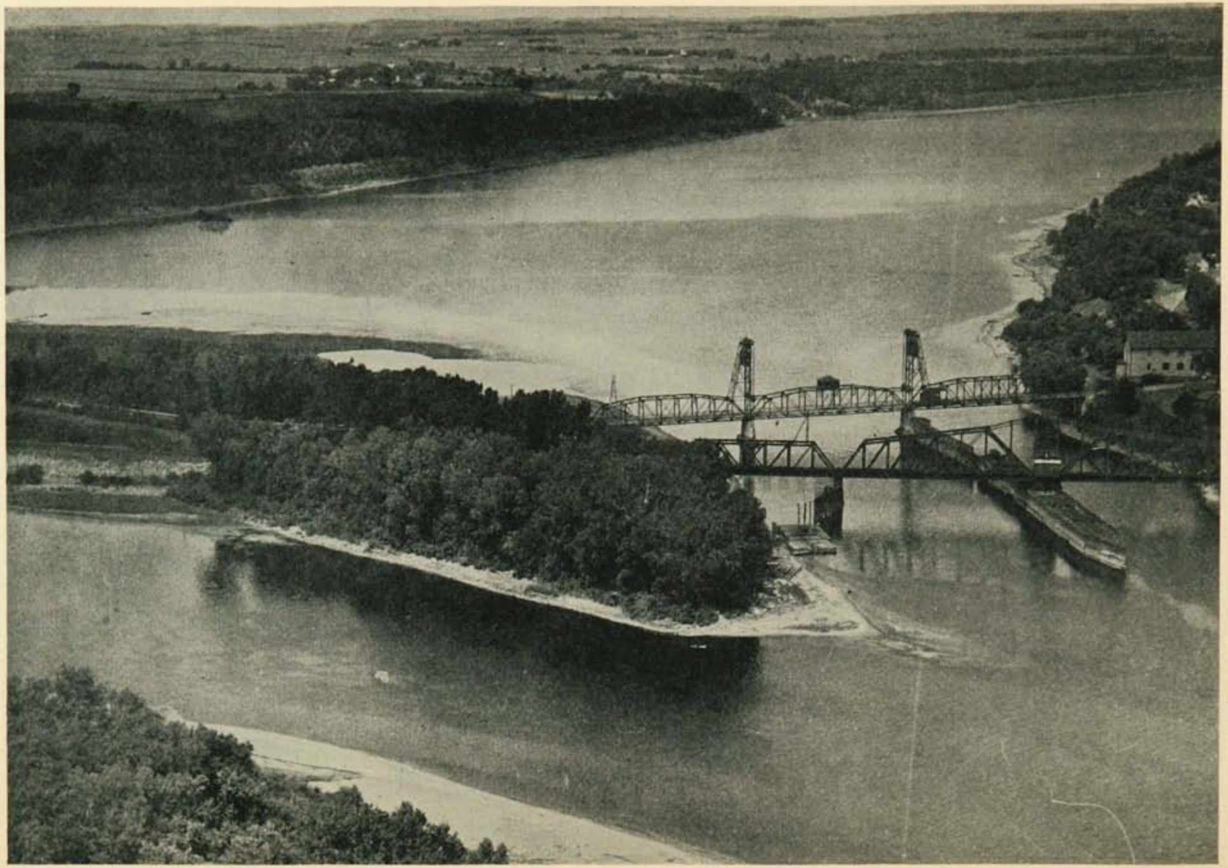

FRONTISPIECE. — Junction of the St. Croix and Mississippi rivers. Point Douglas, Minnesota, on the left; Prescott, Wisconsin, on the right. Photograph by Harry Poague, *Minneapolis Journal.*

UNIVERSITY OF MINNESOTA
MINNESOTA GEOLOGICAL SURVEY
WILLIAM H. EMMONS, DIRECTOR

BULLETIN 27

THE GEOLOGY OF THE MINNEAPOLIS-ST. PAUL METROPOLITAN AREA

BY

GEORGE M. SCHWARTZ

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FOREWORD

Geology, or a knowledge of the rocks and surface features of a region, becomes increasingly important as the region is settled and develops into a center of population. This bulletin is the outgrowth of repeated requests to the director of the Minnesota Geological Survey for detailed data on various geologic phases of the area in and near Minneapolis and St. Paul. The immediate requests resulting in the work came from the Metropolitan Regional Planning Association, the Metropolitan Drainage Commission, and the 1932 Water Commission appointed by the City Council of Minneapolis.

Most earlier reports, being written primarily for the geologist, employed many technical terms; also they gave generalizations rather than the specific data most useful to the engineer. There is need, therefore, of a summary of the detailed knowledge of the geology of the region and a tabulation of quantitative data. This report is an attempt to answer that demand.

The author began the work in December, 1931, with the collection of such data as were available in various Twin City engineering offices. The summers of 1932 and 1933 were largely spent in field work. The time since then has been spent in additional field work and the preparation of the report.

So many individuals, corporations, and public agencies have contributed data that it is impossible adequately to acknowledge their aid. With very few exceptions requests for data were cheerfully complied with, often at considerable inconvenience. Among those deserving special mention are the Metropolitan Drainage Commission and its successor, the Minneapolis–St. Paul Sanitary District; the United States Engineer's Office; the Department of Highways of Minnesota; the sewer, water, and engineering departments of Minneapolis and St. Paul; the county engineers of several counties, especially Ramsey, which has drilled many deep wells; various other officials of the counties, cities, and villages surrounding the Twin Cities; all the railroads entering the cities; the Northern States Power Company; Tri-State Telephone Company; Twin City Rapid Transit Company; and the following firms or individual engineers and architects: E. J. Longyear Company, Magney and Tusler, Inc., Pillsbury Engineering Company, Mr. C. A. P. Turner, Mr. Walter H. Wheeler, Long and Thorsov, Inc., Pike and Cook, Druer and Milinowski, Mr. Clarence H. Johnson, George J. Grant Construction Company, Keys Well Drilling Company, and Messrs. Sven A. Norling, Edward H. Lundie, and Fostin Beaudette. Mr. George H. Herrold, City Planning Engineer of St. Paul, was much interested in the work and encouraged the project in many ways.

To Mr. Edward P. Burch the writer is especially indebted. An engineer of long experience in Twin City engineering and with a great interest in geology, Mr. Burch gave freely of his time and effort without recompense. Mr. Maynard M. Stephens assisted in some of the field work, and Messrs. L. K. Lancaster, L. K. Armstrong, and J. E. Hill were responsible for the drafting, Mr. Hill being made available through an ERA project.

Among the writer's colleagues at the University of Minnesota, Professors Frank F. Grout, C. R. Stauffer, G. A. Thiel, and Carl Dutton rendered much assistance. The section on geography was contributed by Professor Richard Hartshorne and that on vegetation by Professor F. K. Butters.

In the tabulations of data credit has been given to the sources of information. Grateful acknowledgment is made to all who assisted in any way.

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INTRODUCTION

The Minneapolis–St. Paul region is one of considerable geologic interest. The three main rivers, the Mississippi, Minnesota, and St. Croix, have cut through the surficial deposits and exposed the solid rocks to view. Glaciers which repeatedly invaded the region during the glacial or Pleistocene period of earth history have completely altered the surface features. The migration of St. Anthony Falls from Fort Snelling to its present location furnishes one of the most reliable estimates in this portion of North America of the length of time since the last ice invasion. To understand fully the significance of many of the geological features it is necessary not only to know the facts about their location, size, shape, and other features, but also to understand their origin. For these reasons a discussion of geologic processes and of some of the historical aspects of the region is included with the descriptive and tabular matter which comprises much of this report.

The geologic interest of this region has resulted in many publications. Many of the reports are rather old; the last applying to the general region was published in 1916.[1] It was not until 1872, with the creation of the Geological and Natural History Survey and the appointment of Professor N. H. Winchell as state geologist, that active and continuous work on the geology of Minnesota was begun. Twenty-three annual reports, and an additional one for 1895–98, were prepared. In the first of these (pages 22–36) is presented a summary of all scattered information on the geology and natural history of Minnesota available up to that time. The following bibliography starts with this report; for previous data the reader is referred to Dr. Winchell's summary.

Volume 2 of the six-volume Final Report of the Survey presents specific material on the geology of the Metropolitan Area, namely Hennepin, Ramsey, Dakota, Carver, Scott, Anoka, and Washington counties. Of the 26 bulletins published by the Geological and Natural History Survey of Minnesota and its successor, the Minnesota Geological Survey, Nos. 14, 20, 23, and 24 contain considerable data on the Twin City area.

The principal work of the United States Geological Survey on the Twin City region is Folio 201 of the Geologic Atlas of the United States, by Frederick W. Sardeson. This atlas contains, for the four quadrangles known respectively as the St. Paul, White Bear, Minneapolis, and Anoka sheets, topographic and surface formation maps as well as a general description of all phases of their geology and many illustrations. Those

[1] F. W. Sardeson. *Minneapolis–St. Paul Folio* (United States Geological Survey Atlas, Folio 201).

interested in the geology of the area should refer to this folio, since many features described and illustrated there are not repeated in this bulletin. The various publications referred to will be found in the large libraries of the Twin Cities.

Other publications of the United States Geological Survey bearing on the region are Water Supply Paper 256, *The Geology and Underground Waters of Southern Minnesota;* Bulletin 678, *The Clays and Shales of Minnesota;* Bulletin 663, *The Structural and Ornamental Stones of Minnesota;* and Professional Paper 161, *Quaternary Geology of Minnesota and Parts of Adjacent States.* The United States Geological Survey has also published topographic maps of the Minnetonka and Rockford quadrangles, which lie within the area mapped in this report, and of the St. Francis and St. Croix Dells quadrangles of adjacent areas.

Much valuable data is also available in the Report of the Water Supply Commission to the City Council, City of Minneapolis, June, 1932, and in the various miscellaneous publications noted in the bibliography, which is believed to be complete from 1872 to date. The reader is referred to those of most value on each problem by footnotes.

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CHAPTER I

GEOGRAPHY OF THE MINNEAPOLIS–ST. PAUL AREA

BY RICHARD HARTSHORNE

Location of the Area

The region discussed in this report includes the Minneapolis–St. Paul urban district and adjacent rural areas. It corresponds roughly to "the metropolitan region of Minneapolis and St. Paul," as defined by the Minneapolis Civic and Commerce Association and the St. Paul Association of Commerce and adopted, with some modification, by the United States Bureau of the Census in 1930. The maximum area, 1,936 square miles, is included within a circle whose radius reaches 25 miles from a central point between the two cities — the limit of light and power supply from the cities. The basic area is somewhat less, being determined by the limit of various factors, such as retail store deliveries, and commuters; as adjusted to township lines this basic area is approximately 1,500 square miles. To make the geologic map which accompanies this report more useful the area was "squared up" to include about 2,500 square miles — all of Ramsey and Hennepin, most of Washington, and parts of Dakota, Anoka, Scott, and Carver counties. As its eastern boundary is the St. Croix River, which is the state line between Minnesota and Wisconsin, the entire area is within east-central Minnesota.

The importance of the area is in large part a result of its location in relation to the Minnesota and Mississippi rivers. Situated at the northernmost point of the great bend in the wide, mature valley of the Minnesota-Mississippi (glacial River Warren), it includes the junction with the youthful valley of the upper Mississippi and its important Falls of St. Anthony. This location might well be called the headwaters of the main Mississippi, corresponding to Pittsburgh on the Ohio. The most important feature of the area is, of course, the urban district of the Twin Cities, with its population of over three-quarters of a million people. This is not merely the principal urban unit of Minnesota but also the metropolitan center, or economic capital, of the Central Northwest.[1]

The Tributary Area

The tributary area of this Metropolitan center includes nearly all of Minnesota and the two Dakotas and parts of adjacent states.[2] Its most

[1] Mildred Hartsough. *Development of the Twin Cities as a Metropolitan Market* (The University of Minnesota, 1925).

[2] Robert E. Dickinson. "The Metropolitan Regions of the United States," *Geographical Review,* 24:278–91 (April, 1924).

definite limit is on the north, where the tariff wall and the marked separation of railroads on either side of the boundary combine to make a barrier more effective than any mountains in the United States. On the west it extends across the plains area of Montana, probably not quite to the Rocky Mountains, where it meets the region served from Spokane and the Pacific ports. On the southwest and south it is bordered by regions tributary to Chicago and Milwaukee and to Omaha. An approximate limit may be drawn close to the southern boundaries of Minnesota and South Dakota, but there is overlapping throughout a rather wide zone on both sides of this line. On the east the region extends a much shorter distance into northern Wisconsin, probably not much beyond a line drawn from La Crosse to Ashland.

Within this tributary area are included not only the entire hard spring wheat region of the United States and a major part of the Wisconsin-Minnesota dairy region, but also the northwestern margin of the corn-hog belt, and the northern part of the cattle and sheep grazing area of the Great Plains. Since the markets for the commercial products of all these regions and the source of most of their imports lie to the east, the movement of traffic, as influenced by the Great Lakes, both as a waterway and as a barrier, is predominantly between west and east, particularly southeast. It is not surprising, therefore, that the commercial focus of the whole area should be located so near its southeastern margin.

In few of the major regions of the continent are the commercial routes so highly concentrated at one point as are the rail lines of this region at Minneapolis–St. Paul. From almost every part of the region the main routes lead to this center; the only important exception is in the northeast, where the Iron Range is tied to Duluth-Superior.

Relation between the Urban Center and Its Tributary Region

In a region within which rail routes are the all-important means of transportation other than local, and where transportation is of such unusually great importance, the predominant rail center necessarily becomes the unquestioned economic capital of the region. At this center are concentrated not only the terminal, transfer, and repair activities of the railroads and the commercial activities concerned with assembling agricultural products of the region and distributing manufactured products brought in from the east, but also a large group of manufacturing industries which transform in minor degree large quantities of both incoming and outgoing materials, e. g., flour-milling and meat-packing, foundry and machine shops. Since the most important water-power site of the region happens also to be located in this district and since there are no coal mines, no other point within the region, except Duluth, has special advantages for many other kinds of manufacturing sufficient to offset the enormous advantage of the rail center. Over half the manufacturing workers in Minnesota and the Dakotas are found within this district.

Finally, legislative action placed in this same district the political and educational centers of the most important section of the region — the state of Minnesota. Consequently, this metropolitan district has a more nearly complete concentration of the urban aspects of its region than any other such center in the United States. Nearly one-sixth of the total population of the three states forming the greater part of the tributary region is included in this district.

The importance of these activities within the urban district may be observed in various ways. As seen from an aeroplane, or on a map, a striking feature of this area is the number of radiating rail lines and the amount of land given over to terminals, switch-tracks, transfer yards, and carshops. The latter alone employ more workers than any other manufacturing industry in the district. All told, the workers on and for the railroads, together with their families and those who serve them in secondary activities — retail storekeepers, builders, etc. — constitute at least one-sixth of the total urban population, a railroad city of over 100,000. Closely associated with the railroads are the wholesale collective and distributive agencies, with their grain elevators, stockyards, warehouses, and jobbing offices. Manufacturing industries are relatively less important, employing less than 10 per cent of the population, as compared with 15 to 25 per cent in cities of the manufacturing belt east of Chicago. Furthermore, the most important industries other than carshops are of the "commercial" type, largely dependent on the railroad concentration: flour and feed mills and meat-packing plants. The others serve chiefly the consumer needs of the district itself (baking and newsprinting) or of both the district and the tributary area (structural iron work and tractor plants). Some industries serving a national market, notably knit goods, are better known but quantitatively are of minor importance. The activities concerned with the state capital and state university are also of minor importance, together accounting, directly and indirectly, for probably less than 25,000 people.

Basis for Rail Concentration at Minneapolis and St. Paul

It is clear that the importance of the Twin City district is, in one way or another, largely dependent on the network of rail lines entering and leaving it — iron arteries connecting it with its sources of life. That this district rather than any other in southeastern Minnesota, such as Stillwater, Winona, or St. Peter — all of which had optimistic supporters in the early days of development — attained that all-important concentration was the result of no one factor but rather of a number of different advantages to be found within this restricted area. 1. The Twin City area included the northern terminus of ordinary steamboat navigation on the Mississippi. 2. It included also the termini of less important navigation on the Minnesota and the Mississippi above St. Anthony Falls. (Navigation on the St. Croix, once important, declined with the lumbering industry and had little relation to grain shipping from the Red River valley.) 3. Within it is found the northernmost point of the Minnesota-Mississippi Valley, where glacial River Warren changed its direction from northeastward to southeastward. This is the only major obstacle to the dominant routes of the region — a belt 1 to 5 miles wide of river, marsh, and flood plain, bordered by steep bluffs 120 feet high. At the same time the two arms of this valley offered easy gradients to lines following them from both southwest and southeast. 4. The first point from the south where the Mississippi River itself (as distinct from its valley) could be easily crossed is above the junction of the Minnesota, also within this district. 5. Lumber mills and, more important, flour mills had developed around the Falls of St. Anthony. Finally, largely because of all these facts, the two small twin towns had become established before the period of rail construction as the largest in the region.

THE DUAL CHARACTER OF THE URBAN DISTRICT

The structure of this urban district presents a very rare character, that of two practically complete cities in one.[3] There are many pairs of part-cities facing each other across a dividing stream, as at Omaha–Council Bluffs; or of a dominant city with satellite cities next it, as at New York–Jersey City; or of politically separate cities which form part of a single geographic city, as at Kansas City, Missouri-Kansas. Minneapolis and St. Paul are genuine Siamese twins, two cities of coordinate importance, each practically complete in itself, but with immediate and close contact along a common zone.

In spite of the fact that these two cities must be recognized as a single urban area, there is extraordinarily little differentiation of function between them. Not only does each have its own commercial core, or "downtown district," complete and widely separated from the other, but most of the other economic features specified above are distributed through both, notably the railroads with their terminals and carshops, and the wholesale buildings and warehouses. The flour mills, which started at the Falls and have spread into all parts of Minneapolis but not into St. Paul, and the Union Stockyards and associated packing plants at South St. Paul, constitute exceptions. Furthermore, the local activities of the two cities are strikingly separated, as reflected in retail stores, streetcar lines (even though under a single company), and the newspapers. Although one city has grown to be much the larger, it shows very little tendency to absorb functions of the other.

Although this situation had its seeds in the separate origin of the

[3] Richard Hartshorne. "The Twin City District: A Unique Type of Urban Landscape," *Geographical Review*, 22:431–42 (July, 1932). In response to this article it was suggested that Albany and Troy, New York, have a similar relationship, but the topographic maps do not bear this out and certainly they are not alike functionally. More nearly similar is the case of Elberfeld and Barmen in Germany, now joined together politically as Wuppertal.

towns in the prerail period, its development is largely the result of the fact that the railroads concentrated separately at each. Had one of the two been made the single center, the other might well have remained little larger than the other towns of the area, such as Stillwater or Hastings — which originally were but little smaller — or might have been absorbed as a suburb of the dominant city. That this more normal development did not take place here was due to the fact that no one point within the district commanded all the advantages which contributed to the development of rail concentration.

The earliest white settlements near the junction of the Minnesota and Mississippi were not at either of the two present cities, but more immediately at that confluence. The site of Fort Snelling (F on Figure 1), admirably situated to command the two rivers for military purposes, was topographically unsuited to commercial purposes. Mendota (M), located on the small terrace opposite the fort and under its protection, was on the inside of the Minnesota-Mississippi bend, at a point accessible to railroads from but few directions. The original site of St. Paul, at the river levee (L), where the Union Station now stands, occupied the strong commercial position on the outside of the great bend. Here, at the northernmost point to which steamers could navigate without great difficulties, was a series of readily connected terraces; furthermore, the rather wide valley of a preglacial stream (probably the preglacial Mississippi), occupied only by the very small Trout Brook, provided an easy gradient for railroads to leave the main river valley and ascend to the general upland level. The importance of this last-mentioned feature is seen in the dozen or more tracks of four railroads which fill it completely (not to mention one double track line in the very narrow ravine of Phalen Creek, which joins it near the main river).

In Minneapolis, Nicollet Island in the upper Mississippi above the Falls (B-B) provided the easiest crossing of the river and became a point of concentration for roads and, later, railroads from the west and northwest, including those heading for St. Paul. Furthermore, this point was only half a mile above the lumber and flour mills that depended on St. Anthony Falls and was the terminus of what little navigation took place on the Mississippi above the Falls.

The distance of ten miles between these points was too great to permit development to take place at either alone, or at any point between them. Consequently both grew, semi-independently of each other. The long period of struggle between them to pull the railroads to their respective sites appears to have ended in a draw, since practically all of the lines that came to the one sooner or later established their connections and terminals in the other, and all operate today with the two as coordinate centers, though, for the purposes of long-distance traffic, they are rated as one.

The zone of contact between the two cities, though it would naturally

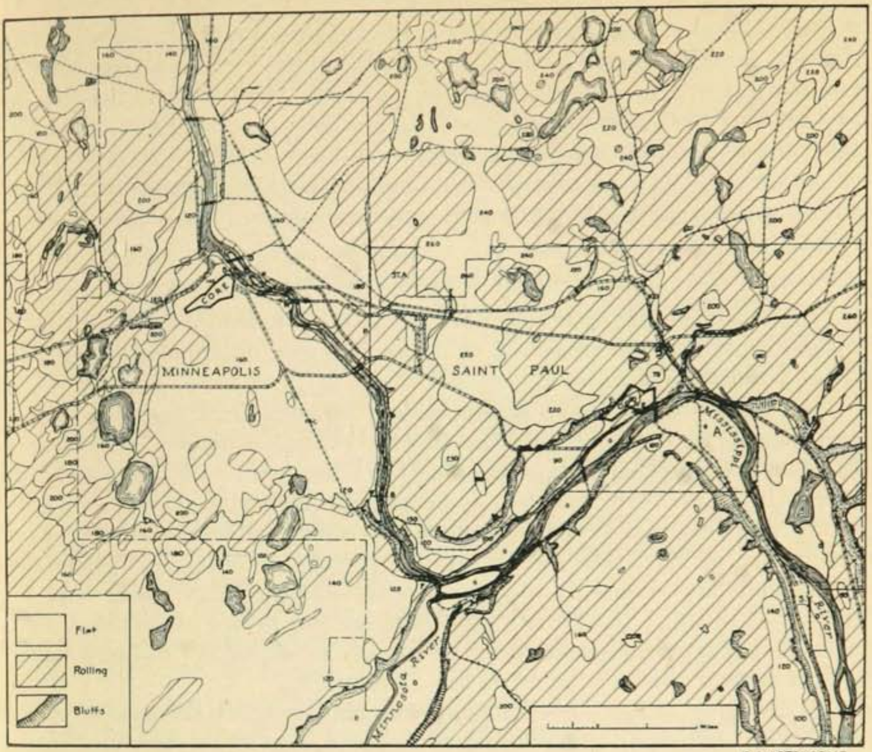

FIGURE 1. — Relation of railroad centers and city centers to surface features.

have resulted from their later growth to metropolitan size, was largely the result of the rail lines. Certain railroads individually, and later all collectively, established terminal and transfer yards (T.Y.) in the then-empty land between the cities; around these yards developed the wholesale and manufacturing industries which make up the Midway district. This is politically a part of St. Paul, but geographically could be regarded as the hyphen connecting the two cities. The same is true of the residential district of St. Anthony Park (St.A.), located on the low morainic hills just to the north, and of the much later development around the Ford factory and the resulting bridge (F. B.) farther south. This is the only major point where large numbers of workers employed in the one city live in the other.

Although the two cities have, in these ways, grown together like independent cells along one side of their peripheries, their two nuclei, the commercial cores, are not only still quite separate but can be expected to remain so. Their growth horizontally is necessarily much more limited than that of the peripheries; besides, the growth of the commercial core of Minneapolis is away from that of St. Paul. The suggestion sometimes made, of establishing a new center for both, presumably in the Midway district, seems impractical in view of the extent to which that area is blocked by widespread rail yards and already filled with industries, to say nothing of the improbability of such wholesale abandonment of the two present downtown districts. Because of these separate centers, political union of the two cities, although a highly desirable recognition of their common geographic interest, would require a unique form of city government.

Contrasts in Urban Landscape

Although the two cities are part of the same urban district, and have for the most part the same sort of urban features, differences in site give them a totally dissimilar appearance.

St. Paul, which climbs up successive terraces from the flood plain and extends up the slope onto the more level upland beyond, crowned by the State Capitol, is a typical river city. Its commercial core extends along the terraces, to which it is necessarily restricted, almost clinging to the river margin. Perhaps because it is older, its streets are narrower and many of them are steeply graded. Some are actually blocked by steep bluffs and others by the great width of the railroad tracks that fill the valley of the Trout Brook. The deep, narrow ravine of Phalen Creek, with its squatter homes set deep in the ravine along the railroad track, is strikingly reminiscent of cities like Pittsburgh.

A few long bridges, one quite spectacular, connect the center of St. Paul with industrial and residential districts located on the flood plain and bluffs across the river. Its most important suburbs extend along this flood plain to the south, where the Union Stockyards and associated packing plants were located for the entire district; on the high terrace above lies the residential district of South St. Paul. Much of the flood plain was too wet for use, so that even close to the city center large areas remained vacant; this made it possible to establish an airport (A) on flat, empty land unusually close to the heart of the city.

In contrast, Minneapolis is an extraordinarily flat city. Over the greater part of its extent, including the core, the relief is barely discernible. The major exception is on the eastern side of the city, where the narrow gorge of the river below the Falls cuts a gash as with a knife. Above the Falls the river is almost at the level of its banks on either side. Though still a serious barrier, the river is crossed by no less than a dozen street bridges and seven railroad bridges, nearly half of them concentrated in one mile between Nicollet Island and Washington Avenue (W). Elsewhere, the major interruptions to the street pattern are the string of lakes along the western and southern periphery, a few steep hills on the west, and the extensive development of railroad tracks — for example, immediately north of the commercial core or, more strikingly, in the area adjoining St. Paul, where there is but a single street crossing in a distance of three miles.

The commercial core, which had its start at the junction of roads on the western side of the first bridge over the island (the Gateway district), has moved westward, abandoning its former areas, and now seems to have no relation to the river. Nicollet Island, which might have been developed into a park, or a city center like the Île de la Cité in Paris, has been abandoned to low-grade stores, poor residences, and dump heaps.

Whereas the morainic hills situated a little to the west of the center of St. Paul offered an advantageous site for a fine residential district largely free of railroads and associated industries, the only large areas of this sort similarly located in northwest and northeast Minneapolis were rendered undesirable by the extensive railroad tracks, originally crossed only at grade, which separated them from the city center. Only in the later stages of its development, particularly after the coming of the automobile, did Minneapolis take advantage of the lakes along its southwestern margin; and even here the railroads had spoiled certain parts.

The generally flat surface of most of Minneapolis permitted the many railroads to enter the city over independent routes, so that their tracks, bordered by elevators, coalyards, and industries, are to be found in practically every part of the city. Although the same is true of most of St. Paul, the steep slopes west of the downtown district, combined with the extraordinary concentration in the Trout Brook valley, left a large area west of the city center free of rail lines and industries.

On the other hand, the gorge of the Mississippi, unspoiled by railroads or industries through most of its course (below Washington Avenue), provides a natural ribbon of parkland reaching nearly to the heart of Minneapolis. The addition to this of the string of lakes on the west and the unspoiled valley of Minnehaha Creek on the south has made possible an unusual parkway almost encircling three sides of the city. Somewhat similar possibilities are offered by the lakes that lie along the northern margin of St. Paul, but the wide river valley of the Mississippi has little to offer for parkway purposes, being well occupied by rail lines, industries, and poor residence districts on the "flats."

It was natural that the greatest concentration of railroads and industrial features should develop on the side where the two cities approached each other. This area was, however, compressed into a particularly narrow belt because of the course of the river on the south, the steep hill of Prospect Park (P), and the extension of the morainic hills of St. Anthony Park from the north. Almost within this congested railroad and industrial district is the campus of the state university (U), a situation obviously disadvantageous in many ways but possessing one advantage found at no other state university — an accessible location close to the population center of the largest urban district of the state.

With the more recent resumption of river traffic on the Mississippi, the old levee at St. Paul, never abandoned, has seen new life, and on the wide, flat flood plain below the city a modern barge terminal has been built. The construction of a federal dam and locks in the gorge of the upper river eliminated the rapids which made navigation to Minneapolis difficult, and a barge terminal and coal docks have been constructed for that city in the much narrower flood plain below the Falls at Washington Avenue (W), the one point where there is a break in the river bluffs.

Of greater importance to the urban district has been the problem of a system of sewage disposal that would eliminate the traditional use of the river as the ultimate sewer. This project is of special interest because it is the first major undertaking requiring the cooperation of both cities, a fact that caused long delay in its execution, only now under way. Here again the flat flood plain south of, and at a lower level than the whole urban district, offered ample opportunity for a disposal plant.

The Area Surrounding the Twin Cities

In comparison with other metropolitan districts of its size, the Twin City district has remarkably few suburbs. Industrial suburbs are not to be expected in a district in which manufacturing is of relatively minor importance and includes few industries requiring peripheral location, i. e., plants that need large areas of land or are dangerous or objectionable within cities. An obvious exception, on both counts, is the stockyards and packing industry at South St. Paul. The attempt to develop an industrial suburb at St. Louis Park, west of Minneapolis, has not been successful.

Why there should be so few residential suburbs is only partially clear. Since the district has two city centers, it is not so congested as are others of the same total population; also, perhaps because it is younger than centers farther east, its residential districts have tended to spread out more, so that there is less urge for people to move outside. No doubt the fine residential areas in each city are also a factor. Whatever the reasons, there are no distinctly suburban towns populated by city workers dependent on local trains for daily movement to and from the cities. On the other hand, the automobile has made it possible for many of the workers in the cities to move out beyond the actual margin of the urban area, where they may do part farming in leisure hours, and for residents of the small towns much farther out to take work in either city and yet maintain their homes in those communities.

Perhaps more important is the increasing development of summer homes for city families at points considerably distant from the cities, yet within the defined metropolitan area. But few cities in the eastern half of the country have as large a number of sites suitable for this purpose. The nearest are the many small lakes in the low morainic hills immediately north of St. Paul, accessible to both cities. More important is the far larger Lake Minnetonka, west of the urban area, which, with its many indentations and the small adjacent lakes, offers over 100 miles of shore line almost fully occupied by cottages and a few hotels. Since this area is but 18 to 28 miles from the center of Minneapolis, it permits daily movement to and from the city during the summer months, and to some extent from the nearer points throughout the year. This area is but little used by residents of St. Paul, partly because of the increased distance involved, but more largely because the trip involves passing a long distance through both cities. For the same reasons the string of cottages located on the St. Croix River from Otisville on the north to Point Douglas on the south are utilized largely by residents of St. Paul. The deep, wooded St. Croix Valley, largely regrown to something near its original appearance since the passing of the lumberman and unspoiled by any major railroad or industrial development, is becoming of increasing importance for summer homes now that the automobile has made the distance — 15 to 30 miles — accessible to the people of St. Paul. Other possible sites for summer homes could be found along the high, sharply etched bluffs of the Minnesota, although its graded stream is less attractive than the St. Croix or the lakes.

The area covered by this report includes in its outer margins farmland and smaller urban settlements which were, and to a large extent remain, independent of the main urban center. However, with the increasing range of automobiles and trucks over hard roads, these are being drawn into increasingly intimate contact with that center. Farmers throughout nearly all this area produce milk, vegetables, and small fruits for direct truck delivery in the urban area. They receive direct delivery of newspapers from one of the two cities and increasingly depend on the stores in that city for their purchases, to the detriment of those in the local towns. Many of the latter stores have become little more than outlying retail points for wholesale stores, bakeries, and ice cream plants usually located in the nearer of the two cities. In many cases they are increasingly dependent on the trade of the summer residents from the cities. Nevertheless, these towns cannot be thought of as purely urban, since they retain to some extent the character of local agricultural centers found in farming areas more remote from large cities.

CHAPTER II

VEGETATION OF THE MINNEAPOLIS–ST. PAUL AREA

BY F. K. BUTTERS

It is well known that there are in Minnesota three major types of native vegetation: the coniferous forests of the northeastern part of the state, the prairies of the south and west, and diagonally between these, from southeast to northwest, a belt of hardwood forest from a few to nearly a hundred miles wide. The Twin City area lies in this third belt, at the point where it attains its greatest breadth. Accordingly, the native vegetation of this area was largely deciduous forest of one kind or another; nevertheless, there were within its boundaries several more or less extended fragments of both the prairies and the coniferous forests, so that three major units of North American vegetation were represented within this relatively constricted area. Moreover, as each of the main types was represented by several subordinate types, the flora of the Metropolitan Area was one of the most varied to be found in any lowland area of its size in the United States.

Hardwood Forests

The Big Woods.—The so-called climax vegetation of our region is a heavy maple-basswood forest, but this type of forest had been attained only in the areas most favorable to tree growth, the rich calcareous clays of the gray drift, belts around some of the lakes, and sheltered ravines and similar places along the bluffs of the larger rivers.

The best developed and most extended example of this type of forest was found in the region known to the early settlers as the "Big Woods." This tract, nearly 100 miles long and about 40 miles wide, lay mostly to the west of the Metropolitan Area, but included the western third of Hennepin County and adjacent parts of Wright, Carver, and Scott counties.

This area was originally clothed with almost continuous forest, mostly of the climax type. The trees were tall, straight, and close-set. The principal species were the sugar maple, basswood, and white elm, with considerable slippery elm and red oak. There was also some intermixture of other trees such as green ash, butternut, and bur oak. This last was much less abundant here than in the drier oak woods, but when it occurred, it reached a large size. With its tall, straight trunk and narrow crown it was very different in appearance than when growing in more open woods.

Almost everywhere the ironwood formed an understory beneath the larger trees, and in many places the ground was covered with a thick growth of seedling maples, such shrubby plants as the dogwoods, and innumerable species of herbaceous undergrowth. In the spring before the foliage of the trees was thick enough to shade the ground, there were many wild flowers, hepatica, wood anemone, bloodroot, Dutchman's-breeches, the large flowered bellwort, trilliums, and others, but later in the season flowers were not conspicuous in the deep shade of the forest.

Much of this forest has now been cleared. Usually, a wood lot was left in some part of each farm, but even there much of the larger timber has been cut for firewood and the undergrowth has been largely destroyed by pasturing. A few fragments of this forest are left, in almost natural condition, in the district around Lake Minnetonka, and farther west in Wright County, but the former extent of the Big Woods can be traced principally by the large native shade trees in farm yards and villages, and occasional wood lots mostly of second growth.

Forest quite similar to the Big Woods occurred along the larger rivers, in ravines and on bluffs facing north and east, also in patches adjacent to some of the lakes. There was such a patch adjacent to Lake Harriet, in Minneapolis, and many of the forest trees still survive there in a strangely altered environment.

Oak woods.—East of the region of big woods the forest was smaller and much thinner and consisted largely of oaks of various species. The white oak was practically confined to those regions where morainic soils of red drift are exposed. It was locally common throughout the central parts of Hennepin County, the northern portion of Dakota County, and here and there in Ramsey and Washington counties, but was practically absent from the Big Woods, and from the extensive outwash plains along the Mississippi. Along with the white oak were often found red oak and the northern pin or Hill's oak. Apparently, the true scarlet oak was also present in some of these forests.

The white oak forest was probably the best developed type of oak forest in the region. Although not as impressive as the Big Woods, the trees were often of considerable size. From the really fine white oak forest, the oak woods graded down through various thinner and scrubbier types. Much of the Anoka Sand Plain, and other especially sandy areas, had a thin and stunted forest of Hill's oak, either in pure stands or mingled with equally stunted bur oaks.

The bur oak was particularly abundant on the gravelly outwash along the Mississippi, often forming what the early settlers called "oak openings," savanna-like country with groves of oak scattered through more or less open prairie. Much of southeast Minneapolis had this type of vegetation, also the downtown district north of Franklin Avenue. The oaks of the University campus are survivors of such groves.

The oak woods, less dense than the Big Woods, had a different sort of undergrowth. Hazel was probably the most abundant undershrub, with abundant growths of wild roses, blackberries, and New Jersey tea; on the Anoka Sand Plain blueberries were abundant. Around openings, particularly among the bur oaks, the wild crab apple and various species of thorn apple were common. The commonest spring wild flowers were wild geranium, rue-anemone, Canada anemone, wild lily of the valley, false Solomon's-seal, and wild sweet peas, both purple and cream-colored.

Since the shade of the oak forest was less effective than that of the Big Woods, many summer and autumn blooming herbs occurred, particularly in more open portions. In many places, for instance, asters and goldenrods were almost as abundant as in the open prairie. Since the oaks often grew upon soil so poor as to be scarcely worth clearing, and since their wood has never been very popular as fuel, much of the oak woods is still standing. Where portions of the original oak forest have been included in urban areas, many of the original white, bur, and red oaks have been preserved as shade trees. Hill's oak, however, tends to die out under such conditions, and rarely persists for any length of time.

River bottom forests. — The bottom lands of the Mississippi and St. Croix rivers were originally well wooded. There was generally a line of gigantic cottonwood trees along the water's edge, and back of these a heavy growth of white elm and soft maple intermixed with many other species. These forests were often hung with the huge, rope-like stems of wild grapevines. In the spring, they had their own types of wild flowers, beds of spring beauty and false rue-anemone, and a little later the blue-lavender phlox. Later in the summer, there was often a dense undergrowth of jewel-weed and wood nettles.

The Minnesota River bottoms were never much forested. Back of the edging of cottonwoods the land sloped off again into marshy tracts, and toward the bluffs there were belts of moist prairie.

Coniferous Forests

The main body of northern coniferous forest stopped short of the Metropolitan Area, but there were certain outliers within the area that reproduced more or less faithfully the conditions of the north woods. The largest and most complete of these was in northeastern Anoka County, just north of Coon Lake. Here there was and still is an area of several square miles covered with Jack Pine on the sandy uplands, and black spruce-tamarack swamps in the hollows. A little farther west there is a large cedar swamp very similar to those found in the northern part of the state.

The white pine was never abundant in the Metropolitan Area, though the first commercial exploitation of this tree in Minnesota occurred only a little way to the northeast, at Franconia near Taylor's Falls. White pines grew, here and there, all the way down the St. Croix Valley, and thence down the Mississippi to beyond the Iowa line, mostly as small groups on the river bluffs in the midst of deciduous forest. Several similar groups of pines occurred along the Mississippi within our area, notably in the Minnehaha glen, on the east bank of the river a little below Summit Avenue, and at Dayton. Some of these groups have entirely disappeared, others are now represented by one or two half-dead trees; only along the St. Croix are they still in a fairly flourishing condition.

Throughout most of our area, however, the northern forests were represented only by tamarack swamps, which were abundant as far south as the Minnesota River. These swamps lacked, indeed, the characteristic evergreen conifers of the north, particularly the black spruce, which in the north almost always accompanies the tamarack, but their flora was distinctly related to that of the north woods rather than to that of the surrounding uplands. Here one found the pitcher plant, twinflower, and bunchberry, the showy pink and white moccasin flower and many other rare orchids. Forty years ago, all these flourished even within the city limits of Minneapolis. One could enter the great swamp southwest of Lake Calhoun and feel that he had been suddenly translated to the northern wilderness.

Probably no natural habitat in our area, except possibly the prairie, has degenerated as thoroughly as the tamarack swamps. Those near the cities, drained and filled in to make house lots, have completely disappeared. Many in the country have been entirely cut out for firewood and fence posts, and the land has reverted to wet, hummocky pasture. Even where the trees are still standing, drainage and pasturing have usually ruined the undergrowth. Only a few of the most remote and inaccessible are still in their original condition.

Prairies

True upland prairies occupied extensive areas, particularly in the outwash plains along the Mississippi and in the portion of Dakota County south of the St. Croix moraines. Also, prairie-like openings were common in many parts of the oak woods. Much of the city of Minneapolis was originally prairie, particularly the region south of Franklin Avenue. Except for groves about the lakes and in the valley of Minnehaha Creek, and a narrow fringe of woodland along the river, the southern half of the city was practically devoid of trees, as was also much of the country south to the Minnesota River. There were also more or less extensive prairies in northeastern Hennepin County between Osseo and the Mississippi, in Wright County in the vicinity of Monticello, and along the east side of the Mississippi northwest of Anoka, as well as scattered patches in Ramsey and Washington counties. The parts of southern Washington County and Dakota County lying outside the limits of the Wisconsin glaciation were almost wholly prairie, broken only by a few small groves, mostly of oaks and poplars. Most of these prairies seem to have owed their existence to gravelly subsoils too porous to hold a reasonable supply of water through a season of drought.

Besides the prairie grasses, the prairies contained many kinds of blossoming herbs and low shrubs, including many of the most striking wild flowers of the region. From the pasqueflowers of March or early April there was a succession of flowers until late June: puccoons, bird's-foot violets, prairie phloxes, wild roses, and many others; and again towards fall sunflowers, blazing stars, goldenrods, and asters rendered the prairies gay. Now there is little left of the natural upland prairie — a few strips along the railroad rights of way, a few hillsides too steep for cultivation, a few extra-barren sandy areas. No natural type of vegetation disappears more thoroughly under contact with civilization than the virgin prairie.

Wet or poorly drained prairie tracts were formerly very common. Among the best examples were those in the bottom lands of the Minnesota River, some of which still exist with but little alteration. In the recent dry years, however, many such tracts have been broken and put into cultivation. Their soil is usually very fertile, but if there is a return to seasons of normal rainfall, they are likely to prove too wet for crops unless they are thoroughly tile-drained. They are probably best left as pasture and hay lands.

Aquatic Vegetation

Finally, there are the various types of aquatic and subaquatic vegetation. Nearly all our lakes have submerged water weeds, even in moderately deep water; many of them have yellow and white waterlilies, bulrushes in shallow water, and cattails fringing low shores. All these plants tend inevitably to fill the lake basin with organic sediment, which slowly obliterates the lake. Then during some dry spell the water falls below the surface of the muck and another lake has disappeared, perhaps only for a season, perhaps for all time. Sooner or later, all our lakes will suffer this change, as many have already done, even in our regions of youngest glacial drift, and as all have already disappeared from the older drift sheets to the south and east of the Twin Cities. For a time, the lake bed continues as a cattail swamp, often with considerable open water. With further filling, it becomes a wet, sedge-covered meadow, and eventually either wet prairie, or a tamarack swamp, if conditions prove suitable for the invasion of that tree. Many such old lake beds, in all stages of decrepitude, occur throughout our area.

CHAPTER III

STRATIGRAPHY OF THE MINNEAPOLIS–ST. PAUL AREA

AGE AND CHARACTER OF THE ROCKS

With the exception of the glacial drift and related unconsolidated deposits, all of the known rocks in the Metropolitan Area are geologically relatively old. Those exposed at the surface were deposited during the Cambrian and Ordovician periods, the oldest subdivisions of the Paleozoic era. A few deep wells, however, encounter rocks that are not exposed in the area, but may be seen in adjacent parts of the state, as at Taylor's Falls, Hinckley, Sandstone, St. Cloud, and Morton. These rocks were formed during what is referred to as pre-Cambrian time, and some of them are very old. The oldest are principally igneous rocks, some intrusive, others extrusive. Intrusive igneous rocks are formed by molten material, or magma, solidifying beneath a cover of other rocks. Rocks are poor conductors of heat; thus these intrusives cool slowly and consequently develop the coarse grain characteristic of granites. Extrusive igneous rocks are formed from molten material poured out on the surface as lava flows. Because the cooling is rapid, the rocks are dense or fine-grained, like basalt or traprock of the type exposed at Taylor's Falls.

The Cambrian and also some of the earlier rocks are principally sedimentary; that is, they were formed at the surface chiefly by the action of water. Those formed in the ocean are referred to as marine sediments; those formed in fresh water on the continents are called continental or simply non-marine sediments. The three principal types of sediments, when consolidated, form sandstone, limestone, and shale.

In the following pages descriptions of each of the various formations are given, including a summary of available data which may be useful to engineers and others. The writer is indebted to Professor C. R. Stauffer for many of the measured sections. The table on the next page presents in outline form the rock formations of the area.

PRE-CAMBRIAN FORMATIONS

Granite. — For only one well in the area is there unquestioned evidence of granite having been reached. This was located in the Lakewood Cemetery property in Minneapolis and reached a depth of 2,150 feet, penetrating granite for 15 feet. (See tabulation of Minneapolis wells, no. 20, page 222.) The exact age of this granite cannot be determined from such scant information, but when it is considered that outcrops of granite

ROCK FORMATIONS OF THE MINNEAPOLIS–ST. PAUL AREA

Period	Formation	Average Thickness (in feet)	Apparent Range in Well Logs (in feet)
Recent	River alluvium		0–150
Pleistocene	Glacial drift, etc.	100	0–400
Ordovician	Galena	top eroded	0– 20
	Decorah shale	75	0– 75
	Platteville limestone	30	25– 35
	Glenwood beds	5	2– 7
	St. Peter sandstone	158	145–165
	Shakopee dolomite	45	35– 60
	New Richmond sandstone	11	0– 15
	Oneota dolomite	80	70– 90
Cambrian	Jordan sandstone	90	80–105
	St. Lawrence formation	180	160–200
	Franconia sandstone	65	45– 80
	Dresbach formation	155*	125–200
Cambrian or Keweenawan	Hinckley sandstone	220	
	Red Clastic series	1,012	(Lakewood well)
Pre-Cambrian	Basalt flows; granites	Unknown	

* The formations below the Dresbach are not exposed in or near the area, but are known from deep wells, notably at Stillwater and at Lakewood Cemetery, Minneapolis.

occur abundantly to the west along the Minnesota River, to the northwest in the vicinity of St. Cloud, and to the north in the vicinity of Mora, it is reasonable to believe that the granite below Minneapolis is of the same age, that is, pre-Cambrian.

Lava flows.—Just beyond the limits of the Metropolitan Area at Taylor's Falls on the St. Croix River, lava flows are exposed. These same flows were penetrated in the deep well at Stillwater. They have been traced continuously from the St. Croix River to Lake Superior in Douglas County, Wisconsin, and are classed as Keweenawan in age.

RED CLASTIC SERIES

Name.—A series of alternating red shales and sandstones, including the Hinckley sandstone, was described by Winchell and Upham[1] in 1884 from the cuttings of a well drilled at Mankato, Minnesota. The terms Hinckley and Red Clastic were not used at that time, but the beds were correlated with the red shales and sandstones at Fond du Lac and else-

[1] *The Geology of Minnesota* (Final Report of the Minnesota Geological and Natural History Survey), 1:423–25.

where along the coast of Lake Superior. The same series was correlated by Meeds as Keweenawan in age in describing the Stillwater deep well in 1891.[2]

The term Red Clastic seems to have been first used in print in Water Supply Paper 256,[3] where it included not only the red shales and sandstones, but the pink to buff sandstone above, which had been called Hinckley by Winchell. The Hinckley is largely a very coarse sandstone and the Red Clastic series below is usually a very fine red shale or shaly sandstone. Because of its importance as a water-bearer the Hinckley is here treated as a separate formation. In the absence of a better term, "Red Clastic" is applied to the red shales and sandstones below the Hinckley sandstone.

Distribution.—The Red Clastic beds are penetrated by a sufficient number of wells to suggest that these beds, in varying thickness, underlie the entire area covered in this report.

Character.—The Red Clastic beds do not crop out anywhere in Minnesota south of Mora, but they are often correlated with the sediments along the coast of Lake Superior. We are, therefore, dependent upon well cuttings for knowledge of these sediments as they occur beneath the Metropolitan Area. In the Stillwater deep well over 2,400 feet of Red Clastic beds were found. (See the Appendix, p. 187.) There are eight samples of this material preserved in the files of the Minnesota Geological Survey. The Survey has Red Clastic specimens from these other localities also: St. Mary's Hospital, Minneapolis; Lakewood Cemetery, Minneapolis; Bunker Hill, Mankato; 1889 well at Stillwater; Exposition Hall, east Minneapolis; and the Chicago, Milwaukee, St. Paul and Pacific Railroad Company well at Hastings. These show dark red, sandy shale and red to brown sandstone, varying to arkose. In the Lakewood well the record was complete only to 1,400 feet; between 1,123 and 1,400 feet there was a compact red clay, or shale, with a reddish brown shale below. In the east Minneapolis well the same horizon was reported as red marl and sandstone. In the Hastings well of the Milwaukee railroad there are 340 feet of red shale and white sand, now correlated with the Red Clastic beds. Other wells in Minneapolis and St. Paul show similar material. At South St. Paul several wells pass through 200–300 feet of sandstone into a conglomerate that is also often reported as granite. In view of the results of still deeper wells but a few miles away, it is probable that there is no granite at this depth.

Thickness.—The thickness of the Red Clastic beds is known at only two places in the Metropolitan Area—the Lakewood and the Stillwater wells. These are the only ones known with any certainty to have pene-

[2] "The Stillwater Deep Well," *Bulletin of the Minnesota Academy of Natural Sciences,* 3:274–77 (1891).

[3] C. W. Hall, O. E. Meinzer, and M. L. Fuller. *Geology and Underground Waters of Southern Minnesota* (United States Geological Survey, Water Supply Paper 256).

trated the full thickness. The Lakewood well, according to the best available data, passes through 1,012 feet of red beds between the Hinckley sandstone and the depth at which granite is reported. The Stillwater well shows 2,458 feet of the beds between the sandstone classed as Hinckley and the Keweenawan diabase at the bottom of the hole.

The surface of the Red Clastic series below the Hinckley sandstone is trough-shaped and has these elevations with respect to sea level: Elk River +590; Glencoe +50; Minneapolis −238; South St. Paul −150 to −190; Stillwater +45; Hudson +317; Hastings −113. The thickness of the Red Clastic series varies with the distance to the pre-Cambrian granite or basalt below.

Hinckley Sandstone

Name.—There was found in the Lakewood Cemetery well and in several other deep wells in the southern part of Minnesota a series of buff to red sandstones and red shales. The upper portion of this series is usually a fairly thick sandstone; in the Lakewood well this was correlated by N. H. Winchell with the Hinckley sandstone.[4] Winchell had previously used the term Hinckley in a short paper on stratigraphy in Minnesota, placing it between the red shales below and the shales of the Dresbach above.

This sandstone lying beneath the Twin Cities has recently been correlated by some workers with the Mt. Simon of Wisconsin, which is typically developed and exposed at Eau Claire. Whether the Mt. Simon as it crops out at Eau Claire is stratigraphically the same as the Hinckley exposed along the Kettle River in Minnesota is a question which is very difficult to settle because of the extensive deposits of glacial drift almost everywhere in the area between the two localities. However, the work of Atwater and Clement indicates that they are not of the same age.[5] The Minnesota Geological Survey is not yet satisfied that the sandstone at the top of the Red Clastic series beneath the Twin Cities should be correlated eastward with the Mt. Simon rather than northward with the Hinckley, a shorter distance and within the major part of the same basin of sedimentary accumulation. It is possible that both sandstones are present beneath the Twin Cities but have not been separated. Whether they can ever be successfully separated is problematical and the Survey insists on further work and more definite information before abandoning one formational name in favor of another which seems scarcely as appropriate. To this end all of the available material from wells and outcrops is being studied. Preliminary studies of well cuttings suggest that beds which should be correlated with both the

[4] *Geology of Minnesota* (Final Report of the Minnesota Geological and Natural History Survey), 2:280 and 286.

[5] G. I. Atwater and G. M. Clement. "Pre-Cambrian and Cambrian Relations in the Upper Mississippi Valley," *Bulletin of the Geological Society of America,* 46:1659–86 (1935).

Mt. Simon and Hinckley are present. Until further studies are made it seems reasonable to continue the use of the term Hinckley and to regard the Mt. Simon, if present, as the basal portion of the Dresbach formation, which is what it appears to be at the type locality in Wisconsin.

Distribution.—The Hinckley sandstone apparently underlies the entire area embraced in this report, since it has been encountered wherever wells of sufficient depth have been drilled. The Stillwater well penetrates it at 568 feet, an elevation of 222 feet above sea level; this depth is the shallowest shown in any well in the Metropolitan Area.

Character.—The Hinckley sandstone as described by Winchell from the Lakewood well cuttings is somewhat variable coarse sand, yellowish and pinkish in color. In the east Minneapolis well it is described mainly as white sandstone. In the Stillwater well the samples now classed as Hinckley are coarse yellow to pink and white sand, varying to red and brown sand with a red sandy shale interbedded. In the Hastings deep well drilled by the Chicago, Milwaukee, St. Paul and Pacific Railroad Company, the Hinckley is described as a coarse sandstone with pinkish sand and a little red shale near the base. In a well recently drilled near Rosemount the Hinckley was a coarse brownish sand very closely resembling rock from the quarries at Sandstone, Minnesota.

Thickness.—It is difficult to delimit the Hinckley in the well records from the Dresbach above and the sandy shales of the Red Clastic series below; therefore statements as to the thickness must be more or less arbitrary. The practice of well drillers is to classify as Dresbach yellow shales and sandy layers, and as Hinckley coarse, salmon-colored sand with shaly layers. In the Metropolitan Area the Hinckley is penetrated in at least 30 wells for which logs are available; in 19 of these the full thickness is probably represented. Those wells give a thickness of 220 feet as an average; as indicated above this may include the Mt. Simon.

CAMBRIAN FORMATIONS

Dresbach Formation

Name.—The Dresbach formation, consisting of "gray shales and thin layers of sandstone, which pass upward into thick layers of sandstone," was named by N. H. Winchell in 1888 from exposures at the town of Dresbach in southern Winona County. The name Dresbach has been used continuously since that time. The base of the formation is not exposed at Dresbach, nor anywhere else throughout the state, except around Taylor's Falls, where it rests on lava flows and the full thickness is not present. The usage in this bulletin is consistent with that of the Minnesota Geological Survey. The question as to what the formation logically includes has been treated exhaustively by Miss Peterson [6] and

[6] Eunice Peterson. *The Dresbach Formation of Minnesota* (Bulletin of the Buffalo Society of Natural Sciences, Vol. 14, No. 2, 1929).

more recently by Trowbridge and Atwater.[7] In Wisconsin the equivalent of the Minnesota Dresbach is divided into the Mt. Simon, Eau Claire, and Galesville members. The Mt. Simon is predominantly a nonfossiliferous sandstone, the Eau Claire a fossiliferous, sandy shale, and the Galesville usually an unfossiliferous sandstone. The latter may be absent or equivalent to the Franconia of deep wells in Minneapolis and St. Paul.

Distribution.—The formation is not exposed in the Metropolitan Area, but does crop out, as noted above, along the St. Croix River near Taylor's Falls and along the Mississippi River in the vicinity of Dakota and Dresbach in Winona County.

It is penetrated by many wells in Minneapolis, St. Paul, South St. Paul, Stillwater, Hastings, and elsewhere. Therefore it is known to underlie the entire area treated in this report. Its position is shown in the cross sections.

Character.—The Dresbach is decidedly variable in lithological and faunal characteristics. At the top it is mainly a shaly sandstone and may thus be confused with the Franconia unless studied in good exposures. The exposure in the type locality at Dresbach is a massive, buff, yellow and white fossiliferous sandstone with shaly beds near the base. The shaly beds are gray and fossiliferous; others are thin-bedded, irregular, greenish gray, with white mica a conspicuous constituent. These shaly beds are usually very fossiliferous. At Dresbach the shale and shaly sandstone extend at least 88 feet, giving a total thickness greater than 100 feet by an unknown amount. The lower limit of the Dresbach as used by the Minnesota Geological Survey is the base of the fossiliferous, shaly and sandy beds that lie on the coarser, purer, unfossiliferous beds of the Hinckley sandstone.

The best exposures of the Dresbach formation near the Metropolitan Area are found at Taylor's Falls. The following section measured by C. R. Stauffer gives the data for the most extensive exposures.

Section of the Dresbach Formation along the New Highway Cut at the Spring One Mile Southwest of Taylor's Falls

	Thickness (in feet)
Franconia sandstone, white to yellow	110
Dresbach Formation	
Shale, light gray to bluish gray, alternating with streaks of sandy glauconite. Contains *Obolella* sp	1.6
Sandstone, very glauconitic	13.8
Covered to river level. Elevation 688 ft	44.3

Thickness.—The average thickness of the Dresbach for the Metropolitan Area is difficult to determine because the limits of the formation

[7] "Stratigraphic Problems of the Upper Mississippi Valley," *Bulletin of the Geological Society of America*, 45:21–80 (1934).

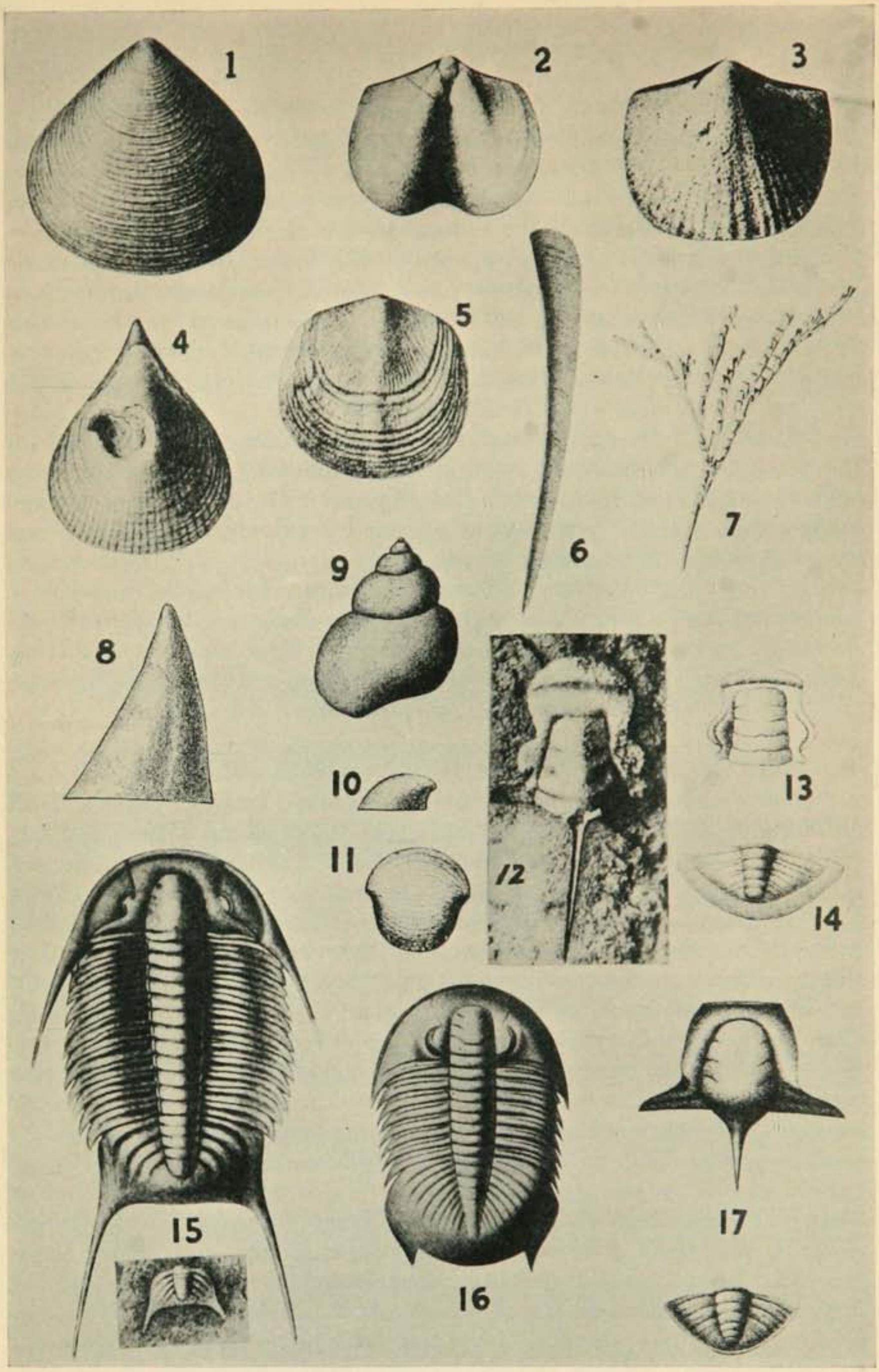

FIGURE 2. — Common fossils of Cambrian rocks in Minnesota.

BRACHIOPODS: (1) *Obolus matinalis*, (2) *Syntrophia primordialis*, (3) *Finkelburgia osceola*, (4) *Lingulella acuminata*, (5) *Bellingsella coloradoensis*; WORMS: (6) *Serpulites murchisoni*; GRAPTOLITE: (7) *Dendrograptus hallianus*; GASTROPODS: (8) *Hypseloconus recurvus*, (9) *Holopea sweeti*, (10) *Tryblidium corpulentum*, (11) *Bellerophon antiquatus*; TRILOBITES: (12) *Saratogia hera*, (13) *Saukiella pepinensis*, head only, (14) *Ptychoparia diademata*, tail only, (15) *Crepicephalus iowensis*, (16) *Dikellocephalus minnesotensis*, (17) *Lonchocephalus chippewaensis*.

are not easily recognized in well cuttings. Normally, the Franconia is a definite sandstone lying above the Dresbach, but in some wells it is either variable or not properly reported. The contact between the Dresbach and the Hinckley is even more difficult to determine. A study of 26 well logs which seem to record the total thickness of the Dresbach indicates an average thickness of approximately 155 feet. The thickness varies between 100 and 200 feet, possibly even more in various wells, no doubt because of confusion with other formations rather than true variation in deposition. Its thickness, location, and stratigraphic relation to other formations are clearly indicated in the series of deep wells at South St. Paul, shown diagrammatically in Figure 4.

Life.—With the exception of some obscure forms the rocks below the Dresbach are not known to contain fossils, but the beds from the Dresbach up are usually fossiliferous. (See Figure 2.) The most common forms are trilobites and brachiopods, but pteropods, cystoids, and worm borings are also found. Some characteristic species found in the Dresbach are listed below. BRACHIOPODS: *Dicellomus politus, Lingulella pinniformis, Obolus matinalis, Lingulella acuminata, Lingulella ampla;* GASTROPODS: *Hyolithes primordialis, Hypseloconus recurvus, Tryblidium corpulentum;* TRILOBITES: *Crepicephalus iowensis, Lonchocephalus chippewaensis, Menomonia calymenoides, Agnostus josephus, Dresbachia armata.*

FRANCONIA SANDSTONE

Name.—The Franconia sandstone was named by C. P. Berkey [8] from outcrops of sandstone along the St. Croix River at the village of Franconia in Chisago County, just north of the area described in the present report. Previous to 1897 these sandstone beds were included in the Dresbach formation. Berkey considered the sandstone sufficiently distinct from the remainder of the Dresbach to deserve a separate name and, in the main, later workers followed his practice. It seems clear that the 100 feet of white sandstone at Franconia was all that Berkey intended to include in the formation and this usage is still followed by the Minnesota Geological Survey. In so far as the area included in this report is concerned, the Franconia is a definite lithological unit which may be correlated with the type section by means of well logs. It has been stated by workers, particularly in Wisconsin, that the section at Franconia is not typical of the horizon elsewhere. However, this does not appear true of the area treated in this report, and it is possible that the so-called Franconia of Wisconsin is in reality the lower sandy phase of the St. Lawrence, as defined by Winchell in his final correlations. The Franconia as included in well logs in Minneapolis and St. Paul is believed by some workers to be the equivalent of the Galesville of the Wisconsin section.

Distribution.—There are no exposures of the Franconia in the Metropolitan Area so far as is definitely known. Part of the sandstone along

[8] "Geology of the St. Croix Dalles," *American Geologist,* 20:373 (1897).

the St. Croix River north of Stillwater and at Marine has been termed Franconia by some workers, but the most recent work makes it appear very doubtful that any of the sandstones cropping out south of Marine are as low stratigraphically as the Franconia. To so classify them involves an improbable thinning of the St. Lawrence sand beds above. The Franconia sandstone is penetrated by many wells in Minneapolis and St. Paul and at a few places outside the cities, especially Hastings and Stillwater. It probably occurs immediately beneath the deep glacial drift in the area several miles west of Lake Minnetonka at St. Bonifacius. (See Plate 1.) In general it is covered throughout the Metropolitan Area by younger formations.

Character. — The Franconia sandstone is normally a rather pure white to yellow sandstone, but may contain some scattered glauconite at various horizons. The type section along Lawrence Creek is given on the next page. A more accessible exposure is that along the new highway cut a short distance north of the type section. This section is also given for comparison.

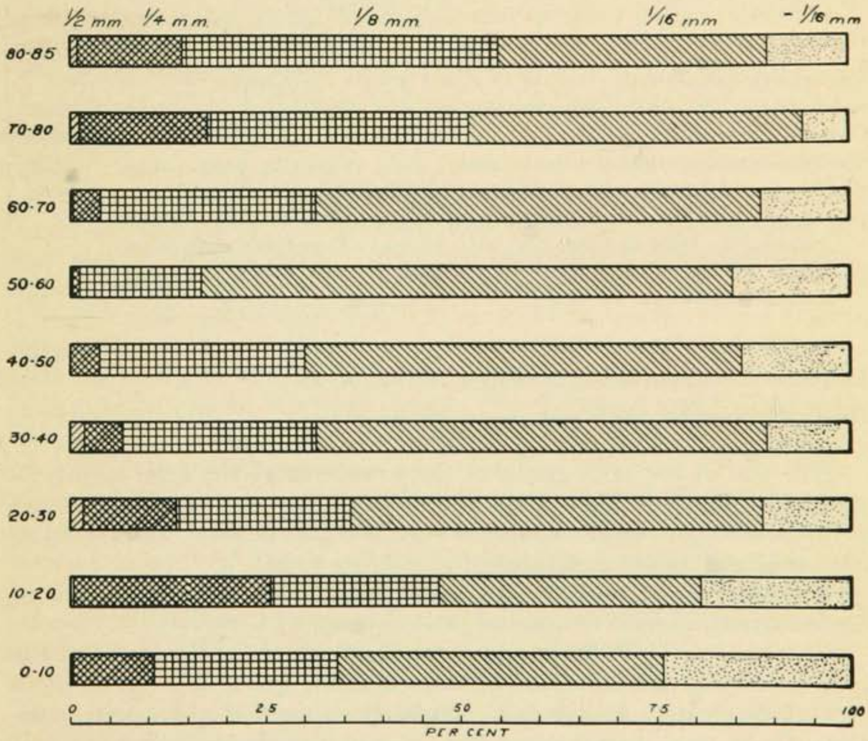

FIGURE 3. — Sieve analyses of Franconia sandstone from Taylor's Falls, given in percentages of weight. The figures to the left represent distances of each channel sample from the bottom of the formation.

Type Section of Franconia Sandstone along Lawrence Creek at Franconia

	Thickness (in feet)
Drift, to railroad station at Franconia	78
Franconia Sandstone	
Sandstone, white to yellow and brown, massive, cliff-forming, medium-grained	51.29
Sandstone, white to yellow and brown, massive, medium to fine-grained, abundantly fossiliferous, containing especially *Obolella polita* and fragments of trilobites. One hundred and fifty yards above the boat landing the basal part of this sandstone is very coarse and hard and rests directly on the diabase	64.36
	115.65

Contact with Dresbach shale and glauconite at elevation 732.3 ft.

Section of Franconia Sandstone along the New Highway Cut at the Roadside Spring One Mile Southwest of Taylor's Falls

	Thickness (in feet)
Drift	55.0
Franconia Sandstone	
Sandstone, white with yellow streaks, massive, friable	25.00
Covered interval	6.80
Sandstone, yellow, thin-bedded to shaly	12.35
Sandstone, white with yellow stains, massive, medium to coarse	44.55
Sandstone, gray to brown, massive to thin-bedded, medium to fine, glauconitic, cross-bedded, and with streaks of greenish shale along some bedding planes. Some layers may be very much indurated. Contains *Obolella*	21.40
	110.10

Elevation of roadside spring at contact 747.7 ft. A. T.

Dresbach formation, shale and glauconitic sandstone	15

The size of the sand grains of the Franconia at the type locality is shown in Figure 3. These data are useful in correlating the exposures with those found elsewhere, also in studies of the possible water yield of the sandstone where penetrated by artesian wells.

The chief heavy accessory minerals in the order of their abundance are leucoxene, garnet, tourmaline, and zircon.

Thickness. — C. P. Berkey gave the thickness of the Franconia at the type locality as 100 feet. Recent measurements given above show it to be slightly greater. As it is not completely exposed at any point in the Twin Cities area, we are dependent on well records for a knowledge of its thickness throughout the region. An average of 42 wells gives a thickness of 65 feet with a range of 45–80 feet.

Life.—The life that existed during the time the Franconia sandstone was being deposited was much like that of the Dresbach. Trilobites, brachiopods, and worm borings are the principal types represented. At certain horizons trilobite fragments are abundant, but only a few species are represented, and complete remains are almost unknown. In general, the sandstone is lacking in identifiable remains. This is often true of sandstone, as sand does not form a very favorable environment for life and provides an even less favorable medium for the preservation of fossils.

Some of the common fossil forms are as follows: BRACHIOPODS: *Dicellomus politus, Lingulella* (various species), *Obolus* (various species); TRILOBITES: *Conaspis bipunctata, Conaspis perseus, Lonchocephalus bunus, Saratogia wisconsinensis, Ptychoparia diademata, Saukia leucosia, Conokephalina misa.*

ST. LAWRENCE FORMATION

Name.—The series of shales, dolomites, sandstones, and greensands lying below the Jordan sandstone were included in a formation named the St. Lawrence by N. H. Winchell from exposures in the village and township of St. Lawrence on the Minnesota River, five miles southwest of Jordan, in Scott County. These beds form a definite lithologic unit between the Franconia sandstone below and the Jordan sandstone above, which is most convenient for practical purposes. This lithologic unit has been used in the present report and corresponds to the standard usage of the Minnesota Geological Survey, as finally worked out by Winchell.[9] Workers in adjacent areas often apply a somewhat different limitation to the formation, perhaps in part because of the addition or absence of certain beds at this horizon in the region outside of Minnesota.

Distribution.—The only exposures of St. Lawrence formation in the Metropolitan Area are along the St. Croix Valley from the vicinity of Afton northward to Marine. The formation is penetrated by many wells in Minneapolis and St. Paul and vicinity. (See Figures 4 and 5.) It is well exposed in the anticlinal structure along Trout Creek southwest of Afton, along the bluffs in and near the village of Afton, near river level at Stillwater, and extensively in the bluffs from Stillwater to Marine, usually near river level. It probably lies immediately beneath the drift in the vicinity and north of Anoka and southwestward to the extreme west end of Lake Minnetonka. (See Plate 1.) It is found in the bed of Sand Creek at Jordan. Elsewhere throughout the region it is covered by the younger formations.

Character.—The St. Lawrence formation is variable in character, with a gray, sandy, dolomitic rock as the predominant phase. This varies from shaly to massive, alternating with sandy, greenish shale. The lower

[9] See C. R. Stauffer. "Type Paleozoic Sections in the Minnesota Valley," *Journal of Geology,* 42:338–42 (1935).

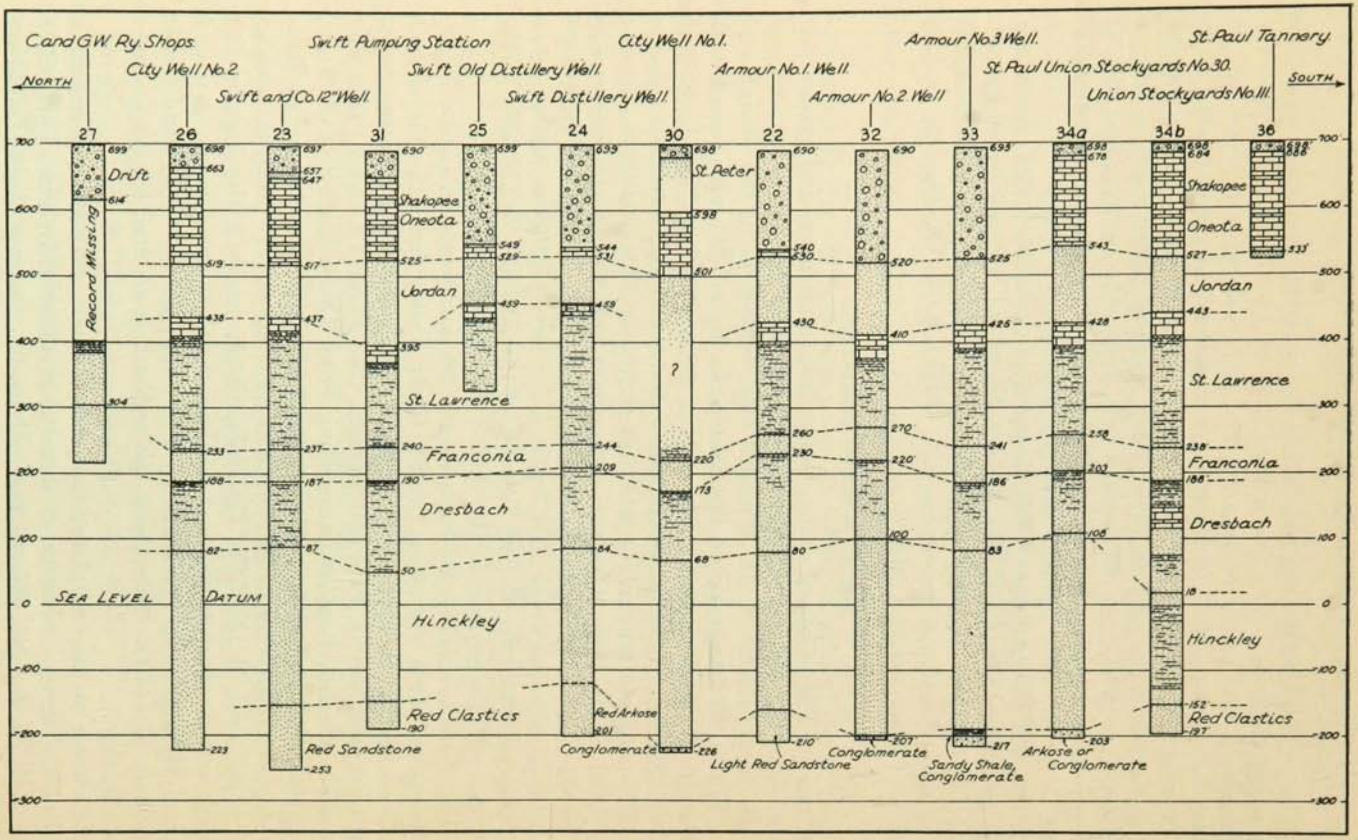

FIGURE 4. — Diagram of well logs at South Saint Paul, Dakota County, showing correlation of formations.

beds are very sandy. Glauconite is a common constituent, especially of the dolomitic beds. Weathering alters the glauconite to a rusty-brown material and leaching may remove the greater portion of the carbonates, leaving a fine-grained porous rock that looks like sandstone and frequently causes confusion in determining whether certain outcrops should be classified with the Jordan or St. Lawrence formation. In general the

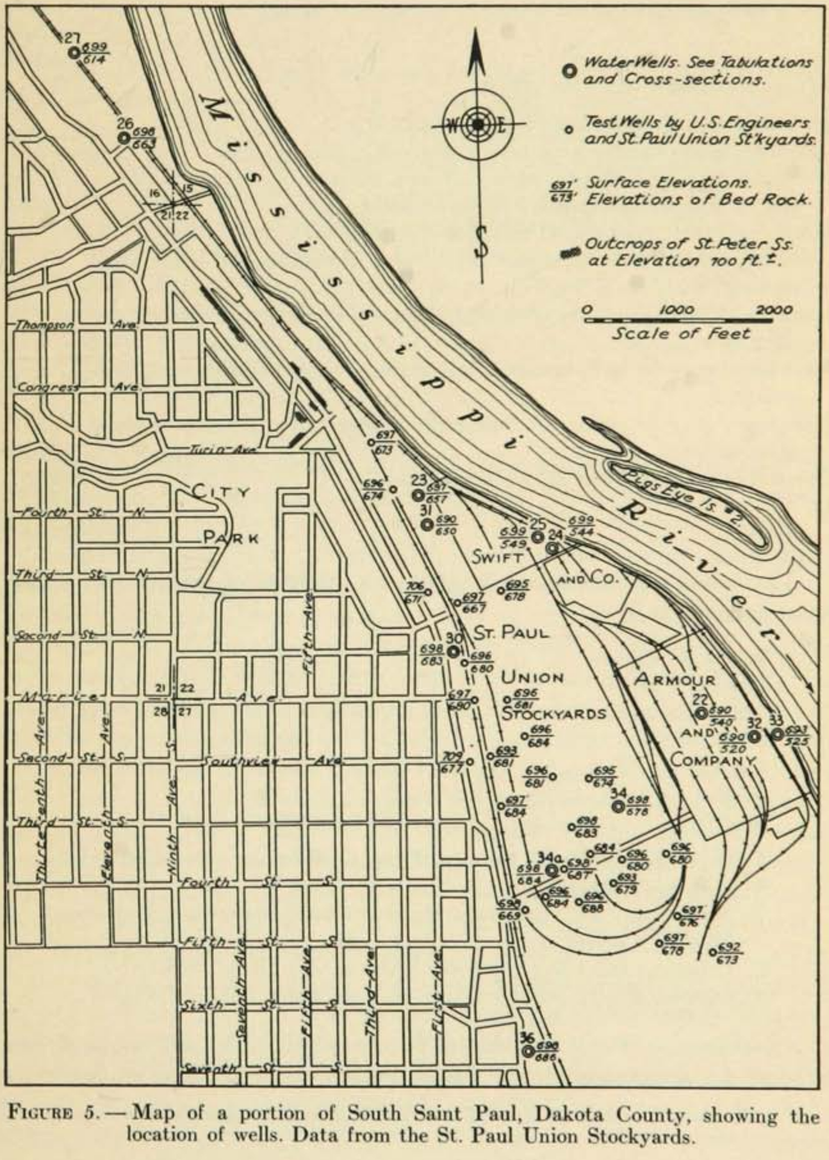

FIGURE 5. — Map of a portion of South Saint Paul, Dakota County, showing the location of wells. Data from the St. Paul Union Stockyards.

green shaly character and abundant glauconite are guides to its recognition in well cuttings.

One of the best exposures examined in the Metropolitan Area is that along the creek at the south end of the village of Afton on the St. Croix River, in Washington County. Other good sections are exposed at the Soo Line High Bridge over the St. Croix near Arcola, and along Mill Creek in Marine. The section of the St. Lawrence at Afton is as follows.

	THICKNESS (in feet)
Jordan sandstone, white to yellow	97
ST. LAWRENCE FORMATION (Top at 818.23 ft.)	
Dolomite, gray, sandy, with sandy, dolomitic gray shales	34.62
Dolomite, gray to buff, fine, even-textured, glauconitic, containing graptolites and *Dikelocephalus minnesotensis*	3.00
Sandstone, gray, massive to thin-bedded; glauconite with thin beds of nearly pure glauconite, and sandy gray dolomite with blue shaly partings	5.58
Sandstone, dolomitic, gray to buff, irregularly bedded, glauconitic, vermicular	7.85
Sandstone, gray to buff, massive, fine-grained, cross-bedded, very glauconitic	30.65
Sandstone, gray to yellow or buff, soft, massive to shaly, fine-grained, glauconitic	14.61
Covered to level of Lake St. Croix at 663.61 A. T.	58.31
Total	154.62

The following tabulation presents an analysis of samples of St. Lawrence formation.[10]

	1	*2*	*3*	*4*
Insoluble silicate		4.6		
Oxides, iron, etc.		2.5		
Total insolubles	7.76	7.10	52.93	54.43
CaO		29.50		
$CaCO_3$	50.66	52.60	25.68	20.01
MgO		19.40		
$MgCO_3$	40.81	40.50	19.83	17.32

1. St. Lawrence, Scott County. From fossiliferous layer with grains of green matter.
2. North bank of Minnesota River opposite lower end of Judson, Nicollet County.
3. *Dikelocephalus minnesotensis* horizon, old prison, Stillwater.
4. *Dikelocephalus minnesotensis* horizon, Fairy Glen, Stillwater.

Thickness.—The true thickness of the St. Lawrence formation is difficult to determine in the Metropolitan Area because of incomplete

[10] C. R. Stauffer and G. A. Thiel. *The Limestones and Marls of Minnesota* (Minnesota Geological Survey Bulletin 23), pp. 72–74.

exposures and wide variations in well records. Furthermore, on escarpments, the solution of the dolomite leaves a sandstone that is much like the Jordan sandstone above. Sixty available well records show that the complete section of the formation has an average thickness of 180 feet. The variation from well to well is rather wide, but most of the thicknesses fall within a range of 160–200 feet. The well logs suggest the possibility of a thickening of the formation toward the south as the amount of St. Lawrence penetrated in Dakota County wells is somewhat greater than in Minneapolis wells.

Life.—Like the other Cambrian horizons, the St. Lawrence formation as delimited in Minnesota is not highly fossiliferous. The forms present belong in general to the same groups as in the formations below. Trilobite remains are most numerous, but brachiopods and graptolites are sometimes abundant in certain horizons.

The following list gives some of the more common forms. GRAPTOLITES: *Acanthrograptus priscus, Dendrograptus hallanus;* BRACHIOPODS: *Billingsella coloradoensis, Lingulella mosia, Lingulella winona, Syntrophia barabuensis;* GASTROPODS: *Pelagiella minutissima, Owenella vaticina;* TRILOBITES: *Dikelocephalus minnesotensis, Saukia pepinensis, Illaenus quadratus, Osceolia osceola.*

JORDAN SANDSTONE

Name.—This sandstone was named by Alexander Winchell[11] from exposures in the quarries in the Minnesota River valley at Jordan in Scott County.

Distribution.—In the Metropolitan Area the Jordan sandstone is exposed in the Minnesota River valley, between Merriam Junction and Jordan, along the Mississippi River east of the Hastings locks, and on the south side of the river at Nininger. It is widely exposed at intervals along the St. Croix River valley from the Soo Line drawbridge to Stillwater. There are excellent exposures along the river highway at and north of Stillwater. Southwest of Afton, Jordan sandstone is found on the upland in the valley of Trout Creek, where it is brought to the surface by a pronounced anticline. (See Figure 36.) North and west of Minneapolis and St. Paul it is not found at the surface but lies immediately beneath the glacial drift in a narrow band from the St. Croix River in northern Washington County to Lake Minnetonka. In the broad area from the St. Croix River to the middle of Lake Minnetonka, and from Anoka to the Minnesota and Mississippi rivers, the Jordan lies beneath a cover of Oneota dolomite and younger rocks and furnishes artesian water when tapped by deep wells. It is in fact the principal source of artesian water for the entire Metropolitan Area, supplying over 20 million gallons a day.

Character.—The Jordan is usually a medium-grained, white to yel-

[11] *Report of a Geological Survey of the Vicinity of Belle Plaine, Scott County,* Minnesota state document, pp. 1–16 (St. Paul, 1872).

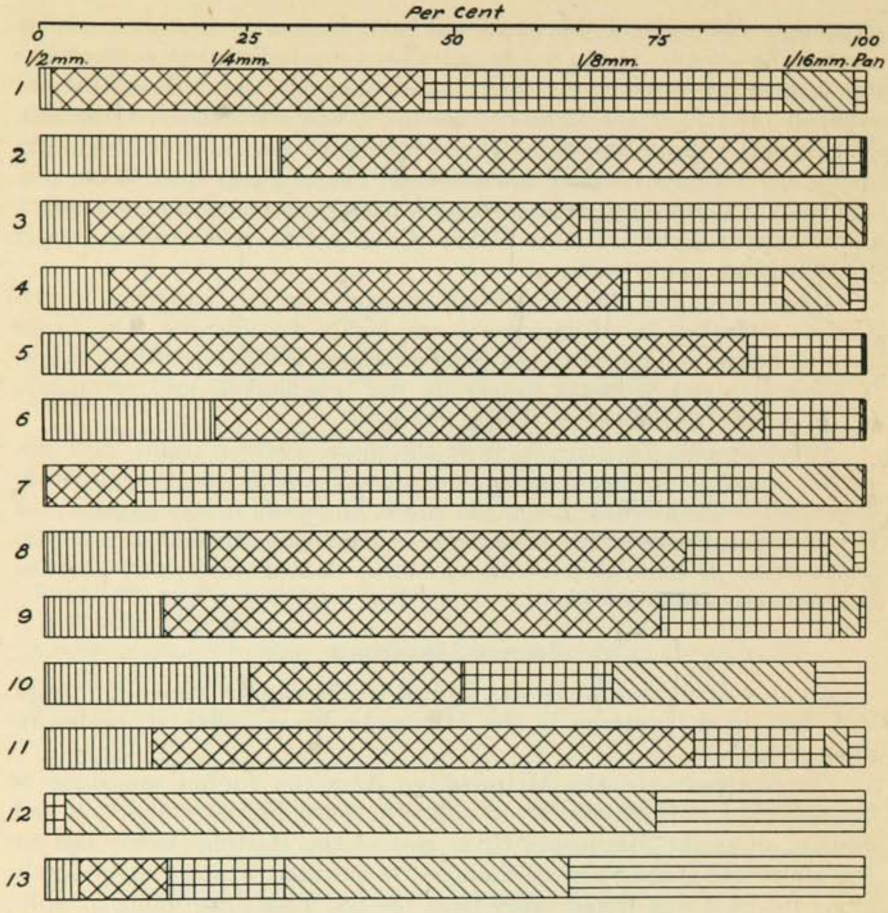

FIGURE 6. — Sieve analyses of Jordan sandstone.

1–4. Samples from south edge of Stillwater, taken from a ten-foot channel beginning at the contact of Jordan and Oneota and extending downward. 5. Sample from the new road cut along Highway No. 45, south of the St. Croix bridge, Stillwater. (Authority: H. R. Kamb, Report of Layne-Northwest Co. to Minneapolis City Council, August, 1932.) 6. Sample taken 75 feet from the top of a formation opposite Hastings. (Same authority as No. 5.) 7. Sample from a beer cave at Jordan. (Same authority as No. 5.) 8–13. Various samples from Washington County. (Authority: W. A. P. Graham, *Journal of Geology*, 38:200, 1930.)

low to brown sandstone, massive to thin-bedded, and poorly cemented. The upper portion is coarse and generally gray to white in color, but may be pink to brown. It is frequently cross-bedded and some layers show ripple marks. The variation in grain size is clearly shown by the graphs of mechanical analyses in Figure 6. The grains are usually well rounded and locally a few small quartz pebbles are found in the upper beds. At places, especially along Van Oser's Creek, four miles north of Jordan, the grains are reconstructed quartz crystals; this fact is commercially important, since the sand has unusually fine cutting properties for sand blast and other abrasive uses. At places circulating waters have stained the sand yellow or brown. The rock varies considerably in hardness because of variations in amount of cementing material. In some places it may be shoveled from an exposure for use as sand, but elsewhere may be cemented thoroughly enough for building material. Locally, there are thin seams of greenish shale. In general the lower part is thin-bedded and the upper part more massive.

