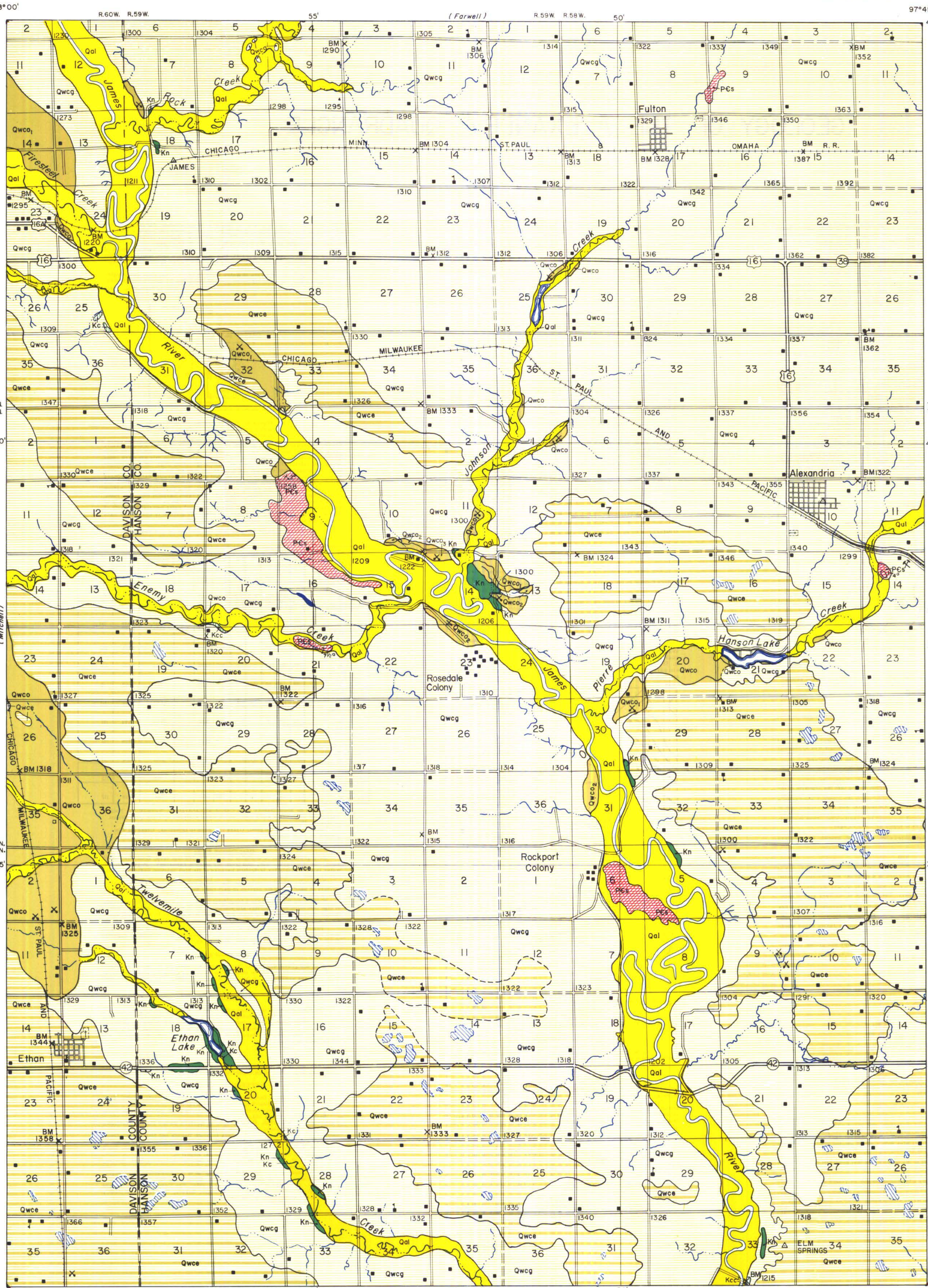
SOUTH DAKOTA GEOLOGICAL SURVEY
ALLEN F. AGNEW, STATE GEOLOGIST

STATE OF SOUTH DAKOTA
RALPH HERSETH, GOVERNOR

GEOLOGY of the ALEXANDRIA QUADRANGLE SOUTH DAKOTA



RECENT

Qal

Alluvium
(Semi-stratified deposits of black loamy clay, silt, and fine sand; 5-39 feet thick; in stream floodplains.)

