SOUTH DAKOTA GEOLOGICAL SURVEY
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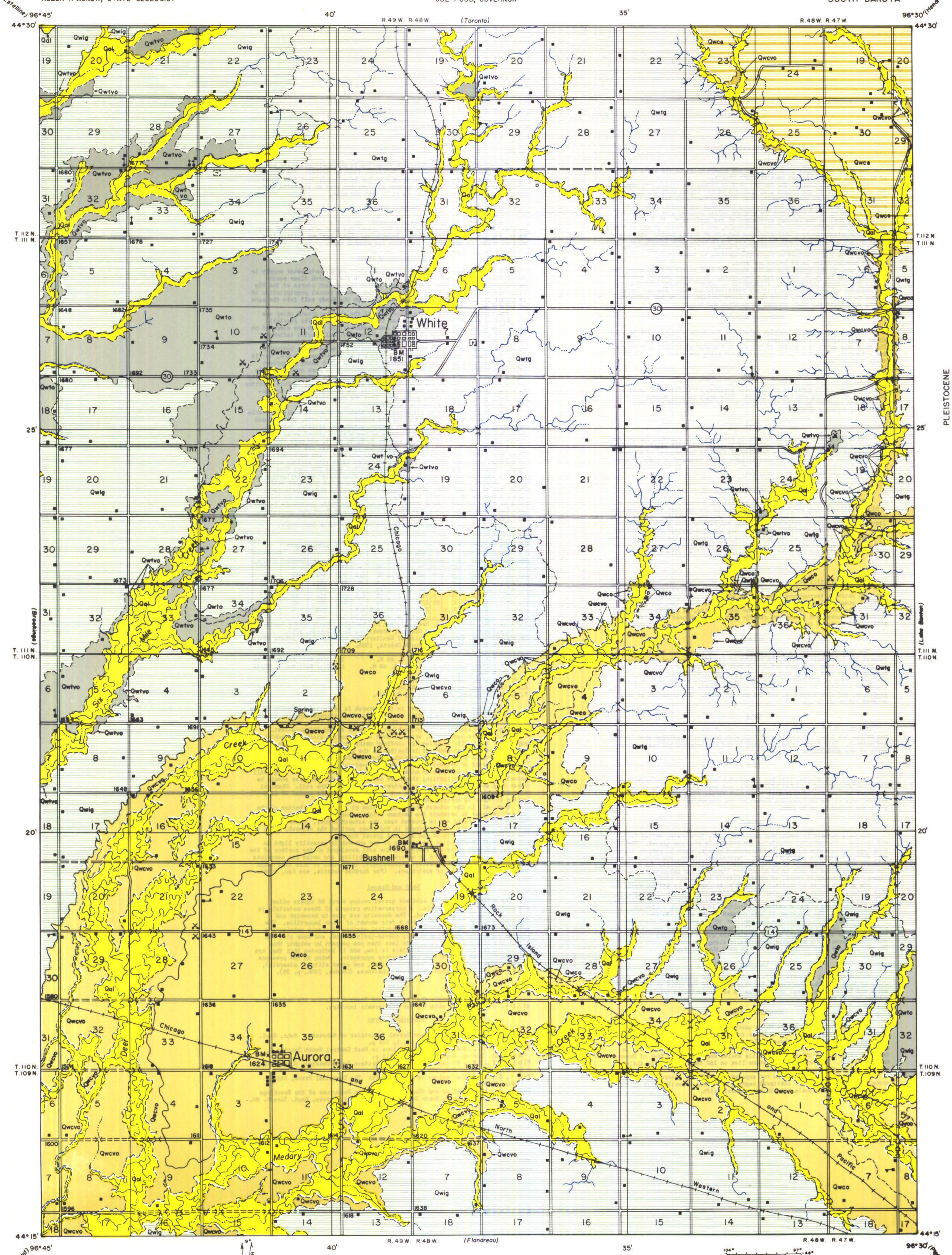
STATE OF SOUTH DAKOTA
JOE FOSS, GOVERNOR

