The University of Minnesota

MINNESOTA GEOLOGICAL SURVEY
WILLIAM H. EMMONS, DIRECTOR

BULLETIN NO. 20

A GUIDEBOOK TO MINNESOTA TRUNK HIGHWAY NO. 1

BY

G. M. SCHWARTZ

MINNEAPOLIS
The University of Minnesota
1925

FRONTISPIECE. FALLS OF THE MANITOU RIVER

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PREFACE

This paper is a description of the chief geologic features that may be seen along Highway No. 1 of Minnesota. This highway begins at the Iowa state line south of Albert Lea, and passes northward through the Twin Cities to Duluth and thence extends along the north shore of Lake Superior to the Pigeon River near Port Arthur, Ontario. The report includes thirteen maps which show the locations of roads, towns, and villages, and most of the rocks and land forms that are described in the text. Essentially all places mentioned in the text are located on one of the maps. The work was in charge of Dr. G. M. Schwartz who traversed the entire route and prepared the text. Numerous earlier reports by the Geological Survey of Minnesota and the United States Geological Survey were drawn upon for data and these are appropriately acknowledged in the text. A section on trees and plants is supplied by Dr. C. O. Rosendahl and Dr. F. K. Butters, of the University of Minnesota, and one on fish and game by Mr. Thaddeus Surber.

The paper is intended for the use of the traveler and the general public and as far as practicable highly technical terms are avoided.

This survey has issued a number of other publications treating the geology, surface formations and agricultural conditions, iron ores, manganiferous ores, clays, building stones, peat, etc. These are sold by the librarian of the University of Minnesota at nominal prices. A list of publications of the survey may be had free on application to the librarian of the University or the director of the State Geological Survey.

WILLIAM H. EMMONS

Additional copies of this publication may be obtained from the Librarian, University of Minnesota, Minneapolis, Minnesota.

CONTENTS

ILLUSTRATIONS

PLATES

TEXT FIGURES

ROUTE MAPS

CHAPTER I

INTRODUCTION

Few states show a greater variety in natural features than Minnesota. The southwestern portion presents large expanses of almost unbroken fertile prairie; the southeast a much dissected area typical of regions farther south where the glacier has not leveled off the topography resulting from stream erosion. A typical glacial moraine topography characterizes the region around Minneapolis and St. Paul. The northern part of the state presents a much more rugged country famous for its iron mines, and of interest to the tourist because of the great areas of wild and wooded country and its lakes, so numerous that it has been well named, the "Land of Ten Thousand Lakes." The lakes, forest, and delightful summer climate have combined to make the state the goal of thousands of tourists from nearly every state in the Union.

Highway No. 1 is well located to give the traveler a comprehensive view of the various types of Minnesota country. The highway begins at the Iowa state line south of Albert Lea, pursues a northerly course through the Twin Cities to Duluth, thence northeasterly along the north shore of Lake Superior over the new scenic highway 170 miles to the Canadian boundary at the Pigeon River. (See Figure 1.) From there a road continues to Port Arthur and Fort William in Canada. The total length of the highway is nearly 450 miles. The road is kept in good condition over its entire length and much of it is of new construction. Over 100 miles are paved and the remainder is graveled. Within a few years it is planned to pave the entire distance from Albert Lea to Duluth. The route is carefully marked by the Minnesota Highway Department which has charge of all state roads.

FIELD WORK AND ACKNOWLEDGMENTS

The entire length of the route was covered by the writer during the summer of 1924, to gather data for this guide. Information has also been drawn from other sources and the writer is much indebted to the various workers whose results have been utilized. The publications of the Minnesota Geological Survey and the United States Geological Survey have been of particular value, especially the *Final Report of the Geological and Natural History Survey of Minnesota,* by N. H. Winchell, and Bulletins 13 and 14 of the Minnesota Survey, by Leverett and Sardeson. The series of guidebooks of the United States Geological Survey have contributed much material. The publications of the Minnesota Historical Society were of great value, especially *Minnesota Geographic Names,* by

Warren Upham. Acknowledgments for much assistance are due to Mr. Solon J. Buck, superintendent of the society. Credit for the chapter on fish and game is due to Mr. Thaddeus Surber, of the Minnesota Game and Fish Department. Dr. Otto Rosendahl and Dr. Frederic K. Butters, of the Botany Department of the University of Minnesota, contributed the chapter on trees and plants. The Minnesota Highway Department furnished several base maps.

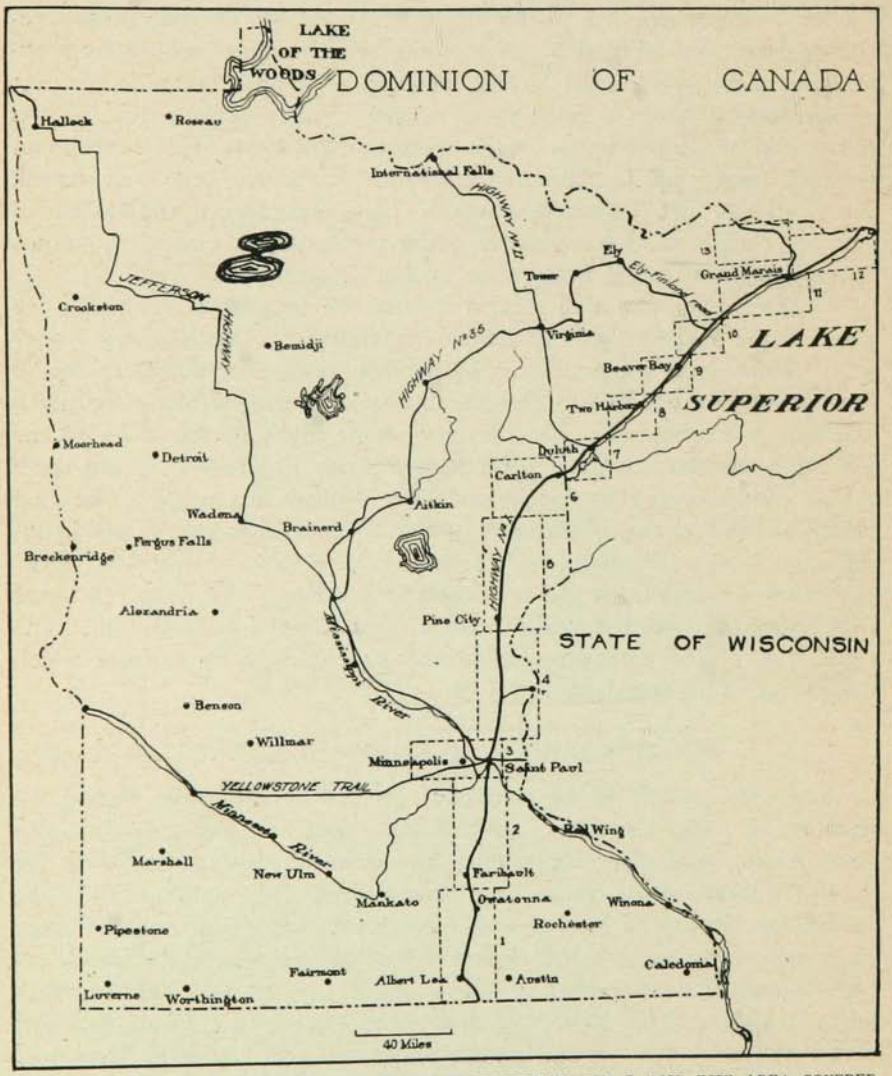


FIGURE 1. KEY MAP SHOWING THE ROUTE OF HIGHWAY NO. 1 AND THE AREA COVERED BY EACH ROUTE MAP

The writer is especially indebted to Dr. W. H. Emmons, Dr. F. F. Grout, and Dr. C. R. Stauffer, of the Department of Geology of the University of Minnesota, for help and criticism. Dr. Grout contributed most of the field data on the Duluth region and Mr. R. D. Harvey assisted greatly in the field work.

Inasmuch as the book is popular in its nature, no attempt has been made to give detailed footnote references.

It should be emphasized that the information contained in this bulletin is but a small part of that available on the state. The Minnesota Geological Survey has a series of bulletins with more detailed information on particular regions and materials, and still others are being prepared. Those interested should send to the survey for a list of its publications.

CHAPTER II

GENERAL CONDITIONS IN, AND GEOLOGY OF, MINNESOTA

Minnesota received its name from the Minnesota River which is the largest river that lies wholly within the state. This river was called the St. Peter's by early English and French explorers. The territorial legislature succeeded in having the aboriginal name restored. Dr. Folwell has recently discussed[1] the origin and meaning of the name. The meaning most generally accepted is "clouded water," or, more poetically, "sky-tinted water," but Dr. Folwell suggests that the word may have been derived from the Dakota word "Minisota," meaning invisible or lost water, referring to the fact that the river empties into the larger Mississippi and thus loses its identity, or more probably to the fact that Pike Island hides the mouth from the view of the voyager on the Mississippi.

NOTES ON THE HISTORY OF THE STATE

The following notes give a few details of the early history of the state, which has been replete with interesting events. Dr. Folwell's four-volume work should be referred to for a comprehensive review of Minnesota history.

There is some doubt as to the identity of the first white men to visit the area now included within the state, but it is probable that two Frenchmen, Medard Chouart (Sieur de Groseillers), and Pierre d'Esprit (Sieur de Radisson), visited the region in 1654. In 1673 Louis Joliet and Father Marquette discovered the upper Mississippi, entering it at the mouth of the Wisconsin, but they did not visit Minnesota territory. Daniel Greysolon (Sieur du Luth) visited the head of Lake Superior in 1679 and then penetrated inland as far as Mille Lacs. In the following year he visited the Mississippi.

Father Hennepin was a member of the first party of white men to ascend the Mississippi to the present sites of St. Paul and Minneapolis. He discovered and named St. Anthony Falls in 1680. The area now included in Minnesota was formally claimed for France by La Salle at a ceremony at the mouth of the Mississippi, April 9, 1682.

Many other French expeditions visited the region and some established posts, but these were not permanent. Probably the first somewhat permanent settlement was the trading post established at Grand Portage Bay, Lake Superior, about 1770. In 1794 a trading post was established at Sandy Lake in the central part of Aitkin County.

[1] Folwell, W. W., A history of Minnesota, vol. 1, pp. 455-57. St. Paul, 1922.

The first, and for some time the principal, settlement in southern Minnesota was begun when a United States Army detachment occupied a camp then called St. Peter's, near the present site of Mendota in 1819. Later the army camp was moved to the present site of Fort Snelling, and St. Peter's, later called Mendota, remained a trading post.

Minnesota was made a territory in March, 1849; the act giving authority for the organization of a state government was passed in 1857; and the state was admitted to the Union on May 11, 1858.

CLIMATE OF MINNESOTA[2]

The climate of Minnesota is much like that of the other northern states of the Middle West. It has the extremes of temperatures and moderate rainfall common to inland areas. The mean annual temperature is about 42°. The coldest months are January and February, with a mean temperature of about 10°. July is the warmest month with an average temperature of 69°. The highest temperature recorded in the state is 107° and the lowest 59° below zero. Temperatures above 100° are rare, many summers passing without that mark being approached. Temperatures below —20° are usually of short duration.

The average date of the last killing frost varies from May 1 in some southern sections to June 5 in the extreme northern portion of the state, near Lake of the Woods. The average date of first killing frost varies from September 1 in the northern portion to October 5 along the Mississippi Valley. Thus the longest growing season is 160 days and the shortest about 100 days.

Precipitation is abundant, with a variation from 32 inches in the eastern part of the state to 20 in the northwest corner. The average for the state for the years 1896 to 1914 was 27.72 inches. The rainfall is rather evenly distributed over the entire growing season. The snowfall averages from 24 to 54 inches and is heaviest in the northern portion of the state. Sunshine is abundant and this combined with the generally cool summers, especially in the northern portion of the state, makes the myriads of lakes increasingly popular as places at which to spend a summer vacation. The cool breezes from Lake Superior are always welcome to those who have suffered the heat of less favored parts of the country. Heavy coats are useful at almost any time along the north shore of the lake. The great depth of the lake is doubtless the reason for its maintaining an average low temperature, thus affecting the temperature of near by land areas.

[2] Abstracted from U. G. Purssell, Minnesota Geological Survey Bull. No. 13, ch. ii.

TOPOGRAPHY OF MINNESOTA[3]

GENERAL STATEMENT

The position of Minnesota is near the center of the North American Continent, and the state embraces an area of 84,682 square miles, of which about 93 per cent is land and 7 per cent, water. Its extreme length is nearly 400 miles, from latitude 43° 30′, at the Iowa line, to a point about 23 miles north of the 49th parallel, in the projection known as the Northwest Angle, northwest of Lake of the Woods. The greatest width is 367 miles, but the average width is only about 225 miles, or but little more than half of the length.

Minnesota presents more variety in surface features than most of the north central states, yet a great part of its surface is level or only gently undulating. The flattest portion falls largely in the northwest quarter, and was once the bed of the glacial Lake Agassiz, a lake held in on the north, in central Canada, by the great ice sheet. The roughest portion is in the northeastern quarter within the area crossed by Highway No. 1. This part is composed largely of volcanic formations and iron-bearing rocks which, though glaciated, were not everywhere buried beneath the glacial deposits. In the southeastern part of the state deep erosion valleys along the Mississippi and its tributaries present bold rock bluffs 300 to 600 feet high. The interior and southern parts of the state have features due almost entirely to the work of the great ice sheets, which at successive times, and from different directions, overspread Minnesota. (See page 18.) The glacial desposits comprise an intricate system of moraines with undulating to hilly surface, associated with which are level outwash plains of sand and gravel, and gently undulating intermorainic till plains.

ALTITUDE

The altitude of Minnesota ranges from 602 feet, the level of Lake Superior, up to 2230 feet, on high rock hills in the northeast part of the state, in western Cook County. A large part of the state falls between 1000 and 1500 feet. The average altitude is not far from 1200 feet. The portions above 1500 feet lie chiefly in two areas, one at the northeast and one at the southwest corner of the state, though there is a good sized area around the sources of the Mississippi River in the western part, and several smaller areas in that vicinity; one of these in the southern part of Otter Tail County is known as the Leaf Hills. The altitude of the elevated area in the northeastern part includes several small areas, chiefly in Cook County, that rise above 2000 feet. The portions below 1000 feet fall in two areas widely separated except for a connecting line along the

[3] Abstracted from Leverett and Sardeson, Minnesota Geological Survey Bull. 13, ch. i.

Minnesota Valley, one being on the western edge of the state and the other on the eastern. There is also a narrow strip bordering Lake Superior.

RELIEF

The most conspicuous relief is found in the "Sawtooth Range" and other prominent ridges that closely border Lake Superior and which rise abruptly from 500 to 900 above the lake. The rock ranges lying back from the shore, though more elevated than those fronting on the lake, seldom rise more than from 200 to 300 feet above the swamps and lakes among them. In fact several of the lakes of Cook County are above 1900 feet or within 300 feet of the level of the highest points in the state. The most prominent part of the Mesabi Iron Range in St. Louis County rises from 400 to 450 feet above bordering plains.

DRAINAGE

The drainage of Minnesota is widely divergent, part of it leading to the Gulf of Mexico, part to the Gulf of St. Lawrence, and part to Hudson Bay. The Gulf of Mexico receives about 57 per cent, the St. Lawrence less than 9 per cent, and Hudson Bay fully 34 per cent of the drainage. There was a time, however, after the glacial ice had melted from Minnesota but was still occupying the northeast part of the Superior basin and neighboring parts of Ontario and Manitoba, when all the drainage was southward to the Gulf of Mexico. The western Superior basin then overflowed into the St. Croix River, while the Red River drainage basin, largely covered by Lake Agassiz, drained southward through Lakes Traverse and Bigstone into the Minnesota Valley.

The drainage to the south, or Gulf of Mexico, has generally a gentle descent, and waterfalls are rather rare, though the Mississippi has notable falls at Minneapolis and there are one or more falls or rapids on several of the tributaries. The drainage to Lake Superior is generally rapid and nearly every stream has several cascades. There is, however, a wide area of the upper St. Louis basin in which that stream and its tributaries have relatively gentle descent for many miles. The Hudson Bay drainage has a few rapids and waterfalls in the headwater part of Rainy River and its tributaries.

LAKES

Throughout much of Minnesota, except the northwest, southwest, and southeast corners, small lakes are a common feature. They usually occupy basins among the moraine ridges and knolls and on the outwash plains, but occur to some extent also on the till plains and among rock knobs. The combined area of the lakes within the state is estimated to be about 5650 square miles, or nearly 7 per cent of the entire area. The largest lake is Red Lake, a very shallow body of water with an area of

440 squares miles. Other large lakes are Mille Lacs, also very shallow, Leech, Winnibigoshish, and Minnetonka. Minnetonka and the southern part of Leech Lake extend into a network of deep depressions among morainic ridges, but the other lakes are largely in plains that are slightly below the neighboring districts, partly morainic and partly plain.

GENERAL GEOLOGY OF THE REGION

NOTE.—Definitions of geologic terms may be found in the Glossary in the back of the book.

In order to understand and appreciate the many features which may be seen in passing along the highways, it is necessary to have as a background a general knowledge of the development of rocks and other features of the earth. The following notes may assist the reader to understand the descriptions.

In general the southern part of Highway No. 1 passes through a region mostly covered with glacial débris, but with outcrops of rock along the Mississippi River and some of the lesser streams. In the vicinity of Duluth and along the north shore of Lake Superior outcrops of solid rock are abundant and very old slates and lava flows are the important types.

The rocks of the earth are grouped according to their age and each subdivision of geologic time, as determined by a study of the succession of rocks and of their enclosed fossils, has been given an appropriate name. A consideration of the basis for this subdivision cannot be taken up here, but any textbook of general geology may be referred to for the details. This arrangement of the rocks into subdivisions has been the result of long studies by many investigators.

Not all of the various geologic periods are represented by the rocks in a given area, and only the periods represented in the areas adjacent to Highway No. 1 are discussed here. The table on pages 10 and 11 lists the rocks which are exposed in Minnesota with a star marking those which exist along Highway No. 1. A table of geologic time is given to show by comparison the parts represented in Minnesota. Figure 2 is a generalized geologic map of the state showing the distribution of the various formations either as outcrops or beneath a cover of soil and glacial drift.

The oldest rocks, known as the Archean (Ancient) rocks, are exposed in northern Minnesota but not in the region traversed by Highway No. 1. Above the Archean are rocks which belong to the Algonkian period which is subdivided into the Huronian and Keweenawan. The Huronian is composed of several formations, but only the upper ones are exposed along Highway No. 1. Perhaps the thickest part of the Huronian is the slate formation which overlies the iron formations of the region and forms the upper part of the Huronian sedimentary series. On the Mesabi Range this is known as the Virginia slate. Some of the other slates found in

northern Minnesota, in Carlton and Cook counties, are usually considered to be equivalent in age to the Virginia slate. These are known as the Carlton and Rove slates.

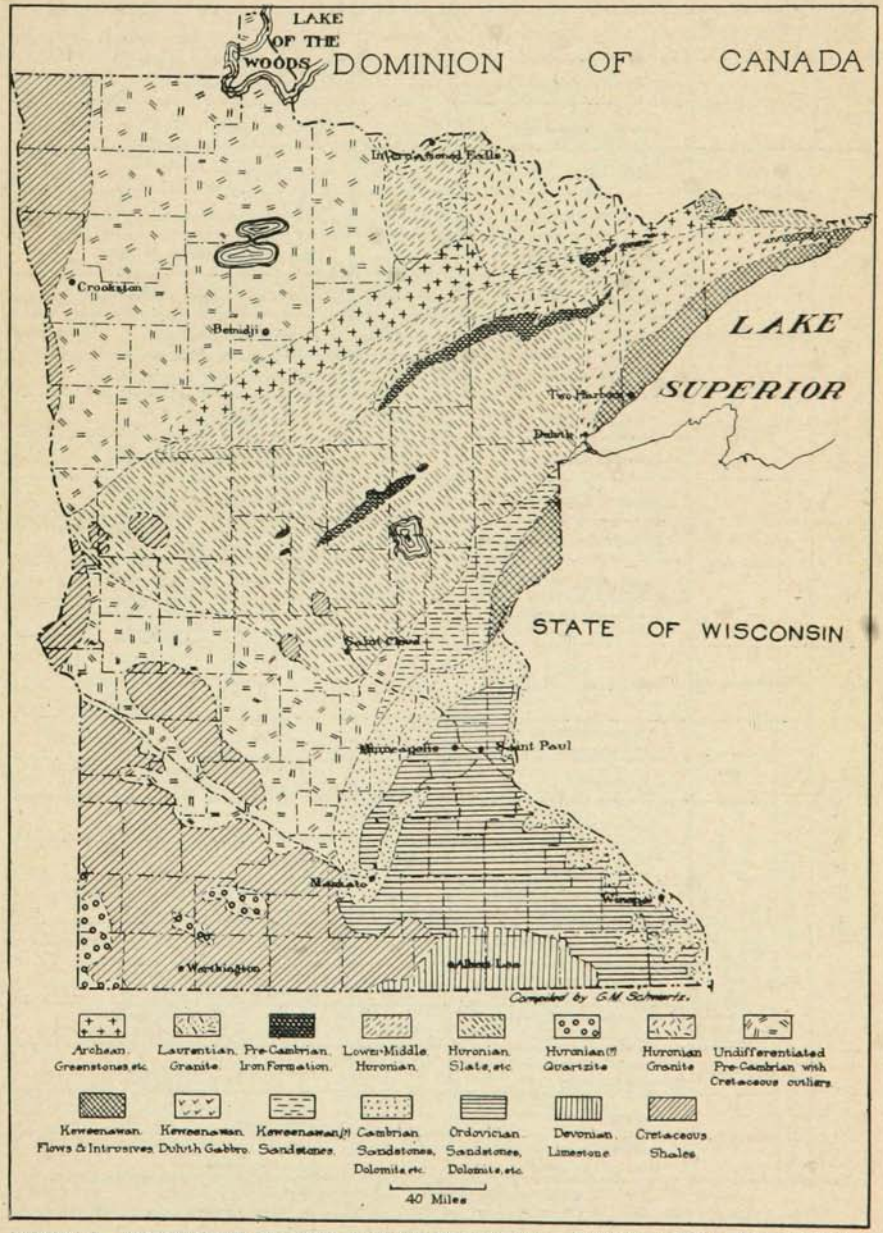


FIGURE 2. GENERALIZED GEOLOGIC MAP OF MINNESOTA. COMPILED FROM THE PUBLICATIONS AND FIELD NOTES OF THE MINNESOTA GEOLOGICAL SURVEY AND THE PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY

Group	System or Series		Formation	Approximate Maximum Thickness (Feet)	Character of Strata
Cenozoic	Quaternary	Recent*			Lake or river silt
		Glacial* Period		600±	Glacial drift, loess, etc.
Mesozoic	Cretaceous		Benton shale*	500	Clays and shales
			Dakota sandstone		Sandstone
Paleozoic	Devonian		Cedar Valley limestone	100	Limestones.
	Ordovician		Maquoketa shale	100	Shales and limestones
			Galena limestone*	100	Limestone with some shale
			Decorah shale*	65	Shale and some limestone
			Platteville limestone.*	30	Dolomitic limestone
			St Peter sandstone.*	200	Sandstone with a little shale.
			Shakopee dolomite.*	100	Sandy dolomite.
			Oneota dolomite.	200	Buff to reddish dolomite.
	Cambrian		Jordan sandstone.	200	White to brown sandstone.
			St Lawerence formation.	200	Buff dolomite with green shale and sandstone
			Franconia sandstone.*	100	White sandstone and green sand.
			Dresbach sandstone and underlying sandstone+shale.*	450	White sandstone with interbedded shales and limestone.
Proterozoic	Algonkian?		Red clastic series.*	2250	Red sandstones and shales.
	Algonkian	Keweenawan	Conglomerates and sandstones.*	500	Conglomerate and sandstones
			Eruptives.*	?	Granites, diabases, gabbros, basalts, etc
		Huronian	Acid and basic intrusives	?	
			Virginia, Rove, and Carlton slates.*	3000±	Slates
			Biwabik and Gunflint iron formations	800	Taconite, iron ore, ferruginous chert, etc.
			Pokegama quartzite	200	Quartzite, slate and conglomerate.
		Lower-Middle Huronian	Giants Range granite and other intrusives	?	Gray to pink granite, granite porphyry, etc
			Slate, graywacke, and conglomerate	5000	Green to gray slates graywackes and conglomerates
Archeozoic	Archean	Laurentian	Granites, gneisses, and porphyries	?	Granites, porphyries, etc.
		Keewatin	Soudan formation	?	Chert and jasper. Iron ore
			Schists, porphyries, and greenstone	?	Green schists, greenstone, porphyries, etc.