The best measured section of the Jordan available in the area is found at Afton. This is probably somewhat more uniform than normal. A more typical section is exposed on the Wisconsin side of the St. Croix River at Osceola. Both sections are given here for reference.

SECTION ALONG THE CREEK AT SOUTHWEST EDGE OF AFTON

	Thickness (in feet)
Oneota dolomite, gray to drab	53
JORDAN SANDSTONE (Top at 915.39 ft. A. T.)	
Sandstone, white to yellow, medium to fine	10.0
Sandstone, white to yellow, massive, coarse to medium	72.16
Sandstone, yellow to white, thin-bedded, fine-grained	15.0
Total thickness	97.16
Contact at 818.23 ft. A. T.	
St. Lawrence formation, dolomite and glauconitic sandstone	96

SECTION AT MILL CREEK AND EAGLE POINT, OSCEOLA, WISCONSIN

	Thickness (in feet)
Oneota dolomite, gray to brown	29
JORDAN SANDSTONE (Elevation of top 877.2 ft. A. T.)	
Sandstone, dolomitic, gray to brown, fine-grained, even-bedded, glauconitic. Rock locally full of holes; some almost a dolomite	37.4
Sandstone, white to yellow, medium to fine-grained, very friable, with pebbles derived from the hard layers, and as much as 3–4 inches in diameter, scattered through it	1.5
Sandstone, yellow to brown, coarse, massive, hard, with loose, sandy beds between	4.0
Sandstone, yellow to white, massive, coarse, cross-bedded, with sandstone concretions in upper part	19.0
Sandstone, brown, medium to coarse, outcropping by railroad station	9.0
Sandstone, yellow to brown, medium to fine-grained, fossiliferous, in Mill Creek and old quarry (Norwalk sandstone)	38.36
Elevation of base, 774 ft. A. T. Total thickness	109.26
St. Lawrence formation	

Figure 6 shows in graphic form the size of the sand grains as determined by mechanical analyses. The grain size is important in connection with the permeability of this important water-bearing formation. As the size decreases, the effect of capillarity increases, making the flow of water more difficult.

Thickness.—There are no complete exposures of the Jordan sandstone in the area except in the cliffs near Afton and Stillwater. As a rule the Jordan is easily recognized in well cuttings because of its clean, sandy nature and the fact that it is a good water-bearer. Nevertheless, the thickness reported in some wells is so different from others near by that an error must be assumed. If the few wells that show unusually high or low values are eliminated, an average of 86 wells shows a thickness of 90 feet. Most of these wells show a range between 80 and 105 feet.

It seems that the formation is somewhat thinner along the St. Croix River in northern Washington County than in Minneapolis and St. Paul. This is especially true at Stillwater, where careful measurements indicate a thickness of 74 feet.

Stauffer[12] has described a composite type section including exposures at Jordan and along Van Oser's Creek four miles to the northeast; the thickness (94 feet) checks very well with the average for the Metropolitan Area. In accordance with Winchell's original description the type section as interpreted is modified only to suit present-day exposures.

Life.—The Jordan, being predominantly a coarse, rather pure sandstone, presented an unfavorable environment for the growth of life and preservation of fossilized remains. Nevertheless, at certain places, notably along the Minnesota River valley, good collections have been made, mainly near the top of the formation. This fauna has not been worked out, but it probably includes BRACHIOPODS: *Lingulella* sp., *Obolus* sp.; TRILOBITES: *Saukia crassimarginata*(?), *Asaphiscus*(?) sp., *Longocephalus* sp.(?).

Along the St. Croix River at Boom Hollow there is a fossiliferous horizon occurring 22–25 feet below the top of the Jordan, in which fossils are very common. This is typical Jordan, probably what Dr. Ulrich calls the Norwalk sandstone.

ORDOVICIAN FORMATIONS

SHAKOPEE-ONEOTA FORMATIONS (PRAIRIE DU CHIEN SERIES)

General.—As shown in the table of formations, the dolomite series with some sandstone, lying above the Jordan and below the St. Peter sandstone, is usually subdivided in Minnesota into the Oneota or lower part, followed at places by the New Richmond sandstone, which is in turn overlain by the Shakopee or upper portion. This classification was

[12] "Type Paleozoic Sections in the Minnesota Valley," *Journal of Geology*, 42:344 (1934).

utilized in the early geologic work in the state by N. H. Winchell. Some confusion has always existed because the Oneota and Shakopee are much alike and the New Richmond between them is not always recognized. This has led workers in adjoining regions to use the name Prairie du Chien for the whole series of beds, although the faunas show that the two formations are very distinct.

Trowbridge and Atwater,[13] Sardeson,[14] and Stauffer[15] have recently discussed the problem at some length. Trowbridge and Atwater in their proposed classification for the upper Mississippi Valley suggest giving Prairie du Chien the rank of a formation, and demoting Oneota, New Richmond, and Shakopee to the rank of members of the Prairie du Chien formation. Sardeson argues strongly for the recognition of the essential difference between the Oneota and Shakopee, especially as to their faunas. Because of the fact that the fossil remains are distinct, and indicate formations of widely different ages, the present members of the Minnesota Geological Survey have not felt justified in changing the rank of the names used by their predecessors. It should be understood, however, that where exposures are not extensive and where the characteristic fossils cannot be found, the formations may be confused. Accordingly it may be well to use the term Shakopee-Oneota to designate these rocks. This applies especially to well logs. An average of 71 wells gives a thickness of 136 feet for the combined formations. It is known, however, that the dolomites thicken rapidly to the south, totaling over 200 feet at Northfield. At Hastings and near Rosemount well logs suggest a thickness of nearly 200 feet.

Oneota Dolomite

Name.—The term Oneota was first used by McGee[16] for beds in northern Iowa which were later shown to be equivalent to the lower dolomite in the Minneapolis and St. Paul region, and the usage has been continued since that time.

Distribution.—The Oneota dolomite is exposed along the Mississippi River near Hastings, where it may be observed overlying the Jordan sandstone from Nininger westward for about a mile and also on the opposite side of the river along the railroad tracks. It is exposed at Point Douglas and along the St. Croix River valley (Figure 7) as far north as a point nearly opposite Osceola. It makes a broad curve beneath a covering of glacial drift from Marine to Lake Minnetonka. It is found beneath the younger rocks throughout the greater portion of the Metropolitan

[13] "Stratigraphic Problems of the Upper Mississippi Valley," *Bulletin of the Geological Society of America*, 45:21–80 (1934).

[14] "Shakopee Formation," *Pan-American Geologist*, 62:29–34 (1934).

[15] "Type Paleozoic Sections in the Minnesota Valley," *Journal of Geology*, 42:337–57 (1934).

[16] W. J. McGee. "Pleistocene History of Northeastern Iowa," 11th Annual Report of the United States Geological Survey, Pt. 1, pp. 331–33.

Area, as shown by the accompanying maps and cross sections. (See Plates 1, 2, and 3.)

Character.—The Oneota beds consist chiefly of dolomite. Near the top sandy beds occur, and oolitic dolomite is also found at some horizons. The dolomite is usually thick-bedded, gray, pink, or buff in color, and is often porous; concretions of chert are common. Fossils are not abundant and generally are poorly preserved; a few species, however, are well known, especially in the chert. To the south along the Minnesota River valley the beds are extensively quarried for building stone. This is also true at several places along the Mississippi River from Hastings southward.

Probably the most typical exposures of the Oneota in the Metropolitan Area are near Stillwater. The following section shows the chief characteristics.

SECTION OF BLUFF AT WOLFE BREWERY, STILLWATER

	THICKNESS (in feet)
Soil	.5
ONEOTA DOLOMITE	
Dolomite, thin-bedded, vesicular to dense, gray to yellow	10.0
Dolomite, even-bedded, fairly dense, gray	3.0
Dolomite, massive, rough, vesicular, gray	3.5
Dolomite, massive to thin-bedded, dense, gray	8.5
Dolomite, massive, rough, vesicular, gray to brown	6.0
Dolomite, massive, dense, even-bedded, gray	8.0
Dolomite, massive, rough, vesicular, arenaceous, gray to brown	10.66
Total	49.66

Jordan sandstone (sharp contact at 763.74 ft. A. T.)

The following analyses of samples show the composition of the formation:

	1 *Railroad cut near quarry, Merriam Junction, Scott County*	2 *Frontenac quarry, Goodhue County. 3.5-foot bed near middle of exposed section*	3 *Frontenac quarry. From bed below No. 2*
Insoluble silica, etc.	4.3	8.8	1.1
Oxides, iron, etc.	1.3	1.3	0.5
Total insolubles	5.6	10.1	1.6
CaO	29.9	28.8	30.3
$CaCO_3$	53.4	51.4	43.1
MgO	19.1	18.8	21.3
$MgCO_3$	40.0	39.3	44.5

Thickness. — The total thickness of the Shakopee-Oneota formations, including the New Richmond beds, averages 136 feet. Of the 71 wells used in determining that average, only 18 report the Oneota separately. These indicate an average thickness for the Oneota of about 80 feet, with a range of 65–95 feet. Undoubtedly this considerable range is due mainly to inaccuracies in the well logs. Plates 2 and 3 and Figures 4, 35, 37, and 42 illustrate the occurrence and thickness of the beds.

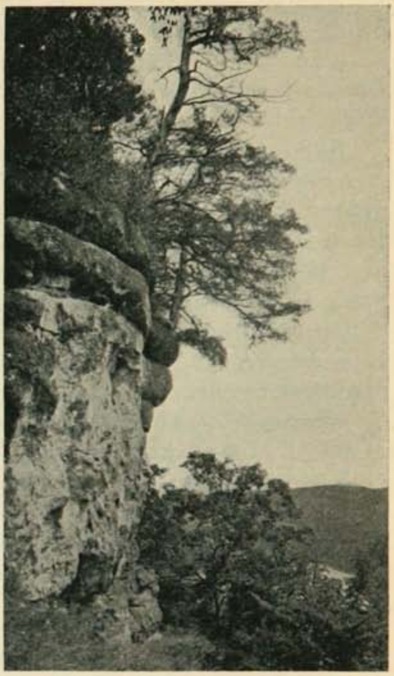

FIGURE 7. — Characteristic cliff of Oneota dolomite along the St. Croix River, two miles northeast of Stillwater.

Life. — The Oneota as a whole is not very fossiliferous, but locally, especially near the top, good fossil zones have been found. The fauna consists mainly of gastropods and cephalopods, but brachiopods and trilobites also are found. Many of the fossils are preserved as chert casts or dolomitized shells. Some of the most common forms follow. BRACHIOPODS: *Syntrophia nonus, Eoorthis vicina, Obolus dolatus, Syntrophia calcifera;* GASTROPODS: *Raphistoma minnesotense, Sinuopea obesa, Gasconadia putilla, Rhacopea typica, Ophileta pepinens, Lecanospira tenuis;* CEPHALOPODS: *Oneotoceras lutheri, Clarkoceras newton-winchelli, Ellesmeroceras winonicum, Burenoceras cornucopiaforme, Ascoceras gibberosum, Piloceras corniculum,* etc.; TRILOBITES: *Platycolpus eatoni, Symphysurina woosteri, Hystricurus oneotensis, Bellefontia nonius*(?).

NEW RICHMOND SANDSTONE

Name. — The New Richmond sandstone received its name from exposures at New Richmond in St. Croix County, Wisconsin. The use of the term New Richmond is continued here, but it is the writer's suggestion that in the eventual revision of nomenclature the term be dropped for the Minneapolis–St. Paul area, since in this region the sandstone is thin and at places entirely missing. Ulrich [17] believes that the horizon of the New Richmond at Stillwater is marked by a slightly irregular contact with from one to three inches of conglomerate, composed of limestone and chert pebbles in a sandy and glauconitic matrix. In some wells

[17] E. O. Ulrich. "Notes on New Names in Table of Paleozoic Formations in Wisconsin," *Transactions of the Wisconsin Academy of Sciences, Arts and Letters,* 21:100–04 (1924).

in the Metropolitan Area a definite sandstone was recognized at this horizon; this is sometimes utilized as a source of water where the quantity required is not great. A case in point is a small well drilled for the Strutwear Knitting Company, South Sixth Street, Minneapolis, which appears to have secured its supply from the New Richmond horizon. Many well logs show no sandstone at the horizon of the New Richmond. At many places it may have been overlooked, since both Shakopee and Oneota formations are somewhat sandy and may contain definite sandstone beds.

At Mankato the New Richmond is represented by six inches of sandy green shale, overlain by five feet of white to yellowish sandstone. In the quarry of the Hastings Stone Company about three miles southeast of Hastings the New Richmond is represented by four feet of sandstone and sandy layers of dolomite. Sardeson[18] doubts the propriety of the name New Richmond and questions whether the sandstones are at any definite stratigraphic position in the Oneota or Shakopee. Even at the type locality the sandstones are interbedded with dolomite carrying Shakopee fossils.

Thickness.—The New Richmond is recognized as a separate horizon in 20 of 71 well logs showing the full thickness of the Shakopee and Oneota formations. Its average thickness is said to be about 10 feet, but in the writer's experience this thickness is unusual. It is questionable whether it is a continuous bed over the entire area; probably there are several interbedded sandstones at about the horizon of the New Richmond and the one so designated is not always the same layer.

Shakopee Dolomite

Name.—The Shakopee dolomite was named by N. H. Winchell[19] from exposures in quarries at the city of Shakopee on the Minnesota River in Scott County.

Distribution.—The Shakopee dolomite outcrops in the Metropolitan Area from the type locality at Shakopee down the Minnesota River as far as Savage. It is also extensively exposed along both sides of the Mississippi River from Newport south for several miles. It is exposed at many places along the St. Croix River from Point Douglas northward and on the highland of southern Washington County between the St. Croix and Mississippi rivers, at least at far northward as Stillwater.

Well logs indicate that the Shakopee is found immediately below the glacial drift in the buried valleys beneath Isles, Cedar, Calhoun, Harriet, and Mud lakes in Minneapolis; also in St. Paul in the Gervais–Lake Phalen–Dayton's Bluff channel. It is found beneath the alluvial fill in the Mississippi River between Fort Snelling and South St. Paul or Newport. It also occurs in a broad belt from the St. Croix River, west across

[18] "Shakopee Formation," *Pan-American Geologist,* 62:32 (1934).

[19] Second Annual Report of the Geological and Natural History Survey of Minnesota, p. 138.

the south half of Washington County, under St. Paul and the east end of Lake Minnetonka, thence to the Minnesota River valley. (See Plate 1.) It is present at depth wherever any of the younger formations, such as the St. Peter sandstone, Platteville limestone, and Decorah shales, are known to be present.

Character.—In general the Shakopee is a gray to buff, dolomitic limestone, massive to thin-bedded, often cherty and sandy, and frequently oolitic.

The type section at Shakopee is as follows:

SECTION OF THE J. B. CONTRE QUARRY, SUPPLEMENTED BY THE WATER WORKS WELL LOG AT SHAKOPEE

	THICKNESS (in feet)
Drift	
SHAKOPEE DOLOMITE (Surface elevation 725 ft.)	
Dolomite, pink to brown, semicrystalline, alternating with compact buff beds; all fairly thin-bedded and uneven; fossiliferous	7
Sandstone, irregular, gray, and sandy gray dolomite	2
Dolomite, gray to pink, fairly massive, but splitting into thinner beds, which extend to the bottom of the quarry	10
Dolomite, thin-bedded, gray to pink or brown, occurring in ditch and water hole below the quarry floor	5
Covered interval to the level of the Minnesota River. In the well and partly in the outcrop above the town this portion is shown to be gray to brown dolomite	14
Total to river level	38

The following analyses[20] show the composition of the beds described above:

	1	*2*	*3*
Insoluble, silica, etc.	1.3	1.5	6.9
Oxides, iron, etc.	0.6	1.3	8.7
Total insolubles	1.9	2.8	15.6
CaO	30.6	30.6	28.7
$CaCO_3$	54.6	54.6	51.1
MgO	21.2	20.6	19.2
$MgCO_3$	44.3	43.1	40.2

1. J. B. Contre Quarry, Shakopee, Minnesota. Thin-bedded, gray to brown dolomite. Lowest bed exposed.
2. Same location as 1, but 12-foot bed above 1.
3. Same location as 1, but 7-foot bed above 2.

Thickness.—The Shakopee formation is not of uniform thickness, partly, at least, because of erosion before the deposition of the St. Peter

[20] Stauffer and Thiel. *The Limestones and Marls of Minnesota* (Minnesota Geological Survey Bulletin 23), p. 70.

sandstone. Fifteen available well logs seem to distinguish the full thickness of the Shakopee from the New Richmond and Oneota below. The average thickness is 45 feet, with a range of 35–60 feet within the area covered by this report.

Life. — The Shakopee is much like the Oneota lithologically, although much more calcareous; the fauna, however, is distinct and is the basis for the belief that a rather long interval of time elapsed between the deposition of the two formations. In fact, farther south in the Mississippi Valley other sedimentary beds intervene between the horizons carrying the Oneota and Shakopee faunas.

There has been rather active leaching of the rock, which destroyed many fossil remains; however, at places very good faunas are found. This is especially true of the flinty nodules found at Cannon Falls and those more recently found in the limestone and sandy beds of a water main excavation in Stillwater above the abandoned McNaughton quarry.

Common forms found in the Shakopee follow. ALGAE: *Cryptozoon minnesotense, Cryptozoon giganteum;* GASTROPODS: *Hormotoma argylensis, Raphistoma ruidum, Subulites exactus;* CEPHALOPODS: *Endoceras consuetum, Eurystomites kelloggi.*

ST. PETER SANDSTONE

Name. — The Minnesota River was called the St. Peter's River by the early French explorers. Consequently the sandstone that cropped out

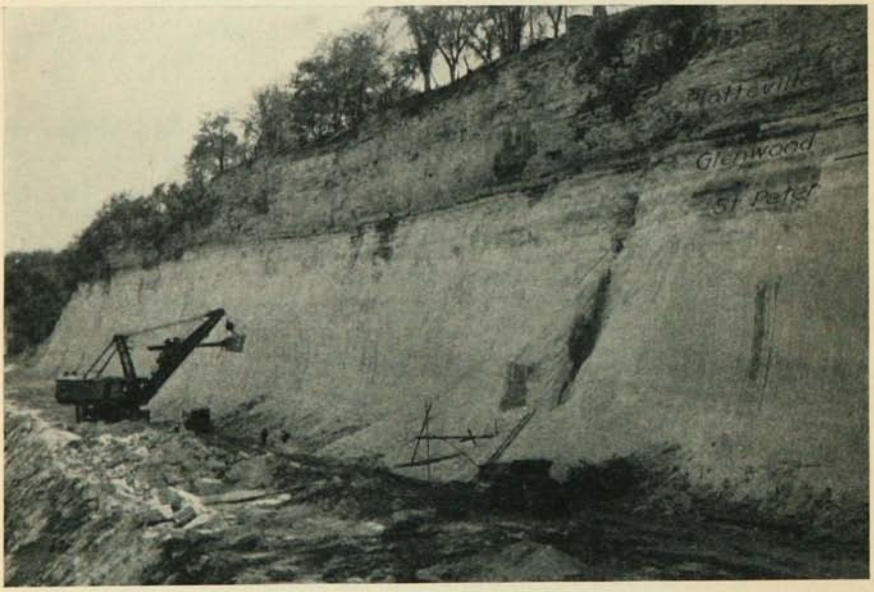

FIGURE 8. — Cliff at Twin City Lock and Dam showing St. Peter sandstone with Glenwood beds and Platteville limestone above Photograph by U. S. Engineers.

along the river valley was named the St. Peter by Owen;[21] his exposures were taken at the mouth of the river on what is now the Fort Snelling reservation.

Distribution.—The St. Peter sandstone is not completely exposed anywhere in the Metropolitan Area. This fact is due largely to the ease with which the sandstone crumbles and forms a loose deposit over the basal portion of the formation. Probably the most complete section is that furnished by the exposures at the Fort Snelling type locality, combined with data from test borings in the river and the railroad well at Mendota.

SECTION OF ST. PETER SANDSTONE AT TYPE LOCALITY, FORT SNELLING

	THICKNESS (in feet)
Glenwood beds, shale (Elevation of contact 778 ft.)	
ST. PETER SANDSTONE	
Sandstone, yellowish brown, iron-stained	8
Sandstone, poorly cemented, medium to fine-grained, massive, white, partly covered at base	65
Sandstone, white, covered, but partly shown in excavation	25
Silt, siliceous, blue to gray, reported as shale in Mendota well	30
Sandstone, white	37
Total	165

Shakopee dolomite in the test hole at Fort Snelling Bridge at elevation 613 ft.

The sandstone is widely exposed along the Mississippi River at intervals from Shingle Creek near the north city limits of Minneapolis downstream to South St. Paul. (See Figure 8.) It has been extensively tunneled for sewers, water pipes, power and telephone cables, also excavated to form caves frequently used for growing mushrooms. The sandstone is also exposed extensively in central and southern Dakota County, where isolated pinnacles received such names as Castle Rock and Chimney Rock. In Washington County the St. Peter sandstone is also exposed at many places near Cottage Grove and northward to the plateau-like area south of Stillwater, which is capped by Platteville limestone. The St. Peter occurs as a narrow belt around all areas underlain by Platteville limestone, but is usually covered by the prevailing thick glacial drift deposits. The belts, as revealed by exposures and well logs, are shown in the geologic map, Plate 1.

Character.—The St. Peter is normally a white, friable sandstone, usually with so little cement that it may be scooped from the outcrop with the hand, although certain beds have been cemented with silica to form a very hard, dense sandstone. Locally it is well cemented, with

[21] D. D. Owen. *Report of a Geological Survey of Wisconsin, Iowa, and Minnesota* (1852), p. 69.

pyrite concretions occurring especially in the upper part, where a yellow stain often results from weathering. The principal accessory minerals in order of abundance are tourmaline, zircon, and rutile. The grains of the sand are medium to fine, well rounded, and frosted. Below the middle of the formation occur beds of a fine gray siltstone, usually reported as shale in well logs. This phase is best known from diamond drill cores obtained from the bed of the Mississippi River in testing for the Intercity Bridge near the Ford Plant and Minnehaha Park. Examination of this material by G. A. Thiel shows that it is not shale, but is composed largely of very fine-grained quartz. Four analyses of the St. Peter sandstone are available. Two of these show the purity of the white sandstone, the third is from the silt horizon about 30 feet above the base.

Because it is poorly cemented, the St. Peter is easily eroded, and caves and water courses are not uncommon in it. Carver's Cave in St. Paul was known to the early explorers. Others have been encountered in subsurface work, especially near the Mississippi gorge. One of these is reported to extend back from the river possibly as much as a mile.

The following analyses show the composition of the St. Peter sandstone.

	1	*2*	*3*	*4*
SiO_2	99.78	97.67	68.64	98.91
Al_2O_3		1.31	16.49	.62
Fe_2O_3	Trace	.55	1.40	.09
MgO	Trace		.50	0.00
CaO	.....	.41	.20	.02
Na_2O	.....	.15	.16	.01
K_2O	.....	.02	6.03	.02
TiO_2	.....	....	.93	.05
H_2O+	.....	....	3.69	
H_2O-	.....	....	.87	
Loss on ignition	.....	....	.95	.27
			99.86	99.99

1. South St. Paul. C. W. Hall and F. W. Sardeson, *Bulletin of the Geological Society of America,* 3:351 (1892).
2. Fort Snelling. N. H. Winchell, *Geology of Minnesota* (Final Report of the Geological and Natural History Survey of Minnesota), 1:203.
3. Siltstone horizon, Minneapolis–St. Paul Intercity Bridge. R. B. Ellestad, analyst.
4. Mendota composite channel sample 50, upper part of formation. A. Willman, analyst.

The size of grain of the formation is shown by a series of diagrams of textural or mechanical analyses given below. (See Figure 9.)

Thickness.—The St. Peter sandstone is so striking in its purity that it is easily recognized in well borings, and since it is in contact with lime-

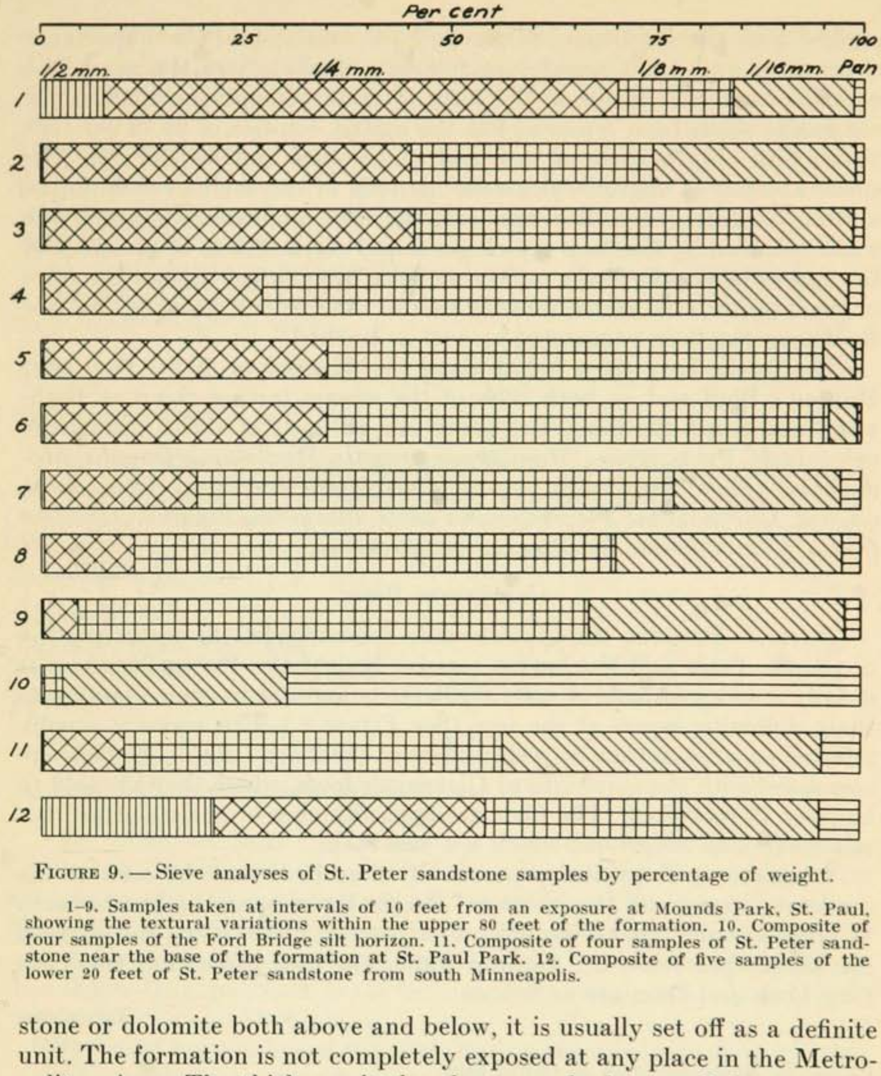

FIGURE 9. — Sieve analyses of St. Peter sandstone samples by percentage of weight.

1–9. Samples taken at intervals of 10 feet from an exposure at Mounds Park, St. Paul, showing the textural variations within the upper 80 feet of the formation. 10. Composite of four samples of the Ford Bridge silt horizon. 11. Composite of four samples of St. Peter sandstone near the base of the formation at St. Paul Park. 12. Composite of five samples of the lower 20 feet of St. Peter sandstone from south Minneapolis.

stone or dolomite both above and below, it is usually set off as a definite unit. The formation is not completely exposed at any place in the Metropolitan Area. The thickness is thus known only from well logs or combined outcrops and logs. (See Plates 2 and 3 and Figures 4, 35, 37, and 42.)

An average of 57 well logs gave a thickness of 158 feet. The greater number of logs show a thickness ranging from 145 to 165 feet. To the south the sandstone thins out as the dolomite below thickens, so that at Northfield the St. Peter is about 100 feet thick.

Life. — The St. Peter sandstone is not a favorable medium for the preservation of fossils. The lack of cement has allowed free circulation of water, which has leached out the calcium carbonate of the shells deposited with the sandstone. Sardeson[22] has emphasized the importance of leaching and fossil remains as follows: "Even where the sandstone contains numerous fossils in the form of casts not only have the thick calcareous shells been removed but the matrix consists of 99.78 per cent silica, with only a trace of iron and magnesium and no calcium. The entire absence of original calcareous material of the shell, even from the matrix, indicates very thorough leaching. The original thickness of the shells is shown by the deep muscle scars and marked lines of growth, but the spaces where the shells once were have been closed up and the form of the interior is impressed into the cast of the exterior, showing that the sandstone has been compacted as well as leached."

The fossils have been found along the Mississippi in St. Paul near Dayton's Bluff and on both sides of the stream farther down at Highwood and South St. Paul. The fossils are all casts of shells, principally pelecypods. PELECYPODS: *Modiolopsis gregalis, Modiolopsis litoralis, Modiolopsis affinis, Vanuxemia fragosa, Cyrtodonta descriptus, Ctenodonta novicia;* GASTROPODS: *Pleurotomaria aiens, Platyceras vetulum, Ophileta fausta;* CEPHALOPODS: *Orthoceras minnesotense.*

GLENWOOD BEDS

Name.—Between the typical white sandstone of the upper portion of the St. Peter and the lowest massive bed of the Platteville there is usually a series of beds of soft, argillaceous and sandy shale, grading to shaly dolomitic layers at the top. (See Figure 8.) This series is usually referred to as soapstone by well drillers in the Twin Cities. The beds are correlated with the exposures at Glenwood, Iowa, where they are said to be fully 15 feet thick. The beds are typically clay or shale and are not related to true soapstone, which is a talc rock.

Character.—A typical exposure of these beds may be seen at the sandstone quarry on the Northern Pacific Railway at the line between Minneapolis and Anoka County and at several places along the gorge of the Mississippi below St. Anthony Falls. The beds exposed at the Twin City Lock and Dam are as follows:

	THICKNESS (in feet)
Platteville limestone, gray to bluish gray	25
GLENWOOD BEDS	
Shale, argillaceous, gray to greenish	2.0
Limestone, arenaceous, gray	0.2
Shale, argillaceous, gray to greenish	0.5
Shale, argillaceous, green	1.5
Sandstone, argillaceous, nodular, yellow to brown	2.7
Total	6.9
St. Peter sandstone to river level below dam	73

[22] *Minneapolis–St. Paul Folio* (United States Geological Survey Atlas, Folio 201), p. 5.

The beds vary somewhat from place to place, as is shown by the following sections at the Washington Avenue Bridge.

	Thickness (in feet)
Platteville limestone	28
Glenwood Beds	
Shale, hard, flaky, blue with shaly blue limestone containing fossils	1.7
Shale, soft, gray to brown	0.3
Shale, argillaceous, green, with scattered grains of frosted quartz; microscopic fossils	1.0
Shale, sandy, yellow to white	0.7
Total	3.7
St. Peter sandstone to river level	32

On the Northern Pacific Railway tracks at Thirty-seventh Street N. E. in Minneapolis the following beds were measured:

	Thickness (in feet)
Platteville limestone	8.5
Glenwood Beds	
Yellowish, argillaceous shale	1.0
Blue, argillaceous shale with fossils	1.0
Sandy, blue to yellow shale	1.3
Total	3.3
St. Peter sandstone to level of railroad tracks	14

The Glenwood beds were recognized in most wells that pass from the Platteville limestone to the St. Peter sandstone and they may usually be seen in adjacent outcroppings of Platteville and St. Peter formations. There is not universal agreement that these beds should be mapped as a separate formation, as recently pointed out by Sardeson.[23] Stauffer[24] has shown that the fossils in the beds are very closely related to those in the Platteville and Decorah.

The chief importance of the shale from a practical standpoint is that it forms a relatively impervious cover for the St. Peter sandstone, preventing water from seeping down easily into it from above and confining water under artesian head to the sandstone horizon below.

Thickness. — The Glenwood beds are not reported in many well logs and as a rule their thickness is probably included with the Platteville limestone. The average of the Glenwood beds in 35 wells is 5 feet. This seems rather thick, compared with the few measured sections available.

[23] "Stratigraphic Affinities of Glenwood Shales," *Pan-American Geologist*, 60:81–90 (1933).

[24] "Conodonts of the Glenwood Beds," *Bulletin of the Geological Society of America*, 46:125–68 (1935).

Life. — Succeeding the long epoch of sand deposition, the sea spread further into the flat land area and mud deposits were formed. During this deposition life was rather abundant and varied. Brachiopods, gastropods, and trilobites similar to those that flourished during the next two or three epochs are common. But microscopic forms were especially abundant. These belonged chiefly to the chaetopods and the conodonts, which are teeth-like crests from the mouths of marine worms and primitive fish-like forms.

The common species of these microscopic forms follow. CHAETOPODS: *Arabellites gregalis, Lumbriconereites affinis, Pronereites glenwoodensis;* CONODONTS: *Bryantodina excellsa, Chirognathus idoneus, Cyrtoniodus complicatus, Oistodus curvatus, Plectodina dilata, Trichognathus barbarus.*

PLATTEVILLE LIMESTONE

Name. — The limestone and dolomite beds that overlie the Glenwood beds are correlated with the limestone beds at Platteville, Wisconsin, the term Platteville being used for the Minnesota beds also. This limestone is referred to as Trenton in many of the older reports, but it is really of Lowville age.

Distribution. — The general distribution of the Platteville at the surface and beneath the glacial drift is shown on Plate 1. It is exposed more or less continuously along the Mississippi River (see Figure 8) from St. Anthony Falls to the Robert Street Bridge in St. Paul, also on both sides of the Minnesota River for a short distance above its mouth. It is exposed in northeast Minneapolis, but many of the old quarries are now

FIGURE 10. — Outliers of Platteville limestone on an upland. Section 8, Afton Township, Washington County.

FIGURE 11. — Level plateau underlain by Platteville limestone. Kruger farm, Section 21, Lakeland Township, Washington County.

filled. It is exposed at many places in central Washington County between Lake Elmo and Cottage Grove (see Figures 10 and 11), also in Dakota County between Rosemount and Farmington and westward.

Character. — In the Metropolitan Area the Platteville beds are nearly 30 feet thick and, because of their exposure along the gorge of the Mississippi River, they are well known to most residents.

A typical section of the Platteville as exposed in the Twin Cities is that measured at the Twin City Lock and Dam.

	THICKNESS (in feet)
Decorah shale, with limestone beds	7
PLATTEVILLE LIMESTONE	
Limestone, gray to brown or buff, dolomitic. Top irregular and impregnated with iron. Fossils abundant	8.2
Limestone, compact, bluish to brown	1.3
Limestone, argillaceous, blue, shaly, breaking with conchoidal fracture	1.3
Limestone, massive, bluish to buff. A black pebble zone and evidences of corrosion at the base. Few fossils; in streaks or "nests"	2.0
Limestone, compact, brown to gray, weathering bluish. Layers thin, irregular, often nodular, and separated by thinner layers of shale. Fossils usually broken	11.0
Limestone, hard, bluish gray	0.7
Limestone, hard, bluish gray, with small black pebbles	1.0
Total	25.5
Glenwood beds, gray to green shale; lower beds sandy	7

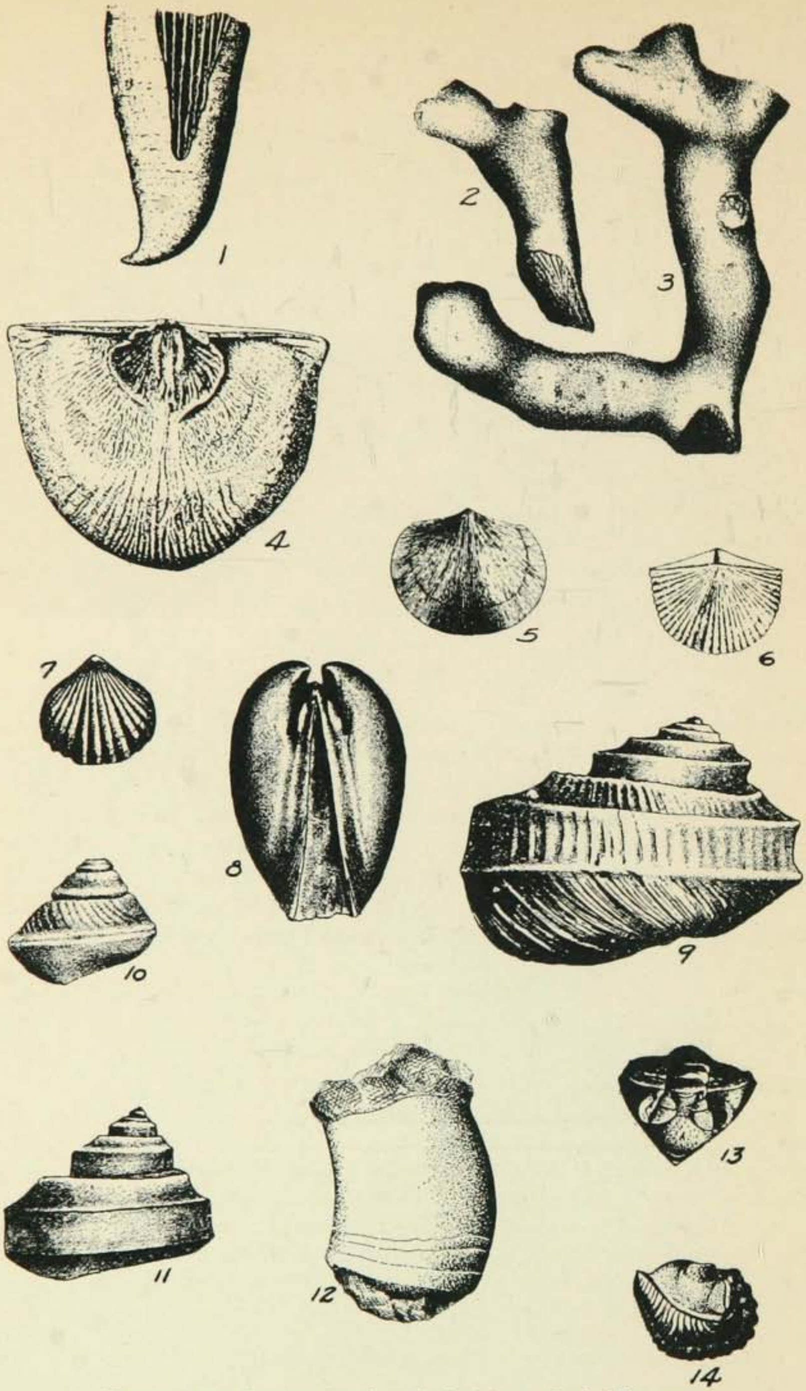

FIGURE 12. — Common fossils of Ordovician rocks in Minnesota.

CORAL: (1) *Streptelasma profundum;* BRYZOANS: (2 and 3) *Batastoma minnesotense;* BRACHIOPODS: (4) *Strophomena incurvata,* (5) *Pianodema subaequata,* (6) *Orthis tricenaria,* (7) *Rhynchotrema minnesotense;* PELECYPOD: (8) *Vanuxemia obtusifrons;* GASTROPODS: (9) *Trochonema beloitense,* (10) *Clathrospira subconica,* (11) *Trochonema umbilicatum;* CEPHALAPOD: (12) *Onoceras carveri;* TRILOBITES: (13 and 14) *Pterygometopus intermedius.*

The general composition of these beds is furnished by a series of analyses of limestone from the Twin City Lock and Dam that may be considered typical of the formation throughout the Metropolitan Area.[25]

		1	2	3	4	5	6
Total insolubles	39.43	13.42	16.44	18.75	41.01	21.72	
$CaCO_3$	33.65	47.88	70.90	69.58	37.74	45.60	
$MgCO_3$	22.16	35.78	10.54	7.46	21.01	30.23	

(1) Bed No. 1. (2) Bed No. 2. (3 and 4) Bed No. 3. (5) Bed No. 5. (6) Bed No. 6.

Thickness.—The Platteville is remarkably uniform in thickness throughout the region. The occasional well logs that report greater thicknesses than normal may include the basal Decorah limestone; abnormal thickness may be considered in error in view of the known uniform thickness as observed in outcrops. As noted in the discussion of the Glenwood beds, there is a tendency to include them in the Platteville in reporting well logs. An average of 22 well logs gives a thickness of 30 feet with a range of 25–35 feet. If the Glenwood beds could be eliminated, the true thickness would probably be closer to 28 feet.

Life.—The Platteville limestone was not only deposited in a sea favorable to life but subsequent conditions have been favorable to the fossilization and preservation of the remains, so that fossils are abundant throughout the formation. Abundant types of life were the brachiopods, cephalopods, pelecypods, gastropods, and trilobites. (See Figure 12.)

A few of the forms are: CORALS: *Streptelasma profundum;* GRAPTOLITES: *Climacograptus putillis, Climacograptus typicalis;* BRACHIOPODS: *Rafinesquina minnesotensis, Pianodema subaequata, Scenidium anthonense, Orthis tricenaria, Rhynchotrema increbescens, Strophomena incurvata;* PELECYPODS: *Vanuxemia obtusifrons, Ctenodonta nasuta, Clionychia lamellosa;* GASTROPODS: *Bucania halli, Clathrospira subconica, Hormotoma gracilis, Hyolithes baconi, Lophospira bicincta, Maclurites bigsbyi, Tetranota wisconsinensis;* CEPHALOPODS: *Endoceras proteiforme, Gonioceras occidentale, Orthoceras beltrami, Spyroceras bilineatum;* TRILOBITES: *Isotelus gigas, Bumastus trentonensis, Thaleops ovatus.*

DECORAH SHALE

Name.—At a few places in St. Paul and Minneapolis and on the south side of the Mississippi River from Mendota to St. Paul there are exposures of a green shale with interbedded limestone known as Decorah shale from the type section at Decorah, Iowa.

Distribution.—The only good exposure of this formation is in the quarry of the Twin City Brick Company on the river bluff below Cherokee Park, St. Paul, and in road cuts in St. Paul and near Mendota. It is preserved locally in the cities and immediately to the south because the basin-like structure of the region carries these beds below the normal

[25] Stauffer and Thiel. *The Limestones and Marls of Minnesota* (Minnesota Geological Survey Bulletin 23), pp. 65–66.

plane of erosion, whereas toward the rim of the basin they have been eroded away.

Character.—The only complete section of Decorah shale, that at the brick plant, has been measured by C. R. Stauffer as follows:

SECTION OF DECORAH SHALE AT TWIN CITY BRICK COMPANY PLANT, CHEROKEE PARK, ST. PAUL

	THICKNESS (in feet)
Galena beds, blue limestone alternating with shale. Contain numerous *Zygospira recurvirostris*	10.66
DECORAH SHALE	
Limestone, hard, brown, iron-stained with "brassy" oolitic grains	1.75
Shale, blue, with a fucoidal bed of limestone at the top	4.2
Shale, soft, blue, with a few lenses of limestone	21.33
Shale, blue, with knotty lenticular layers of limestone	12.0
Shale, soft, blue, nearly free from limestone	4.0
Shale, soft, blue, alternating with lenticular beds of limestone	7.0
Shale, soft, blue, with a few thin lenses of limestone; contains quarrymen's "putty layer," about 9 ft. above the top of the Bentonite	17.66
Limestone, hard, blue	0.66
Shale, soft, blue	2.2
Limestone, hard, partly crystalline, blue	1.8
Shale, soft, blue-green, of varying thickness; an altered Bentonite	0.33
Limestone, hard, blue, pyritiferous	1.25
Total	74.18
Platteville limestone, gray to buff	25

The complete analyses of this shale found below are available because of its importance in the manufacture of face brick.[26]

	1	*2*	*3*
SiO_2	56.35	54.66	50.81
Al_2O_3	18.63	24.04	20.25
FeO and Fe_2O_3	6.19	6.53	5.18
CaO	.96	.45	4.05
MgO	2.97	1.08	2.13
Na_2O	.25	.47	.28
K_2O	7.37	5.37	5.69
H_2O-	2.41	2.35	2.16
H_2O+	4.81	5.15	8.92
TiO_2	.65	.66	.50
	100.59	100.76	99.97

1. Lower shale, Twin City Brick Company plant, Cherokee Park, St. Paul.
2. Lower shale, sampled by another company from the same quarry.
3. Upper shale, sampled by another company from the same quarry.

[26] F. F. Grout. *Clays and Shales of Minnesota* (United States Geological Survey Bulletin 678), p. 152.

Thickness. — The entire section of the Decorah shale is known at only two localities in the Metropolitan Area. They are on opposite sides of the Mississippi gorge west of central St. Paul. The only reliable estimate of thickness is the section at the Twin City Brick plant, which is 74 feet.

Life. — The conditions of deposition of the sediments forming the Decorah shale were also favorable to abundant marine life. The Decorah is, in fact, the most fossiliferous of any formation in Minnesota and scores of species have been collected from single localities, of which the quarry of the Twin City Brick plant is a notable example. Brachiopods, mollusks, bryozoans, corals, and trilobites are common forms.

The following are a few of the numerous species. SPONGES(?): *Rauffella filosa, Receptaculites oweni;* CORALS: *Streptelasma profundum, Aulopora trentonensis, Lichenaria typa, Tetradium fibratum;* BRYOZOANS: *Batostoma minnesotense, Homotrypa subramosa, Prasopora simulatrix, Rhinidictya mutabilis, Stictoporella cribrosa;* BRACHIOPODS: *Dalmanella testudinaria, Rafinesquina alternata, Lingula* (several species), *Pianodema subequata;* PELECYPODS: *Ctenodonta socialis, Cyrtodonta huronensis, Modiolopsis mytiloides, Vanuxemia umbonata;* GASTROPODS: *Archinacella subrotunda, Holopea similis, Trochonema retrorsum;* CEPHALOPODS: *Cycloceras olorus, Endoceras proteiforme, Spyroceras bilineatum, Gonioceras anceps, Zitteloceras hallianum;* TRILOBITES: *Isotelus gigas, Ceraurus pleurexanthemus, Pterygometopus schmidti.*

GALENA (PROSSER) LIMESTONE

The Galena limestone was named from exposures at Galena, Illinois, with which the Minnesota beds are correlated. The lower portion is sometimes called the Prosser limestone in Minnesota from exposures in Prosser Gulch near Wykoff in Fillmore County. In this Twin City region these beds are known only in St. Paul, where they are scantily exposed on both sides of the Mississippi River. The lower beds of the Galena are so much like the Decorah shale that it is difficult to distinguish them, and for practical purposes these beds may be included with the Decorah. The only measured section for this area is at the Twin City Brick plant.

SECTION OF RIVER BANK AT TWIN CITY BRICK COMPANY PLANT, CHEROKEE PARK, ST. PAUL

	THICKNESS (in feet)
Pleistocene and recent drift and soil	125
GALENA (PROSSER) BEDS	
Limestone, bluish, with interbedded bluish shale	10.7
Shale, blue, with thin layers of limestone	5.3
Shale, blue, alternating with blue limestone; contains many *Zygospira*	10.7
Total	26.7
Decorah shale, hard, iron-stained limestone, with brassy oolitic grains	1.7

A well log a short distance south of the brick plant near the corner of Delaware Street and Dodd Road is reported by Fostin Beaudette, the driller, to have penetrated 32 feet of shale beginning at an elevation of about 930 feet. This record, when compared with the elevation of the exposure at the brick plant, suggests a thickness of some 50 feet of Galena at that point.

Life.—The beds of the Galena formation in the Metropolitan Area are separated from the Decorah formation on faunal grounds, although, as noted above, they are lithologically much alike. The fauna in its general aspects is much like that of the Decorah, but there are numerous distinct species confined exclusively to the Decorah or the Galena. Bryozoans and certain of the mollusks are conspicuous forms.

Common fossil forms follow. SPONGES(?): *Receptaculites oweni;* ANTHOZOA (Corals): *Streptelasma rusticum;* GRAPTOLITES: *Climacograptus typicalis;* BRYZOANS: *Arthroclema armata, Batostoma humile, Coeloclema trentonense, Diastoporina flabellata, Helopora mucronata, Pachydictya fimbriata;* BRACHIOPODS: *Plectambonites sericeus, Rafinesquina deltoidea, Strophomena incurvata, Zygospira recurvirostris;* PELECYPODS: *Vanuxemia hayniana;* GASTROPODS: *Conularia trentonensis, Lophospira medialis, Subulites elongatus;* CEPHALOPODS: *Endoceras proteiforme;* TRILOBITES: *Corydocephalus wesenbergensis paulianus, Eoharpes minnesotensis, Isotelus gigas.*

ORDOVICIAN TO PLEISTOCENE

Rocks formed during the periods of geologic history between the Ordovician and Pleistocene or glacial period are not found in the area. Some might have been deposited and later eroded; however, most of east-central and southeastern Minnesota is believed to have been above sea level during the periods following Ordovician time, and erosion rather than deposition took place.

PLEISTOCENE FORMATIONS

GLACIATION IN THE METROPOLITAN AREA

The fact that a considerable part of North America was subjected to glaciation by great continental ice sheets in the period of geologic history preceding the present is so well known that its general nature and proof need not be discussed here. A textbook of general geology will give the reader the history of these ice sheets. We are concerned here mainly with the results of glaciation in the Metropolitan Area and the facts necessary to make clear the relation of this area to glaciation in North America as a whole.

A study of Figure 13 will show that the glacial ice sheets which covered a large area in the north-central states came mainly from two centers far to the north. One was located east, and the other west, of

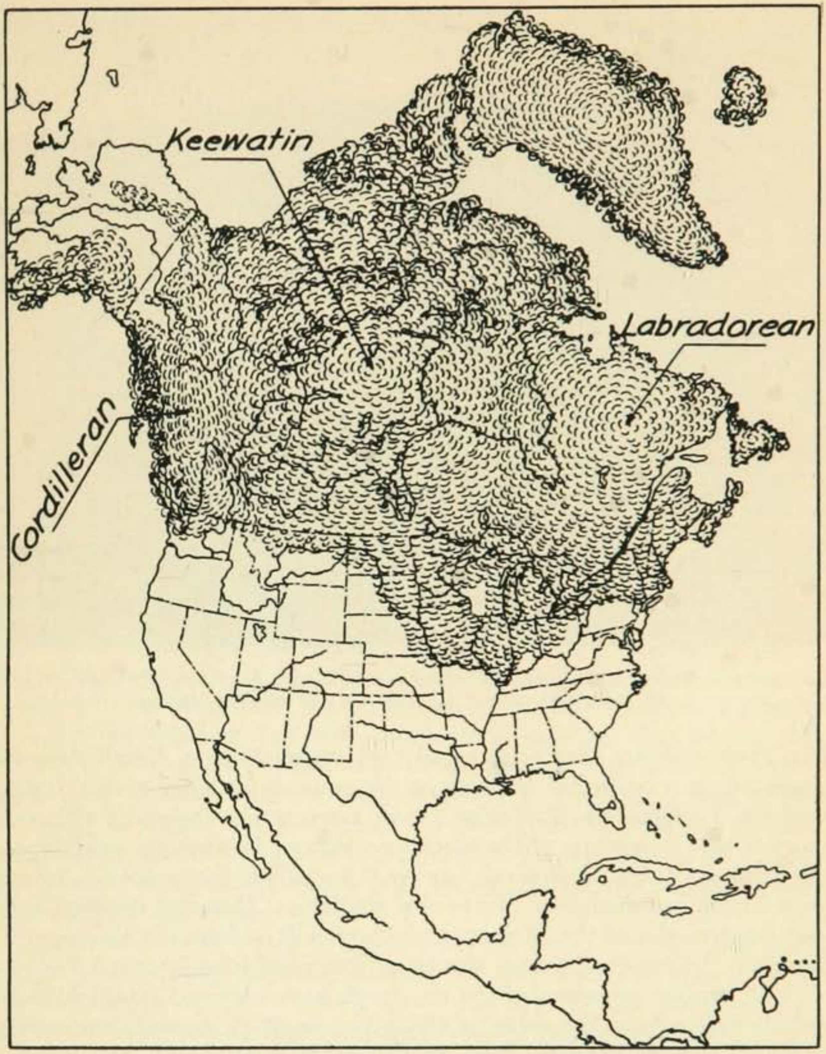

FIGURE 13. — Map of North America showing the area covered by ice during the Pleistocene age. (After Chamberlin.)

Hudson Bay. A lesser center existed south of the bay in the district of Patricia and is thus known as the Patrician center.[27]

The area about Minneapolis and St. Paul was in the path of glaciers or ice invasions from the centers mentioned above. Thus successive sheets of glacial drift overlap to a considerable extent those of earlier age, a fact which explains the complexity of the glacial geology of this area.

[27] J. B. Tyrrell. "The Patrician Glacier South of Hudson Bay," Compte rendu congrès géologique international XII., 1913, pp. 523–34.

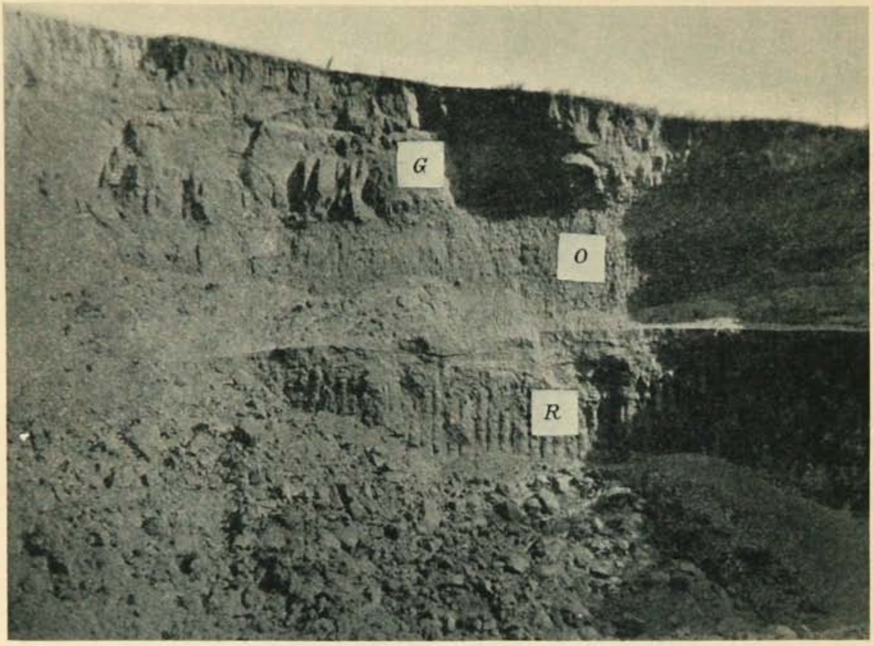

FIGURE 14. — Red drift (R) overlain by outwash (O) with gray drift (G) above. South of the Minnesota River, one mile west of Mendota Bridge.

The Metropolitan Area is so small that its relation to North American glaciation can be better understood by some knowledge of the state as a whole. Fortunately, Professor Frank Leverett has recently completed an elaborate discussion of the glacial geology of Minnesota, published by the United States Geological Survey,[28] to which the reader is referred for a broad knowledge of Minnesota glaciation. Detailed descriptions of four quadrangles of the Metropolitan Area will be found in the report by Sardeson.[29] Cooper discusses the Grantsburg Sublobe in detail.[30]

The various invasions of the ice sheets have received separate names, usually taken from the areas in which the resulting deposits are best exposed and have therefore been studied in greatest detail. The following tabulation shows the sequence of the various drifts in the Twin Cities region (see Figure 14), each representing a stage of glaciation.[31]

[28] *Quaternary Geology of Minnesota and Parts of Adjacent States* (United States Geological Survey, Professional Paper 161).

[29] *Minneapolis–St. Paul Folio* (United States Geological Survey Atlas, Folio 201).

[30] W. S. Cooper. *The History of the Upper Mississippi River in Late Wisconsin and Postglacial Time* (Minnesota Geological Survey Bulletin 26).

[31] Drift, or glacial drift, is a general term applied to the assemblage of rock deposits left by the melting of an ice sheet or glacier. Thus we speak of the Kansan drift in referring to the deposits, and to the Kansan stage of glaciation in referring to the time unit. There are also stages of deglaciation between the above stages of glaciation. For simplicity these have been omitted.

Wisconsin	Gray drift	Important
	Red drift	Important
Iowan (sometimes classified as earliest Wisconsin)		Absent
Illinoian		Scant exposure
Kansan		Scant exposure
Nebraskan (oldest)		Scant exposure

From a practical standpoint it is not so much the age of the deposit that is important as the character of the material and its topography. Continental glaciers form three principal types of deposits, known as terminal and recessional moraines, ground moraines, and outwash plains.

Terminal and recessional moraines are composed of thick accumulations of unstratified material of all sizes which formed at the margin of the ice. If the margin of the glacier remained at the same place for a long time, a very thick deposit was formed. If the time was short, other things being equal, the deposit was thin. Terminal moraines are characteristically irregular, with many rounded knobs and undrained depressions or kettles, as they are sometimes called. The region between Minneapolis and Lake Minnetonka and the area in Dakota County immediately south of St. Paul are good examples of terminal moraine country. (See Figure 15.)

Ground moraine is the deposit formed when a glacier melts over an extensive area at about the same time, thus dropping only the material enclosed in the ice above the given area. This material is not stratified and is often composed of clay, sand, and boulders. The terms till or boulder clay are often applied to it. After chemical weathering it becomes sticky clay, known as gumbotil. The topography of the ground moraine is usually irregular, but moderately so as contrasted with the decidedly irregular, hummocky terminal moraine. (See Figures 15 and 16.) A large area of ground moraine extends from Hamel in Hennepin County northward almost to Dayton.

Vast amounts of water flow out from the front of a melting glacier, carrying with them great accumulations of sediment. The velocity of this water is usually checked after it leaves the front of the glacier and part of its load is deposited. This sediment forms a rather level plain inclined slightly away from the terminal moraine. These plains often have a length and width of five to ten miles. (See Figure 17.) This type of plain is usually referred to as an outwash plain or frontal apron. The deposits are stratified sand and gravel with subordinate amounts of finer material. (See Figure 14 and Plate 4.) Extensive areas of outwash deposits occur around Osseo, in Minneapolis west of the river, and in Dakota County east of Rosemount and Farmington as far as Hastings.

Between the several ice invasions there were periods when the glaciers disappeared from most of North America, known as interglacial epochs. The most interesting fact regarding them is that they were of much longer duration than the glacial periods.

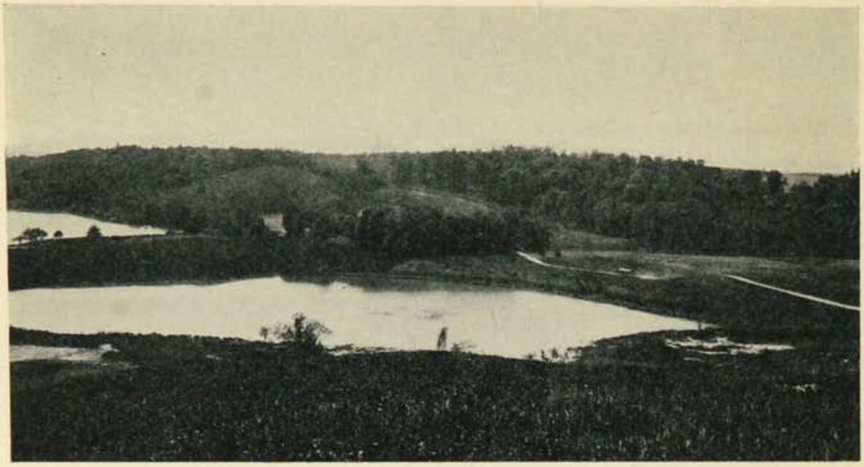

Figure 15. — Terminal moraine topography in Dakota County.

Figure 16. — Red drift moraine with coating of gray drift, north of St. Paul.

FIGURE 17. — Outwash plain of gray drift, west of White Bear Lake.

Kay[32] has recently estimated the total time for the Pleistocene of Iowa and arrived at a figure of 700,000 years. The Kansan and Nebraskan glacial stages — subdivisions of the main glacial period — are each estimated to have lasted about 7,500 years, but the interval between them is put at 200,000 years. The interval between the Kansan and Illinoian ice sheets is given as 300,000 years, but the Illinoian lasted only 9,000 years. The time since the retreat of the ice from Iowa is about 25,000 years; for Minnesota it is somewhat less.

NEBRASKAN (OLDEST OR PRE-KANSAN) DRIFT

It happens that the oldest drift, although scarcely exposed in Nebraska, is named for that state. This drift is also of slight importance in the region embraced in this report because much of it has been thoroughly reworked and covered by the later drift sheets. No areas of this drift are shown in the Metropolitan Area by Sardeson[33] or Leverett;[34] but its occurrence and probable extent are discussed by Leverett, and Sardeson described the possible occurrence as follows:

> Pre-Kansan drift has been recognized at places in Minnesota and Wisconsin on all sides of the Minneapolis and St. Paul district and may at one time have covered the district. Even at those places it has been largely eroded away, only remnants of it being preserved. It has been certainly identified in the district, though possibly some of the drift regarded as Kansan may be older. The Kansan and the pre-Kansan drift are much alike, both being "old gray drift," and in

[32] George F. Kay. "Classification and Duration of the Pleistocene Period," *Bulletin of the Geological Society of America*, 42:425–66 (1931).

[33] *Minneapolis–St. Paul Folio* (United States Geological Survey Atlas, Folio 201).

[34] *Quaternary Geology of Minnesota and Parts of Adjacent States* (United States Geological Survey, Professional Paper 161).

places where they are not separated by a zone of soil or a weathered and oxidized surface they are not readily distinguished. A small mass of till like the pre-Kansan of neighboring areas, darker and more clayey than that of recognized Kansan in this area, and containing many fragments of wood, overlies the limestone in the quarry at the foot of Church Street, Minneapolis. It may possibly be of pre-Kansan age.

While the occurrence of pre-Kansan or Nebraskan drift in this area is an interesting question, it is of little practical importance and may be dismissed without further comment.

Kansan Drift

In the second stage of glaciation a lobe of ice advanced from Canada across Minnesota and Iowa into Missouri, also across North and South Dakota, Nebraska, and Kansas. Thus the area around Minneapolis and St. Paul was probably well covered with ice of this invasion and by deposits left during its retreat. The deposits have, however, been greatly eroded by both ice and water and the patches left by erosion have to a great extent been covered by the later deposits. Considerable areas were recognized by Leverett along the St. Croix River from Taylor's Falls southwestward past Osceola, Wisconsin, and also in the vicinity of Lakeville. (See Plate 4.) The Kansan covers a large area to the south in Dakota, Rice, Goodhue, Dodge, Olmsted, Mower, and Fillmore counties. The Kansan drift is commonly known as the old gray drift. It contains rocks derived from the limestone formations of southern Manitoba and pre-Cambrian crystalline rocks and Cretaceous shale from Canada and northwestern Minnesota. It is usually blue-black, varying to buff when weathered; normally it has a high clay content but locally varies to sand and gravel. It is somewhat consolidated, probably by cementation due to its age. Leverett notes that the drillers liken it to frozen ground. Where the drift is weathered the limestone pebbles have been removed by leaching, but chert and other resistant pebbles remain.

Sardeson[35] describes many of the local details of the occurrence of the Kansan drift. Especially noteworthy are the exposures in the bluffs of the Minnesota River from the Automobile Club to Terrell Creek.

Illinoian (Old Red) Drift

In his recent report Leverett has tentatively referred certain areas of red drift in southern Washington County and in Dakota County south of the Vermillion River to the Illinoian. The average thickness of this drift is about ten feet, but from Hampton southeastward it forms a prominent moraine with hills up to a hundred feet in height, composed largely of gravel. This drift is much more weathered than the Wisconsin red drift. Limestone pebbles have been removed by solution and the

[35] *Minneapolis–St. Paul Folio* (United States Geological Survey Atlas, Folio 201), p. 7.

upper portion is stained a dark, reddish brown. The material in the drift appears to have been largely derived from the pre-Cambrian rocks of the Lake Superior region.

Wisconsin Drift

During the Wisconsin stage of glaciation the region about Minneapolis and St. Paul was invaded by two sheets of ice. The first originated in the Patrician center south of Hudson Bay and moved southwestward over this region. The deposits from this ice sheet are known as the Patrician or young red drift.

The second ice sheet originated to the northwest in the Keewatin center and the drift deposited by it is known as the Keewatin or young gray drift. As its name infers this drift is composed of gray material instead of the red material of the drift below. This is a result of the glacier's having passed over Cretaceous shales and other gray rocks.

Patrician (Red) Drift

As shown in Plate 4 the red drift is found at the surface in the Twin City region mainly in Washington, southwestern Ramsey, and northern Dakota counties. It is present under practically all the remainder of the area, but it is covered by the young gray drift. It is composed of various igneous and metamorphic rocks derived from the pre-Cambrian of the Lake Superior region. It provides a loose-textured, stony, reddish till, suitable for road surfacing. In general the boulders are small but numerous. Most of the areas where this drift is exposed are characterized by a strong moraine topography. Particularly noteworthy is the area in northern Dakota County lying between the Minnesota and Mississippi valleys. It is also very conspicuous in the area west of the Mississippi River above Newport and west of Marine in Washington County. The knob and sag or knoll and basin topography in these belts is very well developed. Most of the basins are not occupied by ponds or lakes because of the pervious character of the stony, sandy drift.

Keewatin (Young Gray) Drift

The Keewatin or young gray drift is the most extensively exposed of any of the surficial deposits of the Metropolitan Area. It is not found east of the heavy line on Plate 4, which marks the farthest eastward movement of the last ice sheet to invade the area. (See Figure 18.) Deposits from this ice sheet thus cover practically all of Hennepin, Carver, and Scott counties, and parts of Ramsey, Washington, and Dakota counties. At places, however, particularly in central Hennepin County, this gray drift is only a thin veneer over the surface of the young red drift, usually not more than 20 feet thick. Near the surface it is leached to a buff or gray color in contrast with the prevailing blue-black color in the unleached portion. It is composed mainly of clay, shale, and calcareous

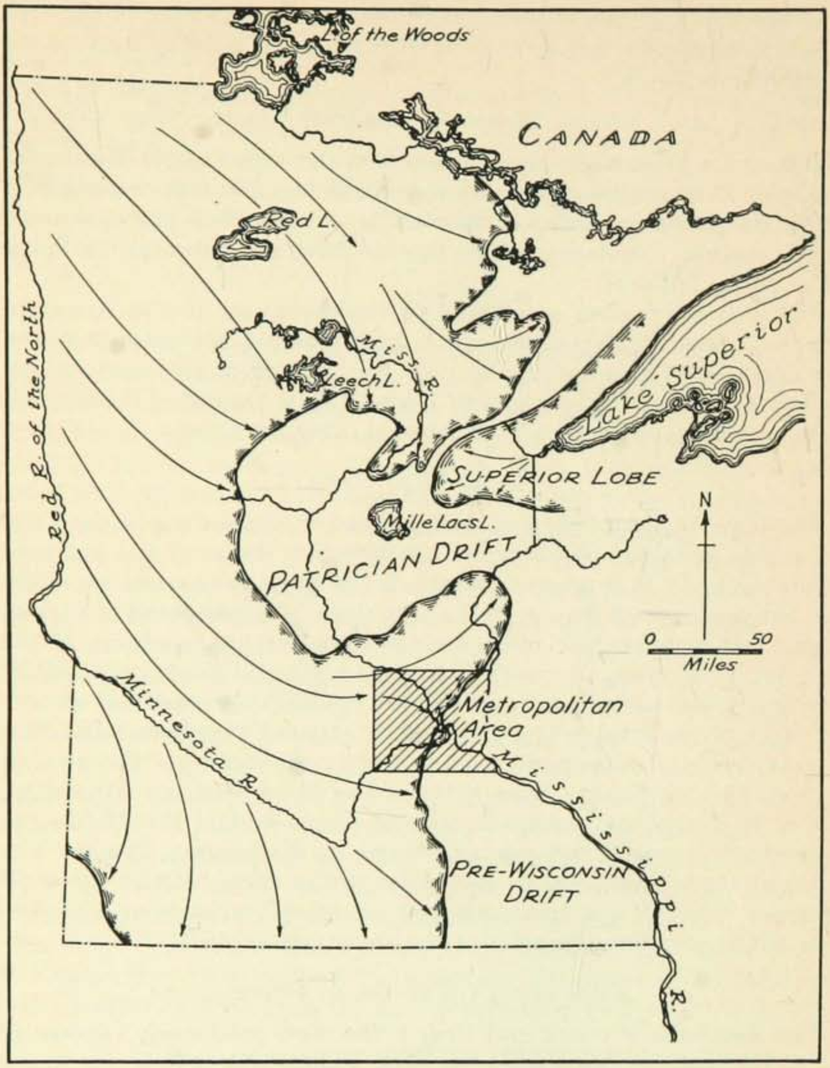

FIGURE 18. — Map of Minnesota showing the area covered by the last ice sheet.

material derived to a large extent from the Cretaceous and Devonian rocks of northwestern Minnesota and Canada. There are some knolls of gravel and sand, but the presence of clay and shale usually makes these deposits of less value than those in the red drift, particularly if the gravel is to be used for concrete aggregate.

During the last ice invasion from the Keewatin center a lobe extended from the main mass in central and western Minnesota as far east as Grantsburg, Wisconsin. It is known as the Grantsburg Sublobe. During the retreat of this lobe extensive outwash material was deposited over a wide area in Anoka County and adjacent areas. This has long been known as the Anoka Sand Plain. It was classified by Sardeson [36] as mainly wind-blown sand, although he stated that not all of the area was covered by wind-blown material. Cooper [37] has recently made a detailed investigation of this sand area and believes much of it to be outwash material. He says that instead of a dune complex we have in the Anoka Sand Plain a pitted outwash plain made by the abundant flow of sand-laden waters around or over masses of stagnant ice. He also points out that the maps of the United States Bureau of Soils show a distinction between the outwash material and dune soil, the latter being much less widespread than formerly supposed. Cooper recognizes well-developed belts of dune sand in the region, but these occupy a relatively small percentage of its area. He says regarding that part of the belt nearest the Twin Cities,[38] "From north Minneapolis an almost continuous belt of dunes extends northwestward for eighteen miles. It lies parallel to the line of division between sand plain and valley train and is nowhere more than two miles distant from it. The maximum width is two miles, the total area about seventeen square miles."

DRAINAGE CHANGES

The region about Minneapolis and St. Paul must have been greatly dissected by stream erosion during the long period which followed the withdrawal of the last ocean waters. When a region is glaciated, however, the topography is greatly modified and when subjected to repeated invasions of the ice — as the area about Minneapolis and St. Paul has been — the details of topography may be completely changed. Because of the great amount of drift deposited by the glaciers there is little relation between the original surface and the present relief. Several of the highest and most rugged areas in the region are actually underlain by deep preglacial valleys excavated in the underlying rock strata. This great modification of conditions raises many problems in regard to water supply, foundation conditions, and tunneling. The need for all possible data bearing on these problems is one of the principal reasons for the compilation of this bulletin. The earliest geologists working in this region recognized the modifications wrought by the glaciers and traced out many of the preglacial valleys as well as those developed in glacial time. The writer, therefore, claims no originality for the ideas set forth and has drawn freely on the published reports of earlier workers. The data presented here are much more complete than it has been possible to give

[36] *Quaternary Geology of Minnesota and Parts of Adjacent States* (United States Geological Survey, Professional Paper 161), p. 88.

[37] *The History of the Upper Mississippi River in Late Wisconsin and Postglacial Time* (Minnesota Geological Survey Bulletin 26), p. 46.

[38] *Ibid.*, p. 82.

before and to that extent the work is original. The Appendix contains the data on which the outlines of the valleys are based.

The credit for recognizing most of the features discussed below must be given to N. H. Winchell, the first state geologist of Minnesota, whose papers, beginning in 1876, outlined and developed the problems. Previous to Winchell's work Warren had shown that the Minnesota Valley was a result of drainage from glacial Lake Agassiz. Later on Upham, Grant, Elftman, Hall, Sardeson, Soper, and Leverett made notable contributions. Complete references to their work are given in the bibliography, and specific references in the text below.

Preglacial Topography

The topography of Minnesota shortly before the glacial period was probably the result of a long and complex chain of events. During Cretaceous time various deposits of sand and clay were laid down over at least part of the state, so that details of the drainage systems as they existed at the beginning of the Pleistocene time must have developed during the Tertiary. Studies covering all of Minnesota and parts of adjacent states suggest that the Mississippi drainage was established and valleys were eroded in preglacial time to considerable depths below the present valley levels, as is shown by numerous well logs. The rock floor of the preglacial valley west of Lake Minnetonka lies at a minimum known elevation of 477 feet above sea level. In Dakota County near Wescott it is not higher than 485 feet. Inasmuch as the elevation of rock hills was higher than at present, the relief in late Tertiary time was considerably greater than at present; in fact the topography in preglacial time was probably somewhat like that found today in the rugged southwestern portion of Minnesota.

Any description of the present topography of the rock surface must necessarily be incomplete, since only a very large number of deep wells properly distributed could furnish sufficient information to outline all of the minor valleys or completely delimit even the major ones.

Preglacial Valleys

In general the principal recognized preglacial valleys (see Figure 23) may be described as in the material below.

The St. Croix River follows a preglacial course along most of its present route. It may have followed other courses in earlier stages, possibly at one time joining the preglacial Mississippi in western Hennepin County, for there is very good evidence that a large stream followed the major preglacial valley that enters the Metropolitan Area near Forest Lake, passed a chain of lakes including Howard, Columbus, Tamarac, Randeau, Reshanau, Pleasant, Vadnais, and Phalen, and thence flowed along the general route of Johnson Parkway in St. Paul to join the Mississippi River east of Mounds Park or Dayton's Bluff.

A smaller preglacial valley enters the Mississippi Valley east of the Union Station in St. Paul and extends northwestward beneath McCarron, Josephine, Johanna, and Long lakes, thence via Rice Creek to Fridley.

A very large valley, usually supposed to be the preglacial course of the Mississippi River, trends under the western part of Hennepin County at St. Bonifacius, three miles west of Lake Minnetonka, thence southeastward across the present Minnesota Valley into Dakota County, where it passes under the site of Wescott (Radio Center) and joins the present Mississippi River valley at Pine Bend.

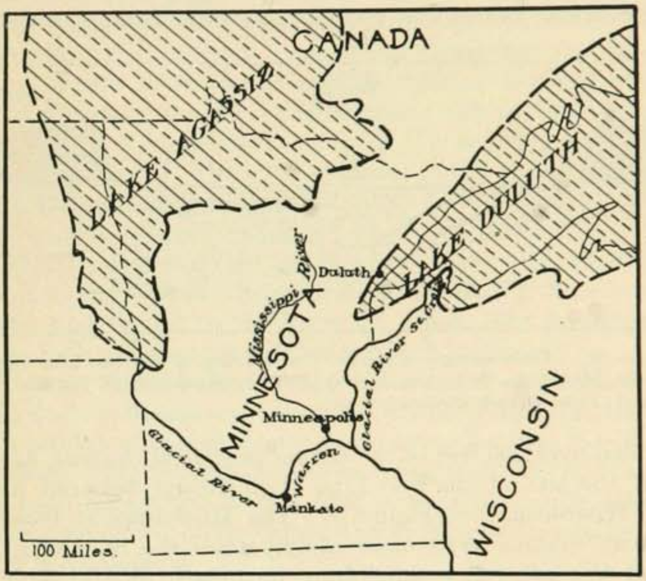

FIGURE 19. — Sketch map of portions of glacial lakes Agassiz and Duluth showing their drainage into the Mississippi River.

Another well-known valley extends southwestward from the present Mississippi River near the Plymouth Avenue Bridge to one-half mile northwest of the Great Northern Railway station in Minneapolis, thence through Lake of the Isles, Lake Calhoun, and Lake Harriet and southward via Grass and Wood lakes to the present Minnesota River, where it probably joined the preglacial Mississippi. Winchell suggested that this valley formed in interglacial rather than in preglacial time. The large valleys of the present day were formed in late glacial time. (See Figure 19.)

Each of these major valleys and known tributaries or subordinate valleys is described in some detail in the following paragraphs. Much of the evidence for them is shown on the geologic map and cross sections (Plates 1 to 3). The complete well logs are given in the Appendix. Modifications will appear as more wells are drilled and the data compared with those presented here.

St. Croix River Drainage Changes

The St. Croix River as it exists today presents decided contrasts in its valley. The lower portion, which forms the eastern boundary of the Metropolitan Area, is a prominent preglacial valley, extending from the Soo Line drawbridge in northern Washington County to Prescott. Its preglacial age is proven by extensive deposits of glacial drift lying deep in the valley and its tributaries. Along this portion prominent terraces exist at elevations as much as 200 feet above the present river; the river

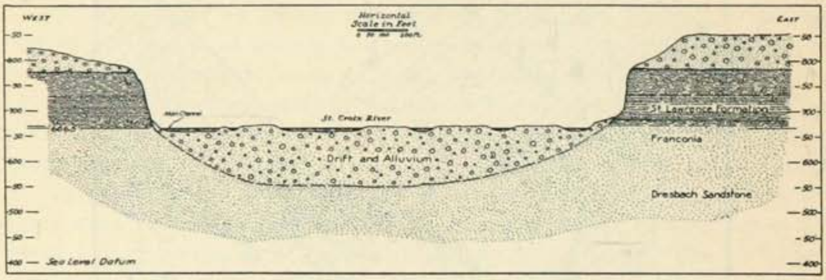

FIGURE 20. — Cross section of the St. Croix Valley at the Soo Line High Bridge near Arcola, Minnesota. Note the thick deposit of unconsolidated material filling the old channel. View looking upstream.

has also filled over 100 feet of the deeper preglacial channel, as shown by drilling at the site of the Soo Line High Bridge between Arcola and Somerset, Wisconsin. (See Figure 20.) The Mississippi at Point Douglas has filled its channel even more rapidly than the St. Croix, with the result that the latter is ponded from its mouth to Stillwater. Farther upstream, in the vicinity of Taylor's Falls, the river has a much more youthful valley with a deep, narrow gorge. Sardeson[39] attributes the beginning of this valley to drainage from the north side of the Grantsburg Sublobe. The main cutting was probably done by the powerful stream that resulted when the St. Croix River drained the Superior Basin during the later stages of the retreat of the ice. (See Figures 18 and 19.) There have been different interpretations of the early course of the river in this middle region. Upham[40] thought that the drainage from northwestern Wisconsin and from Pine County, Minnesota, crossed the present St. Croix Valley and passed southwestward through the central part of

[39] *Quaternary Geology of Minnesota and Parts of Adjacent States* (United States Geological Survey, Professional Paper 161), p. 83.

[40] "The Geology of Chisago, Isanti, and Anoka Counties," *The Geology of Minnesota* (Final Report of the Minnesota Geological and Natural History Survey), 2:399–425; "Pleistocene Ice and River Erosion in the St. Croix Valley of Minnesota and Wisconsin," *Bulletin of the Geological Society of America*, 12:13–14 (1900).

Chisago County, southern Isanti County, and across Anoka County to the Mississippi River. The chains of lakes in Anoka and Isanti counties suggest such a preglacial course. Upham also recognized the possibility that at one stage this drainage may have trended more nearly southerly, where it excavated the valley known to underlie the Centerville chain of lakes, then have continued through Pleasant, Vadnais, Gervais, and Phalen lakes to the Mississippi at the fish hatchery east of Dayton's Bluff. (See Figure 23.)

Elftman [41] noted that the upper St. Croix Valley was essentially preglacial. The preglacial portion ends at Big Bend in Chisago County near Sunrise. From this point to Prairie Hollow, a mile north of the Soo Line drawbridge, the valley is postglacial. Observing the pronounced bend of the present river to the east at Sunrise, Elftman was of the opinion that originally the river flowed nearly due south at Sunrise and passed through the Chisago lakes country. These lakes are presumably depressions in this valley. The scant evidence in this region does not seem to bear out Elftman's suggestion, but there is not enough information available to warrant discarding his hypothesis altogether.

Chamberlin [42] suggested that the St. Croix River may have had a preglacial channel which passed from Dresser Junction in Wisconsin to the Apple River, and thence to the lower St. Croix. The large size of the Apple River valley is strong evidence for such a channel.

The St. Croix River valley presents interesting physiographic problems. At Taylor's Falls and southward to Osceola, Wisconsin, the valley is distinctly youthful, with rock bluffs a prevailing feature. (See Figures 21 and 22.) South of Marine the bluff is an escarpment of Oneota dolomite which has been almost completely hidden by glacial drift. (See Figure 22.) A single abandoned quarry along the bluff and some wells show the existence of the dolomite.

In the region below Lakeland several tributary valleys enter the main valley; remnants of high terraces exist along these valleys and merge into the main terraces of the river.

In the St. Croix River valley as it exists today, and disregarding possible preglacial courses, there is evidence of a complicated history, far from completely known at present. For example, recent levelling on United States Highway No. 12 near Lakeland shows that the elevation of the broad upper terrace is 870 ft. This probably corresponds to an exceedingly wide terrace several miles east of Hudson along the same highway. The main lower terrace on which Lakeland and St. Croix Beach are built is at an elevation of about 720 feet, whereas the low water level of Lake St. Croix is at 667. The present stream, however, filled a much deeper gorge; this extends down to elevation 550 feet at Arcola (see Fig-

[41] "The St. Croix River Valley," *American Geologist,* 22:58–61.

[42] "The Glacial Features of the St. Croix Dalles Region," *Journal of Geology,* 13:238–56 (1905).

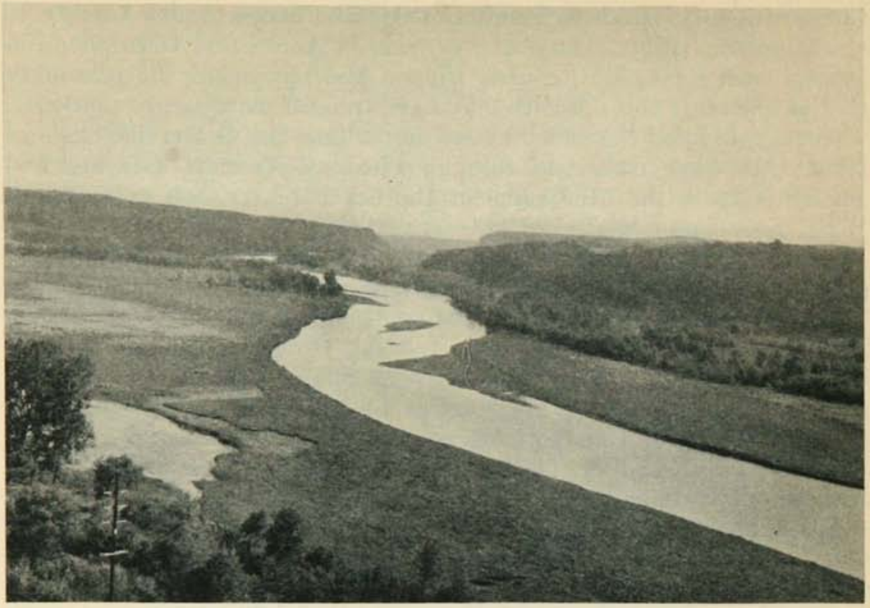

FIGURE 21. — Valley of the St. Croix River looking upstream from Stillwater. Note the wide alluvial flats and the small stream in a wide valley.

ure 20), five miles above Stillwater, and probably is down to about 450 feet at the mouth of the river at Point Douglas. The river above Stillwater now flows in a series of channels or braided stream in a wide flood plain. (See Figure 21.) At many places along the sides of the higher terraces, bluffs bounding the earlier valley are still preserved. (See Figure 22.)

MINNESOTA RIVER DRAINAGE CHANGES

Because of the very broad valley in which it flows, the Minnesota River excited the interest of the early geologists and led to the publication of many descriptions and explanations.

This large valley is mainly the result of drainage from glacial Lake Agassiz, which formed during the retreat of the ice sheet when the drainage to Hudson Bay was still blocked by the glacier. (See Figure 19.) This origin was first suggested by General G. K. Warren,[43] and in 1883 Upham[44] proposed the name River Warren for the glacial Minnesota.

That a preglacial river occupied a valley coinciding with parts of the present valley is shown by the deposits of glacial drift in the valley. The postglacial river excavated a large part of this drift and re-established itself in the old valley. An interesting evidence of this excavation is an

[43] Appendix J, Annual Report of the Chief of Engineers for 1875.

[44] "The Minnesota Valley in the Ice Age," Proceedings of the American Association for the Advancement of Science, 32nd Meeting, 1883, p. 213.

FIGURE 22. — Escarpment of Oneota dolomite covered by glacial drift. Terrace of St. Croix River in the foreground. May Township, Washington County.

abundance of many kinds of large boulders on a terrace in the present valley east and south of Shakopee. Here the finer material has been swept away and the boulders are concentrated at the surface.

The problems of the Minnesota River and the River Warren will be considered only in so far as they apply to the Metropolitan Area. During the advance of the glacier over the area, the valley as it existed in preglacial time was filled with drift and ice. As the ice retreated from Dakota County great quantities of water poured forth, flowing southeastward to join the Mississippi drainage. Winchell [45] believed the Vermillion River to be the shrunken remnant of a large stream which flowed across Dakota County, deriving its water first from the melting ice and later from the Minnesota River deflected from its contemporary course by the ice. At a later time a similar stream is thought to have flowed across Dakota County through a channel which is now marked by the depression of Crystal Lake, and still later by a channel starting near Mendota and extending to Rich Valley.

The map of the preglacial streams (see Figure 23) shows a channel reaching from Savage southeastward to Lakeville and thence east along the Vermillion River to Hastings. Sardeson [46] has suggested such a

[45] "The Geology of Dakota County," *Geology of Minnesota* (Final Report of the Minnesota Geological and Natural History Survey), 2:88–91.

[46] "Glacier Diversion of Cannon River in Minnesota," *Pan-American Geologist*, 59:263 (1933).

stream. Speaking of the Patrician glacier, he says, "That glacier's great St. Croix moraines bury the older Mississippi Valley, as said before, and obstruct it permanently, turning a flood first around through the present Vermillion Creek Valley, across Dakota County, to Hastings."

The 145 feet of drift in the wells at Lakeville can be explained only by a preglacial valley; available evidence suggests such a preglacial gorge toward Savage and down the present Vermillion River. It seems probable that a diversion channel exists as shown.

Mississippi River Drainage Changes

Not enough data are yet available to determine with certainty all changes in the course of the Mississippi River in preglacial and glacial time, but the courses of the main channels seem relatively clear. Many of the facts were developed by N. H. Winchell as early as 1876. Since 1905 F. W. Sardeson has made the most intensive studies of these problems.

The earliest course recognized at present enters the Metropolitan

FIGURE 23. — Map of the glacial and preglacial river valleys of the Metropolitan Area. The black dots represent wells. The numbers give the elevation of the rock surface above sea level.