GEOLOGY of the WHITE QUADRANGLE SOUTH DAKOTA



EXPLANATION

QUATERNARY — PLEISTOCENE — WISCONSIN

Qal — Alluvium
(Silt, sand, and gravel along present creeks and their tributaries)

Qwcvo — Cary Outwash-Valley Train
(Silt, sand, and gravel deposited by streams of glacial meltwater along pre-outwash valleys)

Qwco — Cary Outwash-Plain and Kame Terrace
(Sand and gravel built along the pre-outwash channels by a row of coalescent fans, and along the sides of pre-outwash valleys, 10 to 100 feet above present creek beds; somewhat modified by slopewash)

Qwce — Cary End Moraine
(Boulder-clay till, gray to brownish- to greenish-gray, somewhat bluish-gray; ridgelike; built along the margin of ice sheet; stratified sand lenses included locally)

Qwtvo — Tazewell Outwash-Valley Train
(Silt, sand, and gravel within pre-outwash valleys)

Qwto — Tazewell Outwash-Kame Terrace
(Sand and gravel deposited along the sides of pre-outwash valleys, 10 to 70 feet above present creek beds; somewhat modified by slopewash)

Qwtg — Tazewell Ground Moraine
(Pebble-clay till, gray to brownish- and yellowish-gray, somewhat fissile and blocky; ferruginous sandy pebble till near top; exposed at a higher altitude than the Iowan; well-developed drainage pattern; stratified sand lenses included locally)

Qwig — Iowan Ground Moraine
(Pebble-clay till, gray to brownish-gray, somewhat bluish-gray, mostly oxidized; well integrated drainage pattern and undulating topography; stratified sand lenses included locally)

Contact
(dashed where approximately located)

Gravel Pit

x BM 1851
Bench Mark
(monument showing exact altitude above sea level)

1680
Spot Elevation

House, school, and church

Cemetery

Geology by K. Y. Lee, 1957
Assisted by R. Benson
Vertical and horizontal control surveyed from triangulation and level lines of Federal surveys
Drafted by F. J. Buckmeier, 1958

TRUE NORTH — MAGNETIC NORTH 9°
APPROXIMATE MEAN DECLINATION, 1957

Scale 1:62 500
1 ½ 0 1 2 3 4 Miles

Vermillion, South Dakota
1958

Quadrangle Location

White Quadrangle

INTRODUCTION

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

The quadrangle lies in the central part of Coteau des Prairies upland. The main drainage in the mapped area includes Medary Creek, Deer Creek, Six Mile Creek, and a creek to the northwest; they flow southwesterly into the Big Sioux River in the eastern part of the adjoining Brookings quadrangle. The local relief ranges up to 40 feet, and the maximum relief reaches more than 100 feet. White (pop. 525) is the largest settlement of the quadrangle. U. S. Highway 14 crosses the southern part of the quadrangle, and State Route 30 the northern; they are supplemented by a well-developed network of gravel roads. The main-lines of the Chicago and North Western, and the Chicago, Rock Island, and Pacific railroads traverse the southern and eastern parts of the quadrangle. The climate is characterized by rapid fluctuations in temperature, and the average precipitation 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, South Dakota State College, and to the residents of the quadrangle for their cordial cooperation and help.

SURFICIAL DEPOSITS

The surficial deposits consist chiefly of Wisconsin glacial drift in which three subdivisions are recognized: Iowan, Tazewell, and Cary (Flint, 1955). The Wisconsin drift is composed of tills with included stratified sand lenses, and outwashes. Recent alluvial deposits occur along the sides of creeks and their tributaries.

Iowan

The Iowan drift consists of till with included stratified sand lenses; the depth of leaching averages 19 inches. This drift is well exposed in the western and southern parts of the region, 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 is composed of 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, based on drilling.

Tazewell

The Tazewell drift is represented by till and outwash, and is exposed at a higher altitude than the Iowan; it is mainly in the northern and northeastern parts of the quadrangle. Stratified drift is included locally. The depth of leaching of the outwash averages 18 inches; the leached zone grades downward from the base of soil profile into silty clay and fine-grained sand, locally with pebbles and caliche at the base. Fine laminations in the silty sediments are conspicuous, indicating that these sediments were formed by glacial melt-waters with gentle current, during the last stage of ice retreat.