PLEISTOCENE — WISCONSIN

Qwco3

(Late) Cary Outwash
(Terrace remnants of stratified, poorly-sorted sand and gravel along the James River; average thickness 8 feet; about 20 feet below Qwco2.)

Qwco2

(Middle) Cary Outwash
(Terrace remnant of stratified poorly-sorted sand and gravel along the James River; average thickness 20 feet; about 50 feet below Qwco1.)

Qwco1

(Early) Cary Outwash
(Terrace remnants of stratified poorly-sorted sand and gravel along the James River and its tributaries; average thickness 15 feet.)

Qwco

Cary Outwash
(Crudely stratified, water-sorted sand and gravel; stippled pattern where collapsed; average thickness 15 feet.)

Qwce

Cary End Moraine
(Light olive-gray till; unstratified clay, sand, and gravel; locally stratified sand and gravel pockets in till; rough topography.)

Qwcg

Cary Ground Moraine
(Unstratified clay, sand and gravel, flat to subdued rolling topography.)

QUATERNARY

UNCONFORMITY

UPPER CRETACEOUS

Kn

Niobrara Formation
(Gray to light-tan chalkstone; forms cliffs; maximum exposed thickness 10 feet.)

Kcc / Kc

Carlile Formation
(Bluish-gray shale; contains pyrite and aragonite fragments; thickness 5 feet. Codell sandstone member (Kcc) light-tan, friable, quartzose; shale partings; exposed thickness 20-30 feet.)

CRETACEOUS

UNCONFORMITY

PЄs

Sioux Formation
(Pink to purplish-gray quartzite; bedded and jointed; rippled-m marked; glacial striations; sand grains firmly cemented by silica; exposed along valley floors.)

PRECAMBRIAN

Contact
(dashed where approximately located)

Gravel Pit

x BM 1324
Bench Mark
(monument showing exact altitude above sea level)

△ JAMES
Triangulation Station
(monument marking exact geographic location)

House, school, and church

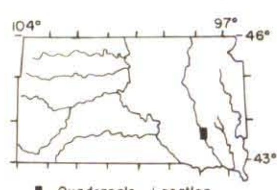
Cemetery

Geology by H. D. Wong, 1959
Assisted by Roy Rymill
Vertical and horizontal control from U.S. Geological Survey topographic maps of Alexandria, Riverside, Ethan, and Rockport Colony 7½ minute quadrangles, 1957
Drafted by H. D. Wong, 1960

TRUE NORTH — MAGNETIC NORTH 11°
APPROXIMATE MEAN DECLINATION 1959

Scale 1:62 500
1 ½ 0 1 2 3 4 Miles

Vermillion, South Dakota
1960



ALEXANDRIA QUADRANGLE

GEOLOGY OF THE ALEXANDRIA QUADRANGLE

by

H. D. Wong

INTRODUCTION

The Alexandria quadrangle lies east of Mitchell in southeastern South Dakota (fig. 1), and includes parts of Hanson and Davison Counties. The quadrangle covers an area of about 217 square miles, and is served by the Chicago, Milwaukee, St. Paul, and Pacific Railroad, and the Chicago and Northwestern Railroad. Principal communities include Alexandria (pop. 715 in 1950), Ethan (pop. 219 in 1950), and Fulton (pop. 139 in 1950).

The climate is characterized by short hot summers and long cold winters. The average annual precipitation is 22 inches, and the average temperature is 48.1°F according to data at the U. S. Weather Bureau Station in Alexandria. Agriculture is the chief industry, with corn, wheat, alfalfa, and barley as the main crops. Livestock production is also of major economic importance.

The Alexandria quadrangle lies in the James Basin of the Central Lowlands physiographic province (figure 1, Rothrock, 1943, p. 8, Fenneman, 1938 map, and Carman, 1915). The surface is a flat to undulating glacial drift plain, with gently rolling swells and swales, which in places is broken by knolls and ridges. Elevations range from 1200 feet along the James River Valley flat to 1340 feet on the surrounding uplands. Average relief on the uplands is about 20 feet. The land area near the James River and its tributaries is rough because of gullying and stream dissection.

