in Sections 14 and 15 that were mapped as loess by Stevenson and Carlson (1951) are here mapped as Ogallala.

Pleistocene and Recent Alluvium

The valley of the Missouri River is filled with clay, silt, sand, and gravel. The tremendous quantities of water flowing from the melting ice sheets at intervals during the Pleistocene caused the river to carve a channel more than 80 feet deep, which has since been filled with the alluvial (Qal) material. The eastern end of the strip rests on the earth-filled Ft. Randall Dam, which is built on alluvium.

Effect of Geology on Highway

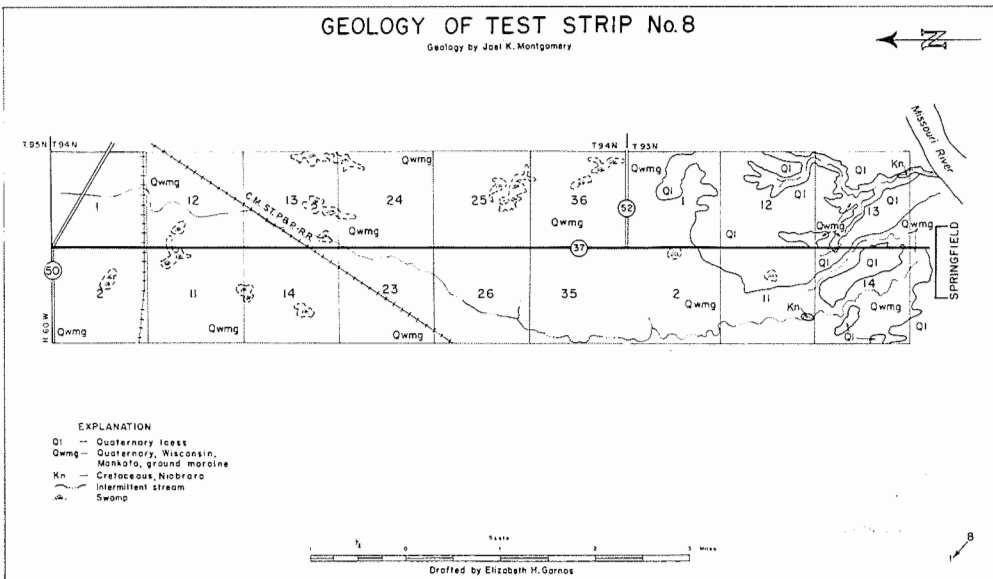
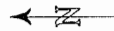
Along Test Strip 7 there are (summer, 1960) several areas of patching caused by failure of subgrade on the Elk Butte Shale near the contact with the Ogallala sands; these are at Stations 50-60, 105-120, 125-130, and 145-150, in Sections 27 and 34, and 26 and 35, T. 95 N., R. 68 W.

In addition, highway patching has been done at Stations 990-1000, (Sec. 15, T. 95 N., R. 66 W.), in the loose Ogallala sands, where the Elk Butte Shale is not far below.

At the eastern end of the strip, where it descends from the upland through the Pierre breaks to the valley of the Missouri River, there are several areas of incipient trouble, but only one has necessitated patching of this five-year old highway; at Stations 1060-1065 (Sec. 18, T. 95 N., R. 65 W.), the failure is due to slump on the Verendrye bentonitic shale.

GEOLOGY OF TEST STRIP No.8

Geology by Joel K. Montgomery



- EXPLANATION**
- Ql - Quaternary loess
 - Qwmg - Quaternary, Wisconsin, Monkota, ground moraine
 - Kn - Cretaceous, Niobrara
 - (dashed line) - Intermittent stream
 - (wavy line) - Swamp



Drafted by Elizabeth H. Garnos

GEOLOGY OF TEST STRIP 8

by

Joel K. Montgomery

Location

Test Strip 8 is situated in Bon Homme County and extends 9.062 miles from Springfield to State Route 50. The Chicago, Milwaukee, St. Paul & Pacific Railroad passes through the northern part of the area.

Previous Work

The only previous geologic mapping of this area is a reconnaissance map of eastern South Dakota by Flint (1955).

Topography and Drainage

The strip is in the James Basin division of the Central Lowland physiographic province (fig. 1). V-shaped valleys exist in the southern part of the area. The gently undulating area has a nearly flat surface which slopes toward the Missouri River. Most of the shallow depressions in the swell and swale topographic area are less than one-tenth mile in diameter. The Missouri River Trench is less than 300 feet below the bluffs.

The area is poorly drained except near the Missouri River where a dendritic pattern is present. Drainage ditches have been dug in the northern half of the area to drain the shallow depressions. The course of the Missouri River channel was probably controlled by the margin of the glacial ice sheet.

Geology

The entire area is underlain by Cretaceous formations. Bedrock is exposed in the valleys at the southern end of the project area. Small outcrops of the Niobrara (Kn) Marl were observed in the southern half of Section 11. The Niobrara consists of white to gray chalk, and the beds are horizontal.

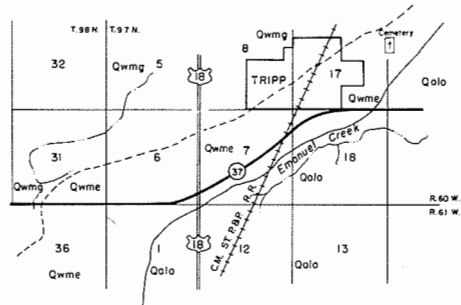
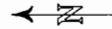
Surficial deposits include an extensive ground moraine of Mankato (Qwmg) age according to Flint (1955). The till contains abundant cobbles of granite, limestone, and Niobrara chalk. There are several boulders in Sections 23, 26, and 36, T. 94 N., R. 60 W. along stream valleys; some are three feet in diameter. Loess (Ql) as much as 10 feet thick overlies bedrock and till along the southern two miles of the strip. In the tributary valleys the loess has been removed by erosion, exposing Niobrara Marl and till. No outwash deposits are present. Thin deposits of recent alluvial material occupy the stream valleys and a few of the kettle holes.

Effect of Geology on Highway

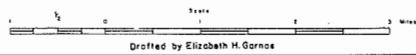
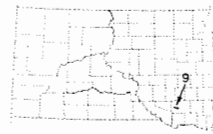
Only one area of road repair is present in the strip; it is over a new culvert at the north end of the strip. The culvert was probably built after the road was paved.