Area northwest of Maple Plain, passes beneath the western part of Lake Minnetonka, with the deepest known point just to the west of Minnetonka at St. Bonifacius, thence southeasterly across the Minnesota Valley between Savage and Fort Snelling, and finally through Westcott to Pine Bend, where it joins the present Mississippi Valley. (See Figure 23.) The evidence for this route is given in detail by the well logs in the Appendix and by the maps and cross sections. Some of the more important indications of this valley are summarized below. At Buffalo, northwest of the area, a railway well shows 386 feet of glacial drift, and at Delano the drift is estimated by Hall, Meinzer, and Fuller[47] to be over 200 feet thick. At Maple Plain a well owned by E. E. Pierson west of the village passed through 216 feet of drift before encountering white sandstone at an elevation of 809 feet above sea level. Other wells show similar and even greater thicknesses of drift. At the St. Bonifacius Cannery a well passed through 480 feet of drift and encountered sandstone at elevation 477, and at Mound 285 feet of drift was penetrated without reaching rock. West of Excelsior near Smithtown Bay and Zumbra Lake several wells penetrate 200–300 feet of drift without encountering rock. The A. F. Meyer well at Howard's Point passed into sandstone at elevation 583. At Eden Prairie the Minneapolis and St. Louis Railroad reached solid rock in a well at elevation 674. Near Bloomington wells pass through a very considerable thickness of drift. Across the Minnesota River in Dakota County equally thick deposits of drift are known in the old channel. A well on the Otto Gentz farm in the northeast quarter of Section 17, Egan Township, penetrates 256 feet of sand with gravel at the bottom but no rock. Near Westcott several wells approach 400 feet, and only that at the Van Dyke farm reached rock, at a depth of 415 feet or elevation 485 above sea level. Thus the known elevation of the bottom of the gorge is 477 feet above sea level at St. Bonifacius and 485 at Westcott. It is presumably somewhat lower at Hastings, but drill holes have not gone down to rock in the deeper part of the gorge. Reconnaissance of the area near Westcott by geophysical means[48] indicates a considerable width, as shown by the distribution of outcrops in Plate 1.

The present course of the Mississippi offers considerable contrast in its valley above and below St. Anthony Falls. If the relation of the river level to the rock surface beneath is considered, it presents even more striking contrasts. Winchell[49] described these features in his first account of the geology of Hennepin County. In this report the opinion is expressed that the Mississippi had a preglacial channel that followed a direct route from the mouth of Rice Creek above Fridley via Johanna, Josephine,

[47] *Geology and Underground Waters of Southern Minnesota* (United States Geological Survey, Water Supply Paper 256), p. 383.

[48] S. W. Wilcox and G. M. Schwartz. "Reconnaissance of Buried River Gorges by the Earth Resistivity Method." *Economic Geology*, 29:435–53 (1934).

[49] "Geology of Hennepin County," Fifth Annual Report of the Geological and Natural History Survey of Minnesota, pp. 131–201.

and McCarron lakes, thence along the valley of Trout Creek to the main valley at Dayton's Bluff. This possibility seems to have been neglected in later writings.

Wells near the mouth of Rice Creek show nearly 100 feet of glacial drift with the rock surface at an elevation of about 740 feet. At New Brighton a well south of the village struck rock at elevation 722; between lakes Johanna and Josephine the rock surface is at 700 feet above sea level. In St. Paul, at the Mississippi Street shops of the Northern Pacific Railway, rock surface is found at elevation 602. At the Vander Bies plant on Partridge Street the rock surface has an elevation of 583 feet. This would indicate a rather shallow but nevertheless rather definite valley most of the way, especially if compared with the rock elevations on both sides. Near its junction with the present main valley in St. Paul, this gorge deepens rapidly, probably because of headward erosion by a stream occupying the valley of Trout Creek in interglacial time.

In his earliest papers Winchell noted the fact that above the mouth of Bassett's Creek the Mississippi flows in a filled preglacial gorge, whereas at St. Anthony Falls it flows over the Platteville limestone. (See Figure 31.) There is an absence of Platteville limestone and of most or all the St. Peter sandstone southwestward from Bassett's Creek, along a belt running nearly due south beneath Lake of the Isles, Lake Calhoun, Lake Harriet, and thence to the Minnesota River, probably at the mouth of Nine Mile Creek. In 1892 Winchell [50] classed this gorge as interglacial, citing his reasons for doing so. The outline of this gorge with its tributaries is well shown on Plate 6, which is a revision of a map published by Soper [51] in 1915.

The contrast between the valleys of the Mississippi and Minnesota rivers at their junction was described by Warren as follows:

> The valley of the Mississippi below the junction, and of the Minnesota above it, is wide and beautiful, and is continuous in direction and of nearly the same breadth, varying from about one to two miles. In marked contrast is the valley of the Mississippi above their junction, it being only about one quarter of a mile wide and nearly at right angles with the other. It is a mere gorge, whose bottom is almost completely filled by the river, and evidently had its origin in the water-fall now at St. Anthony. The fall in quite recent times must have been where the river now joins the main valley, and since receded to its present position seven miles above the junction.[52]

Winchell followed Warren in this interpretation, referring to the larger valley as "old" and the gorge above the Fort as "young." Sardeson has shown that this statement requires some modification for the portion of the Minnesota Valley near Fort Snelling. He classified the valleys of the region as follows: 1. Old valleys, with cliffs or slopes covered by undis-

[50] "An Approximate Interglacial Chronometer," *American Geologist,* 10:69–80 (1892).

[51] "Buried Rock Surfaces and Preglacial River Valleys of Minneapolis and St. Paul," *Journal of Geology,* 23:444–60 (1915).

[52] Appendix J, Annual Report of the Chief of Engineers for 1875, p. 35.

turbed boulder-clay or other glacial drift. Some of the old valleys are entirely buried. Lakes Minnetonka, Calhoun, and others lie in such valleys. 2. Re-excavated old valleys, which were partly buried by glacial drift, but later occupied by the streams again, i. e., the Mississippi southward from St. Paul. 3. New valleys, which have been made since the glacial deposits and whose cliffs are not covered by glacial drift.

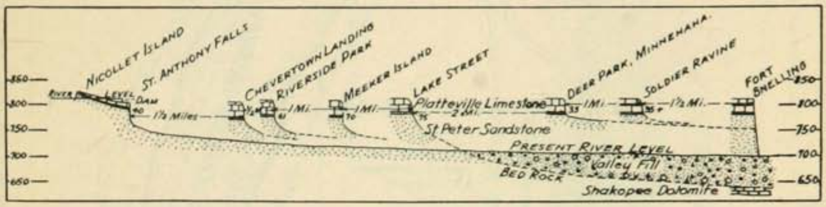

Figure 24. — Generalized profiles of the successive stages of St. Anthony Falls from Soldier Ravine to the present site below Nicollet Island. The bluff at Fort Snelling is not a fall scarp. Note the monoclinal dip of Platteville limestone. (After Sardeson.)

A considerable portion of the Metropolitan Area, especially all of the region above the confluence of the Minnesota and Mississippi, was covered with the last invasion of the Wisconsin ice sheet. (See Figure 18.) Heavy deposits of drift filled the old valleys, making it necessary for the later streams to re-excavate the old valleys or develop new ones. The Mississippi from Fort Snelling to Nicollet Island above St. Anthony Falls is mainly a new excavation and Sardeson suggests that the Minnesota-Mississippi Valley from two miles above Fort Snelling to six miles below is also a newly cut gorge. The terraces along these streams indicate that the Minnesota River (glacial River Warren) was a mile wide in its immediately postglacial stage and that the Mississippi was about one-half mile wide. Both streams flowed at an elevation of about 820 feet above sea level.

When the River Warren had cut down to the Platteville limestone and cleared out the preglacial valley from Dayton's Bluff southward, a fall was established. This migrated westward, cutting the gorge between the present business district of St. Paul and Fort Snelling. A short distance above Fort Snelling the fall met the east side of a preglacial valley and disappeared. When the main fall passed the point where the Mississippi entered the River Warren, St. Anthony Falls came into existence and cut its way back to its present position. Sardeson[53] pointed out that detailed studies of the area north of the present junction of the rivers at Fort Snelling indicate the former existence in this region of a small north-south valley. Its head was perhaps a mile north of Fort Snelling, from which point it trended south across the present site of Mendota, where

[53] "Beginning and Recession of St. Anthony Falls," *Bulletin of the Geological Society of America*, 19:29–52 (1908).

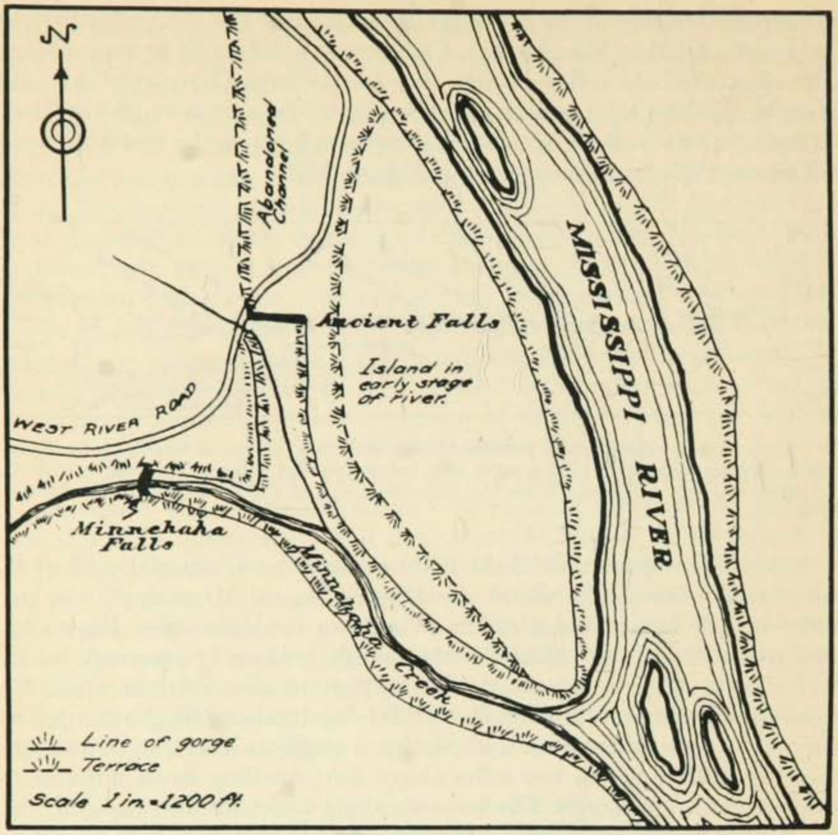

FIGURE 25. — Sketch map of abandoned falls below Minnehaha Parkway.

there is a definite break in the south bluff of the Mississippi. To the south this preglacial valley is further indicated by two small elongate lakes, Augusta and Lemay, lying south of Mendota. This valley may have been tributary to the very deep preglacial valley trending through Westcott. (See Figure 23.) If so, then the St. Anthony Falls started a mile above Fort Snelling rather than at the present junction of the rivers, as usually stated. As St. Anthony Falls migrated northward, it left remnants of fall scarps and broken blocks of limestone, which give a sort of summary of the migration. Figure 24 shows many of the stages as worked out by Sardeson. At Minnehaha Park and the site of the Twin City Lock and Dam the Mississippi was split into two channels, the larger on the east, where the present river exists, and the lesser west of the hill now used as a tourist park. Grant[54] first discussed the history of this interesting

[54] "An Account of a Deserted Gorge of the Mississippi near Minnehaha Falls," *American Geologist,* 6:1–6 (1890).

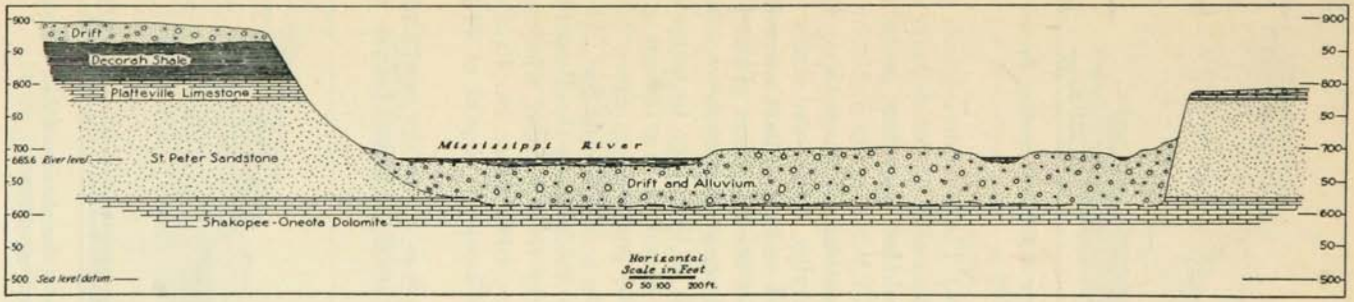

FIGURE 26. — Cross section of the Mississippi River at the High Bridge, St. Paul. View looking upstream.

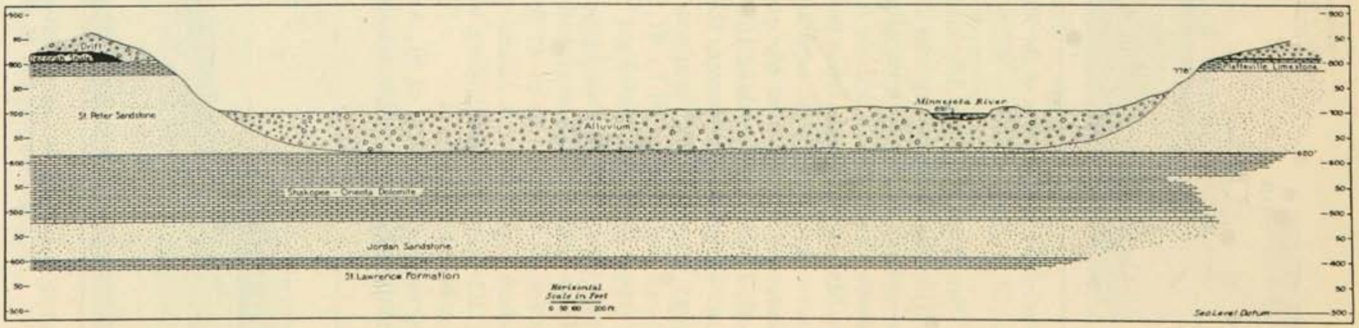

FIGURE 27. — Cross section of the Minnesota River at Mendota Bridge, just above the junction with the Mississippi. View looking upstream.

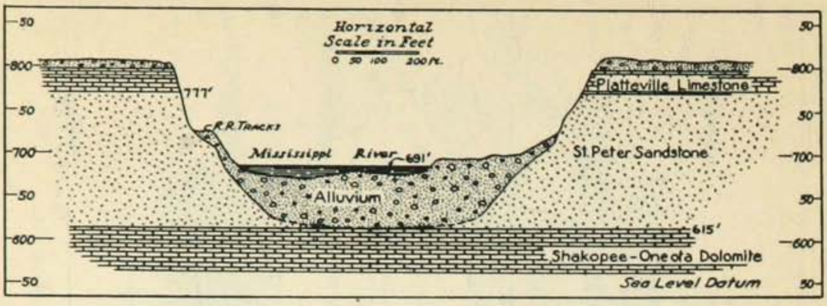

FIGURE 28. — Cross section of the Mississippi River at the Fort Snelling Bridge. View looking upstream.

place. (See Figure 25 for his interpretation.) The abandoned falls just below Minnehaha Parkway was drained of its water when the larger east stream, cutting back more rapidly because of the larger flow, passed the split above the island.

The Mississippi gorge from the government dam to St. Anthony Falls and above has been much modified by quarrying, bridge and street construction, and dredging in the river, as well as by the backwater from the dam. Therefore, much of the evidence of the migration of the Falls has been destroyed; however, the earlier descriptions preserve most of what was known. The change in the depth of the gorge to bedrock is well shown by Figures 26 to 31, which are based on test borings given in the Appendix. Thus, at Fort Snelling, the gorge is cut down to the Shakopee dolomite and has been silted up to a depth of 62 feet. At the Twin City Lock and Dam and the Intercity Bridge near the Ford Plant rock is found at a depth of 47 feet below the river bottom, whereas at the abandoned dam just below the Chicago, Milwaukee, St. Paul and Pacific Railroad bridge drilling revealed sandstone at depths of 20 feet and less below river level.

The rate of recession of St. Anthony Falls is one of the most important yardsticks we have for measuring time since the glacial period. This

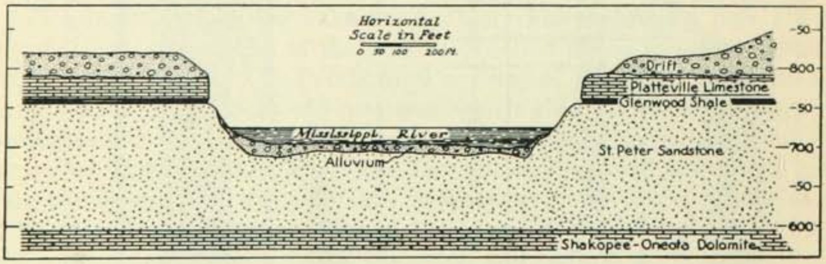

FIGURE 29. — Cross section of the Mississippi River at the abandoned dam between Minneapolis and St. Paul. View looking upstream.

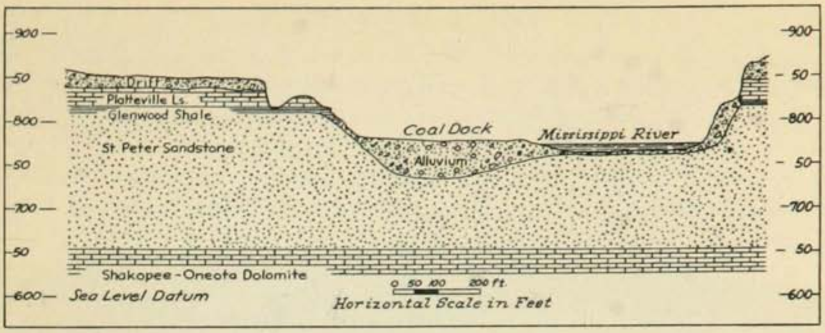

FIGURE 30. — Cross section of the Mississippi River at the University of Minnesota campus. View looking upstream.

was pointed out by Winchell in 1878[55] and covered more fully in the chapter on Hennepin County in the Final Report of the Geological and Natural History Survey of Minnesota. A review, with modifications, was given by Sardeson,[56] and later summaries were given by Sardeson[57] and Leverett.[58]

In view of the number of times the evidence has been repeated, it is unnecessary to give the details here. Winchell estimated the rate of recession at 2.44 feet per year, or a mile in 2,163 years. Taking into account

[55] "The Recession of the Falls of St. Anthony," *Quarterly Journal of the Geological Society of London*, 34:886–901 (1878).

[56] "Beginning and Recession of St. Anthony Falls," *Bulletin of the Geological Society of America*, 19:29–52 (1908).

[57] *Minneapolis–St. Paul Folio* (United States Geological Survey Atlas, Folio 201).

[58] *Quaternary Geology of Minnesota and Adjacent States* (United States Geological Survey, Professional Paper 161), pp. 144–46.

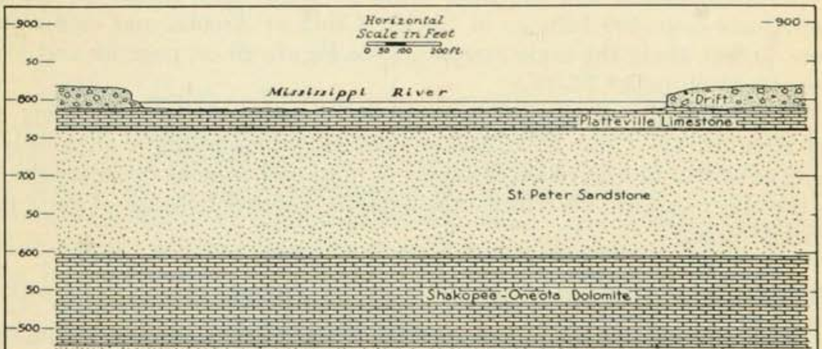

FIGURE 31. — Cross section of the Mississippi River just above St. Anthony Falls, at the Third Avenue Bridge, Minneapolis. View looking upstream.

FIGURE 32. — Alluvial terrace along the Crow River between Hanover and Rockford.

various modifying factors, Leverett estimated that Lake Agassiz began about 18,000 and ended about 8,000 years ago. In other words, the glacier retreated to the north far enough to allow drainage into Hudson Bay about 8,000 years ago.

RECENT DEPOSITS

Since the glacial waters subsided, there has been little deposition in the area. When the glacial waters decreased, the carrying power of the streams decreased, and the main streams filled their gorges to depths sometimes over 100 feet, as in the St. Croix at Arcola, and commonly over 50 feet along the main streams. (See Figure 20 on page 68 and Figures 26–31 on pages 77–79.)

Small deposits of alluvial material have continued to form along all the streams. The Crow River has an especially diagrammatic alluvial terrace, as shown in Figure 32. Deposits of marl and peat have accumulated in the lakes and are described in a separate chapter because of their potential value.

SUMMARY OF THE GEOLOGIC HISTORY OF THE METROPOLITAN AREA

A clearer idea of the events that took place in this region during the long intervals of geologic time can be gained from a chronological treatment of the events themselves than from the detailed descriptions of formations given above. It should be understood that knowledge gained from adjacent regions can be used in interpreting some of the events only obscurely represented by the rocks in the region under consideration.

Pre-Cambrian Time

The oldest known rock within the Metropolitan Area is the granite encountered in the Lakewood Cemetery well at a depth of 2,135 feet. General knowledge of the region suggests that this granite is related to that exposed in the vicinity of St. Cloud or in the Minnesota River valley above New Ulm. Because granites are coarse-grained rocks formed only at a depth where they crystallize slowly, we are justified in believing that considerable erosion followed the intrusion of the granite, eventually exposing it at the surface. Thus the earliest event recorded in the area is the intrusion of bodies of granite into the pre-existing rocks, which were probably basalt lava flows.

The next rocks in chronological order are the Keweenawan flows. A basalt lava flow was encountered in the Stillwater well at the east side of the area, at a depth of 3,100 feet, or elevation −2,413 feet. These lava flows are undoubtedly related to those exposed at Taylor's Falls and are widespread on the north and south sides of Lake Superior. They do not extend far to the west of Stillwater. The Lakewood well at Minneapolis passed directly from sedimentary rock to granite. The lava flows at Hudson, which is six miles south of Stillwater, were encountered at a depth of 883 feet below the elevation of the St. Croix River, or at elevation −213 feet. At about the time that these lava flows were extruded to the northeast, mud and sand were accumulating in the region now occupied by Minneapolis and St. Paul; this clay and sand formed the Red Clastic series of shale and sandstone overlying the granite at Lakewood and the basalt at Stillwater. The character of this material suggests that it was in part derived from the erosion of the lava flows. The red color resulting from iron oxides is characteristic of sands and clays laid down on land or in fresh-water basins, whereas marine sands are more commonly green or white.

Paleozoic Era

Cambrian period.—There is some question as to whether the Red Clastic series and the sandstone at its top, usually referred to as Hinckley sandstone, represent only the late pre-Cambrian or also part of early Cambrian time. In any event there is no certain sedimentary record in Minnesota of the rocks commonly known as early and middle Cambrian, and it may be inferred that this part of North America was above sea level. In late Cambrian time, however, the sea invaded the area from the south, extending to a point somewhat north of the Twin City area. (See Figure 33.) It seems to have encroached farther on the land as time went on so that to the north the formations are thinner and overlap the preceding deposits.

During late Cambrian time life was present in the sea, as shown by the fossil trilobites, brachiopods, and mollusks found in the formations beginning with the Dresbach. (See Figure 2.) Fossils are almost unknown

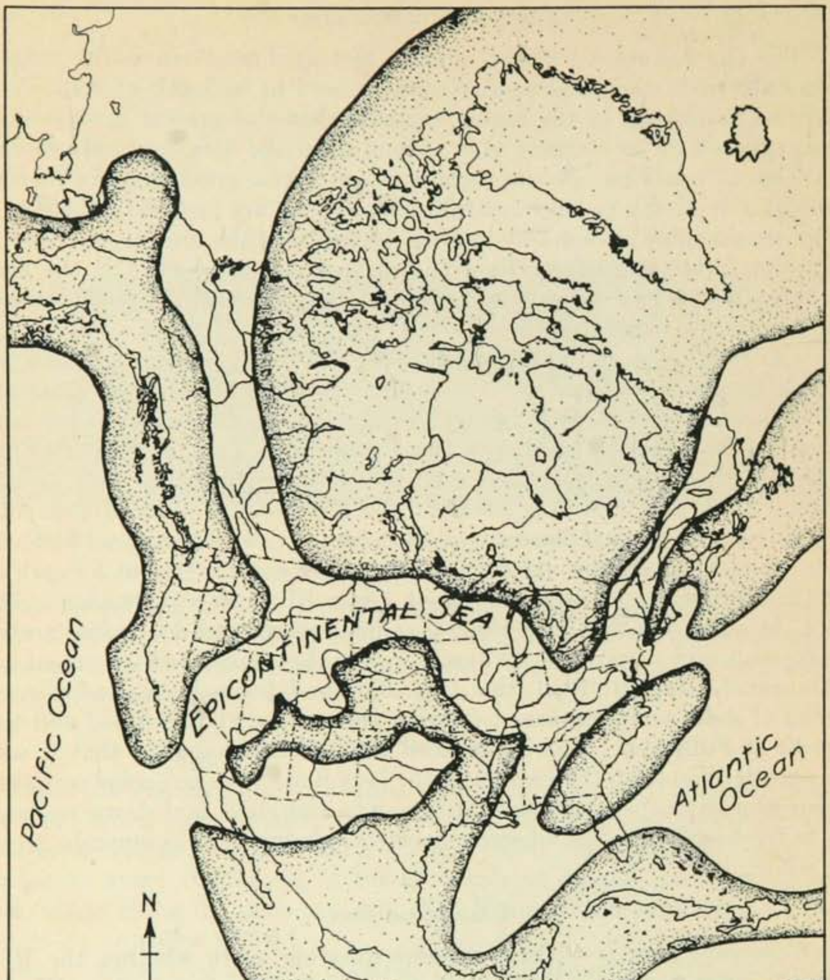

FIGURE 33. — Map of North America showing distribution of land and sea during Cambrian (St. Croixian) time. Stippled areas were land.

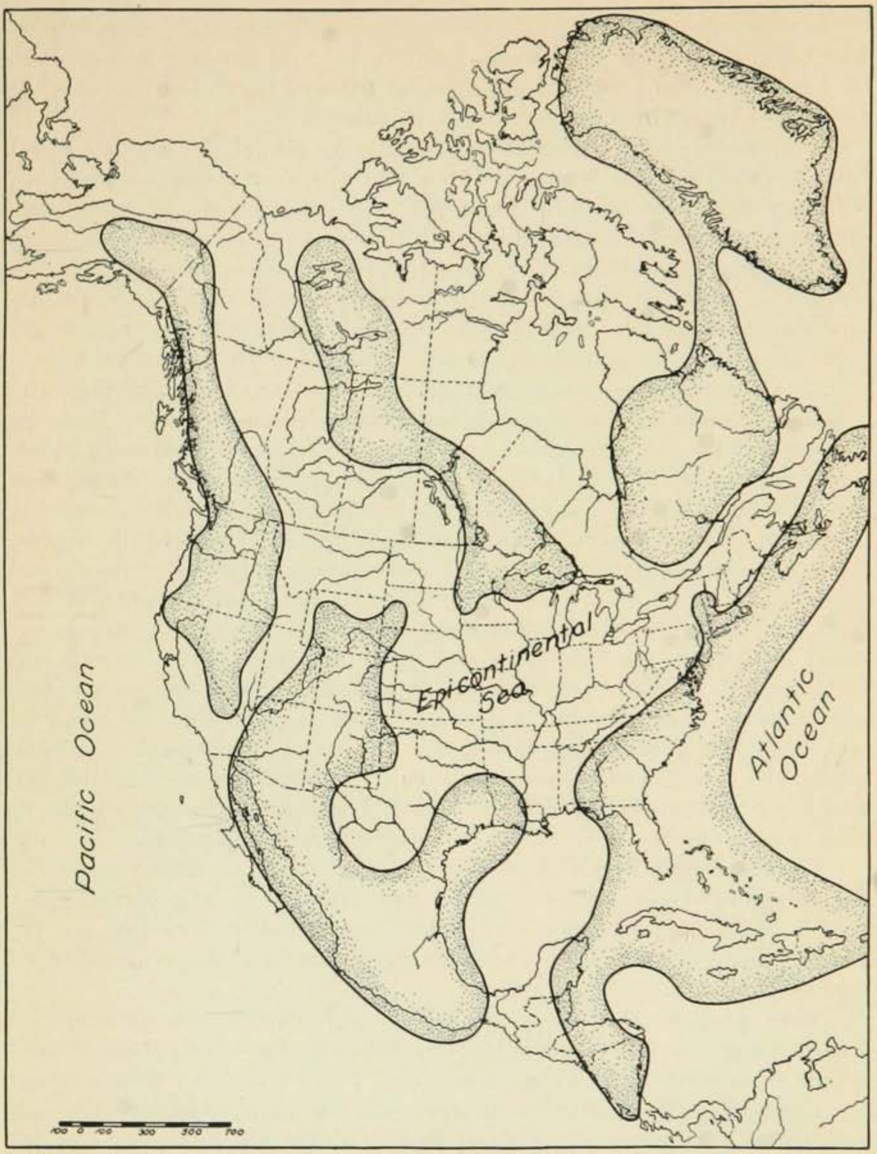

FIGURE 34. — Map of North America showing distribution of land and sea during Middle Ordovician time. Stippled areas were land.

in the Hinckley and Red Clastic series below the Dresbach. The faunas found in the rocks of the various formations, i. e., Dresbach, Franconia, St. Lawrence, and Jordan, are somewhat different and afford a basis for distinguishing and correlating the formations.

Ordovician. — The rocks of the Ordovician period are not separated from the Cambrian in Minnesota by a sharp break; but the sea probably withdrew from the region for some time, as the faunas of the two periods indicate a considerable time interval between them. In any event, ocean water returned (see Figure 34); comparatively quiet water existed during Ordovician time, so that instead of deposition of mechanical sediments biochemical sediments were precipitated by algae and myriads of sea organisms from compounds in the sea water. Thus the lowest formation of the Ordovician is mainly a magnesian limestone; but probably the original sediment was calcium carbonate, later replaced to some extent by dolomite. Some sand was deposited with the carbonate, especially in the lower part of what is now known as the Oneota dolomite. During this time life was abundant in the sea and a new fauna, differing somewhat from that of the Cambrian, appeared. (See Figure 12.) After the deposition of a considerable thickness of carbonate, conditions changed and sands were again deposited. These formed what is now known as the New Richmond sandstones. These sandstones are not everywhere recognized in the Metropolitan Area and must be either thin or absent; but farther south in Minnesota the sandstone is thicker and composes a definite series of beds forming a distinct break between the deposition of the Oneota and Shakopee dolomites. Following the deposition of the sands, the condition for the deposition of carbonates was re-established and the Shakopee beds were laid down. The marine life was similar to that during Oneota time, but their species were not identical.

The sea evidently withdrew at the end of Shakopee time because the top of the Shakopee is known to be very irregular in neighboring areas. In the Metropolitan region the contact between the Shakopee and St. Peter is not well exposed, but well records do not suggest any pronounced irregularity.

After an interval of elevation and possible erosion the sea again invaded the area and deposited the remarkably uniform beds of white sand which compose the St. Peter sandstone. (See Figure 34.) Some change occurred after the deposition of about 35 feet of pure white sand and resulted in the deposition of about 30 feet of fine silt. Following the silt, nearly another 100 feet of white sand accumulated. Fossils are very scarce in the St. Peter, but enough have been found to show that the sea was occupied by such animals as were prevalent at that early period of earth history.

After the deposition of the thick sand beds of the St. Peter conditions changed again, rather gradually. The pure white sand graded into sandy mud, then to rather pure clay, which in turn graded to calcareous mud and finally to nearly pure carbonate material. This zone, composed of a few feet of sandy shale, shale, and calcareous shale, is now referred to as the Glenwood beds. Above this gradational series is the Platteville formation, which was deposited as a series of somewhat shaly carbonate beds. Life was exceedingly abundant during this period and certain upper beds are composed mainly of fossilized shells, chiefly mollusks, which accumulated on the sea floor.

After about 30 feet of carbonate material had accumulated, the character of the deposits again changed somewhat and the Decorah formation was laid down. The Decorah consists mainly of shale, but has many interbedded limestone lenses, suggesting rather irregular conditions in the sea, and alternating intervals of mud and carbonate deposition. Life was abundant and some of the limestone beds are well filled with the fossilized remains of many types of marine animals. The Galena formation, which is recognized in the Metropolitan Area principally by its fauna, was a continuation of the conditions prevailing during Decorah time. Farther south in Minnesota, the Galena is a nearly pure limestone and dolomite, in contrast to the shaly phase present at St. Paul. Only the basal portion of the Galena is now known in the area, but it is probable that the entire thickness was deposited and then eroded. Beds of Ordovician age younger than Galena are present in southern Minnesota; they may have covered part of this area or an extensive emergence from the sea may have prevented their deposition.

The remainder of the Paleozoic era is not represented by beds in the Metropolitan Area and indeed only a single Devonian formation, the Cedar Valley limestone, is found anywhere in Minnesota. It may therefore be inferred that the region had now emerged from the sea; however, the sea remained over part of Iowa, as is shown by extensive marine deposits younger than Devonian. In fact, the sea had remained over much of what is now the upper Mississippi Valley until the end of the Paleozoic era, when it withdrew, probably because of a major uplift accompanying the folding of the Appalachian Mountains and the smaller foldings of the Arbuckle-Wichita uplift in Oklahoma and adjacent areas.

Mesozoic Era

The uplift which closed the Paleozoic era in North America probably elevated the Minnesota area and subjected it to prolonged erosion. During the Cretaceous period which followed a sea invaded Minnesota from the west and much of western Minnesota has thin Cretaceous deposits beneath the glacial drift. Whether this sea covered all or part of the Metropolitan Area is not certain, as the deposits, if ever laid down, have been eroded.

Cenozoic Era

During the part of the Cenozoic era that preceded the glacial periods erosion was general and many deep valleys were formed in the sedimentary rocks. These old river valleys were afterwards filled by the sands and clays of the glacial drifts. Preglacial deposits of this era are unknown in Minnesota.

Pleistocene (glacial period).—Glaciation in the not-distant geologic past was not peculiar to Minnesota nor even to North America, as similar ice sheets covered a large portion of northern Europe at about the same time. Glaciation did not consist of a single ice invasion but of a series of invasions separated by time intervals believed to have been much longer than the time occupied by the actual ice invasions.

The earliest ice sheet to invade Minnesota is known as the Nebraskan, sometimes referred to as the pre-Kansan. The ice came from the northwest and left deposits that are little known because they have been largely covered or destroyed by the later invasions.

The Kansan sheet advanced into Minnesota from the Keewatin center, west of Hudson Bay, and crossed the state from northwest to southeast, apparently covering more of the state than any other ice sheet. The deposits are found in the extreme northwestern part of the state and nearly to the extreme southeastern part. The drift deposited by this sheet is mainly gray and is often referred to as the old gray drift. The withdrawal of the Kansan ice sheet was followed by a long period of time known as the Yarmouth interglacial stage, during which there was no glaciation.

During the stage of glaciation known as the Illinoian the ice, which came from the Labradorean center across the west end of Lake Superior, extended over most of Washington and Dakota counties. The ice was thin and left unimportant deposits except in the Hampton–Cannon River Moraine, where the deposits are about 100 feet thick. As the name indicates, this stage of glaciation was important in Illinois. The drift is composed of gravel and boulder clay of a prevailing red color, so that it is often referred to as old red drift.

The interval of time between the Illinoian stage and the next ice invasion was probably not as long as the interval between the Kansan and Illinoian but has been estimated at 70,000 years.

The Wisconsin stage or stages were perhaps the most extreme of all the glacial advances; ice sheets moved out from several centers in Canada, their tongues or lobes advancing and retreating at various times. The Wisconsin is usually separated into two divisions, an earlier and a later; a still earlier stage, the Iowan, is added by some workers. Its classification is not of great importance here, as deposits of the earlier Iowan sheet, so prominent in Iowa, are not found near the Twin Cities, having been destroyed by the later Wisconsin ice sheets.

During the Wisconsin stage Minnesota was invaded by an ice sheet travelling southwestward and depositing material from the Superior region. Since this is mainly of a chocolate brown to red color it is referred to as the young red drift. It is also referred to as Patrician drift because the ice invasion centered in the Patrician area southeast of Hudson Bay. Later, a southeastward movement brought ice from the northwest. One lobe passed north of Minneapolis and St. Paul, at right angles to the general direction of movement, and extended eastward to Grantsburg, Wisconsin. This glacier brought in grayish sandy and clayey material from the northwest, which is referred to as the young gray drift.

The withdrawal of the second Wisconsin ice sheet brought the glacial period as we know it to an end. The withdrawal from the Metropolitan Area took place about 20,000 years ago. The principal changes after the withdrawal were the establishment of the present rivers and streams in their valleys and the migration of St. Anthony Falls from near Fort Snelling to their present position.

CHAPTER IV

GEOLOGIC STRUCTURE OF THE MINNEAPOLIS–ST. PAUL AREA

General Structure of the Region

The structure of the rocks about Minneapolis and St. Paul is relatively simple. They are, however, not horizontal, although they may seem so to the casual observer. Their divergence from the horizontal is so slight at most places that rather accurate data are necessary to determine the inclination or dip, which in most cases is expressed in feet per mile rather than in degrees. The heavy cover of glacial drift makes it difficult to determine the exact structure.

The elevations of outcrops and wells have been obtained from accurate levels where possible, the elevations of railroads and storage pools above five dams being particularly helpful. For some areas in Washington County elevations were carried from bench marks by plane table and stadia. Many of the elevations, especially outside of the cities, were obtained by use of Paulin altimeters and checked frequently against known elevations. The bench marks established by the United States Coast and Geodetic Survey under a grant of the PWA in 1933 and 1934 were especially valuable. Professor A. S. Cutler kindly made these elevations available in advance of publication. Well logs were obtained from the drillers or others in possession of the information. The tabulations in the Appendix give the source of information.

The general structure of the rocks of the Metropolitan Area is that of a very flat basin or saucer-shaped depression. The structural contours of Plate 5 and the cross sections shown on Plates 2 and 3 give an excellent idea of the structure as a whole.

The elevations used in drawing the structural contours were obtained in some cases by transposing data from outcropping beds or well logs to the Jordan-Oneota contact. If this contact was exposed or penetrated by a well its elevation above sea level was exactly known. Where a contact other than that of the Jordan and Oneota was used a correction was made by either adding or subtracting the number of feet the available contact is above or below the datum plane. On page 89 are given the constants used to determine the Jordan-Oneota contact; these were obtained by using average thicknesses of formations given on page 22.

Since the data used were checked in every possible respect and poor logs eliminated, the contours are essentially correct with the possible exception of places where too few wells reach bedrock. The only difficulty encountered in using these corrections was along the southern border

Contact	*Correction (in feet)*
St. Peter–Platteville	−294
Shakopee–St. Peter	−136
Jordan-Oneota	0
St. Lawrence-Jordan	+ 90
Franconia–St. Lawrence	+275
Dresbach-Franconia	+340

of the area. It is known that the Shakopee and Oneota dolomites have a somewhat greater aggregate thickness in Northfield than in Minneapolis and St. Paul, and that the St. Peter sandstone is much thinner. After considering all available facts, it was decided that 294 feet subtracted from the St. Peter–Platteville contact would give essentially correct results. The 136 feet allowed for the thickness of the combined Shakopee and Oneota is probably too small along the southern border of the area; however, none of the contacts were based upon this figure alone. Fortunately, a number of good logs of deep wells between the Minnesota River and Rosemount gave data on the increasing thickness of the Shakopee-Oneota and the decreasing thickness of the St. Peter and thereby prevented errors in the elevations of the contour lines of the base of the Oneota.

The structural basin in the rocks is slightly elongated in a northeast-southwest direction. The lowest part in Minneapolis and St. Paul lies near the point where the boundary of the two cities intersects the Mississippi. The average dip of the beds on the sides of the basin appears to be about 20 feet per mile. It is evident that the bottom of the basin is decidedly flat. The spacing of the lower contours between the 450- and the 550-foot contours is nearly twice as great as between the 550- and 800-foot contours.

At the south edge of the Metropolian Area and beyond in Dakota County there is a well-defined anticlinal structure, as is clearly shown by Winchell's map of Dakota County in Volume Two of the Final Report of the Minnesota Natural History and Geological Survey. Exposures of Platteville limestone in Eureka, Castle Rock, Hampton, and Douglas townships are surrounded by a 1000-foot contour. As a matter of fact, recently determined elevations in this area show the St. Peter–Platteville contact at elevations up to 1030, a fact which places the Jordan-Oneota contact at an elevation above 700. It is not unlikely that the anticlinal axis, which Winchell noted at Belle Plaine and which has been mapped in more detail by Couser,[1] trends eastward through this area. Areas of local disturbance in southern Washington County and the adjacent areas of Dakota County are described in more detail below.

The major structure of the region is of great importance since it is an artesian basin. The exposure of the formations on the sides, at the surface, or beneath the glacial drift allows water to work into the porous

[1] C. W. Couser. "Paleozoic Stratigraphy and Structure of the Minnesota River Valley," *University of Iowa Studies in Natural History*, 16:451–72 (1935).

sandstones; this finds its way toward the center of the basin, where it supplies numerous deep wells in the Twin Cities district. It should be noted that the older formations occur in general around the outside of the basin. Thus the top of the Jordan sandstone, which is at a depth of about 400 feet in Minneapolis and 350–300 feet in most of St. Paul, occurs immediately beneath the thick glacial drift almost continuously surrounding the area. (See Plate 1.)

Structure near Hastings

Good exposures of bedrock along the Mississippi and St. Croix rivers near their confluence indicate a considerable disturbance of the rocks in that region. On the east bluff of the Mississippi, about a mile above Hastings, and within a thousand feet of the lock and dam at Hastings, are

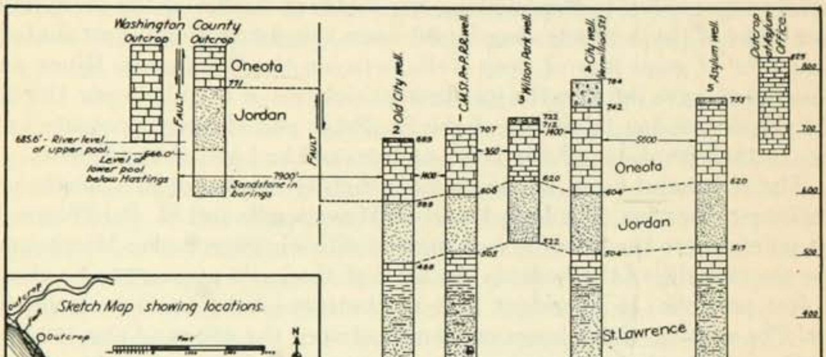

FIGURE 35. — Diagram of wells and outcrops at Hastings, showing evidence for a fault in the Mississippi River.

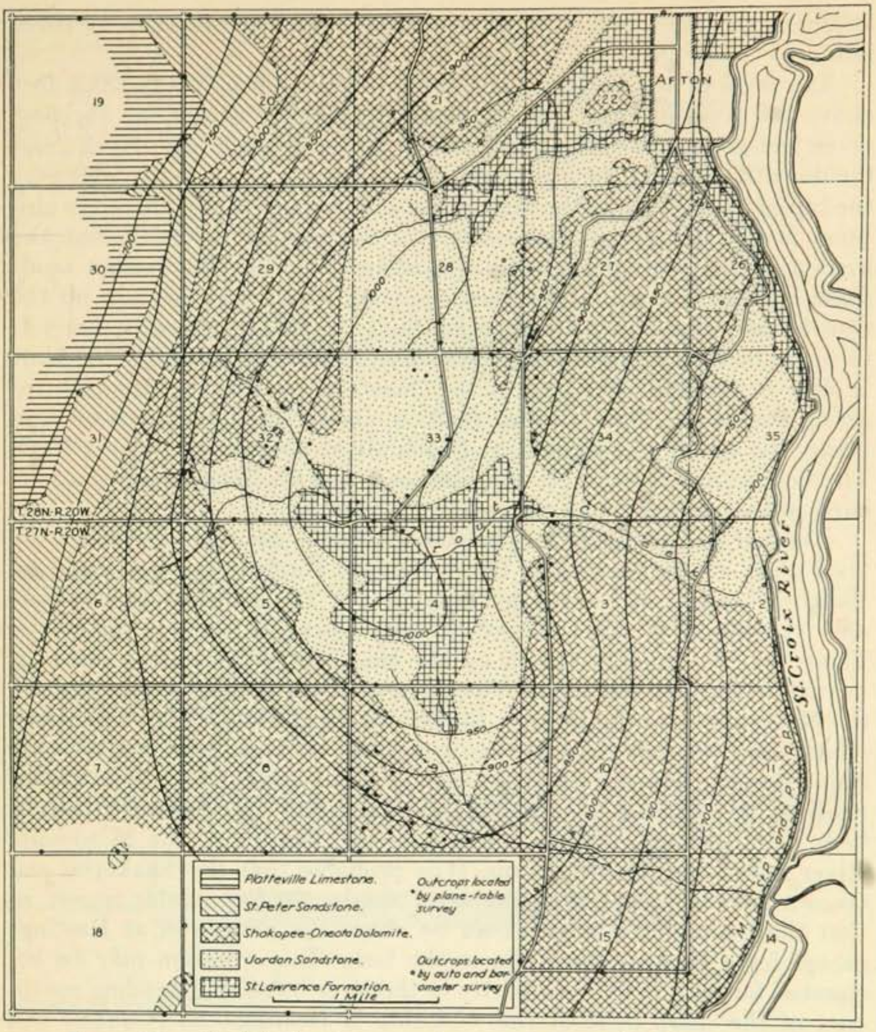

FIGURE 36. — Geological and structural contour map of the Afton anticline. Contours are drawn on the Jordan-Oneota contact.

two well-defined faults, probably the only ones actually exposed in the Metropolitan Area. These faults were described and sketched by Winchell in his discussion of Washington County[2] and also by Hall and Sardeson[3] in a later paper. Winchell refers to Owen's[4] sketch as probably

[2] *Geology of Minnesota* (Final Report of the Geological and Natural History Survey of Minnesota), 2:384.

[3] "Paleozoic Formations of Southeastern Minnesota," *Bulletin of the Geological Society of America*, 3:331–68 (1892).

[4] *Report of a Geological Survey of Wisconsin, Iowa, and Minnesota* (1852), Section 1.

at the same point. Figure 35 shows the writer's interpretation of these faults.

The level of the Hastings pool at the lock and dam was 685.5 feet above sea level in 1934. The exposure is complete except for the first seven feet above the water. The strike of the larger fault is N. 70° E., and the downthrow is on the northwest side. A breccia shows fairly well near the top of the cliff along the fault plane of the larger fault. There are also some poorly developed slickensides on the Oneota dolomite, but the breccia is composed principally of sandstone blocks. The Jordan sandstone rises 86 feet above the Hastings pool, where it is overlain by the Oneota dolomite. North of the main fault the Oneota dolomite extends to water level and possibly slightly below, so that the throw of the fault is close to 100 feet. The base of the Oneota is obscured by the railroad grade and water. The smaller fault is about 300 feet upstream and brings the top of the Jordan sandstone about 20 feet above river level. The downthrow there is on the southeast and the displacement is perhaps 50 feet, with a strike estimated at N. 45° E.

Another and probably larger fault lies in the channel or beneath the flood plain of the Mississippi River opposite Hastings, as was noted by Winchell[5] and more recently by Trowbridge.[6] The evidence for this fault and its relation to the larger of the two described above is shown by Figure 35. The data presented on the cross section indicate a throw of nearly 200 feet for this fault. Winchell was of the opinion that it crossed the Mississippi since, as he says, the beds at Point Douglas have the same relative elevations as those at Hastings. Thus the fault must pass between Point Douglas and the Hastings dam. It also appears from the altimeter readings on outcrops just west of Hastings that the Shakopee-Oneota beds lie at elevations up to 890 feet, or 223 feet above the Mississippi River below the Hastings dam. It is probable that the Shakopee and Oneota have a combined thickness of nearly 200 feet in this region, so that the top of the Jordan would be above the river level at Hastings except for a fault or sharp dip in the beds. This situation may be accounted for by a fault lying partly in the river but also extending southwest of the sharp bend at the west side of Hastings. At Nininger and west to Spring Lake the Jordan does occur above river level; on the opposite or north side of the river the Oneota outcrops down to the level of the Hastings pool. Thus at Hastings the formations are as much as 200 feet higher on the north than on the south side of the river, whereas at Nininger, which is three miles to the northwest, they are higher south of the river. There are probably other local variations in the structures, unknown because of the lack of exposures.

[5] *Geology of Minnesota* (Final Report of the Geological and Natural History Survey of Minnesota), 2:71.

[6] "Upper Mississippi Valley Structure," *Bulletin of the Geological Society of America*, 45:524 (1934).

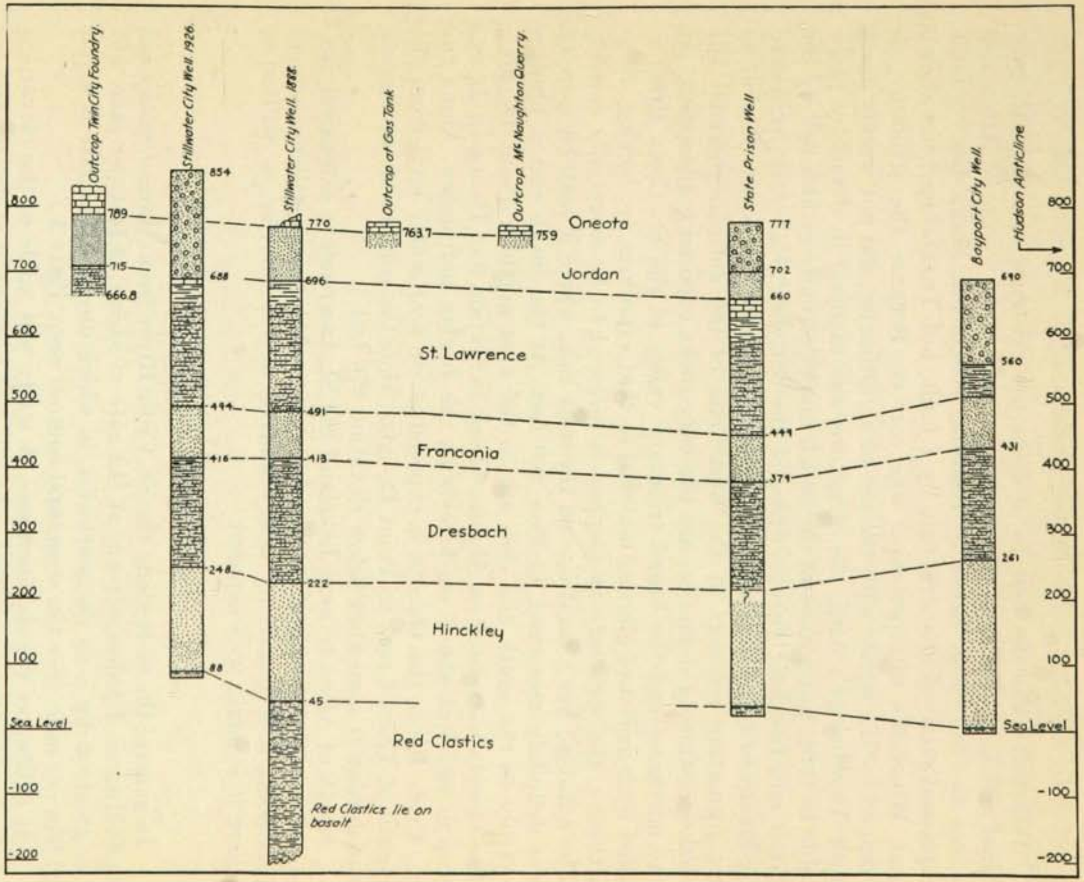

FIGURE 37. — Cross section through Stillwater and Bayport showing correlation of wells and outcrops. (Horizontal scale; 1 inch equals .72 miles.)

Afton Anticline

Winchell[7] was the first to describe the existence of a definite anticlinal axis in Afton township, trending through the village of Afton and across the St. Croix River to Hudson, Wisconsin. Many later writers explained some of this structure by a fault, but Trowbridge[8] has shown that Winchell's interpretation was correct. Because the structure, as mapped by the writer with the use of an altimeter, did not wholly agree with Trowbridge's data, the structure was mapped in detail by plane table in 1934, using some of the bench marks recently established by the Coast and Geodetic Survey. Some of the outlying areas were rechecked by means of the altimeter in 1935. (See Figure 36.) It is not possible to get formation contacts at the south end of the anticline because the Shakopee-Oneota dolomites are the only rocks exposed for mapping. At the northeast end the broad tributary valley of the St. Croix River is filled with drift and alluvial material so that exposures are lacking. Nevertheless, the structure as mapped is believed to be essentially correct. The anticline has a total rise on the west side, where it may be more or less definitely measured, of over 300 feet. At the south end it plunges sharply to the south and dies out in the area north of Point Douglas. The Oneota is exposed on Abilone Creek in Section 9 of Denmark Township at 827 feet above sea level with the Jordan not shown. Along the St. Croix River the Oneota is exposed at or near water level from the mouth of Trout Creek to Point Douglas; thus the contact of the Oneota and Jordan is somewhat below elevation 670 feet.

North of Afton to near Lakeland the St. Lawrence is extensively exposed near the river and locally along some of the creek valleys; beyond this point it is buried by heavy alluvial deposits as far as Stillwater, where it is again well exposed.

Structure at Stillwater

In general the beds along the St. Croix River from Marine southward to Stillwater dip downstream at the rate of about 15 feet per mile, but the greatest dip is to the southwest, in which direction the rate is about 20 feet per mile. (See the structural contour map, Plate 5.)

At Stillwater the dip increases. A study was made of the elevations of the Jordan-Oneota contact, which is well exposed in Stillwater and for about five miles north. The dip from Boom Hollow in Section 14, one and one-half miles north of the city limits, to McNaughton's quarry near the south city limits of Stillwater is 24 feet per mile. South of Stillwater, near the State Prison well, the dip is reversed and the beds in the city well at Bayport are higher than those in the prison well, indicating that

[7] *Geology of Minnesota* (Final Report of the Geological and Natural History Survey of Minnesota), 2:383.

[8] "Upper Mississippi Valley Structure," *Bulletin of the Geological Society of America*, 45:521 (1934).

the city well is on the flank of the Hudson-Afton anticline as mapped by Trowbridge.[9] (See Figure 37.) The beds continue to rise on the Minnesota side of the St. Croix as far as the axis of the Afton anticline, a mile north of the village of Afton.

Summary

The origin of the structures described above is uncertain. The main Twin City basin may be partly due to the settling of the thick series of sediments; that this is not the sole explanation, however, is indicated by the fact that the greatest thickness of sediments is at Sillwater, on the side of the basin. It is probable that earth movements were responsible for the greater part of the deformation.

[9] *Ibid.*, p. 519.

CHAPTER V

ECONOMIC GEOLOGY OF THE MINNEAPOLIS–ST. PAUL AREA

FOUNDATION CONDITIONS

One of the important problems in any area supporting a variety of heavy structures is the character of foundation conditions. The conditions are likely to be especially variable and troublesome in a glaciated region, where the present surface bears little relation to the bedrock surface. Along certain large preglacial valleys lakes may occur, i. e., Lake of the Isles, Lake Calhoun, and Lake Harriet. Old channels of streams may have been readjusted to new valleys, and beds may have been filled to considerable depths with alluvial material, as in the Minnesota and St. Croix rivers and the Mississippi River below Fort Snelling. Thus bridges across these streams may have rock outcrops at both ends, but unconsolidated material as deep as 100 feet near the middle of the stream.

There are three important factors concerning foundation conditions in the Minneapolis–St. Paul Metropolitan Area: (1) the depth to bedrock; (2) the character of the unconsolidated material overlying the bedrock; and (3) the character of the bedrock.

Depth to Bedrock

In general, the depth to bedrock in a glaciated region cannot be determined with much certainty from surface data, though there are generalizations which may be helpful. For example, it will usually be found that areas of terminal moraine have a fairly heavy cover of glacial drift because such deposits were formed where the ice front remained stationary for a considerable length of time and consequently heaped up a great deal of material. It will also be found that a chain of lakes along a course which would logically seem to have been an old valley will usually have a thick fill.

Because of the unreliability of surface information it is necessary to depend mainly upon wells and test borings, or possibly geophysical measurements, to determine the general relations between the surface and the bedrock topography. Once data of this nature have been assembled for an area, it is possible by interpolation to predict with some accuracy the probable depth to rock at any place in or near that area. Also, when the trend of the drainage channels of preglacial time becomes known, it is possible to estimate the depth of unconsolidated material along them.

An example of the importance of foundation conditions is furnished by the history of the old Minneapolis Armory, located on Kenwood

Parkway between Bryant and Lyndale Avenues South in one of the filled preglacial valleys. The location and type of material found at the site are shown in Figure 38. Because of the soft, yielding nature of the material, especially when saturated with water, the building settled unequally; eventually, after considerable expenditure of money had failed to make it safe, it was condemned and torn down.

Dunwoody Institute, across the Parade Grounds from the old Armory, has also experienced difficulties due to its location in the buried valley. The main building settled so seriously that the archway over the entrance opened up, allowing the keystone to drop partly out of place. Some of the piling actually settled away from the building, which became as much as three inches out of plumb. The engineers retained by the Institute preserved the building by driving deep piling with hydraulic jacks and by trussing across places not reached by the piling. The archway and other settled portions were jacked back into place and there has been no further settling. The character of the material penetrated beneath the building, as reported by Mr. George Cook, is as follows: 30 feet of very soft material, 30 feet to a hard stratum, and 20 feet of very hard driving. The deepest piling went down 105 feet.

Another example of the difficulty of securing an adequate foundation is furnished by the new First National Bank Building in St. Paul. As described elsewhere, a deep preglacial valley joins the present Mississippi River channel in the area between the Union Station and Dayton's Bluff. Near this valley the Platteville limestone, and at many places much or all of the St. Peter sandstone, have been eroded away. West of Cedar Street the Platteville limestone remains, forming an excellent foundation for large buildings. To the east the limestone is gone and the St. Peter sandstone is much eroded, softened, washed out, and otherwise disturbed. The First National Building is situated at a point where the St. Peter is uncovered. Knowing this, the engineers and architects planned the building to rest on 84 piers. As shown on Figure 39, the depth to the sandstone was not over 30 feet but the upper portion of the sandstone was so soft that some of the caissons were sunk through 50 feet of soft sandstone to a depth of over 80 feet, where hard sandstone suitable for a permanent foundation was encountered. (See the cross section of Figure 39.)

It is unnecessary to describe in detail the foundation conditions in various parts of Minneapolis and St. Paul as Plates 6 and 7 show the depth to bedrock in considerable detail and the geologic map (Plate 1) shows the rock exposed beneath. In general the most favorable areas for heavy structures are those underlain by Platteville limestone or Decorah shale.

Fully as important as the character of the rock material in foundation work is the amount of water encountered. Usually this depends on the character of the material, although a great deal also depends on whether the foundation extends below the water table. (See Figure 43

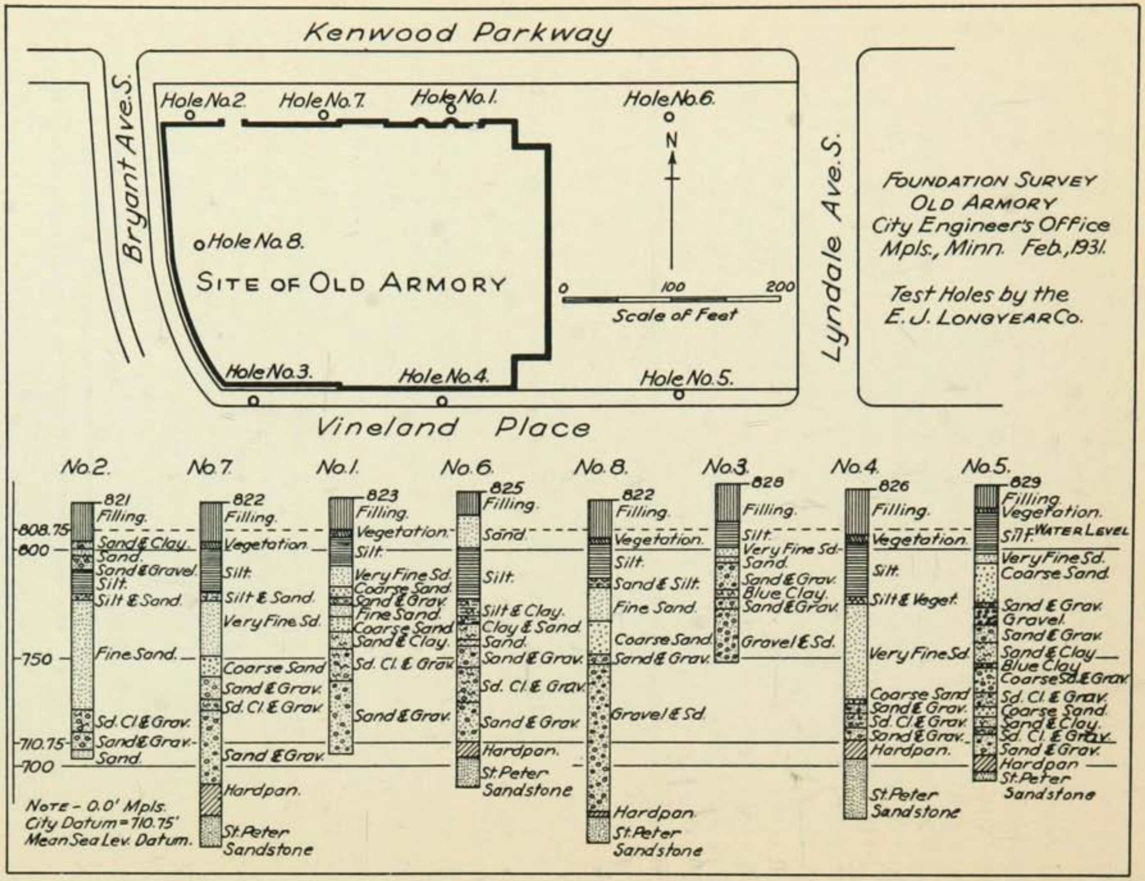

FIGURE 38. — Foundation conditions at the site of the old Armory in Minneapolis.

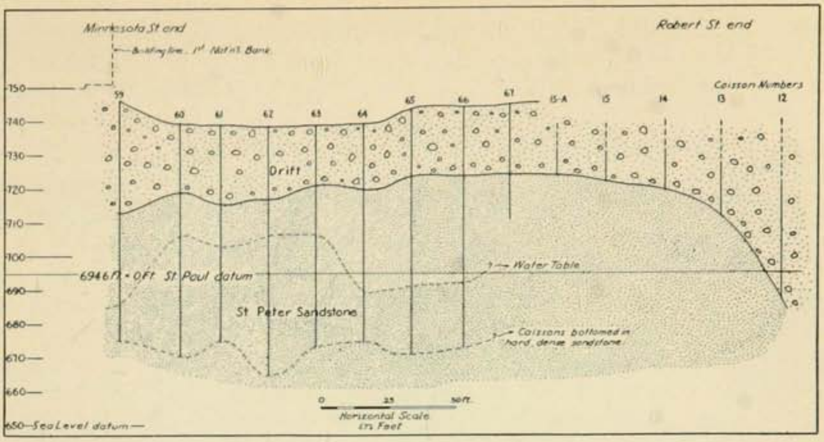

FIGURE 39. — Cross section showing the foundation conditions at the First National Bank Building in St. Paul, taken on an east-west line 30 feet north of the south line of the building. View looking north.

on page 110.) Except in the most porous material only minor amounts of water may be expected above the water table. Below the water table a great deal of water will be encountered in all permeable materials and draining this means either continuous pumping or a lowering of the water table for all of the surrounding area. Since such serious difficulties with water may easily double the cost of subsurface work, careful study of water conditions should always precede actual work.

Bridge Foundations

The fact that the Metropolitan Area is cut by the prominent gorges of the Mississippi, Minnesota, and St. Croix rivers makes the foundations of its many bridges an important problem. This is especially true because many of the present valleys are filled with unconsolidated river deposits to a depth of 75 feet and more, as shown by the cross sections in Figures 26 to 31. The history of these gorges has been discussed. It need only be emphasized here that a knowledge of their origin and history gives a general idea of what may be expected in any given case. This knowledge should be the basis for the detailed testing of the site. Very detailed test records of several bridges are given in the Appendix. These include the Robert Street Bridge in St. Paul, the steel bridge over the Mississippi at Fort Snelling, the Intercity Bridge near the federal dam (see Figure 40), the old and new bridges of the Northern Pacific over the Mississippi at the University of Minnesota, the Third Avenue Bridge in Minneapolis, State Highway bridges at Anoka and Shakopee, and the Soo Line High Bridge over the St. Croix. (See Figures 20, 26, 27, 28, 29, and 31.)

Two types of foundation may be used. One consists of piers that pass through the unconsolidated material and rest on solid rock, i. e., the Mendota Bridge. The second type, more suitable for smaller and lighter

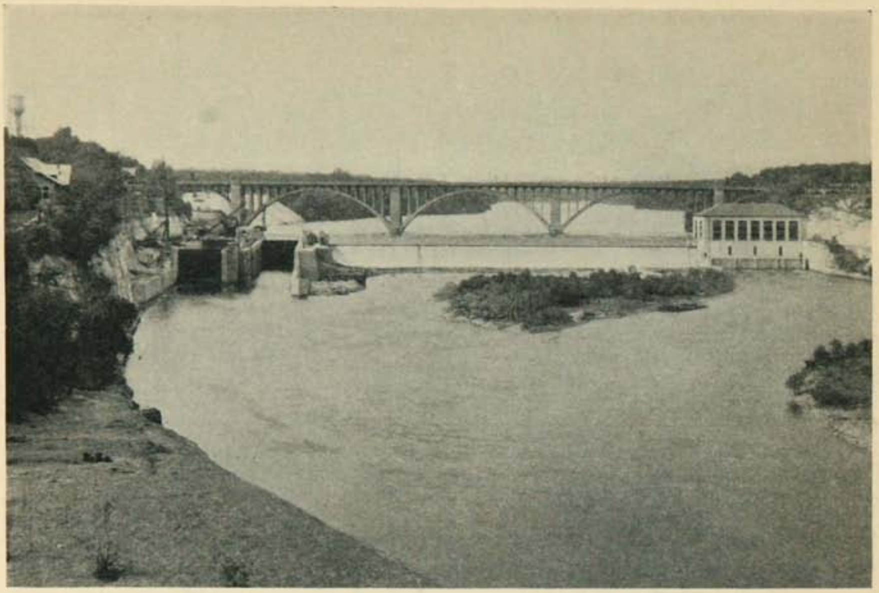

FIGURE 40. — Twin City Lock and Dam and Intercity Bridge over the Mississippi River. Photograph by U. S. Engineers.

bridges, consists of spread foundations which bear the weight because of the great surface covered, supported if necessary by pilings driven before the concrete of the piers is poured.

CONDITIONS AFFECTING TUNNELLING

The softness of the St. Peter sandstone plus its ability to stand without support has resulted in its being much used in Minneapolis and St. Paul for sewer, telephone, power, and heat tunnels, as well as caves excavated for various purposes. As a rule, the upper portion of the sandstone near the river bluffs, where it is relatively free from water, has proven most satisfactory. For the most part this portion of the sandstone may be easily shovelled out, little work being required to loosen it. Somewhat farther down, for example, near river level at the lower end of the government locks, there is a much harder bed. Similar beds were encountered in the main trunk sewer beneath Dayton's Bluff in St. Paul. In foundations for the bridge over the Mississippi near the Ford Plant, and also in the foundation for the sewage disposal plant on Pig's Eye Island below St. Paul, the silt horizon of the St. Peter was encountered. This silt horizon below the Mississippi River near Fort Snelling is found to extend from 35 to 65 feet above the base of the St. Peter, and would, therefore, not be encountered in tunnels.

As a rule, the St. Peter sandstone will be found most favorable for tunnelling where the Platteville limestone still exists above it as a protective cover. Where the limestone has been removed by erosion, the sandstone has yielded easily to the destructive forces and may be disturbed some distance below the surface, as at the First National Bank Building in St. Paul. Where attacked by running water sandstone will erode rapidly, even under the cover of limestone, and result in a cave. Carver's Cave beneath Dayton's Bluff in St. Paul is a probable example of the mechanical formation of a sandstone cave. Soper[1] refers to a cave half a block long at Second Avenue between Fourth and Fifth Streets in Minneapolis. Mr. Carl Ilstrup[2] informed the writer that this may have been formed by water escaping from an abandoned artesian well and washing the sand into the sewer. To prevent further erosion the cave was walled up. Several caves and open water courses in sandstone were encountered in the trunk sewers of the disposal project now under way. The most extensive caves are found near present or preglacial river gorges. An earlier example of the easy erosion of sandstone was furnished by St. Anthony Falls, where the water broke through the thin layer of limestone above the falls and rapidly washed out the sandstone beneath, causing a considerable section to collapse. Breaks occurred in 1871, 1873, and 1875, according to Farquhar,[3] who gives an account of some of the difficulties in remedying the breaks. A cut-off wall was constructed across the river beneath the limestone to prevent water from flowing through the sandstone and eroding it; the breaks were then filled in and a concrete apron constructed over much of the bed of the river. No difficulty has developed for many years.

The preglacial channels, which have been discussed above and which are shown on large scale maps of both cities (Plates 6 and 7), are of considerable importance in tunnel work since the material that fills these gorges is likely to contain blocks of limestone and glacial boulders and also to carry much water, especially if sand or gravel is encountered. The maps depend for their accuracy on the number of observations available. In general it may be expected that tributary valleys will enter the main valleys at intervals; to locate these exploration is necessary.

WATER RESOURCES

Precipitation and Climate

Water is so important in most of the activities of mankind that a detailed consideration of its occurrence, especially of the fundamental geologic factors involved, is an important branch of geology. In most of Minnesota an abundance of water was taken for granted until the period of deficient rainfall, which began in 1920 and, with the exception of 1924

[1] "Pre-glacial River Valleys of Minneapolis," *Journal of Geology*, 23:451 (1915).

[2] Personal communication.

[3] "Preservation of the Falls of St. Anthony," Appendix J, Annual Report of the Chief of Engineers for 1875.

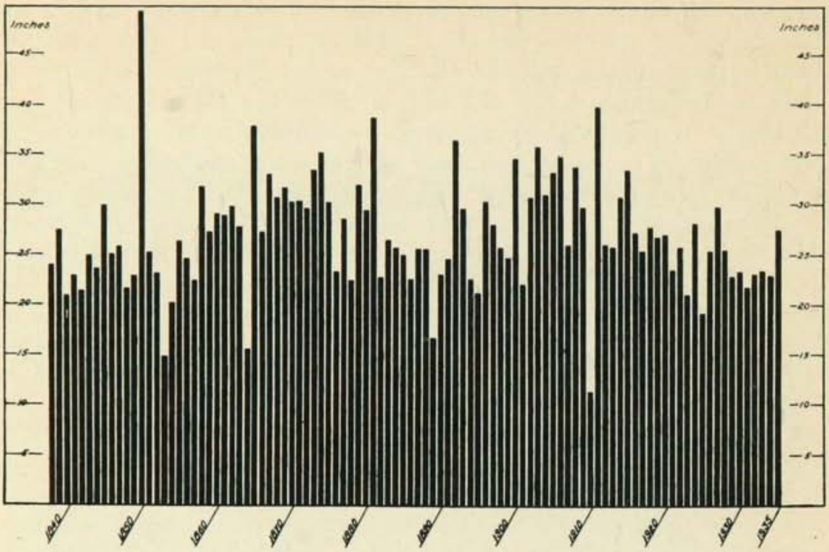

FIGURE 41. — Annual precipitation in the Twin City area from 1837–1935.

and 1927, continued to 1935, which year had about a normal fall. This drouth and its accompanying phenomena have served to focus the attention of even city inhabitants on the importance of a normal supply of atmospheric water and its conservation for the maintenance of ground water and lake levels as well as the production of full crops. Discussion of a more satisfactory domestic water supply for Minneapolis has also served to stimulate the interest of its citizens in the problems involved in such a supply. Because of its importance in connection with problems of water resources a few facts on the climate should be noted.

The climate of Minnesota is much like that of the other northern states of the Middle West. It has the extremes of temperature and moderate rainfall common to inland areas. The mean annual temperature of the Metropolitan Area is given by Purssell[4] as 44°. The lowest recorded temperature for the area is −41° and the highest is 106°. The average date of the last killing frost in the spring varies from April 30 to May 10 for certain parts of the area. The average date of the first killing frost in the fall varies from September 30 to October 5 for different parts of the region. The average annual precipitation also varies somewhat over the region, but 28 inches is a fair average. The accompanying graph (Figure 41) shows the precipitation in Minneapolis and St. Paul from 1837 to 1935.

A concise but fairly complete summary of the climate of Minnesota is given in the chapter by Purssell referred to above.

[4] U. G. Purssell. Chapter 2 in *Surface Formations of the South Half of Minnesota* (Minnesota Geological Survey Bulletin 14, 1919).

Surface Waters

The discussion of surface waters involves mainly a consideration of rivers and lakes. But since the problems of surface waters are intimately connected with those of subsurface waters they must be discussed more or less together.

Rivers.—The three major streams of this region, the Mississippi, Minnesota, and St. Croix rivers, receive the bulk of their flow from headwaters far removed from the area described in this report; therefore, the source of the waters will not be discussed here. Detailed data on all three streams will be found in various Water Supply papers issued by the United States Geological Survey, especially that numbered 193, *The Quality of Surface Waters in Minnesota.* The discharge of the Mississippi and St. Croix rivers is shown by the following tabulations taken from Water Supply Paper 745,[5] which should be referred to for detailed measurements of stream flow. The data for the Minnesota River are not available below Mankato, but approximate figures may be obtained by comparing the figures for the Mississippi at St. Paul with those taken at the Coon Creek Dam near Anoka.

St. Croix River at the power plant near St. Croix Falls. Record 1910–33.
Drainage area: 5,930 square miles.
Maximum mean daily discharge for 1933 (May 4): 7,060 second feet.
Minimum mean daily discharge for 1933 (December 11): 375 second feet.
Maximum daily discharge since 1910: 35,800 second feet.
Average daily discharge for 23 years: 3,200 second feet.

Mississippi River half a mile below Coon Creek. Record 1931–33.
Drainage area: 19,100 square miles.
Maximum discharge for 1933 (June 5): 12,500 second feet.
Minimum discharge for 1933 (September 8): 830 second feet.

Mississippi River at St. Paul. Record 1887–1933.
Drainage area: 36,800 square miles.
Maximum mean daily discharge for 1933 (April 6): 14,400 second feet.
Minimum mean daily discharge for 1933 (August 31): 1,020 second feet.
Maximum daily discharge since 1887: 80,800 second feet.
Average daily discharge for 41 years: 9,390 second feet.

Mississippi River at Prescott, 200 feet below the mouth of the St. Croix River. Record 1928–33.
Drainage area: 45,000 square miles.
Maximum daily discharge for 1933 (April 7): 19,800 second feet.
Minimum daily discharge for 1933 (September 1): 2,520 second feet.
Maximum daily discharge since 1928: 49,600 second feet.

The percentage of total solids in surface waters of the area is indicated by the following table:

[5] *Hudson Bay and Upper Mississippi Basins, 1935* (Surface Water Supplies of the United States, 1933, Part 5), pp. 77–79 and 105.

	1	*2*	*3*
CO_3	48.03	31.59	58.81
SO_4	9.35	31.26	.....
Cl	.83	1.02	.72
NO_3	.73	.43	.....
PO_4	.....	.....	.....
Ca	20.77	17.81	25.52
Mg	7.27	7.61	7.23
Na	5.19	4.12	1.03
K		1.15	2.32
SiO_2	7.78	4.99	4.37
Al_2O_3	.....	.....	.....
Fe_2O_3	.05	.02	.....
Mn_3O_4	.....	.....	.....
Total	100.00	100.00	100.00
Salinity (in parts per million)	200	460	110

1. Mississippi River at Minneapolis, Minnesota. Average of 35 samples formed by ten daily collections between September 10, 1906, and September 11, 1907.
2. Minnesota River at Shakopee, Minnesota. Mean analyses of 30 composite samples taken between September 24, 1906, and October 1, 1907.
3. Lake Minnetonka. *Geology of Minnesota* (Final Report of the Geological and Natural History Survey of Minnesota), 2:311.

The hardness of Mississippi River water used by the city of Minneapolis is indicated by the following data taken from the report of the Water Commission for 1932.

	Total Solids	*Soap Hardness*	*Iron*
Average	210	166	0.07 parts per million
Maximum	240	201	0.10 parts per million
Minimum	182	136	0.04 parts per million

This hardness is high for a river in a region of moderate rainfall and is doubtless due to the abundant lime in the glacial drift which covers the entire drainage area. The gray drifts are fairly high in calcium carbonate but do not always furnish as much lime as the red drift, because of the greater ease of circulation in the latter. This problem has been discussed in detail by Thiel[6] in connection with the origin of the marl deposits of Minnesota.

The courses of the rivers of Minnesota were not determined by normal stream development but owe their characteristics to the effects of glaciation. The valleys of the main streams are many times normal size

[6] Stauffer and Thiel. *The Limestones and Marls of Minnesota* (Minnesota Geological Survey Bulletin 23), pp. 92–101.

for the streams which now occupy them and they have very few tributaries. Much of the area has no direct connection with the streams by surface means but drains by percolation through the relatively porous drift. Surface run-off is very slight in the area, many of the small streams being fed by springs. With the falling water table many springs have disappeared and the streams have become intermittent. Creeks which were once good trout streams are now entirely dry in summer.

Lakes.— In common with most of Minnesota, the Metropolitan Area has numerous lakes, of which Minnetonka is by far the largest; other large lakes are White Bear, Bald Eagle, Forest, Marine, Medicine, and Independence. Most of the lakes are glacial in origin and occupy depressions in the surface of the drift. Others are related to the larger rivers of the area.

A glance at the map (Plate 1) will show that the lakes of the Metropolitan Area are far from equally distributed. This is not an accident, but a result of well-defined differences in the geology of the different parts, more particularly the glacial geology. Different kinds of lakes may be classified on the basis of their origin as follows:

Basins formed by glacial action
1. Irregular deposition of glacial drift
2. Partial filling of preglacial valleys
3. Basins formed by glacial outwash

Basins formed by the action of streams
1. Flood plain lakes
2. Alluvial dams

Most of the lakes in this region fall in the first class — basins formed by irregular deposition of glacial drift. A study of Plate 4 will reveal that the greater number of these are in the moraine areas. This is because the moraines represent a great heaping of glacial debris, which usually results in an uneven topography. A given depression without a surface outlet will have a lake under one of two possible conditions: either the depression must be underlain by an impervious clay, or the bottom of the depression must be below the ground-water table of the region. A good example of the latter type is Lake Minnetonka. Examples of the former type are to be found among the small lakes in the high terminal moraine area in northwestern Dakota County. These lakes are supplied from underground sources as well as by direct rainfall and surface run-in. It is noteworthy that no permanent stream enters many of the lakes; also many of them have no outlets but are controlled entirely by percolation and atmospheric precipitation and evaporation.

Outwash basins are depressions in the sheet of clay, sand, and gravel spread out in front of the ice by water from the melting glacier. Lakes of this type are commonly shallow and may cover extensive areas.

Preglacial valleys were so deep at some places that they were not completely filled; or, if filled, the unconsolidated glacial debris settled, leaving a chain-like series of lakes. A good example is the Minneapolis chain reaching from Lake of the Isles to Lake Harriet and the much longer series extending from Clear Lake, west of the town of Forest Lake, to Phalen Lake in St. Paul. (See Figure 23.) These preglacial valleys are well shown in Minneapolis and St. Paul by the rock surface contour maps (Plates 6 and 7).

Of the lakes formed by stream action, flood plain lakes are the most common. Most of them represent channels abandoned by a meandering stream. Where the stream meanders extensively, as does the lower Mississippi River, the lakes are often shaped like an oxbow. In the Metropolitan Area most of the channels were nearly straight and left long narrow lakes. Good examples are Pickerel Lake, near Cherokee Heights in St. Paul, and Spring Lake, near Pine Bend.

A special type of flood plain lake includes the so-called saucer lakes found along the Minnesota River between Savage and Shakopee. These are more or less round depressions in the flood plain, which are prevented from draining into the river by natural levees built along the present channel of the river. Lake St. Croix, as the river is often called from Stillwater to Point Douglas, is caused by sediment deposited across the mouth of the St. Croix River by the Mississippi River. (See the Frontispiece.)

Perhaps the most important problem regarding the lakes of the area is one of maintaining suitable levels. The subnormal rainfall since 1922, as shown on Figure 41, has been accompanied by an alarming decline in the level of almost every lake in the region. This situation has led to much discussion of causes and possible remedies. Necessary to a proper understanding of the problem is a knowledge of the fundamental conditions which control the fluctuation of lakes. In the first place, it must be understood that a lake is not a permanent feature. Natural processes destroy lakes ultimately, though fortunately their life span is commonly of considerable length.

If the lakes of this area are classified according to the conditions which determine their water level, we find that there are at least three distinct types: (1) lakes whose levels coincide with the ground-water table; (2) lakes perched above the regional water table; (3) lakes determined by stream levels. The last class includes most of the lakes along the principal rivers; they need no discussion as their levels are in most cases determined by the river level.

The character of the lakes and river in the Mississippi Valley from St. Paul to Hastings has been entirely changed by the Hastings Dam. This backwater effect is also felt along the Minnesota River, nearly to Shakopee. The projected dam above Red Wing will also modify the level of Lake St. Croix.

By far the greater number of lakes in the Metropolitan Area, also in the rest of Minnesota, belong to the first class listed above. Therefore, any factor that causes fluctuation of the ground-water level will cause a similar change in the lake levels dependent upon it. (These factors are discussed in the section on underground waters below.) It is necessary to consider not only the level of a lake itself but the entire problem of water levels, for it is obvious that if a lake is artificially raised above the water table it will at once allow seepage into adjacent ground and much more water will be needed to maintain the level than the amount calculated to fill the basin. It is equally useless to try to maintain the lake levels by pumping from shallow wells that draw their water from the regional ground water. Serious depression of both ground-water and lake levels resulted some years ago from attempts of the St. Paul Water Department to augment the city supply by pumping from drift wells at Lake Vadnais and elsewhere in Ramsey and Anoka counties.

Ramsey County has for several years used deep artesian wells to help maintain the levels of the important lakes north of St. Paul. Figure 42 shows diagrammatically the logs of these and other wells in the county. It is clear that the water is obtained from the Jordan sandstone and deeper horizons. The important point here is that the porous sandstones from which the water is derived are largely covered by Oneota and Shakopee dolomites, which doubtless keep surface circulation from replacing the water removed from the artesian beds and account for the success experienced in maintaining these lakes well above the level to which they would have sunk if left unaided.

At Lake Minnetonka, however, conditions are somewhat different, as shown by the cross sections on Plate 2. At the east end of the lake the Shakopee and Oneota dolomites cover the Jordan sandstone, but to the west this covering has been eroded and near the west end of the lake even the Jordan sandstone has been removed. It is thus probable that the Jordan sandstone receives water from the drift beneath Lake Minnetonka. If the drift is permeable, pumping from the sandstone would immediately tend to decrease the lake level by increasing percolation.

Lakes perched above the water table retain their levels by virtue of a bottom of relatively impervious clay, which prevents much percolation from the lake into the ground water. These lakes are likely to be subject to considerable fluctuations in level since their source of supply is local and flood or drouth quickly affects them. In this type dredging or ditching often causes a serious drop in level by breaking the seal of clay. Many of these lakes are surrounded by a local perched ground-water table which fluctuates in unison with the lakes.

Several of the lakes in Carver County south of Lake Minnetonka may belong to this type, as they maintain levels considerably above Lake Minnetonka, and also differ considerably among themselves. In this classification may also be included many of the lakes and ponds in Mendota, Egan, and Inver Grove townships of Dakota County. This relationship is shown graphically on the St. Paul topographic sheet published by the

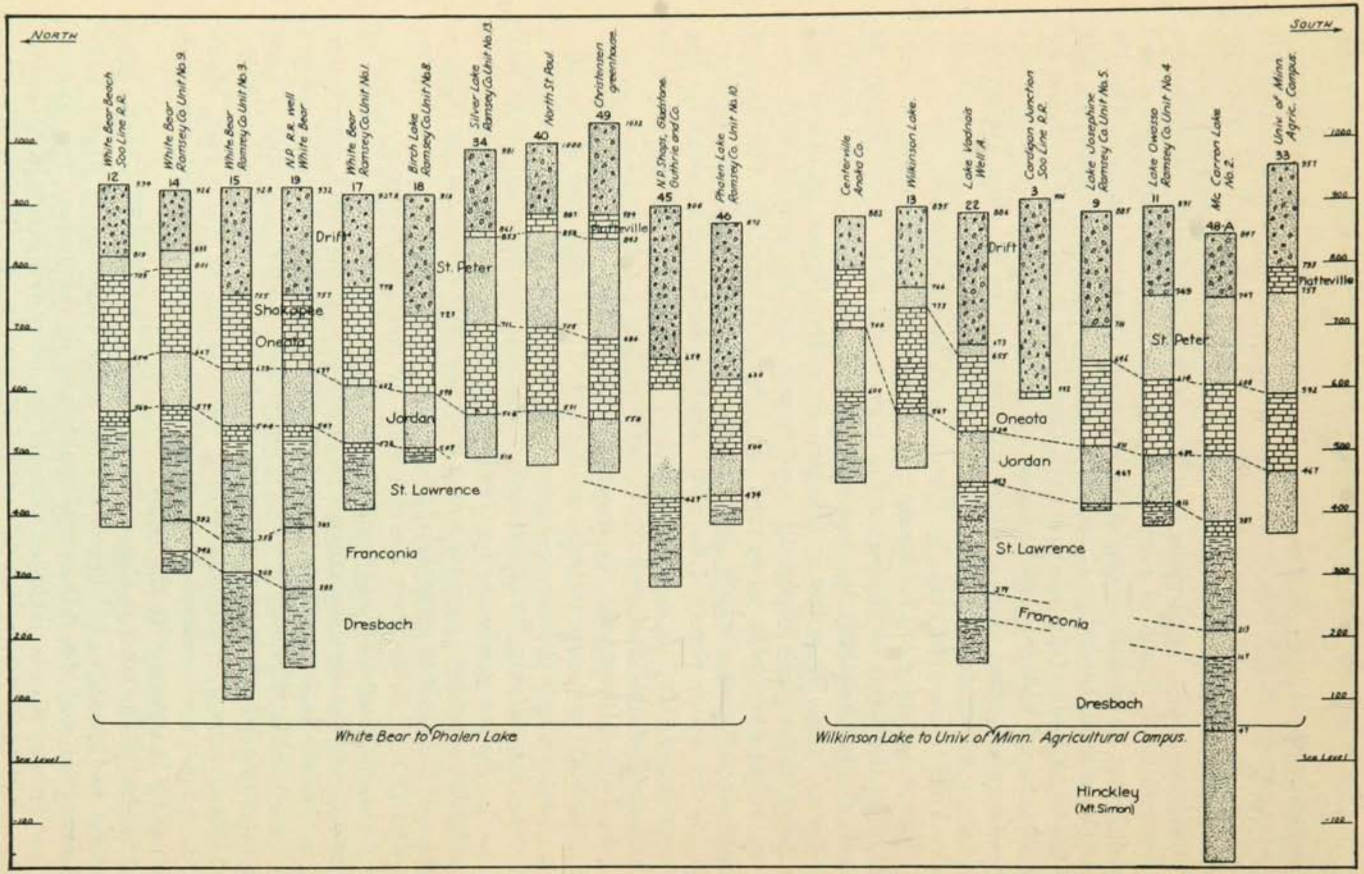

FIGURE 42. — Cross sections of deep wells in Ramsey County. Arranged from north to south.