The James River has cut a southeasterly trench across the quadrangle, with walls 80-100 feet above the alluvial flat. The quadrangle is drained by the James River and its tributaries, which include Rock Creek, Johnson Creek, and Pierre Creek on the east, and Firesteel Creek, Enemy Creek, and Twelvemile Creek on the west. On the upland interfluves there are many undrained depressions, and the drainage in general, is poor. The James River is a meandering stream, with oxbow lakes and meander scars at intervals along its course. The James River has an average gradient across the quadrangle of 3.2 feet per mile. Natural perennial lakes of the area are Hanson Lake and Fulton Lake. Ethan Lake, although a perennial body of water, is artificial.

The geology of the Alexandria quadrangle was mapped under the supervision of M. J. Tipton during the summer of 1959, as part of the State Geological Survey's program of studying the economic mineral resources of South Dakota. Geologic mapping was done on air photos with the assistance of Roy Rymill. Geologic contacts were determined from topographic expression, and hand-auger borings. Depths to sand and gravel beds were determined by a Jeep-mounted auger operated by Roy Alexander and Edgar Naylor.

Thanks are due to Fred V. Steece for his many helpful criticisms and suggestions. The writer also wishes to thank the residents of the Alexandria quadrangle for their cooperation during the performance of the field work.

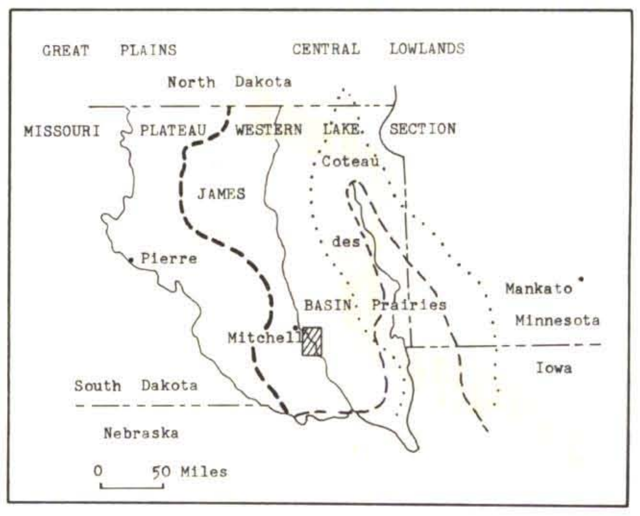


Figure 1. Map showing physical divisions of eastern South Dakota and adjoining areas (after Rothrock, 1943; Fenneman, 1938; and Carman, 1915), and location of Alexandria Quadrangle.

SURFICIAL DEPOSITS

The surficial deposits of the Alexandria quadrangle include glacial drift of Pleistocene age, and stream deposits of Recent age.

Glacial Deposits

Glacial deposits or drift comprise all material transported and deposited by glacial ice. The glacial material within the quadrangle was apparently deposited by the Cary ice, the third advance of the Wisconsin ice sheet, which represents the last of the four major subdivisions of the Pleistocene.

Flint (1955) mapped the drift of the Alexandria quadrangle as Mankato in age (later than Cary) based on his tracing of this drift from its type locality at Mankato, Minnesota 190 miles northeast of Alexandria. However, Zumberge and Wright (1956) showed by radiocarbon dating that the deposits at the Mankato locality are Cary in age, and thus older than had been thought by Flint. In 1958 the South Dakota State Geological Survey obtained fossilized wood from a locality near Roswell 25 miles north of Alexandria, and radiocarbon date of 12,220 ± years was established by the U. S. Geological Survey; therefore the drift which presumably deposited the wood is Cary in age. Thus the drift of the Alexandria quadrangle is mapped as Cary in age.

Drift includes till (boulder clay) and outwash deposits. Till is a heterogenous mixture of unsorted, unstratified clay, silt, sand, gravel, and boulders deposited by the ice.

Till

The surface expression of the glacial till may be divided into ground moraine and end moraine. Ground moraine is drift of low relief and is devoid of transverse linear elements. End moraine is a ridgelike accumulation of drift built along the margin of an ice sheet.

