SOUTH DAKOTA GEOLOGICAL SURVEY

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GEOLOGY of the BROOKINGS QUADRANGLE SOUTH DAKOTA

EXPLANATION

Qal — Alluvium
(Alluvial silt, sand and gravel along the sides of the Big Sioux River and its tributaries)

Qwclb — Cary Glacial Lake Sediments
(Clay and silt, chiefly in Cary till and near source of Cary outwash; mantling lake sediments locally removed)

Qwcvo — Cary Outwash–Valley Train
(Chiefly silt, sand and gravel; deposited by streams of glacial meltwater in the Big Sioux and its tributary valleys to the west and northwest)

Qwco / Qwces — Cary Outwash–Plain
(Chiefly sand and gravel; built along the pre–outwash valleys by a row of coalescent fans; average 18 ft. above present Big Sioux Valley. Eskers locally)

Qwcg — Cary Ground Moraine
(Chiefly sandy till, gray to brownish or greenish–gray; along Cary end moraine, formed during the recession of ice sheet. Poor drainage and undulating land surface. Included stratified sand lenses locally)

Qwce — Cary End Moraine
(Chiefly boulder–clay till, gray to bluish, greenish and locally brownish–gray; ridgelike, and built along the margin of ice sheet. Locally with included stratified sand lenses)

Qwtvo — Tazewell Outwash–Valley Train
(Chiefly silt, sand and gravel; within pre–outwash valleys)

Qwto — Tazewell Outwash–Kame Terrace
(Chiefly sand and gravel, deposited along the sides of pre–outwash valleys; ranging 10 to 70 ft. above present creek beds. Most of the originally flat top deformed by slopewash)

Qwivo — Iowan Outwash–Valley Train
(Chiefly silt, sand and gravel, sporadically present in valley)

Qwio — Iowan Outwash–Terrace
(Chiefly sand and gravel, southeastern side of valley)

Qwig — Iowan Ground Moraine
(Chiefly pebble–clay till, gray to brownish–gray, mostly oxidized, well–developed drainage pattern, and undulating topography. Included stratified sand lenses locally)

RECENT

PLEISTOCENE — WISCONSIN

QUATERNARY — TERTIARY

Geologic Contact
(dashed where approximately located)

Gravel Pit

x BM 1620
Bench Mark
(monument showing exact altitude above sea level)

x 1559 Spot Altitude

▲ Campanile
Triangulation Station
(monument marking exact geographic location)

House, school, and church

Cemetery

Airport

Geology by K.Y.Lee, 1957
Assisted by P. D. Lidel and R. Hamill

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

Map drafted by D.G. Jorgensen, 1958

APPROXIMATE MEAN DECLINATION, 1957

Scale 1:62 500

1 0 1/2 1 2 3 4 MILES

Vermillion, South Dakota
1958

Quadrangle Location

BROOKINGS QUADRANGLE

INTRODUCTION

The Brookings quadrangle includes about 216 square miles in the western part of Brookings county, in east-central South Dakota.

The quadrangle is in the central part of the Coteau des Prairies upland. The Big Sioux River flows southward through the central part of the mapped area; its major tributaries enter from the northeast. Local relief is up to 25 feet, and the maximum relief is about 110 feet. Brookings (pop. 7,764) is the county seat, and U. S. Highways 14 and 77 cross the quadrangle and intersect in that city. State Route 30 joins U. S. 77 in the northeastern corner of the mapped area. The mainline of the Chicago and North Western railroad traverses the central and southern parts of the quadrangle, and a well-developed network of gravel roads serves most of the area. The climate is characterized by rapid fluctuations in temperature; the average rainfall is 19 inches per year.

The geology was mapped during the summer of 1957 on air photos, under the supervision of Dr. A. F. Agnew, State Geologist. Hand-auger borings supplemented the outcrop information. Thicknesses of outwash were determined by jeep-mounted auger drill and electrical resistivity surveys. Special thanks is due to Dr. F. C. Westin of South Dakota State College, and to the residents of the quadrangle for their cordial cooperation and help.