Note- Formations marked * are found in the regions traversed by Highway No. 1

GEOLOGIC COLUMN OF MINNESOTA

ERA		PERIOD	CHARACTERISTIC LIFE	DURATION ACCORDING TO VARIOUS ESTIMATES
CENOZOIC Recent life	QUATERNARY	RECENT	'Age of man.' Animals and plants of modern type.	Millions of years
		GLACIAL PERIOD		
	TERTIARY	PLIOCENE MIOCENE OLIGOCENE EOCENE	'Age of mammals' Possibly first appearance of man. Rise and development of highest order of plants.	1 to 5
MESOZOIC Intermediate life		CRETACEOUS	'Age of reptiles' Rise and culmination of huge land reptiles (dinosaurs), of shell-fish with complexly partitioned coiled shells (ammonites), and of great flying reptiles. First appearance (in Jurassic) of birds and mammals; of cycads, an order of palmlike plants (in Triassic); and of angiospermous plants among which are palms and hardwoods (in Cretaceous).	4 to 10
		JURASSIC		
		TRIASSIC		
PALEOZOIC Old life.		PERMIAN	'Age of amphibians' Dominance of club-mosses (lycopods) and plants of horsetail and fern types. Primitive flowering plants and earliest cone-bearing trees. Begining of backboned land animals (land vertebrates). Insects. Animals with nautilus-like coiled shells (ammonites) and sharks abundant	17 to 25
		PENNSYLVANIAN		
		MISSISSIPPIAN		
		DEVONIAN	'Age of fishes' Shellfish (mollusks) also abundant. Rise of amphibians and land plants.	
		SILURIAN	Shell-forming sea animals dominant, especially those related to the nautilus (cephalopods). Rise and culmination of the marine animals sometimes known as sea lilies (crinoids) and of giant scorpion like crustaceans (eurypterids). Rise of fishes and reef-building corals.	
		ORDOVICIAN	Shell-forming sea animals, especially cephalopods and brachiopods abundant. Culmination of the marine crustaceans known as the trilobites. First trace of insect life and of fishes.	
		CAMBRIAN	Trilobites and brachiopods most characteristic animals. Seaweeds (algae) abundant. No trace of land animals found.	
PROTEROZOIC Primordial life		ALGONKIAN	First life that has left distinct record. Crustaceans, brachiopods, dacteria, and seaweeds.	
ARCHEOZOIC		ARCHEAN	No fossils found except possible algae.	50+

PRINCIPAL DIVISIONS OF GEOLOGIC TIME

HURONIAN SLATES, EROSION, SEDIMENTATION, AND METAMORPHISM

Huronian slates comprise the oldest rocks actually exposed along Highway No. 1. They may be seen at several places along the highway in Carlton County, notably at the bridge over the St. Louis River and along the river through Jay Cooke Park. The Rove slate, which is about equivalent in age, is exposed in the extreme northeastern part of Minnesota, from Grand Portage north to the boundary at the Pigeon River and extending westward to Gunflint Lake. The formations, as the names indicate, are dominantly slate, but the Rove formation particularly has a considerable variation and much graywacke as well as minor amounts of quartzite and conglomerate are found within it.

The material from which the slates and associated rocks formed was laid down by processes of sedimentation and was subsequently subjected to metamorphism. The origin of these rocks may then be briefly explained as follows. Wherever land areas are exposed they are subject to the continual action of water, wind, or ice, and in addition to the chemical action of solutions, that is, of water with various dissolved materials. In this manner rocks are broken down and become subject to transportation by the same agencies, but water is normally the important transporting and depositing agency. The material is carried in solution and in suspension, as may be determined by analyzing any river water. When a river flows into the ocean or a lake its velocity is checked and the material carried in suspension is dropped. If this takes place near the mouth a delta is formed, if ocean currents and waves are active the material may be carried long distances and spread out in extensive but thinner beds. The material carried in suspension forms mud, sand, or gravel depending on the size of the particles. The variability of the constituents may be observed in any outcrops of sedimentary rocks or in material deposited by present day streams. Materials carried in solution, as calcium carbonate, may be precipitated by chemical or organic processes, forming limestone or dolomite.

Where the sediments noted above continue to pile up, those beneath are subject to considerable compression, and they are more or less compacted and usually cemented. If the sediments have been deposited in relatively shallow arms of the ocean, earth movements may result in the elevation of the bed above the sea level and when the upper beds are removed by erosion those beneath are found to have consolidated and form the ordinary sedimentary rocks. The sands have formed sandstone, the mud has changed to shale, the calcareous deposits to limestone and dolomite; gravel, where present, has formed conglomerate. These five types of rock comprise by far the greater part of all sedimentary rocks. Examples of these rocks may be seen along the Mississippi River in

Minneapolis and St. Paul, at Faribault, Northfield, Taylors Falls, Sandstone, and other places noted in the following chapters. As a result of their deposition in water, they are characteristically layered or bedded and may have ripple marks, fossils, and other structures. The types of fossils indicate whether the beds were formed in fresh or salt waters as the animals which live in the ocean are distinctly different from those found in fresh water lakes and rivers.

When sedimentary rocks are very deeply buried and subject to the action of pressure, heat, and movement, they undergo much more profound changes than is the case when unconsolidated sediments are transformed to sedimentary rocks. This change is called metamorphism (change of form) and rocks which have undergone a transformation in this way are called metamorphic rocks. It is known from their composition and original texture, as well as by gradations which have been found in various parts of the world, that shales are thus transformed to slates, and sandstones to quartzites. These transformations naturally involve changes in chemical and mineral composition, as well as in texture and structure. The rocks become hard, cleavage or parting characteristic of slate is developed, and the rocks may be folded and faulted as are the slates along the St. Louis River, but even in that case the original bedding may be distinguished by light and dark bands and by a parting along the bedding. (See Plate 11-c.)

KEWEENAWAN ROCKS, LAVAS, AND IGNEOUS PROCESSES

Directly overlying the slates in the Duluth-Carlton area is a great series of rocks, largely igneous, which are known as Keweenawan rocks from the extensive exposures on Keweenaw Point, Michigan. Similar rocks are exposed at Taylors Falls, on the Snake River east of Pine City, and along the north shore of Lake Superior from Duluth to Grand Portage Bay. (See Figure 2.)

The Keweenawan rocks consist mainly of basalt and rhyolite lava flows, and coarse diabases, gabbro, and syenite, with lesser amounts of sandstone, shale, and conglomerate.

The lava flows consist of rock which was poured out on the surface in a molten condition and thence flowed out into broad sheets. The question immediately arises, how do we know that these rocks were formed as lava flows? If a large outcrop of these rocks is examined, such, for example, as is found along shore below the Two Harbors Tourist Park, where a series of four flows are exposed, it may be seen that there is a dense, massive layer of dark rock which grades upward into a band which is spotted with light colored mineral filling rounded holes. It is known from comparison with present day lava flows, such as occur in the Hawaiian Islands, that this vesicular or amygdaloidal layer is formed by

gas bubbles rising to the top of the flow. Subsequently minerals are deposited in the holes. In some cases the upper surface of a flow is much broken or brecciated and at places sand and pebbles are incorporated in the top of the flow. The sand and pebbles may form separate beds of conglomerate as on the Snake River east of Pine City, or sandstone as at Good Harbor Bay near Grand Marias. The lava flows which border Lake Superior are so extensive that it is doubtful if they could have issued from volcanoes such as those which form conical mountains, but it is believed that they issued from large fissures and spread out over the surrounding country like those in Iceland in historic time. The rocks formed from lava flows are characteristically dense and fine grained as a result of their cooling so quickly that large crystals did not have time to grow.

After the lava flows had been poured out, the molten material (magma) continued to work its way upward, but at places it could not reach the surface and it forced its way between the flows and other rocks and formed huge masses of intrusive rocks now recognized as gabbro, diabase, and syenite. The Duluth gabbro is the largest mass of this material. It extends from Duluth north and east in a broad belt reaching Lake Superior at the Reservation River, twenty-five miles east of Grand Marais. At many places along its border it has affected by its great heat the rocks with which it came in contact. This is true, for example, at Short Line Park near Duluth. (See page 66.) This mass was so large that the molten material segregated more or less after intrusion and near the top the black gabbro grades to "red rock" (syenite or granite). Diabase and gabbro rocks also are found as sills and dikes in the lava flows at places from Duluth to Grand Portage Bay and in the slates north of that point. At places, for example on shore near Encampment Island, the diabase has clearly tipped up the flows by the force of its intrusion.

The gabbros, diabases, and syenites (red rock) are coarse grained rocks, that is the minerals which compose them may be easily recognized with the naked eye. Gabbros and diabases are characteristically dark to black rocks whereas syenites are normally red. The coarse texture is a result of the slow cooling of the mass of molten material under cover. It is known from the poor conductivity of rocks that it must have taken centuries for a mass the size of the Duluth gabbro to cool. There was probably little difference in the composition of the molten material which formed the basalt flows and the gabbro, but the difference in the time of cooling has resulted in a distinctly different texture in the two types. The intrusive rocks are hard and massive, and resist weathering better than the surrounding flows. The almost mountainous character of the north shore country is directly attributable to the presence of the numerous diabasic intrusions.

There are associated with these diabases some peculiar rocks known as anorthosites. These are composed almost entirely of feldspar and are very resistant, forming prominent white hills even in the diabase areas. They are igneous rocks, that is, they were once in a molten condition and they were brought to their present positions about the time the diabases were formed.

CAMBRIAN AND ORDOVICIAN SEDIMENTARY ROCKS

The rocks of the Huronian and Keweenawan periods are very old. They include igneous and metamorphosed sedimentary rocks. At the beginning of the Cambrian, however, volcanic activity and folding, characterized by intense pressure, ceased in this area, and even to the present time only moderate changes have affected the rocks. The Cambrian and later rocks are easily recognizable and in some of them abundant remains of life (fossils) are found. (See table on page 11, and Plate I.)

Cambrian rocks are abundantly exposed along the St. Croix and Mississippi rivers from Chisago County to the southern boundary of the state. (See Figure 2.) The only place where they may be seen in the region described in this bulletin is at Taylors Falls. The rocks which make up the Cambrian include all of the common sedimentary rocks: sandstone, dolomite, limestone, shale, and conglomerate. Sandstone is probably the most abundant and certainly the most conspicuous.

The origin of these rocks has been discussed above under sedimentation, and they afford many examples of the processes noted. The evidence for the conclusion that the Cambrian rocks are younger than the Keweenawan lava flows may be seen at Taylors Falls, where a conglomerate overlies the flows and is composed chiefly of rounded boulders and pebbles of the basalt flows with a matrix of sand which contains characteristic Cambrian fossils. The conglomerate grades upward into sandstone which forms bluffs below the "Dalles." (See page 50.) The boulders doubtless represent blocks broken from the cliffs of Keweenawan rocks by wave action and later the Cambrian sea became deeper and covered them with sand.

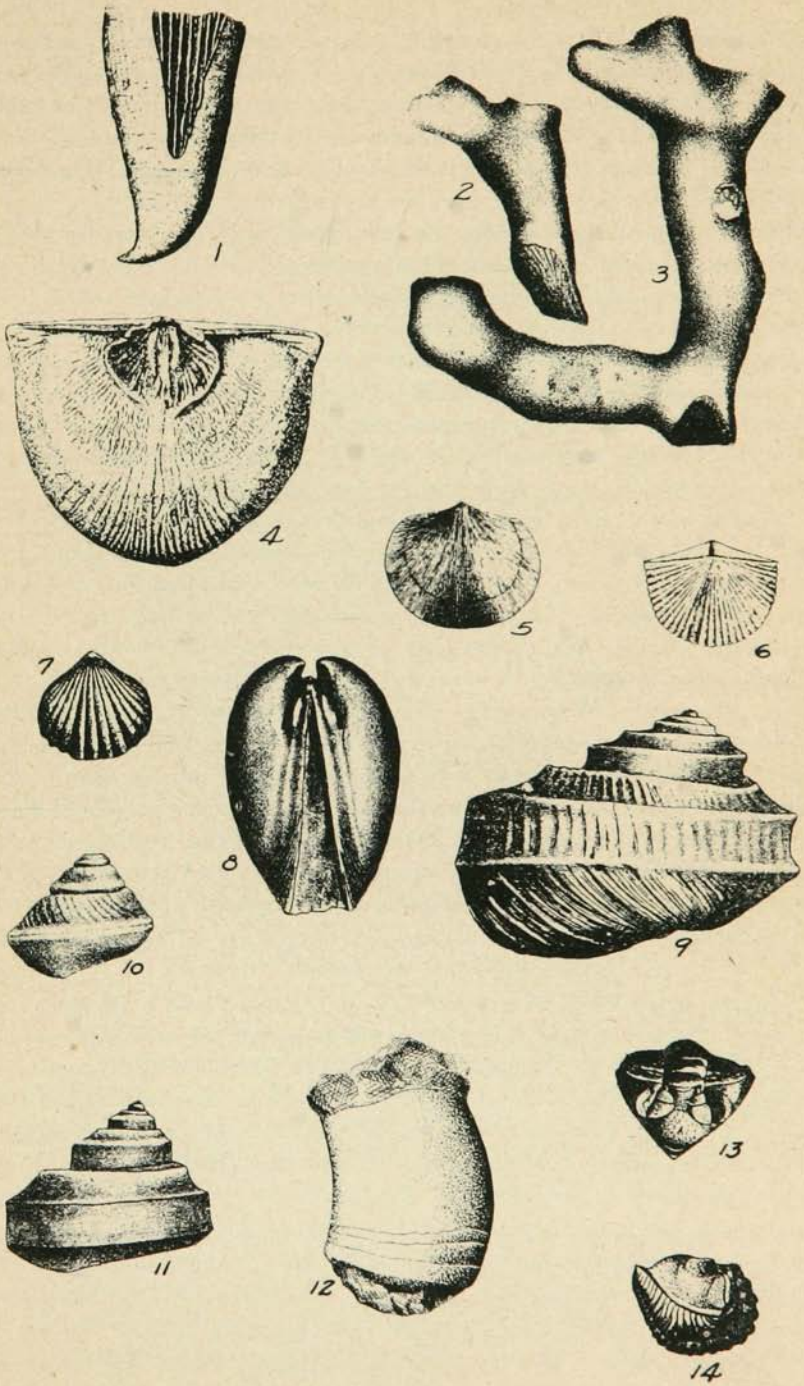
Immediately overlying the Cambrian rocks is a somewhat similar series belonging to the Ordovician period. The chief reason for setting this series apart from the Cambrian is the marked difference in the type of life represented by fossil remains. (See table on page 11.) These remains indicate a progressive development of animal life to higher forms. Referring to the table on page 10, it may be seen that seven formations comprise the Ordovician strata in Minnesota. Of these all but the lowest and highest are exposed in the area covered by this report. These rocks are exclusively sedimentary and consist of sandstones, dolomites, limestones, and shales.

Plate I

Common Types of Fossils Found in Ordovician Rocks in Minnesota

(Any or all of these, and many others, may be found in the Twin Cities)

1. A horn coral (*Streptelasma profundum*). Minneapolis.
2-3. Bryozoans, small and average size (*Batostoma minnesotense*). Minneapolis.
4. A brachiopod (*Strophomena incurvata*). Minneapolis and St. Paul.
5. A brachiopod (*Pianodema subaequata*). Minneapolis.
6. A brachiopod (*Orthis tricenaria*). Minneapolis.
7. A brachiopod (*Rhyncotrema minnesotense*). Minneapolis.
8. A pelecypod (*Vanuxemia obtusifrons*). Minneapolis.
9. A gastropod (*Trochonema beloitense*). Minneapolis and St. Paul.
10. A gastropod (*Clathrospira subconica*). Minneapolis.
11. A gastropod (*Trochonema umbilicatum*). Minneapolis and St. Paul.
12. A cephalopod (*Onoceras carveri*). Minneapolis.
13-14. A trilobite (*Pterygometopus intermedius*). St. Paul.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The Ordovician rocks are confined to the southern part of the state and are not exposed along Highway No. 1 north of Minneapolis and St. Paul. The southernmost exposure along the highway is just north of Owatonna. The St. Peter sandstone and Platteville limestone are well exposed at Faribault and along the Mississippi River through Minneapolis and St. Paul.

The Ordovician rocks were for the most part deposited in ocean waters and most of the formations, especially the Decorah shale and Platteville limestone, have abundant fossil remains of animals which lived in the early seas. The St. Peter sandstone is a remarkably pure white sandstone which is so little cemented that it may be crumbled with the hand. It is composed almost entirely of white rounded quartz grains. A detailed study of the grains indicates that they have been worn by being blown about by the wind, but its layered condition and the occurrence of fossils in it at St. Paul show that it was finally deposited in the sea. On account of its purity it has been used for glass-making, and the Ford Motor Company has recently examined the Minnesota occurrences with that possibility in mind. The formation is very widespread as it extends as far east as Detroit, Michigan, and southward to Arkansas.

Geologic periods not represented in Minnesota.—There are no beds exposed along Highway No. 1 of the ages between the Ordovician and the Glacial period. From studies elsewhere it is known that a great series of beds represent this interval, but if they were ever present in this region, they have been washed away. It is known from drilling records that relatively thin beds of Devonian and Cretaceous rocks are present in Freeborn and Steele counties. Some of the great series of rocks not represented in Minnesota include, for example, the series that contain the great coal beds of the various fields from Iowa, Missouri, and Arkansas to Pennsylvania.

THE GREAT ICE AGE—GLACIATION

The last great event which preceded the establishment of present conditions in Minnesota was the advance of great ice sheets which covered large parts of North America. It has been established by means of the scratches on the rocks that the ice worked outward from three great centers: an eastern center in Labrador (Labradorean); an interior point just west of Hudson Bay (Keewatin), and the third in the Rocky Mountains (Cordillerean). Practically the entire area of Minnesota was covered by the ice at some time. Ice from both the Labradorean and Keewatin centers invaded Minnesota. The ice would advance from one direction and after a time melt back and later a lobe would advance from another direction. These movements have also been proved by the nature of the drift. Outcrops showing scratches are referred to in the

detailed descriptions in succeeding chapters. At least three drift sheets laid down by different advances of the glacier are exposed along Highway No. 1. These three sheets are known as the old gray drift, the red drift, and the young gray drift. The old gray drift was deposited by one of the earlier advances of the ice, usually called the Kansan. The red and young gray sheets are usually referred to the Wisconsin stage of glaciation. The red drift was deposited by a lobe which came from the northeast, whereas the young gray material came from the northwest. Different types of rocks in the regions from which the ice came account for the differences in the types of material.

As a result of the invasion of the ice the nature of the surface in Minnesota was greatly changed. Valleys and other depressions were filled, rock hills were scoured off, heaps of glacial débris were piled up, forming ridges and hills.

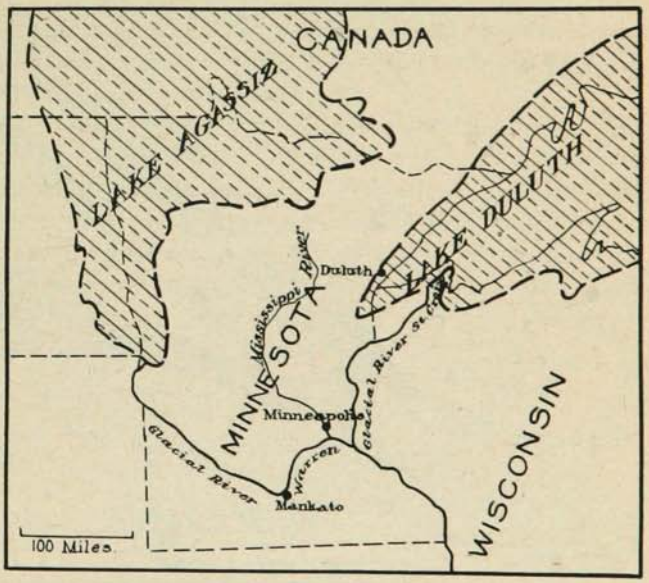


FIGURE 3. SKETCH MAP SHOWING PORTIONS OF GLACIAL LAKES AGASSIZ AND DULUTH. LAKE AGASSIZ DRAINED SOUTHWARD ALONG THE PRESENT VALLEY OF THE MINNESOTA RIVER. LAKE DULUTH DRAINED INTO THE ST. CROIX RIVER. BASED ON MAPS BY UPHAM

There are three main types of deposits left by the glaciers and the waters which poured out from their margins. The thick hilly accumulation made at the edges of the ice sheet when the margin remained stationary for some time is known as a *terminal moraine*. When the glacier melts from a large area it leaves a heterogeneous mass of débris which covers

the surface to a varying depth forming the *ground moraine*. Numerous streams flow out from the ice sheet and spread a broad sheet of silt, sand, and gravel in front of the terminal moraine, forming what is known as an *outwash plain*. The same material found along stream channels is called simply an outwash deposit or a valley train. There are numerous examples of each of these types which have been described in the following chapters.

Where streams formed tunnels under the ice, the tunnel often became more or less filled with the coarser material carried by the stream. When the ice melted this material formed ridges known as eskers. (See page 30.) Where the waters emerged from the ice, hills of gravel were often formed and these are known as kames.

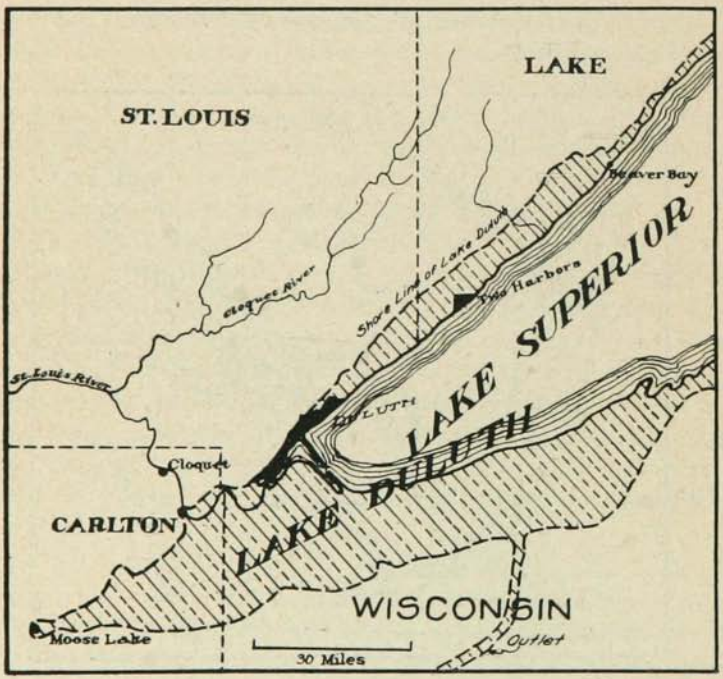


FIGURE 4. SKETCH MAP SHOWING THE RELATION OF LAKE DULUTH TO LAKE SUPERIOR. AFTER MARTIN AND OTHERS. UNITED STATES GEOLOGICAL SURVEY MONOGRAPH 52

The work of the glaciers was not confined to direct deposits, but the large amount of water furnished by the melting produced important effects. Where the natural drainage of the region was in the direction occupied by the glacier, extensive lakes were formed in front of the ice. This was the case in the region now occupied by Lake Superior. When much of the present lake was occupied by ice and the St. Lawrence

outlet was thus cut off, the lake drained to the southward into the St. Croix River, thence into the Mississippi (see Figure 3), and Lake Superior was several hundred feet higher than at present and covered a much larger area. (See Figure 4.) Likewise the drainage from northwestern Minnesota, which would otherwise have flowed northward as it does now, was blocked and a large lake known as Lake Agassiz was formed, which extended through northwestern Minnesota, eastern North Dakota, and northward over a very large area in Canada. This lake at first drained southward into the Minnesota River (see Figure 3), and the large amounts of water thus supplied rapidly eroded a great valley and gorge as may be seen at Fort Snelling and above. Later, when the glaciers had ceased to exist, the amount of water in this and many other streams decreased greatly and now the diminished streams often seem out of proportion to their relatively large valleys. As a result of this diminished water supply the dwindling streams were unable to carry away the large quantities of rock débris supplied to them and it accumulated in the gorges, such as that of the Mississippi which through St. Paul is known to be thus filled to a depth of fully 100 feet.