Till

The Tazewell till is gray to brownish- and yellowish-gray, less oxidized than the Iowan, somewhat fissile and blocky, with bluish-gray streaks and oxidized patches; ferruginous sandy pebble till is usually present in the upper part. A sample collected north of the city of White shows that the pebble fraction consists of 66 percent limestone and dolomite, 22 percent igneous and metamorphic rocks, and 12 percent clastic rocks. The exposed thickness of this till ranges up to 50 feet.

Outwash

The Tazewell outwash is composed of valley train and kame terrace. The outwash was built mainly along the valleys of Six Mile Creek and the creek to the northwest, some tributary valleys of Deer Creek, and Medary Creek; a pre-outwash valley that trends east-west, is due west of White, and attains a maximum filling of 105 feet of outwash. Rock fragments are 58 percent limestone and dolomite, 24 percent igneous and metamorphic rocks, 16 percent shale, sandstone, and clay-ironstone, and two percent chert. The thickness of this outwash ranges up to 105 feet

Cary

The Cary drift belongs to the western rim of the Altamont moraine of the Des Moines ice lobe. It consists of till with included stratified sand lenses, and outwash. This drift is well-exposed in the southwestern and northeastern parts of the quadrangle.

Till

The Cary boulder-clay till has a sand-rich matrix, is gray to brownish- and greenish-gray and somewhat bluish-gray, and weathers light-gray to buff. The depth of leaching of this till is as much as one foot. This till is exposed only at the northeastern corner of the quadrangle, where the exposed thickness ranges up to 50 feet.

Outwash

The Cary outwash is subdivided topographically into plain, valley train and terrace. 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, zircon, 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 is confined to the area between Aurora and Bushnell; this feature was built by meltwater from the end moraine to the northeast. Each side of this outwash was built up as fans along the pre-outwash channels, which coalesced and migrated eastward, resulting in a receding system of coalescent fans. The thickness of this outwash ranges up to 185 feet.

The valley train and terrace are confined to the valleys and along the sides of Deer Creek and Medary Creek. This outwash was derived mostly from the end moraine to the northeast, mainly outside the quadrangle. Some well-developed kame terraces are displayed sporadically along the sides of Deer Creek. The thickness of this outwash ranges up to more than 100 feet.

Alluvium

Recent alluvial deposits of clay, silt, sand,and gravel occur along the sides of Medary Creek, Deer Creek, Six Mile Creek and the creek to the north-west, and their tributaries; these sediments are intermingled locally with the outwash valley train.

SUBSURFACE ROCKS

The subsurface rocks of the White quadrangle are inferred from drillers' logs (Erickson, 1954, p. 88-89) of holes in the adjacent Kingsbury and Hamlin counties to the west and northwest. 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 White quadrangle, it is probably present because of scattered reports that deep domestic wells in the quadrangle penetrated shale beneath the glacial drift.

STRUCTURE

The structure of subsurface rock formation 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 southwestern part of the White quadrangle, and plunges about N. 15° W. at 30 feet per mile.

ECONOMIC GEOLOGY

The Wisconsin drift is of major economic importance in the White quadrangle. The outwash deposits of sand and gravel are good water-bearing sediments, and are used in construction industries. Clay, derived chiefly 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 the quadrangle. The main shallow ground water in the outwash flows southwesterly along pre-outwash channels, and enters the present course of the Big Sioux River west of the White quadrangle. 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 outwash, and their distribution. The physical properties of outwash include porosity and permeability, which are computed on the basis of textural study of outwashes. Generally, well-sorted sediments have a 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 White quadrangle the outwash is generally poorly sorted, and has an average porosity of about 30 percent. Pebble detritus is rather 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 the quadrangle is less than 500 ppm in samples 2, 4, 5, and 6, and more than that amount in samples 3, 7, 11, and 12; the latter four samples are classified as "very hard water" for human use (Fox, 1949, p. 185-186). The concentrations of sulfate, iron, and nitrate, however, should be taken into serious consideration. Samples 7 and 11 show sulfate concentration above 250 ppm; this ion causes a laxative effect on the human body, and also makes poor irrigation water. Samples 6 and 11 show iron concentration above 0.3 ppm; such water gives rise to red and black water. Samples 2, 4, and 12 show nitrate concentration above 10 ppm; this impurity can aggravate the condition in infants known as "blue babies". As a whole, the water of the White quadrangle is comparatively less satisfactory than that of the adjoining Brookings quadrangle.