SURFICIAL DEPOSITS

The surficial deposits consist mainly of Wisconsin glacial drift in which three subdivisions are recognized: Iowan, Tazewell, and Cary (Flint, 1955). The Wisconsin drift is made up of till, outwash, and glacial lake sediments. Recent alluvial deposits occur along the sides of the Big Sioux River and its tributaries.

Iowan

The Iowan drift consists of till with included stratified sand lenses, and outwash; the depth of leaching averages 19 inches. This drift is well-exposed in the northern and eastern parts of the quadrangle, and is characterized by a well integrated drainage pattern.

Till

The Iowan pebble-clay till is gray to brownish-gray, somewhat ferruginous, and mostly oxidized. Scattered patches of loess on this till attain a maximum thickness of 3 feet. The pebble fraction of the till contains 60 percent limestone and dolomite, 29 percent igneous and metamorphic rocks, 9 percent clastic rocks, and two percent chert. The thickness of the Iowan till ranges up to 113 feet in the adjacent White quadrangle, to the east.

Outwash

The Iowan outwash deposits of silt, sand and gravel occur along the sides of a small creek about a mile and half northwest of Brookings. A patch of outwash deposits occurs on the southeastern slope of this creek, and is classified tentatively as kame terrace; however this terrace has lost its distinctive appearance through slopewash. The thickness of the Iowan outwash is up to 38 feet.

Tazewell

The Tazewell drift is represented by outwash deposits of sand and gravel, and occurs along North Deer Creek, Six Mile Creek, and an adjacent creek to the northwest. This outwash was derived from the Tazewell till to the northeast, and has a leached zone that averages 18 inches thick. The leached zone grades downward into silty clay, fine sand with fine laminations, white caliche, with some pebbles near the base. It is believed that this material was formed by gentle currents during the last stage of ice retreat. The pebble fraction of the outwash consists of 58 percent limestone and dolomite, 24 percent igneous and metamorphic rocks, 16 percent clastic rocks, and two percent chert.

The Tazewell outwash was deposited as valley train and kame terrace, which have been eroded, and remain only as patches. The valley train has an average gradient of 12 feet per mile, and the terrace has a gradient of 13 feet per mile. The thickness of the outwash ranges up to 49 feet.

Cary

The Cary drift represents the eastern limb of the James, or Dakota ice lobe, which lay to the west. This drift occupies about two-thirds of the quadrangle, and consists of boulder-clay till with stratified sand lenses, and outwash; the depth of leaching is as much as one foot. Topographically this drift is characterized by ground moraines and end moraines, to the west.

Till

The Cary till is made up chiefly of gray to greenish and brownish-gray, somewhat bluish-gray boulder clay with sand-rich matrix. The rock fragments of the till include about 50 percent limestone and dolomite, 29 percent igneous and metamorphic rocks, 19 percent clastic rocks, and some chert. The exposed thickness of the till ranges up to 45 feet.

Outwash

The Cary outwash is subdivided topographically into plain and valley train. The material comprising the outwash is sand and gravel. The sand fraction consists of more than 85 percent quartz, about 15 percent accessory detrital minerals (feldspar, chert, tourmaline, pyroxene, and iron-oxides), and some fragments of granite, limestone, slate, schist, and shale. The pebble detritus is made up of 52 percent limestone and dolomite, 33 percent igneous and metamorphic rocks, 15 percent clastic rocks, and some chert.

The outwash plain occurs in the western part of the quadrangle, and is well-exposed in the vicinity of Volga. The outwash plain was built by meltwater from the end moriane to the west, and this outwash was formed as fans which coalesced and migrated westward toward the end moraine, resulting in a receding system of coalescent fans on the west flank of the Big Sioux Valley. Small eskers are present near the source of outwash. Patches of the ice-contact stratified sand and gravel appear along the margin of outwash, and are pitted with steepsided kettles made by the melting of masses of buried ice. The thickness of this outwash ranges up to 95 feet.