United States Geological Survey. There is a difference of over one hundred feet in the water level of lakes lying less than three miles apart.

Generally anything which conserves water and allows it to soak into the ground rather than to run off or to be evaporated will aid lake levels. Therefore, every effort should be made to retain water in swamps, marshes, and ponds and to discourage draining them by ditches. Where ditches are in existence it would be helpful to put in temporary dams to prevent runoff and aid percolation. Keeping the soil covered with vegetation will prevent erosion and also serve as a sponge to retain rainfall; therefore, burning of grass and other vegetation in the fall and spring should by all means be avoided. Artificial filling of lakes by pumping or diversion channels may be of some help but in the long run most of our lakes must be preserved by conservation of rainfall, which will in all probability show an increase after the abnormally low average since 1920.

Underground Waters

The water which reaches the earth as rain or snow is disposed of through absorption by soil and rock, by direct runoff into streams, and by evaporation into the atmosphere. The proportion which is disposed of in each way varies greatly with physiographic, atmospheric, and other conditions. Of the water absorbed by the ground some is held in porous soil but much moves downward into the deeper layers of the earth. If the percolation is abundant this water will saturate a zone in the bedrock and overlying unconsolidated deposits. The upper surface of this saturated zone is known as the water table. The depth of the water table below the surface varies greatly, depending on subsurface conditions. It is usually at higher elevations beneath hills, but farther from the surface than in lower areas, where its emergence at the surface may be marked by springs, streams, lakes, or swamps. (See Figure 43.) The ground-water table is subject to fluctuation from many causes, either natural or artificial. In a well-settled region both causes are effective. The most common are as follows:

Natural
1. Variation in rainfall
2. Floods along streams
3. Atmospheric variations in temperature, humidity, and wind

Artificial
1. Wells
2. Dams and reservoirs
3. Drainage ditches
4. Irrigation
5. Mines, tunnels, or other underground works
6. Changing vegetation, for example, removal of forest

Ground waters important in developing wells are usually separated into two types: first, the water that occurs in the ordinary glacial drift

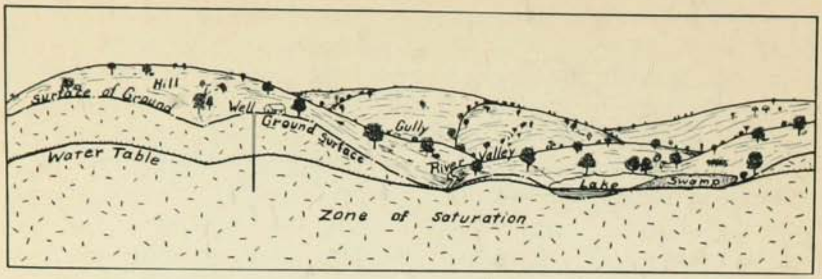

FIGURE 43. — Diagram showing the relation of the water table to the surface of the ground, and to stream, lake, and swamp.

and other unconsolidated deposits, the upper surface of which is known as the water table (see Figure 43); second, artesian water, which is found in the porous rocks, especially sandstones, under pressure from overlying, relatively impervious rocks. When tapped by a well, this water rises to certain heights above the porous source, depending on the pressure. (See Figure 44.)

Water occurring in the glacial drift. — The heavy mantle of glacial drift found over much of the Metropolitan region — reaching extremes of 400 feet near Westcott, south of St. Paul, and 480 feet at the west end of Lake Minnetonka — furnishes abundant water wherever it contains porous gravel and sandy lenses. Where the drift is mainly clay, as near Westcott, it is necessary to sink wells to considerable depths (as much as 400 feet) to obtain water supplies sufficient for an average farm. Fortunately, gravel beds are found at reasonable depths over most of the area to furnish abundant water. A number of records of deeper drift wells are included in the Appendix tabulations. Where the glacial drift is thin or composed mainly of clay, it is usually necessary to penetrate the solid rock to obtain sufficient supplies of water. This is especially true in the southern half of Washington County. Porous sandstones usually furnish the most dependable supplies, but crevices in the limestones and dolomites may furnish an abundance of water if the driller is fortunate enough to strike one of them. The water from dolomite is always very hard.

Great care is needed in the use of springs and shallow wells to avoid pollution. This is especially true when times of drought lower the original water table so that new seepage may be introduced. Not only should wells be placed so as not to receive drainage from buildings or cess pools, but they should be so constructed that water will not drain back in when pumped. A very significant paper was published in 1909 by the United States Department of Agriculture (*Farm Water Supplies of Minnesota*, by K. F. Kellerman and H. A. Whittaker), showing typical examples of water supplies with suggestions for improvement.

Artesian water. — Artesian wells furnish by far the greater amount of underground water used in the region. It is estimated that there are over six hundred artesian wells in the Metropolitan Area. The logs of many of them are given in the Appendix. Data regarding a great number, especially in Minneapolis, may be found in the Report of the Water Supply Commission to the City Council of Minneapolis, June, 1932. It would be difficult to estimate the value of this artesian supply to the area, but certainly it is many millions of dollars. Artesian water is defined as ground water that is under sufficient pressure to rise above the zone of saturation. Artesian wells may be flowing or non-flowing, depending on the elevation of the well. Most of the artesian wells in this area are non-flowing, but a few, especially along the valleys of the three main rivers, are flowing. They derive their waters from the same source as those in the remainder of the area but usually have a much lower surface elevation. The most important flowing well in the area is the Stillwater deep well, which has supplied the city water system for many years.

Artesian water depends upon several well-defined and relatively simple factors: (1) an adequate source of water supply; (2) a porous formation to conduct and store the water, called an aquifer; (3) an impervious bed to retain the water in the pervious bed; and (4) a source of pressure, that is, an aquifer exposed at the surface or beneath the drift at points higher than those where the pressure exists. Figure 44 illustrates these factors. A study of the maps and cross sections accompanying this report, especially Plates 1 to 3, reveals that these conditions are fulfilled in the Metropolitan Area. Hence the area is said to be an artesian basin; its rocks form a basin-shaped depression with Minneapolis and St. Paul at the center.

More specifically the source of artesian water is the rainfall and ground water that flow into the permeable beds where they are exposed

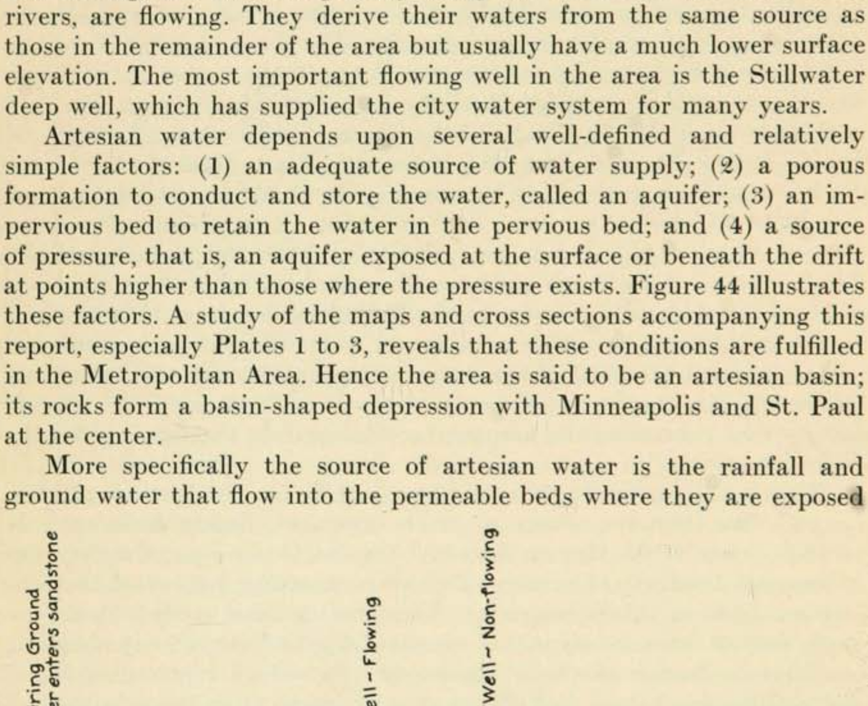

FIGURE 44.—Diagram of an artesian basin, showing the source of the water and the conditions necessary for flowing and non-flowing wells.

around the margin of the basin. Beds so exposed within the Metropolitan Area are shown on Plate 1. Deeper beds are exposed outside the area mapped; their general distribution is shown on the geologic map of Minnesota (1932) and other published maps. The porous formations which furnish the bulk of the water are shown in the table of formations on page 22. They are, from the top down, St. Peter sandstone, Jordan sandstone, Franconia sandstone, Dresbach formation, and Hinckley (Mt. Simon) sandstone. Of these the Jordan sandstone is by far the most important because it has a relatively high porosity and permeability and underlies nearly the entire area at not too great a depth.

The relatively impervious beds which serve to hold in the water and maintain the pressure are: Platteville limestone, Shakopee and Oneota dolomites, and the St. Lawrence formation. The pressure results from the fact that all the formations of the area dip in to the center of the basin, which is located approximately at the boundary line between St. Paul and Minneapolis, in the vicinity of the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge across the Mississippi River. Here the top of the Jordan sandstone occurs at an elevation of about 450 feet above sea level (see Plate 5), whereas at places in Washington County, especially southwest of Afton, it is found at an elevation of 1,000 feet above sea level. The low point of the rim is on the south side of the basin at an elevation of about 725 feet. The pressure in the Jordan sandstone at the low point would thus be equivalent to a column of water 275 feet high minus the large loss due to friction of the water in passing through the sandstone. Obviously the supply of artesian water will be limited by the specific factors that determine the amount percolating into the openings of the rock formations.

Whether the local supply would be adequate for the demands of Minneapolis has been the source of much argument, dating back at least to 1889, when C. N. Hewitt discussed the matter in a paper before the Minnesota Academy of Science. This and succeeding papers on the subject are cited in the bibliography. The most detailed studies have generally led to the conclusion that artesian supplies would be inadequate, but this conclusion has been vigorously opposed by representatives of well drilling companies and others. Any estimate as to the adequacy of wells should be made with reference to their proposed depth. Wells 500 feet deep will penetrate the Jordan sandstone, except where the surface is high. To utilize the Franconia sandstone also requires an additional 250 feet of drilling, the Dresbach 150 feet more, and the Hinckley 220 feet more, the whole series involving a depth of about 1000 feet. Few tests have been made of the amounts of water available in the various individual formations, most wells being open from the top of the Shakopee dolomite down and drawing water from all formations.

It seems fairly obvious that the demands now made on the Jordan sandstone are very heavy in view of the relatively restricted area of exposure tributary to the basin. It is certain that the Jordan is unable to draw water from the east beyond the St. Croix River. South of Afton to Point Douglas any possible transfer of water from east to west is prevented by the Afton anticline. (See Figure 36.) From Afton north almost to Marine the Jordan outcrops above river level. From Marine west the Jordan appears to occur beneath the drift in a broad curve to the west end of Lake Minnetonka, thence south to the Minnesota River. Throughout this extent the Jordan is presumably open to water from the drift. In view of the general low water conditions in recent years it does not seem that contributions from the surface could be very great. From Chaska to the town of Jordan the sandstone is exposed along the Minnesota Valley and here it doubtless receives large amounts of water. In the vicinity of Belle Plaine the dip is reversed and the water is carried southward. Below Chaska and Shakopee the Jordan is exposed only near the Minnesota Valley and from there across the preglacial valley from Prescott to Big Bend and Hastings. Only along this limited exposure, mainly beneath the drift, can water enter it, since farther south it is covered by other formations, and south of Farmington a reverse dip to the south prevents flow from that direction.

The actual exposed area of the Jordan, that is, places where water may enter it to supply the Twin City basin (see Plate 1) is much like that shown in the report of the Minneapolis Water Commission of 1932. This area is approximately 400 square miles. With an assumed percolation of 2 inches a year, this would mean about 14 billion gallons annually available to the entire Metropolitan Area. Some water unquestionably works its way down to the Jordan through the Shakopee and Oneota dolomites, but hardly more than a small percentage of the water available from percolation. At most places where the Shakopee and Oneota are exposed they are relatively solid and obviously would not allow a large circulation of water vertically. That some transfer does take place is shown by the high hardness of water from the Jordan beds. The problems involved in estimating the quantity of water available are discussed in detail in the report of the Minneapolis Water Commission of 1932 and the supplements that follow the main report. Some revision in the statements of these various reports is necessary in view of the fundamental geologic factors described in this bulletin.

There has been much discussion regarding test wells in connection with the Minneapolis and Lake Minnetonka supplies. There seems to be considerable misconception as to what a test well will prove. In the first place it will not prove the adequacy of supply except for that one well. Because one pump delivers a given amount of water from a tank it should not be concluded that a dozen pumps will each deliver as much as that one from the same tank. Neither should it be concluded that because one or more wells can deliver a certain amount of water ten or twenty wells will deliver ten or twenty times as much for an in-definite period. They might do so for a time, but unless the water is replenished by percolation at a rate at least equal to consumption there will eventually be exhaustion. Artesian basins elsewhere have been seriously depleted within a few years by excessive pumping.

The composition of ground water, including artesian waters, is very important in considering its use for domestic and commercial purposes. The analyses for this area follow. They have been selected to show the range of composition rather than the average.

ANALYSIS OF UNDERGROUND WATER IN THE METROPOLITAN AREA [7]
(In parts per million.)

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Silica (SiO_2)	8.8		22		12	13	20		17	1.4	17	15
Iron (Fe) . . .	12			24			4.9		3.4	2.3	0.9	1.7
Calcium (Ca)	65	69	87	49	98	49	72	44	84	64	59	58
Magnesium (Mg)	18	32	27	23	39	26	29	20	31	15	23	22
Sodium and potassium (N and K)	31	9.7	7.5	4.4	5.8	16	1.8	8.3	5.7	0.8	8	8
Bicarbonate radicle (HCO_3) . .	264	387	337	222	414	244	370	226	453	270	294	306
Sulphate radicle (SO_4)	20	66	44	13	94	45	. . .	25	2	2.4	. . .	. . .
Chlorine (Cl)	48	21	68	5.3	65	12	2.8	1.5	2	0.5	1.6	1.3
Total solids	332	310	354	263	580	288	314	215	375	228	254	257

1. Minnesota Potato Starch Co. well, Anoka, December 6, 1907. (Page 132.)
2. Chanhassen, August 14, 1902. (Page 151.)
3. Chicago, Milwaukee, St. Paul, and Pacific Railroad well at Farmington, November 1906. Drift. (Page 168.)
4. Swift and Co. well at South St. Paul. Jordan sandstone. (Page 167.)
5. Chicago, St. Paul, Minneapolis, and Omaha Railway well at Mendota, April, 1901. Dresbach formation. (Page 169.)
6. City well at Hastings, November, 1907. (Page 169.)
7. Chicago, St. Paul, Minneapolis, and Omaha Railway well, Savage. (Page 341.)
8. Chicago, Milwaukee, St. Paul, and Pacific Railroad well at Afton. Drift. (Page 368.)
9. Well at Janney, Semple, Hill, and Co., Minneapolis, 1906. (C. F. Sidener, Plate X; gives a series of 39 analyses.)
10. Foley Brothers and Kelly well, St. Paul, 1905. (Plate XIV; gives a series of 47 analyses.)
11. Well at Lake Vadnais, 1899. Drift. (Plate XIV.)
12. Artesian well at Lake Vadnais. Dresbach formation. (Plate XIV.)

[7] Page numbers refer to Hall, Meinzer, and Fuller, *Geology and Underground Waters of Southern Minnesota* (United States Geological Survey, Water Supply Paper 256), from which all data are taken.

HARDNESS OF ARTESIAN WATER FROM DIFFERENT FORMATIONS[8]

	Grains per Gallon (*1=17.1 parts per million*)
ST. PETER SANDSTONE	
Nicollet Hotel, Nicollet and Washington Aves.	22
Kemps Ice Cream Co., 7 Royalston Ave.	26
Northland Milk and Ice Cream Co., 11 W. 28th St.	30
Clover Leaf Creamery Co., 420 W. Broadway	18
Minneapolis Knitting Works, 626 Bryant Ave. N.	20
Average	23
JORDAN SANDSTONE	
Forum Cafeteria, 36 S. 7th St.	23
Young-Quinlan Co., 901 Nicollet Ave.	19.6
Plymouth Building, Hennepin Ave. and 6th St.	20
Cedar Lake Ice and Fuel Co., 402 Lyndale Ave.	21
Northwestern Bank Building, Marquette Ave. and 6th St.	24
Northland Milk Co., 1004 Glenwood Ave.	22
Land O' Lakes Creamery, 2201 Kennedy St. N. E.	17
Janney, Semple, Hill and Co., Marquette Ave. and 2nd St.	22
Northern States Power Co., Riverside Plant	21.3
Wabash Screen Door Co., 2222 Elm St. S. E.	20
Average	19
JORDAN AND DRESBACH (INCLUDES FRANCONIA SANDSTONE)	
Minneapolis Gas Light Co., 800 Hennepin Ave.	21
American Linen Co., well no. 1, 901 La Salle Ave.	20
Andrews Hotel, Hennepin Ave. and 4th St.	23.8
Municipal Auditorium, Grant and Stevens	18
Powers Mercantile Co., Nicollet Ave. and 5th St.	19.5
Dayton Company, Nicollet Ave. between 7th and 8th Sts.	20.4
First National and Soo Line Building, Marquette Ave. and 5th St.	21
McKnight Building, 2nd Ave. S. and 5th St.	20
Baker Building, 706–2nd Ave. S.	22
Cedar Lake Ice and Fuel Co., 2528 Nicollet Ave.	19
Swedish Hospital, 914 S. 8th St.	18
St. Barnabas Hospital, 901 S. 6th St.	28
Franklin Co-operative Creamery, 2108 Washington Ave. N.	20
Average	20.8
HINCKLEY SANDSTONE	
Curtis Hotel, 10th Ave. between 3rd and 4th Sts.	8 to 9
Y. W. C. A. Building, 1130 Nicollet Ave.	12 to 15
Donaldson Building, 70 S. 7th St.	12.8
Federal Reserve Bank Building, Marquette Ave. and 5th St.	8 to 10
St. Mary's Hospital, 2500 S. 6th St.	5.1
American Linen Co., well no. 2, 901 La Salle Ave.	7
Great Northern Railway, Minneapolis Junction	11
Average	8.3

[8] Data from Minneapolis Water Commission Report, 1932.

These figures should not be taken too literally, as inspection of the data on various wells suggests that the water from other beds is not always completely shut off. However, it seems clear that water from the Dresbach to the St. Peter is of about the same hardness but that that from the Hinckley contains only about one half as much in dissolved salts, or about the same amount as Mississippi River water. Another significant fact is that artesian water from the basin contains at least ten times as much iron as Mississippi River water.

The temperature of ground waters is often significant and now that large amounts of water are used for cooling purposes it is even more important. The general average temperature of soil, rock, and water at a depth of ten feet or more is usually very close to the mean annual temperature of the region, which is about 44° for Minneapolis and St. Paul. The temperature of the water issuing from Glenwood Springs in Minneapolis is said to have been between 46° and 48° for fifty years.

As the earth is penetrated, the temperature rises slowly, so that deep artesian water is usually warmer than that from shallow wells; however, artesian wells deriving their supply from the Jordan sandstone or other rocks at moderate depths show only a slight rise. The following temperatures may be considered representative.

Well	*Depth* (*in feet*)	*Main Source of Water*	*Temperature* (*Fahrenheit*)
Loring Theatre, 1405 Nicollet Ave.	100	St. Peter sandstone	49°
Ivey Candy Co., 925 Nicollet Ave.	370	St. Peter sandstone	45°
Strutwear Knitting Co., 1015 S. 6th St.	295	Shakopee dolomite and Shakopee-Oneota sandstone	46°
Coca Cola Bottling Co., 2035 University Ave. S. E.	431	Jordan sandstone	50°
Municipal Auditorium, Grant and Stevens	823	Jordan to Dresbach	47.5°
Spencer Kellogg and Sons, 25th Ave. and 4th St. S. E.	529	Jordan sandstone	53°
American Linen Co., 901 La Salle Ave.	1068	Hinckley sandstone	55°

Depth to artesian water.—The depth to the water-bearing sandstones in the Twin City artesian basin may be easily calculated from the data supplied in this report. If the well is located at or near recognizable outcrops of rock it is simply a matter of using the figures for thickness of formations as given in the table on page 22. For example, if the well is known to be located at the surface on Platteville limestone (assuming a full thickness of Platteville), it will be approximately 330 feet to the base of the Jordan sandstone. If the full thickness of the Jordan is to be drilled to insure a large supply the total depth would be 420 feet.

The above method is frequently not applicable because outcrops are not available. In that case an estimate may be made by using the structural contours shown on Plate 5. For example, if the 500-foot contour passes near the proposed location, the top of the Jordan will be approximately 500 feet above sea level. At places where the surface elevation is known approximately from contour maps or other sources, simply subtracting 500 from the surface elevation gives the approximate depth that must be drilled to reach the top of the Jordan sandstone.

Springs.—Springs are common in the Metropolitan Area along the stream valleys, more particularly those of the three main rivers. These springs are of different types, as shown by the following classification.

I. Springs in unconsolidated material
 (a) Impervious layers emerging at low points
 (b) Emergence of water table at low points
II. Springs in solid rocks
 (a) Porous rocks underlain by impervious beds
 (b) Porous rocks outcropping near stream levels
III. Springs at contact of unconsolidated material with solid rock

The areas where springs are abundant and large will be briefly described here. Smaller and isolated springs may be found at many places, although these have tended to disappear during the dry years since 1920.

Springs are common along the Mississippi River from St. Anthony Falls to Hastings. In Minneapolis and St. Paul most springs issue from the Platteville limestone, which lies in nearly horizontal layers somewhat like pavement, thus causing the water to flow laterally along the top or between the beds until it issues at the gorge. There are springs of this type still flowing in the botany greenhouse at the University of Minnesota, also at points just north of the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge on the west side of the river, and near the Lake Street Bridge. A large spring possibly of this type flows at the Twin City Brick Company plant in St. Paul. Several still flow between this point and Mendota.

Springs issuing from the St. Peter sandstone below the Platteville are less common. The largest noted issues from beneath Dayton's Bluff along the railroad track. Many are still flowing between St. Paul and Mendota.

By far the largest springs in the area are found at the base of the bluffs at Pine Bend in the region of Spring Lake, which is appropriately named. These springs are probably of three types. Some clearly issue from the contact of the drift and the Oneota dolomite, others from the fissures within the dolomite. The largest issue from the drift is at Pine Bend, where the bluffs change their trend abruptly from north-south to east-west. It is at this point that the Westcott preglacial Mississippi gorge joins the present Mississippi River, and it is therefore probable that these large springs represent the emergence of the ground-water table from this enormous mass of drift, which furnishes a large enough storage to keep the spring flowing relatively undiminished even in dry periods.

Probably similar to the Pine Bend springs are those at the fish hatch-

FIGURE 45. — "Boiling springs," Hattenberger farm, southeast of Shakopee.

ery near Dayton's Bluff. Here, too, as shown on Figure 23, a preglacial gorge joins the present Mississippi.

Springs are common along the Minnesota River valley between Fort Snelling and Shakopee. Some of the larger ones discharge immediately west of Savage on the south side of the river. Here the surface of the Shakopee-Oneota dolomite is covered by a very thin mantle of unconsolidated material; it may therefore be concluded that the large flow of water is due to accumulation in the drift immediately above the rock. The very heavy masses of drift in the bluffs to the south furnish an adequate supply for the large flow.

The so-called "boiling springs" on the Hattenberger farm, about three and one-half miles west of Savage (Sec. 18, T. 115 N., R. 21 W., Glendale Twp.), are probably of this same type. Tests indicate that the dolomite lies only 30 feet below these springs, which form a pool along a small creek valley. These springs "boil" vigorously at intervals of a few minutes. Normally the "boiling" raises the water a foot or more above the surface of the pools but the owners report that occasionally the agitation is much more violent, reaching a height of two or three feet. The water is of normal temperature and the "boiling" is merely an up-welling of water under pressure, probably due to a very fine suspended clay in the pool, which settles down and confines the water until the pressure builds up sufficiently to burst through the clay. This would also explain why the "boiling" shifts from place to place in the pool. (See Figure 45.) It is possible that the water may be supplied from fissures in the dolomite rather than from unconsolidated deposits.

On the north bank of the Minnesota River large springs issue along the tributary valleys as well as at the foot of the main bluffs. This is especially well illustrated in the lower part of Nine Mile Creek, near its emergence onto the flood plain of the Minnesota River. The many springs issuing from the sides of the creek valley keep the lower creek flowing even in the driest weather. Purgatory Creek valley is likewise the location of many springs. It is perhaps significant that its valley is well below the level of Lake Minnetonka. It has been suggested that the mouth of the creek is at about the point where the very deep preglacial valley which extends under the western portions of the lake intersects the present Minnesota Valley. Thus a great reservoir of drift supplies these springs.

The St. Croix River, like the Minnesota and Mississippi below St. Anthony Falls, has cut a deep valley, and springs are found throughout its course. It is noteworthy, however, that the portion below Stillwater, where glacial deposits are relatively thin on the upland, has few large springs and most of the creek valleys formerly fed by springs are now dry during the summer. At and above Stillwater large springs issue from the drift and from the sandstones.

Along the valley of Brown's Creek at the north side of Stillwater are many large springs issuing from glacial drift probably not far above the hard rock surface. Just north of the Stillwater city limits at the falls in Fairy Glen a line of springs issues from sandstone resting on St. Lawrence shale. Several large springs flow from sandstones of St. Lawrence formation near river level above Stillwater and similar springs are numerous as far north as Taylor's Falls.

Commercial springs.—So far as the writer knows only two springs are used commercially in the Twin City area, one in Minneapolis and one in St. Paul. The Glenwood-Inglewood Springs are located in Glenwood Park in the valley of Bassett's Creek. A blue clay overlies the water-bearing white sand bed. The pressure is doubtless derived from the nearby hills. The water utilized at present is not derived from the original spring but from pipes driven through the clay to a maximum depth of 16 feet. The water rises 16 feet above the level of Bassett's Creek; the largest spring flows 10,000 gallons an hour and has a temperature of 46° and 48°. Winchell[9] thought that much of the water rises from the St. Peter sandstone into the overlying material. This water has been used since 1883. A recent analysis is given below.[10]

	Parts per Million
Residue	
Dried at 105°	340
Dried at 180°	332
After ignition	310
Silicon dioxide	18.8
Calcium	78.4

[9] "Deep Wells as a Source of Water Supply for Minneapolis," *American Geologist*, 35: 266–91 (1905).

[10] I M. Kolthoff, analyst.

	Parts per Million
Magnesium	29.6
Sodium	3.9
Potassium	0.8
Sulphate	29.7
Chloride	2.8
Nitrate	7
Bicarbonate	347.7
Iron	less than 0.2
Alumina	less than 0.1
Manganese	0.2

Highland Springs in St. Paul are located on Randolph Street near Lexington Avenue at an elevation of 894 feet above sea level, or 208 feet above the Mississippi River. These springs have been used for over forty years. The larger spring flows about 1000 gallons an hour, and the smaller one about 800.

	Grains per Gallon
Total hardness	16.7
Permanent hardness	6.07
Temporary hardness	10.6
Total solids (110° C.)	27.8
Ignited solids	18.7
Bicarbonate	28.6
Silica	0.114
Iron oxide and alumina	0.108
Calcium	6.2
Magnesium	1.92
Chlorides	1.33
Sulphates	1.26

ECONOMIC DEPOSITS

Stone

A large amount of rock, especially limestone, was quarried during the early settlement of the Metropolitan region. Many of the old quarry sites have been forgotten, though in some cases the present owner of the land may be aware of them. There were two causes for the decline in the stone industry: (1) the lack of deposits as suitable as those in near-by areas of Minnesota; (2) the decrease in the use of stone and the development of concrete, with gravel as a coarse aggregate.

The principal rocks quarried were Platteville limestone and Shakopee and Oneota dolomites. In Minneapolis and St. Paul the Platteville alone is exposed for quarrying. At and above Shakopee as far as Merriam Junction the Shakopee and Oneota were quarried. The latter has been quarried along the Mississippi River near Nininger, and extensively at Stillwater.

Detailed remarks are necessary only where quarries are active or likely to become so. Much detail on quarries active twenty years ago will be found in the United States Geological Survey Bulletin 663, *The Structural and Ornamental Stones of Minnesota.* Up-to-date information on Minnesota stone is given in Minnesota Geological Survey Bulletin 25.[11] Page 142 of this same bulletin also gives a list of inactive and abandoned quarries in the Twin City region.

In Minneapolis and St. Paul only one quarry remains active, principally because of exhaustion of available rock. (That exposed along the Mississippi gorge is largely controlled by the park boards of the cities and is not in use.) This active quarry, the Gopher Stone Company on East Johnson Street, Minneapolis, operates on a small scale, about 25 feet of limestone being exposed in the quarry face. Most of this rock has been crushed but selected stone is used for exterior work on buildings of moderate size.

The only other quarry which has recently produced much stone and may continue to do so when needed is on the Burlington Railroad about two miles south of St. Paul Park in Washington County. This quarry is adjacent to the railroad and the material is more or less easily broken so that it may be loaded onto steam shovels and used for riprap along the tracks exposed to wash by the Mississippi.

On the south side of the Mississippi between Nininger and Spring Lake is a continuous bluff of Shakopee and Oneota dolomite; here quarrying has been extensive and plenty of stone is still available. This rock has been mainly used for riprap and for the most part seems less suitable for dimension stone.

At various places in the Metropolitan Area a little stone is removed from some of the small quarries as some special demand arises, but none appear likely to be of importance.

It is unlikely that the future will see much development of quarries within the Metropolitan Area. There are excellent quarries in dolomite just beyond the area along the Minnesota River and extensive granite quarries have been active for years in the St. Cloud region not far to the northwest. It is likely that these and other developed quarries in Minnesota will supply the Twin Cities with stone indefinitely.

Sand and Gravel

The region about Minneapolis and St. Paul is plentifully supplied with sand and gravel deposited by the glaciers and the waters which poured forth from them. In general, gravel occurs abundantly in terminal moraines and outwash from the ice front. In the terminal moraine proper the deposits are likely to occur as small- to medium-sized pockets, but in certain belts of outwash and along major streams very large blanket de-

[11] Thiel and Dutton. *The Architectural, Structural, and Monumental Stones of Minnesota.*

posits of sand and gravel were formed. Because much of the Metropolitan Area is covered with deposits of terminal moraine small deposits of gravel are so numerous that it is impractical to list them. The large active deposits have washing plants; the following list, furnished by the Minnesota Department of Highways, gives those at present located within the area.

HENNEPIN COUNTY
- Landers-Norblom-Christenson, Broadway and N. E. "K" St., Minneapolis
- Landers, Morrison, Christenson, St. Louis Park
- Minnesota Sand and Gravel Co., St. Louis Park
- Twin City Sand and Gravel Co., St. Louis Park
- Rice Sand and Gravel Co., St. Louis Park
- Hedberg-Freidheim and Co., St. Louis Park
- Century Sand and Gravel Co., St. Louis Park

RAMSEY COUNTY
- J. L. Shiely Co., St. Paul

DAKOTA COUNTY
- Hallet Pit, Hastings
- Standard Sand and Gravel Co., South St. Paul
- United Materials, South St. Paul
- Stiefels Products Inc., South St. Paul

WASHINGTON COUNTY
- Central States Company, Lakeland

FOUNDRY SANDS

A variety of earthy materials, usually described by the terms loam, clay, and sand, are used in foundry work. Many of these materials are found in the Metropolitan Area and elsewhere in Minnesota. A discussion of Minnesota occurrences and a description of deposits are given in *The Foundry Sands of Minnesota,* by G. N. Knapp, published in 1923 as Bulletin 18 of the Minnesota Geological Survey.

The following formations furnish, or are capable of furnishing, sand or other material for use in foundry work. The Jordan sandstone, which crops out along the Mississippi River near Hastings and to a considerable extent along the St. Croix from Afton to the north end of the area, has a coarse phase near the top capable of furnishing essentially pure quartz sand sized to 20 mesh, which is comparable to the standard product from Ottawa, Illinois. St. Peter sandstone, which outcrops extensively in Minneapolis, St. Paul, and elsewhere in the Metropolitan region, furnishes very satisfactory material for ordinary core work in foundries.

Knapp groups the glacial materials of Minnesota with reference to sands and foundry materials as follows: moraines of Wisconsin drift from the north and northeast (red drift); moraines of Wisconsin drift from the northwest; outwash; and glacial lake deposits. In general, the most satisfactory sand from the moraines comes from the red drift, which is the lowest of the moraine deposits in fluxing material. Loams may usually be found in outwash areas. Mr. Knapp's bulletin should be consulted for detailed tests and analyses of material found and used in this area and throughout the state.

Clays and Shales

There are many deposits of clay and shale in Minnesota, a considerable number of which have been developed. Those at Red Wing are of special importance. The occurrence of the deposits in Minnesota is described in detail by Professor F. F. Grout in Bulletin 11 of the Minnesota Geological Survey[12] and Bulletin 678 of the United States Geological Survey.[13] The former is out of print, but the latter is still available at Washington. The following descriptions have been abstracted from the above bulletins.

Anoka County.—The clay deposits of Anoka County are all derived from the glacial drift that covers the county. The most extensive deposit is a laminated gray clay, which extends along both banks of the Mississippi River at the north city limits of Minneapolis. This clay appears to have been deposited along an old wide channel of the Mississippi River. The clay is 30 feet thick at several places. It slakes at once, is highly plastic, and requires 24 per cent of water for moulding. This clay is recommended for common brick and fireproofing. The general average of all the brick tested from these clays gives a crushing strength of over 2000 pounds per square inch.

The red drift was formerly utilized for paving bricks at Coon Creek. Tests described by Professor Grout indicate this material to be of high quality and suitable for extensive use. Clays of fair quality have accumulated in glacial and recent lakes in other parts of Anoka County, but they have not been developed. Chemical analyses follow:

	1	*2*		*1*	*2*
Silica	50.65	60.49	Soda	1.44	2.17
Alumina	12.25	12.62	Potash	1.96	2.53
Iron oxides	4.00	7.80	Ignition	14.40	5.90
Magnesia	4.68	3.68	Moisture	1.20	1.94
Lime	10.65	3.87	Titanium oxide	.52	.42

1. Gray laminated clay along Mississippi River north of Minneapolis.
2. Red drift from Coon Creek.

Carver County.—Bricks have been produced for a long time at Chaska. Gray laminated river clays of the glacial River Warren are used. The section at the clay pit consists of 20 to 40 feet of partly stratified sand and gravel, underlain by 100 to 200 feet of dark gray clay. These beds extend under the river channel for hundreds of acres. Sand is ir-

[12] *Preliminary Report on the Clays and Shales of Minnesota* (1914).
[13] *Clays and Shales of Minnesota* (1919).

regularly mixed with the clay in pockets. By mixing clay from different parts of the pit a uniform quality of brick can be produced.

The clay slakes in one minute and shows a fairly high plasticity, requiring 28 per cent of water for molding. The average clay shows a shrinkage of 7.5 per cent on drying and a buff color on burning. The bricks have a fairly high crushing strength and are satisfactory in all respects. Large quantities were produced in the past.

Dakota County. — The principal clay-bearing formation in this county is Decorah shale, which is extensively developed at the plant of the Twin City Brick Company situated on the Mississippi River bluff partly in West St. Paul and partly in Dakota County. The detailed section of the Decorah shale at this location is given in the description of the formation (page 54). It consists of greenish shale with some limestone beds. The lower shale is smooth and green in color, slakes in two minutes to scales and small lumps, and is highly plastic. It requires 28 per cent of water for molding, has a tensile strength of nearly 200 pounds to the square inch, and is unaffected by rapid drying. The air shrinkage is less than 6 per cent.

The upper shale is picked over at the plant to separate the limestone before it is sent to the crushing machine. The result is a product essentially like that from the lower layers, except that the colors are lighter. With 23 per cent of water it is highly plastic, and its shrinkage and strength are similar to those of the lower shale. The crushing strength of the brick is high, averaging 3300 pounds to the square inch for ten bricks.

Hennepin County. — On the north side of Minneapolis glacial river clays have been utilized for bricks. An abundant supply still remains, but the value of city property has tended to crowd the brick works into Anoka County, where the deposits continue extensively. Similar clay occurs on the southeast side of Minneapolis but is covered with glacial drift. The pebbly gray drift of Hennepin County and recent alluvium along the Mississippi River cannot compete with the deposits in Anoka County. Swamp clay was once used at Hanover and the gray drift at Rogers, but not successfully.

Ramsey County. — Decorah shale, which is used extensively at West St. Paul in Dakota County, occurs also in Ramsey County, but only in localities where property is too valuable for excavation. Leached gray drift has been used in the northern part of St. Paul for red brick, but it has the common defect of containing too much limestone. Red laminated clay was once used at Dayton's Bluff and is known to occur just south of Como Park. An analysis of this clay is given by Grout (page 215). A large part of the county is underlain by red drift of a common pebbly type, though in many places gray drift overlies this deposit.

Scott County. — Gray laminated clays occur in the bluffs along the Minnesota River at many points. At Shakopee the alluvium was formerly used at a plant near the east edge of town. The clay slakes in three minutes and has a rather low plasticity. It requires 23 per cent of water for molding and shrinks 4 per cent on drying. Other deposits have been utilized at Blakeley and south of Belle Plaine.

Washington County.—The clays utilized in Washington County are lake clays, red laminated clays, and red and gray glacial drift. A deposit in the gray drift was utilized just south of Forest Lake. Formerly a red drift clay from across the lake was used, but was abandoned because of the expense of handling.

Peat Deposits

Peat is partly decomposed and disintegrated vegetable matter which has undergone both chemical and mechanical change, but which contains most of the carbon of the original vegetable matter and in which the vegetable structure may be seen. The vegetable matter was usually deposited in water and prevented from complete decay by it. The peat deposits of Minnesota have been exhaustively described by E. K. Soper in Bulletin 16 of the Minnesota Geological Survey,[14] to which the reader is referred for details on its origin, occurrence, distribution, uses, and so on. The present summary is taken from that publication.

In central and northern Anoka County an area of more than 50 square miles of swamp land is largely covered with peat. In addition many smaller bogs exist around the numerous lakes in the southeastern and northern parts of the county. The open marshes contain clean, well-decomposed peat of excellent quality and an average thickness of 7 to 8 feet.

In Carver County a considerable number of small bogs occur in the northeastern part of the county south of Lake Minnetonka. In Dakota County the largest deposits occur along the Minnesota River valley between Savage and Mendota, but this material is rather sandy.

Most of the swamps and marshes in Hennepin County contain peat deposits but most of them are small. Ramsey County contains relatively little swamp land, but it is estimated that about 1200 acres are underlain by peat. In the northern part of Washington County there are numerous small peat bogs, but none are large and the peat is usually not of high quality. Analyses for four counties follow.[15]

Analysis Number	*Moisture as Received*	*Volatile Matter*	*Carbon Fixed*	*Ash*	*Sulphur*	*Nitrogen*	*Thermal Value, Moisture-free*
			Anoka County				
17	8.35	72.94	14.89	12.17	.27	2.87	8.583
18	9.40	62.86	20.53	16.61	.30	2.96	8.062
19	8.70	59.09	15.77	25.14	.30	2.88	7.456
20	9.00	61.43	17.75	20.82	.27	2.78	7.976

[14] *Report on the Peat Deposits of Minnesota* (1919).
[15] *Ibid.*, pp. 76–78.

Analysis Number	*Moisture as Received*	*Volatile Matter*	*Carbon Fixed*	*Ash*	*Sulphur*	*Nitrogen*	*Thermal Value, Moisture-free*
			DAKOTA COUNTY				
80	9.00	68.02	19.40	12.58	1.34	2.40	8.346
			HENNEPIN COUNTY				
92	8.55	62.00	17.66	20.34	.61	3.66	8.014
93	8.60	71.01	17.67	11.32	.30	2.49	8.151
94	9.05	67.89	15.29	16.82	.21	2.80	7.655
95	10.10	72.02	15.97	12.01	.46	3.43	8.210
96	9.50	67.73	19.95	12.32	.61	3.29	8.523
97	9.10	72.66	15.79	11.55	.36	2.95	8.497
			RAMSEY COUNTY				
161	4.85	31.11	3.73	65.16		1.50	
162	10.35	71.65	16.81	11.54	.21	2.88	8.210
163	5.75	49.50	1.53	48.97		1.81	
164	8.95	69.25	14.50	16.25		2.97	7.708

MARL DEPOSITS

Marl is a soft earthy material, composed largely of calcium carbonate, and found as a fresh water deposit in lake basins, bogs, marshes, and low areas once covered with water. The marl deposits of Minnesota have recently been described by Thiel in Bulletin 23 of the Minnesota Geological Survey.[16] The following summary is taken from that report, to which the reader is referred for general facts on origin, occurrence, and uses, as well as for detailed descriptions of deposits.

In the portion of Anoka County included within the Metropolitan Area deposits are found in Sec. 36, T. 33 N., R. 25 W., Secs. 5 and 29, T. 33 N., R. 23 W., Sec. 20, T. 32 N., R. 23 W., and Secs. 10 and 15, T. 31 N., R. 24 W. The deposits vary up to 10 feet in thickness and some are nearly a square mile in area. Soluble carbonates in analyses vary from 56.8 to 77.7 per cent.

In Carver County, which is underlain by clayey drift, marl is not abundant. A small amount is found in a lake about one and one-half miles north of Lake Waconia. The same situation prevails in much of Dakota County and marl deposits of good grade are unknown.

Much of Hennepin County is also unfavorable to the formation of marl, but a few deposits are known. The principal deposits are in Hayden's Lake, T. 120 N., R. 22 W.; Twin Lakes, T. 118 N., R. 21 W.; Medicine Lake, T. 118 N., R. 22 W.; Sec. 23, T. 118 N., R. 23 W.; Sec. 2, T. 117 N., R. 22 W.; and Sec. 22, T. 116 N., R. 22 W. The percentage of soluble carbonates ranges from 28 to 90, and deposits vary up to 20 feet in thickness.

Most of Ramsey County is covered with red drift moraines and

[16] Stauffer and Thiel. *The Limestones and Marls of Minnesota* (1933).

outwash gravel plains among the morainic ridges. The marl beds discovered in the county are located in regions of sand moraine and outwash gravels. Deposits are known in Vadnais, Black, Long, Marsden, and Keller lakes. The percentage of soluble carbonate ranges from 35 to 82, and deposits up to 20 feet in thickness are known.

In Washington County conditions for marl formation are unfavorable in the red drift moraines, but deposits are known at Lake Elmo and Carnelian Lake. Lake Elmo occupies a depression in outwash gravel and as much as 4 feet of marl is known to exist.

APPENDIX

TABULATION OF WELL LOGS, OUTCROPS, AND OTHER DATA FOR THE MINNEAPOLIS–ST. PAUL AREA

In the following tabulations essentially all of the data on exposures and subsurface logs have been included. The principal exception is the area of the Afton anticline, which was surveyed by plane table; a separate map (Figure 36) shows the detail. In some cases where very extensive drilling has been done, as for dam and bridge foundations, only representative logs have been included. The engineer desiring more detail should refer to the original source, i. e., the United States Engineer's Office at St. Paul, for test borings in the Mississippi River. The sources or authority for the information are indicated by footnotes at the end of each of the seven counties and the two cities.

The data are tabulated and numbered separately for each county and for Minneapolis and St. Paul. Where data for the Mississippi River fall in two counties or cities, they are given under the heading of Mississippi River. Within each county the records are numbered and arranged geographically, beginning with the upper left-hand or northwest land survey township and taking the townships in order from west to east, as one would read a page. Within each township the records are arranged according to the sections, the lowest number being in Section 1 and the highest in Section 36. It should be noted that the civil township, which is designated by name, frequently does not coincide with a land survey township. The numbers representing the data for each county will be found on Plate 1, the geologic map of the Metropolitan Area, and on the cross sections shown on Plates 2 and 3.

For Minneapolis and St. Paul the records are tabulated by street intersections, arranged alphabetically and numerically. If a record is not found, for example, under Nicollet and Washington Avenues, it will be found under Washington and Nicollet Avenues. Information always refers to the nearest intersection. For the deep well logs in the cities an additional tabulation follows the alphabetical arrangement, giving the detailed logs in the same form as used for the counties. It was originally intended to publish larger scale maps of each city showing all streets, so that each record could be represented by a dot and a number. The expense would have been so great that the outline maps (Plates 6 and 7) were substituted. The data given may be plotted on published city maps by those who find it necessary to use the data continuously. The numbers assigned the counties and cities are used on the maps and cross sections. Great effort has been used in checking the logs to eliminate errors, but it should be understood that information collected from such diverse sources is not equally dependable.

All elevations given in the tabulations refer to sea level datum.

ANOKA COUNTY

GROW TOWNSHIP

1. Well of Great Northern Ry., 6 miles north of Coon Creek Junction, Andover. Sec. 26, T. 32 N., R. 24 W. Elevation 887 ft.[1]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Clay, gravel, and sand	0– 50	
	Red sandy clay	50– 70	
	Red sand and clay	70–120	
	Red sand and gravel with clay	120–140	
	Sand and gravel	140–212	
	Coarse sand and gravel	212–250	
	Heaving sands	250–260	260+

2. Well of Great Northern Ry., Anoka. Elevation 883 ft.[2]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Sand	0– 20	
	Reddish till	20– 80	
	Soft blue shale	80–120	
	Harder shale	120–140	
	Sand	140–142	142
St. Lawrence	Hard rock (limestone)	142–162	20

RAMSEY TOWNSHIP

3. Well of Minnesota Potato Starch Company, Anoka. Elevation 860 ft.[3]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Sand	0– 20	
	Blue clay	20–180	180
St. Lawrence	Sandstone	180–215	
	Shale	215–275	95
Franconia	Coarse sandstone	275–335	
	Fine sandstone	335–356	81
Dresbach	Sand and shale	356–390	34+

(A second well drilled about 1909. The log was lost, but the well was 420 feet deep and was a flowing well.)

4. City of Anoka well no. 2 (1913). Elevation 860 ft.[4]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Sand, gravel, and hardpan	0–231	231
St. Lawrence	White sandstone	231–246	
	Shale	246–300	69
Franconia	Hard sandstone	300–385	85
Dresbach	Soft sandstone	385–420	35+

5. City of Anoka well no. 3 (1928). Elevation 860 ft.[5]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Unclassified	0–220	220
St. Lawrence		220–300	80
Franconia and Dresbach		300–520	220
Hinckley	Fine red sand	Entered	

6. Well at State Asylum, Anoka. Elevation 860 ft.[6]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Undifferentiated	0–200	200
Unclassified	Sandstone	200–206	6
St. Lawrence,	Dolomite	206–396	190
Franconia,	Sandstone	396–502	106
and Dresbach	Sandrock, limerock, and shale	(?)	(?)

7. Anoka-Champlin Bridge foundation. See Mississippi River tabulations (p. 259).

ANOKA TOWNSHIP

8. Well at Great Northern Ry. Section House, Coon Creek. Sec. 26, T. 31 N., R. 24 W. Elevation 886 ft.[1]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Fine sand	0– 26	

Formation	Description	Depth (in feet)	Thickness (in feet)
	Blue clay	26– 41	
	Red clay	41–114	
	Pack gravel	114–127	127
Jordan	Sandstone	127–176	49+

9. Coon Creek Dam foundations near east bank of Mississippi. Sec. 27, T. 31 N., R. 24 W. Elevation of river bottom 817.5 ft.[7]

Drift and alluvium	Sand and gravel	0– 3	
	Red clay	3–51	51+

10. Well at Coon Creek Power Station, Northern States Power Co. Sec. 27, T. 31 N., R. 23 W. Elevation 821 ft.[8]

Drift	Gravel, clay, and sand	0–100	100
Jordan	Sandrock	100–(?)	
St. Lawrence	Shale	(?)–376	276
Franconia	Sandrock	376–390	14+

11. Well on Weaver property, east end of Coon Creek Dam. Sec. 27, T. 31 N., R. 24 W. Elevation 830± ft.[9]

Drift	Undifferentiated	0–112	112
Jordan	Hard sandstone at bottom.		

CENTERVILLE TOWNSHIP

12. Well at Randeau Lake, near N¼ cor. Sec. 3, T. 31 N., R. 22 W. Elevation 900 ft.[10]

Drift	Undifferentiated	0–260	260+

13. Well at village of Centerville, southeast side of Centerville Lake. Sec. 23, T. 31 N., R. 22 W. Elevation 884 ft.[11]

Drift	Undifferentiated	0–134	134
St. Peter	Sandstone (remnant)	134–146	12
Shakopee-Oneota	Dolomite	146–313	167
Jordan	Sandstone	313–400	87
St. Lawrence	Shale	400–479	79+

(This log does not correlate with ten other wells near by. Probably mislocated.)

14. Well B, Centerville Plant of St. Paul Water Department (12-inch well). Elevation 883 ft.[12]

Drift	Unclassified	0– 93	93
Shakopee-Oneota	Limestone	93–181	88
Jordan	Sandstone	181–282	101
St. Lawrence	Mixed material	282–452	170

(There are several other wells at the Centerville plant varying from 333 to 439 ft. in depth. These are much like the above. No. 13 seems to be in error.)

FRIDLEY TOWNSHIP

15. Well of Walsh Tie Co., National Pole and Treating Co., and Central Avenue and Belt Line R. R. Sec. 12, T. 30 N., R. 23 W. Elevation 880 ft.[12]

Drift	Undifferentiated	0–140	140
Oneota	Dolomite and sandstone	140–280	140
Jordan		280–337	57+

16. Well of S. H. Barker, at mouth of Rice Creek. Sec. 15, T. 30 N., R. 23 W.[13]

Drift	Unclassified	0–94	94
Shakopee-Oneota	Fawn-colored magnesian limestone	94–95	1+

17. Well of Riedel Sanitary Farm Dairy Co., 2 miles north of Hennepin County line on East River Road. Sec. 22, T. 30 N., R. 24 W. Elevation 835 ft.[14]

Drift	Sand and gravel	0– 40	
	Blue clay	40– 96	

Formation	Description	Depth (in feet)	Thickness (in feet)
	Watery sand	96–103	103
Shakopee	Hard rock	103–110	7
New Richmond(?)	Sandstone	110–135	25

18. Well at Hilltop Golf Course, 45th Ave. N. E. and Reservoir Blvd., Columbia Heights. Sec. 30, T. 34 N., R. 24 W. Elevation 1015 ft.[15]

Drift	Unclassified	0–390	390
Shakopee-Oneota	Dolomite	390–436	46
Jordan	Sandstone	436–440	4

19. Sandstone quarry at 41st Ave. N. E. and Northern Pacific tracks, Columbia Heights. Sec. 34, T. 34 N., R. 24 W. Elevation 866 ft.[16]

Platteville	Massive to thin-bedded, mottled limestone, gray to blue in color	8.5	
Glenwood	Yellowish argillaceous shale	1	
	Argillaceous blue shale, with fossils	1	
Probably St. Peter	Sandy blue to yellow shale	1.3	
	Hard yellow sandstone	2.75	
St. Peter	White sandstone, poorly cemented	4	
	Green sandstone with some clay	.5	
	White sandstone, showing some cross-bedding	158+	

[1] Great Northern Ry. Co. [2] T. S. Nickerson, in *Geology of Minnesota,* 2:409, 420.
[3] U. S. Geological Survey, Water Supply Paper 256, p. 130. [4] State Board of Health.
[5] Minneapolis Water Commission. [6] J. B. Estabrook, Pillsbury Engineering Co.
[7] Northern States Power Co. [8] Mr. Laird, superintendent, Northern States Power Co.
[9] B. B. Decker. [10] Keys Well Drilling Co. Verbal report.
[11] U. S. Geological Survey, Water Supply Paper 256, Plate 30; Report, St. Paul Board of Water Commissioners, 1895, p. 134. [12] St. Paul Water Department.
[13] N. H. Winchell, *Geology of Minnesota,* 2:308. [14] E. P. Burch. [15] Renner Well Co.
[16] C. R. Stauffer.

CARVER COUNTY

1. City of Waconia well, back of the City Hall. Elevation 1035 ft.[1]

Drift	Clay, sand, and gravel	0–465	465
St. Lawrence	Dolomitic red shale	465–490	
	Green shale with dolomitic sandstone	490–501	
	Light green shale with fossils	501–527	62
Franconia	Fine-grained sandstone with greensand	527–597	70
Dresbach	Gray sandstone with fossil fragments	597–668	
	Argillaceous gray shale	668–670	
	Coarse, pink to gray sandstone, with well-rounded quartz grains	670–690	
	Red shale containing fossils	690–735	
	Red shale with quartz grains	735–836	
	Red shale with a few rounded quartz grains	836–840	243+

LAKE TOWN TOWNSHIP

2. Well at Moravian Home, east shore of Lake Auburn, near center of Sec. 11, T. 116 N., R. 24 W. Elevation 963 ft.[2]

Drift	Unclassified	0–265+	265+

3. Well at creamery, Victoria. NW¼ Sec. 13, T. 116 N., R. 24 W. Elevation 986 ft.[3]

Drift	Unclassified	0–150	150+

Formation	Description	Depth (in feet)	Thickness (in feet)
	CHANHASSEN TOWNSHIP		
4. Well of J. H. Mitchell, south end of Christmas Lake. NE¼ Sec. 2, T. 116 N., R. 23 W. Elevation 989 ft.[4]			
Drift	Yellow clay	0–124	
	Fine sand	124–260	
	Clay	260–271	
	Gravel	271–281	281+
5. Well at Perry property, south of Excelsior, on county line. Sec. 3, T. 116 N., R. 23 W.[5]			
Drift	Unclassified	0–320	320+
6. Well at E. J. Moline home, 1½ miles south of Excelsior, on Chanhassen road. Sec. 3, T. 116 N., R. 23 W. Elevation 1038 ft.[6]			
Drift	Unclassified	0–271	271
Shakopee-Oneota	Dolomite; shaly hard rock, 59 ft. Dolomite; clean hard rock, 85 ft.	271–415	144
Jordan	Sandstone	415–425	10+
7. Well on Giege property, 2 miles south of Excelsior. Sec. 4, T. 116 N., R. 23 W.			
Drift	Unclassified	0–301	301+
8. Well at Minnewashta Farm, south of Eureka. NW¼ Sec. 5, T. 116 N., R. 23 W. Elevation 976 ft.[8]			
Drift	Unclassified	0–186	186+
9. Well on State Fruit Breeding Farm, ¾ mile south of Zumbra Heights Station. SW¼ Sec. 7, T. 116 N., R. 23 W. Elevation 1020± ft.[9]			
Drift	Yellow till	0– 35	
	Gray and red sand	35– 45	
	Fine, compact, blue till	45–107	
	Coarser blue till	107–176	
	Gray gravel	176–235	
	Coarse gray gravel	235–250	250+
10. Well at home of ex-Governor John Lind, now belonging to Campfire Girls. NE¼ Sec. 8, T. 116 N., R. 23 W. Elevation 1000 ft.[10]			
Drift	Unclassified	0– 80	80+
	YOUNG AMERICA TOWNSHIP		
11. Well of Minneapolis and St. Louis R. R. at Hamburg. Sec. 28, T. 115 N., R. 26 W. (Not on map.) Elevation 999 ft.[11]			
Drift	Yellow clay	0– 7	
	Blue clay	7– 75	
	Hardpan	75–119	
	Soft yellow clay	119–125	
	Hardpan	125–203	203
Franconia(?)	Water-bearing sand	203–209	
	White sandstone	209–244	41+
	BENTON TOWNSHIP		
12. Village of Cologne well. Sec. 13, T. 115 N., R. 25 W. (Not on map.) Elevation 955 ft.[12]			
Drift	Yellow clay	0– 24	
	Blue clay	24–101	
	Hardpan	101–110	
	Fine gravel	110–112	
	Hardpan	112–130	
	Fine, muddy, gray sand	130–187	
	Blue clay	187–252	252
St. Lawrence	Dolomite and shale beds	252–344	92+

Formation	Description	Depth (in feet)	Thickness (in feet)
	CHASKA TOWNSHIP		

13. City of Chaska well (old). Elevation 748 ft.[13]

Drift	Brick clay	0–150	
	Hardpan	150–200	200
Correlation uncertain	White sandstone	200–280	80
	Shale	280–465	185
	White and red sandstone	465–665	200
	Shale	665–680	15+

14. City of Chaska well (1931). Elevation 724 ft.[14]
181 feet in drift. Struck dolomite and stopped. Probably St. Lawrence formation.

[1] C. R. Stauffer. [2] Secretary of Moravian Home. [3] Manager of creamery.
[4] J. H. Mitchell, owner. [5] Mr. Hinds, driller. [6] L. J. Hemphill, driller.
[7] B. B. Decker, driller. [8] L. A. Page, owner. [9] C. W. Hall. [10] E. P. Burch, driller.
[11] Minneapolis and St. Louis R. R. Co. engineering department. [12] A. S. Milinowski.
[13] U. S. Geological Survey, Water Supply Paper 256, p. 150. [14] Layne Northwest Co.

DAKOTA COUNTY

MENDOTA TOWNSHIP

1. Well of Michael E. Defiel, Sibley Memorial Highway, south side of Mississippi River on bluff, west of Cherokee Park, outside St. Paul city limits. Sec. 13, T. 28 N., R. 23 W. Elevation 944± ft.[1]

Drift	Unclassified	0– 60	60
Decorah	Shale	60–125	65
Platteville	Limestone	125–160	35
Glenwood	Shale	160–165	5
St. Peter	Sandstone	165–326	161
Shakopee-Oneota	Dolomite	326–463	137
Jordan	Sandstone	463–474.5	11.5+

2. Outcrop, 1000 ft. east of Chicago and Milwaukee R. R. station, Mendota. Sec. 22, T. 28 N., R. 23 W. Elevation of top of St. Peter 781 ft.[2]
Cliff shows St. Peter sandstone, Glenwood shales, and Platteville limestone.

3. Well of Somerset Golf Club. NE¼ Sec. 24, T. 28 N., R. 23 W. Elevation 950 ft.[1]

Drift	Unclassified	0– 50	50
Decorah	Shale	50–100	50

4. Well at Fischer store, corner of Highway No. 1 and South St. Paul paving. Sec. 25, T. 28 N., R. 23 W. Elevation 860± ft.[3]

Drift	Sand	0– 50	
	Gravel and gravelly clay	50– 90	
	Saudrock(?)	90–110	
	Sand, gravelly clay, and gravelly sand	110–182	182+

5. Well, northwest side of Bunker Hill Golf Course. NE¼ Sec. 26, T. 28 N., R. 23 W. Elevation 852± ft.[4]

Drift	Unclassified	0–180	180
Shakopee-Oneota(?)	Hard limestone	180–220	40+

6. Wells at Riverview Golf Course, Highway No. 52 and Mendota Road. Sec. 26, T. 28 N., R. 23 W. Elevation 860 ft.[4]

Old Well

Drift	Unclassified	0– 50	50

Formation	Description	Depth (in feet)	Thickness (in feet)
Decorah	Soapstone	50– 70	20
Platteville	Limestone	70–100	30
St. Peter	Sandstone	100–175	
	Hard limestone and sandstone	175–200	100
	New Well (1933)		
Drift	Unclassified	0– 53	53
Platteville	Limestone	53– 88	35
Glenwood	Soapstone	88–100	12
St. Peter	Sandstone	100–190	
	Limestone, some flinty	190–250	
	Sandstone	250–251	151
Shakopee	Limestone and flint	251–290	39

At 290 ft. struck a crevice; 2 feet open and much water.

7. Well of Chicago, Milwaukee, St. Paul and Pacific R. R. at St. Paul Junction, Mendota. Elevation 768 ft.[5]

Drift	Unclassified	0– 22	22
St. Peter	Sandstone	22–147	125
Shakopee	Dolomite	147–187	40
New Richmond	Sandstone	187–202	15
Oneota	Dolomite	202–292	90
Jordan	Sandstone	292–397	95
St. Lawrence	Shale	397–597	200
Franconia	Sandstone	597–647	50
Dresbach	Shale and sandstone	647–722	
	Red sandstone and red shale	722–857	210

8. Well (1932) at Sibley Tea House, Main St., Mendota. Elevation 770 ft.[6]

Drift	Unclassified	0–190	190
(?)	Rock	190–197	7

9. Well at Hollywood Inn, southeast end of Mendota Bridge. Sec. 28, T. 28 N., R. 23 W. Elevation 875± ft.[4]

Drift	Unclassified	0– 70	70
Platteville	Limestone	70–100	30
St. Peter	Sandstone	100–180	
	Hard sandstone, etc.	180–218	118+

(Elevation of south end of Mendota Bridge roadway 809.5 ft.)

10. Outcrop on bluff of Minnesota River, east of center of Sec. 28, T. 28 N., R. 23 W. Elevation of Platteville–St. Peter contact 778 ft.[7]

11. Mendota Bridge. Sec. 28, T. 28 N., R. 23 W. Elevation of Platteville–St. Peter contact 778 ft.[8]

Minnesota River bottom consists of hard dolomitic rock 80–90 ft. below normal water level.

12. Wells at Acacia Cemetery, Pilot Knob. Sec. 28, T. 28 N., R. 23 W. Elevation 815 ft.[6]

	Old Well		
Drift	Soil	0– 3	3
Platteville	Limestone	3– 36	33
St. Peter	Sandstone	36–195	159
Shakopee-Oneota	Dolomite	195–324	129
Jordan	Sandstone	324–430	106
	New Well		
Drift	Sand and gravel	0– 55	
	Blue clay	55– 85	85
Decorah	Soapstone	85–124	39
Platteville	Limestone	124–156	32
St. Peter	Sandstone	156–300	144
Shakopee-Oneota	Dolomite	300–365	65

Formation	Description	Depth (in feet)	Thickness (in feet)

13. Drill hole, Minnesota River bottoms. NW¼ Sec. 33, T. 28 N., R. 23 W. Elevation 700 ft.[9]

Alluvium to elevation 632, where St. Peter sandstone was encountered.

14A. Outcrop along Minnesota River 1 mile south of Mendota Bridge at gully where old road comes from railroad to top of Platteville terrace. Near center of Sec. 33, T. 28 N., R. 23 W. Elevation 800+ ft.[2]

Platteville	Limestone	Contact at elevation 785 ft.
St. Peter	Sandstone	

14B. Well (1934) at Mendota Transient Camp. Sec. 33, T. 28 N., R. 23 W.[4]

Platteville	Limestone	0– 12	12
Glenwood	Soapstone	12– 17	5
St. Peter	Sandstone	17–180	163
Shakopee-Oneota	Limestone	180–230	50

15. Abandoned quarry in SW¼ Sec. 33, T. 28 N., R. 23 W.[9]

St. Peter — Sandstone. Exposure of unknown thickness.

16. Outcrops from Mendota Bridge to SW¼ Sec. 33, T. 28 N., R. 23 W. Elevation of contact 777 ft.[10]

Platteville	Limestone	Exposures of each practically continuous. Thickness unknown.
St. Peter	Sandstone	

17. Well at Hultgren house. NE¼ Sec. 35, T. 28 N., R. 23 W. Elevation 900± ft.[11]

Drift	Unclassified	0–115	115
Platteville	Limestone	115–125	10
St. Peter	Sandstone	125–130	5

(At house 200 ft. north, well struck no limestone but sandstone at 150 ft.)

18. Well at Ryan home. SE¼ Sec. 35, T. 28 N., R. 23 W.[11]

Drift	Unclassified	0–120	120
St. Peter	Sandstone	120–(?)	(?)

19. Well near E¼ cor. Sec. 35, T. 28 N., R. 23 W.[3]

Drift	Unclassified	80 (to rock)	80

20. Well at school on Highway No. 63. NW¼ SW¼ Sec. 36, T. 28 N., R. 23 W. Elevation 900 ft.[11]

Drift	Hard clay	0– 15	
	Gravel and clay	15– 35	
	Gravel	35– 50	
	Clay and boulders	50– 73	73
Platteville	Hard and soft limestones	73– 93	
	Soapstone	93– 98	25
St. Peter	Sandstone	98–115	17+

21. Well at SW cor. Sec. 36, T. 28 N., R. 23 W. Elevation 900± ft.[3]

Drift	Unclassified	0–128	128
(?)	Rock	128–140	12

WEST ST. PAUL TOWNSHIP

22. Well no. 1 at Armour & Co. Power House, South St. Paul. Elevation 690 ft.[12]

River deposits	Alluvium; fine gray sand	0–150	150
Oneota	Limestone, magnesian, gray	150–160	10
Jordan	Sandstone, coarse, white	160–260	100
St. Lawrence	Limestone, very sandy, gray	260–310	
	Sandstone, fine to medium, gray, green	310–330	
	Fine greensand	330–360	
	Sandstone, fine, greenish-gray, limy	360–380	
	Greensand, fine, shaly, limy	380–390	

Formation	Description	Depth (in feet)	Thickness (in feet)
	Sandstone, fine to medium, green, gray	390–410	
	Fine greensand	410–430	170
Franconia	Sandstone, fine, greenish-gray, limy	430–460	30
Dresbach	Shale with some sand, green, limy	460–500	
	Sandstone, fine, gray, limy	500–520	
	Shale, greenish-gray, limy	520–540	
	Shale, bright, green, limy	540–590	
	Sandstone, coarse and fine shaly sand, with fossils	590–610	150
Hinckley (Mt. Simon)	Sandstone, coarse to fine, light, gray	610–720	
	Gray limy shale	720–730	
	Sandstone, fine, gray, no lime	730–800	
	Sandstone, fine, gray, no lime	800–850	240
Red Clastic (?)	Sandstone, medium to fine, light red	850–900	50

Very coarse at base. Granite reported at 900; no sample.

23. Well (12- to 6-inch) near Swift & Co. Power Plant, South St. Paul (1932). Elevation 697 ft.[13]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Sand	0– 20	
	Hardpan	20– 40	40
St. Peter	Sandstone	40– 50	10
Shakopee-Oneota	Limestone	50–180	130
Jordan	Sandstone	180–260	80
St. Lawrence	Mixed shale and sandstone	260–310	
	Green shale	310–460	200
Franconia	Sandstone	460–510	50
Dresbach	Mixed shale and sandstone	510–540	
	Shale	540–610	100
Hinckley	Sandstone	610–870	260
Red Clastic (?)	Red sandstone	870–950	80

24. Distillery well of Swift & Co., southeast corner of property on river bank, South St. Paul. Elevation 699 ft.[13]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Sand	0– 50	
	Sand and clay	50– 80	
	Sand	80–125	
	Sand and gravel	125–155	155
Shakopee-Oneota	Limestone	155–168	13
Jordan	Sandstone	168–240	72
St. Lawrence	Shale, sand, and limestone	240–265	
	Limestone	265–305	
	Sandy shale	305–455	215
Franconia	Sandstone	455–490	
	Sandy shale	490–525	35
Dresbach	Hard rock (sandstone?)	525–532	
	Soft rock (sandstone?)	532–540	
	Gray and green shale	540–605	115
Hinckley	Sandstone	605–625	
	Sandstone and shale	625–785	
	Sandstone	785–825	220
Red Clastic (?)	Fine red granite (?) (arkose)	825–850	
	Coarse red granite (?) (arkose)	850–870	
	Fine red granite (?) (arkose)	870–900	75+

(The granite surface is believed to be 1800 ft. deeper. See U.S. Geological Survey, Water Supply Paper 256, Plate 3.)

25. Old distillery well of Swift & Co. See no. 24 above. Elevation 699.35 ft.[13]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Unclassified	0–150	150
Shakopee-Oneota	Limestone	150–170	20

Formation	Description	Depth (in feet)	Thickness (in feet)
Jordan	Sandstone	170–240	70
St. Lawrence	Shale and limestone	240–260	
	Limestone	260–300	
	Sandstone	300–370	130+

26. City of South St. Paul well no. 2, between Concord St. and Chicago and Great Western R. R. and Bryant and Hawley Aves. Elevation 698± ft.[14]

Drift	Brown sand	0– 20	
	Yellow hardpan	20– 35	35
Shakopee-Oneota	Limestone	35–179	144
Jordan	Sandstone	179–260	81
St. Lawrence	Shale and sandstone	260–465	205 *
Franconia	Sandstone	465–510	45 †
Dresbach	Shale and sandstone	510–616	106
Hinckley	Sandstone	616–921	305+

27. Well at Chicago and Great Western R. R. shops, between Summit and Bryant Aves. near Concord, South St. Paul. Elevation 699 ft.[15]

Drift	Unclassified	0– 85	85
Shakopee, Oneota, and Jordan	No record	85–305	220
St. Lawrence	Yellow sandstone	305–340	
	Blue sandstone	340–355	
	Limestone	355–365	
	Blue shale	365–390	
	Shale	390–395	90
Franconia	White sandstone (lower part only is Franconia)	395–487	92+

28. Well of Mr. Weiss on S. Robert St., 1 mile south of St. Paul city limits. SW¼ Sec. 17, T. 28 N., R. 22 W.[16]

Drift	Unclassified	0– 90	90
Platteville(?)	Limerock	90–(?)	(?)

29. Well of Horace Klein, Delaware Ave. SW¼ Sec. 19, T. 28 N., R. 22 W. Elevation 1025 ft.[1]

Drift	Clay	0– 53	53
Decorah	Shale	53–206	153

30. City of South St. Paul well no. 1, between Grand and Marie Sts. and Concord St. and railroad. Elevation 698± ft.[14]

Drift	Brown sand	0– 15	15
St. Peter	Sandstone	15–100	85
Shakopee-Oneota	Limestone	100–197	97
Jordan and St. Lawrence	Sandstone and shale	197–478	281
Franconia	Sandstone	478–525	47
Dresbach	Shale	525–630	105
Hinckley	Sandstone	630–921	291
Red Clastic(?)	Arkose or conglomerate	921–924	3+

(Poor correlation in part.)

31. Well at Swift & Co. Pumping Station, South St. Paul. Elevation 690 ft.[17]

Alluvium	River deposits	0– 40	40
Shakopee-Oneota	Dolomite	40–165	125
Jordan	Sandstone	165–295	130 *
St. Lawrence	Limestone	295–450	155
Franconia	Sandstone	450–500	50
Dresbach	Shale	500–640	140
Hinckley	White sandstone	640–840	200
Red Clastic	No description	840–880	40+

* Thick. † Thin.

Formation	Description	Depth (in feet)	Thickness (in feet)

32. Armour & Co. well no. 2, at Power House, South St. Paul. Elevation 690± ft.[18]

River deposits	Alluvium	0–170	170
Jordan	Sandstone, medium, coarse, white	170–280	110
St. Lawrence	Sandy magnesian limestone	280–320	
	Fine greenish-gray greensand	320–350	
	Limy greensand	350–380	
	Very fine greensand	380–400	
	Fine limy greensand	400–420	140
Franconia	Sandstone, coarse and medium, light, gray	420–470	50
Dresbach	Blue and greenish-gray shale	470–590	120
Hinckley	Sand, fine, clean, white	590–760	170
Red Clastic	Shale, coarse to fine, red, sandy, limy	760–897	137

33. Armour & Co. well no. 3, east of Power House (300 ft. east toward the river). Elevation 690± ft.[19]

Drift	Sand	0– 4	
	Clay	4– 24	
	Sand	24– 95	
	Sand and clay	95–115	
	Sand and rock	115–135	
	Sand	135–168	168
Jordan	Soft sandstone	168–188	
	Shale and sandstone	188–195	
	Shale	195–203	
	Gravel	203–204	
	Sandstone	204–265	97
St. Lawrence	Shale	265–305	
	Sandy shale	305–330	
	Shale	330–452	187
Franconia	Sandstone	452–492	
	Sandy shale	492–507	55
Dresbach	Shale	507–610	103
Hinckley	Sandy shale	610–695	
	Sandstone	695–885	275
Red Clastic (?)	Sandy shale	885–895	
	Probably conglomerate	895–910	25+

34A. Well no. 30 at St. Paul Union Stockyards, opposite 3rd St., 5 blocks east of Concord. Elevation 698± ft.[20]

Drift	Sand and clay	0– 20	20
Shakopee-Oneota	Dolomite	20–155	135
Jordan	Sandstone	155–270	115
St. Lawrence	Shale and sandstone	270–440	170
Franconia	Sandstone	440–495	55
Dresbach	Shale	495–590	95
Hinckley	Sandstone	590–891	301 *
Red Clastic (?)	Probably arkose	891–901	10+

34B. Well no. 111 at St. Paul Union Stockyards. Elevation 697.7 ft.[20]

Drift	Sand	0– 14	14
Shakopee-Oneota	Limerock	14–171	157
Jordan	Soft sandrock	171–255	84
St. Lawrence	Sandstone	255–460	205
Franconia	Sandrock	460–510	50
Dresbach	Shale, sandrock, and limerock	510–680	170
Hinckley	Sandrock and shale	680–850	170
Red Clastic	Red sand	850–895	
	Granite (probably arkose)	895–896.5	46.5+

* Thick.

Formation	Description	Depth (in feet)	Thickness (in feet)

35. Well no. 1 at St. Paul Union Stockyards, at abandoned South St. Paul roundhouse south of Grand Ave. Elevation 695 ft.[20]

Drift	Sand and clay	0– 32	32
Shakopee-Oneota	Dolomite	32–172	140
Jordan	Sandstone	172–250	78
St. Lawrence	Sandy shale	250–265	15+

36. Well at A. C. Lawrence Leather Co., formerly St. Paul Tannery, east of Concord, between 6th and 7th Sts., South St. Paul. Elevation 698± ft.[21]

Drift	Sand	0– 12	12
Shakopee-Oneota	Dolomite	12–165	153
Jordan	Sandstone	165–166	1+

37. Dr. Owen's well at Sunfish Lake. NE¼ NW¼ Sec. 31, T. 28 N., R. 22 W. Elevation 960± ft.[1]

Drift	Unclassified	0–131	131
Platteville	Limestone	131–158	27+

BURNSVILLE TOWNSHIP

38. Well at Corrigan farm. Sec. 35, T. 27 N., R. 24 W.[4]

185 ft. of drift (glacial). No rocks; dry hole.

EGAN TOWNSHIP

39. Several wells near church in Sec. 1, T. 27 N., R. 23 W.[22]

Drift — Mostly clay; some brown sand. Wells vary from 90 to 160 feet in depth.

40. Well at Pat Fee farm north of Wescott. NE¼ Sec. 13, T. 27 N., R. 23 W. Elevation 870 ft.[22]

Drift	Clay; gravel at bottom	0–314	314

41. Well at KSTP Radio Station. SE¼ Sec. 13, T. 27 N., R. 23 W. Elevation 882 ft.[3]

Drift	Gravel and sand	0– 80	
	Gray and blue clay	80–160	
	Fine floury sand	160–336	
	Coarser sand and yellow clay	336–348	348+

42. Well of M. W. Stephens at Wescott (Radio Center). SE¼ Sec. 13, T. 27 N., R. 23 W. Elevation 882± ft.[3]

Drift	Mostly clay	0–301	301+

43. Well in gravel pit 1 mile north of Wescott, Highway No. 65. NW¼ Sec. 13, T. 27 N., R. 23 W. Elevation 900 ft.[4]

Drift	Clay	0–200	
	Gravel	200–204	
	Clay	204–304	
	Sand and gravel	304–344	344

44. Well of Otto Rahn. NE¼ Sec. 17, T. 27 N., R. 23 W. Elevation 860± ft.[11]

Drift	Quicksand, with gravel at bottom	0–256	256+

45. Well of Chas. Woodham. SE¼ Sec. 20, T. 27 N., R. 23 W. Elevation 925± ft.[11]

Drift	Clay, gravel, and quicksand	0–230	230
Shakopee-Oneota	Limestone	230–242	12

46. Well ¼ mile southwest of Wescott, just northwest of Van Dyke farm. Sec. 24, T. 27 N., R. 23 W. Elevation 882± ft.[3]

Drift	Unclassified (may have hit rock)	0–412	412(?)

Formation	Description	Depth (in feet)	Thickness (in feet)
47. Well at Dr. Van Dyke's farm, 1200 ft. southwest of Wescott. Sec. 24, T. 27 N., R. 23 W. Elevation 900 ft.[22]			
Drift	Sand	0– 70	
	Clay	70–415	415
St. Lawrence(?)	Limestone	415–430	15+
48. Well of Fred Shingledecker. SE¼ NE¼ Sec. 33, T. 27 N., R. 23 W. Elevation 960 ft.[3]			
Drift	Unclassified	0–253	253
Shakopee-Oneota	Flinty, solid, blue rock	253–300	47+
49. Well west of center of Sec. 34, T. 27 N., R. 23 W. Elevation 1060+ ft.[3]			
Drift	Gravel, etc.	0–150	150+
INVER GROVE TOWNSHIP			
50. Well at village of Inver Grove. Sec. 2, T. 27 N., R. 22 W.[1]			
Drift	Unclassified	0– 94	94
Shakopee-Oneota	Dolomite	94–147	53+
51. Exposures at Inver Grove, east of Rock Island R. R. shops. Elevation about 940 ft.[23]			
Shakopee	Dolomite	(?)	10
52. Well of Rock Island R. R. at Inver Grove.[24]			
Drift	Unclassified	0– 69	69
Shakopee-Oneota	Dolomite	69–(?)	
53. Well of E. Shingledecker. W½ NE¼ Sec. 5, T. 27 N., R. 22 W. Elevation 950 ft.[3]			
Drift	Unclassified	0–175	175
St. Peter	Sandstone	175–286	111
54. Well of A. Christopherson, near center of Sec. 5, T. 27 N., R. 22 W. Elevation 975 ft.[3]			
Drift	Sand, gravel, and clay	0–180	180
St. Peter	Sandstone	180–250	70
55. Well near S¼ cor. Sec. 6, T. 27 N., R. 22 W.[3]			
Drift	Clay, etc.	0– 60	
	Limerock(?)	60– 77	
	Clay	77–117	
	Sand and gravel	117–180	180+
56. Well of Albert Sax, ⅛ mile southwest of NE cor. Sec. 7, T. 27 N., R. 22 W. Elevation 960 ft.[3]			
Drift	Unclassified	0–304	304
Shakopee-Oneota	Gray flinty rock	304–306	2+
(Mr. Sax reports 14 ft. of limerock and sandrock; total 309 ft.)			
57. Well of John Ferber, near center of NW¼ Sec. 7, T. 27 N., R. 22 W. Elevation 860 ft.[3]			
Drift	Bottom is gravel	0–339	339+
58. Three wells in NW¼ Sec. 9, T. 27 N., R. 22 W.[25]			
Drift	Gravel and sand penetrated for a thickness of 75, 100, and 152 ft. respectively for 3 wells.		
59. Outcrop at Chicago and Great Western R. R. station at Inver Grove. Elevation 717 ft.[26]			
Shakopee-Oneota	Dolomite. Shows at road corner 100 ft. south.		
60. Outcrop at E. T. Matz farm. NE¼ SE¼ Sec. 11, T. 27 N., R. 22 W. Elevation 707± ft.[26]			
Shakopee-Oneota	Dolomite. Exposed in gully entering slough of the Mississippi, and along the slough generally. Extends about 20 ft. above water level.		

Formation	Description	Depth (in feet)	Thickness (in feet)

61. Outcrop 1.2 miles south of Chicago and Great Western R. R. station at Inver Grove. SE¼ SE¼ Sec. 11, T. 27 N., R. 22 W. Elevation 710± ft.[20]

Shakopee-Oneota — Dolomite. Exposed in small gully, along road, and in underpass for railroad, near what is here the main channel of the Missisippi River.

62. Outcrop ½ mile south of Chicago and Great Western R. R. station at Inver Grove. NE¼ Sec. 11, T. 27 N., R. 22 W. Elevation of top 597± ft.[20]

Shakopee-Oneota — Dolomite. Exposed along slough from water level to 10 ft. above.

63. Outcrop on road along river, 1.35 miles south of Chicago and Great Western R. R. station at Inver Grove. NW¼ NE¼ Sec. 14, T. 27 N., R. 22 W.[20]

Shakopee-Oneota — Thin-bedded dolomite. Large exposure in small cliff beside road.

64. Outcrop along river bank, 1.75 miles south of Chicago and Great Western R. R. at Inver Grove. SW¼ NE¼ Sec. 14, T. 27 N., R. 22 W. Elevation 700± ft.[20]

Shakopee-Oneota — Dolomite. Continuous exposure along river bank of about 15± ft. thickness.

65. Outcrop in SE¼ Sec. 14, T. 27 N., R. 22 W. Elevation at top 727± ft.[20]

Shakopee-Oneota — Dolomite. Exposures along railroad and old road at river bank where railroad swings west. Good exposures present on river bank at north and south ends of slough, extending vertically from water level to 40 ft. above.

66. Outcrop on line between Secs. 14 and 23, T. 27 N., R. 22 W. Elevation 687± ft.[20]

Shakopee-Oneota — Dolomite. Good exposures along west side of small lake on river flat 2.5 miles south of Inver Grove station of Chicago and Great Western R. R. A good spring at the foot of the outcrop (south end). The outcrops seem to end at small gullies 200 ft. southwest of the lake. This is the most southerly known outcrop north of Pine Bend.

67. Well of Pat Borden. SW¼ Sec. 14, T. 27 N., R. 22 W.[25]

Formation	Description	Depth	Thickness
Drift	Soil	0– 2	
	Till	2– 10	
	Sand and gravel	10–112	112
Shakopee-Oneota	Limestone	At bottom	(?)

68. Well at Wescott Garage. SW¼ Sec. 18, T. 27 N., R. 22 W. Elevation 882± ft.[3]

Formation	Description	Depth	Thickness
Drift	Unclassified	0–386	386+

69. Well of Peter Luxine. SE¼ Sec. 28, T. 27 N., R. 22 W.[11]

Formation	Description	Depth	Thickness
Drift	Gravel and some gumbo	0–318	
	Quicksand	318–333	333+

70. Well of John Jagoe. NW¼ Sec. 28, T. 27 N., R. 22 W.[25]

Formation	Description	Depth	Thickness
Drift	Gravel	0–140	140+

71. Well at O'Connor farm, near S¼ cor. Sec. 31, T. 27 N., R. 22 W. Elevation 980± ft.[11]

Formation	Description	Depth	Thickness
Drift	Gravel	0–280	280+

72. Well of E. J. Dresser, center of Sec. 34, T. 27 N., R. 22 W.[25]

Formation	Description	Depth	Thickness
Drift	Soil and till	0– 5	
	Gravel and sand, except 2 ft. of clay from 30 to 32 ft.	5–196	196+

73. Well of Harry Veker, near Pine Bend. SW¼ Sec. 34, T. 27 N., R. 22 W.[3]

Formation	Description	Depth	Thickness
Drift	Unclassified	0–331	331+

BURNSVILLE TOWNSHIP *(Continued)*

74. Well in SE¼ Sec. 13, T. 115 N., R. 21 W.[25]

Formation	Description	Depth	Thickness
Drift	Fine sand	0–136	136+

75. Exposure in cut on Minneapolis, Northfield and Southern Ry., 1700 ft. north of Whittier railroad shelter. Sec. 22, T. 115 N., R. 21 W. Elevation 914± ft.[6]

Platteville — Limestone. Six ft. vertical exposure of basal portion for 100 ft.

76. Quarry at center of Sec. 23, T. 115 N., R. 21 W.[27]

Platteville — Dolomite. Exposure of unknown thickness.