After the ice had retreated to the north and the glacial lakes had decreased or disappeared, as water from the melting ice diminished, conditions became much as they are now. Vegetation began to flourish on the barren wastes, forests sprang up, lakes occupied the undrained depressions formed by the irregular deposition of débris by the ice, and the streams found new courses or occupied the partially filled old channels. Thus gradually the present aspect of the country was developed except for the changes made by man in the last century.

CHAPTER III

HIGHWAY NO. 1 FROM THE SOUTH STATE LINE TO THE TWIN CITIES

FREEBORN COUNTY

(Total area 701.94 square miles; covered by water 20.73 square miles)

NOTE.—In following descriptions of the route frequent reference should be made to the maps which accompany various parts. It is assumed that Chapter II has been read. Definitions of geologic terms are given in the Glossary.

The traveler following the Jefferson Highway northward through Iowa enters Minnesota on State Trunk Highway Number 1 near the southeast corner of Freeborn County. This county, in common with practically all of the counties of southern Minnesota, is noted for its very fertile soil which produces large crops of corn, oats, wheat, hay, and other products. Dairying is an important industry. The county is composed of twenty government townships extending five east and west and four north and south. It was established February 20, 1885, and was named in honor of William Freeborn, a member of the council of the territorial legislature.

Where Highway No. 1 begins at the state line (see Route Map No. 1) the topography or surface of the land is gently undulating and the soil consists of material brought down by the glaciers (see page 18) which was deposited in various ways and forms. To the east of the road is an oak grove which represents the type of timber originally found on the rougher portions of the land and along the streams. To the west is a level stretch of prairie which was not originally timbered.

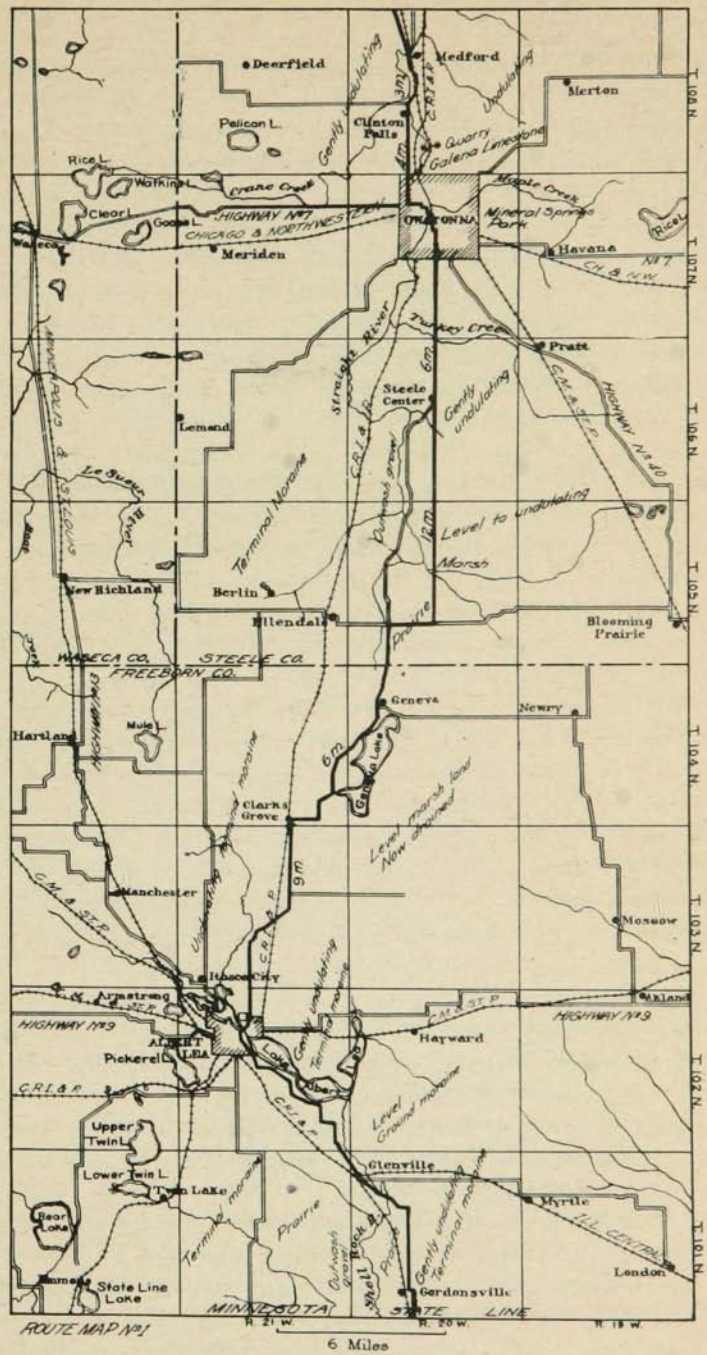
Gordonsville
Population[1] 136
Elevation 1213 feet

Gordonsville is a village on the Chicago, Rock Island and Pacific (Rock Island) Railway, a mile north of the state line. North of the village the undulating surface may be seen only to the east of the road and the traveler passes through almost level prairie broken only by groves of trees which have been planted around the farm buildings. The road turns west toward Glenville and wooded areas are numerous along the sluggish Shell Rock River which flows southward from Lake Albert Lea.

Glenville
Population 379
Elevation 1235 feet

After passing through Glenville the road turns north along the west side of Shell Rock River. To the west lies an almost unbroken prairie while the banks of the stream are wooded. Gravel and sand deposits are abundant near the river and have been opened for local use at several places. The sand and gravel represent outwash material formed by large streams which poured forth from melting ice when the glacier retreated. (See page 20.)

[1] Unless otherwise noted, the population is that of the last census.



HIGHWAY NO. 1 THROUGH FREEBORN AND STEELE COUNTIES. THE HIGHWAY IS INDICATED BY A HEAVY BLACK LINE. DISTANCES BETWEEN TOWNS ON THE ROUTE ARE GIVEN THUS, 9 M.

Lake Albert Lea.—About three miles beyond Glenville and extending to the city of Albert Lea is Lake Albert Lea. The lake, and later the city, were named in honor of a United States Army officer, Albert Miller Lea, who accompanied an expedition to the region in 1835 and mapped the lakes and streams. Much of the lake is shallow and it has been a favorite resting place for migratory water fowl and for this reason the lake and a surrounding area has been designated as a state game refuge.

A gravel pit near the south end of the lake exposes stratified sand and gravel with a great variety of pebbles. The pebbles have been brought from great distances by the ice sheet or glacier and were deposited here by waters which flowed out from the front of the glacier when it remained more or less stationary for a time. Such gravel hills are sometimes known as kames. (See page 20.) The surface of the region is undulating to hilly due to the irregular material left by the ice, forming what is technically known as a terminal moraine.[2] (See page 20.) This moraine is not as characteristic as some found farther north in Minnesota but to the practiced eye it presents the same features on a smaller scale. The road follows the lake shore to the city and the attractiveness of the country is greatly increased by the trees along the shore, which are mostly oak interspersed with aspen, elm, ash, and maple.

Albert Lea
Population 8256
Elevation 1225 feet

Albert Lea is a thriving city beautifully situated on a strip of land between Fountain Lake and Lake Albert Lea. It is served by the Illinois Central; Rock Island; Chicago, Milwaukee and St. Paul; and Minneapolis and St. Louis railways. State highways Nos. 1, 9, and 13 radiate from the city. Albert Lea was first settled in 1855 and was incorporated in 1878. There are 51 manufacturing and wholesale industries in the city, of which the Wilson and Company packing plant is the largest. Fountain Lake on the north is partly surrounded by the city, and a boulevard has been constructed around it. A tourist park is located on the lake shore and is provided with many conveniences. The rolling nature of the surface especially to the west of the city is notable and is formed by the terminal moraine which trends north and south through that area. The city is mainly located on an area of outwash which lies between the moraines to the east and west of town. The moraines have formed the lakes by filling up the old drainage channels. (See page 21.)

For ten miles north of Albert Lea a rolling or undulating topography represents the northward extension of the moraines found at the city. Oak groves occupy many of the knobs and rougher portions, but most of the land is under cultivation.

[2] For definitions and explanations of geologic terms see Glossary at end of book.

Clark's Grove, a railroad station nine miles north of Albert Lea, is named from a grove a mile east of the village in which J. Mead Clark settled in the early days. After passing Clark's Grove, Geneva Lake may be seen occupying the lowland to the east. To the west of the road the surface is undulating like that found farther south. Geneva Lake is about four miles long and one to one and one-half miles wide, but is comparatively shallow. At the end of the Glacial period it was undoubtedly much larger and extended over the marsh land to the south, and was probably connected with what was formerly Rice Lake. This lake and the surrounding marsh land has been drained leaving fertile soil which has been rapidly put under cultivation by a group of settlers from Holland. Truck farming particularly is successful.

Clark's Grove
Population 97
Elevation 1400 feet

To the north of Geneva the country is nearly level. It undoubtedly was prairie when the settlers entered it. The county line between Freeborn and Steele counties is one and one-half miles north of Geneva.

Geneva
Population 207
Elevation 1383 feet

It should be noted that no exposures of solid rock are seen in passing through Freeborn County and none has ever been found, as the glacial drift covers the rock to a considerable depth. From data in surrounding regions it is believed that Devonian (see table of formations and descriptions in Chapter II), and Ordovician rocks underlie much of the county, but Cretaceous rocks probably cover part of the older rocks beneath the drift. The glacial drift consists of three types of deposits: terminal moraines, which form the rougher portions; ground moraines, which are more widespread and form level plains or gently undulating areas; and outwash sand and gravel deposits, which are found along the streams and in the vicinity of Lake Albert Lea.

Steele County

(Total area 430.59 square miles; covered by water 4.6 square miles)

Steele County was established in 1855 and received its name in honor of Franklin Steele, a prominent pioneer of Minneapolis.

The level prairie of Freeborn County extends to the marshy land three miles north of Steele County line. North of the marsh the country is gently rolling and a few of the knolls have oak groves. This gently undulating country extends to Owatonna, the county seat.

The Straight River.—The valley of the Straight River is just to the west of Highway No. 1, south of Owatonna. Several creeks unite in the southern part of the county to form the river which flows northward through Owatonna. The river is said to have received its name by translation of the Sioux word for straight, which is Owatonna. It is supposed that the name was given in derision as the river is very crooked. The

stream is very sluggish and the valley is much larger than the present stream requires. (See page 21 for explanation.) The trees along the valley are worthy of particular note; instead of the scrub oaks which predominate farther south, one sees large elms, basswood, and oaks.

Owatonna is a thriving city and a commercial center for the surrounding country. It is served by the Rock Island; Chicago, Milwaukee and St. Paul; and Chicago and Northwestern railways. Pillsbury Academy, a boys' school, occupies several large buildings on the east side of the city. A fine high school is located just north of the academy, and the State School for Indigent Children is on the west edge of town. An attractive tourist park is provided at Mineral Springs Park on Maple Creek about one mile northeast of the business center of town.

Owatonna
Population 7252
Elevation 1145 feet

Mineral Springs Park.—Mineral springs are found in the valley at the base of a clay bluff. They probably are due to a clay seam overlying a sand or gravel bed. The water from the surrounding country flows in the gravel below the clay, and parallel to the surface, until it escapes at the low points along the creek. A deposit of iron may be noted in the ponds around the springs and the water has a slight mineral taste, but is excellent for drinking purposes. Several huge boulders of granite occur along the creek at the springs, having been left there by the glacier although they perhaps owe their exposure to erosion of the surrounding material by the creek. The boulders were probably brought down from the northern part of the state where granite is known to outcrop.

Leaving Owatonna the highway turns west and crosses the river, thence angling northwest to reach the more level country to the west of the valley. The main slopes of the valley extend about one-half mile on each side of the stream and are about fifty feet below the level of the surrounding country. Aside from the valley the surface is gently undulating and shows no unusual features.

Galena limestone.—About two miles north of Owatonna an east-west road crosses the river and at the bridge are the southernmost outcrops of solid rock seen near the route. (See Chapter II.) The rock has been quarried on both sides of the road thus giving excellent exposures. The rock is a thin-bedded, slabby limestone of Ordovician age and is a part of the Galena formation (see page 10), as is known from the fossils found in certain layers. (See Plate I.) The fossils are the remains of various types of shell-bearing animals which live only in salt water, thus showing that a very long time ago the ocean covered this area.

Continuing northward on the west side of the river one is afforded another opportunity for contrasting the topography and wooded slopes of the valley with the gently undulating surface of the prairie to the west.

Clinton Falls
Population 82

At Clinton Falls a dam furnishes water power for a small mill. Just beyond the village is a fine exposure of stratified sand and gravel where the road has been cut through the hill. Beyond this the road crosses to the east side of the river and then crosses back to the west side at Medford.

A large gravel plant to the east of the road north of Medford obtains gravel from the glacial outwash deposits along the river.

Medford
Population 346
Elevation 1101 feet

The north line of Steele County is about two miles north of Medford.

One exposure of solid rock has been noted in the county and this is the only one known. A deep well at Owatonna passed through 35 feet of glacial drift, 59 feet of sandstone and clay, probably of Cretaceous age (see table of formations, page 10), then the various formations of the Ordovician, beginning with the Galena limestone and ending in the St. Peter sandstone. Most of the county is undoubtedly underlain by Cretaceous and Ordovician rocks. Like Freeborn County, this county is almost completely covered by glacial deposits consisting of irregular north-south belts of terminal and ground moraine with outwash deposits along the valley of the Straight River.

Rice County

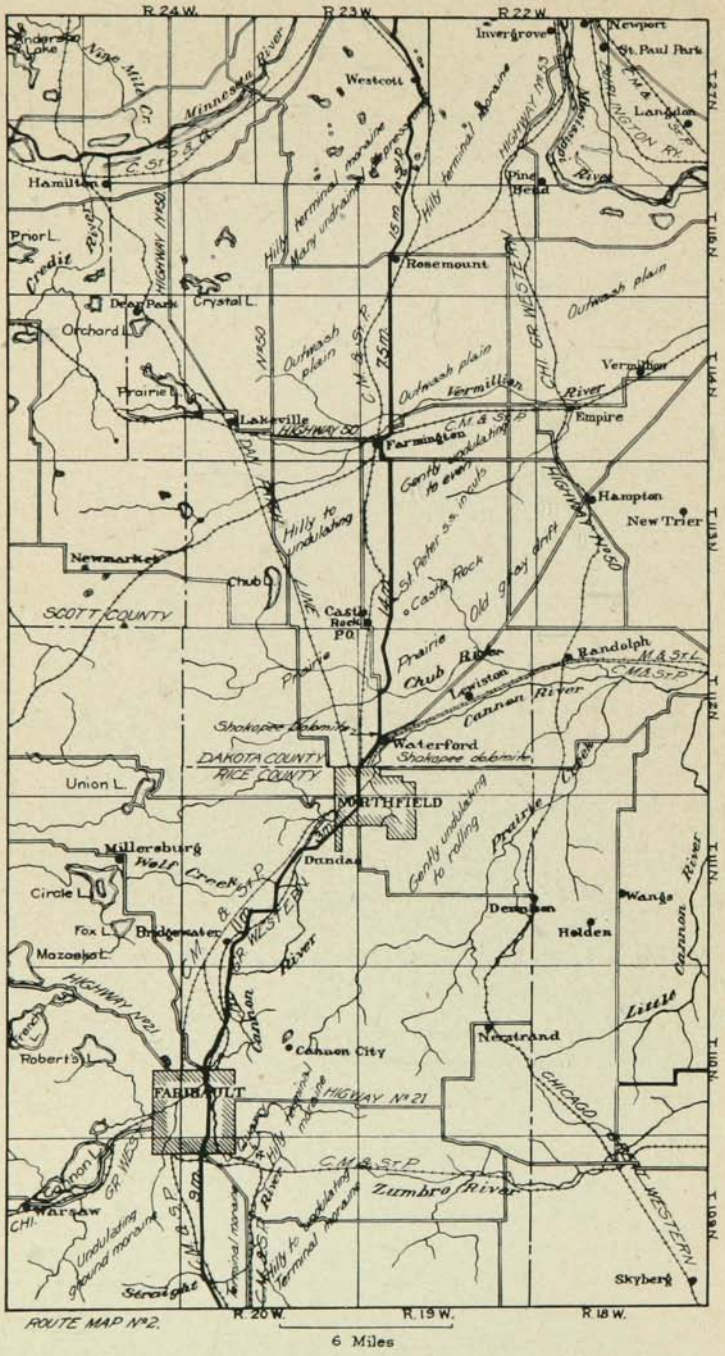
(Total area 504 square miles; covered by water 17.2 square miles)

Rice County was first settled in 1853 and was named in honor of Henry Mower Rice, one of the first United States senators from Minnesota. This county shows more relief than the two counties to the south.

Highway No. 1 has been changed recently to the west side of the Chicago, Milwaukee and St. Paul Railway for about two miles, thence following a course due north to Faribault. The road gradually leaves the valley of the Straight River and follows the rolling land to the west. From the hill tops a good view of Faribault and the high country to the east may be had.

The city of Faribault lies in the valley at the junction of the Cannon and Straight rivers. The depth of the valley here as compared with that at Owatonna is noteworthy. Much of the city is built on a terrace of alluvial material deposited by the Straight River at a higher stage, but part of the city lies on the bluffs on either side of the valley. Those on the east side rise fully two hundred feet above the level of the river. Faribault is the county seat. It was named in honor of Alexander Faribault, eldest son of Jean Baptiste Faribault, an early trader in Minnesota. Alexander came to the Cannon River country to trade with the Indians in 1826 and persuaded a band of Sioux to move to the site of the city in 1834.

Faribault
Population 11,089
Elevation 1003 feet



HIGHWAY NO. 1 THROUGH RICE AND DAKOTA COUNTIES. THE HIGHWAY IS INDICATED BY A HEAVY BLACK LINE

The city is the site of many schools, including Shattuck Military Academy, St. Mary's School, and Seabury Divinity School, all established by Bishop Whipple, an early Episcopal missionary in the region. The above schools, together with the state schools for the deaf, blind, and feeble-minded, are located along the east bluff of the river. The city is served by the Rock Island; Chicago, Milwaukee and St. Paul; and Great Western railways, and is a manufacturing center. Within a distance of from three to ten miles west of the city is a group of ten lakes with many resorts. A special folder issued by the Faribault Chamber of Commerce may be obtained describing the points of interest in and near the city.

Geology at Faribault.—Here one sees the first topography in which glacial deposits fail to mask the underlying rocks. Along the east side of the Straight River a prominent bluff exposes many outcrops of the St. Peter sandstone, a white, sugary, pure quartz rock. This may be seen best at the Third Avenue bridge near the post-office. (See Plate III-A.) About eighty feet of this rock is exposed. Above, but less well exposed, are the Decorah shale and the Platteville limestone. The Platteville limestone is quarried about two miles southwest of town. The pronounced valley of the region is a result of the resistance to erosion of the solid rock, which forced the river to work in a comparatively narrow trench. Exposures on the west side of the valley are limited because of a lack of recent erosion on that side. However, at the tourist camp on the bluff at the southwest edge of town an old quarry exposes the Platteville limestone and the St. Peter sandstone.

A drive through the school grounds and out Highway No. 21 (see Route Map No. 2) shows that the schools are not on the highest part of the valley side, but are on a comparatively level area, or terrace along the river. This terrace was probably formed by erosion along the top of the resistant Platteville limestone. The area to the east is notably hilly, due to strong terminal moraine deposits crossing the region from north to south. From a point on this high land one overlooks the valleys of the Straight and Cannon rivers and the insignificance of the present streams as compared with the size of the valleys is evident.
This is a common feature of glaciated regions, a result of the large amounts of water derived from the melting ice of the glaciers.

Highway No. 1 passes over the Cannon River near the north edge of town, where a dam furnishes power for woolen mills. Continuing northward, outcrops of sandstone may be seen along the east bluff of the river and also at the roadside at a corner a mile north of the bridge. Beyond this the road turns north again and leaves the valley, and passes over undulating moraine country. High gravel ridges and knobs are characteristic, but the St. Peter sandstone is exposed in the road cuts. A big bend

in the river brings it back to the road a few miles north and there the valley is wide and shallow. Six miles north of Faribault the road turns east and at Bridgewater crosses a long ridge which consists of stratified gravel as shown in the road cut. This is known as the Bridgewater esker (see page 20), a more or less continuous ridge extending nearly five miles north and south. The ridge rises at places to a height of seventy-five feet but is not very regular. The rounded pebbles of the gravel show that it was deposited by water probably in a channel beneath the ice. As the ice retreated the gravel, washed more or less free from silt, was left to mark the old channel. The Cannon River has since cut through the ridge.

The valley of the Cannon River is followed north to Dundas, where the road crosses to the east side of the river. It follows the east side to Northfield.

Northfield was platted in 1855 and is said to have been named for two of the founders, John W. North and Ira Stratton Field. The town is known as the "College City" from the fact that two large colleges are located in the city. These are on opposite sides of the river, Carleton on the east side and St. Olaf on the west. The town is served by four railways.

Northfield
Population 5544
Elevation 910 feet

A few rock exposures are found in the valley, and foundations for buildings at the college of St. Olaf are in limestone and sandstone of the Platteville and St. Peter formations. The Shakopee dolomite which lies below the St. Peter is exposed on the edge of the Carleton football field.

Highway No. 1 crosses the river in Northfield and follows the valley to a point a mile north of the city where the river turns sharply east near the Dakota county line.

The geology of Rice County may be summarized as follows: The numerous exposures of bedrock along the valleys of the Straight and Cannon rivers which have been noted in the descriptions of the route, represent five formations of the Ordovician, beginning with the Shakopee dolomite as the lowest and including the St. Peter sandstone, Platteville limestone, Decorah shale, and Galena limestone. The Shakopee dolomite is found in the northern part of the county and the others more or less in order from north to south.

The glacial drift of the western part of the county consists largely of terminal moraine. East of the Straight and Cannon rivers is a belt of old gray drift (see page 19) which consists principally of clay and is a deposit of a glacier which preceded the one which covered most of the area seen thus far. Small areas of outwash along the rivers complete the list of deposits.

Dakota County

(Total area 611.3 square miles; covered by water 5.45 square miles)

Dakota County was established in October, 1849, and was named for the Dakota Indians, a group of tribes originally occupying much of Minnesota and adjoining states.