GEOLOGY OF TEST STRIP No.9

Geology by Joel K. Montgomery



- Qal0 - Quaternary alluvium and outwash, undifferentiated
- Qwmg - Quaternary, Wisconsin, Mankato ground moraine
- Qwme - Quaternary, Wisconsin, Mankato end moraine
- - - - - Geologic contact
- ~~~~~ Intermittent stream



Drafted by Elizabeth H. Gornoe

GEOLOGY OF TEST STRIP 9

by

Joel K. Montgomery

Location

This test strip, 5.49 miles long, is located along State Route 37 in the southern part of Hutchinson County near the town of Tripp. The Chicago, Milwaukee, St. Paul & Pacific Railroad extends through the middle of the area.

Previous Work

This project is included in the area which was mapped in detail by Todd (1903), for the State Geological Survey.

Topography and Drainage

The area of the strip, in the James Basin division of the Central Lowland physiographic province (fig. 1), is mostly level except for a ridge which has a northwest-southeast trend, a steep southwestern side, and a gently sloping northeastern side. The ridge is believed to be largely morainic in origin rather than a preglacial surface feature. The town of Tripp has an elevation of 1550 feet above sea level.

All of the drainage in the area has developed since the area was glaciated. A few intermittent streams flow southward, forming a poor dendritic drainage pattern. Emanuel Creek drains the area south of Tripp, and Dawson Creek drains the area north of the town.

Geology

No bedrock is exposed, but it is known from well data (Todd, 1903) that the area is underlain by the Colorado Group, the Dakota Group, and the Sioux Quartzite.

An end moraine of Mankato (Qwme) age (Flint, 1955) passes through the town of Tripp parallel to the highway, and then swings westward in Section 1, T. 97 N., R. 61 W. It represents the edge of the ice sheet. The ice front was stationary, and material brought by the moving ice and its meltwaters was distributed along the glacial lobe to build up the moraine. Glacial erratics are scattered on the crest of the moraine. A smaller crest trends northwest-southeast and is located a short distance east of the major crest.

Much of the gravel and sand was carried farther to the southwest and deposited as outwash deposits (Qalo) along ancient channels. Gravel pits were noted in the southeastern end of the project area.

Alluvial deposits (Qalo) 10-20 feet in thickness occur along Emanuel Creek; the upper part is black silty loam and the lower part more sandy.

Effect of Geology on Highway

A new highway has just recently been built through the area and no road repairs are present.

GEOLOGY OF TEST STRIP 10

by

Joel K. Montgomery

Location

This project lies between Beresford, South Dakota, and the Iowa-South Dakota State line. It is an east-west strip along State Route 46, is 16 miles long and traces the Lincoln County-Union County boundary.

Previous Work

Baird (1957) mapped this area in detail, as a Master's thesis at the State University of South Dakota.

Topography and Drainage

The region, in the Coteau des Prairies division of the Central Lowland physiographic province (fig. 1), consists of maturely dissected, steep rolling hills. Relief in the mapped area amounts to 315 feet, with a maximum elevation of 1500 feet above sea level.

The Newton Hills region lies between the floodplain of the Big Sioux River and East Brule Creek. A broad level lowland joins the area on the west.

Test Strip 10 is drained southward by East and West Brule Creek, plus other tributaries of the Big Sioux River. The gradient of Brule Creek is approximately 15 feet per mile.

The area has a well-integrated dendritic drainage pattern devoid of undrained depressions, except for the westernmost part of the area which is a high undulating plain overlooking Brule Creek valley to the east.

Geology

The Newton Hills Sand (Qn) crops out in a steep bluff in Section 4, T. 95 N., R. 48 W., Union County; about 40 feet of sand is exposed. It is Middle Pleistocene in age and pre-Iowan. The sand is uniform in texture, medium to coarse grained, and some clay layers are present. Lenses of stream-deposited friable sand 1-8 inches thick are common. No fossils were found.

Structurally, the Newton Hills sand lenses are horizontal and are overlain by a thin sheet of Wisconsin Till, which in turn is overlain by a thick deposit of loess.

In the exposures along the strip the Iowan drift sheet is only 2-6 feet thick, but in most of the area it must be at least 25 feet thick, judging from the relief developed on adjacent exposures of drift.

The Iowan ground moraine (Qwig) was covered with a 30-foot deposit of loess. This eolian material consists of light brownish-yellow to buff silt with some small calcareous concretions. The texture of the loess is uniform throughout the area.

A Cary end moraine (Qwce) is present in the western part of the area; it has knobby low hills and swell and swale topography, and contains kettle holes and erratics. It does not have a well-integrated drainage pattern and is thus characteristic of Cary and younger ground moraines. The Cary till is similar in color to the older Iowan till, but it contains a higher percentage of coarse material (pebbles and shale fragments). The loess cover is much thinner than the loess cover on the Iowan till sheet.

The Iowan till seems to have a finer textured matrix of clay and silt, and a higher percentage of limestone pebbles, than does the Cary till. A pebble concentrate was noted at the top of the Iowan surface in Section 36, T. 96 N., R. 50 W.

Both tills are similar in having a light-brown to dark olive-gray color, and containing a heterogeneous mixture of rock fragments in a calcareous matrix. Some of the sand and gravel in the Cary Till was probably derived from older Iowan outwash deposits and incorporated in the Cary ice sheet. The till sheet commonly has a stratified sand, gravel, and pebble concentrate near its base.

Outwash (Qwio) material is confined to the bottom of the larger drainage valleys and along the floodplain of the Big Sioux River. It consists of loose stratified sand and gravel. Iowan meltwater flowed southward away from the ice front and carried sands and gravels along the old channels of the present streams. The South Dakota Geological Survey maps this outwash as Cary in age, as described by Baird (1957). Two gravel pits occur in Section 2, T. 95 N., R. 50 W., about three miles east of Beresford.

Alluvium (Qal) along the Big Sioux River consists of dark grayish-brown to nearly black silty clay loam, overlying sand. Some alluvium occupies terraces which are 10-15 feet high. The surfaces are smooth to slightly undulating.

Thin deposits of dark-brown silty alluvium, high in organic content, occupy East and West Brule Creeks and other small tributary valleys.

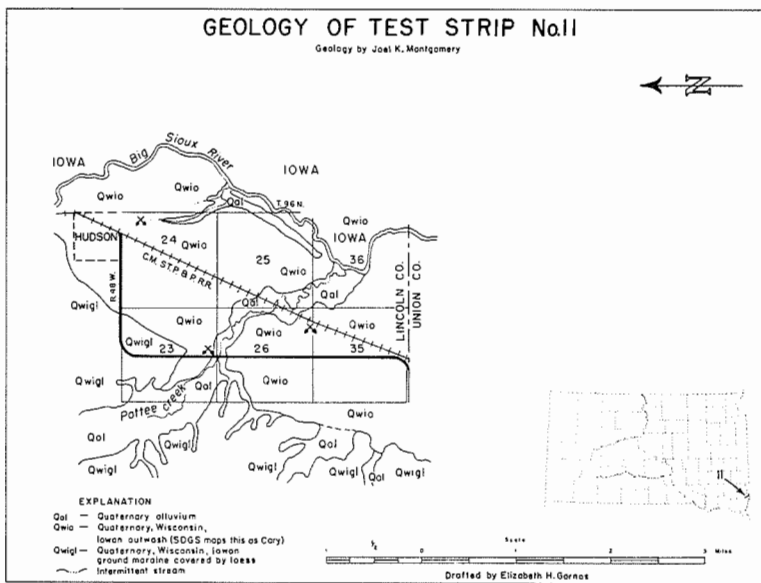
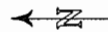
Very productive soil has developed over the entire area. Silty soils overlie the loess, and silty-sandy soils cover the loess-free portions of the area.

Effect of Geology on Highway

Road repairs occur over culverts in Section 5, T. 95 N., R. 48 W., and Section 33, T. 96 N., R. 49 W. These are areas where one would expect to find repaired spots in the highway, and do not bear any relationship to the geology.

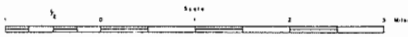
GEOLOGY OF TEST STRIP No. II

Geology by Joel K. Montgomery



EXPLANATION

- Qal — Quaternary alluvium
- Qwio — Quaternary Wisconsin lowland outwash (SDGS maps this as Cory)
- Qwgl — Quaternary Wisconsin lowland ground moraine covered by loess
- Intermittent stream



Drafted by Elizabeth H. Gornes

GEOLOGY OF TEST STRIP 11

by

Joel K. Montgomery

Location

Test Strip 11 lies between Hudson, South Dakota, and the intersection with State Route 46. The Chicago, Milwaukee, St. Paul, and Pacific Railroad passes through the eastern part of the area.

Previous Work

The area was previously mapped in reconnaissance by Flint (1955).

Topography and Drainage

The area falls within the Coteau des Prairies division of the Central Lowland physiographic province (fig. 1). The topography consists of rolling hills in the western part of the test section, and nearly flat floodplain along the Big Sioux River in the eastern part of the area.

The area is drained by the Big Sioux River and one of its tributaries, Pattee Creek. The Big Sioux River drains the Coteau des Prairies.

Geology

No bedrock exposures are present in the area.

Iowan Till covers much of the area, especially in the northwestern part. The till sheet represents a large ground moraine (Qwig) which has been covered with a thick blanket of loess. The general color of the till is olive gray to light brown when weathered, and dark gray when fresh. The clay and fine-grained sandy matrix are more abundant than the coarser material.

Carbonate pebbles in the till are more abundant than igneous or metamorphic pebbles. A one-foot zone of pebbles and cobbles is present near the top of the till along East Brule Creek. Large erratics are rare.

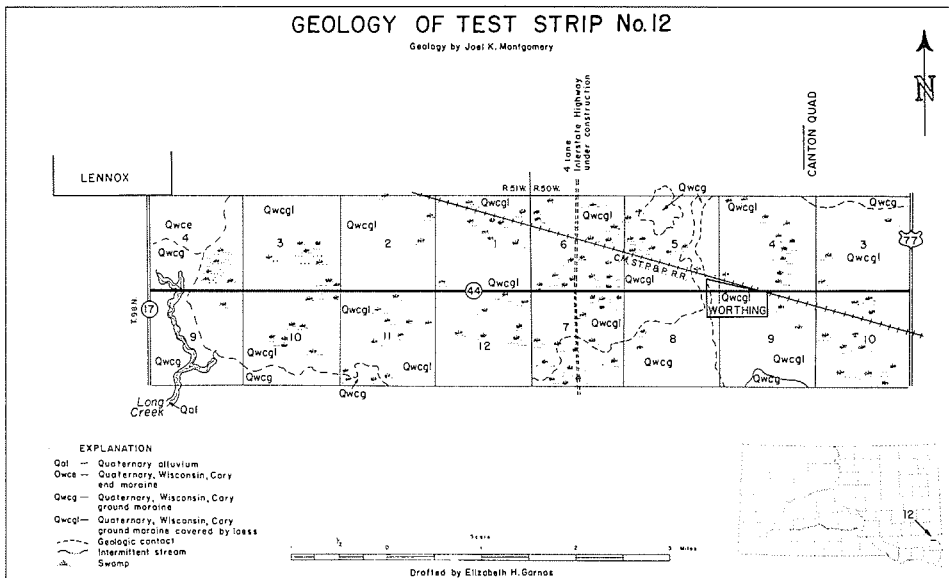
Outwash (Qwio) sand and gravel occur along the Big Sioux River floodplain, and a thin veneer of alluvium covers most of it. The South Dakota Geological Survey maps this outwash as Cary in age, as described by Baird (1957). Alluvium (Qal) is present along Pattee Creek and its tributaries. A terrace ridge of gravel was noted south of Hudson; it is covered with alluvium in Section 24.

Effect of Geology on Highway

This highway strip is free of any road repairs.

GEOLOGY OF TEST STRIP No.12

Geology by Josi K. Montgomery



- EXPLANATION**
- Qal — Quaternary alluvium
 - Qwce — Quaternary, Wisconsin, Cary end moraine
 - Qwca — Quaternary, Wisconsin, Cary ground moraine
 - Qwcl — Quaternary, Wisconsin, Cary ground moraine covered by loess
 - Geologic contact
 - - - Intermittent stream
 - Swamp

Drafted by Elizabeth H. Gornas

GEOLOGY OF TEST STRIP 12

by

Joel K. Montgomery

Location

Test Strip 12 is situated in Lincoln County, and extends along State Route 44 for a distance of eight miles through the small community of Worthing, South Dakota. The Chicago, Milwaukee, St. Paul & Pacific Railroad passes through the eastern half of the area from northwest to southeast.

Previous Work

The area was previously mapped at the east end by Steece (1957a) as a Master's thesis at the State University of South Dakota, and by the reconnaissance of Flint (1955).

Topography and Drainage

Flat bottom-land is characteristic of the entire area of this portion of the James Basin division of the Central Lowland physiographic province (fig. 1). The land is level except for a few minor areas at the western and eastern borders.

Most of the area is poorly drained. Marshes and swampy land are found in nearly every section. A tributary of Long Creek drains the western half of the area. Intermittent streams occupy the eastern half of the area.

Geology

No bedrock is present in the area. The entire region is covered with till of Cary age (Flint, 1955). A small end moraine (Qwce) occurs west of the strip and includes the northwestern part of the mapped area. Several shallow kettle holes and a few erratic boulders of gneiss are present in the western portion of the area.

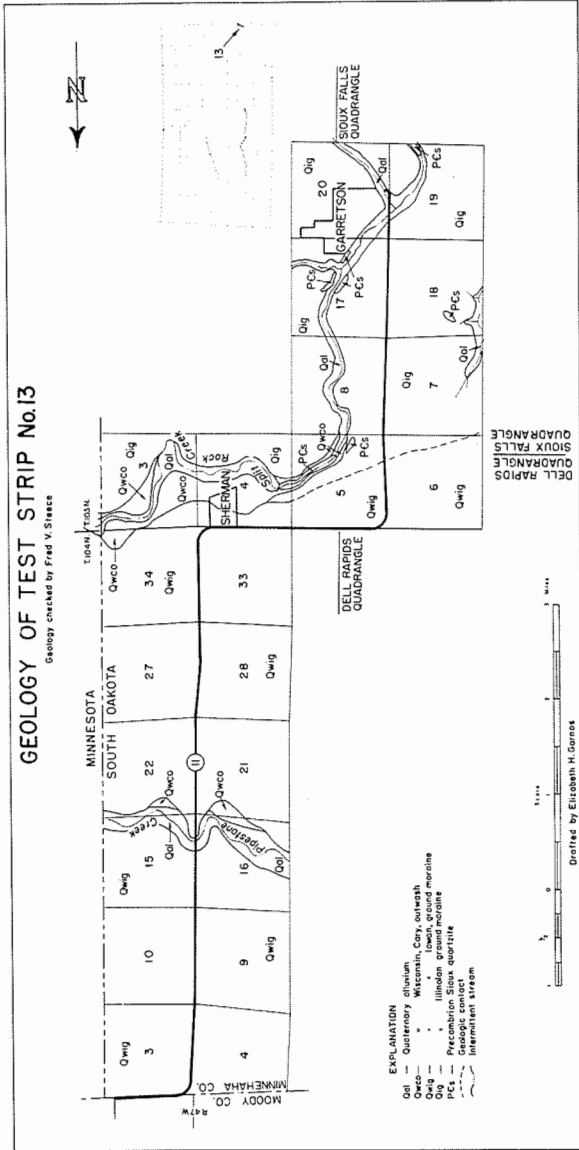
Most of the Cary ground moraine (Qwcg) is covered by a thin sheet of loess. Dark-black silty soil has developed on the surface of the loess. No outwash deposits are present; however, alluvium (Qal) occupies a small stream channel in the western part of the area. Alluvial material also occurs in depressions.

Effect of Geology on Highway

There are no road repairs in this test strip. A new north-south interstate highway is presently being built across the middle of Test Strip 12.

GEOLOGY OF TEST STRIP No.13

Geology compiled by Fred V. Stence



- EXPLANATION**
- Qdgl --- Quaternary alluvium
 - Qweco --- Wisconsin low ground moraine
 - Qwigo --- Illinoian low ground moraine
 - Qig --- Pre-Illinoian low ground moraine
 - P6c --- Precambrian Sioux quartzite
 - (---) Kalamazoo moraine
 - (---) Interfluvial stream

Scale: 0 1 2 3 Miles
 Directed by Elizabeth H. Garross

GEOLOGY OF TEST STRIP 13

by

Fred V. Steece

Location

Test Strip 13 begins on State Route 11 at the Minnehaha-Moody County line in southeastern South Dakota, and extends about 12.164 miles southwestward to Garretson. The strip ends about 14 miles northeast of Sioux Falls.

Previous Work

Rothrock and Newcomb (1926) and Rothrock and Otton (1947) made geologic studies of the sand and gravel and the ground water resources of this part of Minnehaha County, for the State Geological Survey. Steece (1959) and Tipton (1959) mapped the southwestern part of this strip as portions of the Sioux Falls and Dell Rapids quadrangles.

Topography and Drainage

This area, in the Coteau des Prairies division of the Central Lowland physiographic province (fig. 1), ranges from nearly-level and well-drained to rolling and deeply-dissected topography. The Iowan Drift is characterized by the former topography and the Illinoian Drift by the latter. Drainage in the area is controlled by Pipestone and Split Rock Creeks, tributaries to the Big Sioux River. Local relief ranges up to 30 or 40 feet, and the maximum relief of the area is 100 feet; the average elevation is about 1500 feet above sea level.

Geology

Precambrian quartzite, Pleistocene glacial drift, and Recent alluvium are present along this strip.

The Sioux Quartzite (PGs), pink to red silica-cemented sandstone, crops out in small areas along Split Rock Creek, especially near Sherman and Garretson. This rock is extremely hard and is widely used as concrete aggregate and road metal.

Illinoian Drift covers the southern third of the area, as ground moraine (Qig). Typically yellowish-brown to brownish-gray, the Illinoian Till is overlain with as much as 40 feet of tan calcareous loess. The till consists of brownish to grayish clay containing rock fragments of nearly every size. The thickness of the Illinoian Till in this area probably does not exceed 50 feet, although farther south it attains a thickness of 120 feet. The surface of the Illinoian Till is characteristically lineated in a northwest-southeast direction, probably due to the influence of the prevailing northwest winds.

Iowan Drift (Qwig) occupies the northern two-thirds of the area, as ground moraine (Qwig). It is differentiated from the Illinoian by a thinner loess cover, less-deep dissection, more-level topography, and less weathering. The Iowan is similar to the Illinoian in lithologic composition. The Iowan Till probably does not exceed 40 feet in thickness, and is covered with 4-6 feet of loess.

Outwash of Cary (Qwco) age is found along Pipestone and Split Rock Creeks. These sands and gravels range in thickness from several feet to 15 or 20 feet. They contain many rock types, among which are the deleterious chalk, shale and clay-ironstone. Outwash in general supplies water for domestic and industrial use, and sand and gravel for concrete aggregate and for road metal.

Recent alluvium (Qal) occupies the beds of Split Rock and Pipestone Creeks to a thickness of about six or eight feet. Alluvium consists chiefly of black to brown silt and clay, with some sand and gravel.

Road Condition

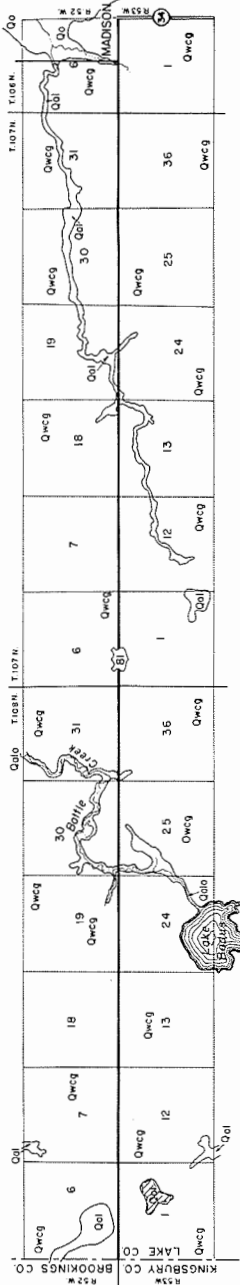
The present road is in generally fair condition because it has been well maintained. There are, however, innumerable patched spots and filled cracks, repaired shoulders and a few large areas that have been completely replaced by new material. The repaired areas apparently have no relation to topography. The cause of these numerous failures is probably the fact that the road is built on the relatively thick loess which everywhere overlies the Iowan and Illinoian Drifts. Loess is fairly well-sorted silt, which expands to some degree upon absorbing water. Thus, freezing and thawing cause heaving and rupturing of the road.

Recommendations

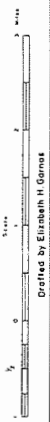
Perhaps a thicker gravel base course or a rolled earth subgrade, using material (till) from beneath the loess, would help to solve the problem of "loess-heaving".

GEOLOGY OF TEST STRIP No.14

Geology by Joel K. Montgomery



- EXPLANATION**
- Qal - Quaternary alluvium
 - Qol - Quaternary lacustrine and beach undifferentiated
 - Qo - Quaternary, outwash
 - Qwcg - Quaternary, well-sorted, ground moraine
 - ~ - Intermittent stream
 - - Intermittent lake



GEOLOGY OF TEST STRIP 14

by

Joel K. Montgomery

Location

Test Strip 14 is located in the north-central part of Lake County. It extends along U. S. Highway 81 from Madison 13 miles northward to the intersection of Kingsbury, Brookings, and Lake Counties.

Previous Work

No previous detailed mapping is recorded for this area. The State Geological Survey mapped the southernmost end of the area (Tipton, 1959). Flint (1955) made a reconnaissance map of the area.

Topography and Drainage

The area, in the Coteau des Prairies division of the Central Lowland physiographic province (fig. 1), consists of broad gently rolling hills and valleys. The relief gets progressively greater toward the north end of the strip. Madison has an elevation of 1680 feet above sea level.

The area is moderately drained by a sub-dendritic pattern of intermittent streams. Battle Creek flows to the east and drains most of the area into Silver Creek which empties into Lake Madison. Lake Badus is about 3/4-mile in diameter and is in the northern part of the area. One small intermittent stream flows southward through the city of Madison.

Geology

The entire area is Cary ground moraine (Qw_{cg}) except for alluvium and gravel in the stream deposits. The Cary Till appears to be more brownish in color than most Mankato tills, which are not present along this strip. It also contains small pebbles of carbonate rock and the matrix constitutes as much as 80 percent of the till. The Cary Till is leached to a depth of 20 inches in most parts of the area. Erratics are rare.

Outwash (Q_o) is present along some of the larger intermittent streams, and beneath the city of Madison.

Alluvium (Q_{al}) occurs along stream channels, and in large depressions; it is not differentiated from outwash along Battle Creek. It consists of dark-brown to black thick transported soil, and contains abundant sand and silt.

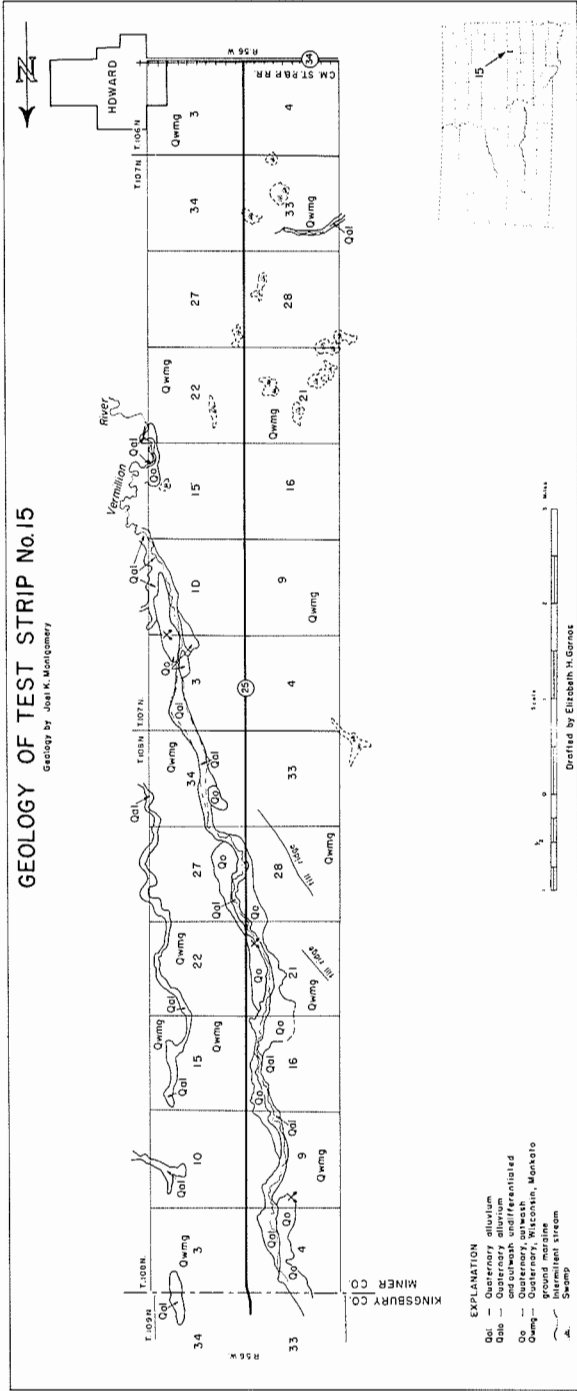
Most of the area is covered by a dark silty loam. No loess deposits occur in the area.

Effect of Geology on Highway

U. S. Highway 81 is in fair to good condition. There are several road repairs in the central part of the strip on till and alluvium. Most repairs occur over culverts which have settled. Many of the repaired spots were found in depressions, where subsidence is more active than in other areas.

GEOLOGY OF TEST STRIP No.15

Geology by Joel K. Montgomery



GEOLOGY OF TEST STRIP 15

by

Joel K. Montgomery

Location

Test Strip 15 is located in Miner County; it is 13.4 miles long and extends along State Route 25 from the Miner-Kingsbury County line southward to its junction with State Route 34, a mile west of Howard, South Dakota. The Chicago, Milwaukee, St. Paul, and Pacific Railroad traverses the southern edge of the strip.

Previous Work

Todd and Hall (1904) mapped the geology of the area in detail.

Topography and Drainage

This project area lies in the east-central part of the James Basin division of the Central Lowland physiographic province (fig. 1). The undulating surface that Test Strip 15 crosses consists of smoothly rolling hills, with low broad sub-parallel ridges trending eastward and lying convex to the south. Local relief rarely exceeds 20-30 feet, and in some places not more than 10 feet. It is an area of ridges and interridges, indented by many barely perceptible closed depressions. Flint (1955) refers to the ridges as end moraines, but the writer believes that the area has typical ground moraine topography. Howard has an elevation of 1570 feet above sea level.