Formation	Description	Depth (in feet)	Thickness (in feet)
77. Four wells at Orchard Gardens. Sec. 26, T. 115 N., R. 21 W. Elevation of station 1012 ft.[4]			
Drift	Unclassified		100–125
Platteville	Limestone		12–15
St. Peter	Water-bearing sandstone		15–25
78. Well near Minneapolis, Northfield and Southern Ry. station at Orchard Gardens. Sec 26, T. 115 N., R. 21 W. Elevation of station 1012 ft.[3]			
Drift	Clay and gravel	0–115	115
Platteville	Limestone	115–124	9
St. Peter	Sandstone, very mixed	124–190	
	Hard white sandstone	190–230	106+
79. Well of Mrs. Davis at Orchard Gardens. Sec. 26, T. 115 N., R. 21 W. Elevation 1085± ft.[22]			
Drift	Gravel	0–160	160
Platteville	Limestone	160–190	30
St. Peter	Sandstone	190–260	70+
80. Well of Gisch farm, 1½ miles southwest of Minneapolis, Northfield and Southern Ry. station at Orchard Gardens. NW¼ Sec. 35, T. 115 N., R. 21 W. Elevation 1105 ft.[4]			
Drift	Clay and some gravel	0–200	200
St. Peter	Flowing sandstone	200–300	
	Hard sandstone	300–315	115
LEBANON TOWNSHIP			
81. Well at Eaton Ranch near E¼ cor. Sec. 16, T. 115 N., R. 20 W. Elevation 1035± ft.[4]			
Drift	Unclassified	0–175	175+
82. Well at S. Figura farm. NW¼ Sec. 17, T. 115 N., R. 20 W. Elevation 1030 ft.[4]			
Drift	Probably all drift (cased)	0–220	220
St. Peter	Sandstone	220–320	100
Shakopee-Oneota	Limestone	320–330	10
83. Well at George Disnovec farm, near S¼ cor. Sec. 17, T. 115 N., R. 20 W. Elevation 1004 ft.[4]			
Drift	Unclassified	0–180	180
St. Peter	Sandstone	180–254	74
84. Well at SW cor. Sec. 21, T. 115 N., R. 20 W.[3]			
Drift	Sand and gravel	0– 90	90
Platteville	Limestone	90–110	20
St. Peter	Running sand	110–135	
	Harder sandstone	135–180	70+
85. Well of J. Lehmann. NW¼ Sec. 22, T. 115 N., R. 20 W. Elevation 1012 ft.[4]			
Drift	Unclassified	0– 90	90
Platteville	Limestone	90–105	15
St. Peter	Sandstone	105–200	95+
(Log doubtful. Mr. Lehmann says well is only 108 ft. deep.)			
86A. Well on John Molitor farm. SE¼ Sec. 24, T. 115 N., R. 20 W. Elevation 945 ft.[6]			
Drift	Unclassified	0–150	150
(?)	Limestone	150–185	35
86B. Exploration well on John Molitor farm. SE¼ Sec. 24, T. 115 N., R. 20 W. Elevation 895 ft.[28]			
Drift	Sand, gravel, boulders, clay at base	0–110	110
St. Peter	Sandstone	110–134	24
Shakopee-Oneota	Gray to buff dolomite	134–325	191
Jordan	Gray to bluish sandstone	325–400	75

Formation	Description	Depth (in feet)	Thickness (in feet)
St. Lawrence	Green shale, dolomite, etc.	400–606	206
Franconia	Gray to blue sandstone	606–670	64
Dresbach	Sandstone and sandy shale	670–705	
	Bluish, gray, and green shale	705–786	
	Sandstone with shale, gray, fossiliferous	786–937	267
Hinckley	Pink to buff sandstone	937–1043	106+

86C. Well of H. Uhle. NE cor. Sec. 24, T. 115 N., R. 20 W. Elevation 912 ft.[3]

Drift	Gravel and quicksand	0–80	80
(?)	Limestone float with good flow of water	80–98	18+

87. Exploration well. NE¼ Sec. 13, T. 115 N., R. 20 W. Elevation about 1000 ft.[28]

Drift	Unclassified	0–200	200
St. Peter	Sandstone	200–250	50
Shakopee-Oneota	Buff to gray dolomite	250–450	200
Jordan	Buff to gray sandstone	450–555	105
St. Lawrence	Bluish sandstone, with a little shale	555–581	
	Bluish sandy dolomite	581–600	
	Green shale	600–752	197
Franconia	Gray to bluish sandstone	752–777	
	Gray sandy shale	777–810	58+

88. Well of P. J. Heins. SW¼ Sec. 25, T. 115 N., R. 20 W. Elevation 966± ft.[20]

Drift	Gravel	0–190	190
St. Peter	Sandstone	190–225	35+

89. Well of J. Dunn. SE¼ Sec. 28, T. 115 N., R. 20 W. Elevation 966± ft.[4]

Drift	Unclassified	0–50	50
Platteville *	Limestone	50–90	40

90. Well of Ernest Johnson. NE¼ cor. Sec. 28, T. 115 N., R. 20 W. Elevation 1016 ft.[4]

Drift	Unclassified	0– 90	90
Platteville(?)	Limestone(?)	90–105	15
St. Peter	Sandstone	105–165	60

(Log doubtful. Owner says 186 ft. deep; rock at about 100 ft.)

91. Well of Mr. McMillan, north side of Sec. 31, T. 115 N., R. 24 W., near center line. Elevation 960± ft.[4]

Drift	Unclassified	0–50	50
Platteville	Limestone	50–60	10+

92. Well at Tousignant farm, near N¼ cor. Sec. 33, T. 115 N., R. 20 W. Elevation 960 ft.[4]

Total depth 45 ft. Struck Platteville limestone.

93. Well on Antlers Park road, 2½ miles southwest of Rosemount. Sec. 36, T. 115 N., R. 20 W. Elevation 985 ft.[22]

Drift	Unclassified	0–130	130
St. Peter	Sandstone	130–(?)	

ROSEMOUNT TOWNSHIP

94. Well on Gray property, east side of Sec. 16, T. 115 N., R. 19 W. Elevation 950± ft.[3]

Drift	Unclassified	0–215	215
Shakopee-Oneota	Dolomite	215–250	35

95. Well on E. Lamberg farm, north side of Sheep Lake. NW¼ Sec. 19, T. 115 N., R. 19 W. Elevation 907+ ft.[3]

Drift	Unclassified Soft sandrock at bottom.	0– 70±	70±

* Somewhat low in elevation.

Formation	Description	Depth (in feet)	Thickness (in feet)
96. Well on O'Rourke farm. Sec. 21, T. 115 N., R. 19 W.[22]			
Drift	Gravel	0–120	120
St. Peter	Soft sandstone	120–310	190+
97. Well at Carrigan farm, near center of Sec. 22, T. 115 N., R. 19 W. Elevation 940± ft.[22]			
Drift	Unclassified	0– 90	90
St. Peter	Sandstone	90–140	50+
98. Well of Wm. Retzikal, at Chicago and Great Western R. R. station at Rich Valley. Sec. 24, T. 115 N., R. 19 W. Elevation 861 ft.[4]			
Drift	Unclassified	0– 95±	95±
Shakopee-Oneota(?)	Limestone	±95–100	5+
99. Wells near railroad station at Rich Valley. Sec. 25, T. 115 N., R. 19 W. Elevation at station 861 ft.[3]			
Drift	Unclassified	0–90	90
Shakopee-Oneota	Limestone	(?)	(?)
100. Well no. 1 on Buck farm, ½ mile east of Rosemount. Sec. 28, T. 115 N., R. 19 W. Elevation 980 ft.[22]			
Drift	Unclassified	0–120	120
St. Peter	Sandstone	120–150	30+
101. Well no. 2 on Buck farm, ½ mile east of Rosemount. Sec. 28, T. 115 N., R. 19 W. Elevation 990 ft.[4]			
Drift	Unclassified	0–125±	125±
St. Peter	Sandstone	±125–130	5+
102. Village of Rosemount well. Elevation 962 ft.[31]			
Drift	Sand	0–162	162
St. Peter	Hard rock, water-bearing	162–165	
	Hard rock, not water-bearing	165–184	
	Sandstone	184–216	54
Shakopee-Oneota	Flinty blue limestone	216–243	27
103. Well in W½ Sec. 36, T. 115 N., R. 19 W.[25]			
Drift	Soil	0– 2	
	Yellowish clay	2– 5	
	Sand and gravel	5–80	80+

NININGER TOWNSHIP

Formation	Description	Depth (in feet)	Thickness (in feet)
104. Outcrop in cave at old boat landing at Nininger. Elevation of contact 702± ft.[2]			
Shakopee-Oneota	Dolomite	0–18	18
Jordan	Rotten brown sandstone to river	18–33	15+

105. Bloomstrand & Olson Quarry. NW¼ Sec. 13, T. 115 N., R. 18 W. Elevation of Oneota-Jordan contact 707 ft.[26]

Contact between Oneota and Jordan is well exposed at east end of quarry, at about 20 ft. above water level. Quarry 400 feet long. 45 feet of buff dolomite.

106. Gentzgrow & Mogren Quarry. NW¼ Sec. 13, T. 115 N., R. 18 W. Elevation of Oneota-Jordan contact 722 ft.[26]

Oneota	Massive buff dolomite; 35 ft. exposed.
Jordan	Sandstone. Thickness unknown.

107. Outcrop at outlet of Spring Lake. SE¼ Sec. 14, T. 115 N., R. 18 W. Elevation of Oneota-Jordan contact 726± ft.[26]

Oneota	Dolomite. Thickness unknown.
Jordan	Sandstone. Exposed to 40 ft. above river.

108. Outcrops 1 mile southeast of Pine Bend. SW¼ Sec. 17, T. 115 N., R. 18 W. Elevation of top outcrop 757 ft.[2]

Formation	Description	Depth (in feet)	Thickness (in feet)
Shakopee-Oneota	Dolomite	0–27	
	Soft seam	27–28	
	Dolomite	28–62	62+

ROSEMOUNT TOWNSHIP *(Continued)*

109. Well on Thomas P. Furlong farm. NE¼ NW¼ Sec. 20, T. 115 N., R. 18 W. Elevation 810± ft.[32]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Unclassified	0– 45	45
Shakopee-Oneota	Dolomite	45–155	110+

NININGER TOWNSHIP *(Continued)*

110. Outcrops at east end of Spring Lake. NE¼ Sec. 23, T. 115 N., R. 18 W. Elevation at top of outcrop 862 ft.[2]

Oneota Dolomite. About 100 ft. exposed.

111. Outcrops on Highway No. 53, near corner of Secs. 24, 25, 19, 30, T. 115 N., Rs. 17, 18 W. Elevation at top of rock 885± ft.[2]

Shakopee-Oneota Dolomite. Several exposures.

112. Outcrops in SW¼ Sec. 18, T. 115 N., R. 18 W.[2]

Shakopee-Oneota Limestone. Several exposures along road.

113. Nininger borings, Mississippi River, hole no. 4. NW¼ Sec. 18, T. 115 N., R. 18 W. Elevation of river bottom 671.3 ft.[33]

Formation	Description	Depth (in feet)	Thickness (in feet)
Alluvium	Fine sand	0–12	12
Jordan	Soft sandstone	12–13.5	1.5+

114. Nininger borings, Mississippi River, hole no. 6. NW¼ Sec. 18, T. 115 N., R. 17 W. Elevation of river bottom 661.7 ft.[33]

Formation	Description	Depth (in feet)	Thickness (in feet)
Alluvium	Sand, coarse, blue, with shells	0–11.8	11.8
Jordan	Sandstone, rather soft	11.8–15.1	3.3+

115. Nininger borings, Mississippi River, hole no. 7. NW¼ Sec. 18, T. 115 N., R. 17 W. Elevation of river bottom 669.3 ft.[33]

Formation	Description	Depth (in feet)	Thickness (in feet)
Alluvium	Gravel	0– 5.3	
	Fine sand	5.3– 9.0	
	Fine gravel	9.0–11.5	11.5
Jordan	Soft sandstone	11.5–15.7	4.2+

116. Nininger borings, Mississippi River, hole no. 3. NW¼ NE¼ Sec. 18, T. 115 N., R. 17 W. Elevation of river bottom 672.1 ft.[33]

Formation	Description	Depth (in feet)	Thickness (in feet)
Alluvium	Blue clay	0– 8	
	Brown sand	8–14	14
Jordan	Sandstone	14–15	
	Soft sandstone	15–19.4	5.4+

117. Nininger borings, Mississippi River, hole no. 2. NE¼ Sec. 18, T. 115 N., R. 17 W. Elevation of river bottom 673.2 ft.[33]

Formation	Description	Depth (in feet)	Thickness (in feet)
Alluvium	Sandy blue clay	0–21	21
Jordan	Sandstone	21–36	15+

HASTINGS TOWNSHIP

118. Outcrop on new grade of Highway No. 53, ½ mile west of Hastings. NE¼ Sec. 29, T. 115 N., R. 17 W. Elevation 890 ft.[2]

Shakopee-Oneota Dolomite. Several exposures.

Formation	Description	Depth (in feet)	Thickness (in feet)

119. Outcrop west of Hastings, on bluff along Mississippi River. SW¼ Sec. 21, T. 115 N., R. 17 W. Elevation 770 ft.[2]

Shakopee-Oneota	Dolomite. Several exposures.		

120. City of Hastings well (drilled about 1910). Elevation 689 ft.[34]

Drift		0– 3	3
Shakopee-Oneota	Dolomite	3–100	97
Jordan	Sandstone	100–200	100
St. Lawrence		200–400	200
Franconia		400–460	60+

121. Chicago and Milwaukee R. R. bridge over Mississippi River at Hastings.[35]

	Hole No. 1, near the Center Pier. Elevation 654 ft.		
Alluvium	Sand	0–17.4	17.4
Oneota	Broken limerock	17.4–25.4	
	Solid limerock	25.4–34.4	17.0
	Hole No. 2, near Hastings Bank. Elevation 658 ft.		
Oneota	Broken rock	0– 9.3	9.3
	Solid limerock	9.3–13.3	4.0
	Hole No. 3, on the Hastings Bank. Elevation 687 ft.		
Alluvium	Sandy loam	0– 6	6
Oneota	Broken limerock	6– 9	
	Solid limerock	9–24	18

122. Well of Chicago and Milwaukee R. R. at Hastings (1885). Elevation 707 ft.[36]

Shakopee-Oneota	Magnesian limestone	0– 80	
	White sandstone	80– 95	
	Sandy magnesian limestone	95–107	107
Jordan	Ferruginous sandstone	107–202	95
St. Lawrence	White sandy shale	202–227	
	Sand, sandy shale, and dolomite	227–270	
	Sand and greensand	270–290	
	Green shale and greensand	290–400	
	Sandy shale, sand, and greensand	400–415	213
Franconia	Sandstone with pyrite	415–475	60
Dresbach	Green sandy shale	475–495	
	Black shale	495–565	
	Sand and greensand	565–585	
	Green shale, sand, and limestone	585–590	115
Hinckley	Sandstone and limestone with pyrite	590–620	
	Fine to coarse sandstone	620–780	
	Fine to coarse sandstone and shale	780–820	230
Red Clastic	White and pink sandstone	820–850	
	Red shale with some white sand	850–870	
	Red and white sandstone	870–885	
	Red shale	885–925	
	White sand and some red shale	925–1160	340

123. Exposures at Hastings. Elevation of rock terrace 710± ft.[26]

Shakopee-Oneota Dolomite. Outcrops all along street east from the Chicago and Milwaukee R. R. station. On street to south continues to outlet of Lake Isabel. Area between lake and bank of the lower terrace of the Mississippi is all a rock terrace, containing quarries. Rock is exposed to water level in a small west-flowing channel at outlet of lake.

124. Outcrops at bridge near mouth of Vermillion River. SE¼ Sec. 27, T. 115 N., R. 17 W. Elevation 690± ft.[26]

Shakopee-Oneota Dolomite. Small exposure.

Formation	Description	Depth (in feet)	Thickness (in feet)

125. City of Hastings well in Wilson Park, 4th, 5th, Spring, and Eddy Sts. (1933). Elevation 722 ft.[35]

Drift	Fill and drift	0– 10	10
Shakopee-Oneota	Hard limestone	10–102	92
Jordan	Sandstone	102–202	100

126. City of Hastings well, Vermillion St. between 8th and 9th Sts. (1930). Elevation 784 ft.[35]

Drift	Hardpan	0– 5	
	Sand	5– 35	
	Gravel	35– 42	42
Shakopee-Oneota	Limestone	42–160	
	Limestone and sandstone	160–195	153
Jordan	Soft yellow sandstone	195–242	
	Hard white sandstone	242–280	85
St. Lawrence	Limestone	280–290	
	Sandstone	290–292	
	Sandy shale	292–350	
	Green shale	350–473	
	Gray shale	473–485	
	Green shale	485–525	245
Franconia	White and gray sandstone	525–590	65
Dresbach	White shale	590–620	
	Green shale	620–670	(?)
Hinckley (in part)	Sandstone	670–905	
	Sandy shale	905–915	(?)
Red Clastic	Red shale entered	915–916	1

127. Outcrops on north side of Vermillion River. SE¼ SE¼ Sec. 31, T. 115 N., R. 17 W. Elevation 820± ft.[26]

Oneota — Dolomite. Loose on bank of river.

128. Outcrops at Vermillion River gorge, at State Asylum bridge, Hastings. Sec. 34, T. 115 N., R. 17 W. Elevation 760± ft.[26]

Shakopee-Oneota — Dolomite. 40-ft. exposure to water's edge.

129. Well at Hastings State Asylum power station. Sec. 34, T. 115 N., R. 17 W. Elevation 755 ft.[37]

Drift	Unclassified	0– 7	7
Shakopee-Oneota	Limestone	7–135	128
Jordan	Sandstone	135–238	103
St. Lawrence	Limestone	238–284	
	Shale	284–454	216
Franconia	Sandstone	454–514	60
Dresbach	Shale	514–600	86
Hinckley (in part)	Sandstone	600–781	181

(The Shakopee is exposed near Asylum office building at elevation 825 ft.)

130. Outcrops at old Ramsey Mill, Vermillion Falls, near Hastings State Asylum. Sec. 34, T. 115 N., R. 17 W. Elevation 740± ft.[26]

Shakopee-Oneota — Dolomite. 50+ ft. exposed.

131. Outcrops at railroad bridge over Vermillion River at Hastings, between King Midas Mill and State Asylum. Sec. 34, T. 115 N., R. 17 W. Elevation of top of outcrop 788 ft.[26]

Shakopee-Oneota — Dolomite. 75± ft. exposed.

132. Outcrops in Vermillion River gorge, Hastings, at King Midas Mill, Highway No. 1 and Vermillion road. Sec. 34, T. 115 N., R. 17 W. Elevation 790± ft.[26]

Shakopee-Oneota — Dolomite. 75± ft. exposed at and below falls.

Formation	Description	Depth (in feet)	Thickness (in feet)
133. Outcrops in road up dry valley east of Hastings. SE¼ Sec. 35, T. 115 N., R. 17 W.[26]			
Shakopee-Oneota	Dolomite. Exposed on side of road.		
RAVENNA TOWNSHIP			
134. Quarry 3 miles southeast of Hastings. NW¼ Sec. 36, T. 115 N., R. 17 W. Rock surface elevation 750 ft.[6]			
Drift	Unclassified		10–30
Shakopee	Dolomite		40
New Richmond	Sandstone		5
Oneota	Dolomite		65+
LAKEVILLE TOWNSHIP			
135. Well on south shore of Orchard Lake. Sec. 11, T. 114 N., R. 21 W.[4]			
Drift	Gravel	0–125	125+
136. Two wells at Brantjen farm. SE¼ Sec. 1, T. 114 N., R. 20 W. Elevation 950± ft.[22]			
Drift	Unclassified	0–100	100
St. Peter	Sandstone	100–130	30+
137. Well of Mr. Hayes at Crystal Lake. NW¼ NW¼ Sec. 5, T. 114 N., R. 20 W. Elevation 985± ft.[4]			
Drift	Unclassified	0–(?)	
Platteville	Limestone	(?)–60	
138. Well of Mr. Lottman, south of Crystal Lake, near NW¼ cor. Sec. 5, T. 114 N., R. 20 W. Elevation 1040± ft.[4]			
Drift	Unclassified	0–(?)	
Platteville	Limestone	(?)–90	
139. Well of Mr. Cook, south of Crystal Lake. NE¼ Sec. 6, T. 114 N., R. 20 W.[4]			
Drift	Gravel	0–85	85+
140. Well in Sec. 8, T. 114 N., R. 20 W.[38]			
Drift	Gray till. Fossil wood at depth of 100 ft.	0–100+	100+
141. Well of John Murphy. E½ SE¼ Sec. 9, T. 114 N., R. 20 W.[25]			
Drift	Loam and sand	0–13	
	Blue clay	13–145	145+
Cretaceous wood, ironstone, etc., in bottom.			
142. Old quarry in S½ SW¼ Sec. 13, T. 114 N., R. 20 W. Elevation of top of hill 980 ft. Elevation of quarry base 945 ft. (approximate base of Platteville).[2]			
Platteville	Limestone. Several poor exposures.		
143. Well on Mike Murphy farm, 1½ miles northwest of Lakeville. NE¼ Sec. 19, T. 114 N., R. 20 W.[4]			
Drift	Clay	0–200	200
St. Peter(?)	Sandstone at bottom	200–(?)	(?)
144. Old quarry on Aitken farm. NE¼ NW¼ Sec. 24, T. 114 N., R. 18 W. Elevation at base 940 ft. (approximate base of Platteville).[2]			
Platteville	Limestone. About 15 ft. exposed.		
145. Quarry of Daniel F. Arthur, 1½ miles northwest of Farmington. SE¼ Sec. 24, T. 114 N., R. 20 W.[39]			
Platteville	Limestone. 6 ft. exposed.		
146A. Old well of village of Lakeville (drilled about 1882). Elevation 967 ft.[40]			
Drift	Unclassified	0–145	145
Shakopee-Oneota	Limestone(?)	145–282	137

Formation	Description	Depth (in feet)	Thickness (in feet)
Jordan to Dresbach	Shales and sandstones	282–1035	753
Red Clastic	Red formation	1035–1085	50+

146B. New well of village of Lakeville (drilled in 1932). Elevation 967± ft.[1]

Drift	Unclassified	0–144	144
Shakopee-Oneota	Dolomite	144–270	126
Jordan	Sandstone	270–302	32+

(Many wells in the village are in St. Peter sandstone at 50 ft. from the surface.)

146C. Well on Nelson farm, 3 miles west of Lakeville. NW¼ Sec. 36, T. 113 N., R. 20 W. Elevation 1095 ft.[41]

Drift for 100 ft. Enters St. Peter sandstone at 100 ft.

147A. Well at Lakeville Creamery. Sec. 29, T. 114 N., R. 20 W. Elevation 967 ft.[1]

Drift	Unclassified	0–138	138
Shakopee-Oneota	Dolomite	138–268	130
Jordan	Sandstone	268–300	32

147B. Well at village of Lakeville. Elevation 967± ft.[11]

Drift	Unclassified	0–62	62
St. Peter	Sandstone	62–70	8+

EMPIRE TOWNSHIP

148. Well of P. J. Heins. SW¼ Sec. 1, T. 114 N., R. 19 W. Elevation 900± ft.[42]

Drift	Gravel	0–225	225+

149. Well of P. J. Heins. SW¼ Sec. 3, T. 114 N., R. 19 W.[42]

Drift	Gravel	0–50	50±
St. Peter	Sandstone	50–80	30+

150. Abandoned quarry on Chicago and Milwaukee R. R., center of Sec. 7, T. 114 N., R. 19 W. Elevation 940 ft. (approximate base of Platteville).[2]

Platteville	Limestone	(?)	5+

151. Well northwest of outcrop in Sec. 12, T. 114 N., R. 19 W. Elevation 922 ft.[2]

St. Peter	Sandstone	0–200±	200±
Shakopee-Oneota	Limestone	at 200 ft.	

152. Outcrop on farm in NE¼ Sec. 14, T. 114 N., R. 19 W.[2]

St. Peter — Sandstone. Extensive outcrop on a northwest-southeast ridge.

153. Well at Westwood Dairy Farm, just north of Westwood. Sec. 22, T. 114 N., R. 19 W.[2]

Drift	Gravel	0–20	20+

154. Well of Magnus Brown at Farmington. Elevation 900± ft.[24]

Drift	Unclassified	0–142	142
Shakopee-Oneota	Dolomite	142–(?)	

155. Well at Twin City Milk Producers' plant, Farmington. Elevation 890± ft.[1]

No data. Depth of well is 700 ft. Log lost.

156. City of Farmington well (1932). Elevation 890± ft.[22]

Drift	Gravel	0–62	62+

157. Well in city of Farmington. Elevation 900± ft.[43]

Drift	Unclassified	0– 60	60
St. Peter	Sandstone	60–150	90
Shakopee-Oneota	Dolomite	150–300	150
Jordan	Sandstone	300–380	80
St. Lawrence	Limestone, sandstone, shale(?)	380–500	120+

(This log does not agree with U. S. Geological Survey, Water Supply Paper 256, p. 168, which gives water from Shakopee-Oneota at 142 ft.)

Formation	Description	Depth (in feet)	Thickness (in feet)

VERMILLION TOWNSHIP

158. Wells at Chicago and Great Western R. R. station at Coates. Sec. 6, T. 114 N., R. 18 W.[3]

Drift	Unclassified	0– 90	90
Shakopee-Oneota	Limestone	90–130	40+

159. Hill south of school and cemetery. NE¼ Sec. 8, T. 114 N., R. 18 W. Elevation 941 ft.[2]

Drift Gravel. Exposed on hill.

(May have been mistaken for St. Peter sandstone by Winchell. See *Geology of Minnesota,* 2:80.)

160. Well in NE¼ Sec. 8, T. 118 N., R. 18 W.[26]

Drift	Gravel	0–92	92+

161. Well of Christ Kasel. W½ SE¼ Sec. 16, T. 114 N., R. 18 W. Elevation 861 ft.[44]

Drift	Unclassified	0– 2	2
Shakopee-Oneota	Dolomite	2–65	63+

162. Hill near NW cor. Sec. 18, T. 114 N., R. 18 W. Elevation of contact 1000± ft.[2]

Platteville Limestone (mainly float).
St. Peter Sandstone. 65± ft. exposed.

163. High hill in NW¼ Sec. 18, T. 114 N., R. 18 W.[2]

St. Peter Sandstone exposure on entire hill.

164. Outlier of sandstone west of railroad, center of Sec. 18, T. 114 N., R. 18 W. Elevation of top 942 ft.[26]

St. Peter Sandstone. 60± ft. exposed.

165. Well just south of outcrop near NW cor. Sec. 18, T. 114 N., R. 18 W. Elevation 895 ft.[2]

St. Peter	Sandstone	0–63	63+

166. Dolomite exposure on hill along road between Secs. 21 and 16, about ¼ mile east of NW cor. Sec. 21, T. 114 N., R. 18 W. Elevation 845 ft.[2]

Shakopee-Oneota	Dolomite		10

167. Abandoned quarry ½ mile southwest of village of Vermillion and 500 ft. west of outcrop on road, near E¼ cor. Sec. 21, T. 114 N., R. 18 W. Elevation 870 ft.[2]

Shakopee-Oneota Dolomite. 26 ft. exposed.

168. Well at store across from Chicago and Milwaukee R. R. station at Vermillion. Sec. 22, T. 114 N., R. 18 W. Elevation 843 ft.[45]

Drift	Sand	0–20	20+

169. Road cut 400 ft. south of railroad just southwest of Vermillion, near W¼ cor. Sec. 22, T. 114 N., R. 18 W. Elevation 875 ft.[2]

Shakopee-Oneota Dolomite. Several feet exposed.

170. Well at Chicago and Great Western R. R. station at Empire. Sec. 29, T. 114 N., R. 18 W. Elevation 859± ft.

Drift	Gravel	0–90	90
Shakopee-Oneota	Limestone	90–(?)	(?)

171. Outcrop at old mill. SE¼ Sec. 30, T. 114 N., R. 18 W. Elevation 843± ft.[46]

Shakopee-Oneota Dolomite. Thickness unknown.

[1] Keys Well Drilling Co. [2] G. M. Schwartz and E. P. Burch. [3] M. W. Stephens, driller.
[4] Fostin Beaudette, driller. [5] U. S. Geological Survey, Water Supply Paper 256, p. 166; Winchell, *Geology of Minnesota,* 2:364. [6] E. P. Burch. [7] A. C. Trowbridge and river maps.
[8] W. H. Wheeler, engineer. [9] *Geology of Minnesota,* 2:81.
[10] G. M. Schwartz, E. P. Burch, and W. H. Wheeler. [11] L. H. Gentz, driller.

[12] F. T. Thwaites. [13] Swift and Co. [14] City Engineer, South Saint Paul. [15] J. D. Estabrook. [16] B. B. Decker. [17] U. S. Geological Survey, Water Supply Paper 256, pp. 166, 304 (insert). [18] Armour and Co. and F. T. Thwaites. [19] Armour and Co. [20] J. C. Lutz, chief engineer, St. Paul Union Stockyards. [21] A. F. Meyer. [22] Mr. Ryan, driller. [23] G. M. Schwartz and U. S. Geological Survey, Water Supply Paper 256, p. 169. [24] U. S. Geological Survey, Water Supply Paper 256, pp. 168–69. [25] *Geology of Minnesota,* 2:97. [26] G. M. Schwartz. [27] *Geology of Minnesota,* 2:81. [28] Mr. Lund. [29] P. J. Heins, owner, and Mr. Ryan, driller. [30] E. Lamberg, owner. [31] A. S. Milinowski. [32] T. P. Furlong, owner. [33] U. S. Engineers. [34] T. A. Brown, city clerk. [35] Chicago, Milwaukee, St. Paul and Pacific R. R. Co. [36] W. E. Swan, driller. [37] W. J. Yanz, superintendent. [38] *Geology of Minnesota,* 2:84. [39] *Geology of Minnesota,* 2:83. [40] Cross section by T. L. Duncan. [41] M. Nelson, owner. [42] P. J. Heins, owner. [43] U. S. Geological Survey, Water Supply Paper 256, Plate 5 (cross section). [44] C. Kasel, owner. [45] Owner of store. [46] *Geology of Minnesota,* 2:74.

HENNEPIN COUNTY

Formation	Description	Depth (in feet)	Thickness (in feet)
	HASSAN TOWNSHIP		
1. Well of Hanover Cooperative Dairy Association, west side of Crow River. Elevation 920 ft.[1]			
Drift	Clay and gravel	0–242	242
Franconia(?)	White sandstone	242–250	8
	DAYTON TOWNSHIP		
2. Wells at village of Dayton. Elevation 880± ft.[2]			
Drift	Unclassified. In shallow wells up to 100 ft. deep.		
Franconia or St. Lawrence	Sandstone. Soft white sandstone with good supply of water in 5 closely spaced wells at depths of 75 ft.		
	GREENWOOD TOWNSHIP		
3. Shallow wells at village of Rockford.[3]			
Drift	Gravel. Shown in driven wells on Crow River terraces.		
	CORCORAN TOWNSHIP		
4. Well in Sec. 26, T. 119 N., R. 23 W. Elevation 970± ft.[4]			
Drift	Mostly clay	0–191	
	Water in sand	At bottom	191+
5. Well of George Cook, 3 miles north of Hamel. Sec. 36, T. 119 N., R. 23 W. Elevation 985± ft.[5]			
Drift	Unclassified, mostly clay	0–178	
	Water in sand	At bottom	178+
	MAPLE GROVE TOWNSHIP		
6. Well of Pat Kelly. NW¼ Sec. 30, T. 119 N., R. 22 W. Elevation 980± ft.[5]			
Drift	Mostly clay, some gravel	0–117	117+
7. Well of Robert Cook, 3 miles north of Hamel. SW¼ Sec. 30, T. 119 N., R. 22 W. Elevation 980± ft.[5]			
Drift	Blue clay and yellow, pebbly clay	0–164	164+
8. Well of W. H. Sadler at Eagle Lake, 4 miles northwest of Robbinsdale. Elevation 900 ft.[6]			
Drift	Unclassified	0–79	79+

Formation	Description	Depth (in feet)	Thickness (in feet)

BROOKLYN TOWNSHIP

9. Well 1 mile south of Lyndale Commercial Building. Sec. 13, T. 119 N., R. 21 W. Elevation 850± ft.[7]

Drift	Unclassified	0–154	154
Jordan	Sandstone	At bottom	

10. Village of Osseo well. Elevation 892 ft.[8]

Drift	Unclassified	0–300	300
St. Lawrence and Franconia	Shales and sandstone	300–537	237+

11. Well on Mississippi River east of Brooklyn Center. Sec. 25, T. 119 N., R. 21 W. Elevation 840± ft.[7]

Drift	Unclassified	0–130	130
Shakopee	Sandstone, etc.	At bottom	

12. Well of Theodore Bigelow, east of Brooklyn Center, near 68th St. and Lyndale Ave. N. NE¼ Sec. 35, T. 119 N., R. 21 W. Elevation 850 ft.[7]

Drift	Unclassified	0– 65	65
St. Peter	Sandstone	65–130	65
Shakopee-Oneota	Rotten limestone	130–(?)	(?)

13. Well of Earle Brown. SW¼ SE¼ Sec. 35, T. 119 N., R. 21 W. Elevation 860± ft.[9]

Drift	Clay, sand, and gravel	0–160	160+

14. Well of E. O. Anderson, Lyndale Ave. N. E½ Sec. 36, T. 119 N., R. 21 W. Elevation 840± ft.[7]

Drift	Unclassified	0–94	94
Shakopee-Oneota	Dolomite	At bottom	

INDEPENDENCE TOWNSHIP

15. Well on northeast shore of Lake Independence. E½ Sec. 12, T. 118 N., R. 24 W. Elevation 973 ft.[10]

Drift	Unclassified	0–183	183+

16. Well of E. E. Pierson, ½ mile west of Maple Plain. S½ Sec. 23, T. 118 N., R. 24 W. Elevation 1025 ft.[11]

Drift	Blue clay, fine sand, and gravel	0–216	216
Jordan	Coarse white sandstone; abundant titanite	216–268	52+

17. Well at Hennepin County School No. 61 at Maple Plain. Basement elevation 1028 ft.[12]

Drift	Unclassified. Cased; no log	0–277	277+

18. Well of H. N. Oliver, Maple Plain. SE¼ Sec. 24, T. 118 N., R. 24 W. Elevation 1024 ft.[13]

Drift	Clay	0– 25	
	Clay and sand	25–195	195
Jordan	Sandstone and quicksand	195–253	58+

MEDINA TOWNSHIP

19. Well at Soo Line station at Loretto. Elevation 995 ft.[14]

Drift	Sand and grav-l	0– 70	
	Hardpan	70–110	
	Blue clay	110–170	170
Jordan	Sandstone	170–260	90
St. Lawrence and lower formations	Red shale	260–290	
	White sand	290–312	
	Red shale	312–335	
	White sand	335–340	
	Gray shale	340–390	

Formation	Description	Depth (in feet)	Thickness (in feet)
	Blue shale	390–420	
	Gray shale	420–440	
	Green shale	440–525	
	Sandstone	525–596	336+

20. Well of Soo Line at Hamel. Elevation 986± ft.[16]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Blue clay with small sand layers	0–113	113+

21. Well on Maple Hill Farm of J. A. Sandeen at Lake Independence. SW¼ Sec. 18, T. 118 N., R. 23 W. Elevation 995 ft.[7]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Unclassified	0–200	200
Jordan, etc.	Sandstone	200–350	150+

ORONO TOWNSHIP

22. Well of John Classen at Classen Lake, 2 miles west of Long Lake. SW¼ Sec. 28, T. 118 N., R. 23 W. Elevation 1000 ft.[7]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Unclassified	0–254	254
Jordan(?)	Sandstone	254–256	2+

23. Well at Medina Mills, Long Lake village. SE¼ Sec. 34, T. 118 N., R. 23 W. Elevation 960 ft.[5]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Gravel and sand; blue clay at bottom	0–175	175+

24. Well of Chapin R. Brackett, south side of Long Lake, north of railroad. NW¼ Sec. 35, T. 118 N., R. 23 W. Elevation 970 ft.[16]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Unclassified	0–192	192+

PLYMOUTH TOWNSHIP

25. Well of J. B. Gilfillian, near Parker's Lake. Lot 3, NE¼ Sec. 28, T. 118 N., R. 22 W. Elevation 952 ft.[15]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Clay and sand	0–200	200
St. Peter	Soft sandstone	200–208	
	Hard sandstone	208–236	36
Shakopee-Oneota	Hard rock and quartz	236–374	138
Jordan	Coarse white sandstone	374–418	
	Fine white sandstone	418–500	126 *
St. Lawrence	Blue shale	500–518	18+

CRYSTAL TOWNSHIP

26. Well at 57th and Lyndale Aves. N. SE¼ Sec. 1, T. 118 N., R. 21 W. Elevation 830± ft.[7]

St. Peter — Sandrock struck at 64 ft.

27. Well of A. Jacobwith, southwest of railroad crossing. Sec. 8, T. 118 N., R. 21 W. Elevation 894± ft.[17]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Clay, gravel, and sand	0–146	146
St. Peter	White sandstone	146–172	26
Shakopee-Oneota	Pink limestone	172–178	
	Sandstone	178–186	
	Limestone	186–203	31+

28. Well at Robbinsdale School, 36th Ave. and Great Northern Ry. tracks. Elevation 902 ft.[7]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Unclassified	0–180	180
St. Peter(?)	"Red stuff"	180–186	6+

29. Well at 3622 Perry St., Robbinsdale, on the southwest side of Crystal Lake. Elevation 900± ft.[7]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Unclassified	0– 40	40

* Thick.

Formation	Description	Depth (in feet)	Thickness (in feet)
Platteville	Limestone	40– 44	4
St. Peter	Sandstone	44–144	100+

30. Well at old Certified Dairy, Elmhurst Dairy Farm, Robbinsdale. SW¼ Sec. 16, T. 118 N., R. 21 W. Elevation 900± ft.[7]

Drift	Unclassified	0–160	160+

VILLAGE OF GOLDEN VALLEY

31. Well at Busch Bros. greenhouse. NW¼ Sec. 31, T. 118 N., R. 21 W. Elevation 920 ft.[10]

Drift	Unclassified	0–128	128
St. Peter	Sandstone	128–183	
	Blue shale	183–185	
	Red shale	185–197	
	Shale and sandstone mixed	197–221	
	Buff shale	221–229	
	Sandstone	229–235	107
Shakopee-Oneota	Dolomite	235–236	1+

32. Abandoned quarry on east shore of Twin Lake. NE¼ Sec. 24, T. 118 N., R. 21 W. Elevation 823–40 ft.[9]

Quarry utilized Platteville limestone; now covered with drift.

33. Wells at 35th Ave. N. and France Ave. car line, Robbinsdale. Elevation 891 ft.[7]

Drift	Unclassified	0–245	245
St. Peter(?)	Sandstone	245–250	5+

34. Well at Lowry Ave. or 32nd Ave. N. and Highway No. 52, Robbinsdale. Elevation 924± ft.[7]

Drift	Unclassified	0–86	86
Platteville	Limestone	86–(?)	(?)

35. Well at Minneapolis, Northfield and Southern Ry. shops, southwest Columbia Park. Elevation 837 ft.[18]

Drift	Clay, hardpan, and gravel	0–60	60+

VILLAGE OF ST. LOUIS PARK

36. Well at Renner residence, 4806 W. Lake St., St. Louis Park. Elevation 880 ft.[16]

Drift	Unclassified	0–69	69
Platteville	Limestone	69–75	6
St. Peter	Sandstone	75–76	1+

37. Well at Deforest home, Lake St. and Interior Ave., St. Louis Park.[16]

Drift	Unclassified	0–73	73
Platteville	Limestone	73–91	18+

38. Well at Star of Bethlehem Home, Oakenwald Ave. and Lake St., St. Louis Park. Elevation 940± ft.[16]

Drift	Unclassified	0–118	118
Platteville	Limestone	118–135	17
St. Peter	Sandstone	135–285	150
Shakopee	Limestone	285–340	55+

ST. ANTHONY TOWNSHIP

39. Well at school east of Columbia Heights, Highway No. 63 and Grand Rounds Blvd., Silver Lake. Sec. 6, T. 29 N., R. 23 W.[7]

Drift	Gravel	0–200	200+

40. Well at Armour Golf Course, St. Anthony Blvd. near 22nd Ave. N. E., Minneapolis. Sec. 7, T. 29 N., R. 23 W. Elevation 918 ft.[19]

Drift	Unclassified	0–122	122

Formation	Description	Depth (in feet)	Thickness (in feet)
Platteville	Limestone	122–157	35
St. Peter	Sandstone	157–272	
	Shale(?)	272–318	161
Shakopee-Oneota	Dolomite	318–450	132
Jordan	Sandstone	450–498	48

MINNETRISKA TOWNSHIP

41. Well at Harrison's Bay, Lake Minnetonka. SW¼ Sec. 13, T. 117 N., R. 24 W. Elevation 940± ft.[10]

Drift	Unclassified	0–150	150+

42. Village of Mound well, opposite State Bank building. Elevation 945 ft.[20]

Drift	Clay, sand, and gravel	0–285	285

43. Well at Krause home, south of schoolhouse, Mound. SE¼ Sec. 14, T. 117 N., R. 23 W. Elevation 955 ft.[7]

Drift	Clay, gravel, etc.	0–265	265+

44. Well of R. P. Gale, Whaletail Lake. SE¼ Sec. 16, T. 117 N., R. 24 W. Elevation 1012 ft.[21]

Drift	Clay and gravel	0–175	175+

45. Well at St. Bonifacius Cannery. Sec. 29, T. 117 N., R. 24 W. Elevation 957 ft.[10]

Drift	Unclassified	0–480	480
Franconia	Coarse white sandstone	480–500	20+

46. Well in E½ NW¼ Sec. 33, T. 117 N., R. 24 W. Elevation 1013 ft.[22]

Drift	Boulder clay	0–100	
	Sand with small flow	100–104	
	Bluish clay	104–250	
	Fine to coarse sand	250–290	
	Sand; good water	290–296	296+

47. Well of Crane Island Association, Lake Minnetonka. Sec. 36, T. 117 N., R. 24 W. Elevation 962 ft.[23]

Drift	Unclassified	0–215	215
(?)	Possibly sandrock	215–220	5+

48. Well of Mrs. C. Rigwell, Crane Island. Sec. 36, T. 117 N., R. 24 W. Elevation 963 ft.[9]

Drift	Unclassified	0–286	286+

49A. Well of C. G. Goodrich (at Palmer Hotel of 1887). SW¼ Sec. 36, T. 117 N., R. 24 W. Elevation 1013 ft.[6]

Drift	Gravel and till	0–90	90+

49B. Well on C. G. Goodrich farm on Zumbra Lake near Highway No. 72. Elevation 949 ft.[6]

Drift		0–175	175

50. Well at Goodrich stable. SW¼ Sec. 36, T. 117 N., R. 24 W. Elevation 980 ft.[9]

Drift	Unclassified	0–125	125+

ORONO TOWNSHIP *(Continued)*

51. Well of E. J. Phelps, Ferndale, Lake Minnetonka. SE¼ Sec. 1, T. 117 N., R. 23 W. Elevation 973 ft.[24]

Drift	Unclassified	0–245	245
Shakopee	Dolomite (hard rock)	245–303	58
New Richmond(?)	Sandstone	303–304	1+

Formation	Description	Depth (in feet)	Thickness (in feet)
52. Well of Benjamin S. Bull, Ferndale, Lake Minnetonka. SE¼ Sec. 2, T. 117 N., R. 23 W. Elevation 945 ft.[10]			
Drift	Unclassified	0–224	224
Shakopee-Oneota	Shale and sandstone(?)	224–275	51+
53. Well of Cargill MacMillan, Orono, Lake Minnetonka. SW¼ Sec. 2, T. 117 N., R. 23 W. Elevation 982 ft.[10]			
Drift	Clay	0–163	
	Hardpan	163–176	
	Clay	176–220	
	Hardpan	220–236	
	Water, sand, and gravel	236–250	250+
54. Well of J. H. McMillan, Orono, Lake Minnetonka, on west line of Sec. 2, T. 117 N., R. 23 W. Elevation 997 ft.[10]			
Drift	Blue clay	0–215	
	Gravel	215–220	
	Red clay	220–245	
	Hardpan	245–257	
	Soft sandstone	257–265	
	Red clay or shale	265–281	
	Sandstone and soapstone	281–300	
	Caving sandstone	300–340	340
Oneota	Dolomite	340–380	40
Jordan	Soft sandstone	380–386	6+
55. Well of Joseph Chapman, Orono, Lake Minnetonka. SW¼ Sec. 2, T. 117 N., R. 23 W.[25]			
Drift	Unclassified	0–247	247

EXCELSIOR TOWNSHIP

Formation	Description	Depth (in feet)	Thickness (in feet)
56. Well of W. H. Dunwoody, 2 miles west of Wayzata. NW¼ Sec. 2, T. 117 N., R. 23 W. Elevation 986 ft.[26]			
Drift	Clay and quicksand	0–350	
	Sand	350–365	365+
57. Well of C. K. Velie, Maxwell's Bay. SW¼ Sec. 4, T. 117 N., R. 23 W. Elevation 994 ft.[10]			
Drift	Unclassified	0–280	280
(?)	Sandstone and shale	280–450	170+
58. Well of Willis White, Stubbs Bay, Minnetonka. NE¼ Sec. 5, T. 117 N., R. 23 W. Elevation 1018± ft.[7]			
Drift	Unclassified	0–240	240+
59. Well of C. C. Webber, north of Lafayette Club, Crystal Bay, Lake Minnetonka. SE¼ Sec. 10, T. 117 N., R. 23 W. Elevation 932 ft.[24]			
Drift	Unclassified	0–170	170+
60. Well of Andy Rahn, Crystal Bay, Lake Minnetonka. NE¼ SW¼ Sec. 10, T. 117 N., R. 23 W. Elevation 945 ft.[27]			
Drift	Yellow and blue clay and sand	0–280	280
Jordan(?)	Sandstone	280–320	40+
61. Well of James Ford Bell, Jr., Ferndale, Lake Minnetonka. NE¼ Sec. 12, T. 117 N., R. 23 W. Elevation 974 ft.[24]			
Drift	Unclassified	0–260	260
Shakopee-Oneota	Sandrock	260–280	
	Dolomite	280–350	90+

Formation	Description	Depth (in feet)	Thickness (in feet)
62. Well of C. M. Case, Jr., Maplewood, Lake Minnetonka. SE¼ Sec. 12, T. 117 N., R. 23 W. Elevation 938 ft.[28]			
Drift	Unclassified	0–180	180
St. Peter	Sandstone	180–303	123+
63. Well on Pence estate, Navarre, Lake Minnetonka, near center of Sec. 17, T. 117 N., R. 23 W. Elevation 940 ft.[9]			
Drift	Clay and quicksand Probably sandstone at bottom.	0–315	315+
64. Well of Hotel Del Otero, Spring Park, Lake Minnetonka. Elevation 958 ft.[29]			
Drift	Sand, gravel, and clay	0–297	297+
65. Well of C. F. Haglin, west end of Big Island, Lake Minnetonka. Elevation 960 ft.[30]			
Drift	Unclassified	0–340	340
Oneota	Dolomite	340–360	20
Jordan	Sandstone	360–485	125 *
St. Lawrence	Shale	485–506	
	Green shale	506–507	22+
66. Well of Minneapolis Suburban R. R., Big Island Park, Lake Minnetonka. Elevation 950 ft.[31]			
Drift	Black soil	0– 3	
	Clay	3– 19	
	Hardpan	19– 21	
	Blue clay	21– 38	
	Sand	38– 59	
	Gravel	59– 62	
	Blue clay	62–168	
	Hardpan and stone	168–198	198
Shakopee-Oneota	Hard limestone	198–343	145
Jordan	Sandstone	343–376	33+
67. Well on Douglas estate, Deephaven, Lake Minnetonka, NE¼ Sec. 24, T. 117 N., R. 23 W. Elevation 1003 ft.[10]			
Drift	Unclassified	0–266	266
St. Peter	Sandstone	266–300	34
Shakopee-Oneota	Dolomite	300–447	147
Jordan	White sandstone	447–490	
	Hard red sandstone	490–496	
	White sandstone	496–534	87
St. Lawrence	Blue shale	At bottom	
68. Well of Ward Burton, Deephaven, Lake Minnetonka. NE¼ Sec. 24, T. 117 N., R. 23 W. Elevation 945 ft.[32]			
Drift	Unclassified	0–240	240+
69. Well of George V. Thompson, on a point at Cottagewood, Lake Minnetonka, near center of Sec. 24, T. 117 N., R. 23 W. Elevation 962 ft.[33]			
Drift	Unclassified	0–240	240+
70. Well at Deephaven, Lake Minnetonka. Elevation 980± ft.[10]			
Drift	Unclassified	0–172	172+
71. Well at Tonka Bay Hotel, Lake Minnetonka. Sec. 27, T. 117 N., R. 23 W. Elevation 956 ft.[31]			
Drift		0–170	170
St. Peter	Sandrock	170–194	24
Shakopee-Oneota	Limerock	194–332	138
Jordan	Sandrock	332–439	107

* Thick.

Formation	Description	Depth (in feet)	Thickness (in feet)

72. Well of Jake Young, Wildhurst, Lake Minnetonka, center of Sec. 28, T. 117 N., R. 23 W. Elevation 960 ft.[34]

Drift	Unclassified	0–298	298
New Richmond(?)	Sandstone	298–302	4+

73. Well of H. G. Aldritt at Crescent Beach, Upper Lake Minnetonka, center of Sec. 28, T. 117 N., R. 23 W. Elevation 940 ft.[35]

Drift	Sand	0–325	325+

74. Well of A. E. Fewell, Birch Bluff, Lake Minnetonka. SW¼ Sec. 28, T. 117 N., R. 23 W. Elevation 951 ft.[16]

Drift	Clay and sand	0–235	235
Shakopee-Oneota	Dolomite	235–325	90
Jordan	Sandstone	325–326	1+

75. Well of A. F. Meyer, Edgewood, Lake Minnetonka. SW¼ Sec. 29, T. 117 N., R. 23 W. Elevation 950± ft.[36]

Drift	Sand, clay, gravel, etc.	0–367	367
Possibly some St. Lawrence	Sandstone	367–433	66

76. Well of G. N. Dayton, Boulder Bridge Farm, Smithtown Bay, Lake Minnetonka, near center of Sec. 31, T. 117 N., R. 23 W. Elevation 965 ft.[37]

Drift		0–320	320
(Casing to 290 ft.)			

77. Well of L. W. Bacon at grocery store, Eureka, Lake Minnetonka. NW¼ Sec. 33, T. 117 N., R. 23 W. Elevation 970 ft.[38]

Drift	Unclassified	0–197	197
Shakopee	Dolomite; fissure at bottom	197–208	11+

78. Minnetonka Country Club, Excelsior, near center of Sec. 33, T. 117 N., R. 23 W. Elevation 980 ft.[39]

Drift	Unclassified	0–210	210
Shakopee-Oneota	Dolomite	210–330	120
Jordan	Sandstone	330–410	80+
(Log incomplete.)			

79. Well of George Gillette, Seter farm, west edge of Excelsior. SW¼ NW¼ Sec. 34, T. 117 N., R. 23 W. Elevation 950 ft.[40]

Drift	Unclassified	0–270	270
Jordan	Sandstone	270–315	45+

80. Well of Mr. Carpenter, west edge of Excelsior. Sec. 34, T. 112 N., R. 23 W. Elevation 940± ft.[35]

Drift	Unclassified	0–275	275
(?)	Sandstone	275–298	23+

81. Well at the Minneapolis and St. Louis R. R. station at Excelsior. Elevation 946 ft.[41]

Drift	Unclassified	0–307	307
Shakopee-Oneota	Dolomite	307–342	35
Jordan	Sandstone	342–393	51+

82. Well on Howard property, southwest edge of Excelsior, on county line.[35]

Drift	Unclassified	0–320	320+

83. Well just north of Christmas Lake and south of St. Albans Bay. Sec. 35, T. 117 N., R. 23 W. Elevation 930± ft.[42]

Drift	Unclassified	0–192±	192±
St. Peter	Sandstone	192–200	8+

Formation	Description	Depth (in feet)	Thickness (in feet)
84. Well at Radisson Inn, Christmas Lake. NW¼ Sec. 36, T. 117 N., R. 23 W. Elevation 934 ft.[27]			
Drift	Unclassified	0–300	300
Jordan(?)	Sandstone	300–400	100+
MINNETONKA TOWNSHIP			
85. Well of George Hoke, south side of Gleason Lake. NW¼ Sec. 5, T. 117 N., R. 22 W. Elevation 965 ft.[9]			
Drift	Unclassified	0–123	123
St. Peter	Sandrock	123–135	12+
86. Well of E. V. Nash, Holdridge, Lake Minnetonka. NW¼ Sec. 8, T. 117 N., R. 22 W. Elevation 950 ft.[24]			
Drift	Unclassified	0–146	146
St. Peter	Sandstone	146–241	95+
87. Well of village of Wayzata. Elevation 948 ft.[30]			
Drift	Unclassified	0–245	245
Shakopee-Oneota	Dolomite	245–375	130
Jordan	Sandstone	375–455	80
St. Lawrence		455–640	185
Franconia		640–715	75
Dresbach		715–922	207
Hinckley		922–962	40
88. Well of Sumner B. Young, Breezy Point, Lake Minnetonka. Elevation 933 ft.[24]			
Drift	Unclassified	0–217	217
St. Peter	Sandrock	217–237	
	Shale	237–250	33
Shakopee-Oneota	Hard rock	250–320	
	Clean hard rock	320–395	145
Jordan	Sandrock	395–442	47+
(Horizons somewhat low as compared with nearby data.)			
89. Well of R. L. Nash, Groveland, Lake Minnetonka. SE¼ Sec. 7, T. 117 N., R. 22 W. Elevation 929 ft.[24]			
Drift	Unclassified	0–100	100
St. Peter	Sandstone	100–221	121+
90. Well of H. W. Norton, Groveland, Lake Minnetonka. SE¼ Sec. 7, T. 117 N., R. 22 W. Elevation 963 ft.[27]			
Drift	Unclassified	0–140	140
St. Peter(?)	Sandstone	140–188	48+
91. Well of Justice F. Lowe, Maplewood, Lake Minnetonka. SW¼ Sec. 7, T. 117 N., R. 22 W. Elevation 950 ft.[24]			
Drift	Unclassified	0–233	233
St. Peter	Sandstone	233–260	27
Shakopee	Hard rock	260–304	44
92. Well of Rufus Rand, Gray's Bay, Lake Minnetonka. SE¼ Sec. 8, T. 117 N., R. 22 W. Elevation 962 ft.[43]			
Drift	Unclassified	0–127±	127±
Platteville	Limestone	127–147±	20±
St. Peter	Sandstone	147–312±	165±
Shakopee-Oneota	Dolomite	312–457±	145±
Jordan	Sandstone	457–540	83+
93. Well of H. C. Core, Gray's Bay. SE¼ Sec. 8, T. 117 N., R. 22 W. Elevation 949 ft.[44]			
Drift	Unclassified	0–212	212
St. Peter	Sandrock	212–237	25

Formation	Description	Depth (in feet)	Thickness (in feet)
Shakopee-Oneota	Hard rock	237–321	
	Pink shale and sandrock	321–351	114+

94. Well of Charles S. Burnes, Gray's Bay, Lake Minnetonka. Near S¼ cor. Sec. 8, T. 117 N., R. 22 W. Elevation 966 ft.[16]

Drift	Unclassified	0–120	120
Platteville	Limestone	120–135	15
St. Peter	White sandstone	135–197	48+

95. Well at Oak Ridge Golf Course, Hopkins. Sec. 13, T. 117 N., R. 22 W. Elevation 930± ft.[26]

Drift	Red clay	0– 42	
	Hardpan	42– 80	
	Sand	80–106	
	Sand, gravel, and clay	106–134	134
Platteville	Blue limestone (probably float)	134–149	
	Shale	149–151	17
St. Peter	Sandstone	151–261	
Shakopee-Oneota	Red shale	261–270	
	Shale	270–310	159
	Hard rock	310–392	82+

96A. Well at Decker house, near Minnetonka Boulevard and Minneapolis and St. Louis R. R., Minnetonka Mills. Sec. 15, T. 117 N., R. 22 W. Elevation 920± ft.[7]

Drift	Unclassified	0–86	86
Platteville	Limestone	86–89	3+

96B. Well at T. W. Bennett home. NW¼ NW¼ Sec. 15, T. 117 N., R. 22 W. Elevation 1038 ft.[24]

Drift	Sand, clay, boulders	0–189	
	Red shale	189–197	197
Platteville	Limestone; shale at base	197–228	31
St. Peter	Sandstone	228–306	78

97. Well of L. Blodgett, south of Groveland, Lake Minnetonka. NW¼ Sec. 17, T. 117 N., R. 22 W. Elevation 970 ft.[45]

Drift	Unclassified	0–130	130
St. Peter	Sandstone	130–131	1+

98. Well of E. J. Moles, Groveland, Lake Minnetonka. SW¼ Sec. 17, T. 117 N., R. 22 W. Elevation 955 ft.[46]

Drift	Unclassified	0–160	160
St. Peter	Sandstone	160–195	35+

99. Well on Ever property, west edge of Hopkins. NE¼ Sec. 23, T. 117 N., R. 22 W.[35]

Drift	Unclassified	0–138±	138±
Platteville	Limestone	138–142	4+

100. Well just north of Deephaven Junction, west of Hopkins on abandoned trolley line. Sec. 23, T. 117 N., R. 22 W.[35]

Drift	Unclassified	0–175	175+

101. Well at Hind's home, 243 8th Ave. N., Hopkins. Elevation 929 ft.[35]

Drift	Unclassified	0–98	98
Platteville	Limestone	98–(?)	(?)

102. Well of village of Hopkins. Elevation 920 ft.[30]

Drift	Unclassified	0– 95	95
Platteville	Limestone	95–120	25
St. Peter	Sandstone	120–210	
	Shale	210–235	
	Sandstone	235–270	150
Shakopee-Oneota	Dolomite	270–390	120

Formation	Description	Depth (in feet)	Thickness (in feet)
Jordan	Sandstone	390–470	80
St. Lawrence	Shale	470–660	190
Franconia	Sandstone(?)	660–705	45
Dresbach	Shale and sandstone(?)	705–780	75+

103. Wells at Clear Spring, 3 miles east of Excelsior. Sec. 30, T. 117 N., R. 22 W. Elevation 950 ft.[35]

Drift	Gravel and sand	0–70	70+

104. Well at Glen Lake Sanitarium. Sec. 33, T. 117 N., R. 22 W.[30]

Drift	Unclassified	0–230	230+

(Rock at 230 ft. Probably Shakopee dolomite. Remainder of log not available.)

105. Several wells around Glen Lake. Sec. 34, T. 117 N., R. 22 W. Elevation 950± ft.[35]

Drift Unclassified. Wells up to 200 ft. in depth do not reach solid rock.

VILLAGE OF ST. LOUIS PARK

106. Well no. 1 at Westwood Hill Country Club, Wayzata Blvd. and Columbus Ave., St. Louis Park. Sec. 6, T. 117 N., R. 21 W. Elevation 887 ft.[47]

Drift	Unclassified	0–128	128
St. Peter	Sandstone	128–134	6+

107. Well at Minneapolis Golf Club, Cedar Lake Rd., St. Louis Park. NE¼ Sec. 7, T. 117 N., R. 21 W. Elevation 920± ft.[7]

Drift	Unclassified	0– 99	99
St. Peter	Sandstone	99–100	1+

108. Well at Landers, Morrison, Christenson gravel pit, southwest of Hopkins Junction. SW¼ Sec. 8, T. 117 N., R. 21 W. Elevation 920± ft.[30]

Drift	Unclassified	0– 82	82
Platteville	Limestone	82–100	18
St. Peter	Sandstone	100–265	165
Shakopee-Oneota	Dolomite	265–280	15+

109. Well at Max Renner's shop, Fulton Ave. and Minnetonka Blvd., St. Louis Park. Elevation 925± ft.[16]

Drift	Unclassified	0– 93	93
Platteville	Limestone	93–113	20
St. Peter	Sandstone	113–118	5+

110. Well of Chicago and Milwaukee R. R. at St. Louis Park (1905). Elevation 921 ft.[48]

Drift	Unclassified	0–107	107
Platteville	Shale and limestone	107–111	4
St. Peter	Shale and sandstone	111–260	149
Shakopee-Oneota	Limestone	260–405	145
Jordan	Sandstone	405–485	80
St. Lawrence	Shale and sandstone	485–515	
	Shale	515–670	185
Franconia	Shale and sandstone	670–750	80
Dresbach	Shale	750–785	
	Shale and sandrock	785–804	
	Shale	804–815	
	Shale and sandrock	815–880	
	Sandstone and shale	880–940	190
Hinckley	Sandstone	940–1002	62+

111. Well of village of St. Louis Park. Elevation 919 ft.[49]

Drift	Unclassified	0–109	109
St. Peter	Sandstone	109–274	165
Shakopee-Oneota	Dolomite	274–398	124
Jordan	Sandstone	398–458	60
St. Lawrence	Shale and sandstone	458–540	82+

Formation	Description	Depth (in feet)	Thickness (in feet)

112. Well of Minnesota Sugar Beet Co., Rex Ave. and 2nd St., St. Louis Park. SE¼ Sec. 17, T. 117 N., R. 21 W. Elevation at base 900± ft.[15]

Drift	Gravel	0–73	73
Platteville	Limestone	73–93	20
St. Peter	Sandstone	93–260	167
Shakopee-Oneota	Dolomite	260–385	125
Jordan	Sandstone	385–504	119
St. Lawrence, etc.	No description	504–813	309
Franconia	No description	813–903	90
Dresbach	No description	903–940	37
	Red sandstone, not water-bearing	940–950	10+

VILLAGE OF EDINA

113. Well at Hansen home, 1000 ft. south of Hopkins road and west of Meadowbrook Golf Course. SE¼ Sec. 19, T. 117 N., R. 21 W. Elevation 910 ft.[16]

Drift	Unclassified	0–79	79
Platteville	Limestone	79–90	11
(Incomplete log.)			

114. Well at home of R. G. Hickerson, Wilkins Ave., Interlachen Park. NE¼ Sec. 30, T. 117 N., R. 21 W. Elevation 920± ft.[16]

Drift	Unclassified	0–94	94
Platteville	Limestone	94–108	14+

115. Well at toolhouse in southwest part of Meadowbrook Golf Course. SE¼ Sec. 20, T. 117 N., R. 21 W. Elevation 905+ ft.[19]

Drift	Unclassified	0–80	80
Platteville	Limestone	80–89	9
St. Peter	Sandstone	89–196	
	Red shale	196–205	
	Sandstone	205–245	156
Shakopee-Oneota	Dolomite	245–370	125
Jordan	Sandstone	370–485	115
St. Lawrence	Dolomite and shale(?)	485–487	2+

116. Well of G. A. Smith, 1 block south of St. Louis Park village well, Central Ave. and Grant St. Elevation 919 ft.[16]

Drift	Unclassified	0–190	190
St. Peter	Sandstone	190–240	50+

117. Well at village of Edina, Minnehaha Creek and Highway No. 169. Sec. 28, T. 117 N., R. 21 W. Elevation 875 ft.[24]

Drift	Unclassified	0–62	62
Platteville	Limestone	62–97	35
St. Peter	Sandstone	97–262	165
Shakopee-Oneota	Dolomite	262–385	123
Jordan	Sandstone	385–391	6+

118. Well of Interlachen Country Club, Mirror Lake. SW¼ Sec. 29, T. 117 N., R. 21 W. Elevation 900± ft.[16]

Drift	Unclassified	0–145	145
St. Peter	Sandstone	145–230	85
Shakopee-Oneota	Dolomite	230–370	140
Jordan	Sandstone	370–430	60+

119. Well on south side of Mirror Lake, Edina. Sec. 29, T. 117 N., R. 21 W. Elevation 950± ft.[7]

Drift	Unclassified	0–135	135
St. Peter	Sandstone	135–235	
	Red shale(?)	235–245	
	Sandstone	245–280	145+

Formation	Description	Depth (in feet)	Thickness (in feet)
	VILLAGE OF ST. LOUIS PARK *(Continued)*		

120. Well at Interior Elevator Co., Salem Ave. and Chicago and Milwaukee R.R. tracks, just west of Minneapolis. Elevation 900± ft.[50]

Drift	Unclassified	0– 75	75
Platteville	Limestone	75–100	25
St. Peter	Sandstone	100–250	150
Shakopee	Dolomite	250–295	45
New Richmond	Sandstone	295–310	15
Oneota	Dolomite	310–390	80
Jordan	Sandstone	390–495	105
St. Lawrence		495–710	215
Franconia	Sandstone (?)	710–755	45+

121. Wells at Hedberg, Freidheim & Co. sandpit, bounded by Raleigh St., Elm Place, Highland St., and Goodrich Ave., St. Louis Park.[16]

Well No. 1 (Elevation 887 ft.)

Drift	Unclassified	0– 60	60
Platteville	Soapstone	60– 80	20
St. Peter	Sandstone	80–249	169(?)

Well No. 2 (Elevation 875 ft.)

Drift	Unclassified	0– 90	90
Platteville	Limestone or soapstone	90–100	10
St. Peter	Sandstone	100–230	130+

(This log probably in error.)

RICHFIELD TOWNSHIP

122. Well at District School No. 17, Edina. SW¼ Sec. 18, T. 28 N., R. 24 W. Elevation 920± ft.[51]

Drift	Unclassified	0– 99	99
Platteville	Limestone	99–109	10+

123. Well at Edina Country Club toolhouse, 54th and Wooddale. Sec. 18, T. 28 N., R. 23 W. Elevation 902 ft.[10]

Drift	Unclassified	0– 82.6	82.6
Platteville	Limestone	82.6–100.0	17.4
St. Peter	Sandstone	100.0–273.2	173.2
Shakopee-Oneota	Dolomite	273.2–397.4	124.2
Jordan	Sandstone	397.4–483.3	85.9+

124. Well of H. Richardson. SW¼ Sec. 20, T. 28 N., R. 24 W. Elevation 890± ft.[51]

Drift	Sand and gravel	0–92	92
Platteville	Bluish to dull rock	92–98	6+

125. Well of D. F. McGuire, Interlachen Blvd. and Josephine Ave., Edina. Elevation 875 ft.[16]

Drift	Unclassified	0–79	79
Platteville	Limestone	79–90	11+

(Record incomplete.)

126. Well of William Fanchon. NW¼ Sec. 31, T. 28 N., R. 24 W. Elevation 850± ft.[5]

Drift	Unclassified	0–46	46
Platteville	Limestone	46–57	11
St. Peter	White sand	57–(?)	(?)

127. Outcrop at north end of Mendota Bridge, mouth of Minnesota River. Elevation of contact 775 ft.[52]

Platteville	Limestone		15
St. Peter	Sandstone		155

(Shakopee top in contact with St. Peter in bridge piers at elevation 620 ft.)

128. Well no. 1 at Fort Snelling, 1600 ft. southwest of Mendota Bridge. Elevation 720± ft.[63]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Soil, hardpan, and boulders	0– 18	18
St. Peter	Sandstone	18– 60	
	Shale	60– 62	
	Sandstone and shale	62–106	
	Sandstone	106–111	93
Shakopee-Oneota	Dolomite	111–243	132
Jordan	Sandstone	243–319	76
St. Lawrence	Sandstone and shale	319–355	
	Sandstone	355–365	
	Hard rock	365–380	
	Gray sandstone	380–405	
	Green sandstone	405–430	
	Gray sandstone	430–443	
	Shale and sandstone	443–458	
	Shale	458–468	
	Hard green shale	468–480	
	Gray sandstone	480–500	181
Franconia and	White sandstone	500–605	
Dresbach	Hard white sandstone	605–630	130+

129. Wells on farms west of Fort Snelling Reservation. NE¼ Sec. 30, T. 28 N., R. 23 W. Elevation 810± ft.[42]

Drift	Unclassified	0–16	16
Platteville	Limestone	At bottom	

130. Well of Gus Hohag, 39th Ave. S. and 68th St. S½ SW¼ Sec. 30, T. 28 N., R. 23 W. Elevation 830± ft.[44]

Drift	Unclassified	0–175±	175±
Shakopee-Oneota	Soapstone(?)	±175–180±	
	Hard rock (dolomite?)	180–212	37+

131. Outcrops at Fort Snelling. Elevation of surface 810± ft.[3]

There is a high bluff of Platteville and St. Peter at the mouth of the Minnesota River, extending only to Mendota Bridge. There are small exposures near the line between Secs. 28 and 29, and in a gully in SW¼ Sec. 29. There is an old quarry near the north line of Sec. 32, and more or less St. Peter sandstone to near the center of Sec. 32, where there are also small exposures of Platteville. No outcrops are found west of these near the Minnesota River.

EDEN PRAIRIE TOWNSHIP

132. Well of Minneapolis and St. Louis R. R. at Eden Prairie. SE¼ Sec. 17, T. 116 N., R. 22 W. Elevation 885 ft.[41]

Drift	Sand and gravel	0– 45	
	Quicksand	45– 55	
	Blue clay	55–145	
	Blue hardpan	145–205	
	Sand and gravel	205–211	211
Shakopee-Oneota	Hard rock (limestone)	211–306	95
Jordan	White sandstone	306–341	
	Brown sandstone	341–376	
	White sandstone	376–420	114
St. Lawrence	Blue shale and sandstone	420–430	10+

133. Well on Smith property, Eden Prairie. NE¼ Sec. 17, T. 115 N., R. 22 W.[64]

Drift	Unclassified	0– 45	
	Fine, pervious, clayey drift	45–145	
	Sand, gravel, and water	145–169	169+

134. Well at Crosby estate. N½ SE¼ Sec. 36, T. 116 N., R. 22 W. Elevation 832 ft.[65]

Drift	Unclassified	0–288	288+

Formation	Description	Depth (in feet)	Thickness (in feet)
	VILLAGE OF EDINA *(Continued)*		
135. Well of Mrs. H. V. Jones. W½ Sec. 5, T. 116 N., R. 21 W. Elevation 1000± ft.[16]			
Drift	Unclassified	0–160	160
St. Peter	Sandstone	160–306	146+
136. Well of W. C. Leach, on hill southeast of Lake Elizabeth. Sec. 6, T. 116 N., R. 21 W. Elevation 960± ft.[16]			
Drift	Unclassified	0–180	180+
137. Well of George W. Harsh, west of Leach well (see above). Sec. 6, T. 116 N., R. 21 W. Elevation 1020± ft.[16]			
Drift	Unclassified	0–300	300+
	BLOOMINGTON TOWNSHIP		
138. Well of Margaret Guthrie. SW¼ SW¼ Sec. 31, T. 116 N., R. 21 W. Elevation 824 ft.[65]			
Drift	Unclassified	0–328	328+
139. Well at Oxboro, 1 mile northwest of Minneapolis, Northfield and Southern Ry. crossing. NE¼ Sec. 9, T. 27 N., R. 24 W. Elevation 840± ft.[7]			
Drift	Unclassified	0–226	226+
140. Well of Leo Pahl, north bank of Minnesota River, ¼ mile east of Cedar Ave. NE¼ Sec. 13, T. 27 N., R. 24 W. Elevation 700± ft.[17]			
Drift		0–192	192
Jordan	Sandstone	192–217	25+
141. Well at Oxboro, near Minneapolis, Northfield and Southern Ry. crossing. NW¼ Sec. 15, T. 22 N., R. 24 W. Elevation 840± ft.[7]			
Drift	Unclassified	0–240	240+
142. Well at Bloomington Consolidated School, south end of Penn. Ave. S. and Highway No. 52. NW cor. Sec. 21, T. 27 N., R. 24 W. Elevation 820± ft.[16]			
Drift	Gravel, etc.	0–130	130+
143. Well of Dr. S. E. Sweitzer, near Lyndale Ave. and Minnesota River. SW¼ Sec. 22, T. 27 N., R. 24 W. Elevation 827 ft.[17]			
Drift	Unclassified	0–270	270
Shakopee-Oneota	Limestone	270–280	10
Jordan	Sandstone	280–315	35+
144. Flowing well on T. J. Hopkins farm, at river flat. SW¼ Sec. 22, T. 27 N., R. 24 W. Elevation 715 ft.[50]			
Drift	Sand, gravel, and blue clay	0– 81	81
Shakopee-Oneota	Limestone	81– 86	
	Sandstone	86–101	
	Limestone	101–181	100
Jordan	Sandstone	181–258	77+
145. Well of Mr. Carpenter, 1 mile southwest of Cedar Avenue Bridge, on north bank of Minnesota River. Sec. 23, T. 27 N., R. 24 W. Elevation 700± ft.[17]			
Drift	Unclassified	0– 80	80
Shakopee-Oneota	Dolomite	80–200	120+
146. Well at Girl Scouts' Club, ½ mile west of Lyndale Ave. S. and ¾ mile north of Minnesota River. SW¼ Sec. 22, T. 27 N., R. 24 W. Elevation 810± ft.[7]			
Drift	Mud and soft sand	0–256	256+
147. Well at Masonic Home heating plant. Sec. 30, T. 27 N., R. 24 W. Elevation 850 ft.[16]			
Drift	Unclassified	Unknown	
Shakopee-Oneota	Dolomite	Unknown	
Jordan	Sandstone	273–363	90

Formation	Description	Depth (in feet)	Thickness (in feet)
148. Well of B. J. Kostuch, 34th Ave. S. and 80th St. NW¼ Sec. 6, T. 27 N., R. 24 W. Elevation 826 ft.[17]			
Drift	Unclassified	0–285	285
Shakopee-Oneota	Dolomite and sandstone	285–300	
	Hard rock	300–340	55+
(Probably Jordan at bottom.)			
149. Well at Masonic Home (farm well no. 2, drilled in 1933). Sec. 4, T. 26 N., R. 24 W. Elevation 822 ft.[16]			
Drift	Unclassified	0–165	165
Shakopee-Oneota	Dolomite	165–260	95
Jordan	Sandstone	260–270	10+
150. Well of John Brown on river bluff near Bloomington Ferry. NE¼ Sec. 6, T. 115 N., R. 21 W.[54]			
Drift	Clay and sand	0– 88	
	Clay	88–178	
	Gravel	178–189	189+

[1] F. E. Ordoff, secretary. [2] Henry L. Beaudry and Henry Kurtz. [3] G. M. Schwartz. [4] *Geology of Minnesota,* 2:306. [5] *Geology of Minnesota,* 2:307. [6] C. W. Hall, notes. [7] B. B. Decker, driller. [8] Report of the Minneapolis Water Commission, 1932. [9] E. P. Burch. [10] Keys Well Drilling Co. [11] E. E. Pierson, owner. [12] School janitor. [13] J. E. Butterfield. [14] Soo Line engineering department. [15] C. W. Hall. [16] Renner Well Co. [17] Fostin Beaudette, driller. [18] Minneapolis, Northfield and Southern Ry. Co. [19] Minneapolis Park Board. [20] A. S. Milinowski, engineer. [21] R. P. Gale, owner. [22] C. W. Hall and E. C. Gale. [23] Secretary of Crane Island Association. [24] L. J. Hemphill, driller. [25] Minnesota State Board of Health. [26] S. Swenson. [27] F. W. Renner, driller. [28] C. M. Case, owner. [29] M. W. Stephens, driller. [30] McCarthy Well Co. [31] G. L. Wilson, chief engineer, Minneapolis Suburban R.R. Co. [32] Mr. Cruickshank, driller. [33] G. V. Thompson, owner. [34] Mr. Klassen, driller. [35] Mr. Hinds, driller. [36] B. B. Decker and T. J. Decker, drillers. [37] G. N. Dayton, owner. [38] L. W. Bacon, owner. [39] Secretary of Minnetonka Country Club. [40] G. Gillette, owner. [41] Minneapolis and St. Louis R.R. engineering department. [42] Gus Hohag, driller. [43] T. Wirth, Minnetonka Report, 1935. [44] H. C. Core, owner. [45] L. Blodgett, owner. [46] E. J. Moles, owner. [47] S. Norling, engineer. [48] Chicago, Milwaukee, St. Paul and Pacific R.R. Co. engineering department. [49] B. H. Bradley, engineer. [50] U.S. Geological Survey, Water Supply Paper 256, Plate 10. [51] *Geology of Minnesota,* 2:309. [52] W. H. Wheeler. [53] C. W. Hall, notes (1902). [54] *Geology of Minnesota,* 2:308. [55] J. H. Kruger. [56] T. J. Hopkins, owner.

RAMSEY COUNTY

MOUNDS VIEW TOWNSHIP

Formation	Description	Depth (in feet)	Thickness (in feet)
1. Well at Snelling and County Road G, near SW cor. Sec. 15, T. 30 N., R. 23 W. Elevation 960 ft.[1]			
Drift	Unclassified	0–185	185
2. County well at north side of Snail Lake, Unit No. 6, near line between Secs. 23 and 24, T. 30 N., R. 23 W. Elevation 888 ft.[2]			
Drift	Peat	0– 24	
	Quicksand	24– 36	
	Sandy clay	36– 56	
	Sand and gravel	56–116	
	Clay	116–124	

Formation	Description	Depth (in feet)	Thickness (in feet)
	Sand and gravel	124–208	
	Clay	208–216	216
Shakopee-Oneota	Vuggy soapstone and limestone	216–245	29+

3. Well of Soo Line at Cardigan Junction, between Grass and Vadnais lakes. Sec. 25, T. 30 N., R. 23 W. Elevation 906 ft.[3]

Drift	Undifferentiated	0–314	314
Shakopee-Oneota	Dolomite	314–322	8+

4. Well at New Brighton, on main highway through village. Elevation 940 ft.[4]

Drift	Gravel and sand	0–192	192
(?)	Slate rock	192–272	80
	White sandrock	272–358	86+

5. Well of Gibbs Coal Co., near south edge of New Brighton. Sec. 29, T. 30 N., R. 23 W. Elevation 920± ft.[5]

Drift	Blue clay	0–218	218
Shakopee-Oneota	Limestone with sandstone lens	218–232	14+

6. Well northeast of Silver Lake on County Road E. Sec. 30, T. 30 N., R. 23 W. Elevation 960 ft.[1]

Drift	Undifferentiated	0–106	106
St. Peter	Sandstone	106–206	100+

7. Well at Schultz home, on Highway No. 63. SE cor. Sec. 32, T. 30 N., R. 23 W. Elevation 905 ft.[1]

Drift	Unclassified	0–48	48
Platteville	Limestone	48–70	22
St. Peter	Sandstones	70–85	15+

8. Well of Carl Christensen, northwest side of Lake Josephine. Sec. 34, T. 30 N., R. 23 W.[6]

Drift	Undifferentiated	0– 86	86
St. Peter	Soft sandstone	86–132	56+

9. Well at Lake Josephine, Unit No. 5. Sec. 34, T. 30 N., R. 23 W. Elevation 885 ft.[2]

Drift	Clay, sand, and gravel	0–184	184
St. Peter	Soapstone (slate or limestone)	184–195	
	Sandstone	195–239	55
Shakopee-Oneota	Shale	239–255	
	Dolomite	255–332	
	Sandy shale	332–374	135
Jordan	Sandstone	374–417	
	Shale and limestone (sediment pocket)	417–478	104

10. Well of G. Keller at Lexington Ave. and County Road E, near SW cor. Sec. 26, T. 30 N., R. 23 W. Elevation 935 ft.[1]

Drift	Unclassified	0– 99	99
Platteville	Limestone	99–103	4+

11. Well at Lake Owasso, Unit No. 4. Sec. 36, T. 30 N., R. 23 W. Elevation 891 ft.[2]

Drift	Yellow clay	0– 27	
	Red clay	27– 47	
	Sand and gravel	47– 72	
	Sandy red clay	72– 94	
	Sand and gravel	94–136	136
Platteville	Limestone (float?)	136–142	6
St. Peter	Sandstone	142–214	
	Shale	212–277	135
Shakopee-Oneota	Limestone	277–312	
	Sandy limestone	312–354	
	Shale	354–390	
	Sandy shale	390–402	125

Formation	Description	Depth (in feet)	Thickness (in feet)
Jordan	Sandstone	402–480	78
St. Lawrence	Limestone	480–514	34+

WHITE BEAR TOWNSHIP

12. Well on west side of Wilkinson Lake. SW cor. NE¼ NE¼ Sec. 5, T. 30 N., R. 22 W. Elevation 895 ft.[7]

Drift	Clay, boulders, gravel, etc.	0–129	129
St. Peter	Sandstone and shell rock	129–141	
	Blue shale	141–147	
	Sandstone	147–152	
	Gray hardpan	152–162	33
Shakopee-Oneota*	Red lime and flint rock	162–250	
	Sandstone	250–253	
	Red flinty hard rock	253–329	167
Jordan	Soft rock	329–333	
	Hard rock	333–338	
	Sandstone	338–422	93+

(This is sometimes referred to as north of Pleasant Lake; there is no city well at Pleasant Lake.)

13. Well at White Bear Beach, Bald Eagle, 1 mile northeast of present Soo Line station at Bald Eagle. Sec. 1, T. 30 N., R. 22 W. Elevation 934 ft.[3]

Drift	Gravel	0– 40	
	Sand	40– 55	
	Hardpan	55– 80	
	Gravel	80– 95	
	Sand	95–115	115
St. Peter	Hard rock	115–145	30
Shakopee-Oneota	Sandrock	145–170	
	Hard rock	170–175	
	Sandrock	175–280	135
Jordan	Shale	280–365	85
St. Lawrence	Sandrock	365–550	185+

14. Well at north point of White Bear Lake, Unit No. 9. Sec. 12, T. 30 N., R. 22 W. Elevation 926 ft.[2]

Drift	Undifferentiated	0– 94	94
St. Peter	Soft sandrock	94–125	31
Shakopee	Limestone	125–177	52
New Richmond	Sandstone	177–189	12
Oneota	Limestone	189–259	70
Jordan	Sandstone	259–347	88
St. Lawrence	Shaly limestone; blue-green shale	347–534	187
Franconia	Sandstone	534–584	50
Dresbach	Shale	584–616	32+

15. Well at northwest part of White Bear Lake, northeast of city, White Bear–Bald Eagle Unit No. 3. Sec. 12, T. 30 N., R. 22 W. Elevation 928 ft.[2]

Drift	Undifferentiated	0–173	173
Shakopee-Oneota	Limestone	173–290	117
Jordan	Sandstone	290–384	94
St. Lawrence	Green shale	384–570	186
Franconia	Sandstone	570–620	50
Dresbach	Sandy limestone	620–632	
	Limestone	632–733	(?)
Hinckley (in part?)	Sandstone	733–827	(?)

16. Well no. 1 of village of White Bear Lake. Elevation 932 ft.[7]

Drift	Sand	0– 28	
	Blue clay	28– 88	
	Sand and gravel	88–127	

* About 30 ft. above the normal thickness.

Formation	Description	Depth (in feet)	Thickness (in feet)
	Shale and rock	127–149	149
Shakopee-Oneota	Limestone	149–299	150
Jordan	Sandstone	299–359	60
St. Lawrence	Slate and limestone	359–409	
	Sandstone	409–421	
	Limestone	421–471	
	Slate and sandstone	471–505	146

17. Well at White Bear Lake, Unit No. 1 (1904). SW¼ Sec. 13, T. 30 N., R. 22 W. Elevation 927.9 ft.[2]

Drift	Undifferentiated	0–150	150
Shakopee-Oneota	Limestone	150–305	155
Jordan	Sandstone	305–400	95
St. Lawrence	Green shale	400–450	
	Sandstone	450–505	105

18. Well at Birch Lake, Unit No. 8. Sec. 15, T. 30 N., R. 22 W. Elevation 918 ft.[2]

Drift	Undifferentiated	0–195	195
Shakopee-Oneota	Limestone and some shale	195–320	125
Jordan	Sandstone	320–411	91
St. Lawrence	Shale	411–430	19

19. Well of Northern Pacific Ry. at village of White Bear Lake. Elevation 933 ft.[8]

Drift	No record	0–176	176
Shakopee-Oneota and Jordan	Limestone	176–386	210
St. Lawrence	Blue shale	386–486	100
	Limestone	486–496	10
	Sandstone	496–521	25
	Limestone	521–550	29
Franconia	Sandstone	550–650	100
Dresbach	Limestone	650–731	81
	Blue soapstone	731–777	46

20. Well of O. Claussen, south side of White Bear Lake, 1 mile west of Ramsey-Washington county line. Sec. 24, T. 30 N., R. 22 W. Elevation 940± ft.[9]

Drift	Unclassified	0–100	100
St. Peter	Sandstone(?)	100–180	80+

21. Well of Thomas Daniels, Gem Lake. SW¼ Sec. 27, T. 30 N., R. 22 W. Elevation 975± ft.[6]

Drift	Undifferentiated	0–280	280
Shakopee-Oneota	Dolomite	280–439.3	159.3

22. Well A at Lake Vadnais, northeast of NW Sec. 31, T. 30 N., R. 22 W. Elevation 886 ft.[7]

Drift	Loam	0– 7	
	Sand	7– 13	
	Boulders	13– 43	
	Hardpan	43– 73	
	Sand and gravel	73– 79	
	Hardpan with boulders	79–105	
	Sand and gravel	105–129	
	Coarse gravel	129–149	
	Sand and gravel	149–213	213
St. Peter	Sandstone	213–231	18
Shakopee-Oneota	Gray limestone	231–301	
	Pink limestone	301–352	121
Jordan	Sandstone	352–433	81
St. Lawrence	Blue shale	433–531	
	White sandstone	531–537	
	Blue shale	537–615	182
Franconia	White sandstone	615–726	111±

Formation	Description	Depth (in feet)	Thickness (in feet)
23. Well no. 9 at Vadnais Plant, St. Paul Water Department. Sec. 31, T. 30 N., R. 22 W. Elevation 883 ft.[7]			
Drift	Loam	0– 3	
	Sand and boulders	3– 29	
	Hardpan	29– 33	
	Gravelly clay	33– 41	
	Sand and gravel	41–232	232
Shakopee-Oneota	Limestone	232–299	67
Jordan(?)	Sandstone	299–326	27
St. Lawrence(?)	Limestone	326–354	28
Franconia(?)	White sandstone	354–666	312+
24. Well at Marten's Greenhouse, White Bear Ave. and Wildwood Road. NW¼ NE¼ Sec. 35, T. 30 N., R. 22 W. Elevation 955± ft.[6]			
Drift	Undifferentiated	0– 57	57
Platteville	Limestone	57– 87	30
St. Peter	Sandstone	87–109	22+
25. Well at Gall Golf Course, County Road D, 1 mile east of White Bear Ave. SW cor. Sec. 36, T. 30 N., R. 22 W. Elevation 980± ft.[10]			
Drift	Gravel	0– 75	75
Platteville	Limestone	75– 95	
	Soapstone	95–105	30
St. Peter	White sandstone	105–230	125+
ROSE TOWNSHIP			
26. Well at Arden Dairy, southwest side of Lake Josephine. Sec. 3, T. 29 N., R. 23 W.[4]			
Drift	Sand and gravel	0–158	158+
27. Well of Anton Weinholtzer at Snelling Ave. and County Road C. SW¼ Sec. 3, T. 29 N., R. 23 W. Elevation 950± ft.[6]			
Drift	Undifferentiated	0–130	130
Platteville	Limestone	130–165	35+
28. Well between Hamline Ave. and County Roads C and B. Sec. 10, T. 29 N., R. 23 W. Elevation 920± ft.[1]			
Drift	Undifferentiated	0–97	97+
29. Well of Mrs. Mertes, Snelling Ave. and County Road A. NW¼ Sec. 21, T. 29 N., R. 23 W. Elevation 960± ft.[6]			
Drift	Clay and hardpan	0– 30	
	Sand and gravel	30–104	104
Decorah	Gray soapstone	104–118	
	Blue rock	118–120	
	Blue soapstone	120–182	78
Platteville	Limestone	182–200	18+
30. Well of Edward Lynch at Cleveland Ave., ¾ mile north of Larpenteur Ave. NW¼ Sec. 16, T. 29 N., R. 23 W. Elevation 960± ft.[6]			
Drift	Red clay	0– 40	
	Stones and sand	40–106	
	Blue clay and gravel	106–116	116
Decorah	Hard soapstone	116–119	
	Hard limestone	119–133	
	Soapstone	133–151	35+
31. Well at Larpenteur and Snelling Aves. Sec. 16, T. 29 N., R. 23 W. Elevation 955± ft.[1]			
Drift	Unclassified	0–137	137+
32A. Well at University of Minnesota Farm School Experimental Station, west of fair-grounds. Elevation 957± ft.[11]			
Drift	Undifferentiated	0–165	165

Formation	Description	Depth (in feet)	Thickness (in feet)
Platteville	Limestone	165–200	35
St. Peter	Sandstone	200–280	80

32B. Well at University of Minnesota Farm Campus Pumphouse.[4]

Drift	Coarse sand and gravel	0– 25	
	Fine sand	25– 90	
	Coarse sand and gravel	90–115	
	Fine sand	115–135	
	Coarse sand or sandstone	135–205	205
Platteville	Limestone	205–280	75

33. Well at University of Minnesota Farm Campus Power Station. Elevation 957 ft.[12]

Drift	Sand and gravel	0– 55	
	Blue clay	55–125	
	Coarse gravel	125–164	164
Platteville	Limestone	164–200	36
St. Peter	White sandstone	200–270	
	Yellow sandstone	270–285	
	White sandstone	285–310	
	Blue shale	310–320	
	Sandy shale	320–365	165
Shakopee-Oneota	Hard rock (limestone)	365–490	125
Jordan	White sandstone	490–590	100
St. Lawrence	Blue shale	590–(?)	(?)