Highway No. 1 enters the county along the valley of the Cannon River which turns eastward just north of the county line and flows to the Mississippi. Where the road leaves the river the Shakopee dolomite outcrops in the road cut. To the north the country is nearly level and was originally prairie. At Castle Rock station, which is a short distance west of the highway, the land is higher and it continues to rise to the north. The road cuts expose St. Peter sandstone and about one-half mile east of the road glimpses may be had of the remains of Castle Rock.

Castle Rock.—This is an isolated shaft of St. Peter sandstone left by the erosion or wearing away of the surrounding material. It was originally forty-five feet high and was an Indian landmark for untold centuries. Nicollet and other early explorers mention it in their writings. The upper part has now fallen, due to the action of the weather, so it is no longer such a prominent feature of the landscape.

It is noticeable at once in passing through the higher country north of Castle Rock that the trees are more numerous and some areas have not been cleared. The soil is somewhat sandy due to the inclusion of considerable amounts of the sandstone in the glacial drift.

Near Farmington the country is somewhat lower and very level. This area is an extensive prairie formed by outwash material which extends east to the Mississippi River and has a width at places of twelve miles. The outwash lies to the south of a pronounced terminal moraine and it was probably derived from the ice front at that location. (See Chapter II.)

Farmington is a railway junction point and a distributing center for the fine farming country surrounding it. State Highway No. 50 branches off from No. 1 here and furnishes a shorter route to Minneapolis than No. 1, which passes through St. Paul.

Farmington
Population 1449
Elevation 900 feet

Beyond Farmington and continuing to Rosemount, is the level outwash area noted above. Just north of Rosemount the country becomes very hilly and there are many sharp knobs and undrained depressions. These are the typical features of a well-developed terminal moraine and represent a long continued heaping up of débris by the melting ice. The moraine continues to the Mississippi River. This area was originally timbered and some of the hilly portions remain uncleared. Oaks are the prevailing trees, but poplar, birch, and others also are found. There are many small lakes occupying the depressions formed by the drift blocking the drainage channels, a typical feature of glaciated

country. About two miles north of Westcott a new road has been constructed to cross the Minnesota River at Mendota and Fort Snelling and to enter Minneapolis on the west side of the Mississippi. From the high points along the road beyond Westcott the cathedral dome in St. Paul may be seen directly ahead.

It has been noted that the St. Peter sandstone outcrops along the highway in Dakota County, but these exposures are small and give little idea of the nature of the rock. Along the Minnesota and Mississippi River gorges there are excellent outcrops not only of this formation but in addition of the Jordan sandstone, Oneota dolomite, Shakopee dolomite, which are stratigraphically below it, and the Platteville limestone, Decorah shale, and Galena limestone above. Detailed discussions of these formations may be found in the various publications of the Minnesota Geological Survey.

The cover of glacial drift which is found over much of Dakota County is rather variable. The southern portion near Castle Rock is composed of old gray drift which has been previously mentioned in the description of Rice County (page 30). The large area of outwash material in the region around Farmington and extending eastward to the Mississippi River has been noted. North of Rosemount and extending the entire width of the county from east to west is a well-developed terminal moraine. In the western part of the county are small areas of ground moraine, terminal moraine, and old gray drift. In general the relief of the surface is pronounced especially in the region near the rivers.

CHAPTER IV

THE TWIN CITY REGION[1]

The cities of St. Paul and Minneapolis are located in Ramsey and Hennepin counties, respectively.

Ramsey County

(Total area 187.15 square miles; covered by water 13.45 square miles)

Ramsey County, with the exception of a part of the city of St. Paul, lies on the east side of the Mississippi River and below the mouth of the Minnesota. It is the smallest county in the state, but embraces St. Paul, the capital. The county was established October 27, 1849, and was named in honor of Alexander Ramsey, the first governor of Minnesota Territory. The county was one of the nine original counties and contained a much larger area, but in 1857 it was reduced to its present size.

Hennepin County

(Total area 605.8 square miles; covered by water 13.45 square miles)

Hennepin County lies north of the Minnesota River and west of the Mississippi River, excepting a small area at St. Anthony falls which lies east of the Mississippi. The county was named for Louis Hennepin, the Franciscan missionary and explorer, who, with Pickard du Gay, first visited the region in 1678.

The traveler following Highway No. 1 northward from the southern part of Minnesota may enter the Twin Cities, as Minneapolis and St. Paul are known, by any one of three routes. Highway No. 1 may be followed practically due north to St. Paul, part of which lies south of the Mississippi River. The main part of the city is reached by passing over the "High Bridge." If Minneapolis is the destination it may be reached from St. Paul by several streets connecting the two cities, or by following Highway No. 50 west and north from Farmington and entering the city on Lyndale Avenue. An alternative is provided by the new cut-off just north of Westcott. This route enters Minneapolis over a new bridge across the Minnesota River from Mendota to Fort Snelling, and takes the traveler directly past the large tourist camp at Minnehaha Park.

The Twin Cities form one of the most important metropolitan centers in the West. The United States Census Bureau on July 1, 1924, estimated the population of Minneapolis to be 417,280 and that of St. Paul to be 243,946. The main business sections of the cities are about ten miles apart, but the area between is built up along the principal connecting streets. Both cities provide information bureaus and camp grounds for tourists and everything practicable is done to help the traveler.

[1] Map No. 3 shows the region on a scale 3/8-inch to the mile.

St. Paul was located at the head of navigation on the Mississippi River and it was there that the cargoes were broken up and distributed. Thus the city received its first impetus. Minneapolis grew up around the power sites at the Falls of St. Anthony.

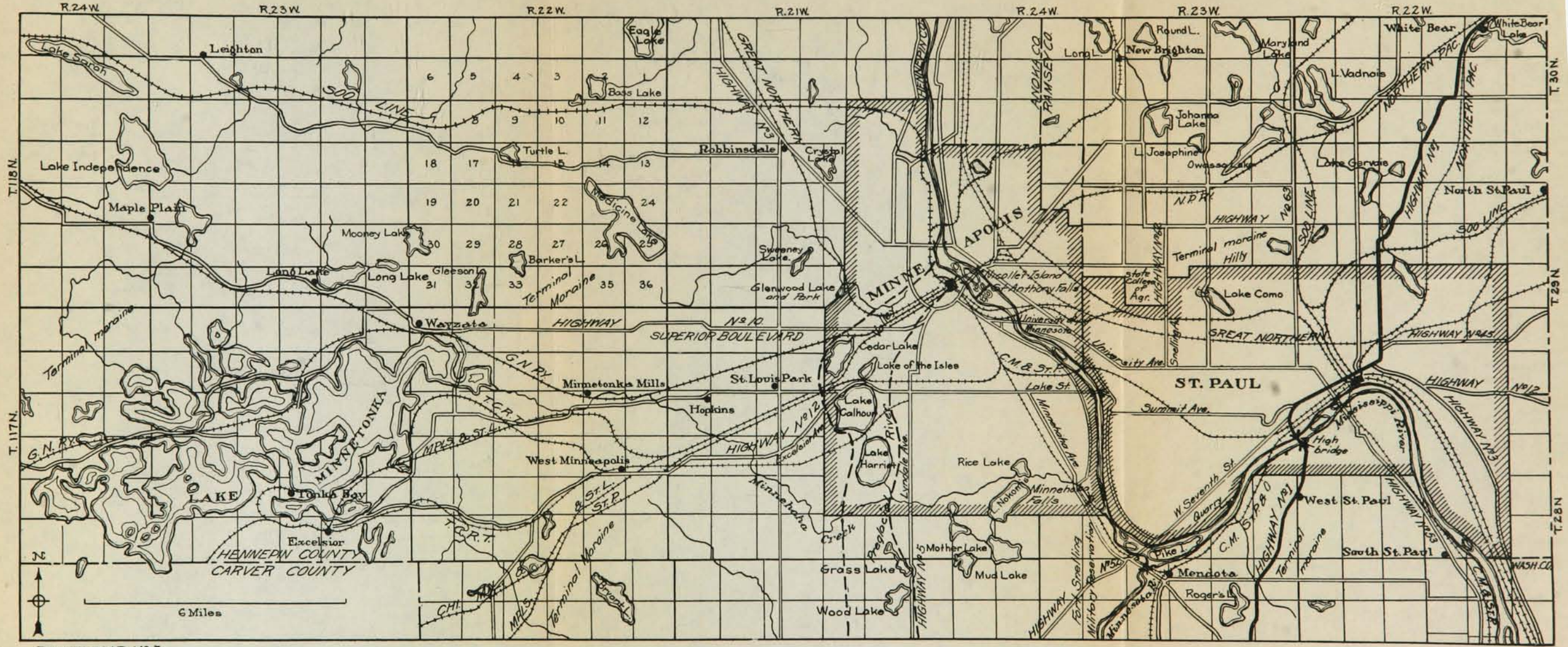
St. Paul

St. Paul is one of the oldest settlements in the state and was made the capital of the territory when it was first organized. The site was first settled by Pierre Parrant in 1838, and the name was taken from the little Catholic chapel built in 1841 under the direction of Father Lucian Galtier. St. Paul soon became the largest settlement in the state, but its population was eventually exceeded by that of Minneapolis. The settlement was organized as a village November 1, 1849, and as a city March 4, 1854. The area within the city limits has grown by repeated additions to 55.44 square miles, all situated within Ramsey County. The city is partly bounded on the south and west by the Mississippi River which makes a big S-shaped curve in this area. An excellent boulevard drive follows the river above Fort Snelling.

In addition to being the capital of the state, St. Paul is an important railway center with ten systems radiating from it, and the city is an important manufacturing center for a great many products. Wholesale houses are important supply centers for the Northwest. Visitors' guides with information as to places of interest are distributed by the St. Paul Association. Places worthy of a visit include: the State Capitol, Central School of Agriculture and University Farm, Hamline University, Macalester College, St. Thomas College and St. Paul's Seminary, the Ford plant and government dam, fish hatchery, River Boulevard and Summit Avenue, the fine residence street, and Mounds Park. One of the most interesting places in St. Paul is the Minnesota Historical Building on the capitol grounds. The museum in this building contains a great many interesting educational exhibits. A large library is also maintained.

Minneapolis

The first settlement within the area of the present city was established in 1849 near the Falls of St. Anthony on the Mississippi. A village named St. Anthony was platted on the east side of the river. The first house on the west bank was built by Colonel John H. Stevens in 1849. Upham in his book on *Minnesota Geographic Names*, gives the following notes on the origin of the name. "The earliest announcement and recommendation of this name was made by Charles Hoag to the editor of the *St. Anthony Express*, George D. Bowman, on the day of publication, November 5, 1852." "Soon this new name, compounded from Minnehaha and the Greek 'polis' for city, displaced the earlier names." The city was



ROUTE MAP No 3

incorporated March 2, 1866. At present it covers 53.29 square miles and includes six large natural lakes within its limits. The Mississippi River flows diagonally through the city from northwest to southeast and this channel, together with the system of lakes, makes the site one of great natural beauty. Minneapolis leads the world in the flour milling industry, with mills having a daily capacity of 95,300 barrels. It is a manufacturing and wholesaling center with an annual output of over $1,000,000,000. The Civic and Commerce Association maintains a tourist bureau which supplies information regarding the city. Points of interest include the milling district, the larger of 127 parks, Victory Memorial Drive, river boulevards, University of Minnesota, Minnehaha Falls, the six lakes, Fort Snelling, and Lake Minnetonka, the summer residence center west of the city.

Fort Snelling[2]

In July, 1805, First Lieutenant Zebulon M. Pike of the United States Army, was sent up the Mississippi River from St. Louis to explore the region to the north and to gather data regarding the Indians and in addition to obtain land for military and trading posts. On September 22, 1805, he arranged a treaty with a party of Sioux warriors granting to the United States, for the establishment of a military post, an area of land nine miles wide on each side of the river, and extending from the mouth of the St. Peter's, as the Minnesota River was then called, up to the Falls of St. Anthony.

It was not until 1819 that the first troops were sent to the site. In that year Lieutenant Colonel Henry Leavenworth was sent out in command of an expedition from Detroit, Michigan, with orders to establish a military post at the mouth of the St. Peter's River. The place was reached on August 24, and a temporary camp was constructed near the present site of Mendota. Early in 1820 Colonel Leavenworth began the construction of a fort near the present site between the Mississippi and the Minnesota and across the Minnesota from the original camp. The summer camp was known as Camp Coldwater and was located near a cold spring on the west bank of the Mississippi and some distance north of the present site. In August Colonel Josiah Snelling relieved Colonel Leavenworth of command and he remained for seven years. Colonel Snelling changed the site to its present position and began the construction of a fort with vigor. Major General Winfield Scott visited the fort in 1824 and was so impressed by the colonel's efficiency that he recommended that the name be changed from Fort St. Anthony to Fort Snelling. For many years the fort was the principal point above Prairie du Chien. The reservation as

[2] For a detailed account of the establishment of the fort, see Folwell, W. W., A history of Minnesota, vol. 1.

first outlined included much of the area now covered by the cities of Minneapolis and St. Paul. It was much reduced in 1852 and again in 1871. It was the main mustering point for the Minnesota regiments in the Civil War and headquarters for the operations incident to the Sioux outbreak of 1862. During the World War it was the location of a large officers' training camp. It is now occupied by a considerable body of the regular army troops, and each summer a number of men are trained there for the organized reserves.

GEOLOGY AND PHYSIOGRAPHY ALONG THE MISSISSIPPI RIVER IN THE TWIN CITIES

The most interesting geological features of the Twin City region are exposed along the Mississippi River from St. Paul up through Minneapolis. If but a limited time is available a trip by auto up one side of the river and down the other will cover more points of interest than any other that might be outlined.

The Mississippi River is first seen by the traveler entering the area from the south on Highway No. 1 at the "High Bridge" in St. Paul. This is an excellent place from which to view the gorge and much of the city as well. The gorge is over 200 feet deep and a half mile wide. The bridge is much higher at the south than at the north end, due to a broad rock terrace on the south side about 80 feet above the river. This terrace extends back from one-half to one mile and is marked by a line of bluffs which rise fully 100 feet to the general level of the country. A striking feature which may be observed from the bridge is the narrowness of the present stream as compared with its gorge. This, as has been explained in Chapter II, is a result of the large stream which flowed in the valley when the ice front retreated to the northern part of the state. The gorge is partly cut through beds of solid rock. The St. Peter sandstone forms prominent white cliffs just above the water level and below the terrace described above. On the south side of the river below the bridge many caves excavated in the soft, sugary sandstone are used for mushroom culture. The south bluff being much higher naturally exposes more rock.

The Twin City Brick Company's plant about one-half mile above the bridge on the south side of the gorge utilizes parts of the Decorah shale for brick-making. The quarry exposes the St. Peter sandstone, Platteville limestone, Decorah shale, and the Glacial drift. (See page 10.) The shale pits of this plant expose many fine fossils of Ordovician age. (See Plate I.) This is perhaps the best place in the cities to see and collect these remains. Some rocks are literally filled with fossil shells.

To follow the river up to Minneapolis the markings on Highway No. 52 on West Seventh Street serve as a guide as far as Fort Snelling. This

street is crossed by Highway No. 1 two blocks from the bridge. For some distance the route remains within the built-up portion of St. Paul. A broad strip of level land forms the terrace noted above and this is bounded on the north by a bluff. The width of the terrace varies from a half mile at the bridge to nearly a mile at the edge of the city and then narrows to less than a quarter of a mile just east of Fort Snelling. Above the fort the terrace is less marked, although at places it is a block or two wide, as near the Shriners' Hospital in Minneapolis. Not only are the terraces less marked above the junction of the Minnesota and Mississippi rivers at Fort Snelling, but it is noteworthy that the Minnesota occupies a broad valley. At some places it is nearly two miles wide, and it is much wider than the gorge of the Mississippi. In general a large stream occupies a larger valley than a small stream, but the opposite is true at this point. The explanation of the large valley occupied by the Minnesota may be seen on Figure 3 which shows that during the Glacial period the valley of the Minnesota was occupied by the glacial river Warren which had its source in the glacial Lake Agassiz, and doubtless a very large amount of water flowed down this outlet. (See page 21.) The narrow gorge of the Mississippi River above Fort Snelling has been formed since the ice melted by the retreat of St. Anthony Falls from the fort up to their present location.

As the traveler continues out West Seventh Street the area that has been built up is passed and a better view of the river valley to the left may be had. Shiely's quarry is located near the river a short distance from the last houses. Across the river from this point rocks may be seen outcropping more or less continuously and showing distinct layers, the St. Peter sandstone at the base, overlain by the Platteville limestone. A thin shale bed between these formations is eroded back, leaving the limestone overhanging to some extent. Excavations show that the Platteville limestone also underlies the terrace on the north side of the river, and doubtless the limestone is in part responsible for the existence of the terrace. When the river had cut down to the limestone it encountered a pavement-like floor with the result that the waters tended to cut from side to side into the soft Decorah shale rather than vertically in the resistant limestone. The Platteville limestone, however, was eroded at its lower edge downstream and the underlying soft sandstone being easily cut away, a cataract was formed which gradually migrated up past the site of St. Paul leaving a deep gorge which has since been partly filled, resulting in present conditions. Wherever the Platteville limestone is well exposed, fossil remains may usually be seen, often in abundance. This is particularly true of the upper layers. (See Plate I for illustrations of these remains.) The St. Peter sandstone is lacking in fossils throughout most of its extent, but the few remains found in it have come from the

Twin City region, particularly in those exposures along the river near South St. Paul.

At Fort Snelling a bridge crosses the Mississippi and affords an excellent view. The Minnesota River empties into the Mississippi a short distance below the bridge. At the bridge the Mississippi abruptly changes its course from a southeast direction to northeast. Pike Island is located in the Minnesota at its mouth and across is Mendota, the earliest settlement in the region. Here the Sibley house, the first stone structure in Minnesota, is preserved as a museum.

From the fort the traveler will find it convenient to continue up the east side of the Mississippi gorge. A short distance up stream from the fort, on the St. Paul side of the river, the Ford plant occupies a large area and utilizes the power from the government dam across the Mississippi at that point. Outcrops of St. Peter sandstone and of the Platteville limestone may be seen at many places along the gorge and a considerable amount of limestone was quarried out just above the dam for its construction.

Upstream on the St. Paul side, St. Paul's Seminary is situated on the river bank and still farther up is the Lake Street bridge, one of the main connecting links between the cities. Another bridge is being constructed at the Ford plant. A short distance north of the Lake Street bridge is the line between the two cities. The Chicago, Milwaukee and St. Paul Railway bridge crosses the river just beyond the boundary line. The Shriners' Hospital for Crippled Children is located on the river bank at this point. The Franklin Avenue, or Cappelen Memorial bridge, is a short distance farther upstream. This bridge is constructed entirely of reinforced concrete and has the longest concrete arch in the world. Still farther upstream the University of Minnesota occupies a large tract on the east bank from a point just below St. Anthony Falls downstream. From the campus a fine view may be had across to the power plants and flour mills grouped around the dams at the falls.

St. Anthony Falls were named by Father Hennepin, a member of the first white party to ascend the Mississippi to their location. At that time the falls afforded a splendid sight, but the water has now been directed to power purposes and dams hold back the water from the natural fall.[3] There are, however, interesting physiographic and geologic problems connected with these falls. (See Sardeson, F. W., *U. S. Geol. Survey Folio*, No. 201.) It is known from the writings of Hennepin that the falls in 1680 were located just above the site of the Tenth Avenue bridge, and later explorers locate them at various other points. The falls are formed

[3] For several excellent views as well as maps and an extended discussion of the falls, see Winchell, N. H., Final report on the geology of Minnesota, vol. 4.

by the river plunging over the nearly horizontal Platteville limestone and undercutting the soft St. Peter sandstone beneath. This process was started when the Mississippi sought a new channel following the retreat of the ice sheet. The falls long ago were situated at the junction of the Mississippi River with the Minnesota River below Fort Snelling and gradually worked back to their present location, leaving the conspicuous gorge noted above. Had the process continued but a short time longer, the falls would have ceased to exist. The reason for this is shown in Figure 5.

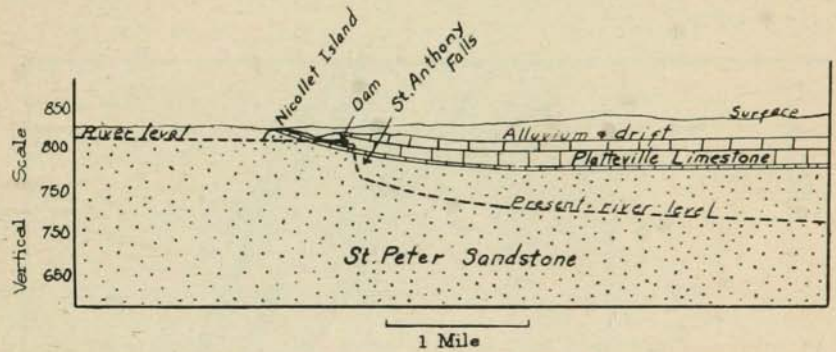


FIGURE 5. CROSS SECTION ALONG THE MISSISSIPPI RIVER NEAR ST. ANTHONY FALLS. SHOWS THE DIP OF THE PLATTEVILLE LIMESTONE WHICH BRINGS IT ABOVE THE RIVER LEVEL AT THE WEST END OF NICOLLET ISLAND. AFTER WINCHELL, SARDESON, AND OTHERS

It has been explained that the falls were formed by the river undercutting the Platteville limestone. The limestone in the region of the present falls has a slight dip to the southeast so that on the upper end of Nicollet Island just upstream the limestone is above the river level, and if the falls had reached that point there would have been no resistant bed to maintain the cliff and the falls would have degenerated into rapids. The power companies have taken proper means to stop the migration, thus maintaining present conditions indefinitely.

The river may be crossed at either Washington Avenue or Franklin Avenue and the West River Boulevard followed southward to Minnehaha Park. At the north side of the park the road swings sharply to the west and crosses an abandoned channel of the Mississippi just above an abandoned falls. The Mississippi occupied this channel as well as the main channel to the east, following the last retreat of the glacier. The present location of the tourist park and Soldiers Home was then an island (see Figure 6), but erosion was more rapid in the main (east) channel and the falls there receded more rapidly for that reason; eventually the falls passed the point where the channel divided and then all of the water

followed the lower gorge, and the west channel was drained, leaving the falls of Deer Park dry.

Minnehaha Falls are located in the park where Minnehaha Creek plunges over the Platteville limestone into a gorge cut principally in the St. Peter sandstone. It is the undercutting of the soft sandstone that causes the limestone to break off with a vertical face, thus maintaining the falls. The distance from the broad abandoned channel of the Mississippi up the narrow gorge of the creek represents the distance Minnehaha Falls have receded since the falls of the Mississippi passed the mouth of the creek gorge.[4]

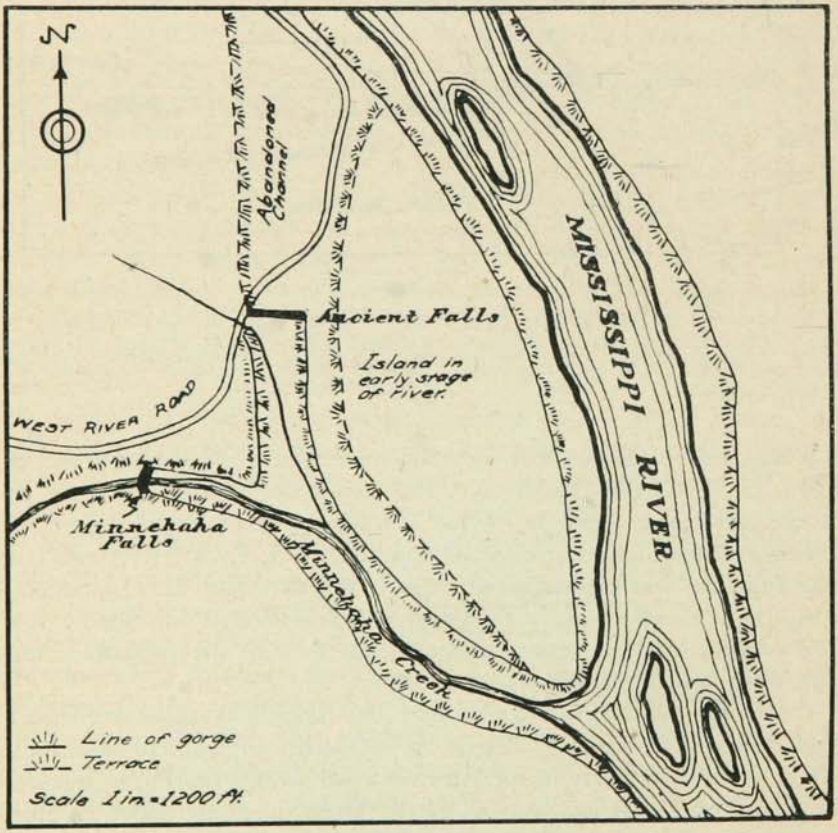


FIGURE 6. SKETCH MAP SHOWING THE RELATION OF MINNEHAHA FALLS TO THE PRESENT MISSISSIPPI RIVER AND AN ABANDONED CHANNEL AND FALLS OF AN EARLIER STAGE OF THE MISSISSIPPI. AFTER GRANT

[4] For a more detailed discussion see Grant, U. S., American Geologist, vol. 6, p. 182.