The northern part of the area is drained by the Vermillion River and the southern part is drained by tributaries of the James River. Small streams occupy broad shallow depressions between till ridges. The drainage in most of the area is poorly developed; there are several swamps and mucky spots. The west branch of the Vermillion River crosses State Route 25 in T. 108 N., R. 56 W. Its course is somewhat confined between small till ridges, which are sub-parallel to the western border of the Coteau des Prairies, just to the east.

Geology

No outcrops of bedrock exist in the area, and nearly all of the surface is covered with Mankato Till (Flint, 1955). This till has been deposited as ground moraine (Qwmg) and end moraine-like ridges as the ice margin retreated to the southwest. The till ridges may represent a temporary halt of the glacier during its wasting. Good examples of till ridges are in Sections 21 and 28, T. 108 N., R. 56 W. A dark-blue clayey till occurs in some outcrops.

Collapsed till exists in the southwestern part of the area. The topography and glacial material is characteristic of collapsed drift.

The till was deposited either on or against the glacier and then collapsed as the ice melted.

Outwash (Qo) deposits are made up of predominantly carbonate pebbles, sand and silt. Local outwash deposits are confined along old stream channels of the present intermittent streams. The outwash deposits consist of elongate strings of sand and gravel which range up to 15 feet in thickness. Three gravel pits were mapped in the area.

Alluvium (Qal) occupies the bottoms of the intermittent streams and overlies some of the outwash deposits. The alluvium is made up principally of dark-brown to black silty sandy transported soil. No loess occurs in this area.

Effect of Geology on Highway

The test strip is in fair to good condition; several minor road repairs occur all along the strip.

GEOLOGY OF TEST STRIP 16

by

Joel K. Montgomery

Location

Test Strip 16 is located in Kingsbury County and is 12.4 miles long. It extends from the Miner-Kingsbury County line to the southern edge of DeSmet, South Dakota. This north-south strip is a northward continuation of Test Strip 15.

Previous Work

Todd and Hall (1904) have previously mapped the area.

Topography and Drainage

The southern part of the area is located in the James Basin division of the Central Lowland physiographic province, and the rest of it in the Coteau des Prairies division (fig. 1). There is a regional slope from north to south, with several northwest-southeast ridges passing through the center of the area. These smooth rolling ridges are flanked with broad sub-parallel ridges lying convex to the south (Flint, 1955). The western escarpment of the Coteau des Prairies passes through the center of the project area. It is an area of ridges and interridges indented by many barely perceptible closed depressions, with the local relief rarely exceeding 20-30 feet and in some places not more than 10 feet. Total relief amounts to approximately 100 feet.

The drainage pattern is somewhat dendritic, but the region is poorly drained by intermittent streams which have several depressions along their courses. A few large undrained kettle holes are present. The northeastern section just south of DeSmet is very swampy. The southern part of the area is drained by a west branch of the Vermillion River. The remainder of the area is drained to the west into Rock Creek.

Geology

Outcrops of bedrock are absent in the area, and Pleistocene glacial till covers the surface of most of the project. The color of the boulder clay is dark-gray to blue when fresh, and tan to dark brown when weathered. Much of the till is underlain by gravel.

The northern half of the area is Mankato end moraine (Qwme). A large end moraine ridge containing large granitic erratics traverses northwest-southeast across the highway, approximately two miles south of the town. In Sections 15 and 22, T. 110 N., R. 56 W. there is much sandy till near the contact with the outwash deposits.

Mankato ground moraine (Qwmg) occupies the southern part of the area and contains several small parallel ridges which are believed to be recessional moraines.

A large deposit of collapsed drift occurs in the northeastern part of the area, southeast of DeSmet; the hilly area is characterized by mixed deposits of mostly gravel and till. The gravel is more abundant and stratified in some places than other places. The collapsed material was apparently deposited either on the ice sheet or at the edge of the glacier, and collapsed as the ice later melted away.

A large outwash (Qo) deposit occurs in Sections 33 and 34, T. 111 N., R. 56 W., near DeSmet; the deposit consists of alternating gravel, sand, and silt with abundant carbonate pebbles and some cobbles. One depression in the center of the area is filled with sandy gravels.

Alluvium (Qal) occurs along both sides of the main intermittent streams, terraces, and ancient channels. Some depressions and kettle holes contain thick deposits of alluvium.

Effect of Geology on Highway

There are two minor road repairs; they both occur over till.

GEOLOGY OF TEST STRIP 17

by

Joel K. Montgomery

Location

This test strip is situated in the south-central part of Hand County and the northern part of Buffalo County. The strip is 13.1 miles long, and is on State Route 45.

Previous Work

This area has been mapped in a reconnaissance way by Flint (1955).

Topography and Drainage

The area, in the Coteau du Missouri division of the Great Plains physiographic province (fig. 1), has a typical morainic surface through its entire length, and swell and swale topography is characteristic. The Wessington Hills lie 10 miles to the east.

A poorly developed dendritic drainage pattern is present in the area. Small depressions occur in the northern and southern parts of the region. Turtle Creek and its tributaries drain the northern half of the area. The central portion of the area is drained into Wall Lake, a large intermittent lake. The southern half of the area is drained by Crow Creek and its tributaries.

Geology

The regional geology is made up chiefly of Cary Drift of Wisconsin age (Flint, 1955). This drift consists of olive-gray to light-brown till which has carbonate and granitic pebbles scattered through it.

Both Cary end moraine (Qwce) and ground moraine (Qwcg) are present in the area. The glacial features have a northwest-southeast trend, and many of the streams trend in the same direction. The Cary end moraine in the northern part of the area has a rougher surface than the surrounding ground moraine. Kettle holes are abundant in the end moraine, and most of them are elongate in a northwest-southeast direction. The ground moraine area is more dissected and contains kettle holes that have been drained. A small patch of ground moraine is isolated in the southern part of the area; however, this may actually be a large depression in the end moraine.

During late Cary time, outwash (Qo) materials were carried westward by the meltwaters and deposited in Crow Creek valley. Outwash gravels occupy the slopes of Crow Creek in the center of the area; sand and Recent alluvium (Qal) occur along the stream channels. Wall Lake (dry) contains a 20-foot thickness of alluvium.

Effect of Geology on Highway

The highway is in good condition; only a few minor road repairs were noticed.

GEOLOGY OF TEST STRIP 18

by

Joel K. Montgomery

Location

This project extends along U. S. Highway 14 from Harrold through Holabird to Highmore, and is 15 miles long. The Chicago and Northwestern Railroad lies south of the highway and parallel to it.

Previous Work

Flint (1955) has previously mapped the area at a reconnaissance scale.

Topography and Drainage

The strip is included in the Coteau du Missouri division of the Great Plains physiographic province (fig. 1). Topographically, the area is flat in the western half, and gently rolling with swell and swale topography in the eastern half. A northwest-southeast ridge traverses the center of the area. Some glacial boulders and a larger number of depressions occur in the eastern part of the area. The depressions vary in size and depth, some having well-defined outlines whereas others grade imperceptibly into the surrounding upland.

A long northwest-southeast trending ridge passes through the town of Highmore and is an end moraine of Mankato age (Flint, 1955). Harrold has an elevation of 1780 feet above sea level and Highmore has an elevation of 1850 feet above sea level, thus giving a difference of 70 feet in relief for the area.

The region is drained to the west by South Medicine Creek, an intermittent stream. The western part of the area has well-developed drainage; the eastern part of the area has poor drainage because of many kettle holes and lack of streams.

Geology

No bedrock is exposed in the project area. In this region the surface materials consist of unconsolidated Wisconsin Drift or "boulder clay" made up of a heterogeneous mixture of rock particles. The surface material is a highly calcareous olive-brown to brownish-gray till containing glacial boulders, cobbles, pebbles, streaks of calcium carbonate, and iron oxide. The western third of the area is considered to be Cary ground moraine (Qwcg); the central third is thought to be Mankato ground moraine (Qwmg); and the eastern third Mankato end moraine (Qwme). There is little if any distinction between the two ground moraines. Flint (1955) drew an indefinite contact line on the basis of topography, but no topographic difference was noted between the two by the writer. The ground moraine is nearly level, with minor swell and swale topography.

The end moraine region to the east is higher and has a rougher surface than the ground moraine region. The dark Mankato Till is composed mainly of fragments of Pierre Shale (90 percent), gypsum, small pebbles and sand. Boulders are scattered over the end moraine surface. Thick black alluvial material occurs along the stream channel of South Medicine Creek and also overlies till south of Holabird in Sections 7-12, T. 112 N., R. 73 W.

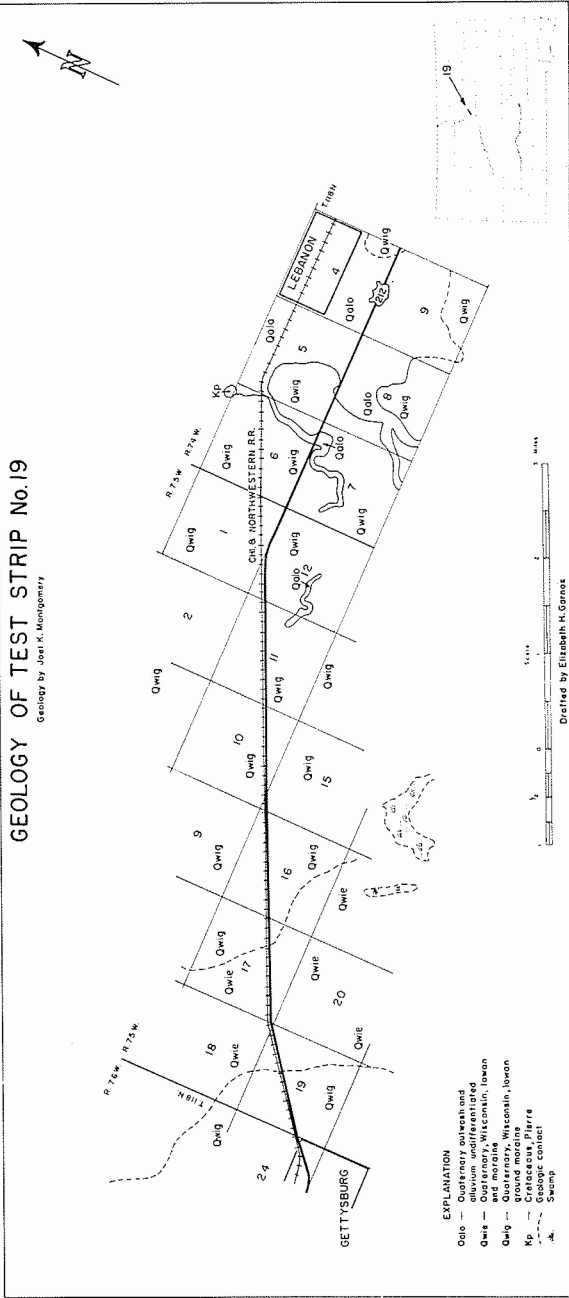
Outwash gravels and alluvium (Qalo) are restricted to the intermittent stream courses. Bedded gravels are exposed along South Medicine Creek near the Hughes-Hyde County line. Erratics are embedded in a gravel pit in the southeast corner of Section 7; this deposit is 12 feet thick and is overlain by 3-5 feet of loess. A blanket of loess covers much of the ground moraine region and some of the outwash deposits. The upper portion of the loess has developed into a thick soil cover over the end moraine.

Effect of Geology on Highway

The highway is in very good condition; no road repairs are present.

GEOLOGY OF TEST STRIP No. 19

Geology by Joel K. Montgomery



- EXPLANATION**
- Qo1o — Quaternary outwash and sand
 - Qwa1 — Quaternary Wisconsin, Iowan and moraine
 - Qw1o — Quaternary Wisconsin, Iowan and moraine
 - Mp — Cretaceous Pierre
 - Qw1c — Quaternary Wisconsin, Iowan and moraine
 - Geologic contact
 - Strip

Drafted by Elizabeth H. Carnot

GEOLOGY OF TEST STRIP 19

by

Joel K. Montgomery

Location

Test Strip 19 lies in Potter County between Gettysburg and Lebanon. It is 10.1 miles long, along U. S. Highway 212. The strip is paralleled on the north by the Chicago and Northwestern Railroad.

Previous Work

Lee (1956) prepared a report for the State Geological Survey on the geology and shallow water resources of the eastern part of the area. He also made textural studies of the outwash sediments in the City Park of Lebanon.

Topography and Drainage

This area, in the Coteau du Missouri division of the Great Plains physiographic province (fig. 1), is nearly flat; however, there are some swell and swale irregularities. The area has a gradual slope from Lebanon to Gettysburg; the elevations of Lebanon and Gettysburg are 1970 and 2080 feet above sea level, respectively.

The eastern part of the area near Lebanon is well drained to the north by a network of intermittent tributaries which empty into Swan Lake. Drainage in the western part of the area is fair; intermittent streams flow southward into Okobojo Creek.

Geology

The Pierre Shale (Kp) is exposed in a road cut near the top of a small hill in the northeastern corner of Section 6, T. 118 N., R. 74 W. The roadcut is 20 feet deep, displaying dark-brown to gray mudstone and fissile shale.

A sheet of Iowan Drift covers nearly the entire area; it has both end moraine (Qwie) and ground moraine (Qwig) features. Two miles east of Gettysburg is a northwest-southeast strip of end moraine; it contains a few depressions and is strewn with erratics. The erratics are of all sizes, and some have striae. The remainder or greater part of the till-covered area is ground moraine; the till consists of gray to olive-gray material containing abundant limonite, calcite, gypsum, and a few pebbles. There are a few boulders and cobbles.

Loess covers most of the western two-thirds of the area to a depth of 0-6 feet. The loess is olive brown, friable and highly calcareous. It stands vertically in road cuts and exhibits a prismatic structure near the top. The loess becomes slightly darker brown in color near the surface; the upper part contains much organic matter and forms a rich top soil.

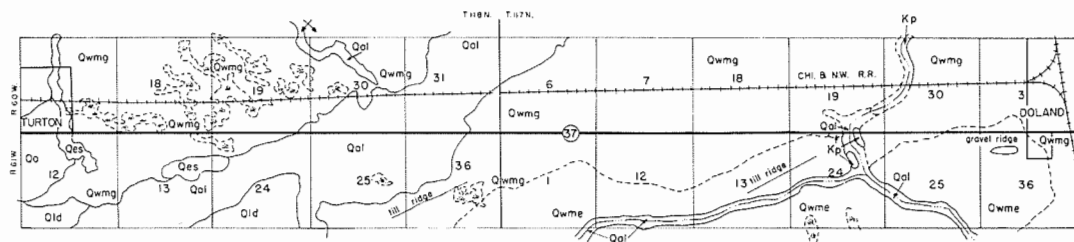
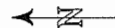
The Cary drift has served as the main source of outwash (Qalo) material in the eastern part of the area. Outwash sands and gravels lie beneath the town of Lebanon. Flint (1955) called the underlying material in the town of Lebanon till, whereas it is actually outwash material. Sand overlies the outwash gravels. The soil is very silty and sandy in composition.

Effect of Geology on Highway

Several road repairs are present in the western part of the area because this part of the highway is older. Repairs occur at spots where the highway crosses alluvium in depressions, and also over culverts.

GEOLOGY OF TEST STRIP No. 20

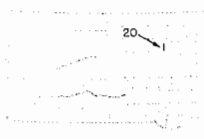
Geology by Joel K. Montgomery



- EXPLANATION**
- Qal — Quaternary alluvium
 - Qld — Quaternary lake deposits
 - Qes — Quaternary esker
 - Qo — Quaternary outwash
 - Qwmq — Quaternary, Wisconsin, Mankato and moraine
 - Qwme — Quaternary, Wisconsin, Mankato ground moraine
 - Kp — Cretaceous, Pierre shale
 - - - - - Geologic contact
 - ~ ~ ~ ~ ~ Intermittent stream
 - Swamp
 - Gravel pit



Drafted by Elizabeth H. Garnos



GEOLOGY OF TEST STRIP 20

by

Joel K. Montgomery

Location

This test section is situated in the northeastern part of Spink County. The strip is 11 miles long and is along State Route 37 between Doland and Turton. The Chicago and Northwestern Railroad parallels the strip and crosses the highway at the southern edge.

Previous Work

Todd (1909) has previously mapped the area.

Topography and Drainage

The surface of the area, in the James Basin division of the Central Lowland physiographic province (fig. 1), in general is undulating but nearly flat, although there are a few small northwest-southeast hills along the western side of the area. Just south of Turton is a small ridge of round-topped, rather steep-sided hills. At two places in the northwestern part of the project is a flat plain which was once occupied by glacial Lake Dakota. Both the northern and southern areas slope toward the center of the strip.

The area is drained by intermittent tributaries and branches of Foster Creek, which lies to the west. A few swamps occur along the east side of the highway south of Turton.

Geology

Bedrock geology in the area consists of a few small outcrops of Late Cretaceous age which belong to the Pierre Shale (Kp). These outcrops appear in the southern part of the area along the sides of a small stream valley. The outcrops are composed of dark-gray noncalcareous shale that contains small iron concretions. Structurally, the beds appear to be nearly horizontal.

During late Wisconsin time a great ice sheet spread a mantle of till and gravel over the pre-Wisconsin surface. The till is composed of boulder clay, an unstratified mixture of clay, sand, and worn pebbles, and some erratics. Erratics are scarce except where they cap till ridges of Mankato end moraine (Flint, 1955) along the western side of the strip. In the southwestern part of the area, end moraine (Qwme) hills rise 50 feet or more above the surrounding level ground moraine (Qwmg). The till is more stony in the end moraine region than in the ground moraine area.

A small series of eskers (Qes) occurs along the southern border of Turton for more than a mile. These features were left by the ice as sand and gravel ridges having undulating crestlines where proglacial channels and crevices in the ice had existed.

Outwash (Qo) gravels occupy ancient stream channels and terraces. The coarse material suggests transport by vigorous streams.

Lake Dakota (Qld) formed along the front of the retreating Mankato ice sheet. The ancient lake bottom is covered by a sheet of gray clay and fine silt, but no stratification was noted in the lake sediments. Most of the silt is composed of quartz. Just west of Doland is a small ridge of stratified sand, gravel, and a ferruginous-cemented conglomerate bed.

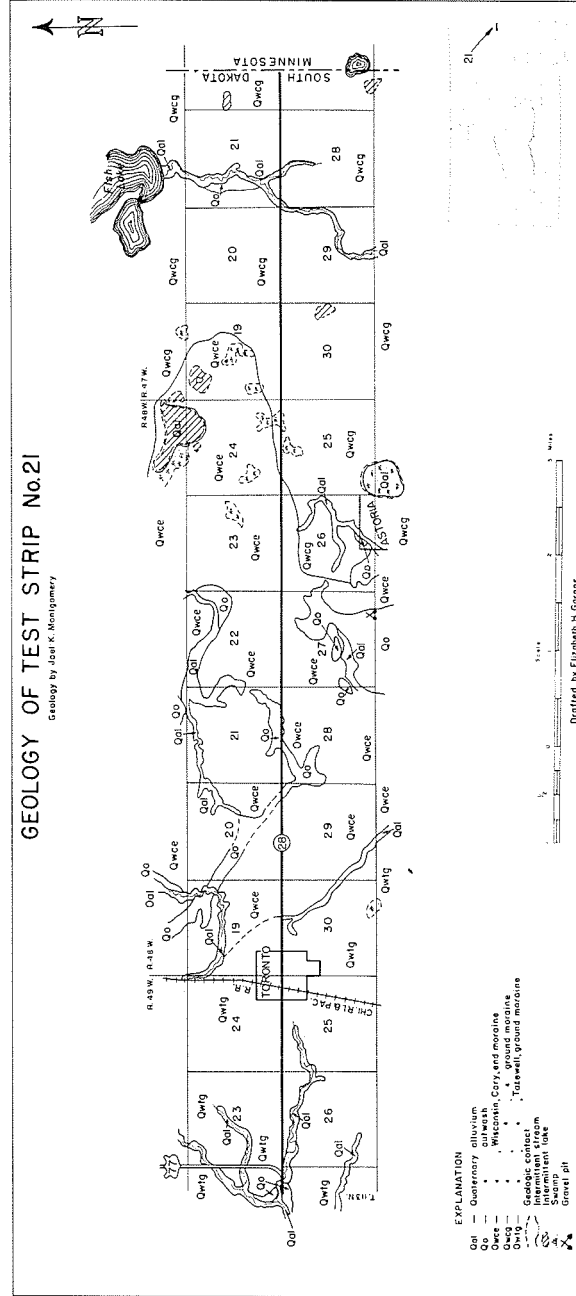
A blanket of loess covers much of the area; it is six feet thick one mile south of Turton. Thick alluvium (Qal) rich in silty clay is present along the floodplains of the streams. Parts of the area are marshy and subject to flooding.

Effect of Geology on Highway

One small road repair was noted in the center of the area, where the highway crosses a broad alluvial floodplain.

GEOLOGY OF TEST STRIP No.21

Geology by Joel K. Montgomery



EXPLANATION

- Qol — Quaternary alluvium
- Qwcc — Wisconsin, Cary, and moraine
- Qwccg — glacial moraine
- Qwccq — glacial moraine
- Qo — glacial moraine
- Qwlg — glacial moraine
- Qwlgg — glacial moraine
- — Geologic contact
- - - - - Submerged ground moraine
- — — — — Interstream moraine
- — — — — Swamp
- — — — — Quaternary pit

Drafted by Elizabeth H. Ganses

GEOLOGY OF TEST STRIP 21

by

Joel K. Montgomery

Location

The test strip is an east-west strip 11.678 miles long, along South Dakota State Route 28, from two miles west of Toronto to the Minnesota border. The Chicago, Rock Island, and Pacific Railroad passes through the town of Toronto.

Previous Work

Flint (1955) included this area in his reconnaissance map of the Pleistocene geology of eastern South Dakota.

Topography and Drainage

The strip is in the Coteau des Prairies division of the Central Lowland physiographic province (fig. 1). The western part of the region is nearly level to gently rolling; the central and eastern parts of the region have a rough topographic surface expression of ground and end moraine, which include lakes, kettle holes, marshes, and knobby hills.

The area west of Toronto has a well-integrated dendritic drainage pattern, with the tributary streams flowing westward. The area extending from Toronto to the Minnesota State line is not so well drained; it contains numerous depressions of various sizes. Streams in the eastern part of the strip flow northward into Fish Lake.

Geology

Nearly all of the area is covered with Wisconsin Drift of Tazewell and Cary age (Flint, 1955). The Tazewell Drift is believed to be as thick and possibly thicker than the Cary Drift, as it occurs at a higher elevation and has about an equal width and geographic distribution. Most of the Tazewell ground moraine (Qwtg) is covered with a sandy loess from one to three feet in thickness.

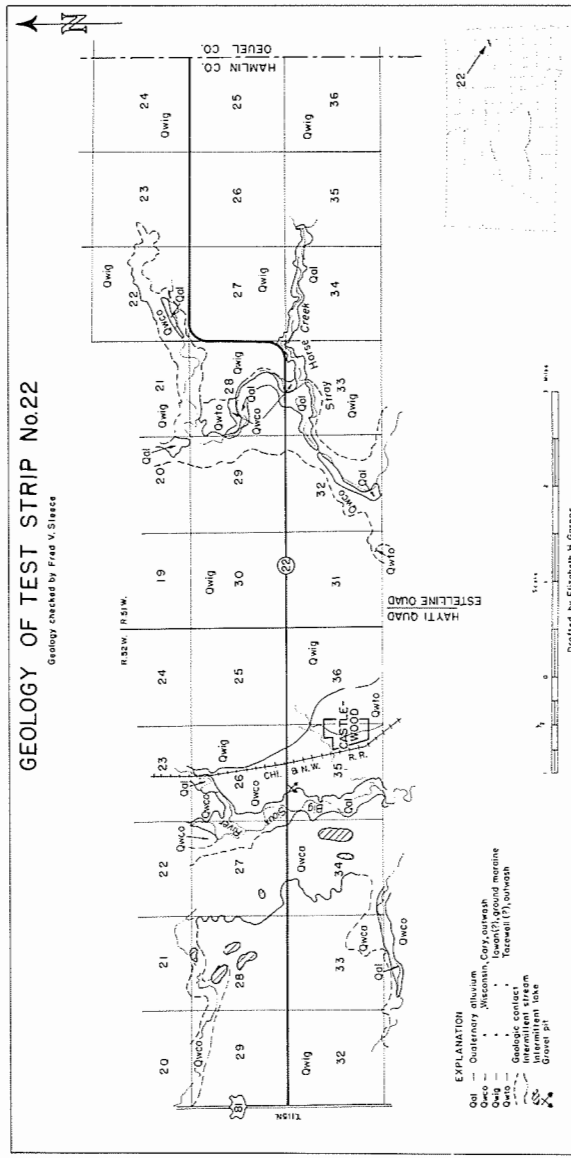