The Cary end moraine of the Alexandria quadrangle is characterized by a subdued knob-and-kettle topography. The surface of the Cary ground moraine has gentle swells and swales, and is in places nearly flat. Both end moraine and ground moraine have many undrained depressions which are indicative of a youthful topography. The moraine surface has an average relief of about 20 feet. There are many minor end moraines in the area, but they are concentrated mainly in areas not far from the James River where they form lenticular very low ridges with a prevailing northwest-southeast trend (fig. 2). These minor end moraines rarely rise to more than a few feet above their surroundings (Gwynne, 1951). Both end moraine and ground moraine are composed of unstratified clay, sand, gravel, and boulders. Stratified sand and gravel occur as pockets or lenses in some of the end moraine tills.

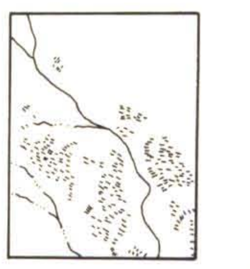


Figure 2. Map of the Alexandria quadrangle showing minor end moraines (after Gwynne, 1951).

Outwash Deposits

A small outwash plain is present ½ to 5 miles north of Ethan. This outwash plain lies between two end moraines, one to the south, the other to the north of the outwash. The internal structure of a gravel pit north of Ethan shows crudely stratified, water-sorted sand, gravel, and small boulders. The gravel is fairly clean, containing only a small amount of clay. Average thickness of sand and gravel in the outwash is about 12 feet.

Above the sand and gravel of this outwash is a clay and silt deposit 3-5 feet thick, and in virtually all of the auger holes that penetrated the complete thickness of this deposit, the lower foot or two contains pebbles and even cobbles embedded in a matrix of silt and clay.

The Cary till has an upper zone known locally as yellow clay and a lower zone known locally as blue clay. The yellow clay is a weathering product of the blue clay, caused mainly by the action of circulating ground water. Another result of the action of ground water on till and gravel was observed along the bluff of the James River in sec. 7, T. 101 N., R. 58 W., where the color of both till and gravel is altered to ash gray, with the till being unusually hard and compact. The maximum exposed thickness of the Cary till in the area is about 50 feet.

The presence of this clay and silt zone above the outwash sands and gravels is explained as follows. Drainage from the ice front that deposited the end moraine to the north of the outwash was discharged through temporarily overloaded stream channels. The end moraine to the south of the outwash acted as a barrier to the southward rush of meltwaters. A temporary lake was thus created between the two end moraines. As the overloaded streams escaped the confines of their channels, and as their waters spread beyond the ice front, their velocities were checked and the deposits of sand and gravel resulted. The damming of the waters by the end moraine south of the outwash also contributed to checking the velocity of the water. Within this temporary body of water the clay and silt held in suspension gradually settled out to form the clay and silt zone deposit above the sand and gravel. The lake water escaped finally to the southeast.

Wind action may have contributed some fine particles to this clay and silt deposit. The retreat of the ice exposed barren till surfaces to the dehydrating action of the sun. Gusty winds were able to winnow the fine particles from the till surfaces, and subsequently deposited their load on the sand and gravel of the outwash.

River terraces of sand and gravel along the bluffs of the James River Valley and along minor streams indicate ancient alluvium or valley train outwash deposits.

Recent Alluvium

The streams of the Alexandria quadrangle are subject to periodic floods, and large amounts of alluvium are deposited on their valley floors. The alluvial flat along the James River attains a maximum width of more than a mile, and the thickness of the alluvium ranges from 5 to 39 feet. Along the James River the alluvial deposits are black loamy clay and silt, with fine sands below. The sand ranges in thickness up to 14 feet.

BEDROCK

The exposed bedrock of the Alexandria quadrangle is of Precambrian and Cretaceous ages.

The Precambrian rocks are the Sioux Formation. This is a pink to purplish-gray quartzite with bedding planes, joint patterns, ripple marks, and glacial striations. The individual sand grains of this quartzite are firmly cemented by silica, which makes the rock extremely hard. Glacial straie display general north-south trends. Some straie at Rockport Colony show a northwest-southeast trend. Measured dips are low, the maximum dip recorded being 7½ on the outcrop along Enemy Creek in Section 21.