NEW CANADA TOWNSHIP

34. Ramsey County well at Silver Lake, Unit No. 13. Sec. 1, T. 29 N., R. 22 W. Elevation 991 ft.[2]

Drift	Undifferentiated	0– 96	96
Platteville	Soapstone and limestone	96–138	42
St. Peter	Sandstone	138–280	142
Shakopee-Oneota	Limestone	280–307	
	Gray and green shale	307–425	145
Jordan	Sandstone	425–494	69
St. Lawrence	No record	494–618	124+

35. Ramsey County well at Round Lake, Unit No. 12. SW¼ Sec. 6, T. 29 N., R. 22 W. Elevation 912.22 ft.[2]

Drift	Clay	0– 18	
	Sand and gravel	18– 23	
	Coarse sand	23– 50	
	Coarse gravel	50– 70	
	Blue clay	70– 73	
	Coarse gravel	73– 79	
	Fine sand	79–128	
	Gravel	128–138	
	Coarse gravel	138–160	
	Sand	160–285	285
Shakopee-Oneota	Limestone with crevices	285–331	
	Sandy limestone	331–408	123
Jordan	Soft sandstone	408–417	9+

36. Well of the Minnesota Hog Farm, Rice St. and County Road B, southwest of SE cor. Sec. 7, T. 29 N., R. 22 W. Elevation 943± ft.[6]

Drift	Undifferentiated	0– 78	78
Platteville	Limestone	78–100	22+

37. Well at electric railway stop, south side of North St. Paul. Sec. 12, T. 29 N., R. 22 W.[1]

Drift	Unclassified	0–76.6	76.6
Platteville	Limestone	76.6–77	.4+

Formation	Description	Depth (in feet)	Thickness (in feet)

38. Well of St. Paul Table Co. (probably Luger Furniture Co.), North St. Paul. Elevation 980± ft.[1]

Drift	Undifferentiated	0–54	54
Decorah(?)	Shale and limestone	54–61	7+

39. Well of John Luger, 311 Eighth Ave. N. E., North St. Paul. Elevation 1005± ft.[1]

Drift	Unclassified	0–138	138
Platteville	Blue soapstone at bottom		(?)

40. Well of village of North St. Paul. Elevation 1000 ft.[7]

Drift	Undifferentiated	0–113	113
Platteville	Gray limestone	113–135	22
Glenwood	Black shale	135–142	7
St. Peter	Sandstone	142–295	153
Shakopee-Oneota	Limestone	295–429	134
Jordan	Sandstone	429–514	85+

41. Well of Martin Smithstak, South Henry St., .4 mile south of South St., North St. Paul. Sec. 13, T. 29 N., R. 22 W. Elevation 1010+ ft.[5]

Drift	Unclassified	0– 91	91
Platteville	Limestone	91–120	29
St. Peter	Sandstone	120–143	23+

42. Well of Jerry Scanlon, south of North St. Paul and .4 mile south of South St. on county line road. NE¼ Sec. 13, T. 29 N., R. 22 W. Elevation 1030± ft.[5]

Drift	Undifferentiated	0–111	111
Platteville	Hard rock (limestone?)	111–143	32
St. Peter	Sandrock	143–170	27+

43. Peters' well on White Bear road just north of Ramsey County Home, near County Road B. NE¼ Sec. 15, T. 29 N., R. 22 W. Elevation 915± ft.[6]

Drift	Hardpan	0– 50	50
Platteville	Limestone	50– 75	
	Soapstone	75– 81	31
St. Peter	Sandstone	81–113	32+

44. Well at Gladstone Public School, near center of Sec. 15, T. 29 N., R. 22 W. Elevation 900 ft.[5]

Drift	Undifferentiated	0–244	244
St. Peter(?)	Sandstone	244–248	4+

45. Well at Northern Pacific Ry. shops, Gladstone. Elevation 900 ft.[13]

Drift	Undifferentiated	0–248	248
Shakopee-Oneota	Limestone	248–448	200 *
Jordan	White sandstone	448–473	25 †
St. Lawrence	Shale	473–503	
	Limestone	503–551	
	White sandstone	551–576	
	Blue shale	576–599	
	White sandstone	599–615	142+

46. Ramsey County well no. 10, north end of Phalen Lake. Sec. 16, T. 29 N., R. 22 W. Elevation 872 ft.[2]

Drift	Red clay	0– 20	
	Sand and gravel	20–110	
	Gravel and boulders	110–120	
	Gravel	120–186	
	Sand and gravel	186–194	
	Gravel	194–240	
	Sand and gravel	240–252	252

* Thick. † Thin.

Formation	Description	Depth (in feet)	Thickness (in feet)
Shakopee-Oneota	Limestone	252–372	120
Jordan	Sandstone	372–438	66
St. Lawrence	Sandy shale	438–467	
	Shale	467–493	55+

47. Well at McCarron Lake Station, St. Paul Water Department. Sec. 18, T. 29 N., R. 22 W. Elevation 846 ft.[7]

Drift	Sand and gravel	0– 60	
	Hardpan	60– 86	
	Soft sand	86–104	104
St. Peter	Sandstone	104–232	128
Shakopee-Oneota	Limestone	232–331	109 *
Jordan	Sandstone	331–453	122 †
St. Lawrence	Blue-green shale and limestone	453–618	165
Franconia	Sandstone	618–681	63
Dresbach	Blue-green shale and sandstone	681–707	26+

48A. Well no. 2 at McCarron Lake Station, St. Paul Water Department. Elevation 847 ft.[7]

Drift	Sand	0– 40	
	Sandstone	40– 50	
	Hardpan	50– 71	
	Sandy hardpan	71–100	100
St. Peter	Sandstone	100–239	139
Shakopee-Oneota	Limestone	239–354	115 †
Jordan	Sandstone	354–460	106 *
St. Lawrence	Blue-green shale and limestone	460-634	174
Franconia	Sandstone	634–680	46
Dresbach	Blue-green shale and sandstone	680–800	120
Hinckley	Sandstone	800–1010	210+

48B. Well no. 3 at McCarron Lake Station, St. Paul Water Department. Elevation 844 ft.[7]

Drift	Sand and gravel	0– 60	
	Clay, sand, gravel, and hardpan	60– 95	95
St. Peter	Sandstone	95–210	115
Shakopee-Oneota	Limestone	210–340	130
Jordan	Sandstone	340–437	97
St. Lawrence	Blue-green shale and limestone	437–631	194
Franconia	Sandstone	631–681	50
Dresbach	Blue-green shale and sandstone	681–717	36

48C. Well no. 4 at McCarron Lake Station, St. Paul Water Department. Elevation 848 ft.[7]

Drift	Sand and gravel	0– 55	
	Gravelly hardpan	55– 84	
	Sand and gravel	84–105	105
St. Peter	Sandstone	105–227	128
Shakopee-Oneota	Limestone	227–349	122
Jordan	Sandstone	349–459	110
St. Lawrence	Blue-green shale and limestone	459–625	166
Franconia	Sandstone	625–675	50
Dresbach	Blue-green shale and limestone	675–711	36+

48D. Well no. 5 at McCarron Lake Station, St. Paul Water Department. Elevation 845 ft.[7]

Drift	Sand and gravel	0– 87	
	Clay, gravel, and hardpan	87–144	144

* Thick. † Thin.

Formation	Description	Depth (in feet)	Thickness (in feet)
St. Peter	Sandstone	144–230	86
Shakopee-Oneota	Limestone	230–319	89
Jordan	Sandstone	319–436	117
St. Lawrence	Blue-green shale and limestone	436–631	195
Franconia	Sandstone	631–686	55
Dresbach	Blue-green shale and limestone	686–714	28+

48E. Well no. 6 at McCarron Lake Station, St. Paul Water Department. Elevation 843 ft.[7]

Drift	Sand and gravel	0– 96	
	Hardpan	96–108	
	Sand and gravel	108–145	145
St. Peter	Sandstone	145–227	82
Shakopee-Oneota	Limestone	227–348	121
Jordan	Sandstone	348–452	104
St. Lawrence	Blue-green shale and limestone	452–638	186
Franconia	Sandstone	638–683	45
Dresbach	Blue-green shale and sandstone	683–718	35+

49. Well at P. Christensen Greenhouse, East and Larpenteur Aves. NW¼ Sec. 24, T. 29 N., R. 22 W. Elevation 1032 ft.[6]

Drift	Undifferentiated	0 –148	148
Platteville	Limestone	148 –184	
	Soapstone	184 –189	41
St. Peter	Sandstone	189 –280	
	Soapstone	280 –282	
	Sandstone	282 –346	157
Shakopee-Oneota	Dolomite	346 –474	128
Jordan	Sandstone	474 –560.5	86.5
St. Lawrence	Shale	560.5–561	(?)

50. Well of Charles Schlattman, ½ mile south of Tanner's Lake. Sec. 1, T. 28 N., R. 22 W. Elevation 975± ft.[6]

Drift	Clay	0–187	
	Gravel	187–193	193+

(Valley extends westward, becoming more pronounced to the west. There was a creek in the valley July 19, 1935.)

51. Well at Railway Car Cafe, ¼ mile east of St. Paul city limits on Hudson road. SW¼ Sec. 36, T. 29 N., R. 22 W. Elevator 995 ft.[14]

Drift	Unclassified	0–120	120
Platteville	Limestone	120–147	27
St. Peter	Sandstone	147–152	5

52. Well at Ramsey County Boys' Farm at Highwood. Sec. 12, T. 28 N., R. 22 W. Elevation 945 ft.[2]

Drift	Sandy clay	0–104	104
St. Peter	Sandstone	104–227	123
Shakopee-Oneota	Hard limestone	227–305	
	Coarse sandstone	305–327	
	Sandy limestone	327–357	130

[1] B. B. Decker, driller. [2] Ramsey County Surveyor's office.
[3] Soo Line engineering department. [4] State Board of Health. [5] J. A. Hoge, driller.
[6] Keys Well Drilling Co. [7] St. Paul Water Department.
[8] St. Paul Water Department and Northern Pacific Ry. Co. [9] E. P. Burch.
[10] A. I. Kuehn, driller. [11] U.S. Geological Survey, Water Supply Paper 256, p. 304.
[12] University of Minnesota Supervising Engineer's office. [13] Northern Pacific Ry. Co.
[14] Hoge Well Co.

SCOTT COUNTY

JACKSON TOWNSHIP

1. Exposures on E. Bluff St., between Dakota and Minnesota Sts., Shakopee. Elevation 720± ft.[1]

Shakopee-Oneota dolomite is exposed in an old quarry and abandoned brick plant. There is about 20 ft. of sandy pink dolomite between a lower terrace about 25 ft. above river level and the upper terrace upon which most of the city of Shakopee is built (probably a rock terrace). There is another outcrop on this east bluff between Market and Main Sts.

2. Highway No. 5 bridge pier at Chicago and Milwaukee R. R. spur at Shakopee. Elevation 727 ft.[2]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Sand, gravel, etc.	0–12	
	Clay and stones	12–14	14
Shakopee	Rock	14–16	2

3. Highway No. 5 bridge pier at south edge of river, Shakopee. Elevation 690 ft.[2]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Sand and silt	0– 9	
	Blue clay	9–22	
	Limestone (boulder)	22–23	
	Silt	23–26	
	Clay	26–29	
	Green clay	29–46	46
Shakopee	Rock	46–47	1

4. Outcrops at Shakopee.[1]

Old quarries and natural outcrops extend for 3 blocks along river bank from 2 blocks west of new bridge on Highway No. 5, showing predominantly pink, vuggy dolomite. The following data are from the map of Trowbridge and Couser:

Elevation:	Top of west quarry	731 ft.
	Bottom of west quarry	705 ft.
	Top of railroad cut	732 ft.
	Bottom of railroad cut	722 ft.

5. Outcrops at Shakopee. Sec. 1, T. 115 N., R. 23 W.[1]

Shakopee-Oneota dolomite is exposed on the west edge of town near the river bank, and at the underpass to railroads on Highway No. 5. It is also exposed in a ditch beginning just west of the corner of Clay and West First Sts., extending to the curve of the railroad bridge.

6. Well of city water works at Shakopee. Elevation 724.6 ft. (Log starts 12 ft. below curb.)[3]

Formation	Description	Depth (in feet)	Thickness (in feet)
Shakopee	Dolomite, brown and sandy	0– 58	58
Jordan	Sandstone, white to brown	58–157	99
St. Lawrence	Shale, sandstone, dolomite	157–333	176
Franconia	Sandstone, white to brown shale	333–431	98
Dresbach	Sandstone	431–632	201
Hinckley	White and brown sandstone	632–703	71+

7. Old quarries 1 mile south of Chicago and North Western Ry. station at Shakopee. Sec. 1, T. 115 N., R. 23 W. Elevation 770 ft.[1]

Quarries and natural exposures extend south from old lime kiln for a mile or more.

8. Well at H. B. Strait's residence, 1 mile south of center of Shakopee. Sec. 12, T. 115 N., R. 23 W. Elevation 720 ft.[4]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Soil and sand	0– 8	
	Clay	8– 38	38
Shakopee-Oneota	Limestone	38–122	84+

9. Well of Matt Huss, south edge of Sec. 12, T. 115 N., R. 23 W. Elevation 820± ft.[5]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Soil	0– 2	
	Sand and gravel	2–15	
	Yellowish till	15–18	18

Formation	Description	Depth (in feet)	Thickness (in feet)
Shakopee-Oneota	Decayed limestone	18–22	
	Hard limestone	22–90	72+

10. Well of John Ederd, near center of Sec. 13, T. 115 N., R. 23 W.[5]

Drift	Stratified sand, clay, and gravel	0–40	40
Shakopee-Oneota	Limestone	40–136	96+

LOUISVILLE TOWNSHIP

11. Outcrops on creek near Minnesota River. Sec. 20, T. 115 N., R. 23 W. Elevation 715 ft.[6]

Oneota-Jordan contact exposed.

12A. Well of Mrs. M. A. Spencer. SE¼ Sec. 20, T. 115 N., R. 23 W. Elevation 720± ft.[6]

Drift	Unclassified	0–(?)	(?)
Shakopee-Oneota	Limestone	(?)–(?)	20+
Jordan	Sandstone	(?)–(?)	(?)

12B. Quarry of Mrs. M. A. Spencer, ⅓ mile east of house. Elevation of quarry 715 ft.; of river 690± ft.[6]

Oneota	Limestone	0–30	30
Jordan	Sandstone	30–34	4+

Oneota-Jordan contact exposed.

13. Outcrops on south side of Sec. 21, T. 115 N., R. 23 W.[7]

Shakopee-Oneota-Jordan contact near southeast corner. Elevation 714 ft.
Shakopee-Oneota dolomite near south corner. Elevation at top 818 ft., at bottom 788 ft.
Other exposures to the east and west.

14. Chicago, St. Paul, Minneapolis and Omaha Ry. well at Merriam Junction (1930). Sec. 28, T. 115 N., R. 23 W. Elevation 758 ft.[8]

Drift	Unclassified	0–39	39
Jordan	Sandstone	39–146	107
St. Lawrence	Gray shale	146–161	
	Limestone	161–185	
	Green shale	185–330	184
Franconia	Sandstone	330–390	60
Dresbach	Gray shale	390–400	
	Brown shale	400–418	
	Green shale	418–440	
	Brown shale	440–470	
	Gray sand	470–485	
	White sand	485–605	215
Hinckley	Light brown sand	605–630	
	Pink sand	630–650	
	Red shale	650–662.5	57.5+

(The log of the 1910 well as given in Water Supply Paper 256 is said by the engineer in charge to be in error.)

15. Exposures along Sand Creek at Jordan in south part of Sec. 29, T. 115 N., R. 23 W. Elevation of contact 724 ft.[1]

Extensive exposures of Jordan and Oneota formations along low bluffs and on islands near Sand Creek.

16. Outcrop in Sec. 31, T. 115 N., R. 23 W. Elevation of crest 693 ft.[9]

Outcrop of Jordan sandstone 2 ft. high at the Little Rapids in the Minnesota River.

EAGLE CREEK TOWNSHIP

17. Exposures 4 miles east of Shakopee. Sec. 3, T. 115 N., R. 22 W. Elevation 720+ ft.[5]

Shakopee dolomite outcrops here beside a small creek north of the road and near the river; above the creek its height is 10–15 ft.

Formation	Description	Depth (in feet)	Thickness (in feet)

18. Shakopee camp for transients. NW¼ NE¼ Sec. 5, T. 115 N., R. 22 W. Elevation 734 ft.[10]

Shakopee-Oneota	Limestone	0–84	84

Hit coarse gravel and stopped. Later well 105 ft. in limerock.
(Outcrop 500 ft. west of camp from Minnesota River level at elevation 691–728 ft.)

19. Outcrops on the Minnesota River near N¼ cor. Sec. 5, T. 115 N., R. 22 W.[7]

Shakopee-Oneota dolomite exposed at 683 ft. and at 703 ft.

20. Exposures on the line between Secs. 5 and 6, T. 115 N., R. 22 W. Elevation at top of outcrop 700± ft.[1]

A ledge of Shakopee-Oneota dolomite is here exposed in a 10–15 ft. high outcrop between the lowest and second terraces. This is probably a continuation of the exposure at the Shakopee brickyard.

21. Well of J. A. Wilder near Shakopee, near NW cor. Sec. 7, T. 115 N., R. 22 W. Elevation 817.3 ft.[4]

Drift	Soil	0– 2	
	Clay	2– 7	
	Sand and gravel	7– 45	45
Shakopee-Oneota	Hard limestone	45–106	
	Quicksand and sandstone	106–108	
	Cherty limestone	108–112	67+

22. Exposures in NE¼ Sec. 8, T. 115 N., R. 22 W. Elevation 760± ft.[1]

Shakopee-Oneota shown by the presence of much buff-colored dolomite in a field just northwest of a cemetery. This indicates that the ledge is very close, and a small shallow pit showed the presence mainly of dolomite.

23. Well of Amos Riggs. SE¼ Sec. 18, T. 115 N., R. 22 W. Elevation 850± ft.[4]

Drift	Soil	0– 2	
	Sand and gravel	2– 40	
	Coarse sand and gravel	40– 50	50
Shakopee-Oneota	Rotten, sandy limestone	50– 55	
	Limestone	55–115	65

GLENDALE TOWNSHIP

24. Flowing well at camp for transients, ¾ miles west of Savage. Sec. 8, T. 115 N., R. 21 W. Elevation 730 ft.[10]

Shakopee-Oneota	Limestone	0–135	135
Jordan	Sandstone	135–225	90
St. Lawrence	Bluish sandrock	225–226	1

25. Outcrop, ½ mile west of Savage. SW¼ Sec. 9, T. 115 N., R. 21 W. Elevation 720 ft.[1]

Outcrop of dolomite at several points on south side of Chicago, St. Paul, Minneapolis and Omaha Ry.

26. Exposures at and near village of Savage (called Hamilton by Winchell). Sec. 31, T. 115 N., R. 21 W. Elevation 730± ft.[5]

"These exposures occur at the lowest points at which the Shakopee-Oneota is seen in the Minnesota Valley. It occurs for about 50 feet along the bottom of the race-way of Quinn Bros. Mill (now a garage in Savage) at a height of 20 to 25 feet above the river. A mile west, and again near Hamilton, abundant fragments of this rock over portions of the bottom lands indicate that ledge is very near the surface."

27. Several wells in village of Savage. Sec. 31, T. 115 N., R. 21 W.[10]

Drift	Soil	0–10±	10±
Shakopee-Oneota	Limestone	±10–30±	20+

28. Well of A. M. Libbey. SE¼ SE¼ Sec. 18, T. 115 N., R. 21 W.[11]

Drift	Soil and clay	0– 5	
	Fine white sand	5–174	174

Formation	Description	Depth (in feet)	Thickness (in feet)
29. Well of Dr. Kenneth Bulkley. SW¼ SE¼ Sec. 18, T. 115 N., R. 21 W. Elevation 870 ft.[11]			
Drift	Clay, etc.	0– 5	5
St. Peter	Sandstone	5–135	130
Shakopee-Oneota	Limestone	135–165	30
30. Test pit at "Boiling Springs" picnic grounds, Hattenberger farm. SW¼ NW¼ Sec. 18, T. 115 N., R. 21 W. Elevation 720± ft.[12]			
Drift	Unclassified	0–30	30
Shakopee-Oneota(?)	Limestone	30–(?)	(?)
31. Well at Conroy's summer resort, Prior Lake. NE¼ Sec. 30, T. 115 N., R. 21 W. Elevation 925± ft. (of Prior Lake 907 ft.).[10]			
Drift	Unclassified	0–165	165
Shakopee-Oneota	Soft limerock and sandrock	165–180	
	Pink limestone	180–255	
	Limestone	255–280	
	White limestone	280–285	
	Gray	285–295	
	Soapstone	295–305	
	Gray soft rock	305–307	137
Jordan	Yellow and red sandstone	307–317	
	White sandstone	317–397	90
St. Lawrence	Blue soapstone	397–427	
	Gray-blue rock	427–437	40

SAND CREEK TOWNSHIP

32. Outcrops in Sec. 4, T. 114 N., R. 23 W. Elevation 757 ft.[13]
Outcrops of Jordan sandstone near top of formation.

Formation	Description	Depth (in feet)	Thickness (in feet)
33. City of Jordan.[14]			
	Exposures along Sand Creek. Elevation of Jordan–St. Lawrence Contact 751 ft.		
Jordan	Sandstone in wells		20±
	Sandstone in quarries, vaults, creek bed, etc. (contact at elevation 751 ft.)		34
St. Lawrence	Dolomite in creek bed		2
	City Well. Elevation 748 ft.		
Drift	Sandy clay and blue clay	0– 36	36
St. Lawrence	Dolomite	36– 41	
	Shale	41–215	179
Franconia	Sandstone	215–290	75
Dresbach	Gray shale	290–298	
	Sandstone	298–303	
	Red shale	303–362	72+
	Minneapolis and St. Louis Ry. Well. Elevation 748 ft.		
Drift	Unclassified	0–112	112
St. Lawrence	Shale and limestone	112–210	98
Franconia	Sandstone	210–285	75
Dresbach	Shale	285–287	2
34. Well of Lawrence Wick, 1 mile north of St. Joe. Sec. 2, T. 114 N., R. 23 W.[15]			
Drift	Unclassified	0–190	190
Jordan	Sandstone	190–200	10+

SPRING LAKE TOWNSHIP

Formation	Description	Depth (in feet)	Thickness (in feet)
35. Well of J. B. Corrigan at village of Prior Lake. Sec. 2, T. 114 N., R. 22 W. Elevation 945 ft.[16]			
Drift	Sand and coarse gravel	0–134	134+

Formation	Description	Depth (in feet)	Thickness (in feet)

36. Railroad station well at Prior Lake (probably at Grainwood, 1 mile west). Sec. 2, T. 114 N., R. 22 W. Elevation 945± ft.[17]

Drift	Soil	0– 2	
	Sand	2– 28	
	Clay	28– 31	
	Sand	31–206	
	Gravel	206–210	210+

37. Well near Prior Lake at railroad station. Sec. 2, T. 114 N., R. 22 W. Elevation 945 ft.[18]

Drift	Unclassified	0–120	120
Shakopee-Oneota	Dolomite	120–210	90
Jordan	Sandstone	210–290	80+

(This well does not correlate with nearby data if elevation 945 ft. is used. No record of any well in town.)

38. Well in village of Spring Lake, between Spring and Long lakes. Sec. 4, T. 114 N., R. 22 W. Elevation 950± ft.[19]

Drift	Gravel and clay	0–120	
	Gumbo	120–330	330+

39. Well of George Hennen. NE¼ Sec. 6, T. 114 N., R. 22 W.[15]

Drift and unknown amount of Oneota		0–200	

Struck Jordan at 200 ft.

40. Well at south side of Spring Lake. SE¼ Sec. 9, T. 114 N., R. 22 W.[15]

Drift	Gravel and clay	0–248	248+

CREDIT RIVER TOWNSHIP

41. Well of Edward Haugh. SW¼ NW¼ Sec. 17, T. 114 N., R. 21 W.[15]

Drift	Unclassified	0–130	130
St. Peter	Sandstone	130–170	40+

42. Well of Casey brothers. SW¼ SW¼ Sec. 17, T. 114 N., R. 21 W. Elevation 990± ft.[20]

Total depth 160 ft. Finished in St. Peter sandstone.

43. Well of L. A. Lord. NE¼ SE¼ Sec. 18, T. 114 N., R. 21 W. Elevation 1025± ft.[21]

Total depth 153 ft. Finished in St. Peter sandstone.

44. Well of John Hauron. SE¼ Sec. 18, T. 114 N., R. 21 W.[15]

Drift	Unclassified	0– 80	80
St. Peter	Sandstone	80–100	20+

45. Well of Mrs. Muelken. NW¼ Sec. 21, T. 114 N., R. 21 W.[15]

Drift	Unclassified	0–100	100
St. Peter	Sandstone	100–120	20+

46. Well of Arnold Pautz. SW¼ Sec. 25, T. 114 N., R. 22 W.[15]

Drift	Unclassified	0–114	114
St. Peter	Sandstone	114–116	2+

(A well in NW¼ Sec. 26 nearby also finished in sandstone.)

[1] G. M. Schwartz. [2] Minnesota Highway Department blueprint. [3] C. R. Stauffer.
[4] *Geology of Minnesota,* 2:125. [5] *Geology of Minnesota,* 2:126.
[6] *Geology of Minnesota,* 2:123. [7] Trowbridge and Couser, map.
[8] Chicago, St. Paul, Minneapolis and Omaha Ry. Co. [9] *Geology of Minnesota,* 2:114.
[10] Fostin Beaudette, driller. [11] Alvah Libbey. [12] H. R. Bergquist. [13] G. A. Thiel.
[14] C. R. Stauffer, *Journal of Geology,* 42:344–45. [15] E. Beaudette, driller.
[16] J. A. Hoge, driller. [17] *Geology of Minnesota,* 2:128–29.
[18] U. S. Geological Survey, Water Supply Paper 256, Plate 5. [19] L. H. Gentz, driller.
[20] Mr. Casey, owner. [21] L. A. Lord, owner.

WASHINGTON COUNTY

Formation	Description	Depth (in feet)	Thickness (in feet)
	FOREST LAKE TOWNSHIP		
1. Well at Forest Lake Creamery. Elevation 915 ft.[1]			
Drift	Unclassified	0–150	150
(?)	Sandstone and shale below	150–450	(?)
2. City of Forest Lake well. Elevation 915 ft.[2]			
Drift	Clay	0– 32	
	Fine water sand	32– 46	
	Red clay	46– 62	
	Red clay, sand, and gravel	62–108	
	Water sand	108–119	119
Jordan	Sandstone	119–145	
	Red shale and sandstone	145–173	
	Fine sandstone	173–192	73
St. Lawrence	Green shale and sandstone	192–277	
	Limestone	277–286	
	Brown shale	286–303	
	Dark green shale	303–320	128
Franconia	Sandstone	320–411	91
Dresbach	Green shale	411–475	
	Sandstone	475–516	
	Green shale	516–520	
	Sandstone	520–532	
	Red shale	532–536	
	Sandstone	536–550	139
Hinckley	Coarse sandstone	550–647	
	Red shale	647–673	123
Granite	Decomposed granite (doubtful; probably arkose)	673–678	5+
3. Well on Mase property at Clear Lake near Forest Lake. Sec. 17, T. 32 N., R. 21 W.[1]			
Drift	Clay	0– 32	
	Quicksand	32– 80	
	Hardpan	80–100	
	Gravel	100–125	125
	Rock	125–129	4
4. Wells in Sec. 32, T. 32 N., R. 21 W.[3]			
200 ft. of gravel; no rock.			
5. Well of Albert Benson, ½ mile north of Scandia. NE¼ Sec. 14, T. 32 N., R. 20 W. Elevation 1035 ft.[3]			
Drift	Unclassified	0– 96	96
Jordan	Sandstone	96–176	80
(?)	Hard rock (black like traprock)	176–191	15
6. Well at Scandia Creamery. Sec. 14, T. 32 N., R. 20 W. Elevation 1020 ft.[3]			
Drift	Unclassified	0–162	162
Jordan	Sandstone	162–202	40+
	NEW SCANDIA TOWNSHIP		
7. Well on north side of Marine Lake. SW¼ Sec. 20, T. 32 N., R. 20 W. Elevation 990± ft.[4]			
Drift	Unclassified	0–80	80
Shakopee-Oneota(?)	Limestone(?)	80–(?)	(?)
8. Well along road on north side of Marine Lake. NW¼ Sec. 20, T. 32 N., R. 20 W. Elevation 990± ft.[4]			
Drift	Unclassified	0–65±	65±

Formation	Description	Depth (in feet)	Thickness (in feet)
Shakopee-Oneota(?)	Light brown rock (limestone?)	65–80	15+

(On south side, in Sec. 19, no rock to 140 ft. depth.)

9. Outcrops along road between Vasa and Scandia, .7 mile northwest of Soo Line. Sec. 25, T. 32 N., R. 20 W. Elevation 962–825 ft.[5]

Jordan-St. Lawrence	White sandstone		137

10. Well of Alvin Dahlin, Marine Lake. NE¼ Sec. 31, T. 32 N., R. 20 W.[4]

Drift	Unclassified	0– 70	70
Shakopee-Oneota(?)	Loose rock (limestone?)	70–100	30+

ONEKA TOWNSHIP

11. Several wells at Hugo.[5]

Drift	Unclassified in wells up to 130 ft. deep; no rock.

12. Well of C. Swanson, east of Hugo. NW¼ Sec. 21, T. 31 N., R. 21 W.[4]

Drift	Unclassified	0–90	90
Shakopee-Oneota(?)	Brownish rock	90–(?)	(?)

MAY TOWNSHIP

13. Well west of tracks near Soo Line station at Marine. Sec. 1, T. 31 N., R. 20 W. Elevation 947 ft. (at station 927 ft.).[3]

Drift	Unclassified	0–98	98
Jordan	Sandstone	98–138	40+

14. Well in SW¼ Sec. 2, T. 31 N., R. 20 W.[4]

Drift	Unclassified	0–160	160+

15. Well at Veteran's Rest Camp, Big Marine Lake. NW¼ Sec. 5, T. 31 N., R. 20 W. Elevation 958 ft.[1]

Drift	Unclassified	0–120	120
Shakopee-Oneota	Rotten limestone	120–133	13
Jordan	Soft sandstone	133–154	
	Hard brown sandstone	154–192	
	White sandstone	192–226	93
St. Lawrence	Dolomite	226–261	35+

16. Well of Elmer Lindgren, southwest of Marine Lake. NE¼ Sec. 7, T. 31 N., R. 20 W. Elevation 1000± ft.[3]

Drift	Unclassified	0–115	115
Jordan(?)	Sandstone	115–136	21+

17. Well ¾ mile north of Soo Line station at Maple Island. Sec. 8, T. 31 N., R. 20 W. Elevation 983 ft.[3]

Drift	Unclassified	0– 96	96
Jordan(?)	Sandstone	96–107	11+

18. Outcrop southwest of Marine, on road up the valley ¼ mile south of town. Sec. 12, T. 31 N., R. 20 W. Elevation of top 860± ft.[5]

Jordan	Sandstone; good outcrop along road.

19. Wells on west side of Big Carnelian Lake. Sec. 34, T. 31 N., R. 20 W. Elevation of lake 912 ft.; of railroad 920 ft.[6]

Drift	Unclassified. Varies from 40–75 ft.
Shakopee-Oneota(?)	Dolomite(?). Water struck at ledge.

20. Well 1 mile east of Carnelian Lake. NW¼ Sec. 36, T. 31 N., R. 20 W.[4]

Drift	Unclassified	0–216	216+

Formation	Description	Depth (in feet)	Thickness (in feet)

MARINE TOWNSHIP

21. Outcrop 1 mile south of Marine Ferry. SW¼ Sec. 7, T. 31 N., R. 19 W. Elevation of top 895± ft.[7]

Jordan	Sandstone. 10 ft. vertical exposure in gully along bluff west of road.		

22. Section at the ferry and along Mill Creek, Marine. Elevation 960.39 ft. (at Soo Line station 929 ft.).[8]

Drift plus	Unclassified to top of hill west of Soo Line station	0.00–157.0	157.0
St. Lawrence	Sandstone, brown, medium to fine, glauconitic (top at 803.39 ft. A. T.)	157.0 –158.5	
	Covered interval, slump and some drift	158.5 –176.55	
	Sandstone, gray, laminated, thin-bedded to shaly, glauconitic, vermicular	176.55–203.85	
	Sandstone, massive, cross-bedded, friable, very glauconitic	203.85–220.52	
	Sandstone, massive, fine-grained, cross-bedded, glauconitic	220.52–239.18	
	Sandstone, massive, mostly covered	239.18–244.18	
	Sandstone, gray to buff, massive, fine-grained	244.18–267.98	
	Sandstone, red to gray, thin-bedded, dolomitic, laminated, with interbedded gray shales and shaly partings in sandstone (to river level at 674.9 ft. A. T.)	267.98–285.49	128.49+

23. Outcrops on highway at south edge of Marine. Sec. 7, T. 31 N., R. 19 W.[5]

Jordan	Sandstone. At bend in road near intersection south of Marine.		

24. Old quarry in NW¼ NW¼ Sec. 19, T. 31 N., R. 19 W. Elevation of top 812± ft.[5]

Shakopee-Oneota	Dolomite. 8 ft. vertical exposure.		

25. Outcrops on highway south of creek, near center of Sec. 19, T. 31 N., R. 19 W. Elevation 772± ft.[5]

Jordan	Sandstone. Wide terrace between river and road shows no rock, but rock is shown on road cut.		

26. Well of C. L. Ramberg. Center of SE¼ Sec. 30, T. 31 N., R. 19 W. Elevation 870± ft.[7]

Jordan	Sandstone	0–128	128
	Soapstone	128–(?)	(?)

(Large outcrop of Jordan sandstone behind barn. Elevation of top 880 ft.)

27. Exposures opposite Arcola Public School. Sec. 30, T. 31 N., R. 19 W. Elevation 920 ft.[8]

Drift(?)	Unclassified	0.0 – 13.3	13.3
Oneota	Dolomite, gray to drab, massive, irregular, rough (in old quarry)	13.3 – 21.3	8.0
Jordan (top at 899.6 ft.)	Sandstone, white to yellow, massive, medium to coarse, with hard layers	21.3 – 31.8	
	Sandstone, yellow to brown and white, massive and thinner-bedded, cross-bedded	31.8 – 63.15	
	Covered interval	63.15– 69.85	
	Sandstone, white, friable, medium-grained	69.85– 71.85	
	Covered interval including the St. Lawrence–Jordan contact	71.85–107.80	94.50
St. Lawrence	Sandstone, yellow to white, massive, cliff-forming (glauconitic)	107.80–142.31	
	Sandstone, gray to yellow, fine-grained, shaly, glauconitic, vermicular	142.31–157.60	
	Sandstone, yellow to white, medium to coarse, cross-bedded	157.60–162.95	

Formation	Description	Depth (in feet)	Thickness (in feet)
	Sandstone, blue to gray, massive to shaly, vermicular, and dolomitic	162.95–179.30	
	Sandstone, gray to yellow, massive, cross-bedded, medium-grained, fossiliferous	179.30–214.20	
	Sandstone, yellow to brown, massive, medium-grained	214.2 –222.90	
	Covered interval to level of St. Croix River	222.9 –230.90	123.1+

28. Old quarry behind Arcola Public School. Sec. 30, T. 31 N., R. 19 W.[5]

Shakopee-Oneota	Dolomite. In old quarry on hill.		

GRANT TOWNSHIP

29. Well at Withrow's store, Kenyon. Sec. 36, T. 31 N., R. 21 W. Elevation 980 ft.[4]

Drift	Unclassified	0–100	100
Shakopee-Oneota	Limestone	100–(?)	(?)

(Wells to south strike no rock at depths up to 140 ft.)

30. Well of Worrel Clarkson, ¼ mile south and 1 mile west of Withrow. Sec. 3, T. 30 N., R. 21 W. Elevation 988± ft.[1]

Drift	Unclassified	0–120	120
Shakopee-Oneota	Dolomite	120–180	60+

31. Well ½ mile north of Duluth Junction. SW¼ Sec. 14, T. 30 N., R. 21 W.[6]

Drift	Quicksand, gravel, etc.	0–120	120+

32. Well of H. P. Gunderson, center of Sec. 16, T. 30 N., R. 21 W. Elevation 1022 ft.[9]

Drift	Sand, gravel, and stony clay	0–88	88+

(At 4 rods northeast St. Peter sandstone is struck at 70 ft. depth.)

33. Well at Lincolntown High School, Mahtomedi. Sec. 20, T. 30 N., R. 21 W. Elevation 990 ft.[1]

Drift	Unclassified	0– 89	89
St. Peter	Soft sandsone	89–209	120
Shakopee-Oneota	Dolomite and sandrock pocket	209–267	58
	Open pocket; sticky black clay	267–272	5+

34. Well of A. E. Kuehn, View St., Mahtomedi. Elevation 980± ft.[10]

Drift	Gravel	0– 75	
	Blue clay	75–105	
	Yellow sand	105–115	115
St. Peter	White sandstone	115–185	70
Shakopee-Oneota	Limestone	185–205	
	Hard limestone with crevices	205–230	45+

35. Well of A. E. Kuehn Well Drilling Co., Mahtomedi. 300 ft. northwest of above.[10]

Drift	Gravel	0– 75	75
St. Peter	White sandstone	75–200	125
Shakopee-Oneota	Limestone with vugs	200–216	16+

36. Well at Soo Line and Northern Pacific Ry. station at Duluth Junction. Sec. 23, T. 30 N., R. 21 W. Elevation 979 ft.[10]

Drift	Red clay	0– 40	
	Blue clay	40– 55	
	Gravel, etc.	55– 85	
	Fine sand	85– 99	99
Shakopee-Oneota	Brown quarry rock (dolomite)	99–119	20+

37. Well at Wildwood Park, White Bear Lake. SW¼ Sec. 29, T. 30 N., R. 21 W. Elevation 939 ft.[11]

Drift	Sand and gravel	0–117	117
	Limestone	117–121	
	Sandstone	121–161	

Formation	Description	Depth (in feet)	Thickness (in feet)
	Slate and sandstone	161–261	140
Jordan	White sandstone	261–311	50
St. Lawrence	Limestone	311–351	40
	Slate and sandstone	351–569.5	218.5

38. Well at Ohio Farm, Birchwood, White Bear Lake. NW¼ Sec. 30, T. 30 N., R. 21 W. Elevation 950± ft.[6]

Drift	Unclassified	0–120	120
Shakopee-Oneota(?)	Limestone	120–130	10+

39. Wells at James' farm. Sec. 30, T. 30 N., R. 21 W.[10]

Drift	Red clay	0– 30	
	Gravel	30– 70	70
St. Peter	White sandstone	70–175	105+

40. Well on north side of Long Lake. Sec. 32, T. 30 N., R. 21 W. Elevation 980 ft.[6]

Drift	Unclassified	0– 85±	85±
St. Peter	Soft white sandstone	85–100±	15+

(Old quarry on west side of lake. Elevation of Platteville 950 ft.)

40A. Well at northwest corner of Long Lake. Sec. 32, T. 30 N., R. 21 W. Elevation 980 ft.[10]

Drift	Unclassified	0– 30	30
Platteville	Limestone	30– 45	15
St. Peter	Sandstone	45–130	85+

41. Abandoned quarry on west shore of Long Lake. SW¼ Sec. 32, T. 30 N., R. 21 W. Elevation of top 950 ft.; of base 935 ft.[12]

42. Well at school in Sec. 35, T. 30 N., R. 21 W. Elevation 939± ft.[6]

Drift	Unclassified	0–100	100
	Sandstone	100–120	20+

STILLWATER TOWNSHIP

43. Quarry along Soo Line tracks near the bridge at Arcola. Sec. 1, T. 30 N., R. 20 W. Elevation of top 900± ft.[8]

Shakopee-Oneota	Dolomite. Exposed in exploration quarry on hill.
Jordan	Sandstone. Exposed in road .1 mile south at elevation 835± ft.

44. Section at the Soo Line–St. Croix River High Bridge, Arcola. Sec. 1, T. 30 N., R. 20 W. Elevation 955 ft.[8]

Drift(?)	Covered interval to top of hill back of old lime kiln	0.00– 12.00	12.00
Oneota	Dolomite, gray to drab, massive, rough	12.00– 32.00	
	Dolomite, gray, somewhat sandy, massive to thin-bedded	32.00– 39.4	
	Covered interval to bottom of quarry	39.4 – 74.8	62.8
Jordan	Covered interval to prominent bench below the old quarry (probably Jordan-Oneota contact at 880.2 ft. A. T.)	74.8 –122.68	
	Sandstone, white to yellow, massive, friable, with thin streaks of greenish shale	122.68–125.68	
	Covered interval over sloping terrace	125.68–189.61	114.81
St. Lawrence	Sandstone, yellow to gray and white, massive, cross-bedded	189.61–216.15	
	Sandstone, yellow to gray, massive, cross-bedded, medium to fine-grained, glauconitic	216.15–230.23	
	Sandstone, gray to blue, shaly, vermicular, glauconitic	230.23–256.37	
	Sandstone, gray, massive, glauconitic, cross-bedded (to level of St. Croix River at 668.9 ft. A. T.)	256.37–294.63	105.02+

Formation	Description	Depth (in feet)	Thickness (in feet)

45. Holes on the Minnesota bank of the St. Croix River, where the Soo Line bridge crosses to Somerset. Sec. 1, T. 30 N., R. 20 W. Elevation of water 666.5 ft.[13]

Formation	Description	Depth (in feet)	Thickness (in feet)
	Hole No. 1		
Drift	Loose rock	0–10	10
(?)	Sandstone	10–14	4+
	Hole No. 2, near West Bank		
	Water	0– 5	5
	Loose rock	5–16	11
	Sandstone	16–20	4+
	Hole No. 4, West Side of West Island		
	Water	0– 6	6
	Soft silt	6–15	9
	Dry silt	15–50	35
	Soft silt	50–65	15
	Light sand and silt	65–80	15
	Hard greensand	80–81	1
	Sandstone	81–87	6+

46. Outcrops on bluff at Harvey's farm. Sec. 11, T. 30 N., R. 20 W. Elevation of contact 840 ft.[7]

Formation	Description
Shakopee-Oneota	Dolomite. About a 45 ft. vertical exposure.
Jordan	Sandstone. Good exposure; contact shown.

47. Section of Boom Hollow, 3 miles north of Stillwater. Sec. 14, T. 30 N., R. 20 W. Elevation 898± ft.[8]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Unclassified	0.00– 20	20
Oneota	Dolomite, gray, rough, vesicular, very massive	20.00– 55	35
Jordan	Sandstone, brown, massive, medium to coarse	55.00– 61	
	Sandstone, gray to white and brown, massive, cross-bedded (top at 843.34 ft. A. T.)	61.00– 76.4	
	Sandstone, white to brown, medium to fine-grained, with numerous trilobites	76.4 – 77.4	
	Sandstone, white to yellow, iron-stained along bedding, massive, cross-bedded	77.4 –129.7	74.7
St. Lawrence	Sandstone, white to green, massive, fine, vermicular	129.7 –151.3	
	Shale of Lodi shale member, blue to gray, compact	151.3 –166.85	
	Covered interval	166.85–185.54	
	Sandstone, gray to brown, massive, dolomitic, medium	185.54–201.34	
	Sandstone, yellow to white, fine, cross-bedded, glauconitic	201.34–222.99	
	Sandstone, gray, glauconitic, vermicular, massive	222.99–231.04	101.34+

48. Exposures on bluff at bend of Highway No. 95 along St. Croix River, 1 mile north of Stillwater bridge. Sec. 15, T. 30 N., R. 20 W. Elevation of top 740 ft.; of river 667.5 ft.[7]

Formation	Description	Depth (in feet)	Thickness (in feet)
St. Lawrence	Sandstone	0–17	
	Green shale and sandstone	17–28	
	Cross-bedded sandstone	28–53	53+

49. Fairy Glen, north of Stillwater. Secs. 15 and 16, T. 30 N., R. 20 W.[7]

Exposures of sandstone for ¼ mile from road to falls. Springs at probable contact of St. Lawrence and Jordan.

50. Old quarry at road bridge over Northern Pacific Ry. and Brown's Creek, Stillwater. NE¼ Sec. 20, T. 30 N., R. 20 W. Elevation of top 864± ft.; of contact 805± ft.[14]

Formation	Description
Shakopee-Oneota	Dolomite. 20 ft. vertical exposure.
Jordan	Sandstone. Exposed in contact with Oneota 1000 ft. downstream. Elevation of contact 805± ft.

Formation	Description	Depth (in feet)	Thickness (in feet)
51. Exposures along Brown's Creek, north edge of Stillwater, from St. Croix River to road bridge over creek and Northern Pacific Ry. Sec. 21, T. 30 N., R. 20 W.[15]			
Fine specimens of oolite in Brown's Creek valley.			
52A. Well at Sycamore and Broadway Sts., Stillwater. Sec. 28, T. 30 N., R. 20 W. Elevation 768 ft.[16]			
Jordan	Sandstone	0–54	54+
52B. Outcrop at rock crusher, Broadway and Stillwater Aves., Stillwater. Elevation of contact 785 ft.[16]			
Contact of Oneota dolomite and Jordan sandstone in crusher pit.			
53. Outcrops in Battle Hollow, behind the old prison, Stillwater. Elevation at base of outcrop 782 ft.[16]			
Shakopee-Oneota	Dolomite. 10 ft. vertical exposure.		
54. Section at the Twin City Foundry, up the bluff and through the C. H. Carli Quarry, Stillwater. Elevation 829.72 ft.[8]			
Drift and soil		0.00– 2.5	2.5
Oneota	Dolomite, gray to buff, thin-bedded to massive	2.50– 14.5	
	Dolomite, gray, massive, rough	14.50– 19.5	
	Dolomite, gray to pink	19.50– 20.5	
	Dolomite, gray to buff, even-bedded, with fucoids	20.50– 23.8	
	Shale and thin-bedded, yellow to buff dolomite	23.80– 24.8	
	Dolomite, gray to buff, rough, massive	24.80– 29.3	
	Dolomite, gray to reddish gray	29.30– 37.3	
	Dolomite, gray to buff, massive, hard, arenaceous. Sharp contact	37.30– 43.3	40.8
Jordan (top at 788.92 A. T.)	Sandstone, white to yellow or brown, massive, hard, medium to coarse	43.30– 66.3	
	Sandstone, white to yellow, massive, cross-bedded, medium to fine-grained	66.30– 97.22	53.92
St. Lawrence	Sandstone, white to yellow, massive, cross-bedded, fine-grained, vermicular	97.22–103.22	
	Sandstone, yellow to white, massive, medium-grained, vermicular	103.22–131.22	
	Sandstone, gray to yellow, shaly	131.22–141.22	
	Covered interval to level of St. Croix River at elevation 666.84 ft. A. T.	141.22–165.94	68.72+
55. Outcrops on bluff at Second and Linden Sts., Stillwater. Elevation 775 ft.[17]			
Shakopee-Oneota	Dolomite. Very small exposure.		
Jordan	Sandstone (upper portion).		
56. City of Stillwater deep well at 4th, 5th, Mulberry, and Myrtle Sts. Elevation (original) 762 ft.[18]			
Data from pit dug in 1934 included:			
Oneota	Dolomite	0– 10	10
Jordan	Sandstone	10– 18.9	
Well:			
Jordan	Sandstone	0– 66	74
St. Lawrence	Shale and glauconitic sandstone	66– 271	205
Franconia	Sandstone, etc.	271– 349	78
Dresbach	Sandstone and sandy shale	349– 540	191
Hinckley	Buff to red sandstone	540– 717	177
Red Clastic	Red shale and arkose	717–3175	2458
Keweenawan flows		3175–3500	325+
57. City of Stillwater well at corner of Laurel and Owen Sts. Elevation 854 ft.[19]			
Drift	Sand and gravel	0–120	
	Blue clay	120–145	

Formation	Description	Depth (in feet)	Thickness (in feet)
	Red clay	145–151	
	Gravel and clay	151–166	166
St. Lawrence	Hard shale and sandstone	166–242	
	Sandstone	242–326	
	Green shale	326–360	194
Franconia	Hard sandstone	360–438	78
Dresbach	Gray shale	438–481	
	Shale and sandstone	481–532	
	Sandstone	532–600	
	Red shale	600–606	168
Hinckley	Sandstone	606–766	160
Red Clastic	Hard gray shale	766–771	
	Red shale	771–776	10+

58. Section of the bluff at the Joseph N. Wolfe Brewery and the gas tank, Stillwater. Elevation 819.9 ft.[8]

Soil	Unclassified	0.0 – .5	.5
Oneota	Dolomite, gray to yellow, thin-bedded	0.5 – 10.0	
	Dolomite, gray, dense, even-bedded	10.0 – 13.5	
	Dolomite, gray, massive, rough, vesicular	13.5 – 17.0	
	Dolomite, gray, massive to thin-bedded, fairly dense	17.0 – 25.5	
	Dolomite, gray to brown, massive, rough, vesicular	25.5 – 31.5	
	Dolomite, gray, fairly massive, even-bedded	31.5 – 39.5	
	Dolomite, gray to brown, massive, arenaceous	39.5 – 56.16	55.66
Jordan (top at 763.74 A. T.)	Sandstone, yellow to brown, massive, cross-bedded	56.16– 60.66	
	Sandstone, white to yellow, massive, medium to coarse-grained, cross-bedded	60.66– 90.66	
	Sandstone, yellow to white, massive to thin-bedded	90.66–101.32	
	Yellow, massive conglomerate	101.32–104.82	48.66
St. Lawrence	Sandstone, white to yellow, massive to thin-bedded	104.82–113.15	
	Sandstone, yellow to white, massive, fine-grained	113.15–119.15	14.33
	Covered interval to level of St. Croix River at 666.84 ft. A. T.	119.15–153.05	33.9+

59. Section through the William McNaughton Quarry, Stillwater. Elevation 866.22 ft.[8]

Drift and soil		0.0 – 1.0	1.0
Shakopee (top at 865.22 A. T.)	Dolomite, gray to buff, massive to thin-bedded, porous	1.0 – 5.0	
	Dolomite, gray, thin-bedded, sandy, with thin layers of sandstone	5.0 – 9.43	
	Dolomite, gray, partly covered	9.43– 19.43	
	Covered interval	19.43– 52.98	
	Dolomite, gray, oolitic (probably Shakopee)	52.98– 53.98	52.98
Oneota	Dolomite, gray to brown, massive; makes up most of McNaughton Quarry	53.98– 82.21	
	Dolomite, drab to gray, massive	82.21–107.21	53.23
Jordan (top at 759.01 A. T.)	Sandstone, yellow to brown, coarse, massive, cross-bedded	107.21–115.21	
	Sandstone, white to yellow, massive, cross-bedded	115.21–155.71	
	Conglomerate, yellow, massive, with flat-lying, flat sandstone pebbles	155.71–159.21	52.00
St. Lawrence	Sandstone, white, fine-grained, with thin streaks of green clay	159.21–161.21	
	Sandstone, yellow to white, massive, banded, fine-grained, full of trails and burrows. Grades into dolomitic sandstone	161.21–179.21	
	Covered interval to level of St. Croix River	179.21–199.38	40.17+

60. Outcrops at the picnic grounds along St. Croix River, south edge of Stillwater.[5]

St. Lawrence(?)	Sandstone, etc., exposed here and north along railroad tracks.

Formation	Description	Depth (in feet)	Thickness (in feet)

OAKDALE TOWNSHIP

61. Well on Berchens farm, near school. Sec. 10, T. 29 N., R. 21 W. Elevation 988± ft.[6]

Drift	Gravel	0– 85	85
Shakopee-Oneota(?)	Limestone	85–120	35+

62A. Well of G. A. Meyer, Lake Elmo village. Sec. 14, T. 29 N., R. 21 W. Elevation 935± ft.[6]

Drift	Unclassified	0–70	70
(?)	Limestone	70–80	10+

62B. Well at Lake Elmo village school. Sec. 14, T. 29 N., R. 21 W. Elevation 930± ft.[6]

Drift	Unclassified	0–110	110±
Shakopee-Oneota	Limestone	110–120	10+

63. Outcrop in Omaha R. R. cut near ¼ cor. Sec. 17/20, T. 29 N., R. 21 W. Elevation 990 ft.[20]

Platteville	Limestone		10

St. Peter sandstone 1100 ft. east. Contact estimated at 970+ ft.

64. Well at Oakdale Lutheran Church, Horseshoe Lake, southeast of Elmo Lake. Sec. 30, T. 29 N., R. 21 W. Elevation 880± ft.[21]

Drift	Unclassified	0– 75	75
Shakopee-Oneota	Yellow limestone	75–200	
	Streak of sand	200–204	
	Hard blue dolomite	204–208	133
Jordan	Soft sandstone	208–211	
	Hard sandstone	211–216	
	White sandstone	216–235	27+

65. Well at Walter home, at northeast end of Tanner's Lake. NW¼ Sec. 31, T. 29 N., R. 21 W. Elevation 983± ft.[21]

Drift	Hardpan, etc.	0– 73	73
Platteville	Flinty rock with brown specks	73–105	32
St. Peter	Sandstone	105–109	4+

66. Well of John Schilten, southeast of Tanner's Lake, 500 ft. from Highway No. 12. Sec. 31, T. 29 N., R. 21 W. Elevation 976 ft.[21]

Drift	Unclassified	0–60	60
Platteville	Limestone	60–70	10+

BAYTOWN TOWNSHIP

67. Outcrops at north edge of Oak Park, south of city limits of Stillwater. NE¼ Sec. 3, T. 29 N., R. 20 W. Elevation of base 743± ft.[5]

Shakopee-Oneota Dolomite. Good exposure.

68. Small abandoned quarry along Omaha R. R. Sec. 3, T. 29 N., R. 20 W. Elevation of base 822± ft.[5]

Shakopee-Oneota Dolomite. 20 ft. vertical exposure.

69. Blasted pit at State Prison springs, Bayport. SW¼ Sec. 3, T. 29 N., R. 20 W. Elevation of Prison Lake 762± ft.; of top of dam 765 ft.[7]

Shakopee-Oneota Dolomite. Small exposure in pit.

70. Well at State Prison, Bayport (1926). Elevation 777 ft.[22]

Drift	Broken limerock, gravel, etc.	0– 75	75
Jordan	Soft sandrock	75–117	42
St. Lawrence	Limerock	117–183	
	Hard sandrock	183–216	
	Shale	216–328	112
Franconia	Sandrock and shale	328–398	70

Formation	Description	Depth (in feet)	Thickness (in feet)
Dresbach-Hinckley	Shale with streaks of sandrock	398–473	
	Soft muddy sandrock	473–508	
	Hard sandrock	508–686	
	Shale	686–688	290
	Sandrock	688–737	
	Shale	737–750	62+

71. Well on Weber property, above prison, about ¼ mile from oil station, between Secs. 4 and 5, T. 29 N., R. 20 W.[21]

Drift	Unclassified	0– 40	40
Shakopee-Oneota	Blue limestone	40–163	123+

72A. Well at Hugo Richard's farm, south of southwest corner of State Prison farm. NW¼ Sec. 10, T. 29 N., R. 20 W. Elevation 820± ft.[6]

Shakopee-Oneota	Dolomite	0–135	135+

72B. Exposures 800 ft. south of southwest corner of State Prison farm, north of Bayport. Elevation of top 810 ft.; of sandstone 790 ft.[20]

Oneota	Dolomite	0–20	20
New Richmond(?)	Sandstone	20–(?)	(?)

73. Well of John Zabo, west of Bayport. Sec. 10, T. 29 N., R. 20 W.[6]

Drift	Unclassified	0– 30	30
Shakopee-Oneota	Dolomite	30–100	70+

74. Village of Bayport well, east of Milwaukee R. R. station (1914). Elevation 690 ft.[23]

Drift	Gravel, etc.	0–130	130
St. Lawrence	Sandrock	130–159	
	Shale	159–179	49
Franconia	Sandrock	179–259	80
Dresbach	Sandrock and shale	259–429	170
Hinckley	Sandrock	429–684	255
Red Clastic	Red shale	684–691	7+

75. Two wells at Bayport. SW¼ Sec. 11, T. 29 N., R. 20 W. Elevation 677± ft.[1]

Drift	Unclassified	0– 95±	95±
St. Lawrence(?)	Rock and some soapstone	95–277	182+

76. Outcrop in SW¼ SW¼ Sec. 15, T. 29 N., R. 20 W. Elevation 904± ft.[7]

St. Peter	Sandstone. Exposed in road cut through hill.		

77. Well at Patrick farm, NW Sec. 16, T. 29 N., R. 20 W. Elevation 987± ft.[6]

Drift	Gravel	0– 40	40
Platteville(?)	Limestone	40– 45	5
St. Peter	Sandstone	45–195	150
Shakopee-Oneota	Limestone	195–212	17+

78. Well at Otto Wolf farm, SW cor. Sec. 16, T. 29 N., R. 20 W. Elevation 990± ft.[6]

Drift	Soil	0– 30	30
St. Peter	Sandstone	30–130	100
Shakopee-Oneota	Limestone	130–(?)	(?)

79. Well on Bahneman farm. NE¼ Sec. 17, T. 29 N., R. 20 W. Elevation 923± ft.[6]

Drift	Gravel	0– 40	40
St. Peter	Sandstone	40– 75±	35±
Shakopee-Oneota	Limestone	75–115±	115+

LAKELAND TOWNSHIP

80. Exposure in road 300 ft. south of NE cor. Sec. 20, T. 29 N., R. 20 W. Elevation 998± ft.[7]

Platteville	Limestone. Small exposure.		

Formation	Description	Depth (in feet)	Thickness (in feet)
81. Well at Carl Krueger farm, SW¼ Sec. 21, T. 29 N., R. 20 W. Elevation 1033 ft.[6]			
Drift	Gravel	0– 14	14
Platteville	Limestone	14– 44	30
St. Peter	Sandstone	44–194	150
Shakopee-Oneota	Limestone	194–274	80+
82. Exposure in SE¼ SE¼ Sec. 21, T. 29 N., R. 20 W. Elevation 1007 ft.[7]			
Platteville	Limestone. Small exposure on hillside.		
83. Quarry of E. M. Keene (opened 1845). SW¼ SW¼ Sec. 22, T. 29 N., R. 20 W. Elevation of floor 1008± ft.[24]			
Platteville	Limestone. 8 ft. high; exposure about 100 by 50 ft. Base of Platteville estimated at elevation 1003± ft.		
84. Well of Henry Vollmer. NE¼ Sec. 22, T. 29 N., R. 20 W.[9]			
Drift	Loam	0– 14	14
Shakopee-Oneota	Limestone	14–132	118+
85. Well of Fred Howalt, St. Croix River road south of Bayport, near W¼ cor. Sec. 22, T. 29 N., R. 20 W.[21]			
Drift	Gravel	0–190	190+
86. Well of John Oliver. NW¼ Sec. 22, T. 29 N., R. 20 W.[9]			
Drift	Loam	0– 14	14
Shakopee-Oneota	Limestone	14–132	118
87. Minnesota side of St. Croix River, from bridge to Hudson on Highway No. 12 north to Bayport.[7]			
Drift	Sand and gravel. 100 ft. exposed along high bank and in cross gullies. No solid rock exposed in this distance.		
88. Well of Elias McKean, north line of Sec. 27, T. 29 N., R. 20 W.[9]			
Drift	Loam	0– 14	14
Shakopee-Oneota	Limestone	14–132	118+
89. Well of Henry Schar. NW¼ Sec. 28, T. 29 N., R. 20 W. Elevation 992± ft.[6]			
Drift	Soil	0– 20	20
St. Peter	Sandstone	20–130	110+
90. Well of John Schrade. SE¼ Sec. 28, T. 29 N., R. 20 W. Elevation 920± ft.[9]			
Drift	Loam	0– 14	14
Shakopee-Oneota	Limestone	14–142	128+
91. Outcrop at Charles Harp farm. SE¼ SW¼ Sec. 28, T. 29 N., R. 20 W. Elevation of contact 1009± ft.[7]			
Platteville	Limestone. Small exposure.		
St. Peter	Sandstone. Small exposure.		
92. Exposure near center of SW¼ Sec. 29, T. 29 N., R. 20 W. Elevation 940 ft.[7]			
St. Peter	Sandstone. Exposed on hillside along road.		
93. Quarry of George H. Vollmer. SE¼ Sec. 30, T. 29 N., R. 20 W. Elevation of contact 1000± ft.[7]			
Platteville	Limestone. Exposed in 50 by 100 ft. opening.		
St. Peter	Sandstone.		
94. Pit on hill near NE cor. Sec. 30, T. 29 N., R. 20 W. Elevation 946–61 ft.[7]			
St. Peter	Sandstone. Total exposure about 15 ft. vertically. Platteville float on top.		
95. Well at school in NE¼ Sec. 31, T. 29 N., R. 20 W. Elevation 908 ft.[6]			
Drift	Unclassified	0–30	30
Shakopee-Oneota	Limestone	30–85	55+

Formation	Description	Depth (in feet)	Thickness (in feet)

96. Well on O. H. Rentz farm, near W¼ cor. Sec. 32, T. 29 N., R. 20 W. Elevation 910± ft.[6]

Drift	Unclassified	0–145	145
Shakopee-Oneota	Limestone	145–150	5+

97A. Average of about 6 wells at Lakeland.[21]

Drift	Gravel	0–80±	80+

97B. Well of Mr. Jones, near Milwaukee R. R. and river, Lakeland.[21]

Drift	Coarse gravel	0–86	86+

WOODBURY TOWNSHIP

98A. Exposures on wooded hill in NW¼ SW¼ Sec. 1, T. 28 N., R. 21 W. Elevation of hilltop 1000± ft.[7]

Platteville	Limestone. Abundant float near top proves that the highland to the south is underlain by Platteville.		
St. Peter	Sandstone. On hillside; contact at about 992 ft.		

98B. Well at Stabenow farm. SE¼ Sec. 2, T. 28 N., R. 21 W. Elevation 955 ft.[7]

St. Peter	Sandstone	0–115	115

99. Well of Margaret Fernholtz, near Oakbury. SW¼ Sec. 6, T. 28 N., R. 21 W. Elevation 1002 ft.[21]

Drift	Unclassified	0–100	100
Platteville	Soapstone	100–104	
	Hard limestone	104–111	11+

100. Exposures along road at the bend in the NE¼ Sec. 12, T. 28 N., R. 21 W. Elevation of contact 992± ft.[7]

Platteville	Limestone. Poor exposure in ditch; 11 ft.		
St. Peter	Sandstone. Poor exposure in ditch; 3 ft.		

101. Outcrop on road near SW cor. Sec. 12, T. 28 N., R. 21 W. Elevation of contact 960 ft.[7]

Outcrop of Platteville and St. Peter in ditch at the roadside.

102. Well of Peter Peterson. NW¼ Sec. 13, T. 28 N., R. 21 W.[6]

Drift	Clay	0– 3	
	Gravel	3–24	24
Platteville(?)	Rock (limestone?)	24–40	16+

103. Outcrop just east of road corner at SW cor. Sec. 13, T. 28 N., R. 21 W. Elevation 983 ft.[7]

Platteville and Glenwood formations in road cut.

104. New road cut near N¼ cor. Sec. 15, T. 28 N., R. 21 W. Elevation of top of St. Peter 945 ft.[7]

Platteville	Buff limestone	0–10	10
Glenwood	Buff shale, etc.	10–12	
	Massive, buff, impure limestone	12–13	
	Gray-green shale	13–14	4
St. Peter	Rusty sandstone	14–24	10+

105. Outcrops on road between Secs. 24 and 25, T. 28 N., R. 21 W. Elevation 970± ft.[14]

Platteville	Limestone. Exposed in bank on both sides of road, ¼ mile west of SE cor. Sec. 24.		

106. Outcrops on road between Sec. 25, T. 28 N., R. 21 W. and Sec. 30, T. 28 N., R. 20 W. (Afton Township).[7]

Platteville	Limestone. Small exposure ¼ mile south of NE cor. Sec. 25.		

107. Outcrop on road in NE¼ Sec. 26, T. 28 N., R. 21 W. Elevation 975 ft.[7]

Platteville in ditch, south and west of NE cor. Sec. 26.

Formation	Description	Depth (in feet)	Thickness (in feet)

108. Well of Ben Urtel, 4 miles north of Cottage Grove and south of Colby's Lake, near NE cor. Sec. 28, T. 28 N., R. 21 W. Elevation 936± ft.[21]

Drift	Sand, etc.	0–183	183
Shakopee-Oneota(?)	Hard rock (limestone?)	183–190	7+

(Sandstone struck at 60 ft. depth one block to the east.)

109. Well of Mrs. William Ramthun, NW¼ Sec. 29, T. 28 N., R. 21 W. Elevation 1022 ft.[1]

Drift	Unclassified	0– 87	87
Platteville	Limestone	87–113	
	Soapstone	113–116	29
St. Peter	Sandstone	116–266	150
Shakopee-Oneota	Dolomite	266–306	40+

110. Well of Frank Turner, 2 miles east of Point Douglas Road on Highway No. 4. Sec. 30, T. 28 N., R. 21 W. Elevation 938± ft.[21]

Drift	Unclassified	0–112	112
St. Peter	Sandstone	112–212	100
Shakopee-Oneota	Limestone	212–237	25+

111. Well of Pat McGuire. SE¼ Sec. 30, T. 28 N., R. 21 W.[9]

Drift	Soil and clay	0–10	
	Sand	10–20	
	Gravel and boulders	20–32	
	Stiff red clay	32–37	
	Sand	37–39	
	Boulders and clay	39–70	
	Hardpan	70–74	74+

112. Well of Ben Schilling, at W¼ cor. Sec. 33, T. 28 N., R. 21 W. Elevation 965 ft.[1]

Drift	Unclassified	0–192	192
Shakopee-Oneota	Limestone	192–247	55+

113. Quarry of Charles Metcher. Sec. 33, T. 28 N., R. 21 W.[24]

Platteville — Limestone. Impossible to locate at present.

114. Exposures on road between Secs. 35 and 36, T. 28 N., R. 21 W. Elevation 970 ft.[7]

Platteville — Limestone. Several exposures along road north from .7 mile north of SE cor. Sec. 35 and east from NE cor. Sec. 35.

115. Outcrops at NE cor. Sec. 36, T. 28 N., R. 21 W. Elevation 1000± ft.[7]

Platteville — Limestone. Several exposures over a rather flat area at and around the corner of Sec. 36.

AFTON TOWNSHIP

116. Well in NE¼ Sec. 6, T. 28 N., R. 20 W.[6]

Drift	Unclassified	0– 40	40
Shakopee-Oneota(?)	Limestone	40–100	60+

117. Well of William Bohn. SW¼ Sec. 6, T. 28 N., R. 20 W.[9]

Drift	Soil and loam	0– 2	
	Gravel, sand, and red clay	2–30	30
Platteville(?)	Rock, unclassified	30–38	8+

118. Exposures near W¼ cor. Sec. 7, T. 28 N., R. 20 W. Elevation 987± ft.[7]

Platteville — Limestone. Good exposure in ditch on east-west road.

119. Exposures in SE¼ SE¼ Sec. 7, T. 28 N., R. 20 W., extending into Secs. 8 and 18. Elevation of contact 996± ft.[7]

Platteville	Limestone. Occurs as a flat-topped outlier.		
St. Peter	Sandstone. On flanks of hill and along road.		

Formation	Description	Depth (in feet)	Thickness (in feet)
120. Exposures in S½ SW¼ Sec. 8, T. 28 N., R. 20 W. Elevation of hilltops 1005± ft.[7]			
Platteville	Broken limestone. 3 or 4 ft. exposed on tops of two pointed hills.		
St. Peter	Sandstone. Exposed on flanks of these two hills.		
121. Exposures in NE¼ SW¼ Sec. 8, T. 28 N., R. 20 W.[7]			
Platteville	Limestone. Occurs as a flat-topped outlier.		
122. Exposures in NW¼ SE¼ Sec. 8, T. 28 N., R. 20 W. Elevation of contact 1001± ft.[7]			
Platteville	Limestone. Forms conspicuous flat-topped hill (abandoned quarry).		
St. Peter	Sandstone. Exposed on north side of road.		
123. Well at Swanson's Sunnyside Farm in NE¼ Sec. 9, T. 28 N., R. 20 W. Elevation 858± ft.[7]			
Jordan(?)	Sandstone and water	0–100	100
124A. Exposures along road through center of Sec. 9, T. 28 N., R. 20 W. Elevation 825± ft.[5]			
Shakopee-Oneota	Dolomite. Exposed in creek valley just west of center of section and for 200 yards downstream.		
124B. Well in center of Sec. 9, T. 28 N., R. 20 W. Elevation 855± ft.[8]			
Shakopee-Oneota	Dolomite	0–100	100
Jordan	Sandstone	100–(?)	(?)
125. Exposure on bluff along Afton Creek, east side of Secs. 9 and 16, T. 28 N., R. 20 W. Elevation of bottom of Oneota 765± ft.[5]			
Shakopee-Oneota	Dolomite. The bluff is composed of this formation.		
Jordan(?)	Much-weathered sandstone in ridge on south side of creek and about 50 ft. above it.		
126. Outcrops at Jennie E. Crocker farm. NW¼ Sec. 11, T. 28 N., R. 20 W. Elevation of Oneota-Jordan 855± ft.[5]			
Shakopee-Oneota	Dolomite. 25 ft. vertical exposure in escarpment.		
Jordan	Sandstone. In quarry west of barn.		
St. Lawrence	Mixed formation. In road in front of house at elevation 736 ft.		
127. Well of Albert Lambrecht, St. Croix Beach, near center of Sec. 14, T. 28 N., R. 20 W.[21]			
Drift	Unclassified	0– 37	
	Quicksand	37– 90	
	Gravel	90–125	125
St. Lawrence(?)	Green, mixed rock, mostly sandstone	125–132	7+
128. Average of about 15 wells at St. Croix Beach.[21]			
Drift	Gravel and some clay	0–60±	60+
129. Exposures on the north edge of Afton village limits. Elevation of top 750± ft.; of base of outcrop 715 ft.[5]			
St. Lawrence	Shaly glauconitic sandstone. Outcrops on west side of highway.		
130A. Outcrops .3 mile south of NW cor. Sec. 16, T. 28 N., R. 20 W.[14]			
Shakopee-Oneota	Dolomite. Good outcrops on north side of bluff.		
130B. Outcrops between center and E¼ cor. Sec. 17, T. 28 N., R. 20 W. Elevation 805± ft.[14]			
Shakopee-Oneota	Dolomite. About a 30 ft. vertical exposure of upper Shakopee at and above creek level and in the road near the center of Sec. 17.		
131. Exposures near ¼ corners of Secs. 17 and 20, T. 28 N., R. 20 W.[5]			
Shakopee-Oneota	Dolomite. In roadside ditch along hill to the north.		

Formation	Description	Depth (in feet)	Thickness (in feet)

132. Exposures just east of SW cor. Sec. 17, T. 28 N., R. 20 W. Elevation of contact 850± ft.[6]

St. Peter	Sandstone. Small exposure in road.
Shakopee-Oneota	Dolomite. Large exposure below the sandstone.

133. Outcrop in road and east of road in NW¼ SW¼ Sec. 18, T. 28 N., R. 20 W.[7]
Elevation of Platteville–St. Peter contact 975 ft.

134. Outcrop in road in SE¼ SW¼ Sec. 18, T. 28 N., R. 20 W. Elevation at outcrop 965± to 990 ft.[7]

Platteville	Limestone. In gully and old quarry beside road.

135. Exposures in road between N½ Sec. 19 and Sec. 20, T. 28 N., R. 20 W. Elevation of Platteville-Glenwood contact 990 ft.[7]

Platteville	Limestone. Good exposure in road cut.
Glenwood	Rusty shale. About 5 ft. vertical exposure.
St. Peter	Sandstone. Good exposure in road cut.

136. Exposures on hill north of SE cor. Sec. 19, T. 28 N., R. 20 W. Elevation of top of St. Peter 988 ft.[7]

Platteville	Limestone. Good exposure as an escarpment.
Glenwood	Shale. About 5 ft. vertical exposure.
St. Peter	Sandstone. Top exposed.

137. Outcrops in Secs. 19 and 30, T. 28 N., R. 20 W. Elevation 987± ft.[25]

Platteville	Limestone	Exposed vertically in a very narrow belt along a bank and in the ditch beside a road.
St. Peter	Sandstone	

138. Outcrops on hill at NE cor. Sec. 20, T. 28 N., R. 20 W. Elevation 960± ft.[5]

Shakopee-Oneota	Dolomite. Exposed at several points on the hill. This evidently is on an anticline.

139. Outcrops in NE¼ SW¼ Sec. 21, T. 28 N., R. 20 W. Elevation 1000± ft.[5]

Shakopee-Oneota	Dolomite. Exposed on hill at crest of divide in road.

140. Exposures near corner of the road, near ¼ corners of Secs. 21 and 28, T. 28 N., R. 20 W. Elevation of contact 954± ft.[5]

Jordan	Sandstone. Outcrops just northwest of road corner, extending .2 mile to the west. Elevations range from 940± ft. to 980± ft., the latter being very near the top of the formation. Oneota to the north in a field.

141. Well at school in northwest part of village of Afton. Elevation 727 ft.[26]

Drift	Gravel	0–90	90+

142. Outcrops south of Afton, where road turns west at railroad bridge. Sec. 26, T. 28 N., R. 20 W. For elevation see below.[5]

St. Lawrence	Mixed formation. Several exposures up creek from railroad bridge at 200 ft. upstream exposed at elevation 698–704 ft.; at 300 and again at 500 ft. upstream exposed at elevation 702–15 ft.

143. Outcrops at railroad bridge 1.1 miles south of Afton. Sec. 26, T. 28 N., R. 20 W.[5]

St. Lawrence	Mixed formation. Exposed beneath railroad bridge.

144. Outcrops along river road south of village of Afton. Sec. 26, T. 28 N., R. 20 W. Elevation of Jordan-Oneota contact .4 mile south of Afton, in gully, 860 ft.[8]

St. Lawrence	Dolomite, etc. Exposed for a mile or more.

145. Outcrops in dry valley at bend in road 1.1 miles south of Afton. Center of SW¼ Sec. 26, T. 28 N., R. 20 W. Elevation of top 845 ft.; of bottom 730± ft.[5]

Jordan(?)	Conglomerate. Definite eastward dip.
Jordan	Massive sandstone.
	Thin shaly sandstone.

Formation	Description	Depth (in feet)	Thickness (in feet)
146. Outcrops in Sec. 27, T. 28 N., R. 20 W. Elevation 981.8 ft.[8]			
Drift	Unclassified	0.00– 13.15	13.15
Oneota	Dolomite, gray to drab, massive, much covered	13.15– 66.41	53.26
Jordan (top at 915.39 ft. A. T.)	Sandstone, white to yellow, medium to fine	66.41– 76.41	
	Sandstone, white to yellow, coarse to medium, massive	76.41–148.57	
	Sandstone, yellow to white, thin-bedded, fine	148.57–163.57	97.16
St. Lawrence	Dolomite, gray, sandy, with sandy, dolomitic, gray shales	163.57–198.19	
	Dolomite, fine-textured, glauconitic, gray to buff, and Lodi shale with graptolites	198.19–201.19	
	Sandstone, gray, glauconitic, massive to thin-bedded	201.19–206.77	
	Sandstone, dolomitic, gray to buff, irregularly bedded, glauconitic, vermicular	206.77–214.62	
	Sandstone, gray to buff, massive, fine-grained, cross-bedded, very glauconitic	214.62–245.27	
	Sandstone, gray to yellow or buff, soft, massive to shaly, fine-grained, glauconitic	245.27–259.88	96.31
(?)	Covered interval (663.61 ft. A. T.)	259.88–318.19	58.31+

147. Outcrops near ¼ cor. Secs. 28 and 33, T. 28 N., R. 20 W. and .2 mile to east. Elevation 941 ft.[14]

Jordan — Sandstone. Outcrops in field and on road.

148. Outcrops between Secs. 28 and 33, T. 28 N., R. 20 W., east from NW cor. Sec. 33. Elevation 980± ft.[7]

Jordan — Sandstone. Outcrops in ditch and along road. Some Shakopee-Oneota float above. A friable sandstone crops out at intervals east to about N¼ cor. Sec. 33.

149. Outcrops on road between Secs. 30 and 31, T. 28 N., R. 20 W. Elevation of contact 1008 ft.[7]

Platteville — Limestone }
St. Peter — Sandstone } Good exposures 3 miles west of NE cor. Sec. 31.

150. Old quarry in NE¼ NW¼ Sec. 31, T. 28 N., R. 20 W. Elevation (lowest) 985± ft.[14]

Platteville — Limestone. About a 10 ft. vertical exposure.

151. Outcrop in SW¼ SW¼ Sec. 31, T. 28 N., R. 20 W. Elevation of base of Glenwood 1015 ft.[7]

Glenwood-Platteville — Small exposure.
St. Peter — Sandstone. Small exposures on hillside.

152. Outcrops on road between houses about .1 mile west of SE cor. Sec. 29, T. 28 N., R. 20 W. Elevation 993± ft.[14]

Shakopee-Oneota — Pink, vuggy dolomite. Exposed in road.

153. Outcrops near center of Sec. 32, T. 28 N., R. 20 W. Elevation of top of Jordan 930± ft.[14]

Shakopee-Oneota — Dolomite. Abundant float lying above Jordan.
Jordan — Sandstone. Good exposures along valley wall.

154. Outcrops along road between Sec. 32, T. 28 N., R. 20 W. and Sec. 5, T. 27 N., R. 20 W. (Denmark Township). Elevation of contact 910± ft.[14]

Jordan — Sandstone. Beside road, near crest of hill west of ¼ cor. Secs. 32 and 5.
St. Lawrence — Mixed rock. 10 rods east of above.

Formation	Description	Depth (in feet)	Thickness (in feet)

155. Outcrop just west of NE cor. Sec. 33, T. 28 N., R. 20 W. Elevation of corner 918± ft.[14]

Shakopee-Oneota Dolomite. Exposed at road corner and on a steep hill immediately to the west.

156. Outcrops between center of Sec. 33 and N¼ Sec. 33, T. 28 N., R. 20 W. Elevation 933± ft.[7]

Jordan Coarse sandstone. Along road and in field at center of Sec. 33 and on a hill near the N¼ cor.

157. Outcrops at bridge on Trout Creek in SW¼ Sec. 34, T. 28 N., R. 20 W. Elevation 797± ft.[14]

St. Lawrence Thin-bedded, sandy, shaly dolomite along creek.
(Shakopee-Oneota dolomite outcrops in bluffs along the creek to the southeast, with Jordan below.)

158. Outcrops .15 mile east of NW cor. Sec. 34, T. 28 N., R. 20 W. Elevation 971± ft.[14]

Shakopee-Oneota Dolomite. Good outcrop near top of a steep hill close to the school.

159. Outcrops in road around gully near NE cor. Sec. 34, T. 28 N., R. 20 W. Elevation 915± ft.[7]

Shakopee-Oneota Dolomite. Exposures on roadside.

160. Outcrops at ¼ corners of Secs. 34 and 35, T. 28 N., R. 20 W. Elevation 943 ft.[5]

Shakopee-Oneota Dolomite. Exposures in road corner.

161. Exposures in W½ SW¼ Sec. 35, T. 28 N., R. 20 W. Elevation of top of Jordan 798± ft.[14]

Shakopee-Oneota Dolomite. Exposed on hill.
Jordan Sandstone. Just below dolomite. Good exposure at bridge across creek valley.

162. Outcrops south of NE cor. Sec. 34, T. 28 N., R. 20 W. Elevation 900± ft.[14]

Shakopee-Oneota Dolomite. Exposed in bank on road and along a creek where road bends around valley.
Jordan Cross-bedded sandstone. Exposed along the creek, ¼ mile downstream from above, at elevation 797± ft.

NEWPORT TOWNSHIP

163. Outcrops on bluff east of road. SE¼ Sec. 25, T. 28 N., R. 22 W. Elevation 879± ft.[5]

Outcrops of Platteville at intervals for 1000 ft. on bluff east of road. Contact of Platteville and St. Peter at elevation 879 ft.

164. Well at cafe on Highway No. 62 and street leading to Cudahy Packing Plant. SW¼ Sec. 25, T. 28 N., R. 22 W.[5]

Drift	Unclassified	0–10±	10±
Shakopee-Oneota	Dolomite	10–92±	82+

165. Outcrop on Cottage Grove road, just south of St. Paul city limits. NW¼ Sec. 25, T. 28 N., R. 22 W.[7]

St. Peter outcrops along the highway.

166. Exposures at Cudahy Packing Plant, Newport. SE¼ Sec. 26, T. 28 N., R. 22 W. Elevation 689 ft.[7]

Shakopee-Oneota Dolomite. Exposed around building.

167. Outcrops in NE¼ Sec. 1, T. 27 N., R. 22 W. (abandoned quarry of John Willoughby.) Elevation 908 ft.[5]

Platteville Limestone. A good 15 ft. exposed on north side of gully. Some quarried.
Glenwood beds Shale. 3½ ft. exposed below Platteville contact at 890 ft.
St. Peter Sandstone. Exposed in gully below at 785 ft.

168. Gas station grease pit, corner of Broadway and Highway No. 62, St. Paul Park.[5]

Drift	Unclassified	0–3	3
St. Peter	Sandstone	3–(?)	(?)

Formation	Description	Depth (in feet)	Thickness (in feet)

169. Well at gas station, corner of Broadway and Third St., St. Paul Park. Bench mark at this point. Elevation 766 ft.[27]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift	Unclassified	0– 4	4
Shakopee-Oneota	Limestone	4–53	49+

170. Outcrops in St. Paul Park. Elevation 690+ ft.[28]

Shakopee-Oneota — Dolomite. Nearly continuous exposure in rock bluff along slough from St. Paul Park to slough that forms Gray Cloud Island.

171. Outcrops in St. Paul Park. SW¼ Sec. 12, T. 27 N., R. 22 W. Elevation 686± ft.[7]

Shakopee-Oneota — Dolomite. Exposed in bluff on east side of Mississippi River opposite Rock Island Ry. water tank, .6 mile south of toll bridge.

172. Exposures at southwest edge of St. Paul Park, on road running south, near W¼ cor. Sec. 13, T. 27 N., R. 22 W. Elevation 755± ft.[7]

Shakopee-Oneota — Dolomite. Occurs as broken rubble in a ditch and outcrops almost continuously up the street running to the bridge.

173. Exposures in NW¼ Sec. 24, T. 27 N., R. 22 W. Elevation 720–50 ft.[5]

Shakopee-Oneota — Dolomite. Outcrops extensively on both sides of a slough. A quarry present on north side of bridge over slough.

174. Exposures on road ½ mile east of river between Secs. 23 and 26, T. 27 N., R. 22 W. Elevation 755 ft.[6]

Shakopee-Oneota — Dolomite. Outcrops here and along road toward river.

175. Exposures in SE¼ Sec. 25, T. 27 N., R. 22 W. Elevation 700± ft.[5]

Shakopee-Oneota — Dolomite. Exposure 20 ft. thick on north side of east end of Balden Lake, 10 ft. above water level. See also *Geology of Minnesota,* 2:389.

176. Exposures north of Balden Lake at intersection of north-south road with east-west road, near ¼ cor. Secs. 25 and 26, T. 27 N., R. 22 W. Elevation 718± ft.[6]

Shakopee-Oneota — Dolomite. Exposed vertically for 25 ft. above lake.

177A. Old quarry at river on Weyerwood estate, north side of Sec. 26, T. 27 N., R. 22 W. Elevation 690± ft.[5]

Shakopee-Oneota — Limestone. Outcrops along slough to east and main river to north. Exposed to within 3 ft. of water level without any Jordan sandstone being visible.

177B. Well at bank of river on Weyerwood estate. Sec. 26, T. 27 N., R. 22 W. Elevation 733 ft. (of river 693 ft.).[7]

Formation	Description	Depth (in feet)	Thickness (in feet)
Shakopee-Oneota	Dolomitic limestone	0–(?)	(?)
Jordan	Sandstone	(?)–315	(?)

COTTAGE GROVE TOWNSHIP

178. Exposures in NW¼ NW¼ Sec. 1, T. 27 N., R. 21 W. Elevation of contact 970± ft.[7]

Platteville — Limestone. Small exposures in several places.

St. Peter — Sandstone. Small exposures in several places.

179. Abandoned quarry in NE¼ SE¼ Sec. 2, T. 27 N., R. 21 W. Elevation of floor 972± ft.[7]

Platteville — Limestone. 15 ft. vertical exposure, several hundred feet long. See also *Geology of Minnesota,* 2:389.

180. Exposures along road between Secs. 1 and 2, T. 27 N., R. 21 W. Elevation 935± ft.[7]

Platteville — Limestone. Small exposures along road.

181. Exposures on St. Paul–Cottage Grove road near SW cor. Sec. 2, T. 27 N., R. 21 W.[7]

Platteville — Limestone. Exposed in road.

182. Outcrops on road between Secs. 3 and 10, T. 27 N., R. 21 W. Elevation 955± ft.[7]

Platteville — Limestone. In ditch .3 mile east of west side of Sec. 3 and near SW cor. Sec. 3. Poor exposure.

Formation	Description	Depth (in feet)	Thickness (in feet)

183. Well of H. House. NW¼ Sec. 3, T. 27 N., R. 21 W.[9]

Drift	Unclassified	0–32±	32±
Platteville(?)	Limestone	32–34	2+

184. Outcrops in road just north of S¼ cor. Sec. 4, T. 27 N., R. 21 W. Elevation 960 ft.[5]

Platteville	Fossiliferous limestone. Exposed in road ditch.