The Cary Drift has a typical morainic surface and is much rougher than the surface of the Tazewell Drift. Both end (Qwce) and ground (Qwgc) moraine are present. The crest of the Cary end moraine trends in a general northwest-southeast direction. Locally, an irregular contact exists between the end and ground moraine. The Cary Till is leached to a depth of at least 24 inches in most exposures.

Outwash deposits (Qo) of gravel and clean sand occur in many places along the strip.

Alluvium (Qal) is confined to stream channels.

Effect of Geology on Highway

Two road repairs were noted. One occurs near the center of the area in the end moraine; the other repair was found over a culvert at the eastern end of the strip.



GEOLOGY OF TEST STRIP 22

by

Fred V. Steece

Location

Test Strip 22 begins about four miles west of Castelwood at the junction of State Route 22 and U. S. Highway 81, and extends eastward for 11.694 miles, to the Hamlin-Deuel County line.

Previous Work

The writer (Steece, 1957b, c) mapped the geology of this area in 1956, for the State Geological Survey.

Topography and Drainage

The topography of the area, which is in the Coteau des Prairies division of the Central Lowland physiographic province (fig. 1), is of two types. The land along the Big Sioux River and Stray Horse Creek is flat and low, and constitutes the flood plains; many flat gravel terraces are high above the present valley floors along these streams. The second type of topography is present on the uplands, where the terrain is gently rolling and well drained, with a well-integrated dendritic pattern of intermittent streams.

The relief is variable and normally is not great except along the bluffs of the Big Sioux River and Stray Horse Creek valleys, where the maximum relief may be as much as 60 feet. The total relief is 165 feet between the Big Sioux floodplain and the uplands east of Castlewood near the Hamlin-Deuel County line.

Geology

Pleistocene glacial deposits and Recent alluvium make up the surficial geology of this area. The Pleistocene deposits include the Iowan (?), Tazewell (?), and Cary substages of the Wisconsin glacial stage.

Iowan (?) ground moraine (Qwig) includes glacial deposits that consist of till or boulder clay which form the uplands away from the streams. The till is olive gray to brown clay, which contains rock fragments up to 3 or 4 feet in diameter. The surface of the ground moraine is well drained and rolling; there are few lakes, ponds, or undrained depressions. The Iowan Till may be as thick as 150 feet. Outwash deposits of Tazewell (?) (Qwto) age are found in terraces along Stray Horse Creek east of Castlewood. The terraces are made up of as much as 35-40 feet of sand and gravel, mostly suitable for concrete aggregate and road metal. The terraces have extremely level surfaces except near the Big Sioux River.

The Cary outwash (Qwco) deposits, similar in composition but at lower levels, form the floodplains of the Big Sioux River and Stray Horse Creek. The Cary Outwash is composed of sands and gravels of many rock types and sizes, up to boulders two or three feet in diameter. These materials are suitable for use as concrete aggregate and road metal, and supply abundant quantities of good quality water for domestic as well as industrial use.

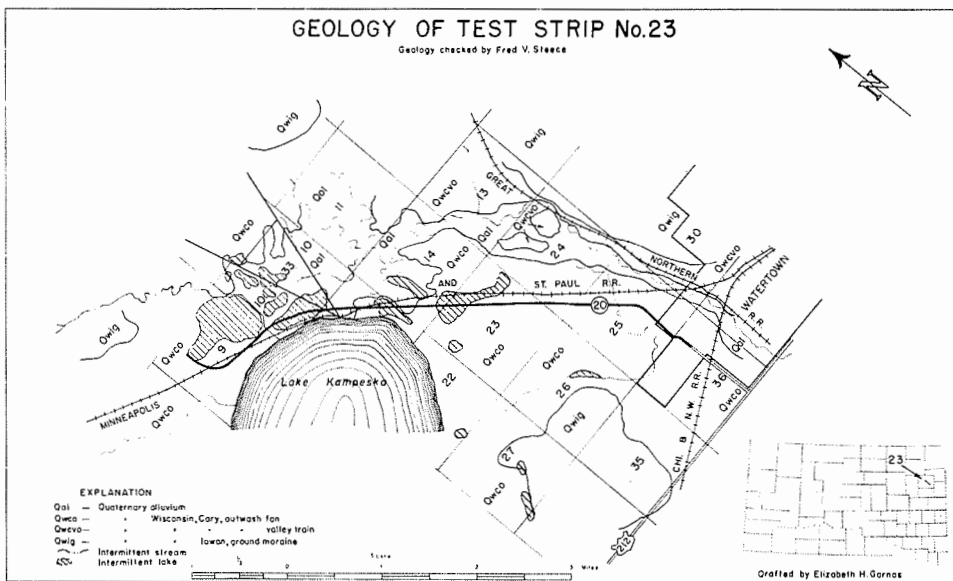
Recent alluvium (Qal) is brown to black silt and clay containing some sand and gravel. In this area the alluvium ranges up to eight or ten feet in thickness, and occupies positions immediately adjacent to the Big Sioux River and Stray Horse Creek, in the floodplain.

Road Condition

This road was finished in 1958, and is in excellent condition. No road repairs other than an occasional crack-filling were noticed in the fall of 1960.

GEOLOGY OF TEST STRIP No.23

Geology checked by Fred V. Steacie



- EXPLANATION**
- Qal — Quaternary alluvium
 - Qwca — Wisconsin, Cary, outwash fan
 - Qwco — valley train
 - Qwlg — low ground moraine
 - Intermittent stream
 - Intermittent lake

Drafted by Elizabeth H. Gornes

GEOLOGY OF TEST STRIP 23

by

Fred V. Steece

Location

Test Strip 23 begins about 5.779 miles northwest of Watertown and follows State Route 20 into the northwestern part of town.

Previous Work

Rothrock (1933) mapped the geology and water resources of the Lake Kameska region, and Steece (1957d) mapped the areal geology of the Watertown quadrangle, both for the State Geological Survey.

Topography and Drainage

The surface of this area, which is in the Coteau des Prairies division of the Central Lowland physiographic province (fig. 1), is relatively flat, being underlain by glacial outwash. The maximum relief probably does not exceed 25 feet, and averages 5-10 feet. The drainage of the northern third of the area is into Lake Kameska, whereas south of the lake's outlet the drainage is eastward into the Big Sioux River.

Geology

The surficial geology along Strip 23 consists of Pleistocene glacial deposits and Recent alluvium. The glacial deposits are Iowan (?) Till and Cary Outwash. Till is brownish to grayish clay containing rock fragments of all sizes from silt to boulders 5-6 feet across, and larger. Till results from the lodgement and dumping of rock debris carried by the glacial ice. The Iowan (?) Till is expressed as ground moraine (Qwig), and is mantled by as much as three feet of windblown silt (loess). Glacial outwash consists of sand and gravel deposited by meltwater from the ice sheet. Outwash is confined to valleys where it is called valley train (Qwcvo) or it is deposited as a fan or delta (Qwco) which has a somewhat rougher topography than the valley train outwash. The outwash may attain a thickness of 100 feet or more although commonly it is no more than 45-50 feet. Outwash consists of rocks of many kinds including deleterious shale, chalk, and clay-ironstone. Nevertheless, the sands and gravels are widely used for concrete aggregate and for road metal.

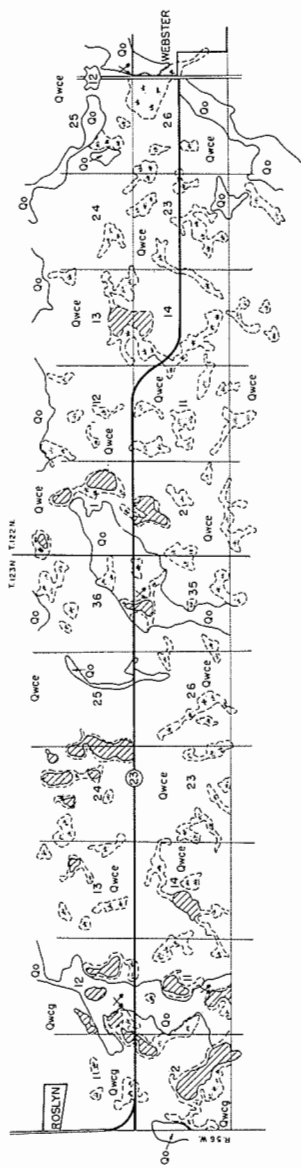
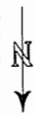
Recent alluvium (Qal) consists of brown to black silt and clay with some sand and gravel, and is confined to the beds of streams. It is as much as 10-12 feet thick over the outwash in this area.

Road Condition

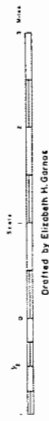
This is an excellent road, virtually without injury or repair; however, this is to be expected, because the road was surfaced recently.

GEOLOGY OF TEST STRIP No. 24

Geology by Joel K. Montgomery



- EXPLANATION**
- Owcg Ogishwanian
 - Owee — boundary Wisconsin, Cary, and moraine
 - Owee — Interstream lake
 - Stream
 - Swamp
 - Gravel pit



Compiled by Elizabeth H. Groat



GEOLOGY OF TEST STRIP 24

by

Joel K. Montgomery

Location

This test strip includes 11.218 miles of State Route 23, extending from Webster to within a mile of Roslyn, South Dakota.

Previous Work

The geology of this project area has been described by Rothrock (1935), for the State Geological Survey, and a reconnaissance map was prepared by Flint (1955).

Topography and Drainage

The area is located in the northern part of the Coteau des Prairies division of the Central Lowland physiographic province (fig. 1). The topography consists of steeply rolling hills and numerous lakes and kettle holes of various sizes; this is the Lake Section of the Coteau des Prairies region. Webster has an elevation of 1830 feet above sea level.

The area is poorly drained; it is heavily dotted with kettle holes, swamps, and small lakes of various sizes. No streams are present.

Geology

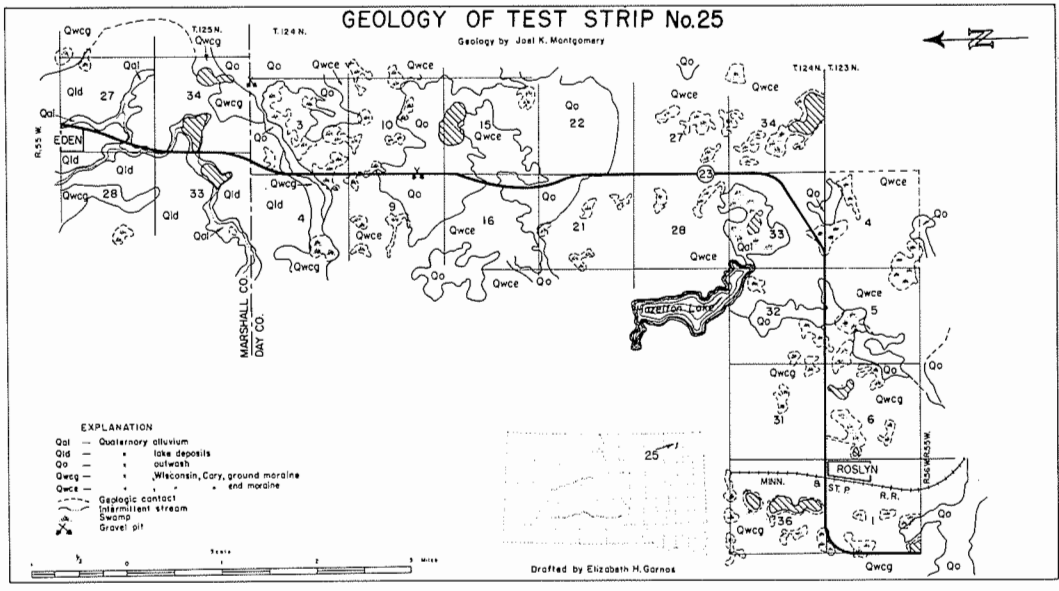
Cary drift and outwash deposits cover the entire area (Flint, 1955). Cary ground moraine (Qw_{cg}) occupies the northern part of the area and the town of Roslyn. Cary end moraine (Qw_{ce}) covers most of the rest of the area. It has a very irregular surface.

Several outwash deposits (Q_o) extend through the area; many of them contain gravel pits. Terrace deposits of gravels (two feet thick) occur along the eastern border of the area, covering hills of till. An old east-west stream deposit occurs in Sections 25 and 26, T. 123 N., R. 56 W.; a vertical section through it shows six feet of tan clayey silt on two feet of yellow sand overlying Cary Till.

Minor deposits of alluvium are present in the depressions.

Effect of Geology on Highway

The highway is in good condition; two road repairs are present in regions of till.



GEOLOGY OF TEST STRIP 25

by

Joel K. Montgomery

Location

Test Strip 25 is located in Day and Marshall Counties. It is a northward extension of Test Strip 24 and extends from Roslyn to Eden, South Dakota. The Minneapolis and St. Paul Railroad passes through the town of Roslyn.

Previous Work

The geology of the area has been described by Rothrock (1935) for the State Geological Survey, and a reconnaissance map of eastern South Dakota was prepared by Flint (1955).

Topography and Drainage

The area lies within the northern tip of the Coteau des Prairies division of the Central Lowland physiographic province (fig. 1). The entire area is composed of steeply undulating topography except for the northern part near the town of Eden, which is nearly flat. Most of the rough relief in the region is attributed to the slowly retreating Cary ice sheet, which left hills and ridges of drift; smoother areas elsewhere are due to more rapid retreat of the ice sheet. This is the Lake Section of the Coteau des Prairies region. The lakes are at higher elevations than other glacial lakes of South Dakota. The general elevation ranges between 1780 and 1890 feet above sea level.

The drainage is very similar to the drainage along Test Strip 24 except for the extreme northern part of Test Strip 25 which has a dendritic drainage pattern; intermittent streams flow westward. Eden is situated in an old glacial lake bottom. Hazelton Lake is the largest lake in the area; it is located two miles northeast of Roslyn.

Geology

No bedrock exposures are present. The surface is covered with Cary Drift, outwash deposits, glacial lake sediments, and alluvium (Flint, 1955). Cary end moraine (Qwce) is very extensive in the region. Cary ground moraine (Qwcg) is present in an area surrounding Roslyn and also near the Day County-Marshall County line.

Large bodies of outwash (Qo) deposits are present and form hilly topography. The outwash consists of unconsolidated sandy gravels containing pockets of silt and clay, especially in Section 16, T. 124 N., R. 55 W. Interstratified drift and gravel was observed in Section 3, T. 124 N., R. 55 W.

Lake sediments (Qld) are present in a broad low area surrounding the town of Eden. The sediments consist of dark-gray to black clay with possibly minor silt content.

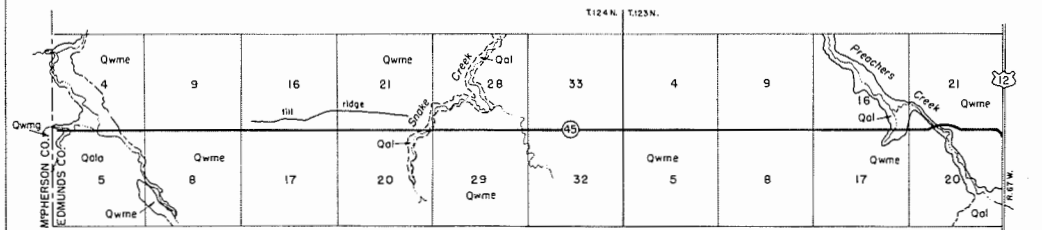
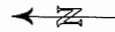
Alluvium (Qal) is confined to the channels of small intermittent streams near Eden.

Effect of Geology on Highway

The new highway is in excellent condition; it has no road repairs.

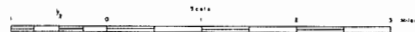
GEOLOGY OF TEST STRIP No.26

Geology by Joel K. Montgomery

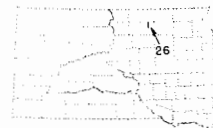


EXPLANATION

- Qal — Quaternary alluvium
- Qalo — alluvium and outwash
- Qwme — Wisconsin, Mankato, and marine
- Qwmg — ground moraine
- - - Geologic contact
- ~ Intermittent stream



Crafted by Elizabeth H. Gornas



GEOLOGY OF TEST STRIP 26

by

Joel K. Montgomery

Location

Test Strip 26 is located in Edmunds County and includes a 10-mile strip along State Route 45 extending from U. S. Highway 12 to the McPherson-Edmunds County line.

Previous Work

Rothrock (1946) mapped the geology of the southern half of the area for the State Geological Survey, following earlier mapping by Todd (1909).

Topography and Drainage

The area lies within the James Basin division of the Central Lowland physiographic province (fig. 1), and ranges from gently rolling hills to nearly level topography. The regional slope is to the south, and the altitude of the entire area shows less than 50 feet of relief from an average elevation of 1500 feet above sea level.

The region is poorly drained to the east by small intermittent streams, Preachers Creek and Snake Creek. The surface has a few small undrained depressions.

Geology

No bedrock exposures are present in the mapped area.

The area is mantled with a sheet of Mankato Drift (Flint, 1955) which includes some small deposits of outwash and alluvium. Most of the drift is considered to be Mankato end moraine (Qwme), although with its low relief it may be partly ground moraine. It contains some depressions, and ridge-like topography. The calcareous till is composed of granite, gneiss, carbonate, and micaceous pebbles and cobbles. Erratics are very rare.

A small patch of ground moraine (Qwmg) occurs along the McPherson-Edmunds County line.

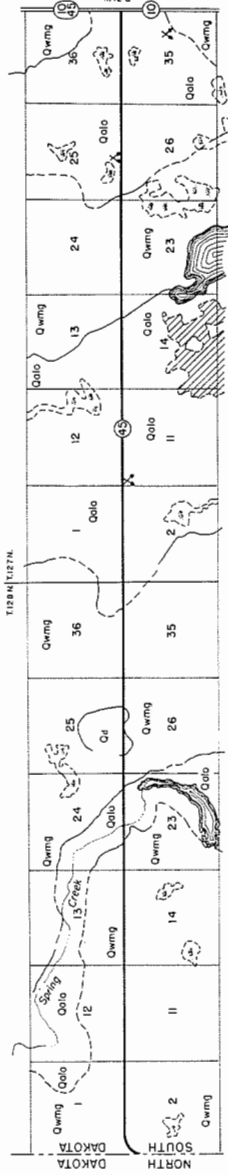
Alluvium (Qal) is present along the stream channels, and outwash (Qalo) is present in the northern part.

Effect of Geology on Highway

There are few road repairs in the area. Two occur over culverts near the northern end of the area, and another one near the middle of the strip. The underlying material is alluvium.

GEOLOGY OF TEST STRIP No.27

Geology by Joel R. Montgomery



- EXPLANATION**
- Q1 - Quaternary deposits
 - Q2 - Quaternary deposits
 - Q3 - Quaternary deposits
 - Q4 - Quaternary deposits
 - Q5 - Quaternary deposits
 - Q6 - Quaternary deposits
 - Q7 - Quaternary deposits
 - Q8 - Quaternary deposits
 - Q9 - Quaternary deposits
 - Q10 - Quaternary deposits
 - Q11 - Quaternary deposits
 - Q12 - Quaternary deposits
 - Q13 - Quaternary deposits
 - Q14 - Quaternary deposits
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 - Q96 - Quaternary deposits
 - Q97 - Quaternary deposits
 - Q98 - Quaternary deposits
 - Q99 - Quaternary deposits
 - Q100 - Quaternary deposits

Printed by Elizabeth H. Green

GEOLOGY OF TEST STRIP 27

by

Joel K. Montgomery

Location

This highway project is situated in the north-central part of McPherson County. The north-south strip is 12 miles long and extends along State Route 45 from State Route 10 northward to the North Dakota-South Dakota boundary.

Previous Work

Flint (1955) included this area in his reconnaissance map of eastern South Dakota.

Topography and Drainage

Project 27 lies within the Coteau du Missouri division of the Great Plains physiographic province (fig. 1). This area has moderate relief in the northern part. The southwestern part is an area of low relief containing several intermittent lakes. The topography is very irregular but the relief does not exceed 200 feet.

The area is drained to the west by two major intermittent tributaries of Spring Creek. Two lakes, each a mile long, occur along the western edge of the area. Small depressions are present in nearly every section.

Geology

Mankato ground moraine (Qwng) covers most of the area (Flint, 1955). The moraine has a northeast-southwest trend. The till contains predominantly granite and carbonate rock types in a clayey matrix.

Extensive deposits of outwash (Qalo) gravels and alluvial sands occur through the central and southern parts of the area, and along Spring Creek valley. The gravels are predominantly granite, gneiss and carbonate in composition, but have minor amounts of chalcedony, chert, schist, and basic rocks.

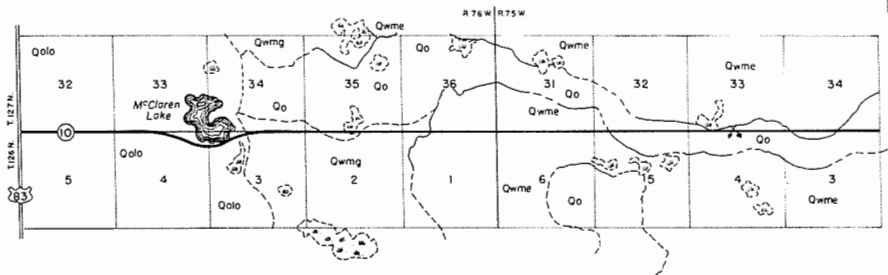
A small deposit of windblown dune (?) sand (Qd) is present in Section 25, T. 128 N., R. 71 W.

Effect of Geology on Highway

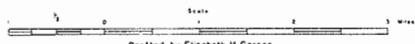
No major road repairs were seen in the highway strip.

GEOLOGY OF TEST STRIP No.28

Geology by Joel K. Montgomery



- EXPLANATION**
- Qolo — Quaternary alluvium and outwash
 - Qo — outwash
 - Qwme — Wisconsin, Mankato, end moraine
 - Qwmg — ground moraine
 - Geologic contact
 - Swamp
 - Gravel pit



Drafted by Elizabeth H. Garros

GEOLOGY OF TEST STRIP 28

by

Joel K. Montgomery

Location

Test Strip 28 is located in the central portion of Campbell County just north of Mound City. It extends nine miles eastward along State Route 10 from the intersection with U. S. Highway 83.

Previous Work

Flint (1955) mapped the area on a reconnaissance scale.

Topography and Drainage

The area lies in the Coteau du Missouri division of the Great Plains physiographic province (fig. 1). The eastern part of the area is higher than the western part. Physical features include erratic-covered ridges, lakes, intermittent streams, and depressions, but the western one-fourth of the area is nearly flat. Valleys and ridges trend north-south. Total relief amounts to approximately 150 feet.

The area has poor drainage. Kettle holes are common through most of the area, especially the eastern part. McClaren Lake, about one-half mile long, is in the western part of the area.

Geology

End moraine and ground moraine are present in the project area. The end moraine (Qwme) consists mainly of clay-rich till containing conspicuous stones and very little stratified drift, with abundant erratics. The end moraine has at least 50 feet of relief. The moraines are Mankato in age (Flint, 1955).

The ground moraine (Qwmg) covers part of the central area of the strip. It represents the western border of the Mankato drift sheet. As the glacier retreated, it halted long enough to form a recessional moraine. With further retreating of the glacier, meltwaters flowed westward from the glaciers across the Mankato end moraine, ground moraine, and the outwash plain. A channel deposit (Qo) composed of predominantly sand and some gravel, at least 100 feet wide and 30 feet thick, traverses the area in an east-west direction, cutting across both the end and ground moraines.

A three-foot thickness of calcareous loess overlies the channel in Section 34, T. 127 N., R. 76 W. Limonitic concretions are present a foot below the surface in the loess deposit. In several places a more recent V-shaped channel can be traced within the old channel deposit. A few erratics occur in the channel deposit, surrounded by and nearly covered with sand.

In the western part of the area is an outwash (Qalo) plain composed mostly of sand with some silt, very little gravel, and no boulders. It is covered with dune sand derived from the old Missouri River floodplain and transported eastward by westerly winds which piled the sand against the western slope of the Mankato moraine (Flint, 1955, p. 132). The sand is fine grained and well sorted; it is probably not more than 30 feet thick.

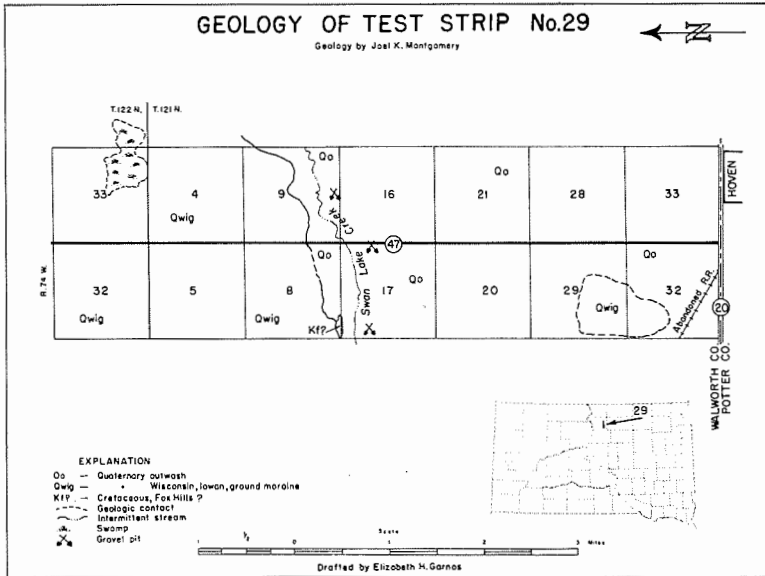
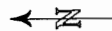
McClaren Lake formed along the outwash-ground moraine contact (along the ice front) during the early stage of retreat of the Mankato glacial sheet. Some of the material associated with the lake may be classified as collapsed outwash. The lake contains much impure black clay and alluvium.

Effect of Geology on Highway

The road is in good to excellent condition. A few minor cracks were noted in the highway near McClaren Lake.

GEOLOGY OF TEST STRIP No.29

Geology by Joel K. Montgomery



EXPLANATION

- Oo — Quaternary outwash
- Owig — Wisconsin lowland, ground moraine
- K17 — Cretaceous, Fox Hills ?
- Geologic contact
- ~ ~ ~ Intermittent stream
- Swamp
- X Gravel pit

Drafted by Elizabeth H. Gornas

GEOLOGY OF TEST STRIP 29

by

Joel K. Montgomery

Location

Test Strip 29 is located in the southeastern part of Walworth County; it extends from Hoven seven miles northward along State Route 47.

Previous Work

Lee (1957) wrote a report on the geology and shallow water resources in the southern part of the area, for the State Geological Survey.

Topography and Drainage

The area is in the Coteau du Missouri division of the Great Plains physiographic province (fig. 1), is relatively flat with few depressions. Swan Lake Creek crosses the middle of the area, dividing it into northern and southern parts. The northern upland is approximately 50 feet higher than that to the south. A small elongate hill is present in the southwestern part of the area.