The oldest exposed Cretaceous formation is the Carlile shale. This shale is bluish-gray, and contains abundant pyrite concretions and aragonite fragments. The Codell sandstone, an upper member of the Carlile, is exposed in the southern wall of the valley along Enemy Creek in Sec. 17, T. 102 N., R. 59 W. Exposed thickness of the Codell sandstone is 20-30 feet. This sandstone weathers rusty brown, but on fresh exposure is a light-tan, friable, fine to medium grained quartzose rock with nearly horizontal bedding planes.

At some places in the quadrangle, the Niobrara chalkstone, which is Cretaceous in age, is exposed above the Carlile Formation. This chalkstone is a cliff-former, but disintegrates readily into small angular slabs 2-4 inches across.

STRUCTURE

The Sioux quartzite was subjected to extensive subaerial erosion during all of Paleozoic and much of Mesozoic time. The topographic ridges and valleys formed in the quartzite during this long period of erosion have affected the attitude of the overlying Cretaceous rocks. In places, the Cretaceous rocks lie unconformably on the Sioux quartzite, and may pinch out against quartzitic ridges (Todd and Hall, 1903).

A short distance north of Alexandria is a bedrock ridge of Sioux quartzite that trends northwesterly, with its axis near Fulton. South of this ridge and with a similar northwesterly trend is a trough that extends from Alexandria to the western boundary of the quadrangle (Todd and Hall, 1903). The above trough and ridge relationship can be seen (figure 3) from the following elevations of the Sioux quartzite. Northeast of Fulton, in Sections 8 and 9, T. 103 N., R. 58 W., the Sioux quartzite attains an elevation of 1330 feet above sea level. In Sections 4 and 9, T. 102 N., R. 59 W., the elevation of the quartzite is 1255 feet, and southeast of Alexandria, Section 14, T. 102 N., R. 58 W., it is 1300 feet above sea level. At Rockport Colony, in the southern part of the quadrangle, the quartzite exposure attains only 215 feet above sea level, showing a general southward slope across the quadrangle.

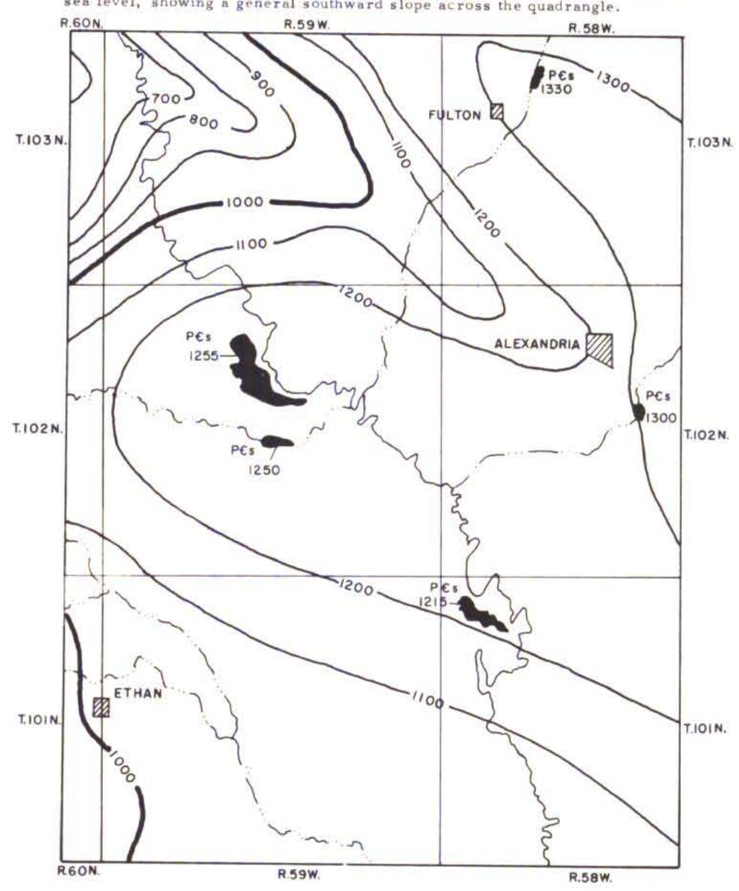


Figure 3. Contour Map showing ridge and trough relationship of surface of Sioux quartzite in the Alexandria Quadrangle (modified from Todd and Hall, 1903).