Minnehaha Falls are widely known because the region around them was utilized by Longfellow as a setting for the poem *Hiawatha*. During the wet season they present a beautiful sight but they dwindle to almost nothing in dry seasons. The Minneapolis Park Board is taking steps to provide a contsant flow of water to preserve their beauty.

Preglacial river valleys of Minneapolis.—It has been noted that the Mississippi River gorge above Fort Snelling is relatively narrow and deep and has a youthful appearance as compared with the river below the mouth of the Minnesota. (See pp. 37-39.) It was recognized by the early geologists who studied the region that the present course of the river was probably not its course previous to the advent of the glaciers. Furthermore there are physiographic evidences of an old river gorge in the area between the parade grounds and Lake of the Isles. Drilling and foundation work have shown that the rock surface was deeply buried along this region. Recognizing this Mr. E. K. Soper[5] compiled all available data and published a paper describing the location of these buried valleys. The following extracts from this paper convey some idea of the main valley:

> In preglacial time the region around Minneapolis was dissected by a large river (referred to tentatively as the preglacial Mississippi), and its tributaries which cut deep valleys into the rock. . . . . The ancient valleys became filled with glacial débris which was brought down by the ice and left behind as a thick mantle covering the entire region when the ice sheet receded to the north. Not only were the old valleys choked up with glacial drift, but the entire rock surface was buried. The depth of this drift has been determined at as many points in the city as possible, and has been found to vary from 0 to 250 feet.
>
> * * * * * * * * * *
>
> The present river follows the ancient course, which it has partially re-excavated from a point beyond the north city limits to the mouth of Basset's Creek in the north central part of the city. At this point the river leaves its preglacial channel, turns to the east and flows southeastward through a narrow gorge to Fort Snelling.
>
> * * * * * * * * * *
>
> The ancient river valley continued southward from the point where Basset's Creek now has its outlet and flowed in a broad valley with gradually sloping banks southward across the region now occupied by the chain of lakes which comprises Lake of the Isles, Lake Calhoun, and Lake Harriet. At Bryn Mawr Meadows a tributary stream joined the river from the northwest and its buried channel is now the course of Basset's Creek between Glenwood Lake and Bryn Mawr Meadows. Glenwood Lake also lies within this tributary valley.
>
> The preglacial river flowed almost due south from Lake Harriet, but no attempt has been made to outline its exact course beyond the city limits. [See Route Map No. 3.] In a general way this course can be traced for about five miles south of Minneapolis through Grass Lake, Wood Lake, and numerous small lakes and ponds.

The location of these buried river channels is of great importance in connection with building operations. Small structures do not have sufficient weight to cause settling, but for large buildings the unconsolidated

[5] Soper, E. K., The buried rock surface and the glacial river valleys of Minneapolis and vicinity: Jour. Geol., vol. 23, pp. 444-60, 1915.

material is not safe and foundations are set on piling to prevent undue settling.

Glacial deposits.—With the exception of more or less extensive areas of outwash sand and gravel along the Mississippi and Minnesota rivers, almost the entire area in and near the Twin Cities and extending west to beyond Lake Minnetonka is covered by a deposit of terminal moraine which results in the pronounced hilly surface found throughout the region. Lake Minnetonka, and most of the other lakes of the area, are due to irregular heaping up of the rock débris by the glacier.

There are two main types of material in the moraines of this area and these are known to be a result of two invasions of the ice. The older, or red drift (see Chapter II), is found in St. Paul and Minneapolis, and the younger or gray drift, in the region around Lake Minnetonka and overlying the red at places in Minneapolis. At places where excavations have been made recently the two may be seen. This is the case at the Johnson Street quarry in Northeast Minneapolis, where the drift has been stripped off to expose the Platteville limestone for quarrying operations. The so-called Kansas drift is found in excavations at places beneath the younger drifts. It is normally a stiff blue clay with a few boulders in it. The surface of the Platteville limestone beneath the drift is often polished and scratched by the glacier, but as a rule this can be observed only when recent stripping has taken place. Specimens of the striated rocks are preserved in the Geological Museum of the University of Minnesota.

Rock products of the area.—The only geologic products of economic importance obtained from the region are crushed stone, sand, gravel, and brick clay and shale. Formerly several quarries were operated along the gorge of the Mississippi River, but fortunately the Park Board of Minneapolis gained control of the land along the river and stopped the work before the beauty of the gorge was destroyed. At present quarries are operated in the Platteville limestone at the Johnson Street quarry in northeast Minneapolis and at Shiely's quarry along the Mississippi at the west edge of St. Paul. This rock was used for many buildings in the early days, but the lower stone is not suitable and its use fell off, but recently the upper layer has been utilized. It offers a very attractive material It may be seen in the University Y.M.C.A. Building, and at least one new fraternity house on University Avenue.

Sand and gravel deposits are abundant in the glacial drift and large pits may be seen at several places in and near both cities. Sand, especially for molding purposes, is obtained from the St. Peter sandstone.

Bricks are made from the shales of the Decorah and Galena formations at the plant of the Twin City Brick Company just west of the south end of the High Bridge, in St. Paul. Several plants utilize interglacial silt and clay along the Mississippi in the northern part of Minneapolis.

CHAPTER V

HIGHWAY NO. 1 FROM THE TWIN CITIES TO DULUTH

Highway No. 1 leaves the city limits of St. Paul at Phalen Park. Continuing northward a number of ponds and swamps are passed which are located in depressions between morainic hills. Farther on the hilly nature of the surface becomes less pronounced and near the village of White Bear the country is practically level. The morainic belt trends northeastward and passes east of White Bear Lake while the road goes west of it.

White Bear Lake.—This lake is the favorite summer home region for St. Paul residents and is surrounded by villages, parks, and clubhouses. The lake is said to have been named from an old Indian legend that a white bear was killed by a brave on one of the islands and that its spirit still haunts the island and lake. The Indian name was Mahtomedi, which has been retained by one of the villages on the east shore.

The city of White Bear was settled in 1850 and incorporated as a city in 1921. It is noted as a summer resort.

White Bear
Population 2022
Elevation 941 feet

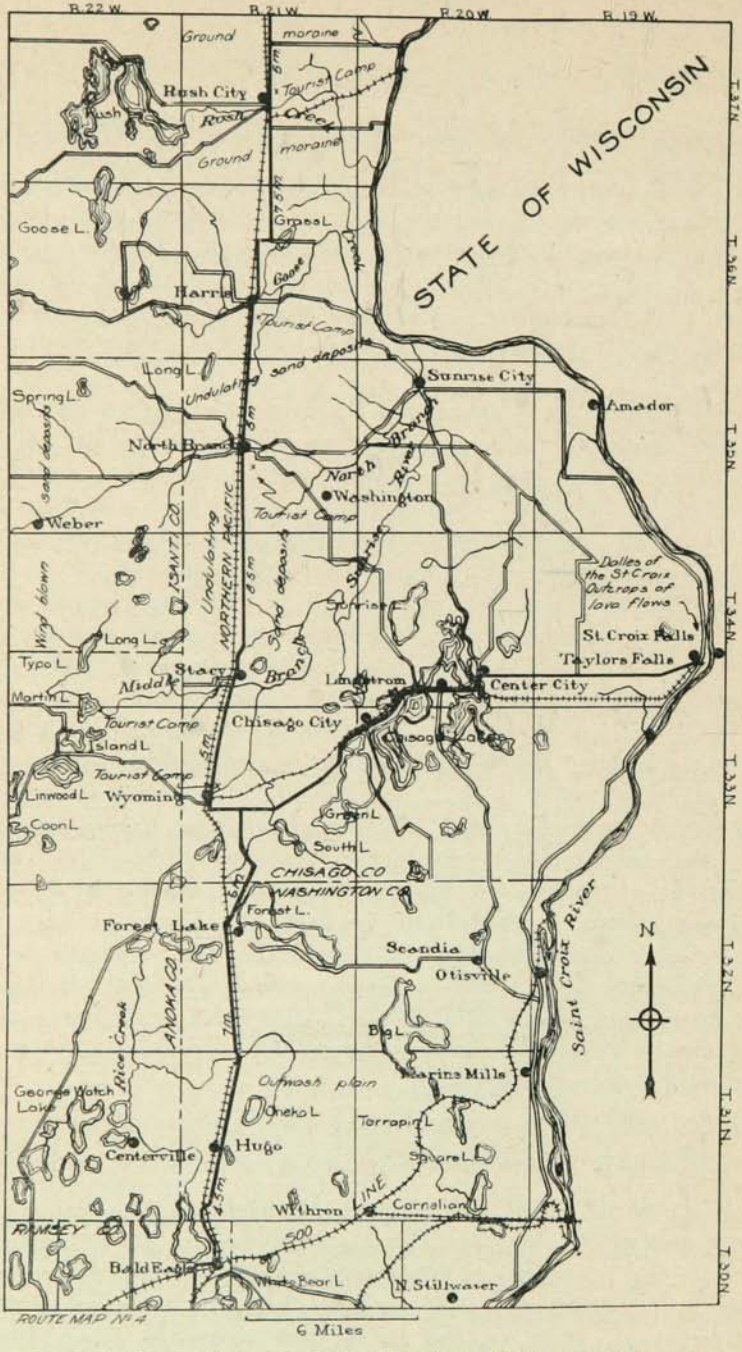
Bald Eagle Lake and the village of Bald Eagle are a short distance north of White Bear. The name was derived from a group of eagles which formerly inhabited one of the islands. Birch, Pine Tree, and Goose lakes are located near by. The soil in the region is sandy and the surface nearly level, most of the material being glacial outwash. West of Bald Eagle Lake is an extensive sand plain which crosses the highway farther north. This plain was formed by a deposit of wind blown sand over the glacial drift. This sand was probably derived from the glacial deposits before they became covered with vegetation. To the east of the road, near the north end of Bald Eagle Lake, is a small tamarack swamp. This is the farthest south that these trees may be seen along Highway No. 1, and it is the first indication of a change in the tree life which is encountered as one travels northward. (See Chapter IX.)

Washington County

(Total area 430.01 square miles; covered by water 21.14 square miles)

At the north end of Bald Eagle Lake the road passes into the northwest corner of Washington County. This was one of the nine original counties of Minnesota but is now much reduced in size, although it is 40 miles long and from 12 to 15 wide. It is bounded on the east by the St. Croix River, the boundary between Minnesota and Wisconsin. Continuing northward from Bald Eagle Lake the same type of level country extends

Hugo
Population 246
Elevation 938 feet



HIGHWAY NO. I FROM ST. PAUL THROUGH CHISAGO COUNTY. THE HIGHWAY AND THE SIDE TRIP TO TAYLORS FALLS ARE INDICATED BY HEAVY BLACK LINES

beyond Hugo, a station on the Northern Pacific Railroad. The topography is undulating as Forest Lake is approached.

Forest Lake
Population 800
Elevation 916 feet

Forest Lake is the name of a village as well as of the lake. The lake was named from the fine wooded shores surrounding it. The village is a summer resort of some importance.

CHISAGO COUNTY

(Total area 451.66 square miles; covered by water 30.64 square miles)

A mile north of Forest Lake the Chisago County line is crossed. The county takes its name from the largest of its many fine lakes, a contraction of the Indian name Ki-chi-sago from two Chippewa words: kichi, large; and saga, fair or lovely.

The southwest corner of the county, along Highway No. 1 has the gently undulating surface of a ground moraine. A mile north of the south line the road turns westward along the shore line of an extinct lake which is marked by a marshy area. Beyond this the road trends due north to a point just south of Wyoming where Highway No. 46, a paved road, extends eastward to the Chisago lakes and Taylors Falls. (See Route Map No. 4.) Highway No. 1 turns west at this point. The region traversed by Highway No. 46 is of such interest that a side trip has been outlined to cover it. The route along Highway No. 1 is continued on page 51.

SIDE TRIP TO TAYLORS FALLS AND THE "DALLES OF THE ST. CROIX"

The country along the road between Wyoming and Taylors Falls cannot be surpassed for pastoral beauty and its charm is difficult to describe. The road pursues a northeasterly course for the first ten miles through the lake country.

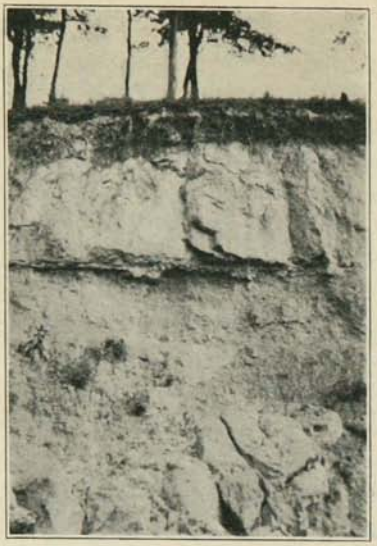
Chisago lakes.—Green Lake is passed first, then Chisago Lake which has numerous bays and extensions both north and south of the road. Sunrise Lake lies north of Chisago Lake and north of the highway. Several smaller lakes are scattered about the surrounding country.

Chisago City
Population 422
Elevation 925 feet

The three villages, Chisago City, Lindstrom, and Center City, are situated on the lakes and on the Taylors Falls branch of the Northern Pacific Railway within a radius of about four miles. All are much utilized as resorts, and hotels, cottages, and camp sites are numerous. Center City is the county seat and received its name from its location midway between Chisago City and Taylors Falls.

Lindstrom
Population 523
Elevation 940 feet

PLATE II



A. EXPOSURE OF GLACIAL DRIFT IN A PIT ON HIGHWAY NO. 46. TAYLORS FALLS. THE LOWER MATERIAL IS RED DRIFT WHICH HAS BEEN SOMEWHAT MODIFIED BY WATER. ABOVE IS A MASSIVE LAYER OF YOUNG GRAY DRIFT

B. THE DALLES OF THE ST. CROIX, INTERSTATE PARK, TAYLORS FALLS

Center City

Population 1285
Elevation 901 feet

The lakes of the region are located in shallow depressions in the ground moraine and the surrounding country has enough relief to make it attractive. The shores of the lakes and the valleys of the streams are wooded. The trees are large and many fine elms, also some maples, ash, oak, and butternut attract the eye. Most of the land is cultivated and many prosperous farms are passed. This type of country continues to within a mile of Taylors Falls, where the deep, broad valley of the St. Croix River may be seen ahead and the road winds down a long steep hill to the town and river.

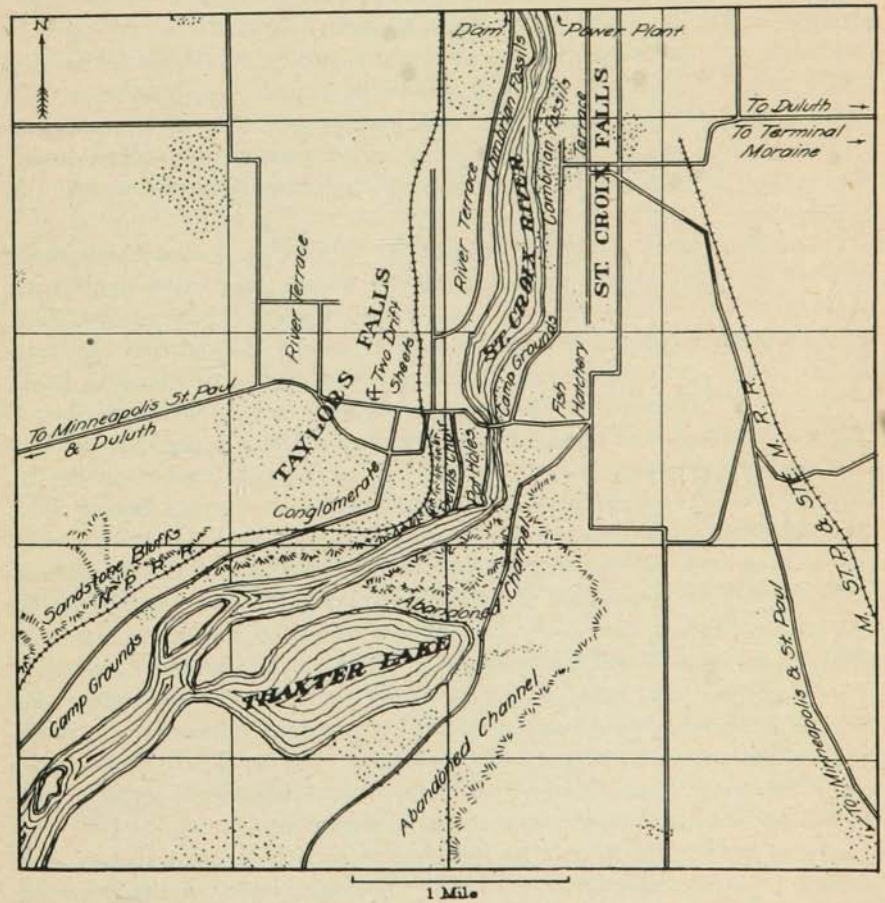


FIGURE 7. SKETCH MAP OF THE TAYLORS FALLS REGION. DOTTED AREAS INDICATE OUTCROPS OF BASALT FLOWS. AFTER BERKEY

INTERSTATE PARK AND THE "DALLES OF THE ST. CROIX"

The St. Croix (Holy Cross) River was given its name by Perrot, a French explorer, in 1689. A cross had been set at its mouth on the Mississippi, probably to mark the grave of a French trader. La Harpe in 1700 described the stream as "a great river called St. Croix because a Frenchman of that name was wrecked at its mouth." The river has its headwaters in northeastern Wisconsin and empties into the Mississippi at Hastings, Minnesota. It forms the boundary between Minnesota and Wisconsin for more than 100 miles.

The points of interest and scenery in the area about the villages of Taylors Falls, Minnesota, and St. Croix Falls, Wisconsin, led the legislatures of the two states to set aside an area of 730 acres in Wisconsin and 150 acres in Minnesota as an interstate park. The center of interest is an area of trap rock through which the St. Croix River flows in a narrow gorge. (See Plate II B and Figure 7.) One of the most attractive features is the growth of large white pines on the rocks forming the gorge. This is the farthest south that this useful species is found in Minnesota.

The villages of Taylors Falls and St. Croix Falls bound the park on the north. The former is located mainly on the most extensive terrace and the latter on a higher terrace of the glacial river, St. Croix. (See Figure 3.) A dam across the river furnishes considerable power, most of which is transmitted to Minneapolis and St. Paul. Taylors Falls and St. Croix Falls were once active in logging and lumbering, but most of the forests are now cut off. A state fish hatchery is located on the St. Croix side and is supplied by large springs issuing from the side of the valley. Abundant facilities are provided for camping on both sides of the river. On the Minnesota side a beautiful area along the river just below the gorge is set aside. A more attractive spot would be difficult to find. On the Wisconsin side sites are provided along the river above the bridge.

Taylors Falls
Population 750
Elevation 795 feet

St. Croix Falls
Population 825
Elevation 812 feet

Geology of the dalles.—The points of interest are so numerous and varied that an extended treatise would be necessary to cover them in detail. Such an article was written some years ago by C. P. Berkey, then an instructor at the University of Minnesota. His paper[1] should be consulted for a more extensive and technical treatment.

In order to understand the significance of the features that may be seen it is necessary to have in mind the geologic history of the region, as given in Chapter II, especially the parts on the Keweenawan and Glacial

[1] Berkey, C. P., Geology of the St. Croix dalles: Am. Geologist, vols. 20 and 21, 1897-98.
——— A guide to the dalles of the St. Croix. Minneapolis, 1898.

periods. The locations of the various points of interest are shown on a sketch map in Figure 7.

The most prominent feature of the region is the gorge (or dalles) of the river which begins at the bridge and extends downstream for nearly a mile. The gorge cuts through a series of diabase or trap flows, exposing vertical cliffs at places over 100 feet high. The rock outcrops extend up the sides of the valley to an elevation more than 300 feet above the river. These rocks are the result of the solidification of Keweenawan lava flows which were probably poured out of great fissures somewhere to the north. Detailed work by geologists has shown that there are at least 10 flows exposed on the Taylors Falls side from the gorge up the hill beyond the schoolhouse. A thin vesicular or amygdaloidal portion marks the top of each flow, where the gases formed bubbles in the molten rock before it solidified. One block west of the schoolhouse, a volcanic ash or breccia marks an interval of explosive activity between flows.

Along the gorge practically vertical rock cliffs are most common and the reason for this may be seen in the structure of the rocks. These old lava flows are cut by extensive joint planes or fractures which cause the rock to fall off in large blocks. The principal joints are vertical, but there is also a somewhat less developed horizontal set. These joints have even affected the course of the river, causing the abrupt right angle turn. The rock at the corner is locally known as "angle rock." The devil's chair is another conspicuous result of erosion influenced by joints.

The potholes.—Perhaps the most interesting feature of the region is the series of potholes in the large area of solid trap rock exposed along the Minnesota side of the gorge between the bridge and the boat landing. The potholes are cistern-like holes varying in size from small depressions a foot across to huge wells many feet across and scores of feet deep. Glacier Kettle is the name applied to one which has recently been cleaned out and found to be 60 feet deep, 12 feet in diameter at the surface, 15 at the 42-foot level, and 3 feet in diameter at the bottom. The irregularity in diameter is accounted for by jointing and variation in the hardness of the rock. At places the walls separating a series of holes have been destroyed by erosion and a gorge has formed. These potholes have been formed by eddies in the swiftly flowing river where the swirl of the water was strong enough to rotate boulders which continued to drill downward in the exceedingly hard and tough rock until the waters ceased to flow above them. Many of these rounded boulders may be observed in the potholes or near by.

Terraces and abandoned channels.—While the river was eroding the valley down to its present position, the channel was not at all times located directly above its present position, but it followed various courses which

are now marked by terraces and abandoned channels. Five more or less distinct terraces are found along the river. The highest is represented by a level area above Taylors Falls where a road runs northward. The next is best developed on the Wisconsin side at the level of the main street of St. Croix Falls. The next lower is best seen upstream from St. Croix Falls along the road which follows the river. A still lower terrace is occupied by the main part of Taylors Falls. The lowest is not widely developed, but forms small benches along the gorge just below the bridge.

An abandoned channel is found on the Wisconsin side from the elbow in the river south past Thaxter Lake (Lake of the Dalles). At a later stage the river was diverted to a channel through Thaxter Lake. (See Figure 7.) A new road has recently been built along the abandoned channel. The cliff which forms the south wall of the gorge was thus an island at an earlier stage in the development of the valley.