185. Outcrops on road between Secs. 4 and 9, T. 27 N., R. 21 W. Elevation 960 ft.[7]

Platteville	Limestone. Exposed for some distance in road ditch.

186A. Exposures at bend in road and on hill near ¼ cor. Secs. 5 and 6, T. 27 N., R. 21 W. Elevation of outcrop 860± ft.[5]

St. Peter	Sandstone. Exposed in road ditch.

186B. Exposures in NE¼ Sec. 6, T. 27 N., R. 21 W. Elevation of outcrop 885± ft.[5]

St. Peter	Sandstone.

(Good esker with northwest trend cuts across from Sec. 5.)

187. Old quarry of Mrs. Cornell. NE¼ Sec. 6, T. 27 N., R. 21 W.[24]
Not found.

188. Outcrops on hill 800 ft. east of Highway No. 3, between Secs. 6 and 7, T. 27 N., R. 21 W., near St. Paul Park. Elevation 830 ft.[5]

St. Peter	Sandstone. Exposed on hillside.

189. Outcrops southeast of St. Paul Park. Sec. 7, T. 27 N., R. 21 W. Elevation of contact 910± ft.[7]

Platteville	Limestone. Exposed in escarpment from just north of intersection of Highway No. 3 and road east through Sec. 7.
St. Peter	Sandstone. Exposed below the Platteville.

190. Outcrops in old quarry at center of NW¼ Sec. 11, T. 27 N., R. 21 W. Elevation 967± ft.[6]

Platteville	Limestone. In small quarry on hillside.

191. Well of O. Keene. SE¼ Sec. 11, T. 27 N., R. 21 W. Elevation 915± ft.[9]

Drift	Soil, etc.	0–10	10
St. Peter	Sandstone	10–(?)	(?)
Shakopee-Oneota	Limestone	(?)–140	(?)

192. Exposures in SE¼ SE¼ Sec. 12, T. 27 N., R. 20 W. Elevation 974± ft.[7]

Shakopee-Oneota	Dolomite. Exposed in road cut.

193. Well of Raymond Roberts, Cottage Grove. NW¼ Sec. 12, T. 27 N., R. 21 W. Elevation 965 ft.[1]

Drift	Unclassified	0–126	126
	Limestone	126–140	14

194. Well of Peter Thompson. NW¼ Sec. 14, T. 27 N., R. 21 W. Elevation 930± ft.[9]

Drift	Soil and loam	0–4	4
St. Peter	White sandstone	4–129	125
Shakopee-Oneota	Hard "flint rock"	129–(?)	(?)

195. Well of R. Bobbins. NE¼ Sec. 15, T. 27 N., R. 21 W. Elevation 915± ft.[9]

Drift	Gravel and sand	0–50	50
	Rock (limestone?)	50–130	80+

196. Exposure ½ mile west of Langdon, on road south of center of Sec. 21, T. 27 N., R. 21 W. Elevation of terrace level 777± ft.[5]

Shakopee-Oneota	Dolomite. Outcrops rather extensively south of the road. Apparently an old quarry.

197. Outcrops in SE¼ Sec. 25, T. 27 N., R. 21 W. Elevation 930 ft.[5]

Shakopee-Oneota	Dolomite. Exposed in diagonal road .2 mile northwest of intersection.

Formation	Description	Depth (in feet)	Thickness (in feet)

198. Quarry along Burlington R. R., 2½ miles south of St. Paul Park. Sec. 30, T. 27 N., R. 21 W.[5]

Shakopee-Oneota Dolomite. Exposed for several hundred feet parallel to the railroad line.

199. Exposures at road intersection ¼ mile north of center of Sec. 30, T. 27 N., R. 21 W. Elevation 733± ft.[5]

Shakopee-Oneota Dolomite. Outcrops in road.

200. Exposures along road south of the center of Sec. 30, T. 27 N., R. 21 W. Elevation of top of outcrop 720 ft.[7]

Shakopee-Oneota Dolomite. An extensive outcrop where the road has been newly graded.

201. Outcrops along north side of Mississippi River. Sec. 33, T. 27 N., R. 21 W. Elevation 687+ ft.[9]

Shakopee-Oneota Massive dolomite. Exposed for about 100 ft. opposite west end of Kemps or Freeborn Island, in bank and in railroad cut down to level of Hasting's pool. Jordan sandstone exposed across river and downstream.

202. Exposures in NW¼ Sec. 35, T. 27 N., R. 21 W.[7]

Shakopee-Oneota Dolomite. Exposed on northwest side of a deep valley along the Milwaukee R. R. tracks, near the center of Sec. 35. This valley ends at Burlington R. R. milepost 413.01.

203. Exposures near Burlington R. R. milepost 412.46, near SW cor. Sec. 36, T. 27 N., R. 21 W. Elevation of river 693 ft.; of top of Oneota 780 ft.[6]

Shakopee-Oneota Dolomite. Exposed up a gully ½ mile long in the center of Sec. 36 and to within 800 ft. southwest of Highway No. 62.

DENMARK TOWNSHIP

204A. Outcrops along Milwaukee R. R., south of Trout Creek bridge. Sec. 2, T. 27 N., R. 20 W. Elevation 680–800 ft.[20]

Shakopee-Oneota Dolomite. Exposures in cut south of bridge.

204B. Outcrops on Trout Brook. Sec. 33, T. 28 N., R. 20 W.[3]

Shakopee-Oneota Dolomite. Exposures at railroad bridge over creek near Lake St. Croix. Further exposures 1 mile south with 8° dip to southeast.

205. Outcrops in NW¼ Sec. 2, T. 27 N., R. 20 W. Elevation 702± ft.[20]

Shakopee-Oneota Dolomite. Exposed 10 ft. above north side of Trout Creek near spring and brook.

206. Outcrops in Trout Creek .9 mile upstream from lower road. NE¼ NW¼ Sec. 3, T. 27 N., R. 20 W. Elevation (highest) 840 ft.[6]

Jordan Cross-bedded sandstone. A good exposure on the south bank. Another good exposure 1 mile north, extending from creek (elevation 762 ft.) to an elevation of 840 ft.

207. Outcrops ½ mile up Trout Creek from lower road. NE¼ Sec. 3, T. 27 N., R. 20 W.[6]

Shakopee-Oneota Dolomite. Exposed in pronounced escarpment on north side of creek. Caps bluffs all along the creek between two parallel (north-south) roads.

208. Outcrops on road in SW¼ Sec. 3, T. 27 N., R. 20 W. Elevation 922 to 975± ft.[14]

Shakopee-Oneota Dolomite. Continuous exposure on north side of Sec. 3 and good exposure east of road.

209. Outcrops near ¼ corners of Secs. 4 and 5, T. 27 N., R. 20 W. Elevation 900± ft.[14]

St. Lawrence Shaly sandstone. Scant exposure in ditch before house about 40 rods north.

210A. Exposures along north turn of road on north line of Sec. 4, T. 27 N., R. 20 W. Elevation of outcrop 864± ft.[7]

St. Lawrence Sandy glauconitic limestone. Good exposure.

FORMATION	DESCRIPTION	DEPTH (in feet)	THICKNESS (in feet)

210B. Exposure in creek valley near road. NW¼ Sec. 4, T. 27 N., R. 20 W. Elevation of base of outcrop 840± ft.[14]

St. Lawrence — Massive crystalline dolomite on south side of creek.

211. Exposures along road between Sec. 5, T. 27 N., R. 20 W. and Sec. 32, T. 28 N., R. 20 W. (Afton Township). Elevation 898–924 ft.[7]

Jordan — Sandstone.
St. Lawrence — Glauconitic limestone.
(St. Lawrence outcrops east from about N¼ cor. Sec. 5. The Jordan outcrops just to the west.)

212. Outcrops just north of school at SE cor. Sec. 5, T. 27 N., R. 20 W. Elevation of contact 976± ft.[14]

Shakopee-Oneota — Dolomite. In field just west of road; also small exposure in road.
Jordan — Sandstone. Good exposures at bend in road.

213. Outcrop .2 mile north of SE cor. Sec. 7, T. 27 N., R. 20 W. Elevation 932± ft.[5]

Shakopee-Oneota — Cherty dolomite. Typical Oneota exposed in cut. Old map showing this as Platteville must be in error.

214. Outcrops near the road between Secs. 7 and 8, T. 27 N., R. 20 W. Elevation 930± ft.[14]

Shakopee-Oneota — Dolomite. Exposed in road .25 mile south of north line. A line of hills showing outcrops extends east.

215. Outcrops from ¼ corners of Secs. 8 and 9 south to SE cor. Sec. 8, T. 27 N., R. 20 W. Elevation of ¼ corners 905± ft.; of SE Sec. 8, 835 ft.[5]

Shakopee-Oneota — Dolomite. In bottom and both sides of valley.

216. Outcrops near ¼ corners of Secs. 8 and 17, T. 27 N., R. 20 W.[7]

Shakopee-Oneota — Dolomite. Several exposures in fields and on road.

217. Outcrops on road .2 mile east of N¼ cor. Sec. 8, T. 28 N., R. 20 W. Elevation 855± ft.[14]

Shakopee-Oneota — Dolomite. Weathered top of the formation is exposed.

218. Outcrops near ¼ corners of Secs. 8 and 9, T. 27 N., R. 20 W. Elevation 854–936 ft.[5]

Shakopee-Oneota — Dolomite. Exposed in bottom and sides of valley.

219. Well of Phillip Hammel. NW¼ Sec. 9, T. 27 N., R. 20 W.[9]

Drift	Soil	0– 2	2
	Sand with thin clay seams	2–130	128+

220. Outcrops along road on south side of Sec. 9, T. 27 N., R. 20 W. Elevation 824–920 ft.[7]

Shakopee-Oneota — Dolomite. Exposures along north side of creek just north of road in SE¼ extend across entire section, being about 40 rods north of the southwest corner.

221. Outcrops near road between Secs. 4 and 9, T. 27 N., R. 20 W.[7]

Shakopee-Oneota — Dolomite. Exposed on hill near road near SE cor. Sec. 4 at elevation 986 ft.
Jordan — Sandstone .1 mile west of above, at elevation 976 ft.; also a good outcrop .2 mile west and another on the west side of a valley near SW cor. Sec. 4 at elevation 962 ft.

222. Outcrops on road near NE cor. Sec. 10, T. 27 N., R. 20 W. Elevation 878± ft.[14]

Shakopee-Oneota — Dolomite. Exposed on top of hill just south of corner.

223. Outcrop on road in SW¼ Sec. 10, T. 27 N., R. 20 W. Elevation 930 ft.[7]

High point of outcrop of the Shakopee-Oneota.

Formation	Description	Depth (in feet)	Thickness (in feet)

224. Outcrops on St. Croix River in SW¼ Sec. 14, T. 27 N., R. 20 W. Elevation of top 785 ft.[7]

Shakopee-Oneota Dolomite. Exposed in bluff at camp Kinnickinnic, near Milwaukee R. R. elevator station.

225. Outcrops along road .2 mile west of NE cor. Sec. 15, T. 27 N., R. 20 W. Elevation of corner 920± ft.[14]

Shakopee-Oneota Dolomite. Exposed on west face of hill. The extremity of this outcrop is .6 mile west on north side of road.

226. Outcrops in road in Sec. 15, T. 27 N., R. 20 W., along 1/16 line.[5]

Shakopee-Oneota Dolomite: .7 mile east of west side of Sec. 15, elevation 860 ft.
.5 mile east of west side of Sec. 15, elevation 872 ft.
.1 mile east of west side of Sec. 15, elevation 930 ft.
At road corner on west side of Sec. 15, elevation 930 ft.

227. Outcrop on hill south of road corner in NW¼ Sec. 15, T. 27 N., R. 20 W. Elevation 924 ft.[7]

Large outcrop of Shakopee-Oneota.

228. Outcrops at SE cor. Sec. 16, T. 27 N., R. 20 W. Elevation 932± ft.[5]

Shakopee-Oneota Dolomite. Good exposure in road and just north.

229. Outcrops on road between Secs. 16 and 17, T. 27 N., R. 20 W. Elevation of south side 920± ft.[5]

Shakopee-Oneota Dolomite. Extensively exposed along road and both sides of east-west valley and its branches.

230. Exposures in road cut just west of NE cor. Sec. 17, T. 27 N., R. 20 W.[7]

Shakopee-Oneota Dolomite.

231. Well of Henry Peterson. NW¼ Sec. 17, T. 27 N., R. 20 W.[9]

Drift	Unclassified	0–(?)	(?)
Shakopee-Oneota	Limestone	(?)–28	(?)

232. Outcrop .2 mile north of SE cor. Sec. 18, T. 27 N., R. 20 W. Elevation (lowest) 956 ft.[30]

St. Peter Sandstone. Exposed in road ditch.

233. Outcrops before house near ¼ corners of Secs. 17 and 18, T. 27 N., R. 20 W. Elevation 968± ft.[14]

Shakopee-Oneota Dolomite. Exposed along road and in field to west.

234. Outcrop in road 3 miles east of SE cor. Sec. 18, T. 27 N., R. 20 W. Elevation 930 ft.[7]

Outcrop of Shakopee-Oneota.

235. Outcrops .4 mile west of NE cor. Sec. 18, T. 27 N., R. 20 W. Elevation 945± ft.[7]

St. Peter Sandstone. Good outcrop along road.

236. Exposures ¼ mile south of NW cor. Sec. 19, T. 27 N., R. 20 W. Elevation 974± ft.[7]

St. Peter Sandstone. In ditch on east side of road and again near the northwest corner.

237. Outcrops on road west of school between Secs. 18 and 19, T. 27 N., R. 20 W. Elevation 980± ft.[14]

St. Peter Sandstone. Exposed in road cut.

238. Outcrops on road between Secs. 17 and 20, T. 27 N., R. 20 W. Elevation 940 ft.[5]

Shakopee-Oneota Dolomite. Small outcrop about .3 mile west of SE cor. Sec. 17. Formerly reported as Platteville limestone.

Formation	Description	Depth (in feet)	Thickness (in feet)

239. Outcrops on road between Secs. 20 and 21, T. 27 N., R. 20 W.[5]

Shakopee-Oneota Dolomite. Many exposures in dry valleys in both sections.

240. Outcrops in N½ SE¼ Sec. 21, T. 27 N., R. 20 W. Elevation (lowest) 913 ft.[8]

St. Peter White sandstone. Small exposure in road near hilltop.

241. Outcrops at river, near end of road at Truax Landing, St. Croix River, between Secs. 27 and 34, T. 27 N., R. 20 W.[5]

Shakopee-Oneota Dolomite. Exposed along road to river at elevation 665 ft. and near railroad tracks at elevation 710 ft.

242. Outcrops .1 to .3 mile east of road intersection in Sec. 28, T. 27 N., R. 20 W. Elevation 868 ft.[5]

Shakopee-Oneota Dolomite. Good exposures.

243. Outcrops on road between Secs. 29 and 32, T. 27 N., R. 20 W. Elevation 925–60 ft.[5]

Shakopee-Oneota Dolomite. Good exposures at bend in road in SE¼ Sec. 29 and in several gullies north of road.

244. Outcrops on road between Secs. 29 and 30, T. 27 N., R. 20 W. Elevation 955± ft.[5]

Shakopee-Oneota Dolomite. Exposed in road .3 mile north of SE cor. Sec. 30.

245. Exposures on road near SW cor. Sec. 30, T. 27 N., R. 20 W. Elevation 946± ft.[7]

Shakopee-Oneota Dolomite. Outcrops in road ditch.

246. Outcrops between Secs. 29 and 32, T. 27 N., R. 20 W. Elevation 930–65 ft.[5]

Shakopee-Oneota Dolomite. Extensive exposure in road cut in SE¼ Sec. 29. Many exposures in valleys in S½ Sec. 29 and in Sec. 32.

247. Outcrops on highway near Point Douglas, between Secs. 33 and 4, T. 27 N., R. 20 W. Elevation 960± ft.[5]

Shakopee-Oneota Dolomite. Exposed in road.

248. Outcrops near center of NW¼ Sec. 4, T. 26 N., R. 20 W., near Point Douglas. Lowest elevation 677± ft.; highest, 800 ft.[5]

Shakopee-Oneota Dolomite. Several excellent exposures at road intersection, at dry falls, and close to railroad tracks near Lake St. Croix.

249. Outcrop in center of SW¼ Sec. 4, T. 26 N., R. 20 W., near Point Douglas. Elevation 845± ft.[5]

Shakopee-Oneota Dolomite. Good exposures in field and in small gully. Two marked terraces show near the river at 820 and at 850 ft.

250. Outcrops near Point Douglas, in road near center of NE¼ Sec. 5, T. 26 N., R. 20 W. Elevation 890 ft.[5]

Shakopee-Oneota Dolomite. Good exposures in road.

251. Outcrops near Point Douglas, in road near center of SW¼ Sec. 5, T. 26 N., R. 20 W. Elevation 870 ft.[5]

Shakopee-Oneota Dolomite. Exposed in road on both sides of low point. Also exposed extensively at old schoolhouse in NW¼ Sec. 5 at elevation 905 ft.

252. Section 100 yds. south of Hastings Dam, Mississippi River. NW¼ Sec. 7, T. 26 N., R. 20 W. Elevation 898 ft.[8]

Formation	Description	Depth (in feet)	Thickness (in feet)
Drift(?)	Covered interval to top of hill	0.0– 60.0	60.0
Oneota	Dolomite, gray to drab, massive, rough, irregular	60.0–118.4	
	Dolomite, gray to tan or buff, arenaceous; lower beds thick, upper beds thin to shaly	118.4–126.5	66.5
Jordan	Sandstone, yellow to white, massive, medium to fine-grained, with some hard layers	126.5–138.1	
	Sandstone, yellow to brown, massive, cross-bedded, medium to coarse	138.1–160.0	
	Sandstone, white to yellow, massive, cross-bedded	160.0–206.1	
	Covered interval to river level above the dam	206.1–213.0	86.5+

Formation	Description	Depth (in feet)	Thickness (in feet)
253. Outcrops at Point Douglas on Highway No. 62, at the north side of the Mississippi River near Hastings, and near center of Sec. 7, T. 26 N., R. 20 W.[7]			
Shakopee-Oneota	Dolomite. Exposed in bluff.		
254. Outcrops at Point Douglas in NE¼ NE¼ Sec. 7, T. 26 N., R. 20 W.[7]			
Shakopee-Oneota	Dolomite. Exposed from .1 to .3 mile east of Highway No. 62.		
255. Outcrops at north edge of Point Douglas where Afton Road turns east. Sec. 9, T. 28 N., R. 20 W. Elevation 805± ft.[5]			
Shakopee-Oneota	Dolomite. Exposures in road and down the hill, also along a road to the west as far as first road to the north.		

[1] Keys Well Drilling Co. [2] L. P. Melbostad, city clerk. [3] Charles Hawkinson, driller.
[4] A. Julian, driller. [5] G. M. Schwartz and E. P. Burch. [6] O. H. Bahneman, driller.
[7] G. M. Schwartz. [8] C. R. Stauffer. [9] *Geology of Minnesota,* 2:393.
[10] A. E. Kuehn, driller. [11] G. L. Wilson, engineer, Minneapolis Street Ry. Co.
[12] *Geology of Minnesota,* 2:389; E. P. Burch and G. M. Schwartz. [13] Soo Line blueprint.
[14] G. M. Schwartz and G. A. Thiel. [15] *Geology of Minnesota,* 2:387.
[16] E. P. Burch, G. M. Schwartz, and Mr. Grove. [17] G. M. Schwartz and Mr. Grove.
[18] C. R. Stauffer, E. P. Burch, and G. M. Schwartz, *Journal of Geology,* 43:637; A. D. Meeds, *Bulletin of Minnesota Academy of Natural Sciences,* 3:274–77 (1889).
[19] Herbert Grove, superintendent, Stillwater Water Commission. [20] E. P. Burch.
[21] J. A. Hoge, driller. [22] McCarthy Well Drilling Co. to R. R. Sweitzer.
[23] August Bahneman, driller. [24] *Geology of Minnesota,* 2:389.
[25] G. M. Schwartz; *Geology of Minnesota,* 2:389. [26] James Maher and Sons, drillers.
[27] Station attendant. [28] Mississippi River Commission, chart no. 168.
[29] E. P. Burch, G. M. Schwartz, and C. R. Stauffer. [30] G. A. Thiel.

TABULATION OF MINNEAPOLIS SUBSURFACE DATA

(Indexed by Street Intersections.)

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Adams St. and:				
Broadway St.	843	7	Platteville	Limestone at elevation 830 between Spring & Sumner Sts.
Spring St.	837	7	Platteville	
Sumner St.	840	14+	(?)	
4th Ave. N. E.	839	10	Platteville	
13th Ave. N. E.	845	13	Platteville	
15th Ave. N. E.	847	7	Platteville	
17th Ave. N. E.	849	6	Platteville	
Aldrich Ave. and:				
7th Ave. N.	813	232+	(?)	
34th Ave. N.	865	70	(?)	
39th Ave. N.	870	5	Platteville	As shale
40th Ave. N.	862	2	Platteville	As shale
41st Ave. N.	858	2	Platteville	As shale
42nd Ave. N.	857	13+	(?)	
Arthur St. and:				
14th Ave. N. E.		15	Platteville	
18th Ave. N. E.		12	Platteville	
32nd Ave. N. E.		65	Rock (1+)	
Benjamin St. & 31st Ave. N. E.		62	Rock (7+)	
Blaisdell Ave. & E. 32nd St.	867	67	(?)	Deep well (no. 1, p. 219)
Broadway St.:				
near Stinson Blvd.	859	40	Decorah shale	
& Stinson Blvd.		45	Platteville (1+)	
between Stinson & Arthur	856	40	Decorah shale	
& University Ave. N. E.	836	1	Platteville	
& Washington St.	841	5	Platteville	
& 2nd Ave. N. E.	831	1	Platteville	Outcrop
& 6th St. N. E.	840	4	Platteville	
Broadway (West) see West Broadway				
Bryant Ave. S. & 29th St.	879	290	Shakopee	Deep well (no. 2, p. 219)
Bryant Ave. N. and:				
33rd Ave. N.	881	13	(?)	
37th Ave. N.	911	35	Platteville	
38th Ave. N.	881	13	Platteville	
Buchanan St. & 18th Ave. N. E.	857	4	Platteville	
Buchanan St. & 19th Ave. N. E.	853	11+	(?)	
Calhoun Bath House	856	215	St. Peter	Deep well (no. 3, p. 219)
Calhoun Beach Club		60+	(?)	
Calhoun Boat Dock	858	237	St. Peter	Deep well (no. 4, p. 219)
Camden Park	835	0	St. Peter	Outcrop
Cecil St. S. E. near the river	807	15	Platteville (30)	
Cedar Ave. near Minnehaha Pkwy.	818	36+	(?)	
Cedar Ave. & 7th St.	841	56	Platteville	
Central Ave. and:				
Broadway St.	840	12	Platteville	
Cemetery St.	837	11	Platteville	
Harrison St.	839	15	Platteville	
Jackson St.	837	14	Platteville	
Main St.	824	14	Platteville	

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Central Ave. and:				
Spring St.	838	16+	(?)	
2nd St. N. E.	833	8	Platteville	
3rd Ave. N. E.	838	12	Platteville	
3rd St. N. E.	838	12	Platteville	
4th St. N. E.	837	13	Platteville	
5th St. N. E.	836	20	Platteville	
6th St. N. E.	834	15	Platteville	
7th St. N. E.	834	11	Platteville	
8th St. N. E.	836	12	Platteville	
9th St. N. E.	837	5	Platteville	
10th St. N. E.	845	13	Platteville	
12th Ave. N. E.	850	11	Platteville	
13th Ave. N. E.	843	2	Platteville	
14th Ave. N. E.	843	8	Platteville	
15th Ave. N. E.	858	14	Platteville	
15th Ave. N. E.			Platteville	Quarry
18th Ave. N. E.	851	13	Platteville	
19th Ave. N. E.	851	9	Platteville	
20th Ave. N. E.	850	10	Platteville	
22nd Ave. N. E.	851	7	Platteville	
23½ Ave. N. E.	851	11	Platteville	
24th Ave. N. E.	850	10	Platteville	
25th Ave. N. E. (Lowry Ave.)	850	17	Platteville	
26th Ave. N. E.	851	16	Platteville	
27th Ave. N. E.	850	10	Platteville	
28th Ave. N. E.	852	57	St. Peter	Deep well (no. 5, p. 219)
36th St.	872	138+	(?)	
Chicago & 45th St. S.	834	45	Platteville (19)	
Cleveland & 31st St.		68	Limestone (12+)	
Colfax Ave. N.:				
& Glenwood Ave.	812	240+	(?)	
& 39th Ave. N.	864	6	Platteville	
& 40th Ave. N.	863	2	Platteville	Outcrop
between 41st & 42nd Aves. N.	845–50		Platteville	Outcrop
& 42nd Ave. N.	858	13+	(?)	
Colfax Ave. S. & 54th St.	888	110+	(?)	
Como Ave. & 14th Ave. S. E.	838	41	Platteville	
Crystal Lake Cemetery (James Ave. N. & 41st St.)			Platteville	Exposed in quarry
Dartmouth & E. River Rd.	830	38	Platteville	
Dean Blvd. & Lake St.	857	243	St. Peter	
Division St. & 10th Ave. S. E.	855	80	Platteville (20)	
Dupont Ave. N. and:				
G. N. R. R. tracks	826	199	Shakopee (26)	
39th Ave. N.	870	12		
42nd Ave. N.	861	3	Platteville	
43rd Ave. N.	860		Platteville	
45th Ave. N.	835	10	St. Peter	Deep well (no. 6, p. 219)
Dupont Ave. S. & 23rd St. S.	878	275	Shakopee-Oneota (32)	
Dupont Ave. S. & 54th St. S.		72+		
E. River Rd. & Cecil St. S. E.	802	11	Platteville	
E. River Rd. & Franklin Ave. Bridge	808	14	Platteville	
E. River Rd. & Seymour Ave. S. E.	807	13+	(?)	
Elm St. & 18th Ave. S. E.	850	45	Decorah	Deep well (no. 8, p. 220)
Emerson St. & 32nd Ave. N.	907	34		
Fairview Hospital and river bank	813	49	Platteville	

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Fillmore St. N. E. and:				
Broadway St.	849	10	Platteville	
Sumner St.	848	20	Platteville	
14th Ave. N. E.	849	5	Platteville	
16th Ave. N. E.	850	12	Platteville	
18th Ave. N. E.	851	7	Platteville	
19th Ave. N. E.	852	9	Platteville	
20th Ave. N. E.	851	8	Platteville	
22nd Ave. N. E.	853	7	Platteville	
23rd Ave. N. E.	859	8	Platteville	
24th Ave. N. E.	862	14	Platteville	
25th Ave. N. E.	867	14	Platteville	
33rd Ave. N. E.	861	14	Platteville	
France Ave. S. and:				
43rd St. S.	904	100	(?)	
50th St. S.	888	90	Platteville	Deep well (no. 9, p. 220)
54th St. S.	895	150	(?)	
Franklin Ave. near the river	814	22	Platteville (29)	Plus 3 ft. of sandstone
Franklin Ave. & Emerald St. S. E.	889	100	Platteville	
Fremont Ave. N. and:				
Plymouth Ave.	853	20	Platteville	
15th Ave. N.	856	15	Platteville	
16th Ave. N.	855	15	Platteville	
39th Ave. N.	869	7	Platteville	
40th Ave. N.	860	3	Platteville	
41st Ave. N.	858	11	Platteville	
42nd Ave. N.	863	16	St. Peter	
43rd Ave. N.	861	2	Platteville	
44th Ave. N.	844	12+	(?)	
Garfield Ave. S. & 29th St.	876	50	(?)	
Girard Ave. N. and:				
11½ Ave. N.	868	2	Platteville (7)	
39th Ave. N.	871	12	Platteville	
40th Ave. N.	861	3+	(?)	
41st Ave. N.	858	12+	(?)	
44th Ave. N.	850	50	St. Peter	
Glenwood Ave. & 7th St.	850	170	St. Peter	
Glenwood Ave. & 10th St. N.	813	190	Shakopee	Deep well (no. 10, p. 220)
Glenwood Lake (west side) at 6th Ave. N.		60	St. Peter	
Glenwood Park	945	265	St. Peter	Sandstone
Glenwood Park	822	45	St. Peter	Deep well (no. 11, p. 220)
Glenwood Park bath house	822	62	St. Peter	Deep well (no. 12, p. 220)
Harrison & Winter Sts. N. E.	836	37	Platteville	Deep well (no. 13, p. 220)
High St. & 2nd Ave. S.	845	31	Platteville	St. Peter at 61 ft.
Hillside & Logan Aves. N.	891	38	Platteville	21 ft. penetrated
Hennepin Ave.:				
& Franklin Ave.	890	120+	(?)	
& Lagoon	885	248	St. Peter (6)	Shakopee-Oneota at 146 ft.
& Lake St.		249	Shakopee	
& Lake St.	880	250	Shakopee	90 ft. penetrated
& Main St.	825	7	Platteville	
& Washington Ave.			Platteville	
& Wunder Sand and Gravel Co.		75	Platteville (21)	(See no. 7, p. 220)
near 2nd St.	839	27	Platteville (15)	
& 2nd St.	834	8	Platteville	
& 3rd St.	839	12	Platteville	

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Hennepin Ave.:				
& 3rd St.	845	20	Platteville	Deep well (no. 14, p. 221)
& 3rd St. (A. M. Smith & Co.)	840	24	Platteville	
& 4th St.	838	14	Platteville	
& 5th St.	848	34	Platteville	Deep well (no. 15, p. 221)
& 5th St.	848	38	Platteville	Deep well (no. 16, p. 221)
& 6th St.	848	34	Platteville	Excavation
& 7th St.	854	40	Platteville	Deep well (no. 17, p. 221)
& 8th St.			(?)	Footings (25 ft.)
& 9th St.		35	Platteville	St. Peter at 50 ft.
& 10th St.	847	44+	(?)	
& 31st St.	883	210+	(?)	
Hennepin Island (shaft 1875)	802	5	Platteville	Shaft (no. 18, p. 221)
Humboldt Ave. & 2nd Ave. N.	813	230+	(?)	
Humboldt Ave. & 6th Ave. N.	836	106	Limestone	
Irving & 24th Aves. N.	895	51	Limestone	
Irving & 37th Aves. S.	916	65	Platteville	Deep well (no. 19, p. 221)
Jackson St. and:				
Broadway St.	842	4	Platteville	
Spring St.	840	15	Platteville	
Sumner St.	841	5	Platteville	
3rd Ave. N. E.	837	14	Platteville	
12th Ave. N. E.	843	4	Platteville	
23rd Ave. N. E.	842	102	St. Peter	
James Ave. S. & 18th St.	910	144+	(?)	
Jefferson Highway & Memorial Drive		58	Platteville (20+)	
Jefferson St. and:				
Broadway St.	842	15	Platteville	
100 ft. south of Broadway	843	13	Platteville	
Spring St.	836	8	Platteville	
Sumner St.	840	9	Platteville	
4th Ave. N. E.	836	13+	(?)	
13th Ave. N. E.	846	14	Platteville	
150 ft. north of 13th Ave. N. E.	846	8	Platteville	
15th Ave. N. E.	846	13	Platteville	
17th Ave. N. E.	848	11+	(?)	
18th Ave. N. E.	845	16	Platteville	
Johnson St. N. E. and:				
Arthur St., between 15th and 18th Aves. N.	854–65	5–12	Platteville	Test holes
14th Ave. N. E.	853	13	Platteville	
14½ Ave. N. E.	854	12	Platteville	
16th Ave. N. E.	854	8	Platteville	
18th Ave. N. E.	859	6	Platteville	
19th Ave. N. E.	865	7	Platteville	
25th Ave. N. E.	923	71	Platteville	
Kennedy St.:				
& Benjamin St.	854	51	Decorah (1)	Test hole
opposite McKinley St.	857	40	Decorah (11)	Test hole
& Stinson Blvd. (southeast of corner)	857	32	(?)	Test holes
& Taft St.	862	55+	(?)	Test hole
between Wilson & "L" St.	866	49	Decorah (5)	Test hole
Kenwood Parkway		66+	(?)	3 wells
Kenwood Parkway (Northrop School)		60+	(?)	Piling
Lake Harriet near Interlachen Ave.	864	237	St. Peter	Well at lower picnic grove
Lake Harriet, old pavilion		262	Shakopee	
Lake Harriet, south of 42nd St.	853	97+	(?)	

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Lake St. & 29th Ave. S.	835	50+	(?)	
Lake St. & Lake Calhoun	859	237	Shale, then sandstone	
Lake St. & W. River Rd	817	25	Platteville (37)	
Lakewood Cemetery	885	318	Shakopee	Deep well (no. 20, p. 222)
La Salle Ave. & 8th St.		105+	(?)	Piling
La Salle Ave. & 9th St.	850	32	Platteville	Deep well (no. 21, p. 222)
Laurel Ave. at Bryn Mawr Meadows		91+	(?)	
Lincoln St. and:				
16th Ave. N. E.	854	6	Platteville	
18th Ave. N. E.	857	5	Platteville	
19th Ave. N. E.	858	4	Platteville	
22nd Ave. N. E.	879	0	Platteville	Outcrops
Linden Ave. & 13th St. S.	853	63	St. Peter	
Logan Ave. & 18th Ave. N.	870	1	Platteville	Limestone outcrop
Logan Park	845	9	Platteville	
Loring Park shelter	823	66	St. Peter	
Loring Park (Grove & 15th Sts.)	819	92	St. Peter	
Lyndale Ave. and:				
Aldrich at 2nd & Chestnut		50+	(?)	Test pits
Glenwood Ave. N.	820	180	(?)	
Soo Line crossing	835	21	St. Peter	
26th Ave. N.	863	27	Platteville	Deep well (no. 22, p. 222)
26th Ave. N.	870	23		
38th Ave. N.	880	14	Platteville	
39th Ave. N.	870	7	Platteville	
40th Ave. N.	860	2	Platteville	
41st Ave. N.	859	0	Platteville (8)	
190 ft. north of 41st Ave. N.	858	0	Platteville (9)	
44th Ave. N.	825	26	St. Peter	
50th St. S. (west side)	890	80	Platteville (7)	230 ft. of drift east of 50th St.
54th St. S.	874	90+	(?)	
56th St. S.	880	110	St. Peter	
Lyndale Park (north end of Lake Harriet)	851	240	Shakopee	
Madison St. and:				
Broadway St.	844	15	Platteville	
Spring St.	837	5	Platteville	
Sumner St.	840	4	Platteville	
3rd Ave. N. E.	836	11	Platteville	
13th Ave. N. E.	845	5	Platteville	
15th Ave. N. E.	847	5	Platteville	
Main St. N. E. and:				
Bank St. near the river	819	31	Platteville (13)	
Central Ave.	840	42	Platteville (28)	Deep well (no. 23, p. 222)
Central Ave. (sewer)	823	14	Platteville	
N. P. R. R. tracks, well no. 1 at 33rd St.	848	133	Shakopee-Oneota (142)	Deep well (no. 25, p. 223)
N. P. R. R. tracks, well no. 2	845	8	St. Peter (117)	Deep well (no. 24, p. 223)
1st Ave. N. E.	831	12	Platteville	
2nd Ave. N. E.	844	25	Platteville	
2nd Ave. S. E.	811	17	Platteville	
3rd Ave. S. E. (Pillsbury Mill)	820	20	Platteville (18)	Deep well (no. 26, p. 223)
3rd Ave. S. E. (sewer)	810	25	Platteville	Sewer data
3rd Ave. N. E.	831	13	Platteville	Sewer data

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Main St. N. E. and:				
4th Ave. N. E.	826	2	Platteville	Sewer data
5th Ave. N. E.	832	5	Platteville	
5th Ave. S. E.	810	25	Platteville	
6th Ave. N. E.	835	0	Platteville	
7th Ave. N. E.	834	0	Platteville	
8th Ave. N. E.	831	17	Platteville	
Marquette Ave. and:				
High St.	838	12	Platteville	St. Peter at 37 ft.
1st St. S.	840	18	Platteville	St. Peter at 51 ft.
1st St. S.	837	14	Platteville	St. Peter at 40 ft.
4th St. S.	843	40	Platteville	St. Peter at 67 ft.
5th St. S. (Soo Line Building)	850	50	Platteville (30)	Deep well (no. 27, p. 223)
5th St. S. (Powers)	850	40	Platteville (35)	St. Peter at 96 ft. Deep well (no. 28, p. 223)
6th St. S. (Rand Tower)	(?)	58	Platteville (32)	Deep well
6th to 7th Sts.	(Data same as above)			
8th St.	847	61	Platteville (12)	St. Peter at 73 ft.
Marshall St. and:				
4th Ave. N. E.	827	1	Platteville	
5th Ave. N. E.	826	31	Platteville	Fill
6th Ave. N. E.	827	2	Platteville	
7th Ave. N. E.	836	0	Platteville	
7th Ave. N. E.	826	28	Platteville	
8th Ave. N. E.	823	25	Platteville	
9th Ave. N. E.	820	23	Platteville	
10th Ave. N. E.	817	15	Platteville	
11th Ave. N. E.	815	9	Platteville	
12th Ave. N. E.	805	35	St. Peter	(See no. 39, p. 225)
25th Ave. N. E.	844	50	Platteville	(See no. 29, p. 223)
Mary St. & 9th St.	851	28+	(?)	Footings
Minnehaha Ave. and:				
24th Ave.	821	144	St. Peter	
26th St.	841	55	Platteville	Deep well (no. 30, p. 223)
52nd St.	818	17	Platteville (29)	
52nd St. (sewer outlet on river)	803	0	Platteville (32)	Glenwood beds (2) St. Peter at elevation 769
Minnehaha Creek and the river (opposite 52nd)	813	10	Platteville (34)	
Minnehaha Falls (Soldiers' Home, well)	760	0	St. Peter	Deep well (no. 31A, p. 224)
Minnehaha Falls (Soldiers' Home, outcrop)	817	12	Decorah	(See no. 31B, p. 224)
Minnehaha Pkwy. & 39th St.	811	11	Platteville	Deep well (no. 32, p. 224)
Monroe St. N. E. and:				
Broadway St.	845	10	Platteville	
Spring St.	839	7	Platteville	
Sumner St.	842	6	Platteville	
3rd Ave. N. E.	837	3	Platteville	
13th Ave. N. E.	848	7	Platteville	
500 ft. north of 13th Ave. N. E.	847	7	Platteville	
15th Ave. N. E.	849	18+	(?)	
440 ft. north of 15th Ave. N. E.	847	13	Platteville	
17th Ave. N. E.	846	7	Platteville	
18½ Ave. N. E.	844	6	Platteville	
20th Ave. N. E.	843	12+	(?)	
Morgan & 19½ Aves. N.		45	St. Peter	
Morgan & 20th Aves. N.		37	Platteville	

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Nawadaha Blvd. & Hiawatha Ave.	820	23	Platteville (26)	
Newton Ave. N. & 21st Ave. N.	870±	20	Platteville	St. Peter at 35 ft.
Nicollet Ave. and:				
Washington Ave.	841	24	Platteville	St. Peter at 48 ft.
Washington Ave.	841	26	Platteville (22)	
1st St.	837	20	Platteville	
2nd St.	840±	27	Platteville (15)	Glenwood beds (6 ft.)
4th St.	849	33	Platteville (10)	St. Peter at 35 ft.
4th St.	845	45	Platteville	Deep well (no. 33, p. 224)
5th St.	854	60	Platteville	Deep well (no. 34, p. 225)
6th St.	854	55	Platteville	Deep well (no. 35, p. 225)
7th St.	854	54	Platteville (15)	
7th St.	854	54	Platteville	St. Peter at 69 ft.
8th St.	850	34	(?)	
9th St.	850	43	Platteville (31)	
9th St.	850	45	Platteville	Deep well (no. 36, p. 225)
9th St. footings	850	45	Platteville	
14th St.	850	59	Platteville	Deep well (no. 37, p. 225)
22nd St.	896	118	Platteville	Deep well (no. 38, p. 225)
54th St.	880	130	St. Peter	
Nokomis Ave. near 47th St.	819	24	Platteville	
Oak St. S. E. & W. River Rd.		31	Platteville base	Elevation at 760 ft.
Oak St. S. E. & Hill St.	835	43	Platteville (31)	
Ontario & Essex Sts. S. E.	826	10	Platteville	
Ontario & Fulton Sts. S. E.	832	10	Platteville	
Penn Ave. S. & W. 60th St.	900±	268	Shakopee (71+)	
Pierce St. & 18th Ave. N. E.	835	8	Platteville	
Pierce St. & 19th Ave. N. E.	852	10	Platteville	
Pleasant Ave. & 54th St. S.	880	110	St. Peter	
Plymouth Ave. N. and:				
Emerson Ave. N.	850	16	Platteville	
Fremont Ave. N.	854	18	Platteville	
Knox Ave. N.	857	16	Platteville	
Logan Ave. N.	856	14	Platteville	
2nd St. N.	805	0	Platteville	Deep well (no. 40, p. 225)
Polk St. and:				
18th Ave. N. E.	850	9	Platteville	
18½ Ave. N. E.	852	12	Platteville	
19th Ave. N. E.	851	11	Platteville	
20th Ave. N. E.	850	10	Platteville	
22nd Ave. N. E.	851	7	Platteville	
23rd Ave. N. E.	852	8	Platteville	
24th Ave. N. E.	853	12	Platteville	
Portland Ave. & 16th St. E.	851	58+	(?)	
Queen Ave. N. & Broadway St.		39	Platteville	
Queen Ave. N. & 12th St. N.		25	Platteville (19+)	
Queen Ave. S. & 51st St.	880	250	Shakopee (40+)	
Quincy St. and:				
Broadway St.	843	7	Platteville	
Spring St.	839	7	Platteville	
Sumner St.	842	8	Platteville	
3rd Ave. N. E.	836	9	Platteville	
River Rd. at east city limits	799	13	Platteville	
(See also East and West River Rds.)				
Riverside Park	830	32	Platteville	
Roosevelt St. opposite Winter St.	861	55+	(?)	
Sheridan Ave. & 42nd St.	925	201+	(?)	

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Spring & Harrison Sts. N. E.	838	22	Platteville	
Spruce Place & Grant St.	810	40	Platteville	Deep well (no. 41, p. 226)
Stevens Ave. & Grant St.	855±	58	Platteville	Deep well (no. 42, p. 226)
Stevens Ave. near 55th Ave. S.		142	Shakopee (1+)	
Taylor St. and:				
Winter St. at G. N. Ry. tracks	838	41	Platteville	Deep well (no. 43, p. 226)
18th Ave. N. E.	849	10	Platteville	
19th Ave. N. E.	852	8	Platteville	
20th Ave. N. E.	851	5	Platteville	
22nd Ave. N. E.	852	6	Platteville	
23rd Ave. N. E.	853	7	Platteville	
24th Ave. N. E.	854	9	Platteville	
Thomas Place & Logan Ave. N.	850	9	Platteville	
Traffic St.:				
& "M" St.	864	58	Decorah	Test hole
opposite Wilson St.	859	57+	(?)	Test hole
& 18th Ave. S. E.	847	44	Decorah (9)	Test hole
& 25th Ave. S. E.	863	48	Decorah	Test hole
Tyler & 18th Aves. N. E.	850	9	Platteville	
Union Depot				Track laid on rock
University Ave. and:				
Broadway St.	838	0	Platteville (13)	Glenwood shale
Central Ave.	838	12	Glenwood shale	
Oak St. S. E.	835±	39	Platteville	Deep well (no. 71, p. 231)
1st Ave. N. E.	835	2	Glenwood shale	
2nd Ave. N. E.	838	10	Platteville	
3rd Ave. N. E.	836	11	Platteville	
4th Ave. N. E.	846	24	Platteville	
5th Ave. N. E.	840	2	Platteville	
6th Ave. N. E.	841	3	Platteville	
7th Ave. N. E.	840	2	Platteville	
8th Ave. N. E.	837	2	Platteville	
9th Ave. N. E.	836	1	Platteville	
10th Ave. N. E.	837	3	Platteville	
13th Ave. N. E.	832	1	Platteville	
14th Ave. N. E.	836	2	Platteville	
14th Ave. S. E.	834	35	Platteville	
15th Ave. N. E.	837	2	Platteville	
16th Ave. N. E.	838	1	Platteville	Limestone outcrop
19th Ave. N. E.	839	15+	(?)	
University of Minnesota campus:				
Profile of Mississippi at abandoned N. P. R. R. bridge site	792		Platteville (27)	St. Peter below
Profile of Mississippi at N. P. R. R. bridge	710 (minimum elevation of St. Peter below river)			
Shaft behind Women's Gymnasium	841	46.5	Platteville (29)	St. Peter below
Shaft north of Music Building	837	46.2	Platteville (32.9)	St. Peter below
Shaft at dormitory, Essex and Harvard Sts.	840	47	Platteville (34)	St. Peter below
Shaft behind Psychology Building	813	17	Platteville (33.8)	St. Peter below
Shaft behind Botany Building	825	(?)	Platteville	Base at elevation 759.2
Well at old power house	838	35	Platteville	Deep well (no. 44, p. 226)
Van Buren St. and:				
Broadway St.	841	8	Platteville	
Central Ave.	838	11	Platteville	

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Van Buren & Sumner Sts.	840	7	Platteville	
Washington Ave. S. & 2nd Ave.	818	25	Platteville	Deep well (no. 45, p. 226)
Washington Ave. S. & Nicollet Ave.	841	24	Platteville	Shaft
Washington Ave. N. and:				
Bryant Ave. N.	841	2	Platteville	
Colfax Ave. N.	843	4	Platteville	
Dupont Ave. N.	840	2	Platteville	
2nd Ave. N.	840	9	Platteville	
3rd Ave. N.	837	8	Platteville	
3rd St. N.	833	10	Platteville (?)	
5th Ave. N.	827		Platteville	Outcrop
6th St. S.	831	41	(?)	
7th Ave. N.		50+		Piling
7th Ave. N. (714)	818	122	St. Peter	Deep well (no. 46, p. 227)
10th Ave. N.	826	22+	(?)	
15th Ave. N.	830	22+	(?)	
17th Ave. N.	825±	12	(?)	
20th Ave. N.	826	13+	(?)	
21st Ave. N.	832	185	Shakopee	Deep well (no. 47, p. 227)
28th Ave. N.	833	14+	(?)	
35th Ave. N.	866	16+	(?)	
35½ Ave. N.	865	0	Platteville	Outcrop
35½ Ave. N.	863	10	Platteville	
36th Ave. N.	856	4	Platteville	
36½ Ave. N.	852	1	Platteville	
37th Ave. N.	837	12	Platteville	
38th Ave. N.	832	16+	(?)	
39th Ave. N.	830			Outcrop
40th Ave. N.	837	13	Platteville	
41st Ave. N.	839	6	Platteville	
42nd Ave. N.	843	3	Platteville	
42½ Ave. N.	840	4	Platteville	
44th Ave. N.	846	19+	(?)	
Washington St. N. E. and:				
Adams St. N. E.	852	6	Platteville	
Broadway St.	842	3	Platteville	
Sumner St.	841	5	Platteville	
5th St. N. E.	841	2	Platteville	
13th Ave. N. E.	847	7	Platteville	
15th Ave. N. E.	850	9	Platteville	
17th Ave. N. E.	849	7	Platteville	
19th Ave. N. E.	851	7	Platteville	
20th Ave. N. E.	852	6	Platteville	
22nd Ave. N. E.	845	13	Platteville	
West Broadway and 4th St. N.	850	230	St. Peter (30)	
West Broadway and Logan Ave. N.	875	40	Platteville (15)	
W. River Rd. & 27th Ave. S. E.	809	10	Platteville	
W. River Rd. & 45th Ave. S.	819	32	Platteville	
Wilson St. opposite Winter St.	864	47+	(?)	Test hole
Xerxes & 19th Aves. N.	932	100	Platteville	Deep well (no. 48, p. 227)
1st St. and:				
1st Ave. N.	839	11	Platteville	
2nd Ave. N.	838	12	Platteville	
3rd Ave. N.	839	8	Platteville	
1st Ave. S. & 10th St.	847	7	Platteville	
2nd Ave. N.:				
& 2nd St.	837	7	Platteville	

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
2nd Ave. N.:				
between 4th & 5th Sts.	846	36+	(?)	
& 5th St.	840	30	Platteville	Deep well (no. 49, p. 227)
2nd Ave. S. and:				
near the river	845	24	Platteville	
1st St. S.	840	25	Platteville	St. Peter at 54 ft.
1st St. S.	842	27	Platteville	St. Peter at 60 ft.
1st St. S.	843	27	Platteville	St. Peter at 62 ft.
1st St. S.	840	20	Platteville	
1st St. S.	830	23	Platteville	Deep well (no. 51, p. 227)
2nd St. S.	834	20	Platteville	
3rd St. S.	834	35	Platteville	Deep well (no. 50, p. 227)
4th St. S.	842	38	Platteville	
4th St. S.	844	39	Platteville (28)	
6th St. S.	845	48	Platteville	Deep well (no. 52, p. 227)
2nd St. N.:				
& 1st Ave. N.	838	12	Platteville	
& 1½ Ave. N.	837	14	Platteville	
& 3rd Ave. N.	836	4	Platteville	
between 3rd & 4th Aves. N.	843	15	Platteville (11+)	
between 3rd & 4th Aves. under railroad bridge	822	40+	(?)	
& 4th Ave. N.	847	21	Platteville (9+)	
& 5th Ave. N.	836	9	Platteville (9)	St. Peter below
& 6th Ave. N.	834	8	Platteville (7)	St. Peter below
& 7th Ave. N.	830	36+	(?)	
& 8th Ave. N.	827	53+	(?)	
2nd St. N. E. and:				
2nd Ave. N. E.	831	1	Platteville	
4th Ave. N. E.	837	5	Platteville	
6th Ave. N. E.	840	5	Platteville	
8th Ave. N. E.	836	2	Platteville	
9th Ave. N. E.	836	0	Platteville	
10th Ave. N. E.	836			
12th Ave. N. E.	830	4	St. Peter	
13th Ave. N. E.	826	5	St. Peter	
14th Ave. N. E.	825	5	Platteville	
15th Ave. N. E.	825	6	Platteville	
2nd St. S. & railroad tracks	820	33	Platteville	Deep well (no. 53, p. 228)
2nd St. S. & 21st Ave.	789	6	Platteville (23)	
3rd Ave. N. and:				
3rd St. N.	842	11	Platteville	
5th St. N.	831	25	St. Peter	
5th St. N.	837	87	St. Peter	Deep well (no. 54, p. 228)
5th St. N.	839	34	St. Peter	Penetrated 3 ft. Outcrop
3rd Ave. N. E. and:				
2nd St. N. E.	833		(?)	
4th St. N. E.	839	12	Platteville (11)	
5th St. N. E.	839	12	Platteville	
3rd Ave. S.:				
near the river	842	52	Platteville	
& 4th St.	843	43	Platteville	St. Peter at 70 ft.
between 4th & 5th Sts.	844	44	Platteville (26)	
& 5th St.		45±	Shaly rock	15 ft. of broken rock
& 10th St.	855	50	Platteville (30)	Glenwood (10 ft.)
& 40th St. E.	839	75+	(?)	
3rd Ave. S. E. and the river	780	0	Decorah	Deep well (no. 55, p. 228)

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
3rd St. N.:				
between 1st & 3rd Aves.	842	16	Platteville	
between 1st & 3rd Aves.	844	11	Platteville	
between 13th & 14th Aves.	828	140	Shakopee (45)	
& 8th Ave.	814	33+	(?)	
near 33rd Ave.	865	12	Platteville	
near 34th Ave.	872	13	Platteville	
3rd St. N. E. and:				
12th Ave.	835	0	Platteville (8)	
13th Ave.	833	0	Platteville (6)	
13th Ave.			Platteville	Exposed in Roger's quarry
14th Ave.	835	0	Platteville (8)	
70 ft. south of 15th Ave.	835	0	Platteville (5)	
16th Ave.	836	0	Platteville (5)	
150 ft. north of 16th Ave.	836	0	Platteville (0)	
3rd St. S. & 9½ Ave. S.	829		(?)	Deep well; no record
4th Ave. N. & 5th St.	830	60+	(?)	
4th Ave. N. E. & Madison St.	836	8	Platteville	
4th Ave. S. & 3rd St.	838	33	Platteville	
4th Ave. S. & 9th St.	840	45	Platteville	Deep well (no. 56, p. 228)
4th St. and:				
1st Ave. N.	851	52	St. Peter	Sandstone at edge of Platteville
1st Ave. N. E.	837	7	Platteville	
2nd Ave. N. E.				No record
4th Ave. N. E.	842	10	Platteville	
5th Ave. N. E.	842	6	Platteville	
6th Ave. N. E.	843	3	Platteville	
7th Ave. N. E.	842	1	Platteville	
8th Ave. N. E.	840	4	Platteville	
9th Ave. N. E.	839	3	Platteville	
12th Ave. N. E.	838	0	Platteville	
13th Ave. N. E.	836	(?)	Platteville	
14th Ave. N. E.	839	(?)	Platteville	
15th Ave. N. E.	842	5	Platteville	
16th Ave. N. E.	844	3	Platteville	
17th Ave. N. E.	848	6	Platteville	
18th Ave. N. E.	846	4	Platteville	
19th Ave. N. E.	845	3	Platteville	
21st Ave. S.	823	35	Platteville (35)	
5th Ave. N. & 5th St.	816	60+	(?)	Drill hole
	816	94+	(?)	Drill hole
	816	60+	(?)	Piling
5th Ave. S. & 10th St.	855	60	Platteville (35)	
5th Ave. S. E. & 2nd St. S. E.	815	20	St. Peter	Deep well (no. 57, p. 228)
5th to 6th Aves. S. & 5th to 6th Sts. S.	841	46	Platteville	31 ft. to St. Peter
5th St. and:				
4th Ave. N. E.	841	10	Platteville	
5th Ave. N. E.	841	5	Platteville	
5th Ave. N. E.			(?)	Small abandoned quarry
6th Ave. N. E.	842	5	Platteville	
7th Ave. N. E.	841	2	Platteville	
8th Ave. N. E.	840	4	Platteville	
9th Ave. N. E.	841	2	Platteville	
13th Ave. N. E.	837	2	Platteville	
15th Ave. N. E.	843	5	Platteville	

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
5th St. and:				
15½ to 16th Aves. N. E.	845	5	Platteville	
18th Ave. N. E.	848	2	Platteville	
19th Ave. N. E.	851	7	Platteville	
20th Ave. N. E.	854	18	Platteville	
46th Ave. N. E.		95±	St. Peter (6+)	
6th Ave. N. & 5th St.	812	36+	(?)	
6th Ave. S. & Washington Ave. (180 ft. northeast)	827	30	Platteville	No record
6th Ave. S. & 4th St.	833	37	Platteville (29)	St. Peter at 73 ft.
6th St. N. and:				
38th Ave. N.	870	3	Platteville	
39th Ave. N.	858	3	Platteville	
40th Ave. N.	853	5	Platteville	
41st Ave. N.			St. Peter	Top at 846 ft.
6th St. N. E. and:				
1st Ave. N. E.			Platteville (8)	Top at 833 ft.
13th Ave. N. E.	842	3	Platteville	
15th Ave. N. E.	848	10	Platteville	
17th Ave. N. E.	851	7	Platteville	
19th Ave. N. E.	851	3	Platteville	
20th Ave. N. E.	849	14	Platteville	
22nd Ave. N. E.	848	16	Platteville	
6th St. & 10th Ave. S.	837	46	Platteville (27)	Deep well (no. 58, p. 228)
7th Ave. S. near the river	801	0	Platteville	Deep well (no. 59, p. 228)
7th Ave. S. & 2nd St.	825	10	Platteville	Deep well (no. 60, p. 229)
7th St. N. E. and:				
2nd Ave. N. E.	836	10	Platteville	
3rd Ave. N. E.	835	9	Platteville	
42nd Ave. N. E.	945	175	Platteville	
45th Ave. N. E.	915	175	Platteville	
8th Ave. N. E. & 6th St.	841	4	Platteville	
8th Ave. S. E. & 6th St.	830	22	Decorah	Deep well (no. 61, p. 229)
10th Ave. N. & 2nd St.	831	160	St. Peter	Deep well (no. 62, p. 229)
10th Ave. S. and:				
3rd St.	849	50	Platteville (31)	Glenwood (10 ft.)
9th St.	830	42	Platteville	
33rd St.	861	107	St. Peter	
Mississippi River	793		Platteville	
10th Ave. S. E. & 2nd St.	808	18	Platteville (28)	
11th Ave. S. near 2nd St.	825	37	Platteville (30)	
11th Ave. S. & 6th St.		23+	(?)	Concrete footings.
13th Ave. N. E. near 3rd St.	836	27	(?)	Well (no. 63, p. 229)
14th Ave. N. E. & "D" St.			Platteville	
14th Ave. N. E. near Stinson Blvd.	871	45+	(?)	Test hole
14th Ave. S. at the river	764	0	Platteville	Deep well (no. 64, p. 229)
14th Ave. S. & 32nd St.	857	76	Platteville	
15th Ave. N. E. & 2nd St. N. E.	836	0	Platteville	Deep well (no. 65A, p. 229)
15th Ave. S. & 34th St.	831	125	St. Peter	
15th St. near Oak Grove St.	828	95	St. Peter	Deep well (no. 65B, p. 229)
18th Ave. N. E. and:				
Central Ave.	850	11	Platteville	
"D" St.		14	Platteville	
Jackson St. N. E.	847	10+	None at 837 ft.	
Monroe St. N. E.	843	5	Platteville	
Quincy St. N. E.	843	8+	(?)	
2nd St. N. E.		124+	(?)	No record for remainder of 420 ft. well.

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
19th Ave. N. E. and:				
Central Ave.	852		Doubtful	
Jefferson St.	853	9	Platteville	
Washington St.	852	5	Platteville	
21st Ave. S. & Minnehaha Ave.	820	59+	(?)	
21st St. between 3rd & 4th Sts. S.	824	22	Platteville	
22nd Ave. N. E. & Pierce St.	859	14	Platteville	
22nd Ave. S. & 7th St.	841	47	Platteville	
22nd Ave. S. E. & 7th St. S. E.	849	62	Platteville	
E. 22nd St. & Seabury	827	33	Platteville	
23rd Ave. N. E. & N. P. R. R. tracks	848	133	Shakopee	Deep well (no. 25, p. 223)
23rd St. S. & Sverdrup St.	820	64	St. Peter	
70 ft. east of above	828	77	St. Peter	
70 ft. southeast of above	830	39	Platteville	
24th Ave. N. at the river	810	18	St. Peter	Deep well (no. 66, p. 229)
24th Ave. N. at the river	825	8	Platteville	Deep well (no. 67, p. 230)
24th Ave. N. & 2nd St.		240	St. Peter	
24th Ave. S. & Minnehaha Blvd.	826	52+	(?)	
24th St. S. between 28th & 29th Aves.		50	Platteville	St. Peter at 85 ft.
25th Ave. N. E. between Polk & Taylor Sts.	856	11	Platteville	
25th Ave. S. E. & railroad tracks near 4th St.	838	47	Platteville	Deep well (no. 68, p. 230)
26th Ave. S. & 29th St.	839	45	Decorah	Shale
26th Ave. S. & 40th St.	822	31	Platteville	
26th Ave. S. E. & G. N. R. R. tracks	849	62	Platteville	Deep well (no. 69, p. 230)
26th St. E. & Dorman Ave.	824	28	Platteville	
26th St. E. & W. River Rd.	824	30	Platteville	St. Peter below
26th St. & 40th Ave. S.	825	34	Platteville (28)	
26th & Riverside Aves.			Platteville (28)	Elevation of base 762 ft.
27th Ave. & 6th St. S.	814	22	Platteville	
27th Ave. N. & the river		8	Platteville	
27th Ave. S. E. & E. River Rd.	811	17	Platteville (32)	
28th Ave. S. & 24th St.		50	Platteville (35)	St. Peter at 65+ ft.
28th St. W. & M. & St. L. R. R.	881	100		
29th Ave. N. E. at the river	831	137	Shakopee	Deep well (no. 70, p. 230)
29th Ave. S. & C. M. St. P. & P. R. R. tracks				No record of deep well
33rd Ave. N.:				
& Washington Ave.	851	16+	None	
between Washington Ave. & 3rd St.	858	13	Platteville	Syncline rises to west
between 3rd & 4th Sts.	868	8	Platteville (6)	
& 4th St. N.	869	16		
near 6th St.	872	13	Platteville (2)	
33rd Ave. N. E. & N. P. R. R. tracks	853	110+	None	
E. 33rd St. & Edmund Blvd.	804	15	Platteville	
34th Ave. S. & E. 47th St.	823	28	Platteville	
36th Ave. S. & E. 47th St.	816	22	Platteville	
36th Ave. S. & near 53rd St.	840	35	Platteville	
37th Ave. S. between 51st & 52nd Sts.	837	34	Platteville (9)	8 ft. of soapstone beneath
38th Ave. N.:				
& Colfax Ave.	885	12	Platteville	
& Lyndale Ave.	880	15	Platteville	
near the river	810	5+	None	
& Washington Ave.	833	17+	None	
& 4th St.	868	16+	None	

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
38th Ave. S. & 53rd St.	835	30	Platteville	
38th St. S. & Edmund Blvd.	817	24	Platteville (33)	3 ft. of soapstone beneath
39th Ave. S. & Minnehaha Ave.	814	16	Platteville (29)	2 ft. of soapstone beneath
39th Ave. S. & E. 51st St.	840	32	Platteville	
40th Ave. S. & 53rd St.	838	35	Platteville	
42nd St. & Edmund Blvd.	811	18	Platteville	
42nd Ave. N. and:				
Bryant Ave.	859	6	St. Peter	
Emerson Ave.	826	4	Platteville	
Girard Ave.	826	19	St. Peter	
Lyndale Ave.	843	2	St. Peter	
45th Ave. N. at the river	835±	89	St. Peter	
45th St. E. projected to Edmund Blvd. S.	803	14	Platteville (18)	
47th Ave. & E. 46th St.	802	5	Platteville	
50th St. & Hiawatha Ave.	818	24	Platteville (21)	
51st St. & Lyndale Ave. N.		97	St. Peter	
52nd St. E. at the river bank	818	17	Platteville (29)	Elevation of base 772 ft.
53rd St. at Snelling Ave. S.	810	6	Platteville (33)	1 ft. of soapstone below
53rd St. E. at the river bank			Platteville (34)	Elevation of base 768 ft.
54th St. S. & 10th Ave. S.	880	95	St. Peter (140)	
57th St. & Lyndale Ave. N.		64	St. Peter	
58th St. and:				
Bryant Ave. S.	870±	90	(?)	
Colfax Ave. S.	870±	70	Platteville	
Girard Ave. S.	840±	100	St. Peter	80 ft. penetrated

* Numbers in parentheses indicate thickness of formation.

MINNEAPOLIS WELL LOGS

Formation	Description	Depth (in feet)	Thickness (in feet)
1. Well of Minneapolis Street Ry. Co., Blaisdell Ave. and E. 32nd St. Elevation 867 ft.[1]			
Drift	Unclassified	0–67	67
Platteville	Limestone	67–107	40
St. Peter	Sandstone	107–265	158
Shakopee	Dolomite	265–402	137
Jordan	Sandstone	402–487	85
St. Lawrence	Mixed formation	487–667	180
Franconia	Sandstone	667–732	65
Dresbach	Sandy shale	732–917	185
Hinckley		917–1002	85+
2. Well at the Sanitary Ice. Co., 29th St. and Bryant Ave. S. Elevation 879 ft.[2]			
Drift	Unclassified	0–290	290
Shakopee-Oneota	Dolomite	290–403	113
Jordan	Sandstone	403–503	100
St. Lawrence	Shale, etc.	503–680	177
Franconia	Sandstone	680–740	60
Dresbach	Shale, etc.	740–800	60+
3. Well at Calhoun Bath House. Elevation 856 ft.[3]			
Drift	Gravel and clay	0–120	
	Hardpan	120–142	
	Gravel	142–160	
	Hardpan, shale, and boulders	160–170	
	Fine sand and coarse gravel	170–178	
	Quicksand and limestone	178–210	
	Hardpan and boulder	210–215	215
St. Peter	Sandstone	215–240	30
Shakopee	Dolomite	240–241	1+
4. Well at Calhoun Boat Dock. Elevation 858 ft.[3]			
Drift	Sand and gravel	0–118	
	Hardpan	118–237	237
St. Peter	Sandstone	237–259	22
Shakopee	Dolomite	259–263	4+
5. Well at Soo Line Shoreham Shops, 1908 28th Ave. N. E. and Central Ave. Elevation 852 ft.[4]			
Drift	Unclassified	0–57	57
St. Peter	Sandstone	57–180	123
Shakopee-Oneota	Dolomite	180–295	115 *
Jordan	Sandstone	295–385	90
St. Lawrence	Shale and sandstone	385–415	
	Shale	415–560	175
Franconia	Sandstone	560–626	66
Dresbach-	Shale and sandstone	626–633	
Hinckley	Shale	633–680	
	Shale and sandstone	680–705	
	Red sandstone	705–845	
	Shales, etc.	845–853	227+
6. Well at Camden Park, Dupont and 45th Aves. N. Elevation 835 ft.[3]			
Drift	Unclassified	0–10	10
St. Peter	Sandstone	10–128	118

* Thin.

Formation	Description	Depth (in feet)	Thickness (in feet)
Shakopee-Oneota	Dolomite	128–299	171 *
Jordan	Sandstone	299–366	67+
7. Well on East Hennepin Ave. at Wunder Sand and Gravel Plant.[5]			
Drift	Unclassified	0– 75	75
Platteville	Limestone	75– 96	21
St. Peter	Sandstone	96–246	150
Shakopee-Oneota	Dolomite	246–406±	160±
Jordan	Sandstone	±406–500	90±
St. Lawrence(?)	Mixed formation	500–510	10+
8. Well at E. S. Woodward Elevator Co., Elm St. and 18th Ave. S.E. Elevation 850 ft.[1]			
Drift	Unclassified	0– 45	45
Decorah	Shale	45– 67	22
Platteville	Limestone	67–109	42
St. Peter	Sandstone	109–189	80+
9. Well at Edina Theater, 50th and France Ave. S. Elevation 888 ft.[6]			
Drift	Unclassified	0– 90	90
Platteville	Limestone	90– 95	5
St. Peter	Sandstone	95–270	175
Shakopee-Oneota	Dolomite	270–400	130
Jordan	Sandstone	400–415	15+
10. Well at Twin City Milk Producers, 1001 Glenwood Ave. Elevation 813 ft.[7]			
Drift	Unclassified	0–190	190
Shakopee-Oneota	Dolomite	190–293	103
Jordan	Sandstone	293–388	95
St. Lawrence	Shale, etc.	388–585	197
Franconia	Sandstone, etc.	585–660	75
Dresbach	Shale, etc.	660–809	149+
11. Well at Glenwood Lake, Glenwood Park (Xerxes and 9th Ave. N. extended). Elevation 822 ft.[3]			
Drift	Unclassified	0– 45	45
St. Peter	Sandstone	45–165	120
Shakopee-Oneota	Dolomite	165–190	25+
12. Well at Glenwood Park Bath House. Elevation 822 ft.[8]			
Drift	Unclassified	0– 62	62
St. Peter	Soft sandstone	62–107	
	Soft sandstone and shale	107–122	
	Hard sandstone and shale	122–160	118+
13. Well no. 2 at Great Northern Ry. Roundhouse, Harrison and Winter Sts. Elevation 836 ft.[9]			
Drift	Sand and gravel	0– 37	37
Platteville	Limestone	37– 52	15
St. Peter	Sandstone	52–168	
	Shale	168–190	
	Shale and sandstone	190–220	168
Shakopee-Oneota	Hard limestone	220–338	118
Jordan	Sandstone	338–440	102
St. Lawrence	Shale	440–455	
	Sandy shale	455–625	185
Franconia	Sandstone	625–680	55
Dresbach	Shale	680–776	
	Gray rock	776–813	
	Green shale	813–824	
	Red shale	824–829	149

* Thick.

Formation	Description	Depth (in feet)	Thickness (in feet)
Hinckley	Pink Hinckley	829–931	
	Red shale	931–933	
	Pink Hinckley	933–1056	227+

14. Well in the Boston Block, northwest corner of 3rd St. and Hennepin Ave. Elevation 845 ft.[1]

Drift	Unclassified	0– 20	20
Platteville	Limestone	20– 40	20
St. Peter	Sandstone	40–210	170
Shakopee-Oneota	Dolomite	210–325	115 *
Jordan	Sandstone	325–400	75
St. Lawrence	Mixed formation	400–595	195
Franconia	Sandstone, etc.	595–695	100+

15. Well at West Hotel, 5th St. and Hennepin Ave. Elevation at ground level 848± ft.[10]

Drift	Sand and gravel	0– 34	34
Platteville	Limestone	34– 54	20
St. Peter	Sandstone	54–218	164
Shakopee-Oneota	Dolomite	218–351	133
Jordan	Sandstone	351–447	96
St. Lawrence	Mixed formation	447–608	161
Franconia	Sandstone, etc.	608–638	30+

16. Well at Minneapolis General Electric Co., 15 S. 5th St. Elevation 848 ft.[11]

Basement		0– 38	38
Platteville	Limestone	38– 56	18
Glenwood	Shale	56– 61	5
St. Peter	Sandstone	61–181	
	Shale	181–213	152
Shakopee-Oneota	Hard, red limestone	213–327	114
Jordan	Sandstone	327–457	130
St. Lawrence	Sandstone and shale	457–600	143
	Sandstone	600–646	46+

17. Pantages Theatre, 704 Hennepin Ave. Elevation 854 ft.[12]

Drift	Unclassified	0– 40	40
Platteville	Limerock	40– 70	30
St. Peter	Sandrock	70–225	155
Shakopee-Oneota	Dolomite	225–340	115
Jordan	Sandstone	340–358	18+

18. Shaft on Hennepin Island, Mississippi River. Elevation 802 ft.[13]

Drift	Unclassified	0– 5	5
Platteville	Weathered, disintegrated limestone	5– 9	
	Argillaceous limestone	9–14	
	Blue limestone	14–30	
	Shale and clay	30–32	
	Blue argillaceous limestone	32–35	
	No record	35–36	31
St. Peter	Iron-stained sandstone	36–39	
	White thin-bedded sandstone	39–55	
	Hard, uniform, white sandstone	55–73	
	Hard iron-stained sandstone	73–77	
	Soft white sandstone	77–80	44+

19. Well at Folwell Park, 37th Ave. N. and Irving Ave. Elevation 916 ft.[3]

Drift	Unclassified	0– 65	65
Platteville	Limestone	65– 83	18
St. Peter	Sandstone	83–263	180 †
Shakopee-Oneota	Dolomite	263–357	94 *
Jordan	Sandstone	357–369	12+

* Thin. † Thick.

Formation	Description	Depth (in feet)	Thickness (in feet)
20. Well at Lakewood Cemetery, opposite 39th St. and Irving Ave. S. Elevation 885 ft.[14]			
Drift	Various	0– 256	
	Pure quartz sand	256– 318	318
Shakopee-Oneota	Dolomite; some sand	318– 416	98
Jordan	White quartz sand	416– 504	88
St. Lawrence		504– 694	190
Franconia		694– 780	86
Dresbach		780– 935	155
Hinckley		935–1123	188
Red Clastic		1123–2135	1012
Granite		2135–2150	15

Reported to have struck granite at bottom for 15 ft.; see *Minneapolis–St. Paul Folio* (U. S. Geological Survey Atlas 201), p. 3.

Formation	Description	Depth (in feet)	Thickness (in feet)
21A. Well at Y. M. C. A., La Salle and 9th St. Elevation 850 ft.[15]			
Drift	Sand	0– 32	32
Platteville	Limestone	32– 61	29
St. Peter	Sandstone	61–226	165
Shakopee-Oneota	Dolomite	226–341	115
Jordan	Sandstone	341–428	87
St. Lawrence	Shale, etc.	428–600	172
Franconia	Sandstone	600–650	50
Dresbach	Shale	650–651	1+
21B. Well of American Linen Co. at 909–11 La Salle Ave. Elevation 850 ft.[16]			
Drift	Unclassified	0– 40	40
Platteville	Limestone	40– 68	28
St. Peter	Sandstone	68– 244	176
Shakopee-Oneota	Dolomite	244– 360	116+
Jordan	Sandstone	360– 464	104−
St. Lawrence	Mixed formation	464– 634	170
Franconia	Sandstone	634– 695	61
Dresbach	Shale and sandstone	695– 822	127
Hinckley and Red Clastic	Shale, sandstone, etc.(?)	822–1074	252+
22. Well at Fairview Park, Lyndale Ave. and 26th Ave. N. Elevation 863 ft.[17]			
Drift	Gravel and hardpan	0– 27	27
Platteville	Limestone	27– 39	12
Glenwood	Sand and clay	39– 46	7
St. Peter	Sandstone	46–208	162
Shakopee-Oneota	Dolomite	208–210	2+
23. Well at Exposition Building, Central Ave. and Main St. Elevation 840 ft.[18]			
Drift	Sand, glacial gravel, and red till	0– 42	42
Platteville	Blue limestone	42– 70	28
St. Peter	White sandstone	70– 234	164
Shakopee	Red limestone	234– 336	
	Gray limestone	336– 352	118 *
Jordan	White sandstone	352– 468	116 †
St. Lawrence	Bluish mixed formation	468– 596	128
Franconia	White sandstone	596– 678	82
Dresbach	Blue shale	678– 848	
	Sandy limestone	848– 857	179
Hinckley	White sandstone	857– 987	
	Sandy marl	987– 995	
	White sandstone	995–1074	217
Red Clastic	Red marl	1074–1131	
	Sandstone and red marl	1131–1421	347+

* Thin. † Thick.

FORMATION	DESCRIPTION	DEPTH (in feet)	THICKNESS (in feet)

24. Northern Pacific Ry. Power House, well no. 2, Northtown Junction, near 32nd Ave. N. and Main St. N. E. Elevation 845 ft.[19]

Drift, etc.	Cinders, sand, etc.	0– 8	8
St. Peter	Sandstone	8– 80	
	Shale	80–125	117
Shakopee-Oneota	Hard	125–175	50
	Brown sandstone and shale	175–187	12
	Limestone and sandrock	187–265	83
Jordan–St. Lawrence	Sandstone and shale	265–520	255
Franconia	Sandstone	520–600	80
Dresbach	Shale and some sandstone	600–614	14+

25. Northern Pacific Ry. well no. 1, Northtown Junction, 33rd St. N. E. (on main line). Elevation 848 ft.[20]

Drift	Sand, gravel	0– 36	36
	Blue clay	36–133	97
Shakopee-Oneota	Limestone	133–275	142
Jordan	Sandstone	275–361	86

26. Well at Pillsbury "A" Mill, 3rd Ave. S. E. and Main St. Elevation 820 ft.[1]

Drift	Unclassified	0– 20	20
Platteville	Limestone	20– 55	35
St. Peter	Sandstone	55–155	100+

27. Well at Soo Line Building, Marquette Ave. and 5th St. Elevation 850 ft.[2]

Drift	Unclassified	0– 50	50
Platteville	Limestone	50– 80	30
St. Peter	Sandstone	80–245	165
Shakopee-Oneota	Dolomite	245–375	130
Jordan	Sandstone	375–465	90
St. Lawrence	Shale, etc.	465–645	180
Franconia	Sandstone	645–715	70
Dresbach	Shale, etc.	715–748	33+

28. Well at Powers Mercantile Co., in alley on Marquette between 4th and 5th Sts. Elevation 850 ft.[21]

Drift	Clay, etc.	0– 40	40
Platteville	Limestone	40– 75	35
St. Peter	Sandstone	75–213	138+

29. Russell-Miller Milling Co., 2500 Marshall Ave. S. E. Elevation 844 ft.[22]

Drift	Unclassified	0– 50	50
Platteville	Limestone	50– 80	30
Glenwood beds	Shale	80– 90	10
St. Peter	Sandstone	90– 250	160
Shakopee-Oneota	Dolomite	250– 372	122
Jordan	Sandstone	372– 457	85
St. Lawrence	Shales	457– 625	168
Franconia	Sandstone	625– 700	75
Dresbach	Shales	700– 830	130
Hinckley	Sandstones	830– 950	120
Red Clastic	Shales	950–1100	160

30. Wells at Chicago and Milwaukee R. R. shops, 26th St. and Minnehaha Ave. Elevation 841 ft.[23]

Well No. 1 [23]

Drift	Sand and gravel	0– 16	
	Hardpan and boulders	16– 55	55
Platteville	Limestone	55– 96	41
St. Peter	Shale and sandstone	96–104	

Formation	Description	Depth (in feet)	Thickness (in feet)
	Sandstone	104–210	
	Shale	210–225	
	Shale and sandstone	225–255	159
Shakopee	Hard dolomite	255–295	40
New Richmond	Sandstone	295–300	5
Oneota	Hard dolomite	300–370	70
Jordan	Soft sandstone	370–426	
	White shale and sandstone	426–450	
	Coarse sandstone	450–460	90
St. Lawrence	Shale and sandstone	460–500	
	Shale	500–645	185
Franconia	Sandstone	645–715	70
Dresbach	Shale	715–805	
	Sandstone	805–844	
	Shale and sandstone	844–865	
	Sandstone	865–920	205
Hinckley	Red and yellow sandstone	920–995	75+

(This well gives the Shakopee-Oneota as 115 ft., which is below normal thickness.)

Well No. 2[24]

Drift		0– 54	54
Platteville	Limestone	54– 82	28
St. Peter	Sandstone	82–245	163
Shakopee-Oneota	Dolomite	245–381	136
Jordan	Sandstone	381–465	84
St. Lawrence	Sandy glauconitic shale	465–655	190
Franconia	White and gray sandstone	655–704	49

31A. Well at Soldiers' Home, Minnehaha Falls. Elevation 760± ft.[25]

St. Peter(?)	Yellow, medium sand	0– 150	150
Shakopee-Oneota	Dolomite	150– 280	130
Jordan	Coarse white sandstone	280– 415	135
St. Lawrence	Mixed formation	415– 552	137
Franconia	Sandstone	552– 700	148
Dresbach	Shale and sandstone	700– 950	250
Hinckley	Mixed formation	950–1110	160+

(Platteville outcrops at elevation 767 ft.)

31B. Outcrop at Soldiers' Home, near outlet of Minnehaha Creek. Elevation 817 ft.[26]

Drift	Soil, etc.	0– 12	12
Decorah	Shale	12– 18	6
Platteville	Limestone	18– 44	26
Glenwood	Shale	44– 51	7
St. Peter	Sandstone	51–124	73+

32. Well at Longfellow Park, 39th St. and Minnehaha Pkwy. Elevation 811 ft.[3]

Drift	Unclassified	0– 11	11
Platteville	Limestone	11– 47	36
St. Peter	Sandstone	47–200	153
Shakopee-Oneota	Dolomite	200–325	125
Jordan	Sandstone	325–405	80
St. Lawrence	Shale, etc.	405–603	198
Franconia	Sandstone	603–673	70
Dresbach	Shale, etc.	673–731	58+

33. Well of Palace Clothing Co., Nicollet Ave. and 4th St. Elevation 845 ft.[27]

Drift	Sand and gravel	0– 45	45
Platteville	Limestone	45– 52	
	Soapstone	52– 57	12
St. Peter	White sandstone	57–140	
	Brown sandstone	140–160	
	White sandstone	160–180	

Formation	Description	Depth (in feet)	Thickness (in feet)
	Brown sandstone	180–230	173
Shakopee-Oneota	Dolomite	230–350	120
Jordan–St. Lawrence	Sandstone	350–510	160+

34. Well at Leader (Syndicate) Building, Nicollet Ave. and 5th St. Elevation 854 ft.[2]

Drift	Unclassified	0– 60	60
Platteville	Limestone	60– 87	27
St. Peter	Sandstone	87–245	158
Shakopee-Oneota	Dolomite	245–365	120
Jordan	Sandstone	365–470	105+

35. Well at Donaldson Building, near corner of 6th St. and Nicollet Ave. Elevation 854 ft.[28]

Drift	Unclassified	0– 55	55
Platteville	Limestone	55– 85	30
St. Peter	Sandstone	85–245	160
Shakopee-Oneota	Dolomite	245–380	135
Jordan	Sandstone	380–460	80
St. Lawrence	Mixed formation	460–625	165
Franconia	Sandstone	625–685	60
Dresbach	Shale, etc.	685–777	92+

36. Well at Young-Quinlan Co., Nicollet Ave. and 9th St. Elevation 850 ft.[29]

Drift	Unclassified	0– 45	45
Platteville	Limestone	45– 73	28
Glenwood	Shale	73– 82	9
St. Peter	Sandstone	82–252	170
Shakopee-Oneota	Dolomite	252–367	115
Jordan	Sandstone	367–385	18+

37. Well at Loring Theatre, 1405 Nicollet Ave. Elevation 850 ft.[30]

Basement		0– 25	25
Drift	Gravel and clay	25– 59	34
Platteville	Limestone	59– 89	30
St. Peter	Sandstone	89–100	11+

38. Well at Lee Mortuary, 2217 Nicollet Ave. Elevation 896 ft.[31]

Drift	Unclassified	0–118	118
Platteville	Limestone	118–132	14
Glenwood	Shale	132–135	3
St. Peter	White sandstone	135–201	66+

39. Well at Minneapolis Brewing Co., 12th Ave. N. E. and Marshall. Elevation 805 ft.[1]

Platteville	Limestone, probably float	0– 35	35
St. Peter	Sandstone	35–150	115 *
Shakopee	Dolomite	150–210	60
New Richmond	Sandstone	210–222	12
Oneota	Dolomite	222–307	85
Jordan	Sandstone	307–352	45+

40. Well at Northern Pacific Ry. Roundhouse, Plymouth Ave. N. and 2nd St. Elevation 825 ft.[1]

Drift	Unclassified	0– 20	20
Platteville	Limestone	20– 35	15
St. Peter	Sandstone	35–155	120
Shakopee	Dolomite	155–185	30
New Richmond	Sandstone	185–196	11
Oneota	Dolomite	196–301	105
Jordan	Sandstone	301–336	35

* Thin.

Formation	Description	Depth (in feet)	Thickness (in feet)
41. Well of John King, Spruce Flats, 805 Spruce Place, near Grant St. Elevation 810 ft.[4]			
Drift	Unclassified	0– 40	40
Platteville	Limestone	40– 60	20
St. Peter	Sandstone	60–220	160+
42. Well at Municipal Auditorium, Grant St. and Stevens Ave. Elevation 856.2 ft.[32]			
Drift	Unclassified	0– 58	58
Decorah(?)	Shale	58– 69	11
Platteville	Limestone	69– 90	21
St. Peter	Sandstone	90–255	165
Shakopee	Dolomite	255–278	23
New Richmond	Sandstone	278–288	10
Oneota	Dolomite	288–378	90
Jordan	Sandstone	378–460	82
St. Lawrence	Mixed formation	460–654	194
Franconia	Sandstone, etc.	654–722	68
Dresbach	Shale and sandstone	722–801	79+
43. Well at Great Northern Ry. Junction No. 1, south of Taylor and Winter Sts. Elevation 838 ft.[9]			
Drift	Gravel	0– 41	41
Platteville	Limestone	41– 66	25
St. Peter	Sandstone	66– 175	
	Shale	175– 190	
	Sandstone and shale	190– 210	
	Sandstone	210– 212	146
Shakopee-Oneota	Hard rock	212– 230	
	Limestone	230– 334	122
Jordan	Sandstone	334– 440	106
St. Lawrence	Shale	440– 500	
	Blue shale	500– 550	
	Shale	550– 628	188
Franconia(?)	Shale and sandstone	628– 647 *	19
Dresbach	Shale	647– 794	
	Sandstone	794– 806	
	Sandstone and shale	806– 820	173
Hinckley	Sandstone	820–1032	212
Red Clastic	Red shale	1032–1034	
	Sandstone	1034–1038	
	Yellow clay	1038–1039	
	Sandstone	1039–1045	
	Coarse-grained sandstone	1045–1050	18+
44. Well at old University of Minnesota power house (near present Business Building). Elevation 838 ft.[33]			
Drift	Unclassified	0– 35	35
Platteville	Limestone	35– 60	25
St. Peter	Sandstone	60–220	160
Shakopee	Dolomite	220–265	45
New Richmond	Sandstone	265–277	12
Oneota	Dolomite	277–367	90
Jordan	Sandstone	367–447	80
St. Lawrence	Mixed formation	447–627	180
Franconia	Sandstone	627–717	90
Dresbach	Sandstone, shale, etc.	717–865	148+
45. Well at Old Minneapolis Post Office, 3rd Ave. S. and Washington Ave. Elevation 818 ft.[34]			
Drift	Sand and gravel	0– 25	25

* Thin.

Formation	Description	Depth (in feet)	Thickness (in feet)
Platteville	Limestone	25– 50	25
St. Peter	Sandstone	50–150 *	100
Shakopee-Oneota	Limestone	150–355 †	205
Jordan	Sandstone	355–490 †	135
St. Lawrence	Shale and limestone	490–640	150
Franconia	Sandstone	640–700	60
Dresbach	Shale, etc.	700–707	7+

46. Well at Great Northern Ry. Warehouse, 714 Washington Ave. N. Elevation 818 ft.[35]

Drift	Unclassified	0–122	122
St. Peter	Sandstone	122–183	61
Shakopee-Oneota	Dolomite	183–308	125
Jordan	Sandstone	308–375	67
St. Lawrence	Mixed formation	375–383	8+

47. Well at Franklin Co-operative Creamery, Washington and 21st Aves. N. Elevation 832 ft.[2]

Drift	Unclassified	0–185	185
Shakopee-Oneota	Dolomite	185–292	107
Jordan	Sandstone	292–392	100
St. Lawrence	Shale, etc.	392–557	165
Franconia	Sandstone	557–640	83
Dresbach	Shale, etc.	640–710	70+

48. Well at Ewald Bros. Creamery, Xerxes and 19th Aves. N. Elevation 932 ft.[2]

Drift	Unclassified	0–100	100
Platteville	Limestone	100–116	16
St. Peter	Sandstone	116–276	160
Shakopee-Oneota	Dolomite	276–392	116
Jordan	Sandstone	392–450	58+

49. Well of Baltimore Packing Co., 2nd Ave. N. and 5th St. Elevation 840 ft.[1]

Drift	Unclassified	0– 30	30
Platteville	Shale (?)	30– 45	15
	Limestone	45– 65	20
St. Peter	Sandstone	65–225	160+

50. Well at Metropolitan Life (Guaranty Loan) Building, 2nd Ave. S. and 3rd St. S. Elevation 834 ft.[1]

Drift	Unclassified	0– 35	35
Platteville	Limestone	35– 60	25
St. Peter	Sandstone	60–235	175
Shakopee	Dolomite	235–270	35
New Richmond	Sandstone	270–285	15
Oneota	Dolomite	285–360	75
Jordan	Sandstone	360–445	85
St. Lawrence	Mixed formation	445–615	170
Franconia	Sandstone, etc.	615–670	55
Dresbach	Sandstone and shale	670–765	95+

51. Well of Janney, Semple, Hill & Co., 2nd Ave. S. and 1st St. Elevation 830 ft.[1]

Drift	Unclassified	0– 23	23
Platteville	Limestone	23– 58	35
St. Peter	Sandstone	58–208	150
Shakopee	Dolomite	208–283	75
New Richmond	Sandstone	283–298	15
Oneota	Dolomite	298–408	110
Jordan	Sandstone	408–453	45+

52. Well at Minneapolis Athletic Club, 612 2nd Ave. S. Elevation 845± ft.[36]

Drift	Unclassified	0– 48	48

* Thin. † Thick.