ECONOMIC GEOLOGY

The economic mineral resources of the Alexandria quadrangle include shallow and deep ground water; sand, silt, and clay deposits; and quartzite.

Shallow Ground Water

Shallow ground water in the quadrangle is derived from sand lenses and gravel pockets in the glacial till, from outwash sand gravel, and from stream terraces.

The quantity of water available depends on the recharge and the amount and shape of pore spaces in the deposit. The ratio of pore space to the total volume of the deposit is called porosity, and the capacity of the deposit for transmitting fluid is called permeability. The degree of permeability depends upon the size and shape of the pores, the size and shape of their interconnections, and the extent of the latter. In general, sands and gravels have greater permeability than silts and clays.

The outwash deposit north of Ethan covers approximately 5000 acres, but has only 2 feet of water-saturated sand and gravel. Thus it contains an estimated 975,000,000 gallons of water. The outwash sand and gravel forms an aquifer (water-bearing formation) in which the water table acts as the upper surface of the zone of saturation. Recharge is from precipitation, underflow, and surface water percolating downward. Thus, during years of drought, a lowering of the water table takes place, owing to free underdrainage through the permeable sand and gravel.

The terrace north of Firesteel Creek could not be penetrated by auger borings because of boulders, but judging from the springs that issue from this terrace, and on the basis of interviews with the farmers whose wells are located in the terrace gravel, it is possible that a supplemental supply of water could be obtained for a city as large as Mitchell during emergencies.

Many tills contain lenses or pockets of sand and gravel. These have great porosity and permeability, and wells penetrating them can produce a supply of water adequate for domestic and livestock uses. Springs issue from these lenses, especially along the walls of the James River Valley.

Other shallow ground water supplies may be associated with deposits of buried stream channels (figure 4), two of which have been mapped by Flint (1955). In addition, a few shallow wells along the James River obtain an adequate supply of water for domestic use from the alluvium.

Table 1 gives the analyses of water samples in the Alexandria quadrangle. All ground water has some dissolved mineral salts, but the nature and quantity of the chemical salts in solution may vary from formation to formation. Some dissolved minerals, such as iron or sulphur, give to water a disagreeable taste or render the water unfit for certain industrial uses. Among the most abundant soluble salts found in the ground water within this area are compounds of calcium (Ca), sodium (Na), and magnesium (Mg). In some localities, the presence of calcium and magnesium may not be in sufficiently large quantities to affect the taste of water, but give it the quality called hardness which affects its domestic and industrial uses. Ground water ordinarily has been filtered through the earth, sometimes for long periods of time, before it is utilized; it is, therefore, relatively free from harmful bacteria, mud, and other suspended materials. The degree of hardness in water usually is expressed in terms of parts of dissolved mineral salts per million parts of water. Water containing more than 120 parts per million is considered hard water; below this figure, water is considered soft.

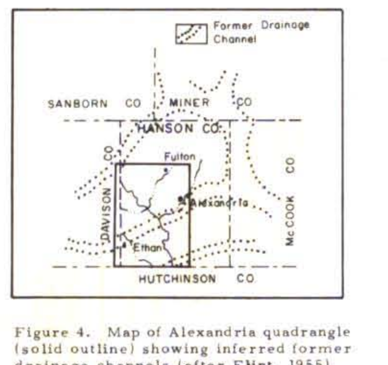


Figure 4. Map of Alexandria quadrangle (solid outline) showing inferred former drainage channels (after Flint, 1955).