The valley train is confined to the Big Sioux Valley and its tributaries to the west. This material was derived mainly from the end moraine to the west and northwest of the quadrangle, and has a braided channel pattern along the sides of the Big Sioux River. The thickness of this outwash ranges from 10 to 92 feet.

Glacial Lake Sediments

The glacial fine-grained sediments, clay and silt, are confined to the areas of Cary till or near the source of Cary outwash, and accumulated in temporary lakes held in depressions.

Alluvium

Recent alluvial deposits of clay, silt, and sand and gravel occur along the sides of the Big Sioux River and its tributaries, and they are intermingled locally with the outwash valley train.

SUBSURFACE ROCKS

The subsurface rocks of the Brookings quadrangle are inferred from drillers logs (Erickson, 1954, p. 88-89) of holes in the adjacent Kingsbury and Hamlin counties to the west and north. The rock formations constitute 182-362 feet of Pierre shale, which overlies 30-138 feet of Niobrara chalk, which is followed below by 184-250 feet of Carlile shale, and then 22-35 feet of Greenhorn limestone. The Greenhorn limestone lies on 160 feet of Graneros shale, which rests on the Dakota sandstone.

Although the Pierre shale is not exposed in the Brookings quadrangle, it is probably present because of scattered reports that some deep domestic wells in the quadrangle penetrated shale beneath the glacial drift.

STRUCTURE

The structure of the subsurface rocks is extrapolated on the basis of drillers' logs in adjacent counties (Erickson, 1954, p. 51-54). The regional structure west of the quadrangle shows a rather broad anticlinal fold whose crest extends approximately SSE through the eastern part of the quadrangle, and plunges about N. 15° W. at 30 feet per mile.

The southwestern limb of this anticline turns around a broad synclinal fold near the southwestern margin of the quadrangle. This synclinal fold plunges about N. 30° W.; its axis lies just southwest of the quadrangle.

ECONOMIC GEOLOGY

The Wisconsin drift is of major economic importance in the mapped area. The outwash deposits of sand and gravel are good water-bearing sediments, and are used in construction industries. Clay, derived mainly from glacial tills, is potentially important for ceramic ware.

Shallow Ground Water

The outwash deposits of sand and gravel yield an adequate water supply in this region. The main shallow ground water in the outwash flows generally along the pre-morsaine channels, and drains southeasterly along the present course of the Big Sioux River. The average annual precipitation of 19 inches can percolate entirely downward through the sandy soil into the zone of saturation, thus recharging the outwash.

The factors controlling the occurrence of the shallow ground water are the physical properties of the outwash, and their distribution. The physical properties of outwash include porosity and permeability, which are computed on the basis of textural study. Generally, well-sorted sediments have high porosity, whereas poorly sorted sediments are less porous. Permeability is defined as the capacity for transmitting water under hydraulic head. A sediment containing very small interstices may be very porous, but it might be difficult to force water through it; on the other hand, a coarser-grained sediment that may have less porosity, commonly is much more permeable than a fine-grained sediment. In the Brookings quadrangle the outwash has an average porosity of 34 percent. Coarse and rather poorly sorted gravel is predominant in the outwash; therefore the passage of fluid is comparatively easy through these sediments. Thus the processes of discharge, recharge, and recovery are readily carried out.