Cambrian rocks.—Thus far the only rocks mentioned are the lava flows, but a short distance down the railroad tracks, below the dalles, high cliffs of Franconia sandstone, a Cambrian formation, compose the valley walls. (See Figure 7.) Fossils are numerous, but not many are well preserved. The position of this sandstone with reference to the flows may be observed by following the railroad back to the hill near the schoolhouse, where a conglomerate may be seen at the road and railway crossing, and farther up the hill a fine exposure occurs where the road cuts through the rock. Here large boulders of trap compose the conglomerate, which grades upward into the Franconia sandstone, thus showing that the sandstone is younger than the flows. That the conglomerate is Cambrian is shown by the fossils it contains.

Excellent Cambrian fossils are found in outcrops of Dresbach shale on both sides of the river nearly opposite the Taylor House.

Glacial geology.—The country around Taylors Falls was of course swept by the glaciers when they crept down from the north and as a result deposits peculiar to glaciated country were left. By taking either road which trends east from St. Croix Falls, one climbs rapidly to a height of five hundred feet above the river. Here the country is extremely hilly with rounded knobs and rudely circular depressions or kettles alternating. This topography is typical of a well-developed terminal moraine, and it forms a belt about two miles wide, which trends roughly north and south through the region.

Where Minnesota Highway No. 46 descends the hill into Taylors Falls large openings for gravel have been made in the hillside and in this the glacial drift is clearly of two kinds. At the base is a red gravelly drift with more or less stratified sand and gravel in the upper part. Overlying this is a bed of gray boulder clay of a distinctly different type. (See

Plate II A.) The red drift was deposited by a glacier which advanced from the northeast and the gray drift, by a later one which advanced from the northwest. (See page 19.) The action of water stratified or modified the upper part of the red drift before the gray material was deposited above it.

HIGHWAY NO. 1

(Continued from page 45)

Wyoming was settled in 1855 by people from Wyoming, Luzerne County, Pennsylvania. It is a supply point for the surrounding farms and a station on the Northern Pacific Railway. From Wyoming north to Stacy the country is level and the soil notably sandy, the area being part of a great sand deposit covering the drift over much of Anoka and Isanti counties, and extending into Sherburne on the west and Chisago on the east. The sand was apparently deposited by winds which swept over the barren areas when the glacier retreated and before vegetation had become established.

Wyoming
Population 253
Elevation 905 feet

Stacy
Population 84
Elevation 928 feet

Stacy was established as a station on the Northern Pacific in 1875. Except for the creek valley at the village the sand plain continues unbroken to North Branch. Midway between the towns a few pine trees may be noted west of the road. The village takes its name from the creek which is the north branch of the Sunrise River. The creek has a pronounced valley, indicating a larger stream at some past time. From North Branch to Harris the surface is more undulating and the soil less sandy than that to the south.

North Branch
Population 742
Elevation 901 feet

Just north of the village the surface is decidedly more hilly due to a small belt of terminal moraine which trends northwest-southeast across the highway. Beyond the moraine and extending past Rush City, is a gently undulating to level ground moraine area with a very fertile soil.

Harris
Population 673
Elevation 904 feet

Rush City was named from the Rush River which in turn was named from the rushes found along it in low areas. Three miles north of the town the road crosses into Pine County.

Rush City
Population 971
Elevation 922 feet

A brief description of Chisago County has been given in connection with the side trip to Taylors Falls. The only rock outcrops found are along the St. Croix River and these have been described. The topography is very level except for the St. Croix Valley with its tributaries. The Chisago Lake country is in a large area of ground moraine extending from Wyoming to the river. It is bounded on the southeast and northwest by narrow belts of terminal moraine. From Wyoming to Harris the sand plain has

been noted. From Harris north is an area of ground moraine except for a narrow belt of terminal moraine. A considerable outwash deposit is found along the St. Croix River in that part of the county.

Pine County

(Total area 1444.5 square miles; covered by water 24.7 square miles)

Pine County was named from the extensive forests of white and yellow (Norway) pine which once covered the region. The county is large, extending eight government townships north and south and six east and west at the north, but only three at the south, where the St. Croix swings westward.

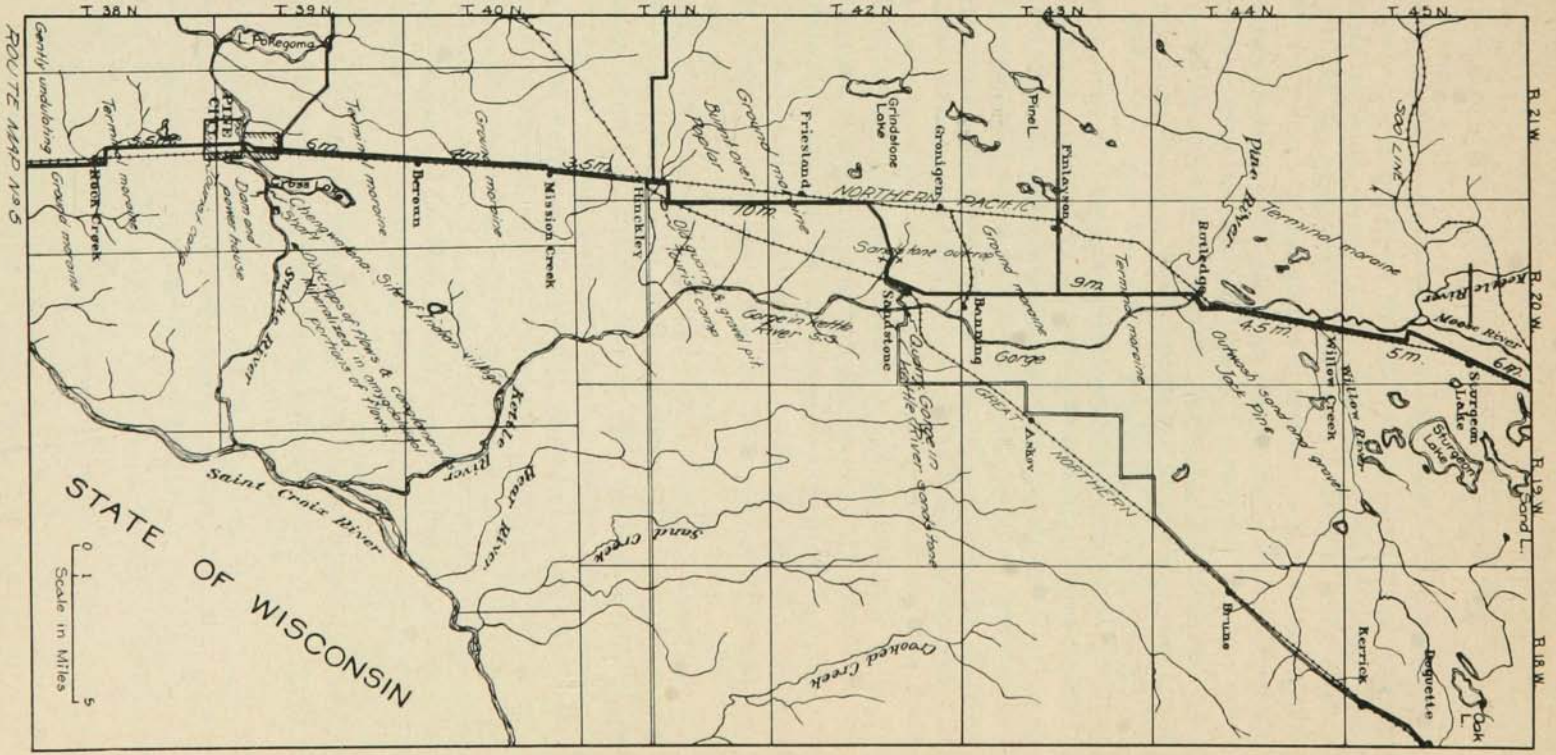
South of Rock Creek the surface is gently undulating but north of the town a small terminal moraine appears and there is a more rolling topography. A short distance beyond Rock Creek a few large white pines may be noted towering above the hardwood trees and from there north they become more abundant. It is also noteworthy that the hardwood trees of this region are larger than those found on the sandy belts of Chisago County. Oak, elm, ash, and basswood are common. There is little change in the topography until Pine City is reached; there a small moraine trends northeast across the county and is doubtless responsible for the two lakes of the vicinity. Cross Lake bounds the city on the east while Pokegama Lake is four miles west of town.

Rock Creek
Population 163
Elevation 945 feet

Pine City received its name by a translation of Chengwatana, the name of an Indian village which had been located at the outlet of Cross Lake into Snake River. The Snake River likewise received its name by a translation of the Ojibway name Kanabec. The same is true of Cross Lake, a translation of Bemidji, a name applied by the Indians from the fact that Snake River flows in and out of, or crosses the lake. Pokegama is also an Ojibway word. Pine City is a prosperous town serving a considerable area and is a station on the Northern Pacific Railway.

Pine City
Population 1303
Elevation 955 feet

Geology along Snake River.—Outcrops of solid rock are rare in the area lying north of St. Paul except along the St. Croix River. For this and other reasons a series of exposures along Snake River just east of Cross Lake are of considerable interest. A road follows the lake shore to the south of Pine City and crosses Snake River a short distance below the place where it leaves the lake. Just below the bridge is a power dam and from there downstream for two miles are numerous outcrops. These rocks are very similar to those at Taylors Falls, those on the north shore of Lake Superior, and the prevailing rocks in the Michigan copper country. (See Chapter II.) For this reason exploration for copper has



HIGHWAY NO. I THROUGH PINE COUNTY. THE HIGHWAY IS INDICATED BY A HEAVY BLACK LINE

been carried on at several points, but with unsatisfactory results. Numerous outcrops may be seen for one-half mile below the power house and others occur farther down. The rock consists mostly of dense basalt or diabase flows with amygdaloidal portions representing the tops of the flows, which vary from 8 to 200 feet in thickness.

Professor C. W. Hall[2] has identified 65 lava flows and 5 conglomerate beds in this series of outcrops. The total thickness he estimates at over 4000 feet. The beds have been notably tilted from their original horizontal position and now strike north 10 degrees east and dip about 67 degrees east. At the end of the channel for the tail race one of the thick red conglomerates may be seen interbedded with the flows. A short distance farther down is another conglomerate which is not as thick. About a mile down from the bridge are two exploration shafts which followed a showing of native copper in the amygdaloidal parts of flows. The dumps show many minerals, such as calcite, laumontite, orthoclase, and native copper.

A very interesting feature of this region was brought out some years ago when a well 700 feet deep was drilled at Pine City on the west side of Cross Lake. The first 230 feet penetrated river sand and glacial drift, while the remainder was in sandstone doubtless analogous to that along the Kettle River. This shows conclusively that the lava flows end abruptly at Cross Lake. This abrupt change is no doubt a result of a large fault which has dropped the rocks west of Cross Lake with respect to those east of the lake.

North of Pine City.—Beyond the Snake River at Pine City is a gently undulating country which extends for three miles, then comes a pronounced rise with a rolling to hilly surface indicating a terminal moraine deposit. The moraine continues to Beroun, a station on the Northern Pacific Railroad. From Beroun to Hinckley the surface is level to undulating with large marshes. Some of the land is quite stony and part of it has not been cleared but is covered with a second growth of birch and poplar, characteristic trees on burnt-over land. Mission Creek is an abandoned station on the Northern Pacific Railroad, so named from a mission to the Ojibways established near there in 1838, but broken up by a war party of Sioux, May 24, 1841.

Hinckley was named in honor of a stockholder of the St. Paul and Duluth Railroad. It is roughly half way between St. Paul and Duluth.

Hinckley

Population 673
Elevation 1032 feet

The village was destroyed by a disastrous forest fire which swept the region on September 1, 1894. Four hundred eighteen people perished at Hinckley unable to escape in any direction. The town was promptly rebuilt and has continued to grow.

[2] Hall, C. W. Bull. G. S. A., vol. 12, page 314, 1901.

Between Hinckley and Sandstone the surface is undulating to level and the soil is stony. Much of the land has not been cleared, but some prosperous farms show the possibilities of the land.

Sandstone

Population 1200
Elevation 1119 feet

Sandstone was settled as a village in 1885 when quarries were opened in the sandstone outcrop along the Kettle River and quarrying remains the principal industry.

The Kettle River gorge.—The Kettle River is a small stream which enters Pine County near the northeast corner and flows southward to a point within ten miles of its mouth, where it turns eastward and empties into the St. Croix. In its upper stretches the river flows in a relatively shallow valley in glacial drift and outwash gravel; but, about two miles below Rutledge, Keweenawan sandstone is exposed and the stream has intrenched itself in this rock. The gorge becomes rapidly deeper to the south and has ragged cliffs on each side ranging from 50 to 100 feet in height. This continues to a point opposite Hinckley where the river crosses into lava flows. The gorge may be most easily seen at Sandstone by driving along the county road to the east edge of town a distance of only half a mile from Highway No. 1.

The Kettle River sandstone quarries.—A bridge crosses the river at this point and gives a good view of the gorge and the quarries which are located along the west side, mainly above the bridge. The sandstone has been quarried for a distance of 2000 feet along the river and to a height of 100 feet. The rock is used for structural purposes, paving blocks, and crushed stone for concrete. It is of a light pink or salmon color but varies near the top to a darker yellow. The rock contains no fossils but its relations to outcrops elsewhere suggest that it belongs to the Keweenawan series. Its position is above the flows. (See page 10.) The beds vary from one to six feet in thickness and have but few joints, giving a massive appearance to the quarry face. The stone is attractive on account of its light color and has been used in many buildings, among them the Library, University of Illinois; Spokane Club, Spokane, Washington; Des Moines Public Library; Great Northern Station, Minneapolis; Pillsbury Hall, University of Minnesota; courthouses at Elk Point, South Dakota, and Crookston, Grand Rapids, and Benson, Minnesota. The quarries may be reached by a road from the west end of the bridge and will be found well worth a visit.

The highway north of Sandstone.—North of Sandstone for six miles is a deposit of level to gently undulating ground moraine which is largely covered with poplar and brush. Near Rutledge is a somewhat more hilly and sandy belt of terminal moraine which is covered mainly with jack pine trees, which flourish on sandy soil.

At Rutledge the highway crosses to the east side of the Kettle River, which has a shallow valley at this point, and no rock outcrops are found. The road and railroad follow the river valley to Willow Creek and Sturgeon Lake.

Rutledge
Population 90
Elevation 1036 feet

Beyond Sturgeon Lake the soil is sandy and gravelly and the country comparatively level. The sand and gravel are well stratified and represent outwash material deposited by glacial waters. Jack pines are the prevailing trees.

Willow Creek
Population 247
Elevation 1038 feet

The principal rock outcrops in Pine County are sandstones and lava flows of Keweenawan age. It is quite probable that a considerable portion of the county is underlain by these on the extreme northwest corner where older slates outcrop. In general the cover of glacial drift is not so thick as farther south so that outcrops have been found at various places through the county especially along the streams.

Sturgeon Lake
Population 208
Elevation 1080 feet

The glacial drift consists principally of ground moraine with a few terminal moraines with a northeast trend across the county. Extensive areas of outwash are found along the St. Croix River in the southeast portion, and along the Kettle River in the northern part of the county.

CARLTON COUNTY

(Total area 867.19 square miles; covered by water 9.47 square miles)

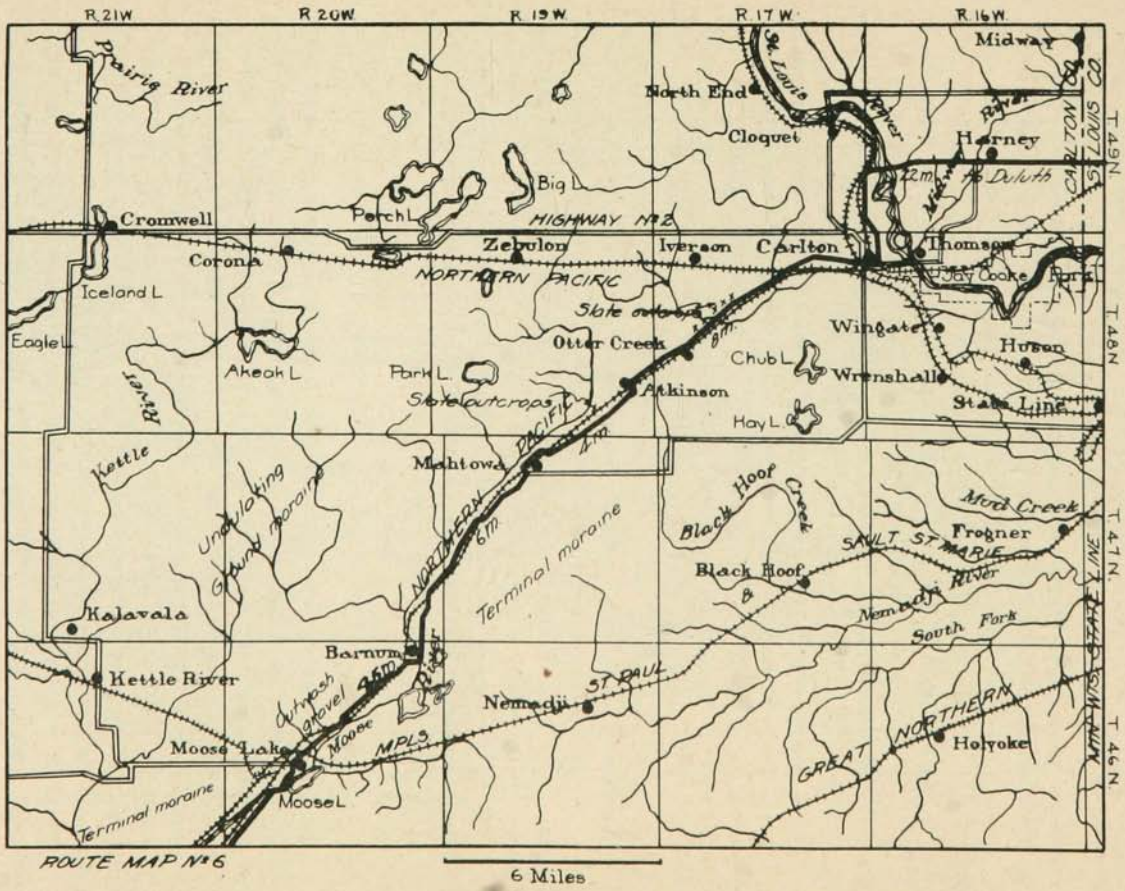
Carlton County extends six townships east and west and four north and south. It was named in honor of Reuben Carlton, an early settler.

Highway No. 1, entering the south side, follows the valley of the Moose River, which was formerly an outlet for glacial Lake Nemadji, a stage of Lake Superior when most of the present lake was filled with ice. (Another stage known as Lake Duluth is shown in Figure 4.) South of Moose Lake the valley widens and includes the lake. The south shore of the glacial Lake Nemadji follows the present shore of Moose Lake while on the north it is some distance back from the present lake.

At Moose Lake the Soo Line and Northern Pacific railroads cross. The town was entirely destroyed by the disastrous forest fire of October, 1918, in which Cloquet and several smaller towns also were practically destroyed. More than 300 people lost their lives in the catastrophe. The town was promptly rebuilt along modern lines and is now an up-to-date and thriving village.

Moose Lake
Population 571
Elevation 1065 feet

Between Moose Lake and Barnum the road follows the level country on the west side of the Moose River. Huge pits along the railroad expose the stratified gravel which underlies the valley. The deposits were laid down by the large river which occupied the valley when Lake Superior was filled by the glacier.



HIGHWAY NO. 1 THROUGH CARLTON COUNTY. THE HIGHWAY IS INDICATED BY A HEAVY BLACK LINE

From Barnum to Mahtowa the road continues to follow the outwash gravel terraces along the river. Mahtowa is an Ojibway word meaning bear. About a mile south of Atkinson on the west side of the railroad is a low outcrop of slate, the first exposure of this rock near the road. This slate represents the oldest rock exposed along Highway No. 1 and is of Upper Huronian age. (See page 10.) Striae or grooves formed by the scraping of the ice over the rocks are well marked on the top of the outcrop and show the movement of the ice to have been in a direction south 80 degrees west. A short distance beyond are three similar ridges all showing a rounded elongate form, due to the grinding action of the ice. The middle ridge shows especially fine glacial striae.

Barnum
Population 242
Elevation 1102 feet

Mahtowa
Population 380
Elevation 1152 feet

From this point to Carlton the same sort of rock is repeatedly exposed, especially just west of town, where there are numerous rounded, elongate ridges to which the name "roche moutonées" has been applied because they are supposed to resemble the backs of sheep lying in a pasture.

Atkinson
Population 319
Elevation 1146 feet

Carlton is the county seat and is a railroad center; several lines of the Northern Pacific and Great Northern systems radiate from it. The village of Thomson is located on the east side of the St. Louis River just beyond Carlton. Formerly Highway No. 1 crossed the river between Carlton and Thomson, but it was rerouted in 1924 over a new paved road extending north from Carlton and crossing the river about three miles to the north, and then connecting with the old route.

Carlton
Population 700
Elevation 1077 feet

JAY COOKE STATE PARK

Jay Cooke State Park consists of 3000 acres of wild rugged land on both sides of the St. Louis River extending from Thomson to Fond du Lac. (See Figure 8 for a map of the park.) The park is named in honor of Jay Cooke, a pioneer in railroad building, who secured the land along the river for power purposes. Later much of the land was found unnecessary, and in 1915, 2350 acres were donated to the state by the Cooke heirs and others have since made additions. The park auto road follows the grades of the first railroad to Duluth, now long abandoned.