The entire area is fairly well drained, especially the northern half. Swan Lake Creek flows westward and drains the entire area. The major intermittent tributaries flow into Swan Lake Creek.

Geology

Exposed bedrock is either the Cretaceous Fox Hills Formation (Kf?) or is Tertiary in age. A 30-foot exposure occurs in the southwestern corner of Section 8, T. 121 N., R. 74 W., and contains brown, yellow, and green clays and mudstones (shales?). Pelecypods are present. The strata seem to have a slight dip to the northwest.

The Iowan ground moraine (Qwig) has low relief and is devoid of transverse linear features. The till is olive-green to gray when moist, and light-yellowish gray when dry. It has a silt-rich matrix and contains rounded to subrounded fragments of granite, gneiss, and carbonate rocks. The matrix is far more abundant than the coarser material. Pelecypod fossils were found in the till in the southwestern part of the area. The till is leached in places to a depth of 20 inches.

A blanket of loess 0-7 feet thick overlies the Iowan Till. Caliche occurs as coatings on pebbles and as white cement at the base of the loess and in the top of the till. No fossils were found in any of the loess deposits. Much of the loess has been removed from the upland tributaries, thus exposing till.

Outwash deposits (Qo) consist of cobbles, pebbles, cross-bedded sand lenses, and interbedded silt; all of these features suggest strong

current action at the time of deposition. The source area lay to the east, judging from the coarseness and thickness of the outwash deposits along Swan Lake Creek. In Sections 20 and 29, T. 121 N., R. 74 W., the outwash deposits consist predominantly of well-sorted sand and silt. Coarser outwash materials were found near the western margin of the area. Gray limestone and light-gray dolomite are most abundant, followed by granite, black shale, clay-ironstone, basalt, quartzite, and gneiss.

In the northern half of the area the soil is a brown silty loam developed on loess. In the southern half of the area the soil is a dark-brown to black sandy loam.

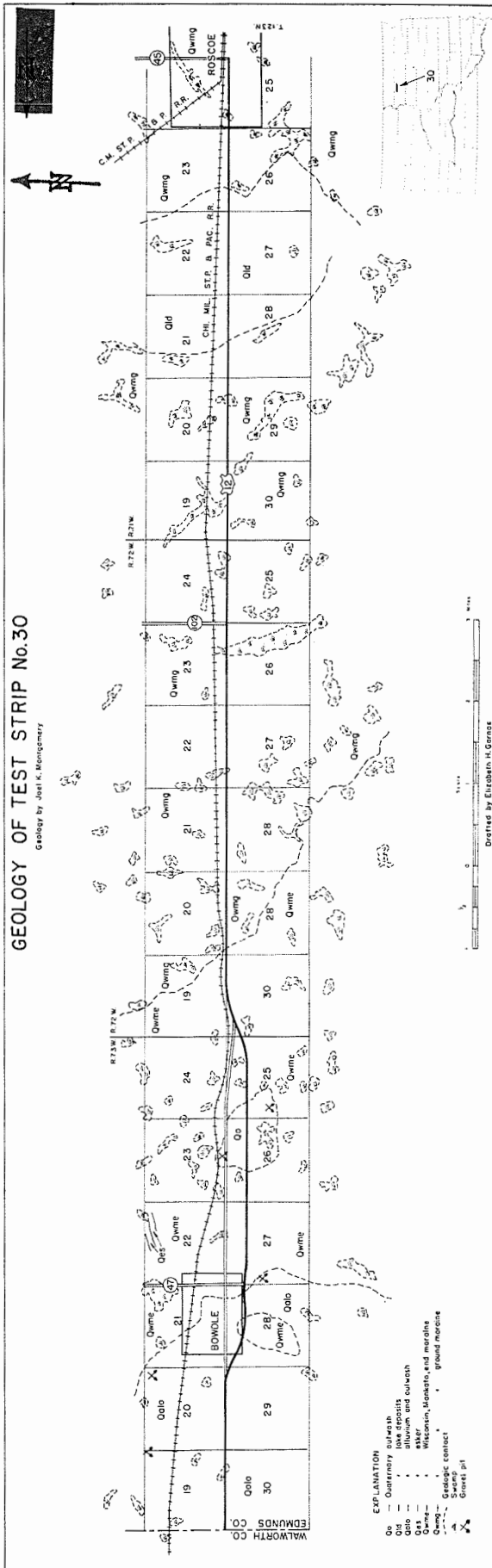
Swan Lake Creek came into being probably at the end of Tazewell time, when much outwash was deposited. In late Cary time, outwash materials were derived from Cary Drift and carried by meltwaters and added to the Iowan outwash deposits; still later Mankato Outwash was deposited along Swan Lake Creek (Flint, 1955, p. 96, 146, 148).

Effect of Geology on Highway

The road is graveled; no repairs were seen.

GEOLOGY OF TEST STRIP No.30

Geology by Just K. Montgomery



EXPLANATION

- Ow — Owens
- Old — Old
- Ed — Ed
- Al — aluminum and outwash
- Sk — silt
- W — water
- M — Manganese, Mn, and nodules
- G — ground moraine
- Geologic contact
- Great pit

Drafted by Elizabeth H. Gansz

GEOLOGY OF TEST STRIP 30

by

Joel K. Montgomery

Location

Test Strip 30 is in the west-central part of Edmunds County. It traverses the Bowdle Hills along U. S. Highway 12 and extends 17.8 miles westward from Roscoe through Bowdle to the Walworth-Edmunds County line. The highway is paralleled by the Chicago, Milwaukee, St. Paul and Pacific Railroad.

Previous Work

Lee (1957) mapped the outwash deposits in the western third of the strip, and Rothrock (1924) mapped outwash and other glacial features of the area, both for the State Geological Survey.

Topography and Drainage

The topography ranges from gently sloping flat land of the James Basin division of the Central Lowland physiographic province (fig. 1) in the east, to an area of ground and end moraines in the central part, which is in the Coteau du Missouri division of the Great Plains physiographic province (fig. 1); the western part is gently sloping flat land also of the Missouri Coteau. The ground moraine has an undulating surface with kettles and sloughs; it grades westward into rough end moraine. The end moraine contains knobby hills and is dotted with numerous kettle holes and erratics. The central moraine belt is a prominent topographic feature known as the Bowdle Hills and was formerly referred to as a part of the Altamont moraine; it is 4-5 miles wide.

The drainage is very poor in the area, especially near Roscoe at the eastern end. Many kettle holes are swampy during much of the summer season.

Geology

The region is made up chiefly of Mankato (Flint, 1955) or Late Cary (Lee, 1957) drift and outwash, with small Recent alluvial deposits along intermittent streams and in some of the kettle holes. A large end moraine (Qwme) passes northward through the area, forming the Bowdle Hills. It represents a vast accumulation of glacial drift at the western margin of the ice sheet. Depressions in the end moraine are much deeper than those in the ground moraine. The local relief in the ground moraine (Qwmg) is only 20 feet, whereas it is at least 30-50 feet in the end moraine area. The ground moraine appears to be nearly flat and is made up of unsystematic swales and swells. Some swales are 1000 feet in diameter and lie 10-20 feet below the swells. Eskers ? (Qes) in Section 22,

T. 123 N., R. 73 W., and other ice contact features exist along the western front of the end moraine (Rothrock, 1924).

An outwash (Qo) deposit of bedded gravel and sand, more than 20 feet thick, represents ice-contact stratified sediments which were laid down not far from the source by rapidly moving meltwaters as the glacier retreated. The gravels are well rounded to subrounded, and are somewhat sorted. Coarse gravels are commonly interbedded with pod-like sand lenses. A 2-foot thick yellowish to dark-brown till or colluvial material was noted above stratified gravel deposits in Section 23, T. 123 N., R. 73 W.

Alluvium (Qalo) consists of laminated clay, silt, and sand along the margin of the outwash deposits in the western part of the area. It consists of dark sand, silt, clay, and transported soil.

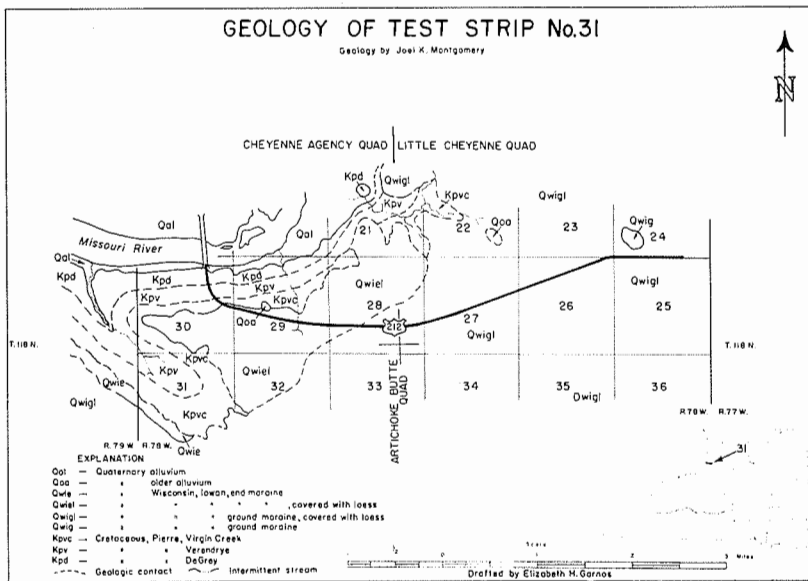
Just west of Roscoe the ground moraine shows as flat land that consists of clayey, silty loams. Some of the sediments appear to be lacustrine (Qld) in origin.

Effect of Geology on Highway

No road repairs were present in the newly built highway strip; it is in excellent condition.

GEOLOGY OF TEST STRIP No.31

Geology by Joel K. Montgomery



GEOLOGY OF TEST STRIP 31

by

Joel K. Montgomery

Location

This test strip lies in west-central Potter County. It extends eastward for a distance of 5.2 miles from the new Missouri River bridge at the abandoned Cheyenne Agency, along U. S. Highway 212.

Previous Work

Flint (1955) mapped the reconnaissance geology of the area. Mickelson (1952a, b) mapped for the State Geological Survey the detailed geology of the Cheyenne Agency and Little Cheyenne quadrangles, which include the highway strip, and Stevens (1952) did the same for the Artichoke Butte quadrangle.

Topography and Drainage

The Missouri Valley Trench is about 290 feet deep below the upland. Steep rugged bluffs and narrow floodplains border the Missouri River. These physical features of the area, which is in the Coteau du Missouri division of the Great Plains physiographic province (fig. 1), are the result of a combination of glaciation, slumping, and subsequent erosion. The steep escarpment along the trench is gullied by several narrow canyons having steep gradients.

The upland is devoid of undrained basins and has a well-integrated drainage pattern. All of the intermittent streams flow westward into the Missouri River. Many small intermittent streams and some springs occur in the steep ravines along the sides of the Missouri Trench.

Geology

Cretaceous bedrock of the Pierre Formation is well exposed in the bluffs of the Missouri River Trench. The DeGrey (Kpd), Verendrye (Kpv), and Virgin Creek (Kpvc) Members crop out in the area.

The Agency facies of the DeGrey Member consists of gray papery hard siliceous shale containing bentonite. It weathers to a light-gray color and into thin flakes. The pelecypod fossil Inoceramus was collected near the base of the new bridge. The Agency facies at Whitlock's Crossing (Cheyenne Agency) contains a 6-inch limestone concretionary bed near the base. The concretions are two feet in diameter, composed of fine-grained gray limestone, contain small brachiopods, and weather brown. This bed of limestone concretions may possibly correlate with the concretionary bed of limestone in the DeGrey near Pierre (Test Strip 1). Smaller concretions 3-6 inches in diameter and 1 inch thick occur near the top of the Agency facies. The Agency facies is believed by the writer to be equivalent to the lower part of the Oacoma facies near Chamberlain.

The Oacoma facies of the DeGrey Member overlies the Agency facies and is probably less than 50 feet thick. It consists of dark-gray shale with abundant iron-manganese concretions which have unaltered centers of greenish-brown to gray shale. Contacts are poor because of overlying boulders and slumped material from above.

The Verendrye (Kpv) Member consists of a brown to gray clay or shale which weathers to a gumbo. Small iron-manganese concretions are abundant.

Near the rim of the Missouri River Trench, lower beds of the Virgin Creek (Kpvc) Member are exposed in Sections 31 and 32, T. 118 N., R. 78 W. The member consists of a dark-gray to black shale or mudstone containing bentonite beds and fossil Baculites.

A small Iowan end moraine (Qwie) devoid of loess cover occurs along the rim of the trench in the western part of the area (Sec. 31, T. 118 N., R. 78 W.), although it is loess-covered elsewhere (Qwiel). A sheet of Iowan Drift is wide-spread as ground moraine (Qwig, Qwigl) over the pre-glacial erosion surface of the Pierre Shale in the upland region of the eastern part of the area. The till is composed of abundant pebbles and some boulders scattered throughout a silty, clay-rich matrix having a medium-gray to yellowish-brown color. Rocks in the till are predominantly granite, limestone, dolomite, and fragments of Pierre Shale.

Loess averaging 3-5 feet in thickness mantles most of the drift sheet with the exception of some of the end moraine ridges. In Section 30, T. 118 N., R. 78 W. is a 7-foot section of loess overlying 10 feet of ferruginous-cemented conglomerate.

A large alluvial deposit (Qal) of sand occurs in the floodplain adjacent to the Missouri River channel. Older sand deposits (Qoa) were found as patches in the bluffs along the Missouri River Trench.

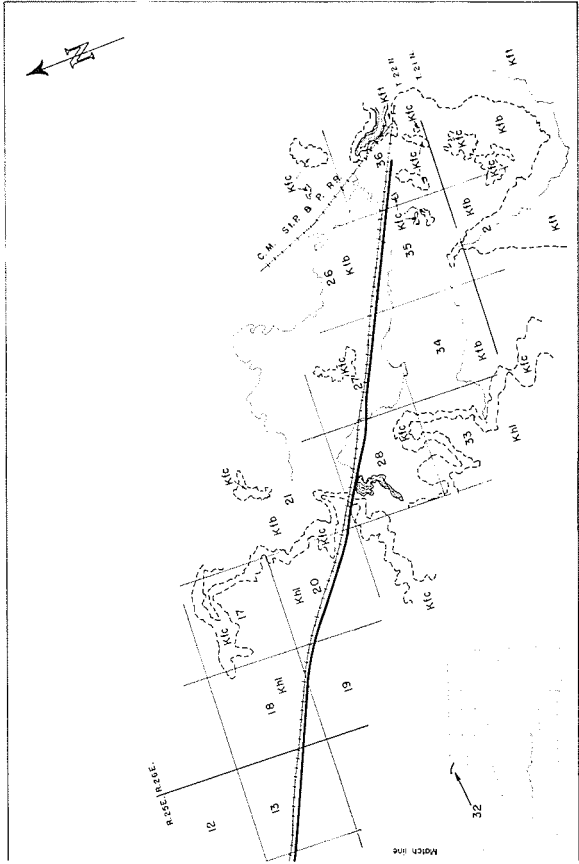
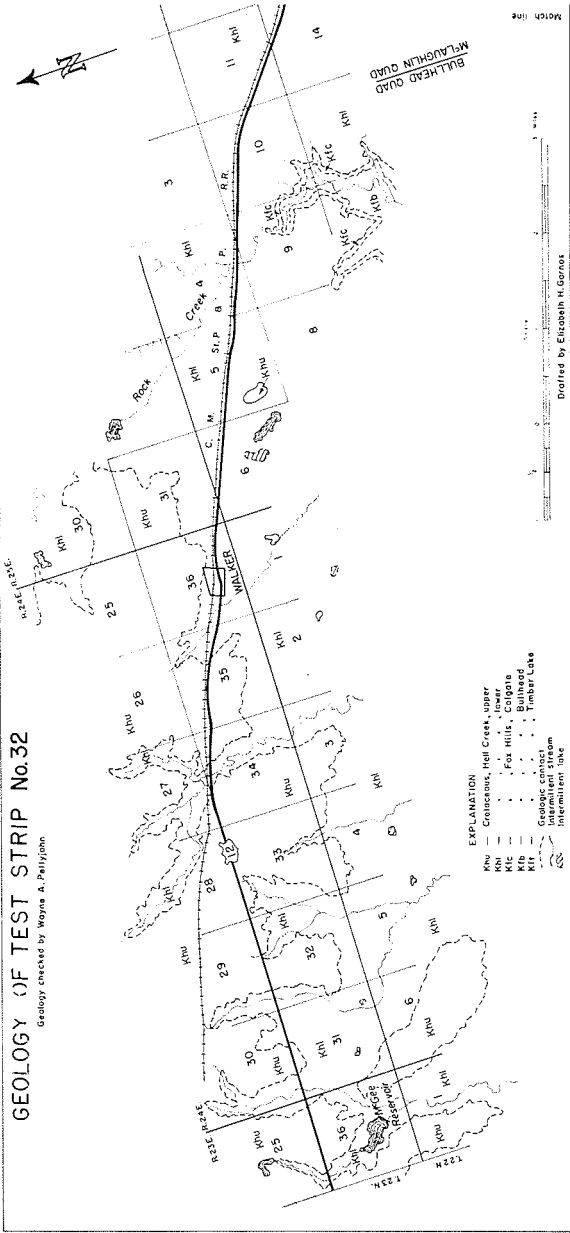
Extensive slumping has occurred in the Pierre Shale along the bluffs of the Missouri River Trench, but was not mapped separately. Some places in the sides of the Missouri River Trench have concave surfaces along which slump movements have taken place. One slump block of Virgin Creek Shale in Section 29, T. 118 N., R. 78 W. is tilted down in a N 39° E direction.

Effect of Geology on Highway

No highway repairs occur along this new highway strip.

GEOLOGY OF TEST STRIP No.32

Geology checked by Wayne A. Pelizzoni



GEOLOGY OF TEST STRIP 32

by

Wayne A. Pettyjohn

Location and Topography

Test Strip 32 is located in northern Corson County. It is a 16.033-mile strip along U. S. Highway 12. This area, in the Cretaceous Tableland of the Missouri Plateau division of the Great Plains physiographic province (fig. 1), is gently rolling with maximum relief of about 230 feet. It is well drained.

Geologic Formations Present

The geology was mapped by R. E. Stevenson (1956a, 1957b) for the State Geological Survey. The Bullhead and Colgate Members of the Cretaceous Fox Hills Formation are present near the southeastern end of this strip, but the Hell Creek Formation is the dominant one.

Fox Hills Formation

(Timber Lake Member, Kft)

The Timber Lake Member is cross-bedded buff to light-gray medium- to fine-grained sand that is locally silty. It contains numerous nodular concretions of fossiliferous iron-cemented sandstone, and is more than 80 feet thick.

(Bullhead Member, Kfb)

The Bullhead Member is composed of alternating thin beds of buff slightly bentonitic sandstone, siltstone and clay, and attains a thickness of about 130 feet.

(Colgate Member, Kfc)

The Colgate Member is white to gray fine- to medium-grained gray-wacke. Some cross-bedding and ripple marks are present. This member varies between 8 and 18 feet in thickness.

Hell Creek Formation

(Lower Hell Creek Unit, Khl)

This unit is composed of lensing medium- to dark-gray bentonitic clays, silts, sands, and thin peat-clay beds. Throughout these 50 feet of strata are scattered dinosaur bones.

(Upper Hell Creek Unit, Khu)

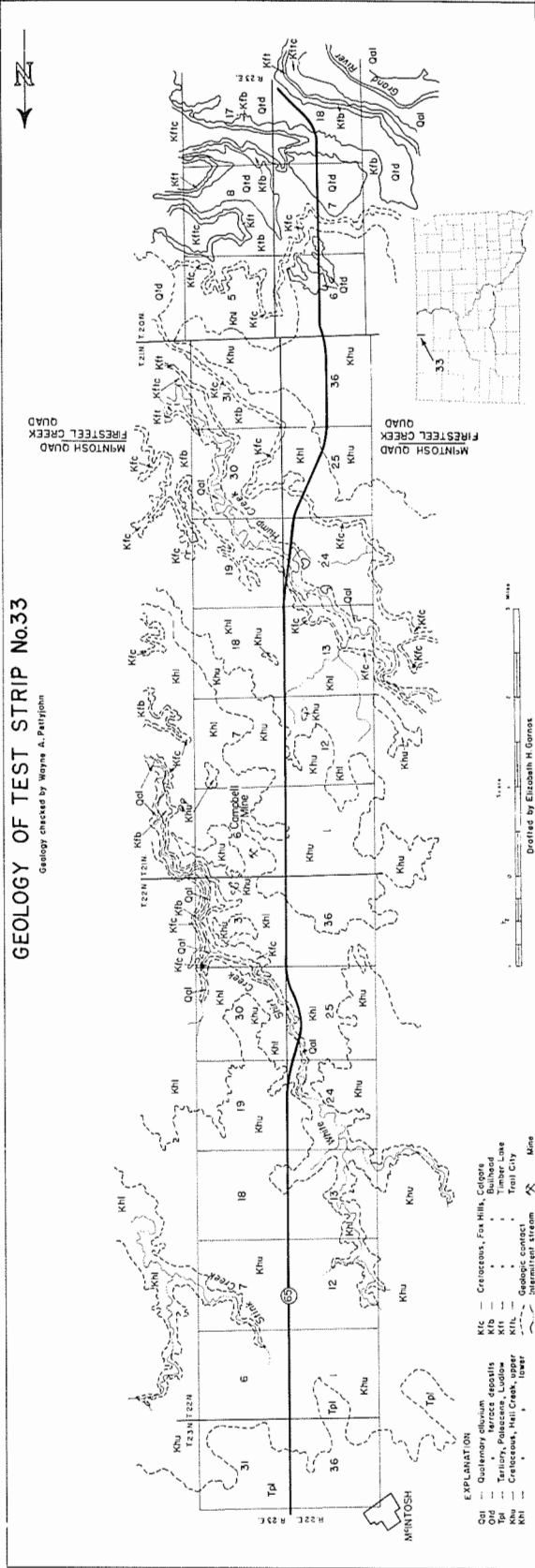
The upper Hell Creek is composed of lensing units of bentonitic clays, fine-grained slightly bentonitic graywacke and arkosic sands, silt, and sandy clay. Some layers of ferruginous concretions may be present.

Road Condition

This highway is in very good condition (summer, 1960). A few patches of repair work have been completed where the highway crosses alluvium in depressions and also over culverts. No evidence of slumping or heaving was noted.

GEOLOGY OF TEST STRIP No.33

Geology checked by Wayne A. Patterson



- EXPLANATION**
- Oqd --- Quaternary alluvium
 - Old --- Terraces, Paleocene, Ludlow
 - Tpl --- Tertiary, Paleocene, Ludlow
 - Kfb --- Cretaceous, Fox Hills, Cadogan
 - Kfc --- Cretaceous, Fox Hills, Cadogan
 - Kft --- Cretaceous, Fox Hills, Cadogan
 - Kfi --- Cretaceous, Fox Hills, Cadogan
 - Kk --- Cretaceous, Fox Hills, Cadogan
 - Kkh --- Cretaceous, Fox Hills, Cadogan
 - Kki --- Cretaceous, Fox Hills, Cadogan
 - Kkl --- Cretaceous, Fox Hills, Cadogan
 - Kkm --- Cretaceous, Fox Hills, Cadogan
 - Kkn --- Cretaceous, Fox Hills, Cadogan
 - Kku --- Cretaceous, Fox Hills, Cadogan
 - Kkv --- Cretaceous, Fox Hills, Cadogan
 - Kkw --- Cretaceous, Fox Hills, Cadogan
 - Kkx --- Cretaceous, Fox Hills, Cadogan
 - Kky --- Cretaceous, Fox Hills, Cadogan
 - Kkz --- Cretaceous, Fox Hills, Cadogan
- Geologic contact
 --- Hermitian stream
 --- Mine



Drafted by Elizabeth H. Gannax

GEOLOGY OF TEST STRIP 33

by

Wayne A. Pettyjohn

Location and Topography

Test Strip 33 is located in Corson County from McIntosh south to the Grand River, in the Cretaceous Tableland of the Missouri Plateau division of the Great Plains physiographic province (fig. 1). It is a 20.082-mile strip along State Route 65. This area is gently rolling with a maximum relief of about 220 feet, and is well drained.

Geologic Formations Present

The Bullhead and Colgate Members of the Cretaceous Fox Hills Formation are present near the southern end of the strip, according to Stevenson (1957a) and Curtiss (1954), who mapped the area for the State Geological Survey. The Hell Creek Formation, which includes the Isabel-Firesteel coal, is the dominant one of this highway strip. The Tertiary Ludlow Formation is present at the extreme northern part of the strip. Gravel terraces (Qtd) and stream alluvium (Qal) are also present.

Fox Hills Formation

(Trail City Member, Kftc)

The Trail City Member consists of thin beds of gray bentonitic silty clay with thin streaks of sand. It is as much as 80 feet thick.

(Timber Lake Member, Kft)

The Timber Lake Member is cross-bedded buff to light-gray medium to fine-grained sand that is locally silty. It contains numerous nodular concretions of fossiliferous iron-cemented sandstone, and is more than 80 feet thick.

(Bullhead Member, Kfv)

The Bullhead Member is composed of alternating thin beds of buff slightly bentonitic sandstone, siltstone, and clay, and attains a thickness of about 130 feet.

(Colgate Member, Kfc)

This member rims the lower reaches of Hump Creek and Grand River valleys. The Colgate Member is white to gray fine- to medium-grained graywacke. Some cross-bedding and ripple marks are present. This member varies between 2 and 15 feet in thickness.

Hell Creek Formation

(Lower Hell Creek Unit, Kh1)

This unit is composed of lensing medium- to dark-gray bentonitic clays, silts, sands, and thin peat-clay beds. Throughout these 60 feet of strata are scattered dinosaur bones.

The Isabel-Firesteel coal, which divides the Hell Creek Formation, is composed of black subbituminous coal, lignite, brown peat-clay, and a red to buff burned claystone. The coal varies between zero and six feet.

(Upper Hell Creek Unit, Khu)

The upper Hell Creek unit is composed of lensing bentonitic clay, fine-grained slightly bentonitic graywacke and arkosic sand, silt, and sandy clay. Some layers of ferruginous concretions may be present. The unit is 80 feet thick.

Ludlow Formation (Tp1)

The Ludlow Formation is composed of interbedded fine arkosic sands, "salt and pepper" graywacke sands, and brown to gray slightly bentonitic clays. Some interbedded lignites are also present. The Ludlow is 65-160 feet thick.

Terrace Gravels (Qtd)

Clay, sandy clay, silt, sand, and gravel were deposited during the down-cutting of the Grand River. This material lies some distance above the present river valley.

Alluvium (Qal)

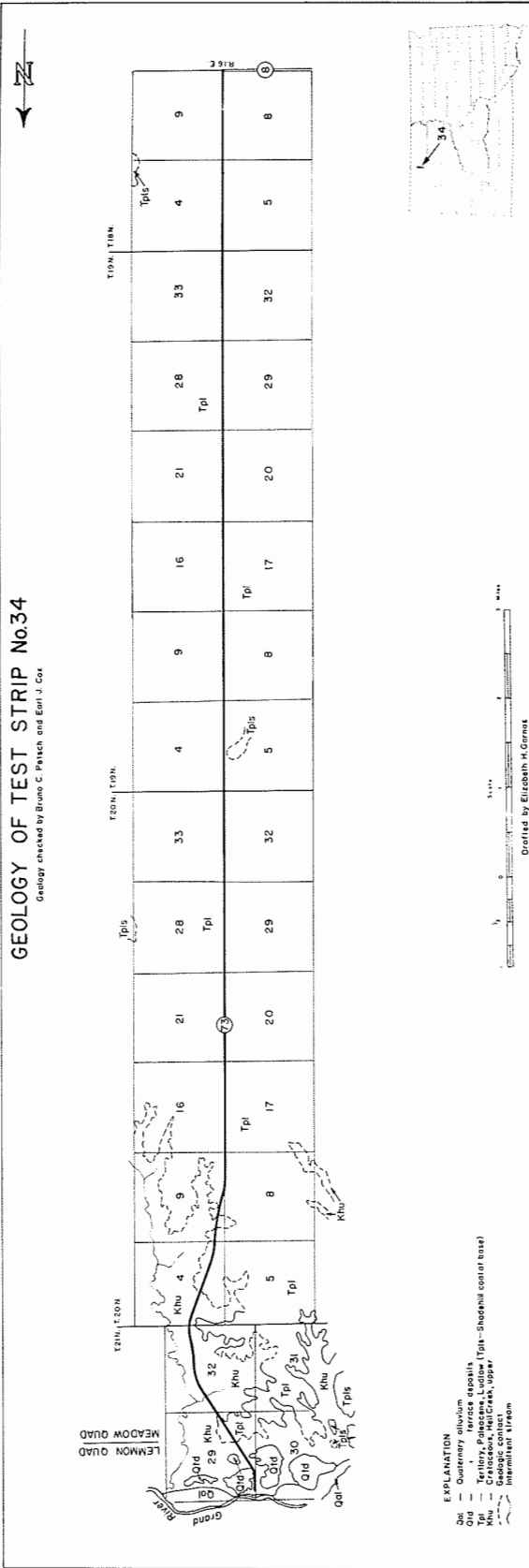
Recent floodplain deposits of clay, silt, and sand are present along the existing channel of the Grand River and Hump Creek.

Road Condition

This highway is in excellent condition (summer, 1960). A few small patches of repair work have been completed where the highway crosses alluvium in depressions and also over culverts. No evidence of slumping or heaving was noted.

GEOLOGY OF TEST STRIP No.34

Geology checked by Bruno C. Patzsch and Earl J. Cox



GEOLOGY OF TEST STRIP 34

by

Earl J. Cox

Location

Test Strip 34 includes 16.052 miles of State Route 73 in Perkins County from the Grand River southward to the junction of State Routes 73 and 8. The strip is in the Cretaceous Tableland of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geologic Formations Present

The geology was mapped by Stevenson (1954), and Bolin (1955), for the State Geological Survey. Geological formations present on this strip are the upper Hell Creek, the Ludlow, and terrace deposits, and alluvium.

Upper Hell Creek (Khu)

The upper Hell Creek consists principally of light- to dark-gray bentonitic clay and argillaceous silt. Most exposures show the typical "somber" colors of the Hell Creek. Lenticular coal beds are present in the gray clay. Horizons of large, flattened calcareous concretions form discontinuous ledges in steep exposures, and numerous zones of manganese-iron concretions are present.

Ludlow (Tpl)

The Ludlow is made up of sand, silt, and silty-clay. In places the sand has been consolidated into hard, calcareous sandstone lenses. Near the base of the formation as many as five thin coal beds are present. The maximum thickness of any coal bed is usually not more than 30 inches. Associated with the coal is gray clay, peat-clay, "blackjack", and in places argillaceous silt. The maximum thickness of the Ludlow in this area is estimated at 120 feet.

Terrace Deposits (Qtd)

Along the Grand River are a number of terraces capped by fine to coarse sand, some silt and local pebble conglomerate. This capping ranges from a thin veneer to about four feet in thickness.

Alluvium

Alluvial material (Qal) is present in the river bottoms and low terraces (Qtd) of the Grand River Valley.

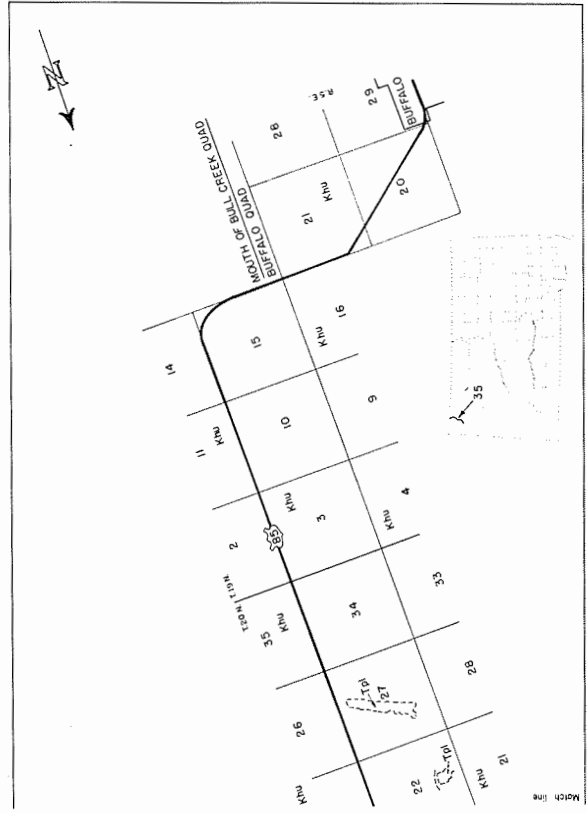
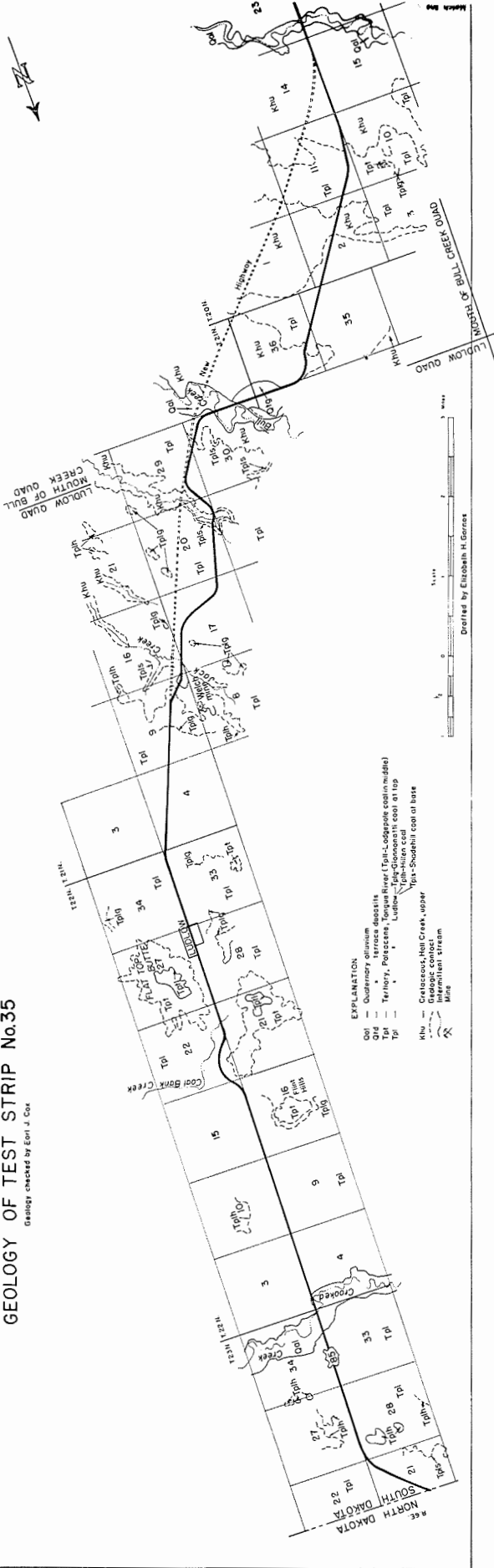
Road Condition

The general surface condition of the road is good (summer, 1960). No trouble spots were noted nor had there been any extensive patching done on the road.

The shoulders of the road are wide and surfaced, which gives more support to loads, and tends to prevent water from seeping under the road mat and resulting in failures.

GEOLOGY OF TEST STRIP No.35

Geology checked by Earl J. Cox



GEOLOGY OF TEST STRIP 35