The quality of water is discussed on the basis of chemical analyses (Table 1), which show that the principal ions are bicarbonate, sulfate, calcium, and magnesium. The subordinate ions are sodium, potassium, nitrate, chloride, iron, and silica. The carbonate hardness of the shallow ground water in this region is mostly less than 500 ppm, except for the city water of Brookings (sample 10); thus it is generally satisfactory for human use (Fox, 1949, p. 185-186). The concentrations of sulfate, iron, and nitrate, however, should be taken into serious consideration. Samples 1 and 10 show sulfate concentration above 250 ppm; this ion causes a laxative effect on the human body, and also makes poor irrigation water. Sample 10 shows iron concentration above 0.3 ppm; generally such water gives rise to red and black water. Sample 1 shows nitrate concentration above 10 ppm, and this impurity can aggravate the condition in infants known as "blue babies". The best quality water is represented by samples 8 and 9, which show below normal alkalinity, acidity and nitrate.

TABLE 1. Water Analyses of Shallow Wells in the Brookings Quadrangle*

Contents (ppm) Sample No.	Ca	Mg	Na	K	SO_4	N	Cl	Fe	SiO_2	$CaCO_3$ (bicarbonate)	$CaCO_3$ (carbonate)	Hardness ($CaCO_3$)
1	174	200	74	3	415	122	180	-	26	200	-	407
8	84	43	30	8	88	-	20	-	27	315	10	385
9	56	33	7	2	58	-	5	-	17	215	10	275
10	126	54	21	3	268	-	5	7	23	277	10	535

*Analyst: Dr. Oscar Olson, Head of Station Biochemistry, South Dakota Agricultural Experiment Station, State College, Brookings, South Dakota, 1957.

1. G. Intermill, sec. 2, T. 111 N., R. 51 W.
8. H. J. Clapp, city of Volga.
9. P. Skovlund, sec. 1, T. 111 N., R. 51 W.
10. City Well No. 1, Brookings.

The storage capacity of water in the outwash is estimated according to the average porosity of the sediments; thus the potential storage capacity in the outwash is about 496,000 acre-feet, of which the Big Sioux outwash contains about 72 percent. During the summer of 1957 the total amount of water stored in the outwash was estimated at 192,000 acre-feet, of which 56 percent was stored in the Big Sioux Valley.

In the Brookings quadrangle, water is used for domestic, stock, and public supplies. The public supplies are confined mainly to the city of Brookings, where the water pumpage per month during the summer of 1957 was about 29,000,000 gallons.

The future development of irrigation in this region appears very favorable. However, several items concerning such irrigation deserve mention.

As a result of evapo-transpiration and re-circulation especially during the dry season, an increase in mineralization of the shallow ground water will probably accompany irrigation; therefore necessary counter measures should be taken to prevent the excessive concentration of salts in the soil. Chemical analysis of water should be carried out regularly during the period of irrigation in order to observe changes of water composition.

Each well in the outwash should be drilled at least to the bottom of the outwash in order to maintain the maximum height of water in the well. Wells for irrigation should not be located near the outwash border. Generally, a great amount of water can be stored in the lower part of the outwash, owing to the rather high porosity of the sand and gravel there.

The soil developed on the surface of the outwash is generally light in texture, and more silty and sandy than the soil developed on the surface of the till; the former has a rapid to moderate permeability, and water can percolate downward into the outwash easily. Accordingly, irrigation of this land could be carried out be means of sprinklers. (For further details, see Lee, 1958).

Sand and Gravel

The outwash deposits of sand and gravel occupy about 88 square miles (40 percent) of the quadrangle. A conservative reserve of these materials is computed as 2,356,000,000 cu. yd. The outwash is gray to brownish and reddish-gray, calcareous, and ferruginous, with a considerable amount of impurities. The gross composition of the outwash is a mixture of quartz pebbles and cobbles associated with fine- to coarse-grained sand, and some silt and clay. The silt and clay fraction is generally one percent by weight; thus, these materials have a low plasticity index, and are suitable for road construction and concrete aggregate. They are not good refractory substances, owing to the presence of calcite, alkalies, iron oxides, and other silicate minerals (Condra, 1908, p. 35).

Clay

In the Brookings quadrangle the Cary and Iowan drifts are the main source of clay. Clay is a raw material for the ceramic industry.

REFERENCES CITED

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