The park is a game refuge, but fishing is permitted. Camp sites are numerous and are kept in condition by the state. The scenery along the river is very attractive and the geology presents many significant and important phenomena. The gorge is the most conspicuous topographic feature of the region as may be seen at the bridge between Carlton and Thomson. (See Plate III B.) A large dam just north of the

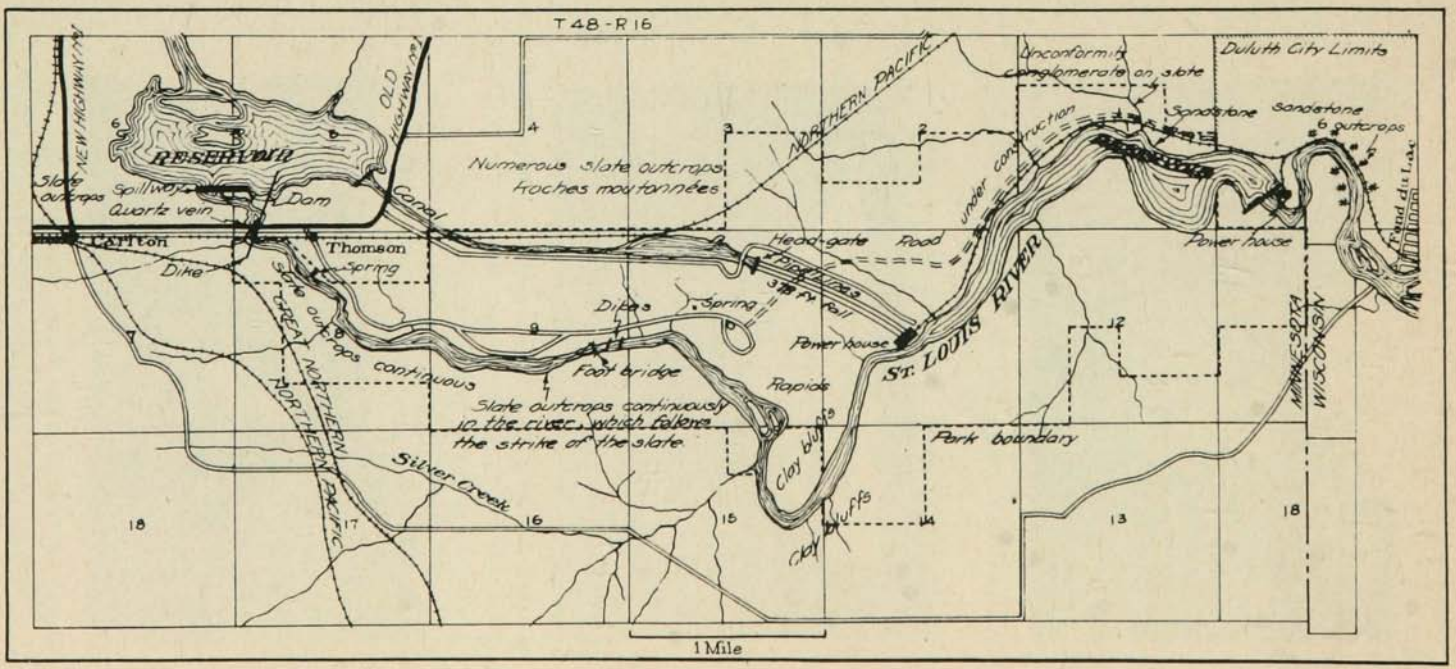


FIGURE 8. SKETCH MAP OF JAY COOKE STATE PARK AND ADJACENT AREAS ALONG THE ST. LOUIS RIVER

A. BLUFF OF ST. PETER SANDSTONE ON THE STRAIGHT RIVER, FARIBAULT

B. GORGE OF THE ST. LOUIS RIVER BETWEEN CARLTON AND THOMSON. ROCKS EXPOSED ARE CARLTON SLATE

C. BEDS OF CARLTON SLATE DIPPING TO THE SOUTH. THE WATER HAS WORN CHANNELS ACROSS THE BEDS ALONG JOINTS. ST. LOUIS RIVER, JAY COOKE STATE PARK

bridge shuts off most of the water from this part of the gorge, but this only serves to expose the rocks more fully. The chief rock exposed is a slate of the same series that was noted at Carlton. Some of the layers, or beds exhibit cleavage or parting and break into rhombic blocks which are as regular as if artificially cut. At places sharp folds may be observed showing that the rock was at one time under sufficient stress to cause it to bend. (See page 13.) A conspicuous feature of the slates are the holes which are formed by the weathering out of carbonate nodules or concretions. A most interesting feature is the manner in which the slate has affected the course of the river. The slate beds in general dip at an angle of 45 degrees to the south. (See Plate III C.) Erosion has resulted in a sawtooth effect at places and the water follows along the depressions for some distance. Cross joints result in narrow channels from one depression to another.

Near the center of the park in Section 10, the slate exposures end abruptly and the river flows in a broader gorge with red clay banks. No outcrops occur between this point and about the center of Section 1, a half mile above the lower power plant. There slate is overlain by conglomerate of Keweenawan age probably the base of the Kettle River sandstone. (See Chapter VI for further description.)

Formerly Highway No. 1 continued north and eastward of Thomson and Jay Cooke Park to the Cloquet road where it turned east. Outcrops of slate continue for some distance, then the area is covered with a heavy deposit of glacial drift. No conspicuous features appear until the St. Louis County line is passed. The new highway passes over country similar to that of the old route.

The most notable feature of Carlton County, especially as contrasted with the counties to the south, is the occurrence of abundant outcrops of slate. These have been noted in detail above. A large area extending eastward from Moose Lake is occupied by the deposits of glacial Lake Nemadji and glacial Lake Duluth. (See Figure 3.) Northwest of this area are the usual morainic deposits with areas of outwash gravel along the streams.

CHAPTER VI

THE DULUTH REGION[1]

St. Louis County

(Total area 6503 square miles; covered by water 365 square miles)

St. Louis County is the largest county in Minnesota, and also the largest county east of the Mississippi River. It extends from Lake Superior north to Rainy Lake, a distance of 130 miles. The county is named from the St. Louis River which was probably named by Verendrye, a French explorer who visited the region in 1731 and later. The king of France conferred the Cross of St. Louis on him in recognition of his discoveries, and this doubtless accounts for the name. The county is famous for its iron mines found on the Mesabi and Vermilion ranges. Much of the northern part of the county is unsettled and is included in the Superior National Forest. Numerous lakes make much of the county a tourists' and campers' paradise.

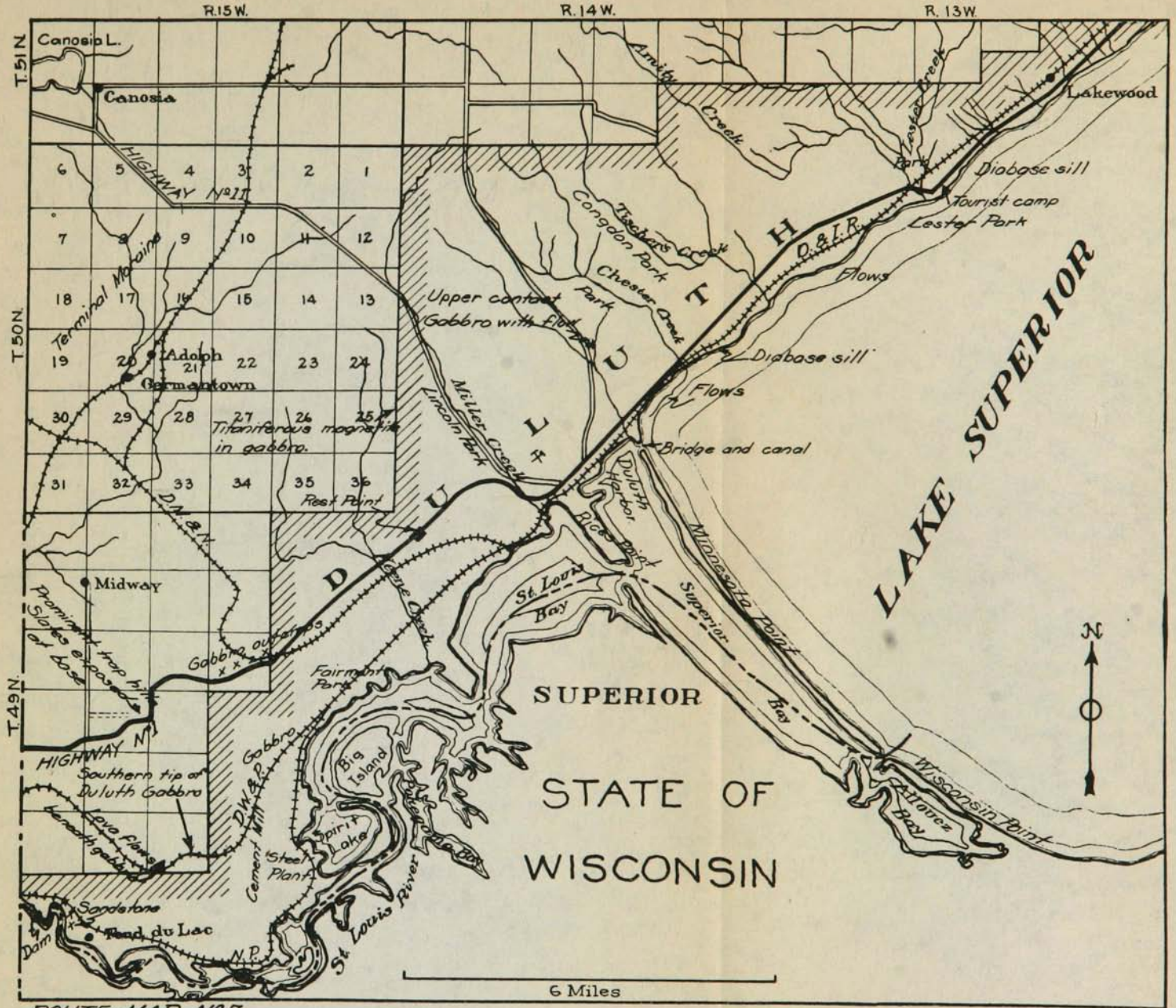
The county is entered over Highway No. 1 about six miles northeast of Thomson. The area from Thomson to a point about two miles east of the county line is underlain by the slates, which are well exposed near Carlton. About two miles east of the county line there is a very conspicuous change in the aspect of the county. Prominent rock bluffs rise, one on each side of the road and the country is more rugged from this point to the Canadian boundary.

The first outcrops of rock are ancient Keweenawan lava flows in Section 20, T. 49 N., R. 15 W. These are related in age and character to those exposed east of Pine City and at Taylors Falls, but here they lie more nearly flat, not having been greatly disturbed since their formation. These first bluffs are of black trap rock or basalt.

The basalt lavas lie on sand and conglomerate and anyone interested in their exact relations to other formations should take short side trips from Highway No. 1.

Turning north on the west side of Section 20, T. 49 N., R. 15 W. (see Map No. 7) is a road which runs several miles and crosses outcrops of slates like those at Carlton. Running east through the center of Section 20 is a road that crosses the hill of lava. If the explorer follows the west side of this hill about a quarter of a mile north from the road he will find the lava resting on white pebbly sandstone at the base of the bluff. Within 200 yards west of the bluff outcrops of slate are visible in the fields.

[1] See Route Map No. 7 for the city and surrounding area.



ROUTE MAP No 7

THE DULUTH REGION. THE HIGHWAY IS INDICATED BY A HEAVY BLACK LINE. NOTE THAT A LARGE SCALE IS USED FOR MAPS NOS. 7 TO 13.

Beyond the first prominent hills described above, the road continues to climb and within a short distance numerous outcrops of coarse black gabbro are exposed. The rock belongs to the formation known as the Duluth gabbro—which includes thousands of cubic miles of rock and is traceable to a point nearly 150 miles northeast along Highway No. 1. (See pages 65-66 for further description and origin of this rock mass.)

Within about two miles the crest of the hill is reached and the traveler is treated to a view that is surpassed at few places. The cities of Duluth and Superior (Wisconsin) occupy the foreground and Lake Superior and its south shore in Wisconsin, the background.

DULUTH

(Population: Federal Census Bureau estimate July 1, 1924, 108,395; elevation: level of Lake Superior 602 feet; high points of bluff: 1400 feet)

Duluth is the third largest city in Minnesota and is a lake port of great importance. The city was named in honor of Daniel Greysolon Du Luth, a French explorer who made a canoe journey to Lake Superior in 1678. He spent two years exploring the region and held a great convocation of Indian tribes on the site of the city September 16, 1679. The first settlement in the region was an American Fur Company trading post built at Fond du Lac in 1817. The first house on Minnesota Point was built by George B. Stunz in 1852.

The harbor is known as the Duluth-Superior Harbor and government statistics are compiled for the harbor as a whole, and are not divided between the two cities. The freight handled in the harbor in 1923 was valued at over $449,000,000. Goods manufactured and handled at Duluth aside from the lake freight had an aggregate value of over $100,000,000. The shipping of iron ore, grain, lumber, coal, and salt constitutes an important part of the trade. Fish-packing and the manufacture of pig iron, steel, cement are of special importance. An economical feature of the lake transportation is that boats coming up from lower lake ports carry coal, salt, and other products and then return with loads of iron ore and grain.

LAKE SUPERIOR

Lake Superior is the largest of the five Great Lakes of North America and the largest body of fresh water in the world. It is of vast importance as a waterway and source of fresh water fish, but its appeal to most people is in its scenery and the invigorating climate it affords near-by land areas.

The name was first used by Father Marquette on a map made in 1673 and refers to its position as the upper lake of the group. The boundary between the United States and Canada passes through the lake and its shores are touched by three states: Minnesota, Wisconsin, and

Michigan. It is 360 miles long and has a maximum width of 160 miles, its area being approximately 32,000 square miles. Its surface is 602 feet above sea level and its greatest depth is 978 feet, or nearly 376 feet below sea level. Isle Royale is the largest island, having a length of 45 miles. The island lies near the Minnesota and Canadian shore, but is a part of Michigan.

The water of the lake is remarkably clear and pure. Analyses show very little organic matter and a maximum of about 60 parts per million of dissolved salts. Cities on the lake have a source of pure soft water without treatment. The lake is remarkable for the low temperature which the water maintains even in warm weather. Some measurements indicate a maximum temperature of not over 48 degrees for the summer months. Only rarely does it warm up enough near shore in bays for pleasant bathing. Large amounts of ice form along the shore during the winter, but the lake is never entirely frozen over. It is reported to have frozen from Isle Royale to Keweenaw Point. The presence of large numbers of moose on Isle Royale is taken as an indication that it has been connected to the north shore by ice, allowing the migration of these animals to the island where they have been marooned ever since. It was estimated in 1924 that there were 1800 moose on the island.

GEOLOGY IN AND NEAR DULUTH

From the point where the city and lake are first seen the paved highway wends its way down a steep grade toward Duluth. At a point a short distance down, the city and civic bodies have provided a place known as "Rest Point," where there is ample space for the traveler to park and enjoy the view. The point is 488 feet above the lake. A brass plate set in a stone monument bears an inscription giving a sketch of the history of the region and drawing attention to salient points which may be seen.

The St. Louis River forms one of the prominent features of the view, winding its way as a broad irregular sheet of water to the westmost tip of Lake Superior. (See Map 7.) The Duluth-Superior Harbor docks are mainly located along the lower stretches of this river and the very tip of the lake, which is protected by Minnesota Point, a long sand bar with a natural opening between it and Wisconsin Point. This sand bar has been built up from the sand dropped by shore currents which swept across the end of the lake from one shore to the other, depending on the prevailing wind.

One of the significant physiographic features which may be seen is that the present Lake Superior does not fill the basin in which it lies. To the southeast a great extension of the basin is outlined by the hills and it requires only a little imagination to visualize the lake at the higher

stages known as Lake Nemadji and Lake Duluth, when it completely covered the area of this basin. (See Figure 3.) Another evidence of the existence of the higher lake stages may be seen in the terrace that was once a gravel beach and now is utilized as a road bed for the "Boulevard Drive," about 450 feet above the present lake level. This drive branches off Highway No. 1 a few blocks below "Rest Point," and affords the traveler a series of excellent views of the cities and harbor.

The boulevard is built near the top of a bluff which extends the entire length of Duluth and passes outcrops of gabbro at many places. A convenient place to examine some of the features of the gabbro is on the bluff at "Rest Point." More or less of this material has been excavated for the road. Where affected by the weather the gabbro shows a slight banding of dark and light layers, which dip east about 20 degrees. Weathering along joint planes in the rock has produced spheroidal masses like boulders. A small aplite dike may also be seen to cut the gabbro.

From "Rest Point," Highway No. 1 trends eastward down the bluff for some distance, thence turning back southeast until it reaches the level area along the St. Louis River, where it turns into the streets and the business section of the city.

Many points interesting, both industrially and geologically, may be found at the extreme western end of Duluth, including the village of Fond du Lac. To reach this region Grand Avenue may be followed westward from the corner where Highway No. 1 meets that street.

The first points of interest are the steel plant and cement mill. All of the intricate processes of making steel products from iron ore may be observed.

Those interested in geological detail may continue west to Fond du Lac. Up the river there are two power plants; the upper one has been mentioned in the description of Jay Cooke State Park. Half a mile west of the lower plant, a creek enters the river from the north and along its banks are exposures of sandstone and conglomerate that seem to be Keweenawan sediments. A comparison with the rocks exposed in Section 20, four miles to the north, suggests that the lava flow spreading over 100 miles from the east may have reached its limits in this area.

Fond du Lac	Section 20
Crumpled slate	Vertical slate
White quartz conglomerate	White quartz conglomerate
Red sand and conglomerate with trap pebbles	Trap rock lava flow

The slates are undoubtedly members of the same formation; and the two white conglomerates are probably the same bed. When the lava flow reached Section 20, it apparently did not cover the Fond du Lac area, but produced a hilly country, from which débris was washed down to Fond du Lac, forming a different sort of conglomerate.

After many trap rock lava flows had accumulated around Duluth, the lava evidently had more difficulty in reaching the surface of the ground and a large amount of the material forced open and filled a huge chamber. This great chamber full of magma (lava underground) finally cooled down to form a solid coarse grained rock, the *Duluth gabbro*. A side trip near the steel plant in the west part of Duluth will be of interest to geologists who wish to see the details of the relations of this gabbro to other rocks.

One of the most interesting regions to the geologist may be reached by following a road that passes between the Universal Portland Cement mill and the steel mills, to Short Line Park, a station on the Northern Pacific Railway. Just north of this station a stone crusher is operating on stone from a quarry in basalt flows. If one follows the Duluth, Winnipeg and Pacific Railway east from the stone crusher he sees numerous rock exposures. Four successive lava flows, dipping east at angles of about 10 degrees, may be distinguished along the railway cuts by their softer amygdaloidal upper zones. One of them has a pillow structure (ellipsoids) near the bottom. One is cut through by the tunnel of the railway. East of the tunnel the character of the rocks changes gradually. The diabase texture of the basalt of the flows changes to a sugary texture, and there are dikes and stringers of other rocks in increasing numbers. Finally at the east end of the next larger railway cut, east of the tunnel, the Duluth gabbro begins to appear. From this point to the center of Duluth, gabbro is exposed in about as large quantities as anywhere in the world.

The dikes and stringers in the flows near the gabbro are pegmatites of unusual character.

The first half mile of gabbro exposed along the railway is not the sort of rock exposed in most places, but evidently is the part of the great chamber full of magma which was first to solidify, and collected at the bottom of the chamber.

There are many points of interest throughout the city but only the more important are described in this chapter. The city has reserved space for a park along each little creek which flows down over the 800-foot bluff that borders the lake. The rocks of the region are well exposed in each of these.

At Fairmount Park, in the western part of West Duluth, the outcrops are representative of the main mass of the Duluth gabbro. The other parks along the bluff show special and unusual varieties rather than the normal and abundant rock of the formation.

Lincoln Park, at Twenty-fifth Avenue West, shows near the highway abundant outcrops of a coarse gabbro, rich in feldspar—anorthosite. If one walks up the creek towards the upper end of the park, a change can be noted in the rocks. Underlying the coarse gabbro, and west of it, is a mixture of fine black gabbro and "red rock." These two are evidently related and both intrude the coarse gabbro in dikes. The "red rock" is considered an "aplite" derived from the black gabbro.

A side trip near Lincoln Park might be made by geologists who are interested in the development of gabbro varieties.

The Hermantown Road starts northwest from Piedmont Avenue and two miles out beyond the boulevard, reaches the east side of Section 25, where it turns west. There are some outcrops north of the road about one hundred yards west of this corner, that were once prospected for iron. The gabbro is banded and some bands have unusually large amounts of titaniferous magnetite. Exposures are perhaps even better at the barn south of the road a little farther west.

At the road a mile farther west is an outcrop of anorthosite, much like those included in diabase along Highway No. 1 farther east, near Split Rock River, Beaver Bay, Tofte, and other places.

At Thirteenth Avenue West and Third Street, is a small quarry in "red rock." East of the quarry is coarse feldspathic gabbro, anorthosite, which has evidently been intruded by red rock. The contact is brecciated and the rocks so changed that there seems to be an almost complete gradation between two very different rocks.

Near Cascade Park, where Mesaba Avenue crosses Lake Street, just up the hill from the center of town, the character of the rocks changes abruptly. The great gabbro mass that extends from the steel mill at Gary to the center of the city, is again replaced by a series of surface volcanic rocks. Within a block above the park there is an outcrop of dense black rock which shows on its weathered surface that it was formed by a volcanic explosion. It now consists of fragments of various sizes well cemented in a fine ash or dust from the volcano.

The actual top of the gabbro mass, where lava flows were intruded by the later underground magma, is not exposed near Highway No. 1. If one wishes to see such a contact it can be best seen by a side trip from Cascade Park or Mesaba Avenue, out County Highway No. 11. At a point one and one-fourth miles from Cascade Park the outcrops are visible in a hill one-fourth mile northeast of the rock. Here black basalt is underlaid by gray gabbro.

From the center of the city, eastward for many miles, the main rocks exposed are volcanic lava flows. The most convenient place for one to see such a sequence of flows is reached by turning two blocks to the left of Highway No. 1 (Superior Street), about Second or Third Avenue East. Then if one goes east on Second Avenue to a point between Fourth and Sixth avenues, rocks are found in the bluff near the road. (See Figure 9.)

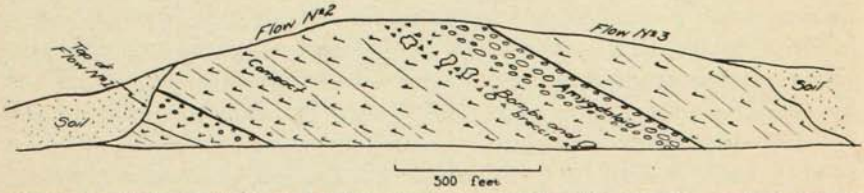


FIGURE 9. CROSS SECTION OF OUTCROP SHOWING THREE LAVA FLOWS. SECOND STREET BETWEEN FOURTH AND FIFTH AVENUES EAST, DULUTH. AFTER GROUT

A longer series of flows can be counted by anyone who cares to walk along the shore of the lake from Fourth to Fourteenth Avenue East. About ten flows

may be distinguished by their soft amygdaloidal zones, alternating with hard, black, dense basalt. At Twelfth and Thirteenth Avenues East the flows are interrupted by some sandstones, which no doubt derived their material largely from the flows. The sands are conspicuously cross bedded and end abruptly at a fault plane near Thirteenth Avenue.

Chester Park is along a creek in the lava flows. East of this series of flows the lake shore cuts into a large sill of diabase from Fifteenth Avenue to Twenty-fifth Avenue East. The rock is much like the gabbro of the western part of the city and may be connected with the same chamber. The top of this sill shows a change in the color of the rock from black to red. The change is easily examined in Congdon Park, Thirty-third Avenue East, by walking up the creek from Superior Street which is here about four blocks above the lake. The sill was formed by the forcing of a sheetlike mass of magma between the lava flows. Having solidified under cover, the rock is coarsely crystalline as compared with the flows and the change in composition from black to red is a result of segregation within the mass before solidification. Presumably the red portion rose to the top, somewhat like cream on milk, because of its lighter weight.

Above the sill is a series of lava flows and fragmental volcanic rocks, that are bright red, noticeably different from the black basalts farther west. These extend to about Forty-fourth Avenue East; and thence, alternating with darker flows, to Lester Park beyond Sixtieth Avenue East.

Lester Park is along the banks of Lester River which cuts a very beautiful gorge in basalt lava flows. East of Lester Park for about a mile, Highway No. 1 crosses another big sill like that from Fifteenth to Twenty-fifth avenues. It grades into a reddish rock at the top and has more flows east of it. The surfaces of many of the outcrops are polished and striated by the glacier. There is a more or less continuous exposure along shore of a series of flows with well-developed amygdaloidal tops to the city limits which are just north of Clifton, a station on the Duluth and Iron Range Railway.

CHAPTER VII

HIGHWAY NO. 1 ALONG THE NORTH SHORE OF LAKE SUPERIOR

The north shore of Lake Superior is a wonderfully beautiful country with its broad expanses of clear blue water backed by a coast which is almost mountainous over much of its length. To make the region more readily accessible the Minnesota Highway Department has completed a highway which follows the lake shore from Duluth to the Reservation River, thence turning inland about ten miles to the Canadian border. In this chapter some of the features of the lake shore country are described but the space is inadequate for many things worthy of note. Route maps Nos. 7 to 13 show this area in detail. Northeast of Two Harbors the country is thinly settled and the camper will find numerous excellent places to stop.