Formation	Description	Depth (in feet)	Thickness (in feet)
Platteville	Limestone	48– 74	26
Glenwood beds	Shale, etc.	74– 86	12
St. Peter	White sandstone	86–230	144
Shakopee-Oneota	Dolomite	230–372	142
Jordan	Coarse sandstone	372–470	98
St. Lawrence	Gray shale	470–503	
	Green, sandy shale	503–600	130+

53. Well at Humboldt Flour Mill, 2nd St. S. and railroad tracks. Elevation 820± ft.[31]

Drift	Hardpan, gravel, etc.	0– 33	33
Platteville	Limestone	33– 58	25
St. Peter	Sandstone	58–215	157
Shakopee-Oneota	Dolomite	215–355	140
Jordan	Sandstone	355–430	75
St. Lawrence	Mixed formation	430–450	20+

54. Well at Minneapolis and St. Louis R. R. Fruit Depot, 3rd Ave. N. and 5th St. Elevation 837 ft.[37]

Drift	Unclassified	0– 87	87
St. Peter	Sandstone	87–200	113
Shakopee-Oneota	Dolomite	200–307	107+

55. Well at St. Anthony Falls plant of Minneapolis General Electric Co., 3rd Ave. S. E. at the river. Elevation 780 ft.[1]

Decorah	Shale	0– 22	22
Platteville	Limestone	22– 52	30
St. Peter	Sandstone	52–207	155
Shakopee	Dolomite	207–257	50
New Richmond	Sandstone	257–277	20+

56. Well at Zier Building, 4th Ave. S. and 9th St. Elevation of street 851 ft.; of well 840 ft.[1]

Drift	Unclassified	0– 45	45
Platteville	Limestone	45– 75	30
St. Peter	Sandstone	75–230	155
Shakopee	Dolomite	230–275	45
New Richmond	Sandstone	275–290	15
Oneota	Dolomite	290–385	95
Jordan	Sandstone	385–480	95
St. Lawrence	Mixed formation	480–540	60+

57. Well at Central Creamery Co., 123 5th St. S. E. Elevation 815 ft.[4]

Drift and alluvium		0– 20	20
St. Peter	Sandstone	20–170	150
Shakopee-Oneota	Dolomite	170–310	140
Jordan	Sandstone	310–403	93+

58. Well at Strutwear Knitting Co., 1015 S. 6th St. Elevation 837 ft.[38]

Drift	Unclassified	0– 46	46
Platteville	Limestone	46– 73	27
St. Peter	Sandstone	73–246	173
Shakopee–New Richmond	Dolomite	246–295	49

59. Well at North Star Woolen Mills, 7th Ave. S. near the river. Elevation 801 ft.[39]

Platteville	Limestone	0– 30	30
St. Peter	Sandstone	30–200	170
Shakopee-Oneota	Dolomite	200–325	125
Jordan	Sandstone	325–362	37+

Formation	Description	Depth (in feet)	Thickness (in feet)
60. Well at Washburn-Crosby "C" Mill, 2nd St. and 7th Ave. Elevation 825 ft.[18]			
Drift and peaty soil	Otherwise unclassified	0– 10	10
Platteville	Limestone	10– 36	26
St. Peter	Sandstone	36–204	168
Shakopee	Dolomite	204–205	1+
61. Well of J. S. Lane, 625 8th Ave. S. E. Elevation 830 ft.[1]			
Drift	Unclassified	0– 22	22
Decorah	Shale	22– 42	20
Platteville	Limestone	42– 77	35
St. Peter	Sandstone	77–232	155
Shakopee	Dolomite	232–277	45+
62. Well at Northern Pacific Ry. Roundhouse, 10th Ave. N. and 2nd St. Elevation 831 ft.[10]			
Drift	Yellow sand	0– 25	
	Black sand	25– 98	
	Black and white sand	98–102	
	Clay and stone	102–142	
	Sand	142–150	
	Clay	150–160	160
St. Peter	Sandstone	160–180	20
Shakopee-Oneota	Hard limestone	180–302	122
Jordan	Sandstone	302–328	26+
63. Well at Ritz Theatre, 345 13th Ave. N. E. Elevation 836 ft.[6]			
Drift	Unclassified	0– 27	27
St. Peter	Sandstone	27–185	158
Shakopee-Oneota	Dolomite	185–290	85+
64. Well at Minneapolis Gas Light Co., 14th Ave. S. and Mississippi River. Elevation 764 ft.[40]			
Platteville	Limestone	0– 3	3
St. Peter	Sandstone	3–119	
	Shale (siltstone)	119–129	
	Sandy shale	129–169	166
Shakopee-Oneota	Hard rock (dolomite)	169–294	125
Jordan	Sandstone	294–374	80
St. Lawrence	Shale	374–559	185
Franconia	Sandstone	559–609	50
Dresbach	Sandy shale	609–629	
	Shale	629–742	113+
65A. Well of William Langley, between 2nd and 3rd Sts. N. E. and 15th and 16th Aves. N. E. Elevation 836 ft.[4]			
Platteville	Limestone	0– 5	5
St. Peter	Sandstone	5–132	126+
65B. Well of Northwestern National Life Insurance Co., 15th St. near Oak Grove St. Elevation 828 ft.[41]			
Drift	Sand and gravel	0– 95	95
St. Peter	Sandstone	95–222	127
Shakopee-Oneota	Dolomite	222–342	120
Jordan	Sandstone	342–370	28+
66. Well at Chicago and Omaha Ry. Roundhouse, 24th Ave. N. at the river. Elevation 810 ft.[1]			
Drift	Unclassified	0– 18	18

Formation	Description	Depth (in feet)	Thickness (in feet)
St. Peter	Sandstone	18–143	125
Shakopee	Dolomite	143–213	70
New Richmond	Sandstone	213–223	10+

67. Well at Chicago and Omaha Ry. Roundhouse, 24th Ave. N. at the river. Elevation 825 ft.[34]

Drift	Unclassified	0– 8	8
Platteville	Limestone	8– 9	1
St. Peter	Sandstone	9– 81	
	Shale	81–126	
	Sandstone	126–176	
	Sandstone and shale	176–188	179
Shakopee-Oneota	Limestone and sandstone	188–271	
	Shale and sandstone	271–526	
	Sandstone	526–606	418+

68. Well at Spencer Kellogg Co. (Kellogg Grain & Elevator Co.), Gurney Park Addition, 25th Ave. S. E. at the railroad tracks. Elevation 838 ft.[24]

Drift	Unclassified	0– 47	47
Platteville	Limestone	47– 84	37
St. Peter	Sandstone	84–260	176
Shakopee	Limestone	260–325	65 *
New Richmond	Sandstone	325–340	15
Oneota	Dolomite	340–425	85
Jordan	Sandstone	425–517	92
St. Lawrence	Shale	517–529	12+

69. Well at Great Northern Ry. Minneapolis Union Yards, 26th Ave. S. E. Elevation 849 ft.[42]

Drift	Sand and gravel	0– 62	62
Platteville	Limestone	62– 85	
	Soapstone	85– 95	33
St. Peter	Sandstone	95– 248	
	Hard sandstone	248– 255	160
Shakopee-Oneota	Limestone	255– 380	125
Jordan	Sandstone	380– 480	100
St. Lawrence	Blue shale	480– 630	150
Franconia	Sandstone	630– 675	45
Dresbach	Shale and sand	675– 705	
	Shale	705– 810	135
Hinckley	Sandstone	810– 908	
	Shale	908– 911	
	Clay	911– 926	
	Sandstone	926– 976	
	Clay	976– 978	
	Sandstone	978– 996	186
Red Clastic	Red clay	996– 998	
	Sandstone	998–1020	24+

70. Well at Northern States Power Co., Riverside Station, 29th Ave. N. E. at the river. Elevation 802 ft.[43]

Drift	Clay, hardpan, and boulders	0–137	137
Shakopee-Oneota	Dolomite	137–249	112
Jordan	Sandstone	249–320	71
St. Lawrence	Sandy shale	320–370	
	Shale	370–531	211
Franconia	Sandstone	531–603	72
Dresbach	Sandy shale	603–608	5+

* Thick.

Formation	Description	Depth (in feet)	Thickness (in feet)
71. Well at Coca Cola Bottling Co., University Ave. and Oak St. Elevation 835± ft.[44]			
Drift	Sand and gravel	0– 39	39
Platteville	Limestone	39– 68	29
Glenwood	Shale	68– 72	4
St. Peter	Sandstone	72–234	162
Shakopee-Oneota	Dolomite	234–356	122
Jordan	Sandstone	356–431	75+

[1] U. S. Geological Survey, Water Supply Paper 256, Plate 10. [2] McCarthy Well Drilling Co.
[3] Minneapolis Park Board. [4] C. W. Hall. [5] B. B. Decker, driller. [6] Renner Well Co.
[7] Minneapolis Water Commission Report. [8] E. K. Soper.
[9] Great Northern Ry. Co. blueprint. [10] W. E. Swan (1885). [11] Northern States Power Co.
[12] Liebenberg and Kaplan, architects. [13] Print by F. Cook, U. S. Engineer's Office.
[14] *Geology of Minnesota,* 2:282; John W. Forbes, foreman. [15] E. W. Elliot, chief engineer.
[16] F. M. Steiner, president, American Linen Co. [17] Minneapolis Park Board blueprint (1909).
[18] *Geology of Minnesota,* 2:279. [19] Northern Pacific Ry. Co. water service department.
[20] Northern Pacific Ry. Co. water service department, blueprint 462.6.
[21] William E. Rentfrous, agent. [22] E. A. Rynearson.
[23] Chicago, Milwaukee, St. Paul and Pacific R. R. Co. engineering department.
[24] C. W. Hall, file. [25] C. W. Hall, notebook no. 26, p. 47.
[26] Stauffer and Thiel, *Limestones and Marls of Minnesota* (Minnesota Geological Survey Bulletin 23), p. 26. [27] S. Swenson, driller. [28] Swenson Well Co. (1900).
[29] S. M. Tomlinson, mechanical engineer. [30] T. C. Lotz, engineer. [31] E. P. Burch.
[32] Mr. Jordan, manager.
[33] U. S. Geological Survey, Water Supply Paper 256, Plate 10; C. W. Hall, file.
[34] State Board of Health. [35] Keys Well Drilling Co.
[36] Secretary, Minneapolis Athletic Club. [37] Minneapolis and St. Louis R. R. Co.
[38] Strutwear Knitting Co. [39] A. D. Hoglund (1894). [40] S. S. Alwin, engineer.
[41] Northwestern National Life Insurance Co. record.
[42] Great Northern Ry. Co. water service department. [43] J. A. Colvin.
[44] O. E. Gore, chemist.

TABULATION OF ST. PAUL SUBSURFACE DATA

(Indexed by Street Intersections.)

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Adrian & Hathaway Sts.	784	2	Platteville (13)	St. Peter below
Adrian St. & Vista Ave.	788	4	Platteville (12)	St. Peter below
Afton Rd. (lower) at city limits	975	90	St. Peter (194)	Shakopee below. Deep well (no. 1, p. 248)
Afton Rd. (lower) & Pt. Douglas Rd.		68+	(?)	
Alaska Ave. and:				
May St.	796	1	Platteville (6+)	
Otto Ave.	799	1	Platteville	Tunnel from Otto Ave. to Race St. on Alaska Ave. at elevation 755–65.
Race St.	793	1	Platteville	
Albion Ave. and:				
W. 7th St. (northwest corner)	797	12+	(?)	4 shallow holes
W. 7th St. (southwest of above)	797	15+	(?)	Shallow hole
W. 7th St. (near above)		18+	(?)	4 shallow holes
Arbor & Grace Sts.	797	32	St. Peter	
Arbor & James Sts.	790	25	St. Peter	
Arcade & Maryland Sts.		220+	(?)	
Armstrong Ave. & Bay St.	800	2	Platteville (18)	St. Peter below
Ashland & Syndicate Aves.	930	35	Platteville (19+)	
Audubon & Drake Sts.	761		(?)	
Audubon & Osceola Sts.	784		(?)	
Baldwin Ct. & C. M. St. P. & P. R. R. tracks	838	48	Platteville	Deep well (no. 2, p. 248)
Banfil & Duke Sts. to Dousman St.	789–95		(?)	
Banfil & W. 7th Sts.	787		St. Peter	At unknown depth
Bates Ave. & Elliot Place	841	7±	Platteville	Sewer data
Bay & Palace Sts.	795	30±	St. Peter	Sewer data
Bayard Ave. & Milton St.	798	4	Platteville (23)	St. Peter below
Bellows & Isabel Sts. to Delos St.	815	10±	Platteville (28)	St. Peter below
Bidwell & Congress Sts.	812	5	Platteville (29)	St. Peter below
Bidwell & Isabel Sts.	813	7	Platteville (35)	St. Peter below
Berkeley & Finn Aves.	879±	5±	Rock	2 ft. of rock pierced
Berkeley Ave. & Mt. Curve Blvd.	863±	5±	Rock	
Broadway Bridge (2 blocks below) at the river bank	699	132	Shakopee	Deep well (no. 3, p. 248)
Broadway St. and:				
Kellogg Blvd.		100+	(?)	
8th St.	763	67+	(?)	
first alley north of 8th St.	763	65+	(?)	
Brook & 4th Sts.	716	125	Shakopee	Deep well (no. 4, p. 248)
Brunson St. & Woodward Ave. (northwest corner)	747	56+	(?)	
Burns Ave. & Mound St. (near St. Paul drill hole no. 57)	868	46	Platteville (30)	St. Peter below
Butternut Ave., 109 ft. north of Otto Ave.	760±	7±	Tumble rock	
Canton St. and Otto Ave. to Logan St.			St. Peter	Sewer tunnel

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Carroll Ave. and:				
Cretin Ave.	900	70	Decorah (45), Platteville (28), St. Peter (20)	Cross section of Kitsondale sewer system
Oxford St.	883	203+	(?)	Cross section of Kitsondale sewer system
Terrace Park	905	65	Decorah (50), Platteville (28), St. Peter (12)	Cross section of Kitsondale sewer system
Wilder Ave.	905	60	Decorah (60), Platteville (27), St. Peter (12)	Cross section of Kitsondale sewer system
Cascade St. and:				
Colborne St.			Rock	At elevation 745 ft.
Duke St.	783	21	Rock	
Oneida St.	779			Tunnel in rock at elevation 737 ft.
Upper Levee	699	95	Shakopee (15+)	
Cedar St. and Kellogg Blvd. test holes:				
no. 1, 60 ft. east of southeast corner of Cedar & Kellogg	781	7	St. Peter (28+)	
no. 2, 55 ft. east of northwest corner of Cedar & 2nd Sts.	776	14	St. Peter (17+)	
no. 3, 70 ft. south and 10 ft. east of southeast corner of Cedar St. & Kellogg Blvd.	784	11	St. Peter (19+)	
no. 4, 25 ft. west and 70 ft. south of southwest corner of Cedar St. & Kellogg Blvd.	788	None	Platteville (15+), St. Peter (12+)	
no. 5, 125 ft. west and 50 ft. south of southwest corner of Cedar St. & Kellogg Blvd.	787	6	Platteville (9+), St. Peter (15+)	
no. 6, 5 ft. east and 15 ft. south of southwest corner of Minnesota St. & Kellogg Blvd.	771	11	St. Peter (13+)	
Cedar St.:				
& Kellogg Blvd.	781	15	St. Peter (18+)	Tri-State Tunnel
& 4th St.			Platteville	Foundation
& 4th St.	775	9	St. Peter (25+)	Shaft
& 5th St.		25+	(?)	Foundation
between 8th & 9th Sts.	778+	5±	St. Peter	
& 9th St.	773		(?)	Tunnel in St. Peter at elevation 747 ft.
& 10th St.	798		(?)	Tunnel in St. Peter at elevation 765 ft.
Chatsworth St. between Jefferson & Pleasant Aves.	823	33	Platteville (29), St. Peter (5)	
Chatsworth St. between Juliet Place & Jefferson Ave.	813	32	Platteville (29+)	
Chatsworth St. and:				
Otto Ave.	795±	7±	Rock struck	
Race St.	793±	3±	Rock (4+)	
Rogers St.	797±	3±	Rock (4+)	
railroad near Ridgewood Ave.	844	25+	(?)	
St. Anthony Ave.	889	97	Platteville	Deep well (no. 5, p. 248)
232 ft. west of Sherburne Ave.	879	124	St. Peter (38+)	
Sherburne Ave.	880	90	Platteville (6+)	

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Cherry St. & Bates Ave.	837	15	Platteville (30)	St. Peter below
Cherokee Heights along River Rd. to Mendota	1030	125	Galena	Deep well (no. 6, p. 248)
Chestnut St. near Smith Ave.			Rock struck	
Chicago Ave. & Custer Ave.	690	90	Shakopee	Deep well (no. 7, p. 248)
C. M. St. P. & P. R. R., St. Paul yards	702	60	Shakopee	Deep well (no. 31, p. 253)
C. M. St. P. & R. R., east track & Osceola Ave. to St. Clair St.	875	15+	(?)	
C. St. P. M. & O. Ry. tracks, Ramsey County line (below brick plant)		80	Shakopee (10+)	
Cleveland Ave. and:				
Bayard Ave.	873	7±	Rock (1+)	Sewer data
Eleanor St.	869	7±	Rock (1+)	Sewer data
Hartford Ave.	872	7±	Rock (1+)	Sewer data
Niles Ave.	877	7±	Rock (1+)	Sewer data
Otto Ave.	865	7±	Rock (1+)	Sewer data
Pinehurst Ave.	862	7±	Rock (1+)	Sewer data
Randolph St.	885	7±	Rock (1+)	Sewer data
Scheffer St.	871	7±	Rock (1+)	Sewer data
Villard St.		0	Decorah	Deep well (no. 8, p. 249)
Clifton & Palace Sts.	801	12	St. Peter	
Clinton Ave. & Delos St.	749	125	Shakopee	Deep well (no. 9, p. 249)
Colborne & St. Clair Sts. to Jefferson St.	789		St. Peter	At elevation 754± ft.
Commercial St. & E. Kellogg Blvd.	722±	5±	Rock struck	
Como Ave. & Capitol Sts.		102	Platteville	Deep well (no. 10, p. 249)
Como & Farrington Aves.	852	58	Platteville	Deep well (no. 11, p. 249)
Como Ave., Wheelock Pkwy., & Maryland St.		45+	(?)	
Como & Lakeview Aves.		12+	(?)	
Como Ave. & South St.		14+	(?)	
Como Park, well no. 2	887	93	Platteville	Deep well (no. 12, p. 249)
Como River & Mississippi River Blvds.	820	45	Platteville(13)	Glenwood 5 ft. beneath
Como Shops of N. P. Ry., between Hamline & Lexington Aves.	938	85	Decorah	Deep well (no. 13, p. 249)
Cottage & Arcade Sts.	901	7	Rock struck (?)	Water Department data
Cottage & Greenbrier Sts.	904	7	Rock struck (?)	Water Department data
Cretin Ave. and:				
Berkeley Ave.	863±	5	Rock struck (2+)	
James St.	861±	5±	Rock struck	
Otto Ave.	853±	5±	Rock struck (2+)	
Palace St.	863±	5±	Rock struck (2+)	
Randolph St.	857±	5±	Rock struck	
St. Clair St.	864±	5±	Rock struck	
Sargent Ave.	865±	5	Rock struck (2+)	
Curtice & Robert Sts.	861±	5±	Rock struck	
Dale & Minnehaha Sts.	860	62	Platteville (38)	Deep well (no. 14, p. 250)
Dale St. & G. N. Ry. tracks	882	90	Platteville (35)	Deep well (no. 15, p. 250)
Davern & Leonard Aves.	796		Platteville (25)	At elevation 797 ft.
Davern Ave. & W. 7th St.	810	5	Platteville (34)	St. Peter below
59 Dayton's Bluff, between Hester & Griffith Sts. projected	733	29	St. Peter (3+)	
58 Dayton's Bluff, between Hester & Griffith Sts. projected	754	25	St. Peter (6+)	
Dealton & W. 7th Sts.	814	17	Platteville (25)	St. Peter below

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Delos St. and:				
Bellows St.	813	7	Platteville	
Hall Ave.	819	10	Platteville	St. Peter below
Winslow Ave.	815	9	Platteville (30)	St. Peter below
De Soto St. near Wheelock Pkwy.		125	St. Peter (8)	
Douglas & W. 7th Sts. to Ramsey St.	784–90		St. Peter	
Test borings at proposed Levee gas plant (Douglas St. projected ⅛ mile south of St. Clair):				
no. 1	711	56+	(?)	
no. 2	712	76+	(?)	
no. 3	712	75+	(?)	
no. 4	707	89+	(?)	
no. 5	707	51+	(?)	
1926 test borings for Levee gas plant:				
no. 1	707	50+	(?)	
no. 2	706	45+	(?)	
no. 3	698	45+	(?)	
no. 4	703	54+	(?)	
no. 5	704	58+	(?)	
no. 6	710	50+	(?)	
no. 7	705	65+	(?)	
no. 8	707	79+	(?)	
no. 9	703	48+	(?)	
no. 10	706	81+	(?)	
Dousman & Von Minden Sts.	783	6	Platteville (6)	St. Peter below
Drake & Randolph Sts.	779		St. Peter	
Duke & W. 7th Sts.	784	18	Platteville	
Dunlap St. & St. Anthony Ave.	925	73	Decorah	Deep well (no. 16, p. 250)
Eagle St. at the river	715	65	Shakopee-Oneota	Deep well (no. 17, p. 250)
Eaton & State Sts.	695	84	Shakopee	Deep well (no. 18, p. 250)
Edgecumbe Rd. and:				
Caulfield Ave.	805±	5±	Platteville	
Morgan	808±	4	Platteville	
W. Quirnia			Decorah	
Eleanor St. and:				
240 ft. west of Chatsworth St.	797±	7±	Rock struck	Sewer data
Lexington Ave.			Rock struck	
Pleasant Ave. to Palmer St.	803		Rock struck	
W. 7th to Chatsworth St.	795	4±	Platteville 3+	
Erie & Grace Sts.	788	6	Platteville	Deep well (no. 19, p. 251)
Erie & W. 7th Sts. to St. Clair Ave.	784	13	Platteville (17)	St. Peter below
Euclid St. & Maria Ave.	823	7	Rock	
Exchange St.:				
west of St. Peter St.	794	11	Platteville (15)	St. Peter below
& 4th St.		10	Platteville	St. Peter (17 ft.)
& 9th St.		13	Platteville	
Fairfield Ave. & Walter St.	708	75	Shakopee (125)	Jordan below
Fairmont and Osceola Aves. (alley between) & C. M. St. P. & P. R. R. tracks	893	28+	(?)	
Fairview Ave.:				
& Roblyn Ave.	917	43	Platteville (34+)	
& St. Anthony Ave.	918	65	Decorah	Deep well (no. 20, p. 251)
& St. Paul Ave.	804±	2	Platteville	
& Sheridan St.			Rock	At elevation 802 ft.

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Fairview & Stewart Aves.	809	9	Platteville (27)	St. Peter below
Fauquier & Westminster Sts.	812	110+	(?)	
Farrington & Central Aves.	864	68	Platteville (35)	St. Peter below
Field & Bellevue Aves.	809	11	Platteville (31)	St. Peter below
Flandrau St. & Hudson Rd.	910±	100	Platteville	
Forbes Ave. & W. 7th St.	783	1	Platteville (13)	St. Peter below
Ford Rd. & Cleveland Ave.	861±	7±	Rock struck	Sewer data
Ford Rd. & Mt. Curve Blvd.	817±	7±	Rock struck	Sewer data
Forest St. & Hastings Ave.	863	113	St. Peter (1+)	
Franklin St. and:				
Chestnut St.	756	7±	Rock struck	
4th St.	788	10	Platteville (10)	St. Peter below
4th St. (test hole no. 1)	787	2	Platteville (15)	St. Peter below
4th St. (test hole no. 4)	787	3	Platteville (16)	St. Peter below
5th St. (test hole no. 2)	788	3	Platteville (16)	St. Peter below
5th St. (test hole no. 3)	789	4	Platteville (16)	St. Peter below
Fulton St. & Jefferson Ave.	799	5±	Rock (2+)	
George St. and:				
Humbolt Ave. to S. Robert St. (see Humboldt & George)	799	12	St. Peter	
Livingston Ave.	818±	5±	Rock struck	
Maurice St.			Sandstone	
George St.–South St. Paul Quarry			Platteville	St. Peter below
Glen Terrace, Benson to Youngman Ave.			Rock struck	
Goodrich Ave. & C. M. St. P. & P. R. R. tracks	922	35	Decorah (23+)	
Goodrich & Pleasant Aves.	815	17	Platteville (29)	St. Peter below
Grace St.:				
& Bay St.	800	11	Platteville (13+)	
& Osceola Ave.	794	5	Platteville (24)	St. Peter below
Pleasant Ave. & Vance St.	802	6	Platteville (34)	St. Peter below
Graham St. & Bellevue Ave.	803	5	Platteville (27)	St. Peter below
Grand & Fairview Aves.	907	30	Decorah (89)	Deep well (no. 21, p. 251)
Grand Ave. & C. M. St. P. & P. R. R. tracks	924	35	Decorah (20+)	
Griggs St. & St. Anthony Ave.	925	39	Decorah (38)	Deep well (no. 22, p. 251)
Griggs St. & Summit Ave.	932	38	Decorah (23)	
Grove & Canada Sts.	778	78+	(?)	
Grove St. & Soo Line R. R. tracks (approximate)	757	66+	None	
Hague & Hamline Aves.	932	44	Decorah (8+)	
Hague Ave. & Oxford St.	920	200+	(?)	
Hall Ave. & Prospect Terrace	812	6	St. Peter	
Hamline & St. Anthony Aves.	925	38	Decorah	Deep well (no. 23, p. 251)
Harrison Ave. & Garfield St.	785	16	St. Peter	
Hastings Ave. and:				
Euclid St.	821	34	Plateville	
Maple St.	860.4	30	Platteville (30) Glenwood (4)	St. Peter below
Mounds St.	854	30	Platteville (27) Glenwood (4)	St. Peter below
Hathaway & W. 7th Sts.	794	10	Platteville (19)	St. Peter below
Hawthorn between White Bear Ave. & Flaudrau St.		40	Decorah (35)	Platteville below
Highland-Ford Blvd. & Mt. Curve Blvd. (See Ford Rd. & Mt. Curve Blvd.)				

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Highland Blvd. at the river. Borings made for steam plant:				
no. 1, just south of hydro-electric station	719	2	St. Peter (45+)	
no. 2, 150 ft. south of no. 1	719	5	St. Peter (35+)	
no. 3, 154 ft. south of no. 2	719	12	St. Peter (13+)	
no. 4, 184 ft. south of no. 3	718	36	St. Peter (6+)	
no. 5, 150 ft. south of no. 4	718	37+	(?)	
no. 6, 150 ft. south of no. 5	712	34+	(?)	
no. 7, 160 ft. south of no. 6	713	39	St. Peter (5+)	
no. 8, 84 ft. east of no. 7	717	41	St. Peter (5+)	
no. 9, 66 ft. east of no. 10	723	16	St. Peter (5+)	
no. 10, 65 ft. east of no. 8	722	40	St. Peter (5+)	
Highwood Park		139	St. Peter (121+)	
Hill St. & Kellogg Blvd.	788	7±	Sandstone	Sewer data
Hoffman Ave. & E. 4th St.	770	71+	(?)	
Hoffman Ave. & E. 6th St.	798	48+	(?)	
Hudson Ave. & Commercial St. (approximate)	738	10	Sandstone (5+)	
Hudson Ave. & Maria St. to Hoffman St.			St. Peter	At elevation 787± ft.
Humboldt Ave. & George St.	810±	0	Rock struck	
Humboldt Ave. & Robie St.	794±	0	Rock struck	
Indiana Ave. & Walter St.	700		Platteville	St. Peter below
Isabel St. and:				
Hall Ave.	812	16	Platteville (15)	St. Peter below
S. Wabasha St.	752	7±	Rock struck	
Winslow Ave.	815	8	Platteville (30)	St. Peter below
Jackson St. and:				
G. N. Ry. shops	827	35	Platteville	Deep well (no. 24, p. 251)
Pennsylvania Ave. roundhouse	836	36	Platteville	Deep well (no. 25, p. 251)
University Ave.	810	114+	(?)	
4th St. (G. N. Ry. office)	720	101	St. Peter (3)	(See no. 26, p. 252)
11th St.	788	46	St. Peter (44+)	
Jefferson Ave. and:				
Cleveland Ave.	905±	2±	Rock struck	
Cretin Ave.	861±	2±	Rock struck	
Milton St.	806	15	Platteville (27+)	
Pleasant Ave.	802±	6±	Rock struck	
Vance St.	797±	3	Rock struck (5+)	
View St.	796±	3	Rock struck (5+)	
7th St.	780	15	St. Peter	
John & 4th Sts (gas works)	724.8	141.2	St. Peter	At elevation 583.6 ft.
John & 5th Sts.	725	90	Shakopee (150)	Jordan below
Joy Ave. at Mystic Caverns			St. Peter (100)	Shakopee below
Joy Ave. near Mystic Caverns		70	St. Peter (25)	Shakopee below
Juno St. and:				
Bay St.	791±	7±	Rock struck	Sewer data
Milton St.			(?)	Rock at elevation 793 ft.
View St.	794±	7±	Rock struck	Blasting
Kellogg Blvd. test holes: †				
1000 ft. east of Broadway St. and 38 ft. south of Kellogg Blvd.	705	82+	(?)	Test hole no. 10
1100 ft. east of Broadway St. and 38 ft. south of Kellogg Blvd.	705	92+	(?)	Test hole no. 11
1100 ft. east of Broadway St. and 22 ft. north of Kellogg Blvd.	706	85+	(?)	Test hole no. 11a

* Numbers in parentheses indicate thickness of formation.

† For the following test holes on Kellogg Boulevard the location is the center line of all streets.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Kellogg Blvd. test holes *(continued)*: †				
1200 ft. east of Broadway St. and 28 ft. south of Kellogg Blvd.	706	74+	(?)	Test hole no. 12
1300 ft. east of Broadway St. and 28 ft. south of Kellogg Blvd.	706	54+	(?)	Test hole no. 13
1400 ft. east of Broadway St. and 28 ft. south of Kellogg Blvd.	706	75+	(?)	Test hole no. 14
1500 ft. east of Broadway St. and 28 ft. south of Kellogg Blvd.	706	83+	(?)	Test hole no. 15
1600 ft. east of Broadway St. and 28 ft. south of Kellogg Blvd.	706	59+	(?)	Test hole no. 16
1700 ft. east of Broadway St. and 28 ft. south of Kellogg Blvd.	706	59+	(?)	Test hole no. 17
1788 ft. east of Broadway St. and 28 ft. south of Kellogg Blvd.	707	60+	(?)	Test hole no. 18
1900 ft. east of Broadway St. and 38 ft. south of Kellogg Blvd.	708	72+	(?)	Test hole no. 19
2000 ft. east of Broadway St. and 26 ft. south of Kellogg Blvd.	709	81+	(?)	Test hole no. 20
2165 ft. east of Broadway St. and 38 ft. north of Kellogg Blvd.	710	83+	(?)	Test hole no. 21
2270 ft. east of Broadway St. and 39 ft. north of Kellogg Blvd.	711	86+	(?)	Test hole no. 22
2400 ft. east of Broadway St. and 24 ft. south of Kellogg Blvd.	703	75	Shakopee (1+)	Test hole no. 24
2500 ft. east of Broadway St. and 27 ft. south of Kellogg Blvd.	710	80+	(?)	Test hole no. 25
2600 ft. east of Broadway St. on Kellogg Blvd.	709	68+	(?)	Test hole no. 26
2700 ft. east of Broadway St. on Kellogg Blvd.	709	60+	(?)	Test hole no. 27
2800 ft. east of Broadway St. on Kellogg Blvd.	711	70+	(?)	Test hole no. 28
2900 ft. east of Broadway St. and 29 ft. north of Kellogg Blvd.	719	50+	(?)	Test hole no. 29
3100 ft. east of Broadway St. and 26 ft. south of Kellogg Blvd.	728	59+	(?)	Test hole no. 31
3200 ft. east of Broadway St. and 26 ft. south of Kellogg Blvd.	739	58+	(?)	Test hole no. 32
3300 ft. east of Broadway St. and 15 ft. south of Kellogg Blvd.	747	60+	(?)	Test hole no. 33
3400 ft. east of Broadway St. and 16 ft. south of Kellogg Blvd.	759	54+	(?)	Test hole no. 34
3506 ft. east of Broadway St. and 36 ft. south of Kellogg Blvd.	765	35+	(?)	Test hole no. 35
3580 ft. east of Broadway St. and 13 ft. south of Kellogg Blvd.	778	56+	(?)	Test hole no. 36
Kellogg Blvd. & Market St. (See Hill St. & Kellogg Blvd.)			St. Peter	Excavation
Kellogg Blvd. & St. Peter St. test holes for City Hall–County Court House:				
no. 4, 80 ft. north of corner of Kellogg Blvd. & St. Peter St.	791	5	Platteville (19)	St. Peter below
no. 5, corner of Wabasha & 4th Sts.	780	3	Platteville (5)	St. Peter below

* Numbers in parentheses indicate thickness of formation.
† For the following test holes on Kellogg Boulevard the location is the center line of all streets.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
no. 6, 80 ft. north of Kellogg Blvd. (sidewalk on Wabasha St.)	779		Platteville (11)	St. Peter below
no. 8, Kellogg Blvd. & St. Peter St.	790	12	Platteville (8)	St. Peter below
no. 10, center of block on 4th St.	780	10	Platteville (6)	St. Peter below
no. 11, center of court house block	779		Platteville (7)	St. Peter below
Kellogg Blvd. & College Ave.	831±	7±	St. Peter	
Kellogg Blvd. & Pleasant Ave.	797±	7±	St. Peter	
Kittson & 5th Sts.	714	24±	(?)	
Kittson & 7th Sts.	750	60+	(?)	
Lake Como (west side, above pavilion)	887	93	Platteville (38)	St. Peter below
Lake Como (west side, above pavilion)	884	40	Platteville (40)	Deep well (no. 27, p. 252)
Larpenteur & East Aves.	1042	165	Platteville	Deep well (no. 28, p. 252)
Laurel Ave. & Mississippi River Blvd.	823±	7±	Decorah	
Laurel & Scheunemann Aves. (C. M. St. P. & P. R. R. tracks)	929	39	Decorah (11+)	
Lexington Pkwy. and:				
Bayard Ave.	847±	7±	Rock struck	
Hague Ave. (approximate)	912	185	St. Peter (14+)	
Hague Ave. (approximate)	917	94	Decorah (14+)	
Otto Ave.	802	30	Platteville (3)	St. Peter below
Portland Ave.	916	187	St. Peter (14+)	
St. Anthony Ave. (see Pleasant & Vista)	892	105	Platteville (31)	St. Peter below
Scheffer St.	839±	7±	Rock struck	Sewer data
Sherburne Ave.	891	101	Platteville (1+)	
Sherburne (approximate)	885	166+	(?)	
Vista	821	23	Platteville (36)	St. Peter below
Lincoln Ave. & C. M. St. P. & P. R. R. tracks	925	37	Decorah (23+)	
Livingston & Chicago Aves. (approximate)	718±	7±	St. Peter	
McBoal & W. 7th Sts.	787	3	Platteville (15)	St. Peter below
Mackubin St. & St. Anthony Ave.	892	29	Decorah (3)	Deep well (no. 29, p. 252)
McLean & Maria Aves.	826	5	Rock struck	
Madison St. and:				
Benson St.	795±	0	Platteville	
Rockwood St.	793±	0	Platteville	
Stewart Ave.	791±	0	Platteville	
W. 7th St.	807	8	Platteville (2+)	
Youngman St.	790±	0	Platteville	
Main Ave. and:				
W. 6th St.	797	4	Platteville (27)	St. Peter below
W. 9th St.	795±	4	Platteville (22)	Deep well (no. 30, p. 252)
W. 10th St.	808±	4±	Platteville	
Maria Ave. & Cherry St.	828	2	Platteville (31)	St. Peter below
Maria Ave. & Urban Place	827	0	Platteville (36)	St. Peter below
Marshall & Hamline Aves.	932	45	Decorah (3+)	
Marshall Ave. at the river	820	23	Platteville (42)	St. Peter below
May St. and:				
Middleton Ave.	795	2	Platteville (25)	St. Peter below
Middleton Ave.	795±	2	Platteville (5+)	
160 ft. north of Middleton Ave.	796±	2	Platteville	

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
May St. and:				
Rogers Ave.	797	3	Platteville (29)	St. Peter below
Vista Ave.	797±	2	Platteville	
W. 7th St.	797	8	Platteville (21)	St. Peter below
Milton St., 50 ft. north of Selby Ave.	910.9	120	Platteville (24) Soapstone (6)	St. Peter below
Minnehaha St.:				
& Cable Ave.	823	36	St. Peter	
between Payne & Greenbrier Aves.	828	23	Platteville (15)	Deep well (no. 32, p. 253)
& St. Albans Ave.	821	26	Platteville (37) Soapstone (3)	St. Peter below
Minnesota Transfer, Archer & Co.	900	70	Platteville (35) St. Peter (50+)	
Minnesota & 2nd Sts. to Kellogg Blvd. test holes:				
no. 7, 5 ft. east and 15 ft. north of northwest corner of Minnesota & 2nd Sts.	757	7	St. Peter (19+)	
no. 8, 165 ft. east and 5 ft. south of southeast corner of Minnesota St. & Kellogg Blvd.	761	23+	(?)	
no. 9, 150 ft. east and 8 ft. north of northeast corner of Minnesota & 2nd Sts.	746	26+	(?)	
no. 10, 70 ft. east and 8 ft. north of southeast corner of Minnesota St. & Kellogg Blvd.	766	29+	(?)	
no. 11, 27 ft. east and 3 ft. north of northeast corner of Minnesota & 2nd Sts.	753	20+	(?)	
no. 12, southeast corner of Minnesota St. & Kellogg Blvd.	770	19	St. Peter (11+)	
no. 13, 22 ft. north of northeast corner of Minnesota & 2nd Sts.	754	4	St. Peter (16+)	
Minnesota St.:				
& 4th St.	740	75	Shakopee (20)	Deep well (no. 33, p. 253)
100 ft. north of 4th St.		50	St. Peter (14)	
& 6th St.			Deep drift (?)	
& 7th St.	762	46	Platteville (4+)	
& 7th St. (diagonally opposite)	762	42	Platteville (8+)	
& 8th St. (northwest corner)	771	75	St. Peter (10+)	
& 10th St. (southeast corner)			Platteville	Robert & 4th Sts., above sidewalk level
& 10th St.			Platteville	St. Peter 4 ft. below surface
between 10th & 11th Sts.			Platteville	Near surface
near 11th St.	797±	5±	Rock struck	
Minnetonka & Kentucky Sts.	702	146	Shakopee (146)	Jordan below
Milton St. & Central Ave.	883	91	Platteville (31)	St. Peter below
Milton St. & Ridgewood Ave.	816	26+	(?)	
Mississippi St. yards of N. P. Ry.	787	185	Shakopee (42+)	
Montreal Ave. & W. 7th St.	805	68+	(?)	
Montrose Lane, 400 ft. south of Randolph St.	857±	5±	Rock struck	
Montrose Lane, 500 ft. south of Randolph St.	850	7	Rock struck	Sewer data

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Mounds Blvd. & Hudson Ave.			St. Peter	At elevation 787 ft.
Mt. Curve Blvd. and:				
Bayard Ave.			Decorah	
Eleanor St.	828±	5±	Decorah	
Hartford Ave.	850±	5±	Decorah	
Jefferson Ave.	859±	5±	Rock struck	
Randolph St.	847±	5±	Rock struck	
Scheffer St.			Decorah	
St. Clair St.	860±	5±	Rock struck	
Munster St. & Edgcumbe Rd.	831±	7±	Rock struck	
Munster & W. 7th Sts.	817±	7±	Rock struck	
Nebraska & Rice Sts.		13	(?)	
Oak Grove Place & Osceola Ave.	905	185+	(?)	
Otis & Carroll Aves. (projected)			Decorah (42)	At elevation 830 ft.
Otto Ave. and:				
Chatsworth Ave.	795	6	Platteville (22)	St. Peter below
Mississippi River Blvd.	809±	5±	Platteville	
Mt. Curve Blvd.	821±	5±	Platteville	
Pleasant Ave. (see Pleasant & Otto)	802±	5±	Platteville	
Rogers Ave.	797±	1±	Platteville (6+)	Rock struck
Oxford Ave. (projected) & north side of C. M. St. P. & P. R. R. tracks	852	61	Platteville (30)	St. Peter below
Oxford Ave. to Lexington Pkwy. on north side of C. M. St. P. & P. R. R. tracks	859	68	Platteville (32)	St. Peter below
Oxford & Central Aves.	877	179	St. Peter (6)	St. Peter below
Oxford & Hague Aves. (approximate)	924	135	Platteville (4+)	
Palace St. & Cleveland Ave.	894±	7±	Rock struck	
Pascal & St. Anthony Aves.	926	39	Decorah (34)	Deep well (no. 34, p. 253)
Patridge St. & Payne Ave.	775±	190	Shakopee	Deep well (no. 35, p. 254)
Patridge & Otsego Sts. (projected)	738	33+	(?)	
Phalen Creek near Phalen Lake outlet	863	235	Shakopee	Deep well (no. 36, p. 254)
Phalen Creek & 5th St.	715	25+	(?)	
Phalen Lake (just north of lake on Highway No. 1)	881	255	Shakopee	See Ramsey County wells
Pig's Eye Island, test pit no. 1	687	87	St. Peter	Siltstone horizon
Pig's Eye Island, holes:				
no. 1	693	100+	(?)	
no. 2	693	32+	St. Peter	
no. 3	693	35+	St. Peter	
no. 4	693	52+	St. Peter	
no. 5	692	52+	St. Peter	
no. 6	697	17	St. Peter (22)	
no. 7	694	20	St. Peter (14)	
no. 8	696	37+	(?)	
no. 9	691	31+	(?)	
no. 10	694	28+	(?)	
no. 90	687.8	12	St. Peter (23)	
no. 99k	692	22	St. Peter (12) / Shakopee (5)	
(Also several other holes not listed)				
Pig's Eye Island & Hamline to Syndicate Aves.			St. Peter	

Post Office excavations. Complex of shale, gravel, sand, clay, etc., in old river gorge.

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Pleasant Ave. and:				
Albion Ave	794±	7±	Rock struck	
Bayard	806	10	Platteville	
Chestnut	796	12	Platteville (15)	St. Peter below
Fulton	801±	5±	Rock struck	
Jefferson	802±	5±	Rock struck	
Lisbon St.	800	17	Platteville (14)	St. Peter below
Montreal at W. 7th St.	807±	5±	Rock (3+)	
Otto St.	802	5	Platteville (28)	St. Peter below
Ramsey	791	8	Platteville (23+)	
Ramsey to Thompson	789	7	Platteville (15)	St. Peter below
Scheffer	804	9	Platteville	
Thompson	787	5	Platteville (14)	St. Peter below
Tuscarora	810	15	Platteville	
Vista Ave. (see Lexington & Vista)	821	23	Platteville (31)	St. Peter below
W. 6th St.			Platteville	At elevation 801 ft.
Portland Ave. & east side of C. M. St. P. & P. R. R. tracks	932	39	Decorah (19+)	
Portland Ave. & Mississippi River Blvd.	835	8	Decorah (38)	Deep well (no. 37, p. 254)
Preble St. & Phalen Creek, below Beaumont St.	805	24	St. Peter	
Princeton Ave. at the river			St. Peter	Tunnel
Prior & St. Anthony Aves.	917	75	Decorah (49)	Deep well (no. 38, p. 254)
Prospect Terrace & Stryker Ave.	814	7	Rock	
Prospect Terrace & Winslow Ave.	817	10	Rock	
Race St. and:				
Alaska Ave.	793	3	Platteville (23)	St. Peter below
Chatsworth St.	793±	5±	Rock struck	Sewer data
May St.	796	4	Platteville (24)	St. Peter below
Randolph St. at the river	824		St. Peter	At elevation 757 ft.
Richmond St. between Michigan & Superior Sts.	792	4	Platteville	
Robert St.:				
& George St.	807±	7±	St. Peter	Sewer data
& Louisa St.	819±	7±	Rock struck	Sewer data
& Robie St.	777±	7±	St. Peter	Sewer data
& Wood St., C. & G. W. R. R. tank, West St. Paul	701	56	Shakopee (140)	Jordan below
near south bank of the river	720	80	Shakopee (145)	Jordan below
& 7th St.	750	50	St. Peter (95)	Deep well (no. 39, p. 254)
near 9th St.			(?)	
& 11th St.	796	22	St. Peter (16+)	
Robert St. Mississippi River Bridge test holes:				
U	707	56	St. Peter (20+)	
S. (Robert St. & Kellogg Blvd.)	739	72+	(?)	
T	733	83	St. Peter (27+)	
A	694	63	St. Peter (16)	Shakopee (10+ ft.)
B	691	59	St. Peter (16)	Shakopee (11+ ft.)
C	684	67	Shakopee (10+)	
D	679	65	Shakopee (10+)	
E	678	64	Shakopee (10+)	
F	672	56	Shakopee (10+)	
G	689	76	Shakopee (10+)	
H	692	73	Shakopee (10+)	

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
I	684	70	Shakopee (10+)	
J	683	69	Shakopee (10+)	
K	680	67	Shakopee (10+)	
L	679	66	Shakopee (10+)	
M	706	92	Shakopee (10+)	
N	706	92	Shakopee (10+)	
R	707	92	Shakopee (10+)	
P	706	92	Shakopee (10+)	
O	707	91	Shakopee (10+)	
Robie St. and:				
Humboldt Ave.	794±	2±	Rock (5+)	
Stryker Ave.	813±	5±	Rock (2+)	
Winslow			Rock	At elevation 810 ft.
Rome Ave. and:				
Argonne Ave.	862±	7±	Rock struck	Sewer data
Fairview Ave.	926±	7±	Rock struck	Sewer data
Howell Ave.	904±	7±	Rock struck	Sewer data
Rondo & Arundel Sts.			Rock at 857 ft.	
Rosabel & 4th Sts. (opposite above)		60+	(?)	
St. Albans St. & Central Ave.	918±	77	Decorah (42)	Deep well (no. 41, p. 254)
St. Albans & St. Clair Sts.	801	9	Platteville (26)	St. Peter below
St. Anthony Ave. and:				
Fry St.	925	45	Decorah (87) Platteville (30) St. Peter (5)	
Hamline Ave. (see Hamline & St. Anthony Aves.)	922	37	Decorah (95) Platteville (33) St. Peter	
50 ft. west of Chatsworth St.	888.2	95	Platteville (32) St. Peter (53)	
205 ft. west of Chatsworth St.	887	101	Platteville (16) Glenwood (9) St. Peter (49)	
315 ft. west of Chatsworth St.	885	180+	(?)	
176 ft. west of Lexington Pkwy.	887.8	171+	Limestone block (9)	
47 ft. west of Lexington Pkwy.	888	171+	Soapstone (?) (16)	
300 ft. west of Oxford St.	883	162+	(?)	
St. Clair St. and:				
Cliff St.	777	2	Platteville (6)	St. Peter below
Finn Ave.	877±	7±	Rock struck	Sewer data
Mississippi River Blvd.	831±	7±	Rock struck	Sewer data
Snelling Ave.	945	54	Galena	Deep well (no. 42, p. 254)
Spring St. (projected)	695	55	Shakopee (75+)	
St. Paul Ave. and:				
Bellevue Ave.	803	0	Decorah (4) Platteville (23)	
Calvin Ave.			Rock struck	
Cleveland Ave.	858±	7±	Rock struck	Sewer data
Montreal Ave.	865±	7±	Rock struck	Sewer data
Prior Ave. (projected) to Edgecumbe Rd.	819	10	Platteville (36)	St. Peter below
Saunders Ave.			Rock struck	
Snelling Ave.	806			
St. Peter St. and:				
Kellogg Blvd.	788±	7±	St. Peter	In water pipe excavation

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
St. Peter St. and:				
Tilton St.	852	51	Platteville (29)	St. Peter below
6th St.	787	0	Platteville (16)	St. Peter below
6th St.	788	5	Platteville (10)	St. Peter below
7th St.			St. Peter	Tunnel
Scheffer St. and:				
Chatsworth St.	798	9	Platteville (22)	St. Peter below
Mississippi River Blvd. to Mt. Curve Blvd.				Tunnel in St. Peter
Pleasant Ave.	804±	5±	Platteville	
Rogers Ave.	801±	5±	Platteville	
Seven Corners	785	8	Platteville (9)	St. Peter below
Sherburne Ave. & Marion St. (approximate)	858	64	Platteville (2+)	
Short St. between Maria Ave. & Mounds Blvd. (St. Paul drill hole no. 56)	823	3	Platteville (32)	Sandstone below
Sibley & 10th Sts. (approximate)	772	95+	(?)	
Smith Ave. High Bridge (east end)	704	89	Shakopee (96+)	
Smith Ave. and:				
Cherokee Heights Blvd.	889	83	Platteville (29)	St. Peter below
Chestnut St. (approximate)	786±	5	Rock struck	
Kellogg Blvd. (approximate)	792±	5±	Rock struck (2+)	
5th St.	793	11	Platteville (15)	St. Peter below
Snelling Ave. and:				
St. Anthony Ave.	927	37	Decorah (36)	Deep well (no. 40, p. 254)
W. 7th St.	801	4	Platteville (29)	St. Peter below
W. 7th St. (northeast corner)	812	14	Platteville (29)	St. Peter below
W. 7th St. (northwest corner)	810	13	Platteville (1+)	
Somerville Ave. at the river			(?)	Sewer tunnel in sandstone
State Savings Bank (rear)		46	St. Peter (14+)	
Stewart Ave. and:				
Alton St.	793±	0	Rock	
Bellevue Ave.	801	2	Platteville (25)	St. Peter below
Fairview Ave.	809	9	Platteville (28)	St. Peter below
Lamm Place	793±	0	Platteville	
Madison St.	791±	0	Platteville	
309 ft. west of Madison to Alton	792±	2±	Platteville	
Purnell	786±	0	Platteville	
Rankin	786±	0	Platteville	
Springfield Ave.	789±	0	Platteville	
Victoria Ave.				Old quarry
W. 7th St. & Mississippi River Blvd.			Platteville	
Stillwater Ave. and:				
Duncan St. (approximate)	860±	170+	(?)	
Duncan St.		156+	(?)	
Hazelwood Ave.	870±	62	Platteville (20)	St. Peter below
Stryker Ave. & Delos St. to Prospect Terrace	818	11	Rock (Decorah?)	
Sturgis St. & Western Ave.	786±	5±	Rock struck	
Summit Ave. and:				
Cedar St.	808	85	St. Peter (28+)	
Cretin Ave.	866±	4±	Rock (3+)	
Lexington Pkwy.	911	201	St. Peter (17+)	
Mississippi River	827	37	Platteville (43)	St. Peter below

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Syndicate & St. Anthony Aves.	935	48	Galena	Deep well (no. 44, p. 255)
Toronto St. & Jefferson Ave.	788	7±	Rock struck	Sewer data
Toronto St. & St. Clair Ave.	799	7±	Rock struck	Sewer data
Tuscarora St. & Pleasant Ave. to Chatsworth Ave.				Rock surface at 795± ft.
Union Depot	707	91	Shakopee (122)	Jordan below
University Ave. and:				
Fairview	898	41	Decorah (62)	Platteville below
Robert St. (approximate)	846	74	St. Peter (25+)	
Western Ave.	865	50	Platteville	Deep well (no. 43, p. 255)
Vance St. and:				
Grace St.	802±		Rock (5+)	
Jefferson St.	795±	3	Rock (5+)	
Palace St.	796	6	Platteville (20)	St. Peter below
View & Grace Sts.	805	25+		
View & Jefferson Sts.	797±	3	Rock (5+)	
View St. & Pleasant Ave.	806±	3	Rock (5+)	
Vista & Race Sts.	795±	5±	Rock struck	
Von Minden & Ann Sts.	785	1	Platteville (16)	St. Peter below
Wabash Ave. & Vandalia St.	898	114	Decorah	Deep well (no. 45, p. 255)
Wabasha St. Bridge shaft (Mississippi River)	798	65	St. Peter (1+)	
Wabasha St. and:				
College Ave.	803	4	Platteville (28)	St. Peter below
College Ave. (alley in rear)	805	8	Platteville (26)	St. Peter below
College Ave. to the river	803	4	Platteville (28)	St. Peter below
Exchange St.	792	6	Platteville (15)	St. Peter below
Fairfield Ave.	707	80	Shakopee (100)	Jordan below
Iglehart Ave.	831	30	Platteville (31)	St. Peter below
5th St.	787	20	Platteville (7)	St. Peter below
5th St. (50 ft. west of Wabasha)	786	45	St. Peter (111)	Deep well (no. 46, p. 255)
5th St.	787	6	Platteville (11)	St. Peter below
5th St.	787	20	Platteville (7)	St. Peter below
5th St. (160 ft. east of Wabasha)	778	8	Platteville (6)	St. Peter below
5th St. (160 ft. west and 75 ft. south of Wabasha)	780	12	Platteville (8)	St. Peter below
6th St.	785		St. Peter	Tunnel elevation 750 ft.
7th St.	784	8	Platteville (5)	St. Peter below
7th St.	783	0	Platteville (10)	St. Peter below
between 7th & 8th Sts.		20+	(?)	
9th St.	787	2	Platteville (13)	St. Peter below
10th St.	798	4	Platteville (22)	St. Peter below
12th St.	810	41	St. Peter (31+)	
Wabasha St. 71 ft. south of Summit Ave. (no. 1)	818	60	St. Peter (8)	
Wabasha St. 71 ft. south of Summit Ave. (across street from no. 1)	719	58	St. Peter (7)	
Wabasha St. 46 ft. north of Summit Ave.	824	31	Platteville (19)	St. Peter below
Wabasha St. 39 ft. south of Summit Ave.	815	66+		
Washington & 5th Sts.	790	7	Platteville (13)	St. Peter below
Water tunnels downtown (ends of these = ± end of St. Peter going east):				
Kellogg Blvd., 90 ft. west of Minnesota St.				
4th St., 25 ft. east of west line of Cedar St.				

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
Water tunnels downtown (ends of these = ± end of St. Peter going east):				
5th St., 100 ft. west of Cedar St.				
6th St., 80 ft. east of Wabasha St.				
8th St., 160 ft. east of Wabasha St.				
9th St., west line of Cedar St.				
Watson & Pleasant Aves. to Chatsworth St.	803–11	15	Platteville	
Webster Ave. and:				
James St.	782±	5±	Rock struck	
Randolph	770±	5±	Rock struck	
7th St.	788±	5±	Rock struck	
Wellesley Ave. and:				
Cleveland Ave.	907±	7±	Rock struck	
Finn Ave.	877±	5±	Rock (2+)	
Mt. Curve Blvd.	864±	5±	Rock (2+)	
Western & Harrison Aves.	788	4	Platteville (15)	St. Peter below
Wheelock Pkwy. & Langtry St.	930	133	Platteville (50)	St. Peter below
Willius & 9th Sts. (approximate)	765	60+	(?)	
Winifred St. & Humboldt Ave. (approximate)	777±	7±	Sandstone	Sewer data
Winslow Ave. and:				
Colorado St.	819	9	Rock	
Congress St.	809	4	Rock	
Robie St.	818	13	Rock	
Wood & S. Robert Sts.	773	104	St. Peter (6)	Deep well (no. **47**, p. **255**)
Woodward St. (50 ft. north) & N. P. Ry. yards	736	46+	(?)	
Youngman Ave. and:				
Madison	790±	0	Rock struck	
Rosenberger Place	793±	1±	Rock struck	
386 ft. east of Springfield St.	785±	1±	Rock struck	Sewer data
4th St.:				
& Minnesota St. test hole		51	St. Peter (15+)	
& Minnesota St. (approximate), test hole no. 3		15	St. Peter (14+)	
near Rosabel St.		30+	(?)	
between St. Peter & Wabasha Sts.			St. Peter	See Figure 39, p. 99
near Sibley St.	707	91	Shakopee	Deep well (no. 48, p. 255)
from Wabasha to Cedar Sts.			St. Peter	Tunnel
First National Bank Building caissons on line 20 ft. north of 4th St., from Robert to Minnesota Sts:				
no. 59	746	27	St. Peter (6+)	
no. 61	738	25	St. Peter (39+)	
no. 63	738	17	St. Peter (46+)	
no. 65	743	19	St. Peter (53+)	
no. 67	744	20	St. Peter (12+)	
5th & Minnesota Sts.	762±	33	St. Peter	Deep well (no. 49, p. 255)
5th St. near John St.	720	30+	(?)	
6th St. near Washington	788±	5±	St. Peter	
6th St. Viaduct (beneath)	728	38+	(?)	
7th St.:				
& Albion Ave.	797±	5±	Rock struck	
& Alton St. (C. M. St. P. & P. R. R. tracks, see Snelling & W. 7th St.)	781	4	Rock (3+)	Sewer data
between Davern & Munster Sts.	810±	5±	Rock struck	

* Numbers in parentheses indicate thickness of formation.

Location	Surface Elevation (in ft.)	Glacial Drift (in ft.)	Rock Formations *	Remarks
between Jackson & Robert Sts.		20+	(?)	
& Mounds Blvd................	747	57+	(?)	
between Sibley & Wacouta Sts.			(?)	
near Western Ave...........	786±	5±	Rock struck	
& 5th St......................	789	6	Platteville (12)	St. Peter below
8th St. near Wacouta St...........	762±	5±	Rock struck	
10th & St. Peter Sts. (approximate)	801±	5±	Rock struck	
10th & Roberts Sts. (approximate)	796			

* Numbers in parentheses indicate thickness of formation.

ST. PAUL WELL LOGS

Formation	Description	Depth (in feet)	Thickness (in feet)
1. Well of Bob Abel, north of Lower Afton Rd. NE cor. Sec. 11 (city limits). Elevation 975 ft.[1]			
Drift	Unclassified	0–90	90
St. Peter	Sandstone	90–284	194
Shakopee-Oneota	Hard rock (dolomite)	284–285	1+
2. Test hole, Baldwin Ct. (north end), and Chicago and Milwaukee R. R. tracks. Elevation 838 ft.[2]			
Drift	Sand, gravel, etc.	0–29	
	Blue clay	29–42	
	Sand and gravel	42–48	48
Platteville	Limestone	48–73	
	Soapstone	73–77	29
St. Peter	Sandstone	77–80	3+
3. Well on Lower Levee, about 2 blocks east of Broadway Viaduct, near the river. Elevation 699 ft.[3]			
Drift	Unclassified	0–132	132
Shakopee-Oneota	Dolomite	132–262	130
Jordan	Sandstone	262–298	36+
4. Northern Pacific Ry. tank at Brook and 4th Sts. Elevation 716 ft.[4]			
Drift	Unclassified	1–125	125
Shakopee-Oneota	Limestone	125–250	125
	Blue shale	250–260	10
Jordan	White sandstone	260–356	96+
5. Drill hole 75 ft. east of Chatsworth St. on south side of St. Anthony Ave. Elevation 889 ft.[5]			
Drift	Sand and gravel	0–20	
	Gravel	20–70	
	Fine sand	70–97	97
Platteville	Limestone	97–124	
	Soapstone	124–130	33
St. Peter	Sandstone	130–177	47+
6. Section of Cherokee Heights along the River Road to Mendota at Twin City Brick Plant. Elevation 1030+ ft.[6]			
Drift	Drift and soil	0–125	125
Galena	Bluish limestone	125–136	
	Blue shale	136–141	16
Decorah	Blue and brown shale with limestone lenses	141–226	85
Platteville	Gray fossiliferous limestone	226–234	
	Argillaceous blue limestone	234–239	
	Mottled blue limestone	239–251	25
Glenwood	Sandy green shale	251–256	5
St. Peter (to river level; elevation 695± ft.)	White friable sandstone	256–335	79+
7. Well at Pioneer Maple Products, Chicago Ave. and Custer St. Elevation 705 ft.[7]			
Drift	Unclassified	0–90	90
Shakopee	Dolomite	90–150	60
New Richmond	Sandstone	150–165	15
Oneota	Dolomite	165–240	75
Jordan	Sandstone	240–340	100+

Formation	Description	Depth (in feet)	Thickness (in feet)
8. Well of Joseph H. Masele, 1101 S. Cleveland Ave. (near Villard St.).[1]			
Decorah	Blue shale	0– 40	40
Platteville	Limestone	40– 85	45
St. Peter	Sandstone	85–180	95+
9. Well at Chicago and Great Western R. R. Engine House No. 6, Clinton and Delos Sts. Elevation 749 ft.[4]			
Drift	Blue clay	0– 125	125
Shakopee-Oneota	Blue limestone	125– 214	
	White limestone	214– 309	184 *
Jordan	Yellow sandstone	309– 429	120 *
St. Lawrence	Green shale	429– 509	
	White limestone	509– 529	
	Green shale	529– 564	135
Franconia	White sandstone	564– 604	40
Dresbach	White limestone	604– 644	40
	(No record)	644– 730	86
Hinckley	Red sandstone	730– 822	
	White sandstone	822– 902	172
Red Clastic	Red slate	902– 992	
	White sandstone	992–1018	
	Red shale	1018–1058	156+
10. New well at Bethesda Hospital, Como, Viola, and Capitol. Elevation 895± ft.[8]			
	Basement	0– 20	
Drift	Sand	20– 40	
	Quicksand	40–100	
	Sand and clay	100–102	102
Platteville	Limestone	102–135	33
St. Peter	Sandstone	135–295	160
Shakopee-Oneota	Dolomite	295–420	125
Jordan	Sandstone	420–500	80+
11. Elevator "B" well, Como and Farrington Aves. Elevation 852 ft.[9]			
Drift	Unclassified	0– 58	58
Platteville	Limestone	58– 83	25
St. Peter	Sandstone	83–235	152
Shakopee-Oneota	Dolomite	235–375	140
Jordan	Sandstone	375–478	103
St. Lawrence	Mixed formation	478–672	194
Franconia and Dresbach	Sandstone and shale	672–850	178+
12. Well no. 2 at Como Park. Elevation 887 ft.[10]			
Drift	Peat and black sand	0– 12	
	Sand	12– 58	
	Clay and stone	58– 93	93
Platteville	Limestone	93–122	
	Shale	122–132	39
St. Peter	Sandstone	132–138	6+
13. Well at Como Shops of Northern Pacific Ry., between Hamline Ave. and Lexington Pkwy. Elevation 938 ft.[11]			
Drift	Humus	0– 2	
	Clay	2– 4	
	Sand and gravel	4– 45	
	Hard pan	45– 65	
	Black gravel and quicksand	65– 85	85
Decorah	Soapstone and blue clay	85–142	57

* Thick.

Formation	Description	Depth (in feet)	Thickness (in feet)
Platteville	Limestone	142–176	34
Glenwood beds	Soapstone	176–181	5
St. Peter	White sandstone	181–287	106+
14. Well at Great Northern Ry. shops and stores, Dale and Minnehaha Sts. Elevation 860 ft.[12]			
Drift	Peat and sand	0– 9	
	Clay	9– 25	
	Sand	25– 62	62
Platteville	Limestone	62– 96	
	Shale	96– 100	38
St. Peter	Sandstone	100– 258	158
Shakopee-Oneota	Limestone	258– 382	124
Jordan	Sandstone	382– 475	93
St. Lawrence	Sandstone and shale	475– 550	
	Shale	550– 650	175
Franconia	Sandstone	650– 700	50
Dresbach	Shale	700– 780	
	Sandstone and shale	780– 870	170
Hinckley	Sandstone	870–1116	246
Red Clastic	Red clay	1116–1120	4+
15. Well at Shiely Co. gravel pit, Dale St. and Great Northern Ry. tracks. Elevation 882± ft.[8]			
Drift	Unclassified	0– 90	90
Platteville	Limestone	90–125	35
St. Peter	Sandstone	125–285	160
Shakopee-Oneota	Dolomite	285–420	135
Jordan	Sandstone	420–500	80+
16. Well at Dunlap St. and St. Anthony Ave. Elevation 925 ft.[13]			
Drift	Sand and gravel	0– 73	73
Decorah	Shale	73–141	68
Platteville	Limestone	141–169	28
Glenwood beds	Shale or soapstone	169–171	2
St. Peter	Sandstone	171–181	10+
17. Well at Electric Light Plant, Eagle St. and Mississippi River. Elevation 715 ft.[3]			
Drift	Unclassified	0– 65	65
Shakopee-Oneota	Dolomite; shale near base	65–298	233 *
Jordan	Sandstone	298–388	90+
18. Madsen well, Oregon and State Sts. (approximate). Elevation 695 ft.[4]			
Drift	Loam	0– 20	
	Gray sand	20– 32	
	Blue clay	32– 36	
	Gray sand	36– 68	
	Sand and gravel	68– 78	
	Yellow sand	78– 84	84
Shakopee	Gray limestone	84–132	48
New Richmond	White, water-bearing sandstone	132–138	6
Oneota	Limestone	138–212	74
Jordan	Sandstone	212–296	84
St. Lawrence	Gray shale and limestone	296–362	
	Water-bearing, sandy shale	362–444	
	Limestone	444–446	
	Quicksand	446–450	
	Sandstone	450–457	
	Limestone	457–464	
	Gray sandstone and shale	464–488	192

* Thick. Seemingly an error.

Formation	Description	Depth (in feet)	Thickness (in feet)
Franconia	Coarse, white, water-bearing sandstone	488–540	52
Dresbach	Gray sandstone and shale	540–560	20+
19. Sewer shaft, Erie and Grace Sts. Elevation 788 ft.[14]			
Drift	Shale (?)	0– 6	6
Platteville	Limestone	6–19	13
Glenwood beds	Shale	19–24	5
St. Peter	Sandstone	24–(?)	(?)
20. Shaft at Fairview and St. Anthony Aves. Elevation 918 ft.[15]			
Drift	Unclassified	0– 65	65
Decorah	Shale	65–126	61
Platteville	Limestone	126–146	20
Glenwood beds	Shale	146–153	7
St. Peter	Sandstone	153–166	13+
21. Well at Grandview Theater, Grand and Fairview Aves. Elevation 907 ft.[8]			
Drift	Unclassified	0– 30	30
Decorah	Soapstone	30–119	89
Platteville	Limestone	119–137	28
St. Peter	Sandstone	137–299	162
Shakopee-Oneota	Dolomite	299–300	1+
22. Well at Griggs St. and St. Anthony Ave. Elevation 925 ft.[12]			
Drift	Sand and gravel	0– 39	39
Galena	Shale and soapstone	39– 77	38
Decorah	Shale and soapstone	77–142	65
Platteville	Limestone	142–172	30
St. Peter	Sandstone	172–180	8+
23. Test shaft, Hamline and St. Anthony Aves. Elevation 925 ft.[13]			
Drift	Sandy loam	0– 36	
	Sand	36– 38	38
Galena and Decorah	Shale	38–136	98
Platteville	Limestone	136–165	29
Glenwood beds	Soapstone	165–172	7
St. Peter	Sandstone	172–185	13+
24. Great Northern Ry. Shops, Jackson St. Elevation 827 ft.[3]			
Drift	Unclassified	0– 35	35
Platteville	Limestone	35– 73	38
St. Peter	Sandstone	73–173	
	Soapstone	173–191	
	Shale	191–229	156
Shakopee-Oneota	Red limestone	229–359	130
Jordan	Sandstone	359–462	103
	No record	462–762	300
	Sandstone	762–833	71+
25. Well at Great Northern Ry. Roundhouse, Jackson St. and Pennsylvania Ave. Elevation 836 ft.[4]			
Drift	Gravel	0– 14	
	Hardpan	14– 36	36
Platteville	Limestone	36– 64	28
Glenwood beds	Shale	64– 71	7
St. Peter	Sandstone	71–150	
	Shale	150–163	
	Hard gray shale	163–170	
	Limestone	170–182	
	Shale	182–199	
	Sandstone and shale	199–222	

Formation	Description	Depth (in feet)	Thickness (in feet)
	Sandstone	222–226	155
Shakopee-Oneota	Limestone	226–354	128
Jordan	Sandstone	354–449	95
St. Lawrence	Shale	449–569	120
Franconia and	Sandstone and shale	569–707	
Dresbach	Shale	707–797	228
Hinckley(?)	Sandstone	797–955	158+

26. Great Northern Ry. office building, Jackson and 4th Sts. Elevation 720 ft.[16]

Drift	Sand and gravel	0–101	101
St. Peter	Hard sandstone	101–104	3
Shakopee-Oneota	Limestone	104–245	141
Jordan	Soft sandstone	245–305	60
St. Lawrence	Shale and soapstone	305–379	
	Shale and sandstone	379–397	92+

27. Well at Como Park, west side of lake, above the pavilion. Elevation 884 ft.[4]

Drift	Peat	0– 13	
	Sand	13– 28	
	Clay and stone	28– 40	40
Platteville	Shell rock	40– 80	40
St. Peter	Sandstone	80–220	140
Shakopee-Oneota	Limestone	220–386	166
(?)	Shale	386–398	12
	Clay	398–408	10+

(This well does not check with no. 12 nearby, especially in thickness of drift.)

28. Hillcrest Golf Club, just southwest of Larpenteur and East Aves. Elevation 1042 ft.[17]

Drift	Unclassified	0–165	165
Platteville	Limestone	165–190	25
St. Peter	Sandstone	190–350	160
Shakopee	Dolomite	350–382	32
New Richmond	Sandstone	382–395	13
Oneota	Dolomite	395–490	95
Jordan	Sandstone	490–550	60+

29. Well at Mackubin St. and St. Anthony Ave. Elevation 892 ft.[5]

Drift	Sand, sandy clay, clay, and gravel	0– 29	29
Galena	Soapstone and limestone	29– 32	3
Decorah	Limestone	32– 36	
	Soapstone	36– 90	
	Soapstone and limestone	90– 94	62
Platteville	Limestone	94–124	30
	Shale	124–131	7
St. Peter	Sandstone	131–184	53+

30. Well at St. Joseph's Hospital, Main Ave. and W. 9th St. Elevation 795± ft.[18]

Drift	Unclassified	0– 4	4
Platteville	Limestone	4– 26	22
Glenwood	Shaley limestone	26– 28	2
St. Peter	Fine white sandstone	28–155	127
Shakopee-Oneota	Sandy dolomite	155–178	
	Dolomite	178–187	
	Limestone	187–210 *	
Classification	White sandstone	210–320 †	
Uncertain	Limestone	320–360	
	Calcareous sandy clay	360–412	
	Calcareous, green sandy clay	412–415	
	Calcareous gray clay	415–480	
	Green sandy clay	480–520	

* Very thin. † Thick.

Formation	Description	Depth (in feet)	Thickness (in feet)
	Brown sandy clay	520–533	
	Sandy clay	533–600	
	Green sandy clay	600–654	
Franconia(?)	White quartz sand	654–700	46
Dresbach(?)	Sandy clay	700–790	
	Green sandy clay	790–795	
	White quartz sand	795–827	127+

31. Well in St. Paul yards of Chicago and Milwaukee R. R., Pig's Eye Shops. Elevation 702 ft.[19]

Drift	Sand	0– 60	60
Shakopee-Oneota	Limestone	60–193	133
Jordan	Sandstone and shale	193–287	94
St. Lawrence	Fine sandstone and shale	287–317	29+

32A. Well at Hamm Brewing Co., Minnehaha St. and Greenbrier Ave. Elevation 828 ft.[20]

Drift	Unclassified	0– 23	23
Platteville	Limestone	23– 38	15
Glenwood	Shale	38– 50	12
St. Peter	Sandstone	50–199	149
Shakopee-Oneota	Dolomite	199–328	129
Jordan	Sandstone	328–405	77
St. Lawrence	Mixed formation	405–620	215
Franconia	Sandstone	620–650	30 *
Dresbach	Shale and sandstone	650–808	158+

32B. Well at Hamm Brewing Co., Minnehaha St. between Payne and Greenbrier Aves. Elevation 828± ft.[4]

Drift	Loose earth	0– 16	
	Yellow shale	16– 23	23
Platteville	Blue limestone	23– 38	15
St. Peter	White sandstone	38–163	
	Gray shale	163–172	
	White sandstone	172–188	150
Shakopee-Oneota	Black shale	188–200	
	Hard blue shale	200–338	150
Jordan	White sandstone	338–427	
	Blue shale	427–432	
	White sandstone	432–451	113
St. Lawrence	Blue-green shale	451–623	172
Franconia	Quicksand	623–642	
	Gray sandstone	642–662	39
Dresbach	Gray and black shale	662–768	
	White sandstone	768–790	128+

33. Well at St. Paul Dispatch–Pioneer Press, Minnesota and 4th Sts. Elevation 740 ft.[7]

Drift	Unclassified	0– 75	75
Shakopee-Oneota	Dolomite	75–195	120
Jordan	Sandstone	195–285	90
St. Lawrence	Shale, etc.	285–440	155
Franconia	Sandstone	440–500	60

34. Test hole, Pascal and St. Anthony Aves. Elevation 926± ft.[5]

Drift	Sandy clay, sand, and gravel	0– 39	39
Galena	Shale	39– 73	34
Decorah	Shale	73–138	65
Platteville	Limestone	138–166	28
Glenwood beds	Shale	166–173	7
St. Peter	Sandstone	173–183	10+

* Thin.

Formation	Description	Depth (in feet)	Thickness (in feet)
35. Well at Vander Bie's Ice Cream Co., Patridge St. and Payne Ave. Elevation 775± ft.[8]			
Drift	Clay, sand, gravel, and hardpan	0–190	190
Shakopee-Oneota	Dolomite	190–282	92
Jordan	Sandstone	282–386	104
St. Lawrence	Mixed formation	386–387	1+
36. Well of St. Paul Harvester Works, near Phalen Creek, south of Phalen Lake outlet. Elevation 863 ft.[21]			
Drift	Sand and gravel	0–235	235
Shakopee-Oneota	Dolomite	235–360	125
Jordan	Sandstone	360–460	100
St. Lawrence	Mixed formation	460–671	211+
37. Portland Ave. outfall sewer at Shadow Falls Creek, just below Missisisppi River Blvd. Elevation 835 ft.[14]			
Drift	Unclassified	0– 8	8
Decorah	Soft soapstone	8–30	
	Hard soapstone	30–46	38
Platteville	Limestone	46–81	35
Glenwood	Soft soapstone	81–84	3
St. Peter	Sandstone	84–85	1+
38. Test hole at Prior and St. Anthony Aves. (approximate). Elevation 917 ft.[13]			
Drift	Unclassified	0– 75	75
Decorah	Shale	75–124	49
Platteville	Limestone	124–159	35
St. Peter	Sandstone	159–192	33+
39. Well at the Golden Rule, Robert and 7th Sts. Elevation 750 ft.[7]			
Drift	Unclassified	0– 50	50
St. Peter	Sandstone	50–145	95
Shakopee-Oneota	Dolomite	145–275	130
Jordan	Sandstone	275–305	30+
40. Test hole at Snelling and St. Anthony Aves. Elevation 927 ft.[13]			
Drift	Loam, sand, and gravel	0– 23	
	Clay	23– 31	
	Fine sand	31– 37	37
Galena	Soapstone	37– 43	
	Limestone	43– 47	10
Decorah	Soapstone	47– 73	
	Limestone	73– 76	
	Soapstone	76–134	87
Platteville	Limestone	134–165	31
Glenwood beds	Soapstone	165–167	2
St. Peter	Sandstone	167–215	48+
41. Test hole at St. Albans St. and Central Ave. Elevation 918 ft.[12]			
Drift	Sand, etc.	0– 77	77
Decorah	Shale	77–119	42
Platteville	Limestone	119–154	35
St. Peter	Sandstone	154–166	12+
42. Test hole at St. Clair St. and Snelling Ave. Elevation 945 ft.[22]			
Drift	Sand	0– 7	
	Sandy yellow clay	7– 13	
	Sandy brown clay	13– 24	
	Sand and water	24– 26	
	Brown clay, sand, and gravel	26– 28	
	Gray clay, sand, and gravel	28– 48	
	Sand	48– 54	54

Formation	Description	Depth (in feet)	Thickness (in feet)
Galena	Soapstone	54– 56	
	Limestone	56– 64	10
Decorah	Soapstone and limestone alternate strata	64– 87	
	Limestone	87– 93	
	Soapstone	93–155	91
Platteville	Limestone	155–185	30
Glenwood beds	Shale	185–188	3
St. Peter	Sandstone	188–235	47+
43. Well at Minnesota Mills Co., University and Western Aves. Elevation 865 ft.[8]			
Drift	Unclassified	0– 50	50
Platteville	Blue limestone	50– (?)	(?)
St. Peter	Sandstone	(?)–255	(?)
Shakopee-Oneota	Dolomite	255–389	134+
44. Well at Syndicate St. and St. Anthony Ave. (Concordia College). Elevation 925 ft.[23]			
Drift	Gravel, clay, and sand	0 – 48	48
Galena	Limerock	48 – 55	7
Decorah	Blue clay and limerock	55 –137	82
Platteville	Blue limestone	137 –165.5	28.5
Glenwood beds	Blue clay	165.5–170.5	5
St. Peter	White sandrock	170.5–252	81.5+
45. Well of U. S. Bedding Co., Wabash and Vandalia Sts. Elevation 898 ft.[24]			
Drift	Unclassified	0–114	114
Decorah	Shale	114–116	2
Platteville	Limestone	116–142	26
St. Peter	Sandstone	142–255	
	Dolomite (probably silt horizon)	255–279	
	Sandstone	279–315	173
Shakopee-Oneota, Jordan, and St. Lawrence	Mixed formation	315–715	400
Franconia	Sandstone	715–758	43+
46. Well at south side of 5th St., about 50 ft. west of Wabasha St. Elevation 786 ft.[3]			
Drift	Unclassified	0– 45	45
St. Peter	Sandstone	45–146	111
Shakopee-Oneota	Dolomite	146–300	154
Jordan	Sandstoue	300–358	58+
47. Well of Peters Sausage Co., Wood and S. Robert Sts. Elevation 733± ft.[8]			
Drift	Unclassified	0–104	104
St. Peter	Sandstone	104–110	6
Shakopee-Oneota	Dolomite	110–255	145
Jordan	Sandstone	255–330	75
St. Lawrence	Shale and sandstone	330–368	38+
48. Well at Union Railway Station. Elevation 707.49 ft.[16]			
Drift		0– 91	91
Shakopee-Oneota		91–213	122
Jordan		213–305	92
49. Well at the Federal Land Bank, 5th and Minnesota Sts. Elevation 762± ft.[8]			
Drift	Clay	0– 15	
	Tumble rock	15– 33	33
St. Peter	Sandstone	33–135	102
Shakopee-Oneota	Dolomite	135–271	136
Jordan	Sandstone	271–309	38+
50. Well of A. Booth Packing Co. (location uncertain).[18]			
Drift	Unclassified	0– 8	8
St. Peter	Fine white sand	8– 96	88

Formation	Description	Depth (in feet)	Thickness (in feet)
Shakopee-Oneota	Dolomite and sandy dolomite	96–235	139
Jordan	Fine, frosted, white sand	235–315	80+

51. Well at Kopper's Gas and Coke Co., Great Northern Ry. tracks, between Hamline and Lexington Aves. Elevation 937 ft.[25]

Drift	Sand and gravel	0– 80	
	Hard pan	80–110	110
Decorah	Clay or soapstone	110–180	70
Platteville	Limestone	180–210	30
St. Peter	Sandstone	210–350	140 *
Shakopee-Oneota	Dolomite	350–475	125
Jordan	Sandstone	475–565	90

* Thin.

[1] J. A. Hoge, driller. [2] Kitsondale sewer system, profile map. [3] J. D. Estabrook.
[4] St. Paul Water Department. [5] Metropolitan Drainage Commission. [6] C. R. Stauffer.
[7] U. S. Geological Survey, Water Supply Paper 256, p. 304. [8] Keys Well Drilling Co.
[9] *Geology of Minnesota*, 2:360. [10] Blueprint of J. D. Estabrook.
[11] Northern Pacific Ry. Co. water service department.
[12] Great Northern Ry. Co. water service department.
[13] Metropolitan Drainage Commission, profile map. [14] St. Paul Sewer Department.
[15] St. Paul Department of Public Works, geological cross section.
[16] Great Northern Ry. Co. water service department. [17] Renner Well Co.
[18] U. S. Geological Survey samples.
[19] Chicago, Milwaukee, St. Paul and Pacific R. R. Co. engineering department.
[20] W. H. Lang, Hamm Brewing Co. [21] *Geology of Minnesota*, 2:361.
[22] Metropolitan Drainage Commission, well record. [23] *Geology of Minnesota*, 2:359.
[24] State Board of Health. [25] Kopper's Gas and Coke Co.

MISSISSIPPI RIVER

Borings at Hastings Lock and Dam[1]

Boring no. 1. West bank at base line 2600 ft. below clay. Elevation 678 ft. Clay and sand, 100 ft.
Boring no. 2. 1185 ft. southwest of no. 1. Elevation 675 ft. Clay and sand, 149 ft.
Boring no. 3. 1625 ft. southwest of no. 2 on east shore of Lake Rebecca. Elevation 682 ft. Clay, sand, and gravel, 150 ft.
Several holes on east bank 2600 ft. below dam. Sandstone of St. Lawrence formation encountered at elevations varying from 597–631 ft.
Boring on base line of dam on east bank. Sand 14 ft. to sandstone at elevation 657 ft.
Boring in river at dam, 100 ft. west of east bank. Sand 41 ft. to sandstone at elevation 632 ft.
Many borings in river at dam. No rock to elevation 605 ft.
Borings no. 82 to 85 at dam. Sandstone of St. Lawrence formation at elevations of 622–57 ft.

Borings at Fort Snelling Bridge[2]

U.S. Number	Elevation (in feet)	Thickness of Alluvium (in feet)	Formation	Thickness of Formation (in feet)
2	715.1	2	St. Peter	2
3	702.5	30	St. Peter	24
7	697.4	63	St. Peter Shakopee	21 1
10	698.9	40	....	
12	678.0	40	....	
16	684.0	62	St. Peter Shakopee	5 1
19	674.0	39	....	
21	678.0	45	St. Peter	1
23	698.3	8	St. Peter	41
26	719.2	7	St. Peter	17
29	728.8	1	St. Peter	4

New Lock at Twin City Lock and Dam. Series of 14 Test Borings[3]

U.S. Number	Elevation (in feet)	Drift (in feet)	Elevation at Top of St. Peter (in feet)
1	723	47	676
2	723	36	687
3	723	27	696
4	723	36	687
5	723	37	686
6	723	19	694
7	723	25	698
8	723	10	713
9	723	5	718

[1] U.S. Engineer's maps and logs. The U.S. Engineer's Office has an extensive record of test holes.
[2] U.S. Engineer's notebook (November 30, 1906). [3] U.S. Engineer's notebook (1929).

New Lock at Twin City Lock and Dam — *(Continued)*[3]

U. S. Number	Elevation (in feet)	Drift (in feet)	Elevation at Top of St. Peter (in feet)
10	723	8	715
11	723	10	713
12	723	14	709
13	723	9	714
14	723	14	709

Borings on Center Line of Intercity Bridge near Ford Plant and Twin City Lock and Dam[4]

Hole Number	Distance West of Woodlawn Ave.* (in feet)	Elevation (in feet)	Thickness of Alluvium (in feet)	Formation	Thickness (in feet)
1	75	809	12	Platteville	33
				St. Peter	12
2	120	761	10	St. Peter	26
3	164	747	7	St. Peter	16
4	205	737	7	St. Peter	15
5	261	746	32	St. Peter	20
6	400	711	12	St. Peter	12
7	425	704	10	St. Peter	15
8	713	701	47	St. Peter	15
9	1088	696	39	St. Peter	13
10	1376	718	28	St. Peter	1
11	1411	723	10	St. Peter	19
12	1549	777	7	Platteville	5
				St. Peter	1
13	1585	819	14	Platteville	7

* West of west line of Woodlawn Avenue.

Partial Summary of Borings at Abandoned Twin City Lock and Dam near Chicago and Milwaukee R. R. Bridge[5]

U. S. Number	Distance West of Intersection of City Limits and East Bank (in feet)	Elevation (in feet)	Alluvium (in feet)	Formation	Thickness (in feet)
18	20	701	9	St. Peter	13
21	75	699	13	St. Peter	7
65	120	700	8	St. Peter	8
58	276	704	13	St. Peter	9
59	375	704	11	St. Peter	9
60	485	704	7	St. Peter	13
74	556	704	8	St. Peter	10
45	645	704	16	St. Peter	8
43	734	714	21	St. Peter	5

[3] U. S. Engineer's notebook (1929).
[4] Blueprint, Joint Bridge Commission, 1925.
[5] U. S. Engineer's notebook.

Well at Meeker Island, near Abandoned Dam. Elevation 710 ft.[6]

Formation	Description	Depth
St. Peter	Sandstone	0–110
Shakopee-Oneota	Dolomite	110–265
Jordan	Sandstone	265–360
St. Lawrence	Mixed formation	360–535

Borings at Anoka-Champlin Bridge[7]

Number	Location	Elevation (in feet)	Alluvium (in feet)	Formation	Thickness (in feet)
1	Pier no. 2	824	42	Jordan	6
2	Pier no. 3	826	46	Jordan	10
3	Pier no. 4	826	42	Jordan	2
4	Pier no. 8	826.5	48	Jordan	6
5	Pier no. 1*	832	47	Jordan	15
6	Pier no. 7	828	38	Jordan	8
7	Pier no. 6	828	45	Jordan	14
8	Pier no. 9	834	50	Jordan	1
9	Pier no. 5	827	53	Jordan	2

* Pier no. 1 is on the south bank.

[6] U. S. Geological Survey, Water Supply Paper 256, Plate 10.
[7] Minnesota Highway Department.

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