TABLE 1. Water Analyses of Shallow Wells in the White Quadrangle

Contents (ppm) / Sample No.	Ca	Mg	Na	K	SO_4	N	Cl	Fe	SiO_2	$CaCO_3$ (bicarbonate)	$CaCO_3$ (carbonate)	Hardness ($CaCO_3$)
2*	104	52	12	2	78	36	38	-	22	225	-	475
3*	118	52	28	4	80	6	45	0.1	24	342	30	510
4*	81	30	14	4	75	11	8	-	26	185	10	325
5*	80	39	12	2	63	7	10	-	24	235	20	361
6*	92	43	26	3	15	4	45	1.6	20	311	64	405
7*	106	58	47	85	323	6	13	-	24	255	40	504
11**	153	50	31.5	-	279	0.9	4.8	3.5	-	398	-	595
12**	139	64.4	1.7	-	55.6	56	49.7	0.16	-	342	-	616

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

** Analyst: O. D. Dunbar, Division of Sanitary Engineering, South Dakota State Board of Health, Pierre, South Dakota, 1953.

2. W. A. Yule, sec. 12, T. 111 N., R. 49 W.
3. C. Churchill, sec. 28, T. 111 N., R. 49 W.
4. C. C. Bulen, city of Aurora
5. P. E. Norton, city of Bushnell
6. L. Engel, sec. 4, T. 110 N., R. 49 W.
7. E. H. Meyer, sec. 12, T. 110 N., R. 49 W.
11. City Well No. 2, White
12. City Well No. 1, White

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 603,000 acre-feet. During the summer of 1957, the total amount of water stored in the outwash was estimated at 184,000 acre-feet.

In the White quadrangle, water is used for domestic, stock, and public supplies. The public supplies are confined mainly to the city of White.

The future development of irrigation in the quadrangle appears 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 by means of sprinklers. (For further details, see Lee, 1958).

Sand and Gravel

The outwash deposits of sand and gravel occupy about 86 square miles (39 percent) of the quadrangle. A conservative reserve of these materials is computed as 2,405,000,000 cu. yd. The deposits are gray to brownish and reddish-gray, and ferruginous, with a fair amount of other impurities. The gross composition of the outwash is a typical mixture of quartz pebbles and cobbles associated with fine-to very coarse-grained sand, and some silt and clay. The silt and clay fraction is less than one percent by weight; thus the plasticity index of these materials is low, and it indicates that they are suitable for road construction and concrete aggregate. Owing to the presence of impurities (calcite, alkalies, iron-oxides, and other silicate minerals), these deposits are not good refractory substances (Condra, 1908, p. 35).

Clay

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

REFERENCES CITED

Condra, G. E., 1908, The Sand and Gravel Industries of Nebraska: Nebr. Geol. Survey (first series), vol. 3, pt. 1, 201 p.
Erickson, H. D., 1954, Artesian Conditions in East Central South Dakota: S. Dak. Geol. Survey, Rept. Invest. 74, 116 p.
Flint, R. F., 1955, Pleistocene Geology of Eastern South Dakota: U. S. Geol. Survey Prof. Paper 262, 173 p.
Fox, C. S., 1949, The Geology of Water Supply: The Technical Press, Ltd, London, 209 p.
Lee, K. Y., 1958, Geology and Shallow Ground Water Resources of the Brookings area, Brookings County, South Dakota: S. Dak. Geol. Survey, Rept. Invest. 84.