by

Earl J. Cox

Location

Test Strip 35 covers 30.04 miles of U. S. Highway 85 in Harding County between the town of Buffalo and the North Dakota State line. The strip is in the Cretaceous Tableland of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geologic Formations Present

Geological formations present on this strip are the Hell Creek, Ludlow, Tongue River, and terrace gravel and alluvium, according to Erickson (1956), Petsch (1956), and Stevenson (1956b), who mapped the area for the State Geological Survey.

Hell Creek (Khu)

The Hell Creek consists of light- and dark-gray bentonitic clay or mudstone, yellowish-gray and light-gray bentonitic clay and silt, dark-gray and greenish-gray graywacke, local thin lignites, peat clay and carbonaceous shale. Abundant rusty and black iron-manganese concretions are present and weather out in gravel-size chunks.

Ludlow (Tpl)

The Ludlow is characterized by a series of lensing and interfingering sandy sediments and associated lignitic facies. It is dominantly cross-bedded, white to buff, fine- to medium-grained, clayey or silty, subgraywacke sand. Interlensing with the sand are bentonitic silt and clay. Scattered throughout the sand are reddish-yellow limonitic concretions.

At the base of the Ludlow is the Shadehill facies (Tpls), which contains as many as nine seams of lignite coal. The seams are separated by sand, silt, and clay.

Approximately 140 feet above the Shadehill is the Hillen facies (Tplh). This facies contains three to five seams of lignite coal that are separated by clays.

Fifty feet above the Hillen is the Giannonatti facies (Tplg). It is a series of interbedded clays that contain one to five seams of lignite coal.

Tongue River (Tpt)

The Tongue River is characterized by upper and lower massive sandstones that are light-colored, calcareous, and subgraywacke. About 140 feet above the base of the Tongue River is the Lodgepole facies (Tptl), which contains one to three seams of uraniferous lignite.

Terrace Gravel (Qtd)

The terrace gravels are coarse and consist of concretionary material, chert, and sandstone chunks. The gravels may be as much as six feet thick.

Alluvium (Qal)

The alluvium consists of recent accumulations of silt, sand, gravel and clayey stream deposits.

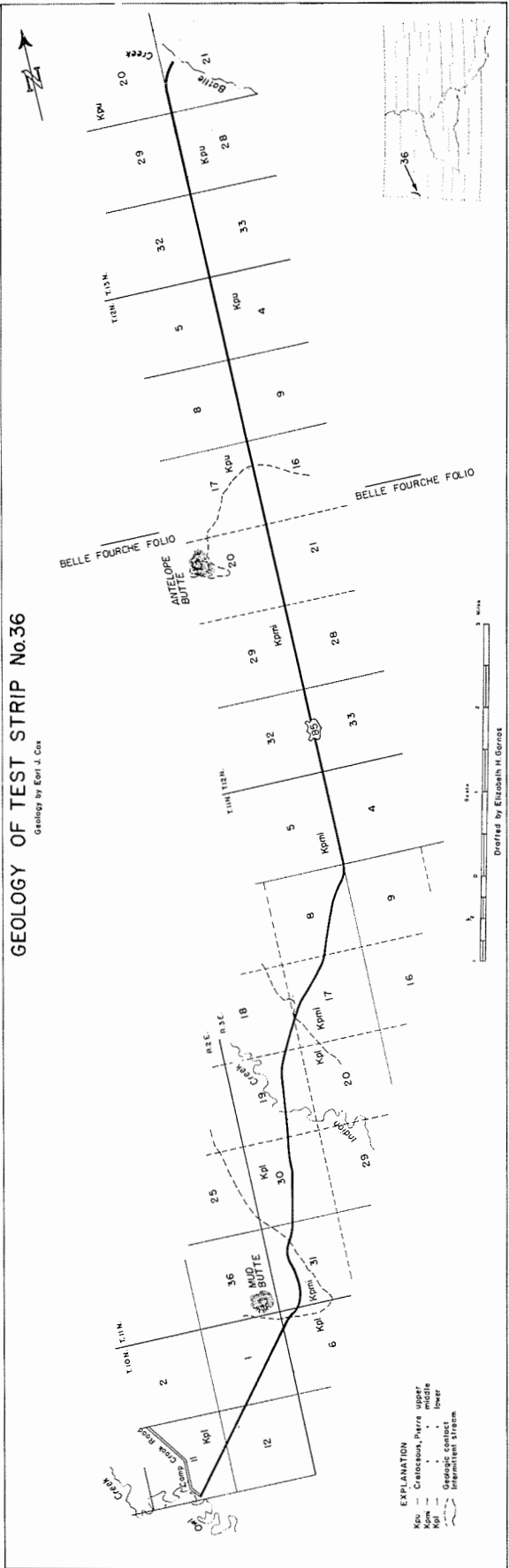
Road Condition

A four-mile section of road, from three to seven miles northeast of Buffalo, shows numerous failures of the east shoulder (summer, 1960). In examining this stretch it was found that the "center line" was not centered, but was closer to the east shoulder. Where the east shoulder had failed the east lane was only nine feet wide while the west lane was twelve feet wide. The narrow east lane, which caused traffic to drive on the thin edge of the pavement, undoubtedly was a factor in the shoulder failure. A contributing factor may have been numerous north-bound trucks hauling heavy loads of cement from Rapid City. The road seems to be holding up adequately except for the failures noted above.

At the time the geology of the project was studied (September, 1960), a twelve-mile stretch of new road was in the process of construction. The new construction begins seven miles from Buffalo and ends at Ludlow. The approximate location of the new highway is indicated on the map.

GEOLOGY OF TEST STRIP No.36

Geology by Earl J. Cox



EXPLANATION
 Kpu — Cretaceous, Pierre upper
 — middle
 — lower
 Kpm — Cretaceous, Pierre lower
 ——— Geologic contact
 - - - - Intermittent stream

Drawn by Elizabeth H. Dennis

GEOLOGY OF TEST STRIP 36

by

Earl J. Cox

Location

Test Strip 36 begins at the junction of U. S. Highway 85 and the Camp Crook road north of Belle Fourche in Butte County, and continues north for 17.708 miles to Battle Creek. It is in the Pierre Hills of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geological Formations Present

Reconnaissance geologic mapping was done by Darton and O'Harra (1909), in the southern two-thirds of this strip. Only one formation, the Pierre, is present on this project. The Pierre Shale has been here divided into three separate (unnamed) members which are shown on the map. The contacts between the mapped units of the Pierre are transitional, and were chosen because of their position about midway between two distinctly different lithologies.

Lower Pierre Unit (Kpl)

The shale of the lower unit is dark gray in color but may be brownish gray to silver gray on weathered surfaces. Horizontal and vertical cracks within the shale are locally stained brown, presumably by iron oxide, as are numerous veinlets of selenite. The shale is hard and brittle when dry but changes rapidly to a sticky gumbo when moistened. Occasional thin, reddish-brown limestone concretions and plates are present in this member. It is about 400 feet thick.

Middle Pierre Unit (Kpmi)

The middle unit takes up approximately the middle half of the formation, and is about 900 feet thick. This shale is gray in color and is locally very calcareous. Limestone and claystone concretions are common, as are fossil Baculites and Inoceramus. Some bentonite beds occur in this unit but they are not characteristic or diagnostic.

Upper Pierre Unit (Kpu)

The upper unit usually includes the upper one-fourth of the formation in western South Dakota. The shale is dark gray in color and contains abundant reddish-brown coated concretions and gypsum crystals. The concretions are gray, calcareous, septarian, usually with cephalopods and gastropods; they range from six inches to two feet in diameter. Usually

a fossil zone of pelecypods occurs near the base of this unit, with a barren zone extending above the fossil zone to the top of the formation. The upper unit of the Pierre is usually noncalcareous, and is approximately 400 feet thick.

Antelope Butte, underlain by the upper Pierre unit, is veneered with blocks of younger sandstone (probably Tongue River or Ludlow), which have been let down.

In this area the total thickness of the Pierre Formation is approximately 1700 feet.

Road Condition

The road has been patched extensively over its entire length. The area four to five miles from the southern end seems to be giving the most trouble. The southern end of the test strip lies on the lower unit of the Pierre Formation, which contains abundant bentonite beds. The amount of repair work on roads over the Pierre Shale seems to be proportional to the number of bentonite beds in the shale. The bentonite may range from microscopic coverings on the shale plates, up to beds several feet thick.

Recommendation

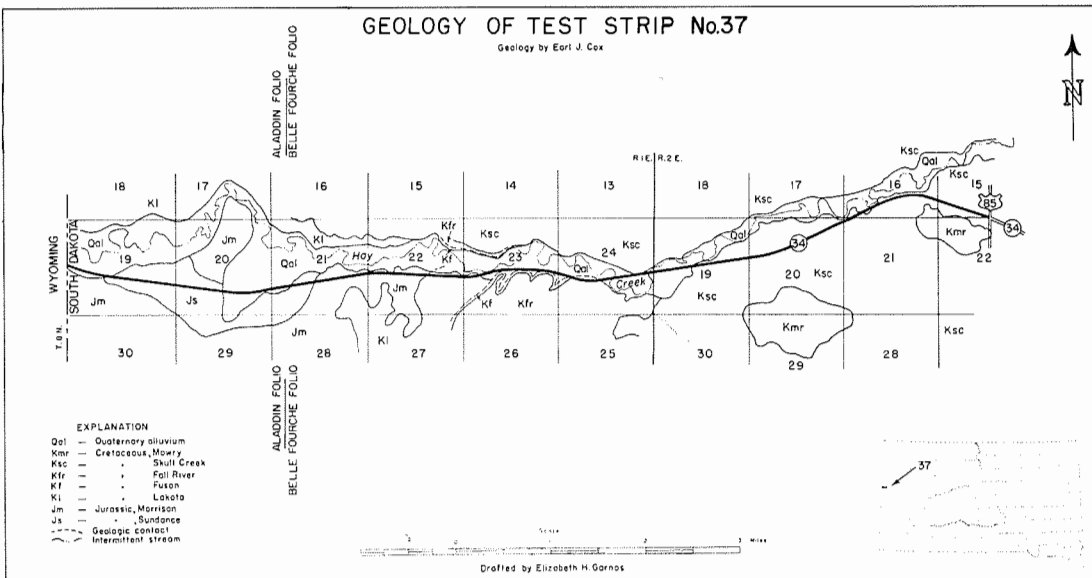
The building of stable roads over bentonitic shales continues to present a major problem in most of western South Dakota. The maintenance of these roads is expensive because of failure caused by the bentonite in the roadbed absorbing large amounts of moisture, which results in heaving or depression caused by plastic flow and accompanying changes in volume.

One approach to the problem might be to destroy the bentonite characteristic which allows it to absorb many times its own volume of water. Sodium chloride (common table salt) has this ability. It should be possible to mix sodium chloride with the water used during construction. Another possibility might be to include dry salt in the sand and gravel used in construction.

Experiments by the Soils Laboratory of the State Department of Highways would be necessary to determine feasibility, the ratio of salt to be used, and the manner of introducing the salt. The salt would tend to decrease vegetation on the shoulders and in the ditches, and would thus lead to more rapid erosion. Spraying a coating of road oil on the shoulders, and lowering the angle of slope might eliminate this objection. Seeding of the shoulders with grass which has an affinity for salt may also help solve this problem.

GEOLOGY OF TEST STRIP No.37

Geology by Earl J. Cox



GEOLOGY OF TEST STRIP 37

by

Earl J. Cox

Location

Test Strip 37 includes 9.851 miles of State Route 34 in Butte County from the Wyoming State line eastward to the junction with U. S. Highway 85 south of Belle Fourche. It is in the fringe of the Black Hills and the Missouri Plateau divisions of the Great Plains physiographic province (fig. 1).

Geological Formations Present

Geological formations present along this strip are the Sundance, Morrison, Lakota, Fuson, Fall River, Skull Creek, Mowry, and Recent alluvium. Reconnaissance geologic mapping of the area including this strip was done by Darton and O'Harra (1905, 1909).

Sundance (Js)

Sandstone and shale make up most of the Sundance. The sandstone is gray, yellow, or maroon in color, and may be tightly or loosely cemented. Alternating with the sandstone are layers of gray, fissile, and usually calcareous shale. Thin beds of limestone occur throughout the formation.

Morrison (Jm)

Varicolored shale with intermittent sandstone and limestone layers make up the Morrison Formation. Greenish-gray shale is typical of the unit, and most of the Morrison is calcareous.

Lakota (Kl)

The Lakota is a hard coarse-grained cross-bedded gray sandstone. The thick massive sandstone layers are separated by thin layers of shale, clay, and locally coal. The thickness of the Lakota along this strip is about 115 feet.

Fuson (Kf)

The Fuson usually forms a noticeable topographic depression between the more resistant Fall River Sandstone above and the Lakota Sandstone below. It consists of alternating variegated shale and fine to coarse-grained sandstone. Commonly a sequence of massive fireclay at the top, soft and poorly sorted pink sandstone near the middle, and buff-colored

clay at the bottom is present in the Fuson. Locally an additional layer of black carbonaceous shale occurs at the top of the Fuson, directly beneath the basal Fall River Sandstone. The Fuson is about 40 feet thick on this project.

Fall River (Kfr)

Along this strip, the Fall River Formation can be divided into three main parts. The lower part is 50 feet thick; it and the upper part, which is about 25 feet thick, are mostly nonresistant units consisting mainly of dark-gray fissile siltstone and silty shale interbedded with light gray thin-bedded siltstone and fine-grained sandstone.

Separating the upper and lower parts of the Fall River is a massive cliff-forming sandstone unit that has been called the Keyhole Sandstone Member of the Fall River Formation (Davis and Izett, 1958). In the Belle Fourche area the Keyhole Member is about 30 feet thick. The member is light- to medium-brown, fine-grained, cross-stratified and contains iron-cemented concretions and gray calcareous concretions. The Fall River is about 105 feet thick along this strip.

Skull Creek (Ksc)

The Skull Creek Shale consists of dark-gray to black clayey shale containing basal sandy lenses and limestone concretions. Outcrops are usually rare as the member is normally "grassed over". The finely disseminated bentonite particles in the shale cause it to become greasy when wet.

Newcastle

The Newcastle Sand normally is present between the Mowry Shale and the Skull Creek Shale. However, the Newcastle could not be identified on this strip. At the east end of the project and south of the highway are a number of sandstone dikes. The dikes are probably derived from the Newcastle Member by being squeezed into fractures in the overlying and underlying shales (Petsch, 1949).

Mowry (Kmr)

The Mowry Formation is a hard siliceous silver-gray shale. The shale contains fish scales. Oak or pine trees usually grow on the Mowry. This shale does not decompose to gumbo when wet.

Alluvium (Qal)

The alluvium consists of sand, gravel and silt deposited by the present streams. It merges into the slope-wash material on the sides of the valleys, making it difficult to define the boundaries.

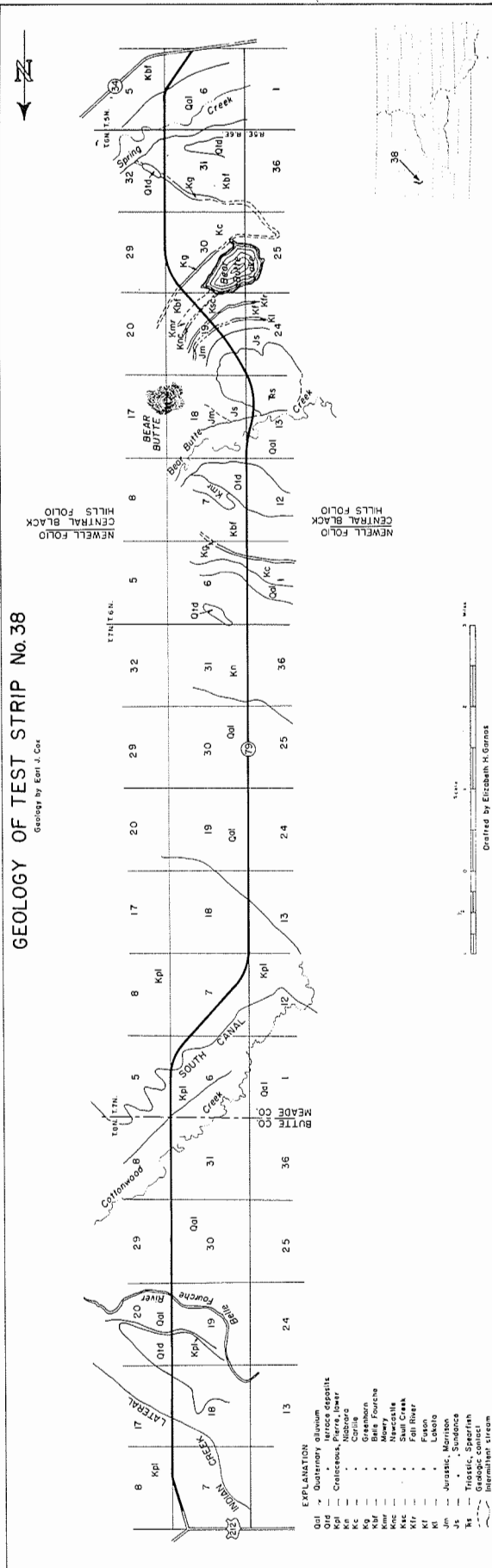
Road Condition

The general surface condition of the road is good (summer, 1959). No trouble spots were noted, nor had any extensive patching been done.

Where the Morrison Formation forms the shoulders of the road, they tend to wash and erode readily. To retard this, a coating of sprayed road oil might be used, and seeding of the shoulders may help eliminate the problem.

GEOLOGY OF TEST STRIP No. 38

Geology by Earl J. Cox



- EXPLANATION**
- Qal Quaternary alluvium
 - Qld Quaternary dune deposits
 - Kpl Pleistocene
 - Kc Cretaceous
 - Kk Cambrian
 - Kf Devonian
 - Ks Silurian
 - Kt Ordovician
 - Kx Devonian
 - Kz Devonian
 - K1 Devonian
 - K2 Devonian
 - K3 Devonian
 - K4 Devonian
 - K5 Devonian
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 - K99 Devonian
 - K100 Devonian

Scale: 1 inch = 1 mile
 Prepared by Elizabeth H. Garros

GEOLOGY OF TEST STRIP 38

by

Earl J. Cox

Location

Test Strip 38 includes the 18.427 miles of State Route 79 between its junction with State Route 34 and its junction with U. S. Highway 212. The strip crosses from the foothills of the Black Hills onto the Pierre Hills subdivision of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geological Formations Present

A reconnaissance geological survey was made by Darton (1919) and by Darton and Paige (1925).

Spearfish (Trs)

This formation usually appears as a well-drained lowland except where it is capped by a hard gypsum bed. The Spearfish consists mostly of red sandy shale but has layers of sandstone and gypsum, with gypsum being more abundant. A persistent gypsum bed as much as 25 feet thick occurs near the top of the formation, and is a good marker bed.

Sundance (Js)

Sandstones and shales make up most of the Sundance. The sandstone may be gray, yellow, or maroon in color, and may be tightly or loosely cemented. Alternating with the sandstone are layers of gray, fissile, and usually calcareous shales. Thin beds of limestone occur throughout the formation, the most striking of which is a ledge of almost solid oyster shells occurring near the top of the formation. The Sundance is about 305 feet thick on this project.

Morrison (Jm)

Varicolored shales with intermittent sandstone and limestone layers make up the Morrison Formation. Greenish-gray shales are typical of the unit and are recognizable in outcrop areas. Most of the Morrison is calcareous.

Lakota (Kl)

The Lakota is a hard coarse-grained cross-bedded gray sandstone. Thick massive sandstone layers are separated by thin layers of shale, clay, and locally coal. The thickness of the Lakota along this strip is about 115 feet.

Fuson (Kf)

The Fuson commonly forms a noticeable depression between the more resistant Dakota Sandstone above and the Lakota Sandstone below. It consists of alternating variegated shales and fine- to coarse-grained sandstones. Commonly a three-fold sequence of massive fireclay at the top, soft and poorly sorted pink sandstone near the middle, and buff-colored clay at the bottom is present. Locally an additional layer of black carbonaceous shale occurs at the top of the Fuson, directly beneath the basal Fall River sands. The Fuson is about 50 feet thick along this strip.

Fall River (Kfr)

The Fall River is a gray to buff sandstone that weathers brown on the outcrop. It can usually be divided into an upper member of brown, slabby sandstone containing small iron-carbonate pellets and a lower, more massive member that weathers dark red and forms steep cliffs. The thickness of the Fall River in the western part of the State varies from 60 to 160 feet.

Skull Creek (Ksc)

The Skull Creek Shale consists of dark-gray to black clayey shale containing basal sandy lenses and limestone concretions. It usually forms a valley between the more resistant Newcastle above and Fall River Sandstone below.

Newcastle (Knc)

The Newcastle Sandstone is a thin and intermittent unit ranging up to 20 feet thick. It is a gray to buff quartz sandstone that weathers tan to reddish brown on the outcrop. Some of the sandstone layers are separated by carbonaceous shale or bentonitic clay layers.

Mowry (Kmr)

The Mowry Shale is a hard dark-gray siliceous shale containing thin beds of fine-grained sandstone and bentonite. The persistent Clayspur bentonite bed occurs near the top of the formation. The Mowry weathers to hard, light-gray to silvery-gray plates and is commonly covered by a growth of trees in contrast to the grasslands on the adjacent shales. The formation is marked by low inconspicuous ridges.

Belle Fourche (Kbf)

The Belle Fourche Formation is a dark bluish-gray marine shale. The upper part of the formation is less bentonitic than the lower. Numerous thin bentonite beds occur throughout the formation, as do abundant ferruginous and calcareous concretions. A layer of large ironstone concretions occurs at the approximate contact with the underlying Mowry Shale.

Greenhorn (Kg)

Thin limestone layers with thick calcareous shale partings make up the Greenhorn Formation. It usually forms ridges, in contrast to the shale topography of the Carlile above and the Belle Fourche below. The outcrop weathers buff from its original gray color. This formation is 25 to 30 feet thick.

Carlile (Kc)

The Carlile varies from 600 to 800 feet in thickness. Usually the following three-fold division can be applied to the formation.

The upper Carlile is a dark-gray shale containing numerous calcareous concretions. These concretions are badly cracked and in the cracks are brown veins of crystalline calcite.

The middle Carlile is also a dark-gray shale but the concretions are typically ferruginous. Several sandy layers and large sandy concretions occur in this middle zone.

The lower Carlile consists of a dark-gray fissile shale with occasional siltstone and sandstone streaks. Large limestone concretions occur at some horizons but these are seldom continuous. The only bentonite bed seen in the Carlile is in this lower unit but it is doubtful if this bed is persistent or characteristic of the zone.

Niobrara (Kn)

The Niobrara is a chalky calcareous shale that is dark gray on the fresh surface, but weathers to a light gray, brown, or white. This formation erodes easily and its outcrop is therefore usually in a valley or a well-drained lowland. The formation is about 200 feet thick.

Lower Pierre (Kpl)

The shale is fissile, thin bedded, grayish brown, noncalcareous, and contains a few fossils. In places the bedding planes are stained brown.

Gravel Terrace (Qtd)

The terrace deposits are mainly sands, silts, gravels and boulders which were deposited by streams that have since cut their valleys to lower levels.

Alluvium (Qal)

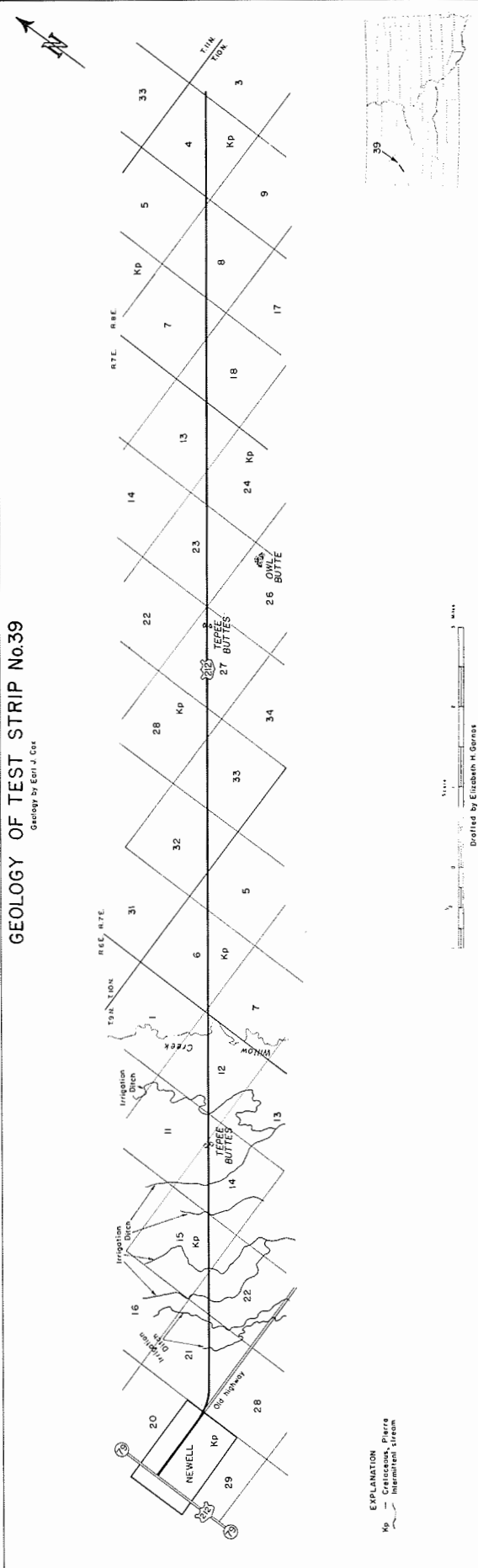
The alluvium consists of sand, gravel, silt and clay, deposited by the present streams. It merges into the slopewash (colluvium) on the walls of the valleys, making it difficult to define the boundary.

Road Condition

The surface is in excellent shape and the shoulders are holding up well. No patching or failures were noticed on the project.

GEOLOGY OF TEST STRIP No.39

Geology by Earl J. Cox



EXPLANATION
 Kp — Cretaceous Pierre
 M — Missouri

Scale: 0 1 2 3 4 5 6 7 8 9 10 Miles
 Drafted by Elizabeth H. Gores

GEOLOGY OF TEST STRIP 39

by

Earl J. Cox

Location

Strip 39 starts at Newell in Butte County and continues northeast along U. S. Highway 212 for 17.26 miles. The strip is in the Pierre Hills of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geological Formations Present

The middle part of the Pierre Shale underlies all of the project. A reconnaissance geological survey was made by Darton (1919).

Pierre Shale (Kp)

The formation consists of a succession of dark-gray to black shales containing concretions and occasional fossils. Many of the concretions are oval and up to 12 inches in diameter, and are either gray or brown in color.