Table 1. --Analyses* of Water Samples from the Alexandria Quadrangle

Samples	Parts Per Million									
	Ca	Na	Mg	Mn	Fe	Cl	SO_4	NO_3	Hardness ($CaCO_3$)	Total Solids	Irrigation Class **
Public Health*** Drinking Standards			125	0.3	0.3	250	250			1000	
Norman Adams Sec. 11, T. 101N., R. 59 W.	670	143	226	0.3	8.2	73	2437		2600	4120	III
Alexandria	29	99	148	0.6	3.4	2	1058	1.5	1314	2092	
John Baxter Sec. 28, T. 101N., R. 59 W.	397	49	127	Tr.	1.3	11	1319		1514	2314	III
Ethan	336	165	83		0.9	145	1252	1.0	1306	2497	
Don Freeman Sec. 13, T. 101N., R. 59 W.	463	95	49		Tr.	113	1314		1355	2266	III
Edwin Freeman Sec. 11, T. 101N., R. 59 W.	397	150	137		Tr.	108	1308		1554	2266	III
Tom Green Sec. 13, T. 103N., R. 59 W.	98	4	30			9	129		369	460	I
Hanson Bros. Sec. 27, T. 102N., R. 59 W.	385	247	120	Tr.	1.6	17	1718		1453	2816	III
H. Hoffman Sec. 32, T. 101N., R. 59 W.	72	449	1.8		0.7	79	842		1355	1694	III
Bruce Lyman Sec. 15, T. 101N., R. 59 W.	393	129	53			75	1321		1199	2304	III
William Reinsbach Sec. 13, T. 101N., R. 59 W.	449	60	338	Tr.	0.9	74	2032		2511	3584	III
Joe Schmitt Sec. 14, T. 102N., R. 59 W.	845	170	13			84	1027		913	1858	III
Bert Tobin Sec. 18, T. 101N., R. 59 W.	227	51	47			10	650		761	1308	III

* Analyses by South Dakota State Chemical Laboratory, Vermillion, 1960, except for Alexandria and Ethan, which were analyzed by State Department of Health, Pierre, 1959.

** Class I - excellent to good, Class II - good to injurious, Class III - injurious to unsatisfactory

*** not to exceed

Deep Ground Water

Deep ground water is available in wells 100-300 feet deep, from the Codell sand, the Niobrara chalk, and from the Dakota sandstone. In general, the water is not suitable for irrigation because of its high calcium carbonate, sulfate and iron content.

Jorgensen (1960) reports that the city of Ethan obtains its water from a mixture of sand and shale derived in part from the Graneros rocks. This mixture is termed "wash".

Water from the Codell has a large total solid content, owing to the presence of high concentration of sulfates and sodium. Codell water is considered "soft", though analysis of the water from a thin sand lens similar to the Codell sandstone was found to be of poor quality (Jorgensen, 1960, p. 8).

The "wash" yields water of even poorer quality than that obtained from the Codell sandstone. High concentration of sulfates, and calcium is reported from the "wash" water (Jorgensen, 1960, p. 8).

Sand and Gravel

Sand and gravel deposits in the Alexandria quadrangle occupy an estimated area of 5120 acres within the outwash and terraces along the stream valleys. Reserves are approximately 165,000,000 cubic yards. The gravels are used as road metal.

Quartzite

The Sioux quartzite is extremely hard and durable, and jointing and bedding render it amenable to quarrying. Because most of the exposures are near streams, keeping the quarries dewatered constitutes a real economic problem. The quartzite makes excellent concrete aggregate, road metal, and building and ornamental stone. Other uses include rip-rap, tube-mill liners, and refractory purposes.

Clay

The clays in the till are generally not suitable for brick-making and ceramic purposes, owing to an excessive amount of calcareous material.

REFERENCES CITED

Carman, J. E., 1915, The Pleistocene Geology of Northwestern Iowa: Iowa Geol. Survey, Annual Rept., v. 26, p. 233-445.

Flint, R. F., 1955, Pleistocene Geology of Eastern South Dakota: U. S. Geol. Survey, Prof. Paper 262, 173 p.

Fenneman, N. M., 1938, Physiography of Eastern United States: McGraw-Hill Book Company, Inc., New York.

Gwynne, C. S., 1951, Minor Moraines in South Dakota and Minnesota: Geol. Soc. Amer., v. 62, p. 235-241.

Jorgensen, D. G., 1960, Geology and Ground Water Resources at Ethan, South Dakota: S. Dakota Geol. Survey, Special Report 5.

Rothrock, E. P., 1943, A Geology of South Dakota: S. Dakota Geol. Survey, Bull. 13, map.

Todd, J. E. and Hall, C. M., 1903, Description of the Alexandria Quadrangle, South Dakota: U. S. Geol. Survey Geol. Atlas, Folio 100, 6 p.

Zumberge, J. H. and Wright, H. E. Jr., 1956, The Cary-Mankato-Valders Problem: Geol. Soc. America, Gdbk. Series, No. 3, Glacial Geol., Eastern Minnesota, p. 65-78.