A thick zone of fossiliferous cream-colored porous concretions containing Lucina occidentalis occurs between Stations 217 + 00 and 219 + 00 (Sec. 14, T. 9 N., R. 6 E.). The shale weathers away from these concretions leaving small conical hills called "tepee buttes". The buttes are commonly capped with the limestone masses. The main "tepee butte" zone occurs about 1000 feet above the base of the Pierre Shale.

A sparse zone of "tepee buttes" occurs near Station 571 + 00 (Sec. 27, T. 10 N., R. 7 E.). This zone occurs about 250 feet above the main "tepee butte" zone.

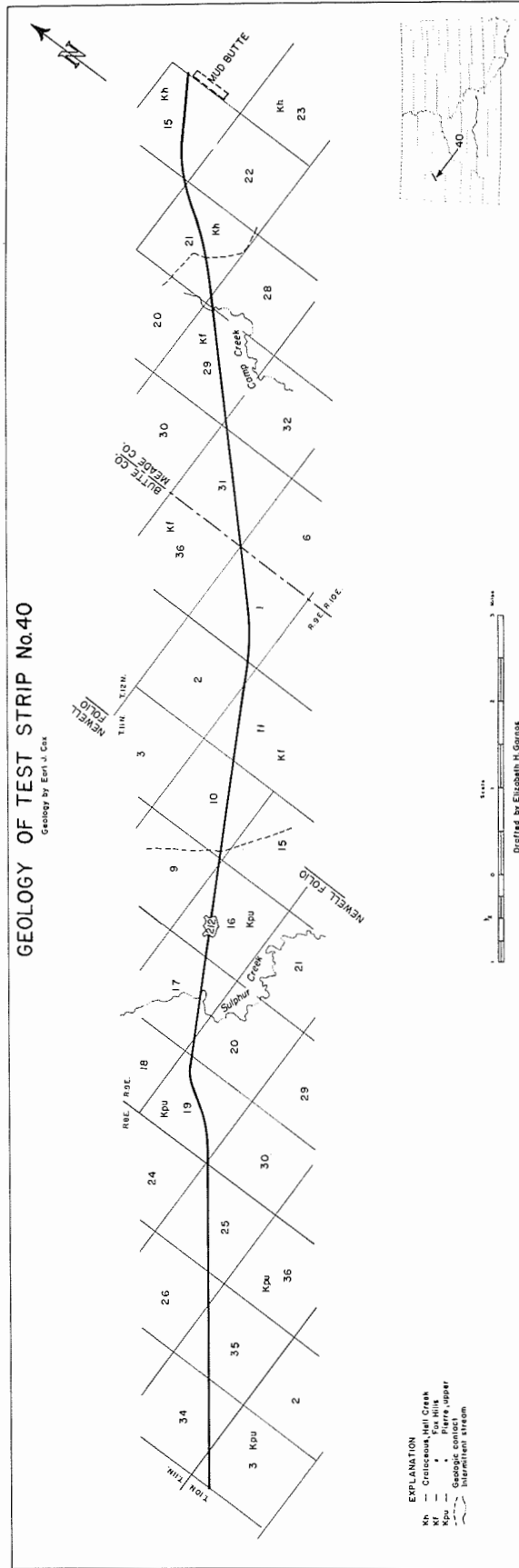
The Pierre Shale is usually noncalcareous. The only bentonite noticed was a four-inch bed at Station 777 + 00 (Sec. 7, T. 10 N., R. 8 E.).

Road Condition

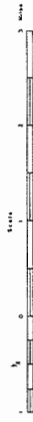
Between Stations 412 + 50 and 414 + 50 (center S. line sec. 32, T. 10 N., R. 7 E.) the shoulders were slumping and there were cracks in the surface of the road both crosswise and lengthwise. The road surface has humps and depressions in it. The failure is on a summit and may be the result of a slump fault although no surface indications of this were seen. Other areas had minor humps and depressions.

GEOLOGY OF TEST STRIP No.40

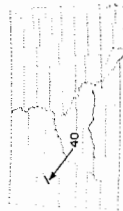
Geology by Edw. L. Cox



EXPLANATION
 Kh — Cretaceous Hill Creek
 Kpu — Pierre (Upper)
 Kpi — Pierre (Lower)
 ——— Geologic contact
 - - - - - Intermittent stream



Drafted by Elizabeth H. Gornost



GEOLOGY OF TEST STRIP 40

by

Earl J. Cox

Location

Strip 40 begins 17.260 miles northwest of Newell on U. S. Highway 212, in Butte County, and continues northeast for 16.346 miles to Mud Butte in Meade County. It is in the Pierre Hills of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geological Formations Present

The project covers the upper Pierre, Fox Hills and Hell Creek Formations. A reconnaissance geological survey was made by Darton (1919).

Pierre Shale, Upper Unit (Kpu)

The upper Pierre unit consists of brown to dark-gray shale that is usually noncalcareous. White limestone concretions that contain pelecypod fossils are present in places, as are sandy bentonite beds as much as 12 inches thick. The decomposed shale becomes gumbo when wet.

Fox Hills Formation (Kf)

The lower part of the Fox Hills is transitional with the Pierre and consists of brownish-gray sandy shale that grades into a fine-grained bentonitic shaley clay. The sand and shale may be slightly calcareous, and contain carbonaceous material.

The upper part of the formation contains greenish-yellow unconsolidated sand and bentonitic shales. The sand may contain reddish limonite nodules.

Hell Creek Formation (Kh)

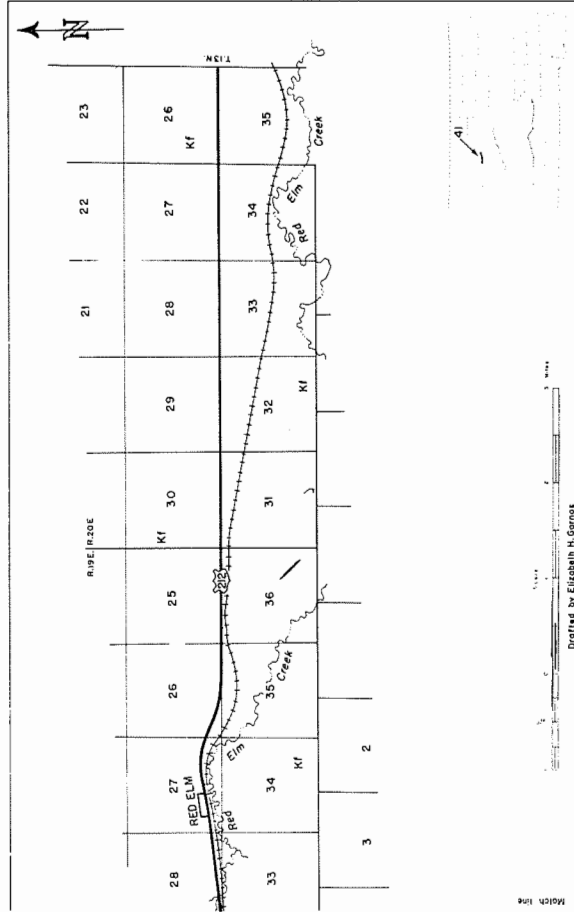
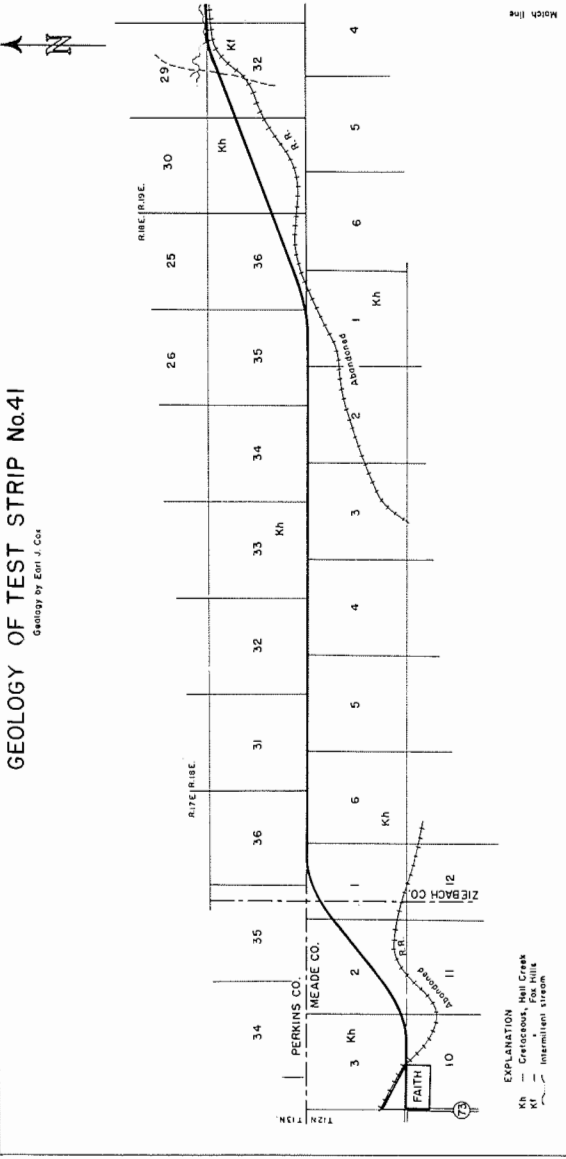
The beds are somber in appearance consisting predominantly of light-to dark-gray, buff, and brown bands of bentonitic clay, silt, and sand. Limonite concretions, fragments of selenite, and purplish-black iron-manganese concretions are present, as is an occasional layer of black carbonaceous clay. Three sand and sandstone layers occur at the top, middle, and lower parts of the formation. The sandstones are highly cross-bedded.

Road Condition

The road surface is good along the entire length of the project. Little patching had been done and the road had no noticeable bumps or bad spots. Only the seal coat has not stood up, as much of it has worn completely off and left the bare road surface exposed.

GEOLOGY OF TEST STRIP No.41

Geology by Edm. J. Cox



GEOLOGY OF TEST STRIP 41

by

Earl J. Cox

Location

Project 41 in Meade and Ziebach Counties is composed of that part of U. S. Highway 212 from Faith to $7\frac{1}{2}$ miles east of Red Elm. The project is 20.915 miles in length. The strip is in the Cretaceous Tableland of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geological Formations Present

Two formations are present on this project, the Hell Creek and the Fox Hills.

Fox Hills Formation (Kf)

An average thickness of 100 feet has been assigned to the Fox Hills Formation. The lower part of the Fox Hills Formation is a brownish sandy shale that grades to clay. Limonitic nodules are fairly abundant. The upper unit is composed of buff to yellow cross-laminated fine- to medium-grained sand and sandstone containing plant remains.

Hell Creek Formation (Kh)

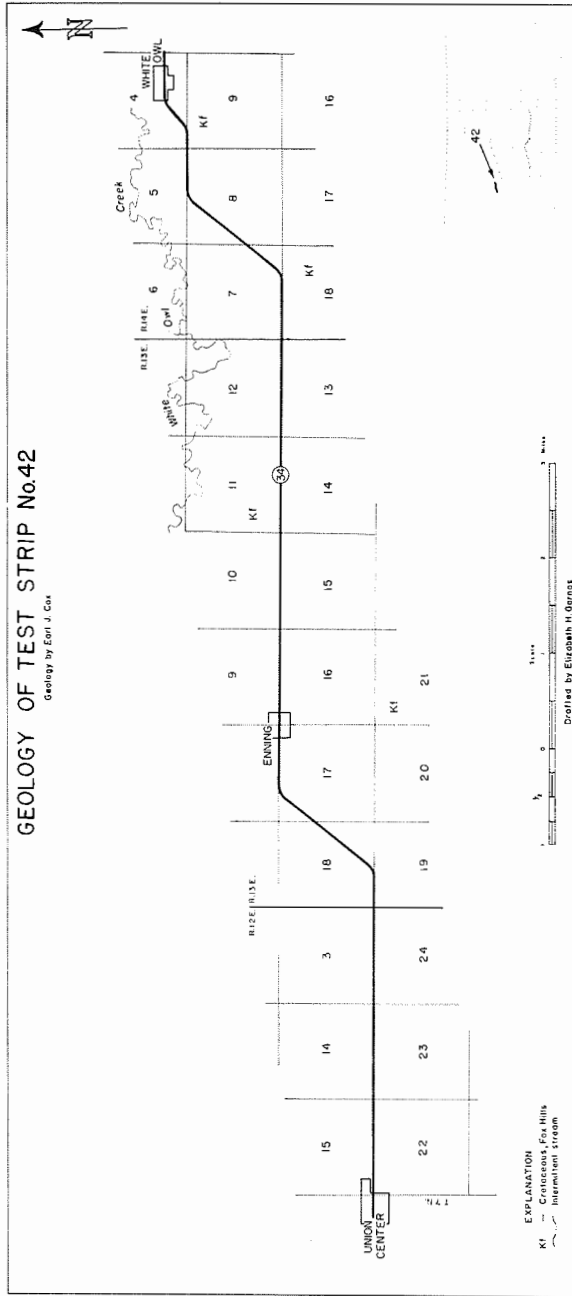
In this strip the thickness of the Hell Creek did not deviate appreciably from a rough figure of 400 feet. The beds are somber in appearance as they consist predominantly of light- to dark-gray, buff, and brown bands of bentonitic clay, silt, and sand. Some color is given to the formation by limonite, fragments of selenite, and purplish-black iron-manganese concretions. An occasional layer of black carbonaceous clay is also present. Sand and sandstone layers occur at the top, middle, and lower parts of the formation. The sandstones are highly cross bedded and resemble the sandy layers in the underlying Fox Hills Formation.

Road Condition

Road and surface conditions on this project are excellent (summer, 1959). No patching or areas needing repairs were noted.

GEOLOGY OF TEST STRIP No.42

Geology by Earl J. Cox



GEOLOGY OF TEST STRIP 42

by

Earl J. Cox

Location

Strip 42 covers that portion of State Route 34 in Meade County between the towns of Union Center and White Owl, for a distance of about 12 miles. This strip is in the Cretaceous Tableland of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geological Formations Present

The only formation present on this project is the lower unit of the Fox Hills Formation.

Fox Hills Formation (Kf)

The lower unit of the Fox Hills Formation consists of alternating beds of consolidated sandstone, and beds of poorly consolidated sandstone containing sandy shale seams. The sandstone is calcareous and light colored, and contains calcareous concretions that range in size from one-eighth of an inch to eight feet in diameter. Occasionally carbonaceous streaks are present in the sandstone and give it a banded appearance. The sandstone is fine grained and locally cross bedded.

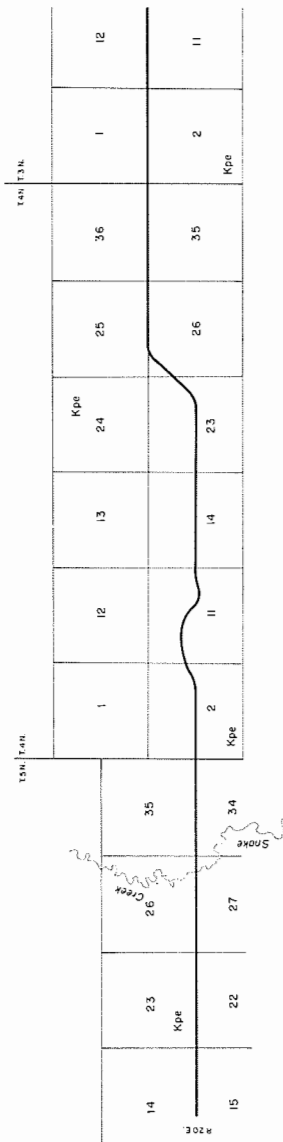
The topography is rolling. The higher hills are capped with a consolidated sandstone layer that is more resistant to erosion than the softer layers.

Road Condition

The road seems to be holding up well (summer, 1959). No patching or failures were noted on the project.

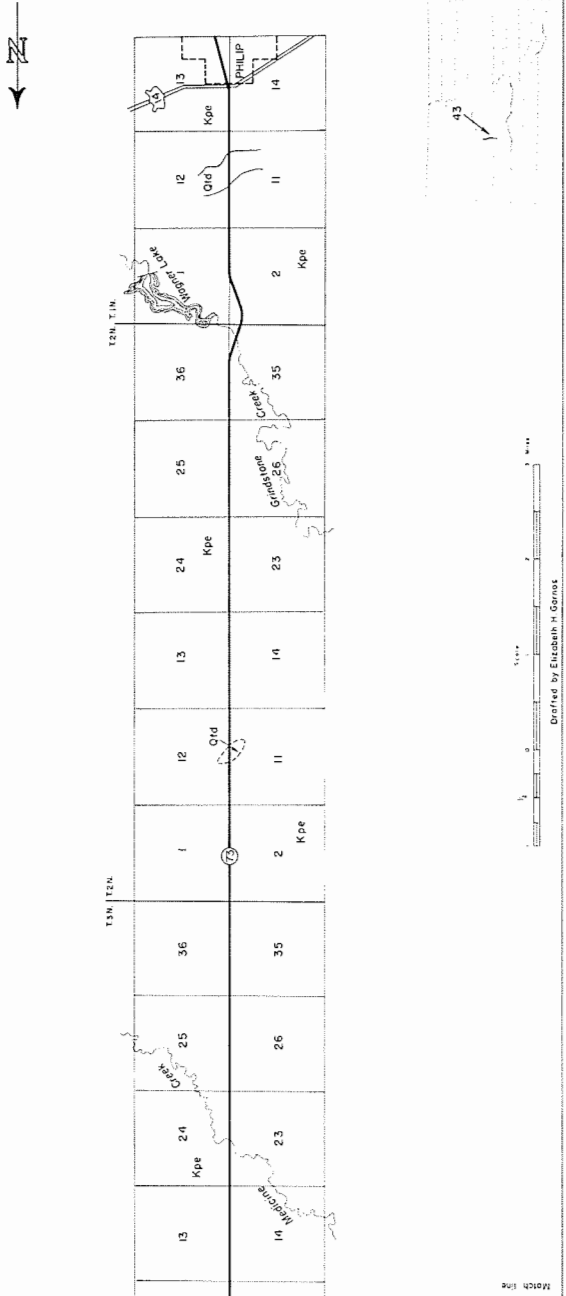
GEOLOGY OF TEST STRIP No.43

Geology by Earl J. Cox



EXPLANATION
 Old — Quaternary terrace deposits
 Kpe — Kpe
 — Intermittent stream

Match line



Match line

Drafted by Elizabeth H. Gornost

GEOLOGY OF TEST STRIP 43

by

Earl J. Cox

Location

Test Strip 43 covers 25.383 miles of State Route 73 from Philip to one-fourth mile south of Billsburg in Haakon County. It lies in the Pierre Hills subdivision of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geological Formations Present

The upper, or Elk Butte Member of the Pierre Shale has been tentatively identified as covering the entire project, with the exception of several areas that are blanketed with terrace gravels.

Elk Butte Member (Kpe)

The Elk Butte Member in this area is a non-calcareous fine-textured gray to grayish-black shale. In some areas the vertical joints and locally the bedding planes are stained brown. Scattered calcareous concretions are present, and some contain fossil remains. Selenite crystals are scarce. No bentonite beds were noticed on this project.

Gravel Terrace (Qtd)

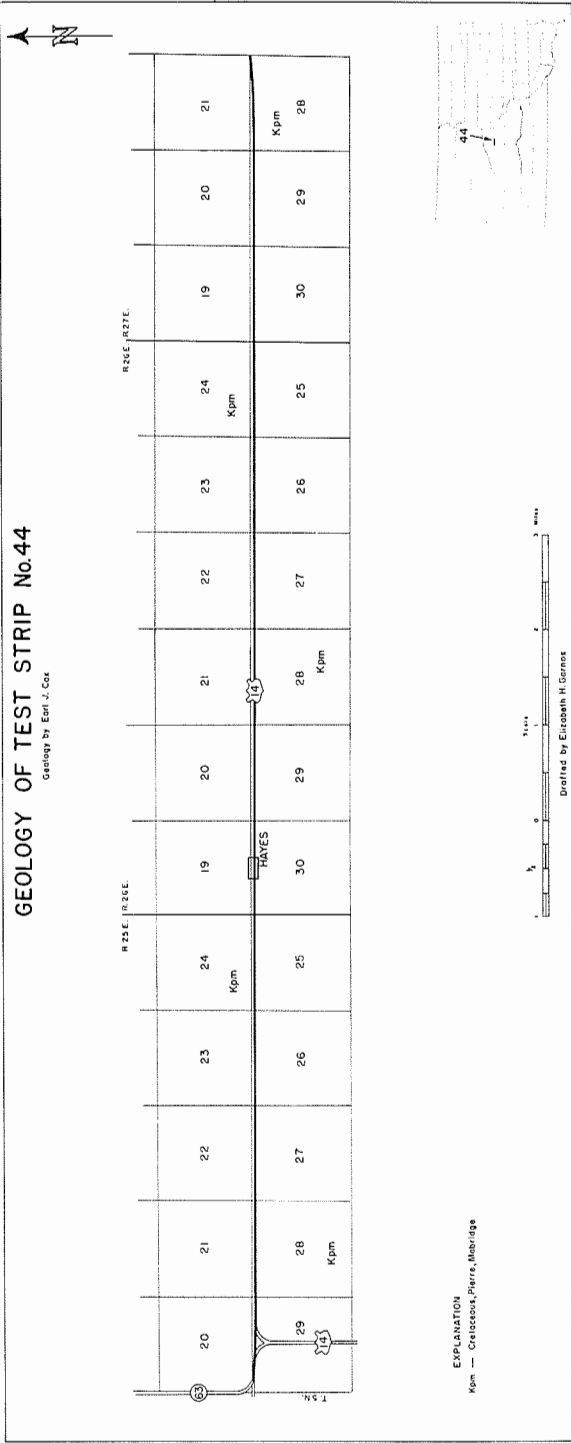
The deposits consist of gravel in beds of fine, rounded sand grains. In places the deposits contain lenses of white nonbentonitic clay.

Road Condition

The condition of the road is generally good (summer, 1959), with no areas either needing or having undergone extensive patching. Only small patched spots were noted and these were randomly distributed over the entire length of the project.

GEOLOGY OF TEST STRIP No.44

Geology by EPH J. Cox



EXPLANATION
 Kpm — Cratons, Piers, Moberge



Drawn by Elizabeth H. Gurness

GEOLOGY OF TEST STRIP 44

by

Earl J. Cox

Location

Strip 44 begins at the junction of U. S. Highway 14 and State Route 63 in Stanley County, and continues eastward for a distance of 13.887 miles. It is in the Pierre Hills subdivision of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geological Formations Present

The Mobridge Member of the Pierre Shale is the only bedrock.

Mobridge Member (Kpm)

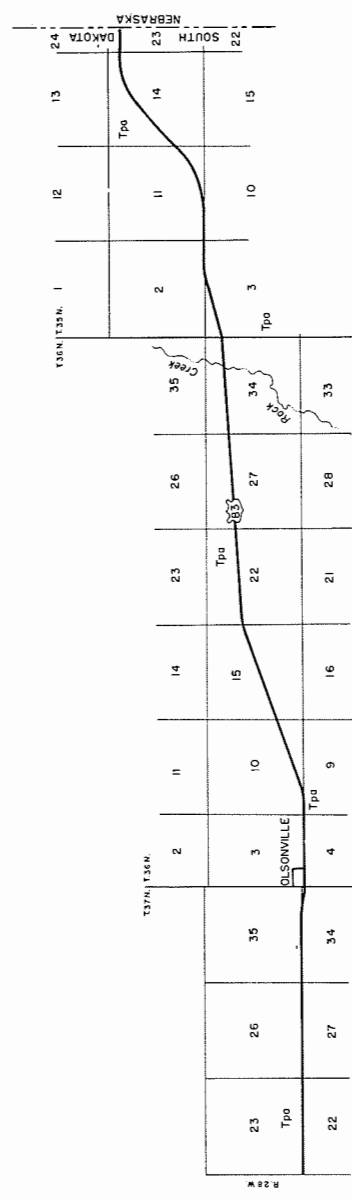
The Mobridge Member of the Pierre is a smooth gray calcareous sandy shale that weathers brown or buff. Thin limestone lenses and brown or white limestone concretions are present, as are Baculites fossils. No bentonite beds were noted.

Road Condition

The road appeared to have been newly surfaced (summer, 1959). The surface is in good condition, with no patches or failures.

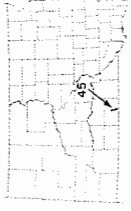
GEOLOGY OF TEST STRIP No. 45

Geology by Allen F. Ames and William D. Sevon



EXPLANATION
 Tpo — Territory, Ploocene, Ash Hollow
 Intermittent stream

Drafted by Elizabeth H. Gernes



GEOLOGY OF TEST STRIP 45

by

Allen F. Agnew

Introduction

Highway Strip No. 45, 12.44 miles long, traverses U. S. Highway 83 from the Nebraska State line northward toward Mission, South Dakota.

Topography and Drainage

The area including this highway strip is upland of the Tertiary Tableland of the Missouri Plateau division of the Great Plains physiographic province (fig. 1). It is moderately well dissected by intermittent tributaries of the Keyapaha River, to the east. The total relief is about 100 feet.

Geologic Formations

The only geologic formation present is the Ash Hollow (Tpa) Formation of the Ogallala Group, of Pliocene age. The Ash Hollow is pinkish-white calcareous partly consolidated silt and fine sand, and totals probably 100 feet or more.

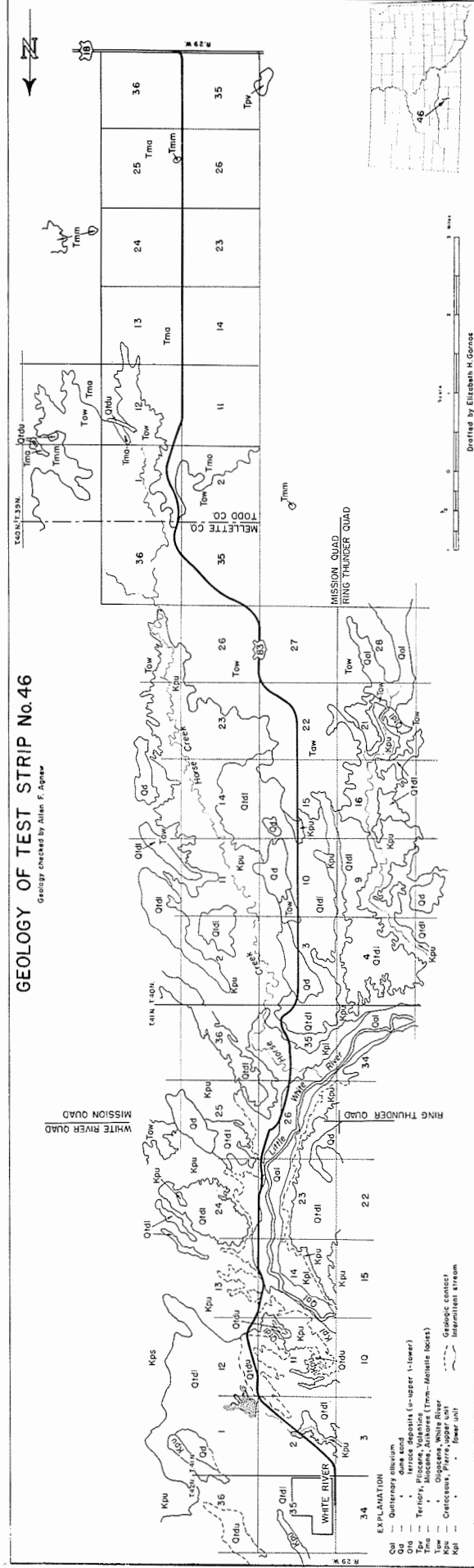
A thin veneer of wind-blown silt covers part of the upland.

Effect of Geologic Conditions on Highway

The highway is in excellent condition (summer, 1960) except for a small patched area at Station 365 (Sec. 27, T. 36 N., R. 28 W.) at a culvert.

GEOLOGY OF TEST STRIP No. 46

Geology checked by Allan F. Agnew



- EXPLANATION**
- Qol - Quaternary alluvium
 - Oidi - Older deposits (lower)
 - Oidj - Older deposits (upper to lower)
 - Tow - Tertiary, Pliocene, Volcanic
 - Tmo - Miocene, Anokse (Tmm - Mellette (lower)
 - Kpu - Gneiss, Pierre-Upper unit
 - Kps - Pierre-Upper unit
 - Kpl - Pierre-lower unit
 - Geologic contact
 - - - - - Intermittent stream

Drawn by Elizabeth H. Gannon

GEOLOGY OF TEST STRIP 46

by

Allen F. Agnew

Introduction

Highway Strip 46, which is 20.081 miles long, extends along U. S. Highway 83 from the town of White River southward to the junction with U. S. Highway 18. The geology of the strip was mapped previously by Agnew (1957 and "In press") and Sevon (1960), for the State Geological Survey.

Topography and Drainage

The area including this highway strip is partly upland of the Tertiary Tableland (southern part) and partly in the valley of the Little White River in the Pierre Hills (northern part), both in the Missouri Plateau division of the Great Plains physiographic province (fig. 1). The northern part of the area is well dissected, with a topographic relief of 175 feet. On the other hand, the relief of the less-dissected southern part of the strip is normally less than half that figure.

Geologic Formations

The geologic formations present along the strip range from the Cretaceous Pierre Shale upward to Recent alluvium.

Pierre Shale

The Pierre Shale in the area of Strip 46 is divided into a lower and an upper unit. The lower Pierre unit (Kpl) exposed from about Station 150 (NE $\frac{1}{4}$, sec. 14, T. 41 N., R. 29 W.) to Station 350 (center Sec. 35, T. 14 N., R. 29 W.), is mainly gray and dark-gray shale that weathers light gray. It is partly bentonitic. The shale contains layers of dark-gray argillaceous limestone concretions, many of which have the long fossil Baculites as cores. About 100 feet of this unit is present along the strip.

The upper Pierre unit (Kpu) is gray calcareous shale below, and brownish silty shale above, corresponding generally with the Mobridge and Elk Butte Members, respectively. The "Mobridge" is dark-gray blocky calcareous shale, with white spots of calcareous material. The shale weathers brownish gray in places. The "Mobridge" contains poorly preserved megafossils, and abundant microfossils. The "Elk Butte" is brownish to olive shale that is blocky near its base, to thin bedded and platy near the top. It is generally silty, and contains fine sand in the upper part. Gypsum and iron-sulfate minerals fill veins and bedding planes throughout. Near the top of the "Elk Butte" are large yellowish-brown iron-bearing calcareous septarian concretions with cone-in-cone structure. Fossils are sparse and are poorly preserved. The upper Pierre unit is

210-230 feet thick in this area, the variation being due to an unconformity at its top. This unconformity is locally marked by a 30-40 foot reddish-brown weathered zone of bentonitic shale that is olive and yellowish-brown platy shale where fresh.

White River Group (Tow)

The White River Group is present along Strip 46 between Stations 430 and 435 (Sec. 3, T. 40 N., R. 29 W.) and between Stations 500 and 749 (Sec. 15, 22, 26, 27, 35, and 36, T. 40 N., R. 29 W.). The White River totals 205-225 feet thick, and can be divided into the Chadron Formation, below and the Brule, above.

The Chadron is only 20-40 feet thick and thus is not mapped separately. The Chadron is mainly light-greenish and olive-gray silty very bentonitic clay. Near the base it locally is characterized by a poorly cemented conglomerate or gravel containing rounded quartz and feldspar pebbles as much as 3 or 4 inches across. The upper boundary of the Chadron is locally marked by a lenticular yellowish-gray "algal" silty limestone or marl that is commonly silicified in part. It pinches out from three feet thick to zero within 40 feet laterally. Where this limestone is absent, the silty bentonitic clays at the Chadron-Brule contact are differentiated mainly by the slight change in color from greenish below to pinkish above. The bentonitic Chadron weathers into rounded humps or "haystacks" in contrast to the stair-step profile of the overlying Brule, and to the relatively smooth cut-banks or rolling uplands in the underlying Pierre.

The Brule Formation can be divided into two units. The lower one is mainly banded pinkish and grayish clayey tuffaceous laminated siltstone and fine quartzose poorly cemented sandstone interbedded with silty bentonitic claystone. The wormy ledges are irregularly cemented with iron and calcium carbonate. "Peaball" clay pellets are present locally, as are thin veinlets of chalcedony. This lower unit is about 110 feet thick. It is overlain by pinkish to brownish very bentonitic clay, pinkish waxey calcareous clay, and brown and pink nodular fine calcareous quartzose sand. The bentonitic beds of the Brule weather to rounded surfaces, whereas the siltstone, clay, and sandstone weather vertically. This upper unit of the Brule is as much as 75 feet thick, making a total of 185 for the whole formation.

These White River rocks appear to be relatively unfossiliferous except for the upper division of the Brule, which contains vertebrate bones.

Arikaree Group (Tma)

The Arikaree is reddish-brown cross-bedded quartzose channel sandstone that is overlain by gray and pinkish unconsolidated tuffaceous quartzose sand. Locally within 10 miles east of the strip, the base of the Arikaree rests on a 20-foot bed of white volcanic ash.

In the upper part of the Arikaree is the Mellette facies (Tmm), which consists of a series of fine-grained thin-bedded pinkish dense

limestones separated by grayish-pink uncemented tuffaceous sand. The limestone weathers white and is fossiliferous with small gastropods. It caps buttes $1\frac{1}{2}$ miles west and 2 miles east of Station 800 (near the Todd County line), a mile east of Station 930, and along the strip at Station 980 (Sec. 25, T. 39 N., R. 29 W.). The Mellette facies appears to be 150 feet thick along the strip, giving a total thickness of the Arikaree of about 230 feet.

Valentine Formation (Tpv)

The Valentine Formation of the Ogallala Group is a grayish fine sand and silt, somewhat ashy. It caps a butte a mile west of Station 1030-1040. It is less than 30 feet thick here.

Quaternary Deposits

Stream deposits are present as floodplain alluvium (Qal) along the present valley of Little White River. Deposits from former streams are present as terraces (Qtd), along the northern part of the strip. These terraces are at two levels, about 200 feet and higher above the present stream; they consist of silt, sand and gravel.

Wind deposits (Qd) are fine to coarse dune sand developed on the White River sediments not far above the terrace level referred to above.

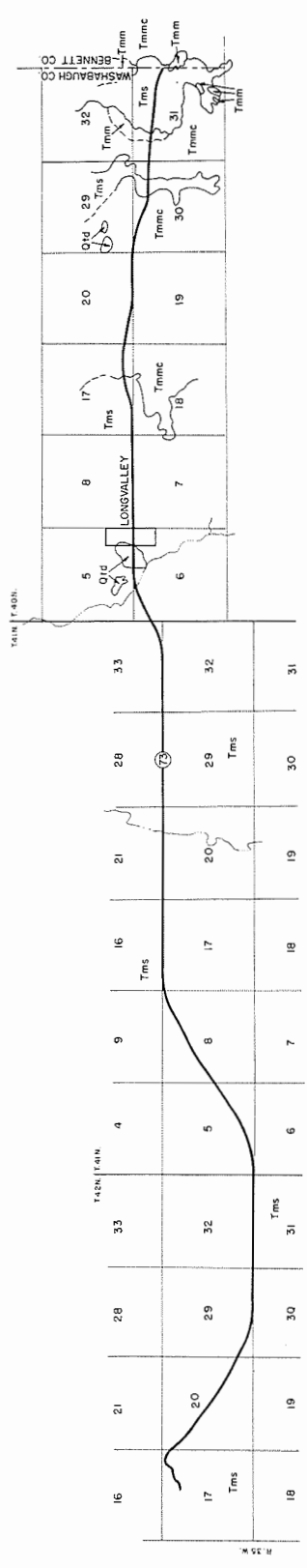
Effect of Geology on Highway Conditions

This road has been in very poor condition and was extensively patched in 1959. Most of the numerous failures can probably be traced to construction rather than to geologic effects.

However, as mentioned in the discussion of the geology, potential trouble spots include bentonitic zones in the lower Pierre especially along the slopes near Station 160-170 (Sec. 14, T. 41 N., R. 29 W.) and Station 350-360 (Sec. 35, T. 41 N., R. 29 W.). Also, the bentonitic Chadron is a likely source of trouble, between Station 500 and 520 (Sec. 15, T. 40 N., R. 29 W.). The upper part of the Brule might give some trouble between Station 740 and 770 (Sec. 1, T. 39 N., R. 29 W.) where it is bentonitic.

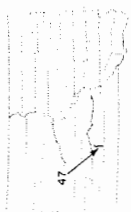
GEOLOGY OF TEST STRIP No. 47

Geology by Sam G. Collins



- EXPLANATION**
- Old — Quaternary terrace deposits
 - Tmsc — Tertiary, Miocene, Monks Creek
 - Tmm — Tertiary, Miocene, Helena
 - Tmmc — Tertiary, Miocene, Helena
 - — Geologic contact
 - — Intermittent stream

Drafted by Elizabeth H. Gonet



GEOLOGY OF TEST STRIP 47

by

Sam G. Collins

Introduction

The project includes 16.235 miles along State Route 73, from the Washabaugh-Bennett County line northward. The strip is in the Tertiary Tableland of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geologic Formations Present

The bedrock units which crop out along this project are of Miocene and Quaternary age and consist of relatively poorly consolidated sedimentary rocks of non-marine origin. The units are discussed below in order of stratigraphic position, the oldest and lowest first.

Arikaree Group

The Arikaree Group in this area includes the Sharps Formation below, and the Monroe Creek Formation above. At the base of the Monroe Creek is a limey zone that is mapped as the Mellette facies.

(Sharps Formation)

The Sharps Formation (Tms) crops out more extensively along this project than any other unit, and is exposed at the surface in all of the area north of Longvalley. The Sharps consists of massively bedded light pinkish-gray clayey very fine feldspathic sandstone, generally slightly to moderately calcareous, and mostly poorly consolidated. The composition is fairly uniform, although calcareous nodules, local thin layers of clay, and scattered slightly siliceous zones occur particularly along the northernmost (topographically lowest) part of the route. The calcareous nodules are characteristic of the Sharps, although they are present only in scattered localities. They are generally elongate ellipsoidal and are 2-5 inches in diameter. The nodules normally occur as singles dispersed several inches to several feet apart in the clayey sandstone, but locally they are more or less fused into irregular clusters. The topography developed on this unit is gently rolling, with few abrupt rises. The Sharps appears to be more subject to erosion and weathering than the Monroe Creek, probably because it contains a much greater proportion of clay and calcareous material.

(Mellette Facies)

The Mellette facies (Tmm) crops out only near the southern end of the project. It occurs in this area in the base of the Monroe Creek

Member, although elsewhere it lies higher in the Monroe Creek. The Mellette facies consists of a more or less continuous, highly calcareous zone 2-5 feet thick. Most of the zone is soft limey very fine sandstone, but lenticular layers of fairly pure creamy-white dense limestone crop out as discontinuous resistant ledges 1-6 inches thick. The limestone contains pockets as much as $\frac{1}{2}$ -inch across, and thin seams of pink montmorillonite clay. These clay pockets weather out on exposure, giving the rock a "wormy" appearance. The limestone also characteristically contains small seams of clear crystalline calcite, 1 mm or less in thickness. This limestone has fairly good structural properties. It has been used locally as a building stone and elsewhere has been crushed and used in bituminous road surfacing. The deposits here are of limited extent, but may contain enough limestone to warrant more detailed investigation.

(Monroe Creek Formation)

The Monroe Creek Formation (Tmmc) crops out only along the southern part of the project in T. 40 N., where the unit occupies the topographically higher positions. The Monroe Creek is fairly uniform in composition, consisting of medium-brown to light pinkish-gray very-fine well-sorted feldspathic or mostly quartzose noncalcareous sandstone that contains only a little clay. The Monroe Creek is poorly to moderately consolidated, massively bedded, and blocky. Where not covered by soil, the sandstone weathers to a grayish or very light-buff color. A rolling topography without flat-topped prominences is developed on the Monroe Creek.

The Monroe Creek and Sharps Formations are very similar in gross appearance. They differ mostly in that the Monroe Creek has no concretions, much less clay, and is much less calcareous.

Quaternary Deposits

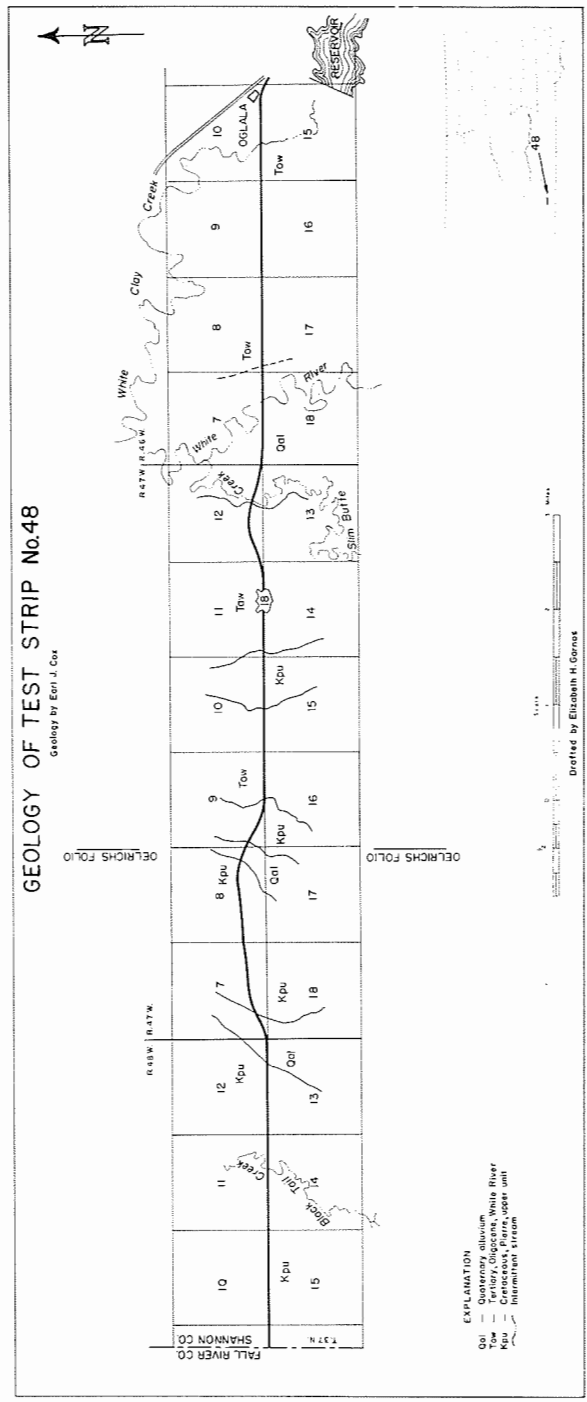
Gravel deposits of probable Pleistocene age occur as terraces (Qtd) about fifty feet above present drainages in Sections 5 and 6, T. 40 N., R. 35 W. Similar gravel occurs at a higher elevation in Section 29, T. 40 N., R. 35 W. These deposits consist of 55-75 percent calcareous fine and medium sand, and 25-45 percent poorly to moderately rounded soft limey concretionary and nodular fragments, 1-4 inches in diameter. The maximum thicknesses measured were 55 feet in the higher deposits, and 16 feet in the lower. The material has been used locally as road metal on secondary roads and as sub-base material in highway construction.

Road Condition

The road was in excellent condition, with only one patched area present, in Section 29, T. 42 N., R. 35 W.

GEOLOGY OF TEST STRIP No.48

Geology by Eric J. Cox



EXPLANATION
 Topography
 Water
 Cretaceous, Pierre, upper unit
 Intermittent stream

Drafted by Elizabeth H. Geros

GEOLOGY OF TEST STRIP 48

by

Earl J. Cox

Location

Strip 48 begins at the Fall River-Shannon County line east of Oelrichs, and continues eastward for 13.328 miles along U. S. Highway 18 to Oglala in Shannon County. It crosses the border between the Pierre Hills and the Tertiary Tablelands, of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geological Formations Present

Formations present on the project are the upper unit of the Pierre, the White River Group, and Recent alluvium. A reconnaissance geological survey was made of the western part of the area by Darton (1902).

Pierre Shale, Upper Unit (Kpu)

The upper unit of the Pierre on this project is a fine-grained, usually thin-bedded noncalcareous shale. Brown-weathering concretions of gray limestone as much as eight inches in diameter are present at random in the unit. The shale is dark gray, but oxidizes to a brown color.

White River Group (Tow)

The lower part of the group is composed of light- to medium-gray and buff bentonitic clay, chert, quartz sand, and occasional cross-bedded and lenticular sandstones. The formation has a "popcorn" weathered surface.

The upper part of the group consists of green, brown, and pink bentonitic clays, quartzose sandstone, and dikes of chalcedony.

Although the White River Group contains a larger amount of bentonitic material than the Pierre, less problems are encountered in building roads over the White River Group than over the Pierre. It is suspected that the bentonites of the White River contain less montmorillonite than does the bentonitic Pierre Shale, resulting in a decrease in the ability of the White River bentonites to absorb water.

Alluvium (Qal)

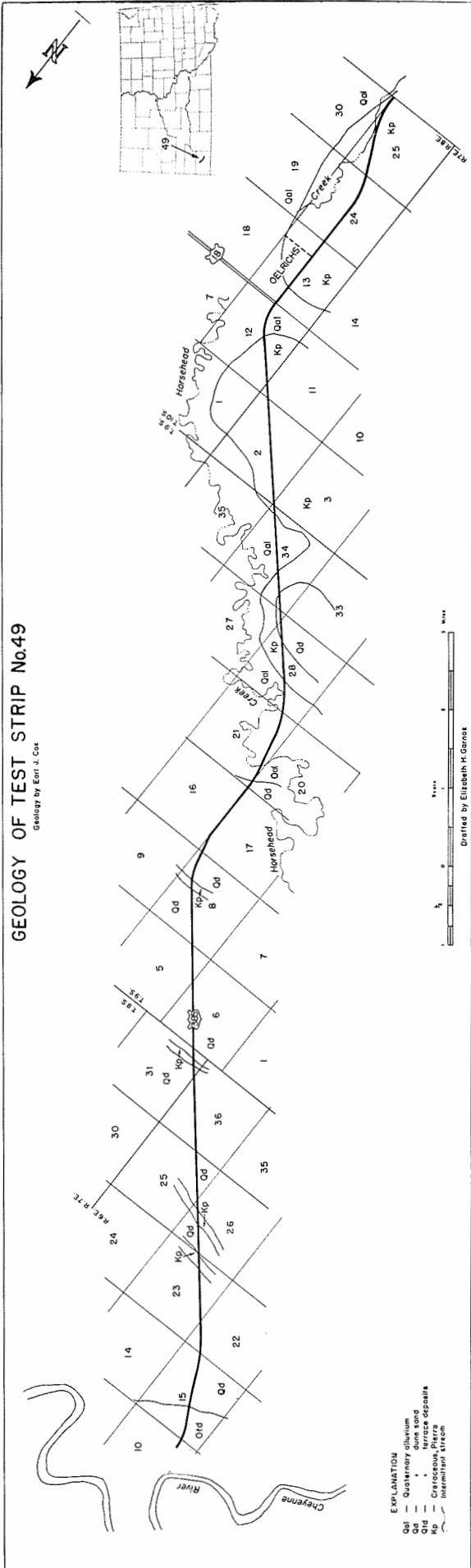
The alluvium consists of stream-deposited reworked White River materials, or a combination of reworked White River and Pierre Shale.

Road Condition

Extensive surface repair has been done on the road. All repair work has been done on those parts of the road overlying the Pierre Shale.

GEOLOGY OF TEST STRIP No.49

Geology by Earl J. Cox



- EXPLANATION**
- Od — Quaternary alluvium
 - Kp — Cretaceous Pierre terraces deposits
 - Creeks
 - Cheyenne River
 - Intermittent stream

Drafted by Elizabeth H. Garros

GEOLOGY OF TEST STRIP 49

by

Earl J. Cox

Location

Project 49 covers approximately that portion of U. S. Highway 385 from two miles south of Oelrichs north to the Cheyenne River in Fall River County, for a total distance of 16.1 miles. It lies in the Pierre Hills subdivision of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geological Formations Present

A reconnaissance geological survey was made by Darton (1902).

Pierre (Kp)

The lower two-thirds of the Pierre Shale is exposed on the project. The exposures at the north end of the project are only a few hundred feet above the base of the Pierre, while on the south end of the project near Oelrichs the exposures are about 1000 feet above the base. The shale is gray and usually noncalcareous, with brown calcareous concretions in it. Selenite crystals and fossils are present in the shale.

Terrace Deposits (Qtd)

The terraces are old river deposits of sand, gravel and silt. The deposits may be as much as 30 feet thick. The deposit at and near the surface is fine quartz sand, which grades at depth into gravels that may be two inches in diameter.

Dune Sand (Qd)

The dune sand is derived from alluvial deposits on the river flats and blown southeastward by the prevailing winds. The deposit is of varying thickness, and in places the shales may be only a few feet below the surface. The sand grains are fine and rounded and give rise to the sand hill topography of dunes and blowouts.

Alluvium (Qal)

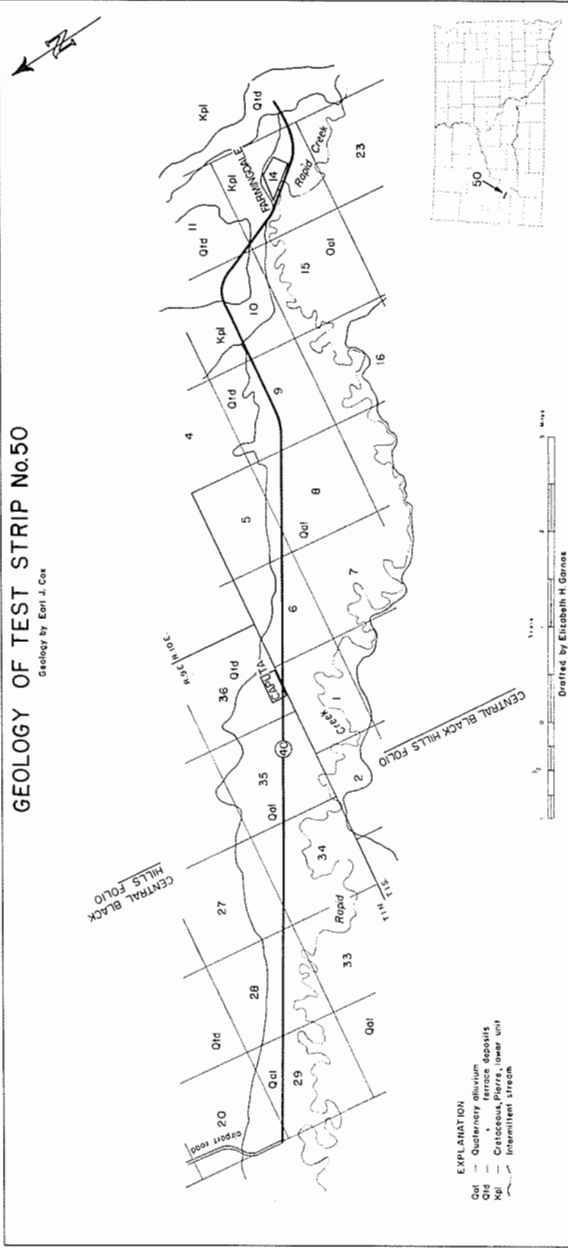
The alluvium is stream deposited sand, shale and silt.

Road Condition

The road appears to have held up well. However, as this is a comparatively new road failures may not have had time to appear.

GEOLOGY OF TEST STRIP No.50

Geology by Earl J. Cox



EXPLANATION
 Qol — Quaternary alluvium terrace deposits
 Qld — Quaternary lacustrine deposits
 Ool — Oligocene sandstone
 Kpl — Cretaceous sandstone
 --- Intermittent stream

Drafted by Elizabeth H. Garlock

GEOLOGY OF TEST STRIP 50

by

Earl J. Cox

Location

Project 50 begins at the junction of State Route 40 and the road leading to the Rapid City Municipal Airport in Pennington County, and continues southeastward along State Route 40 for 11.180 miles to just beyond Farmingdale. It is in the Pierre Hills subdivision of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geological Formations Present

Formations present on the project are the lower unit of the Pierre, gravel terraces and alluvium. The western part of the area was mapped by Darton and Paige (1925).

Pierre Shale, Lower Unit (Kpl)

The shale is thick bedded, gray to black in color, and is noncalcareous. Reddish concretions as much as 12 inches in diameter are present, some of which have yellow calcite in cracks. The shale contains selenite crystals and bentonite beds as much as three inches thick. Fossils are tentatively correlated with those in the Sage Creek fossiliferous concretion zone, 25 miles to the east.

Gravel Terrace (Qtd)

The terrace deposits contain sand, gravel and silt.

Alluvium (Qal)

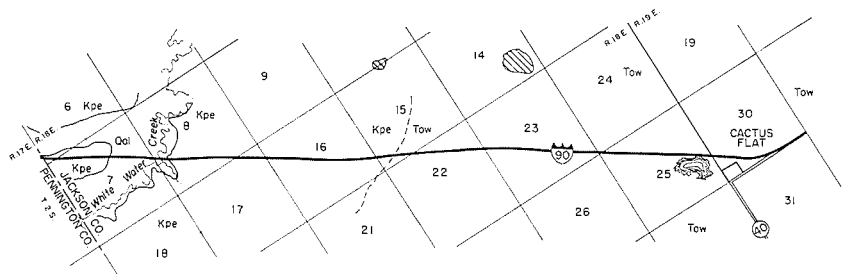
The alluvium consists of stream-deposited sand, gravel, silt and decomposed shale.

Road Condition

Failures were noted at Stations 75 + 00 and 85 + 00 (Sec. 14, T. 1 S., R. 10 E.) near the southeast end of the project, and occurred over the Pierre Shale. The failures were in an area where steep slopes of shale meet the alluvium in the valley of Rapid Creek. The failures were probably caused by slumping of the Pierre Shale.

GEOLOGY OF TEST STRIP No.51

Earl J. Cox, Geology by



- EXPLANATION**
- Qal — Quaternary alluvium
 - Tow — Tertiary, Oligocene, White River
 - Kpe — Cretaceous, Pierre, Elk Butte
 - Geologic contact
 - ~ Intermittent stream



Drafted by Elizabeth H. Gornos



GEOLOGY OF TEST STRIP 51

by

Earl J. Cox

Location

Project 51 in Jackson County includes the 8.113 miles of Interstate 90 between Cactus Flat and the Jackson-Pennington County line. It lies in the Tertiary Tableland subdivision of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geological Formations Present

Formations identified on this project are the Pierre Shale and the White River Group. The Pierre exposure has been tentatively identified as the Elk Butte Member.

Elk Butte Member, Pierre Shale (Kpe)

The shale is brown to grayish black, fine grained and massive, and is seldom calcareous. The shale has a buff color on the outcrop. Local brown flat calcareous concretions up to eight inches in diameter are present. No bentonite beds were seen.

White River Group (Tow)

The lower part of the group is composed of light- to medium-gray and buff bentonitic clay, chert, and quartz sand, and occasional cross-bedded and lenticular channel sandstones. The clay weathers into rounded humps which have a bentonitic or "popcorn" surface.

The upper part of the group consists of green, brown, and pink bentonitic clays, quartzose sandstone, layers of caliche and dikes of chalcidony, and it weathers to a "fluted" appearance on near-vertical walls.

On this project the surface is rolling and grass-covered, and exposures of White River are rare.

Alluvium (Qal)

The alluvium consists primarily of reworked White River Group along White Water Creek.

Road Condition

The road was under construction at the time that this study was made (summer, 1959), with the grading and sub-base phase nearly completed. Numerous soft spots in the grade were being repaired by the contractor, the most serious being between Stations 938 + 00 and 954

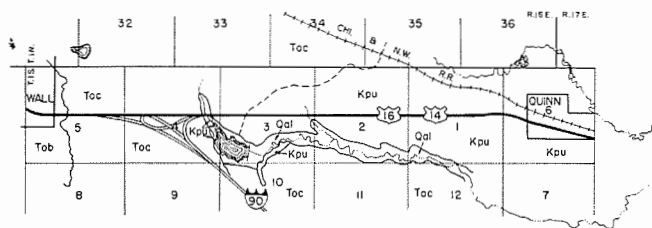
+ 00 (Sec. 23, T. 2 S., R. 18 E.). A fill of greenish bentonitic clay had been used, which apparently was not satisfactory. This area should be watched closely, for it is possible that failures in the flexible pavement surface will occur here.

Recommendation

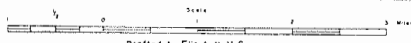
The use of salt water during construction should be considered in building roads over the bentonitic White River Group.

GEOLOGY OF TEST STRIP No.52

Geology by Earl J. Cox



- EXPLANATION**
- Qal — Quaternary alluvium
 - Tab — Tertiary, Oligocene, Brule
 - Toc — Tertiary, Chadron
 - Kpu — Cretaceous, Pierre, upper
 - Intermittent stream



Drafted by Elizabeth H. Gornes

GEOLOGY OF TEST STRIP 52

by

Earl J. Cox

Location

Strip 52 in Pennington County extends along U. S. Highways 14 and 16 between Wall and Quinn. The length of the project is 5.962 miles. It lies near the border between the Pierre Hills and the Tertiary Tableland subdivisions of the Missouri Plateau division of the Great Plains physiographic province (fig. 1).

Geological Formations Present

The White River Group, the upper unit of the Pierre, and alluvium were mapped.

Pierre Shale, Upper Unit (Kpu)

The shale ranges in color from brown to dark gray, and is usually slightly calcareous. It is fine grained, breaks into thin plates, and may have sandstone streaks up to $\frac{1}{4}$ -inch thick. This shale has been weathered yellowish or reddish brown, and has been called the "Interior Formation". The weathering occurred prior to the deposition of the overlying White River Group. The weathered shale becomes gumbo when wet.

White River Group

The White River Group is composed of two formations. The lower formation is the Chadron (Toc) and is composed of light- to medium-gray and buff bentonitic clay, chert, and quartz sand. This formation weathers into rounded humps and has a bentonitic "popcorn" surface.

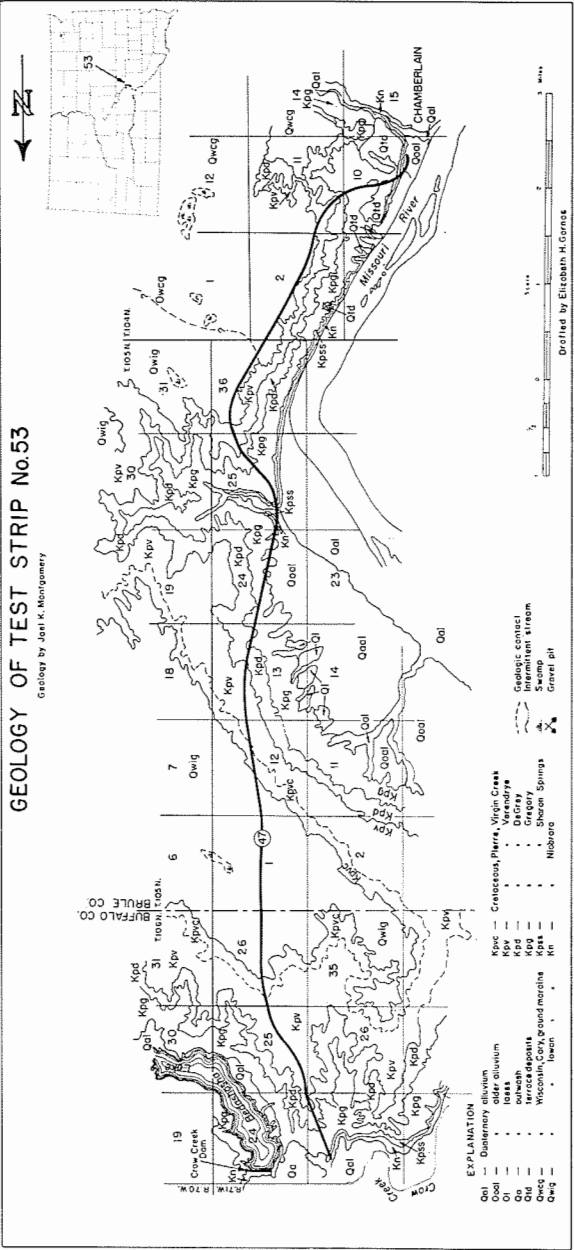
The upper formation is the Brule (Tob) and consists of green, brown, and pink bentonitic clays, quartzose sandstone, layers of caliche, and dikes of chalcedony. The Brule weathers to a fluted appearance on near-vertical walls.

Alluvium (Qal)

The alluvium consisted of reworked White River Group.

Road Condition

The recent seal coat applied to this highway made it impossible to detect those areas where surface repairs may have been applied. At Station 596 + 00 (Sec. 3, T. 1 S., R. 16 E.) there was evidence of heaving, and probably resulted from a bentonitic zone in the Pierre Shale.



GEOLOGY OF TEST STRIP 53

by

Joel K. Montgomery

Location

Test Strip 53 extends northward from Chamberlain approximately 12.5 miles to opposite the Crow Creek Dam, along State Route 47. The strip lies in both Brule and Buffalo Counties. It is in the Coteau du Missouri division of the Great Plains physiographic province (fig. 1).

Previous Work

Petsch (1952) mapped the Chamberlain quadrangle. Searight (1937) described the Pierre stratigraphy, and Wing and Gries (1941) and Gries and Rothrock (1941) described the structure and the manganese-bearing beds, respectively, all for the State Geological Survey.

Topography and Drainage

The highway passes over both Missouri River floodplain topography, level upland topography of the Coteau du Missouri, and the sides of the Missouri River Trench. The trench has steep dissected bluffs which have a height of 450 feet above the river.

The region is drained southward by the Missouri River. Crow Creek in the northern part of the area, and American Creek in the southern part of the area are the only two permanent tributaries; all of the streams exhibit dendritic drainage patterns and have steep gradients. Most of the tributaries extend from the top of the Missouri bluffs to the river.

Geology

Upper Cretaceous formations are exposed at the surface in this area of Missouri River bluffs. The Niobrara Marl (Kn) is the oldest Cretaceous rock unit present. Only the upper 60 feet of the formation is exposed; it consists of light- to medium-gray foraminiferal chalk containing numerous thin bentonite layers. The formation weathers light gray to buff and crops out as vertical cliffs in Section 15, T. 104 N., R. 71 W., and Section 25, T. 105 N., R. 71 W.

Above the Niobrara is the Pierre Shale, consisting of a thick series of gray to dark-brown shales with numerous bentonite beds and concretion zones. Approximately 600 feet of the Pierre is exposed in the area.

The Sharon Springs Member (Kpss) is the lowermost member of the Pierre; it lies conformably on the Niobrara. It is composed of dark-gray to black fissile, bituminous shale that contains abundant fish scales. Numerous thin bentonite layers are present along with selenite and yellow

melanterite which occurs in joints and along bedding planes. Near the base of the member is a 5-inch bed of ash. The Sharon Springs is 15-17 feet thick.

The Gregory Member (Kpg) of the Pierre Shale overlies the Sharon Springs and is exposed in the central and northern parts of the area. This member consists of alternating beds of calcareous buff shale with noncalcareous beds of gray shale. Brown limonite concretions are scattered throughout the upper part of the unit. The basal 6-8 feet is a light-gray chalk or marl. A chalky bed occurs just below the top of the member at the mouth of Crow Creek. The member is approximately 40 feet thick.

The Crow Creek Member consists of a 10-inch basal brown silty sandstone and approximately eight feet of light-gray marl. In most areas it is grassed over and weathers to a yellow soil; it is included with the DeGrey Member on the map.

Above the Crow Creek Member lies the Agency facies of the DeGrey Member (Kpd). The Agency is gray bentonitic clays and siliceous shale having some iron concretions. The Agency is less siliceous here than it is farther north in Sully County.

The Oacoma facies of the DeGrey is medium to dark-gray shale containing many beds of yellow bentonite and black iron-manganese concretions. The concretions are 1-4 inches thick and 3-8 inches in diameter. In many places the nodules have formed concretionary beds as much as eight inches thick and 10 feet long. The interior of each nodule is greenish-gray to brownish-gray in color. Some of the concretions are calcareous. Fossil pelecypods occur in the concretions and have been replaced by prismatic calcite. A 2-inch layer of fibrous calcite prisms oriented perpendicular to the bedding plane was noted near the upper contact. Wing and Gries (1941) noted two distinctive bentonite beds in the Oacoma facies; one is the "lower micaceous bentonite" bed, 2 inches thick, and the other is the "upper thick bentonite" bed, 6 inches thick. The Agency facies of the north (Strip 1) wedges out southward and is equivalent to the lower Oacoma beds in the Chamberlain area.

The Verendrye Member (Kpv) lies conformably on the Oacoma; in fact, there is no traceable contact but a transition zone between the two. The Verendrye is approximately 170 feet thick (Searight, 1937) and includes all the strata between the top of the Oacoma and the basal bentonitic beds of the Virgin Creek Member. The Verendrye consists of medium- to dark-brown, banded, gumbo-forming shale beds which contain numerous layers of purplish-black iron-manganese concretions. The fresh surface of the concretions is greenish gray and calcareous.

The Virgin Creek Member (Kpvc) overlies the Verendrye conformably and includes all beds up to the basal calcareous shale of the overlying Mobridge. The lower part of the member is composed of gray to black shales and numerous thin bentonitic beds, with some barite rosettes. It weathers to thin fragmental flakes less than half an inch in diameter. The upper part of the formation consists of dark-brown to gray shale with limestone septaria and cylindrical concretions. Fossil crab remains occur near the top of the member. Most of the upper part weathers to gumbo.

Blowout depressions caused by wind deflation are common. A particular type of cactus grows in the soil on the Virgin Creek. The Virgin Creek Member is approximately 50 feet thick.

During Pleistocene time, a great ice sheet spread a mantle of till and gravel over much of the pre-glacial surface. The glacial drift is Cary (Qwcg) and Iowan (Qwig) ground moraine (Flint, 1955). It is characterized by gentle swell and swale topography with small kettle holes and ponds.

Terrace gravels (Qtd) occur in the southern part of the strip. Outwash (Qo) plain covered with loess occurs west of Crow Creek Dam. Patches of loess (Ql) occur on the older alluvium (Qoal) near the middle of the strip.

Recent alluvium (Qal) consists of sand, silt, and clay deposits which are confined along the Missouri River floodplain and its tributary streams.

The Cretaceous strata are nearly horizontal; some beds have a slight eastward dip, while others have a very gentle regional dip to the northwest.

Effect of Geology on Highway

No road repairs were noted in the newly built highway strip.

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