The city limits of Duluth are less than a mile southeast of Clifton station on the Duluth and Iron Range Railroad. The shore opposite Clifton is rocky and forms a rounded point where the Talmadge River flows into the lake, through a small gorge in Keweenawan basalt or trap flows. (See Chapter II.) Amygdaloidal or vesicular tops of flows are not closely spaced along this stretch of rock exposures, indicating rather thick flows with a trend or strike nearly parallel to the shore line. A state fish hatchery is located on the east bank of French River just north of the highway bridge. A short distance beyond the French River the rocks are concealed and the first outcrops a mile beyond form a point made up of a thick basalt flow with thick amygdaloidal beds exposed on each side of the point. Scattered outcrops occur from here to Sucker River where a broad bay has a gravel beach. A prominent point at the northeast side of the bay shows the first outcrops of a hard, coarse, black diabase or gabbro sill like that at Lester Park. The rock is beautifully mottled where it is exposed to the action of the weather or the grinding and polishing effect of the waves. The rock shows a well-defined banded structure, dipping toward the lake, at an angle of about 15 degrees with a trend or strike of north 55 degrees east. Glacial striae are common on the smooth upper surfaces of the rocks. These show that the ice moved in a direction about 60 degrees west of south. The diabase forms a very rocky and bold coast and the hills back of the point stand out on the comparatively level terrace or beach which extends from Lester Park to Arthur. The diabase is continuous along shore to the mouth of Knife River in Lake County, a distance of four miles.

The character of the tree life along the shore from Duluth eastward deserves comment. Nearly all of this area has been burned over so recently that only brush has grown up. At places, however, the older trees have escaped and these consist mainly of pine, balsam, and spruce with some birch and poplar. The typical hardwood trees occurring so abundantly in the southern counties of the state are almost entirely lacking here.

Lake County

(Total area 2100 square miles; covered by water 262 square miles)

Lake County covers a large area 36 miles wide extending from the coast of Lake Superior north to the Canadian boundary, a maximum distance of nearly 90 miles. Much of the county is rough and rocky and is unsettled. The Superior National Forest covers a large area in the northern part and the remainder is patrolled by the State Forest Service. There are many lakes in the northern half of the county and they afford excellent fishing. Many fine trout streams empty into Lake Superior.

Knife River is the largest village between Duluth and Two Harbors. Previous to 1923 it was the head of the Duluth and Northern Minnesota Railroad which was built principally for logging operations. The traffic was not sufficient to support it after the timber operations ceased and in 1923 it was torn up.

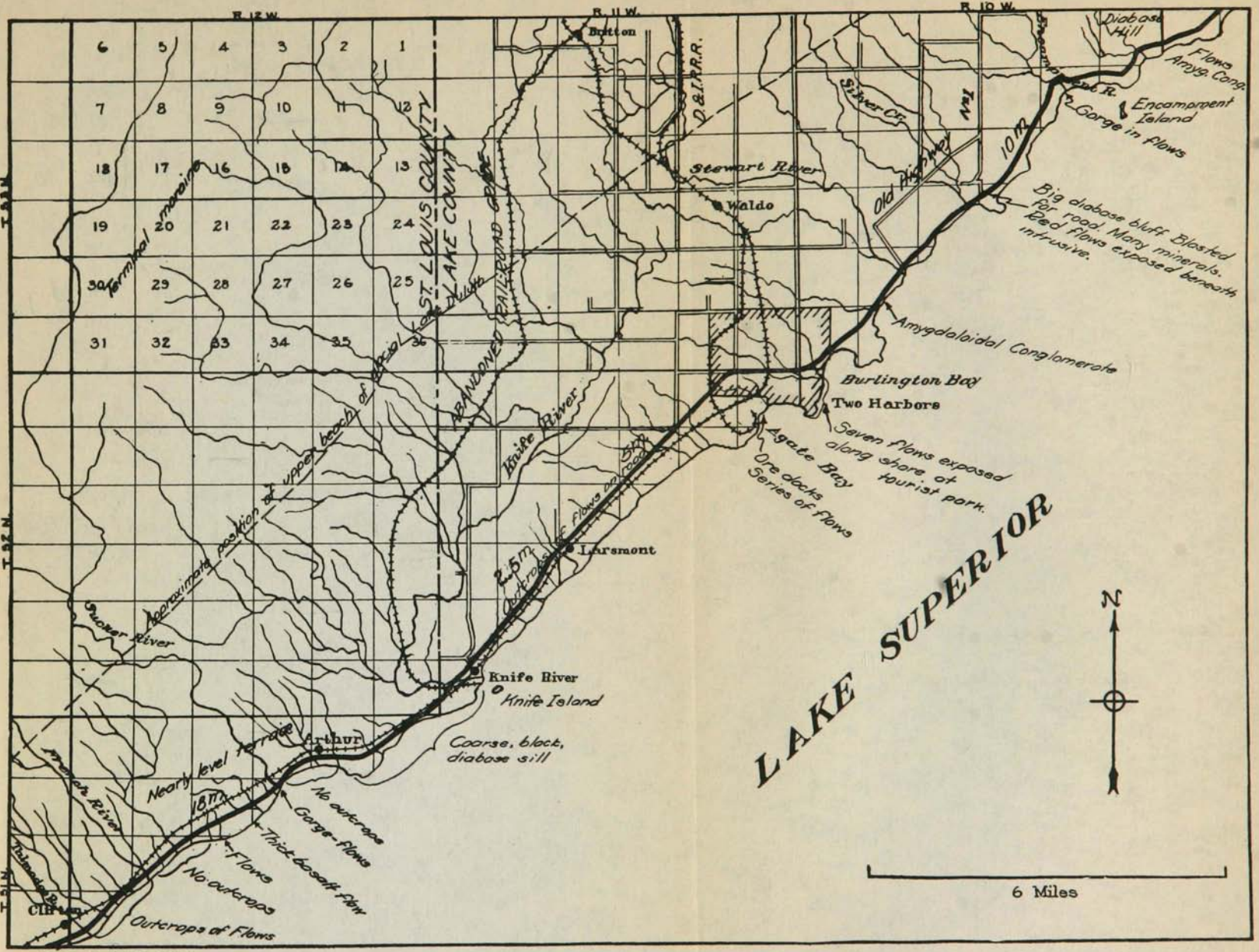
Knife River
Population 125

The diabase sill described in the preceding pages is not exposed east of the mouth of the Knife River. On the east bank of that stream and northward along the road are numerous outcrops of flows with well-developed amygdaloidal tops. Outcrops of this type continue to a point about a mile east of Larsmont station beyond which there are no exposures along the road as far as Two Harbors.

Two Harbors received its name from the two small bays or natural harbors of the coast. The westernmost bay which is utilized for the harbor is known as Agate Bay from the agates found in the sand along the shore. The eastern bay is known as Burlington Bay. The city is the location of the shops and iron ore docks of the Duluth and Iron Range Railroad which brings down large amounts of ore from the Mesabi and Vermilion ranges to be shipped to eastern lake ports. A new hotel was built in 1924 and a tourist camp on Burlington Bay affords a fine spot for a camp on the lake.

Two Harbors
Population 4546

Geology at Two Harbors.—On the shore of Burlington Bay just below the tourist camp is a great series of lava flows with amygdaloidal tops. From the sandy beach of the bay to the power house, the shore trends diagonally across the strike of the rocks and five distinct flows are exposed, forming sharp points of rock projecting into the bay. The divide between Burlington and Agate bays is formed by the fifth. One of the



ROUTE MAP No. 8

HIGHWAY NO. 1 ALONG THE NORTH SHORE OF LAKE SUPERIOR NEAR TWO HARBORS. THE HIGHWAY IS INDICATED BY A HEAVY BLACK LINE. DISTANCES BETWEEN TOWNS ARE GIVEN THUS, 18 M.

amygdaloidal beds directly below the tourist camp is unusually thick and shows much pink laumontite and white calcite. The main flow contains agates which were formed by filling holes once bubbles or gas holes in the flow by silica deposited concentrically forming the agate structure. The main harbor in Agate Bay is protected by a breakwater. The inner part of the bay shows no outcrops but on the southeast side beyond the ore docks are prominent cliffs. Here are found three flows with amygdaloidal tops which weather out easily. The trend or strike of the rocks is apparently north 45 degrees east.

Northeast of Two Harbors the road follows a level terrace with a red, lake clay soil deposited by Glacial Lake Duluth. (See Figure 4.) No exposures of rock occur along the road as far as the bridge over the Stewart River where the flows are again exposed. Along the lake shore, however, outcrops are frequent and about a half mile west of the river a considerable amount of red sand is incorporated in the amygdaloidal portion of a flow.

Just beyond the Stewart River the old inland highway turns northward and follows a route ranging from two to ten miles from shore to Cross River in Cook County where it returns to the shore.

About two miles beyond the Stewart River is a prominent bluff on the lake shore and Highway No. 1 has been blasted out along the face of this cliff with much difficulty. The rock that forms the cliff is a diabase or gabbro which was intruded into the flows of the region. It is the same type of rock as that found at Lester Park. The flows may be seen exposed along the water's edge beneath the diabase, and at the northeast end the contact is exposed at the level of the road. The road rises to a height of 125 feet above the water and the bluff is 120 feet higher. The cliff originally formed one of the boldest places along the Minnesota shore. Widely spaced joints cut the rock forming huge blocks, which gave much trouble by sliding down when the road was being constructed. Weathering along the joint planes has rotted the rock at places and a few are filled with secondary minerals, some of which are rare. The bluff trends northward away from the road and forms a high inland ridge. Abundant outcrops of basalt and amygdaloidal basalt flows are found along the road for a half mile beyond the cliff; to the northeast the red, lake clay covers the rocks as far as the Encampment River.

Along shore at the mouth of the Encampment River a group of Minneapolis families have organized a summer colony under the name of "Encampment Forest Association." Many fine white pines line the road, forming the best stand of these trees along the coast. Encampment Island lies somewhat to the east of the mouth of the river. Opposite the island on the mainland is another ridge not unlike the one described just above.

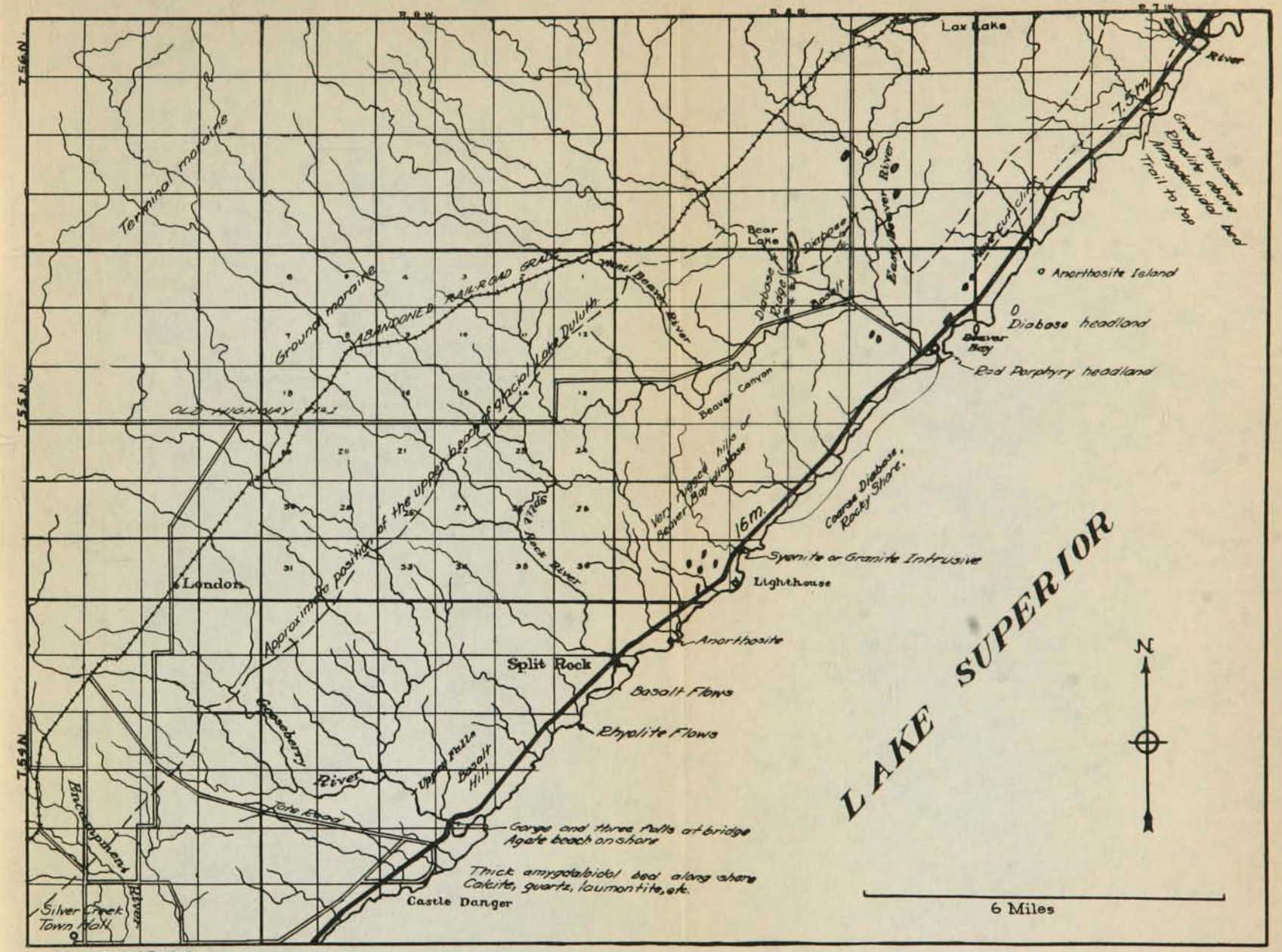
but the rock is porphyritic, that is, it has large crystals of feldspar embedded in a matrix of finer grained material. The decomposed layer covering much of this rock is to be especially noted. It is a rusty brown, crumbly material which was formed from the hard black diabase by weathering, that is, by the action of water and air. This is an example of the manner in which soil and loose material has been formed by the weathering of the various types of rocks.

On the north side of the point and along the shore the contact of the diabase intrusive with the flows may be seen. The flows overlie the diabase and are locally tilted up at an angle of 45 degrees. Farther northeast along shore the flows may be seen to have a dip of 10 degrees toward the lake. The flows are much seamed and fine specimens of the minerals laumontite, epidote, and chlorite may be had. The beach gravel of the bay beyond the point contains many agates which may be most easily found just at the water's edge.

The road passes over a creek and beyond this is another point with a high cliff along the water's edge for some distance. Beyond the point the coast is relatively low and a level beach extends inland for some distance, and along the coast past Castle Danger. This rather extensive level area is doubtless an indication that there are no diabase intrusions among the rocks as they are resistant and tend to form hills and ridges.

Geology at the Gooseberry River.—The Gooseberry River empties into Lake Superior about two miles beyond the settlement of Castle Danger. The name of the river is a translation of the Ojibway name. Just above the bridge is a falls with a drop of 25 feet, and less than 300 feet downstream are two falls with a total drop of fully 75 feet. (See Plate IV A.) Upstream about a mile from the bridge is still another. This series of falls show very clearly the effect of the variation in hardness of rocks on the erosion by running water. Examination of any of the falls shows that the water plunges over a massive basalt flow which is underlain by the soft amygdaloidal bed of the flow beneath. This softer material is undercut or worn out more rapidly than the hard bed above, thus causing the massive bed to break off in large blocks leaving vertical faces.

Below the lowest falls on the east side is a high basalt cliff, but the west side is largely clay and the river has cut a wide channel in this soft material and now follows a pronounced meander in the valley. Along shore, west of the river as far as the Lind farm, is a very interesting stretch of coast. The beach gravel near the mouth of the river contains many agates broken out of the amygdaloidal rocks which form the shore. Just east of the Lind farm a thick amygdaloidal bed (20 to 25 feet) lies beneath a massive basalt. The amygdaloidal bed is heavily mineralized and shows many fine specimens of calcite, including some very transparent material, laumontite, quartz, and minor amounts of other minerals. Geodes, or small openings lined with crystals, are common.



ROUTE MAP No 9

HIGHWAY NO. I ALONG THE NORTH SHORE OF LAKE SUPERIOR NEAR BEAVER BAY. THE HIGHWAY IS INDICATED BY A HEAVY BLACK LINE. THE BLACK SPOTS SHOW THE LOCATION OF ANORTHOSITE HILLS.

Beyond the river the road mounts a high hill and the road cuts expose the flows for some distance. From the crest of the hill a wonderful view may be had of the coast to the southwest as far as Two Harbors. The road passes over the crest into a small valley and then swings southward around another hill and from this point an equally fine view is afforded of the coast to the northeast, where its rugged, mountainous character is very striking.

Beyond the hill the road continues down a long grade and passes close to shore. Ahead, two prominent knobs stand out conspicuously near the shore, and beyond a lighthouse may be seen. To the left of the road are good examples of the abandoned shore lines or beaches. The road follows the lower level, and two lines of cliffs, one back of the other, mark successively higher ones.

The rocks along this part of the road are decidedly red and contrast strikingly with the black basalts and diabases which are found from Duluth to this point. This rock is probably a lava flow as it is very dense like most rocks which cool quickly. The red, dense rocks are known as rhyolites or felsites. (See Glossary.)

The Split Rock River flows through a broad valley in the basic flows which replace the red rocks found to the southwest. At its mouth it empties through a narrow gorge in rock, whence its name. About three fourths of a mile northeast of the river and west of the lighthouse are two prominent white hills which are composed of anorthosite. A mass of this rock has been blasted away along the road, exposing it for easy examination. It is made up almost entirely of one mineral, plagioclase feldspar, forming a white or nearly colorless rock with a greenish tinge. It is an unusual rock and will doubtless be utilized some day as a decorative stone, although it is harder than most rock used for that purpose. The origin of this rock has been the source of much speculation by geologists. It forms several pronounced knobs north of the road in the region of Lighthouse Point. The prevailing rock, aside from the anorthosite, is a coarse, black diabase much like that noted at several places along shore. Just beyond the lighthouse amygdaloidal basalts are found outcropping along the road. A short distance farther on a small gorge cuts deeply into the solid rock, and on the south side a coarse, red rock of the syenite or granite type is exposed. From this point to Beaver Bay, a distance of several miles, the road passes over a rough rocky country. Here outcrops of the coarse diabase are practically continuous. The coast is rocky and bold, due to the erosion of the diabase along the well-developed systems of joints.

Beaver Bay.—At Beaver Bay the Beaver River empties into the lake through a gorge in diabase. The abundant exposures of diabase in this region lead to the adoption of the name Beaver Bay diabase for the series

of diabase intrusives found along the coast in Minnesota. From the bridge a view of the lower falls may be had. The village of Beaver Bay was the county seat of Lake County until 1888, when the offices were moved to Two Harbors. A post office, store, and garage mark the location at present. A summer colony of Minneapolis people controls the land on the west side of the bay.

Just southwest of the mouth of the river are outcrops of anorthosite in diabase; beyond this, and forming a part of the southwest headland, are cliffs of red porphyry. On the southwest side of the headland is coarse diabase with huge blocks of anorthosite included in it. Beyond this is an exceedingly coarse phase of the diabase with a mottling on the weathered surface due to the alteration of the more soluble minerals, especially olivine.

Just back of the post office are other anorthosite masses in diabase, and anorthosite may be observed in the road cuts just east of the post office. The northeast headland of the bay is apparently all diabase.

Northeast of Beaver Bay, Highway No. 1 passes close to shore over the same type of diabase found east of the bay. Several rocky islands dot the shore, and ahead the Great Palisades stand up, above the surrounding country. About a mile northeast of the headland several anorthosite masses are found along shore and on the islands. North of the road is a wave-cut cliff which swings toward the present shore three miles northeast of Beaver Bay, where the road passes around the old cliff. Many exposures of diabase and flows are found along the road and a gradation of dark diabase to red syenite may be noted.

The Great Palisades.—The Great Palisades form one of the prominent points along shore and some time may be profitably spent by the more adventuresome traveler climbing over the rock mass. At the west side a path leads from the road to the summit of the hill where one may obtain a remarkable view of the coast in both directions. The Sawtooth Mountains of Cook County stand out to the northeast. Inland the topography is very rough and several rounded white knobs of anorthosite are conspicuous. To the southwest the coast may be seen as far as the lighthouse at Split Rock. The five islands off the coast near Beaver Bay and the many points and inlets form a most picturesque coast line.

The palisade hill is composed of a dense, red rock which on close examination is found to be porphyritic; that is, it has visible grains of smoky quartz and white and red feldspar with a dense ground mass. It may be called a rhyolite porphyry. The maximum height of the hill is 315 feet and the vertical cliff on the lake rises over 200 feet at places. At the base of the cliff along the southwest side the porphyry overlies basalt flows with much amygdaloidal material. The dip is toward the lake, so that at the place where the cliff faces the open lake, the porphyry

reaches the water level. Near the contact the porphyry is beautifully brecciated and banded, probably due to the flowing of the porphyry over the basalt flow. The cause of the vertical cliff of the palisades is found in this contact. The amygdaloidal portion of the underlying basalt flow is easily eroded by the waves, thus leaving the rock above unsupported, causing it to break off along the vertical joints or fractures. The condition is essentially the same as that forming water falls in rivers. Beyond the palisades is a broad terrace which extends to the Baptism River.

The Baptism River.—The Baptism River flows through an exceedingly rough country which may be seen to advantage from the steel bridge over the gorge. (See Plate IV B.) At its mouth are cliffs of rhyolite flows similar to the rock at the Great Palisades. The rhyolite is not extensive, as basalt flows are found a short distance southwest. Just east of the mouth are a series of cliffs which form the Little Palisades. (See Plate V A.) The river flows in a deep, but comparatively narrow, gorge near its mouth. Basalt and rhyolite flows outcrop along the gorge. Some diabase intrusions cut the flows. At the first falls a half mile upstream the river plunges over a massive, dense basalt with the channel along joints. The gorge above the first falls is narrow and about a quarter of a mile farther up is a series of small falls due to erosion along amygdaloidal beds. About one and one-half miles above the road is a large fall where the river plunges over a vertical cliff fully 50 feet high. (See Plate IV C.) The rock at the falls is a rhyolite porphyry similar to that at the Great Palisades. This massive red rock is undercut along the soft basic flow on which it rests. This stream and its many tributaries furnish perhaps the best trout fishing along the north shore. The traveler has probably noted the brown color of the water in most of the streams in this region and wondered at its cause. It is a result of the organic matter which is taken up by the rivers from the forests and swamps. This material is not in the least harmful.

Beyond the Baptism River the road follows a route some distance from the shore to avoid the extremely rough coast along the Little Palisades. The first road cut exposes the rhyolite porphyry continuous with that which forms the palisade cliffs. The road swings farther inland to pass around a gorge. West of the bridge an old aerial tramway standard is located on the south side of the road. The tramway led to an old quarry in anorthosite a half mile north of the road. This is known as the Crystal Bay quarry.

Northeast of the creek the road swings shoreward around a basalt bluff which marks the old shore line. The terrace is broad from this point on for a mile or more. Basalt and diabase outcrops are numerous along the road. At a point three miles northeast of the Baptism River the road swings around a big hill which consists principally of anorthosite,

Plate IV

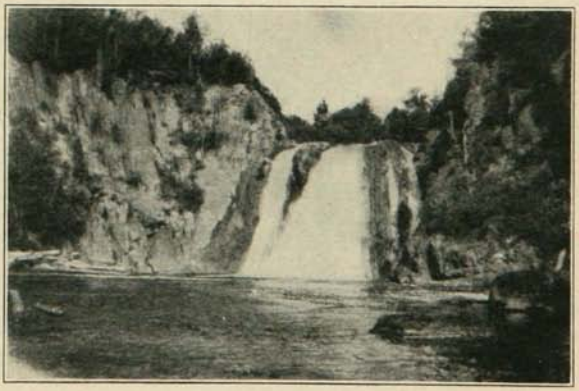
A. Double falls of the Gooseberry River, 300 feet below Highway No. 1. Each fall is formed by the undercutting of a massive basalt flow along the amygdaloidal top of the flow beneath.

B. Valley of the Baptism River. The pronounced hills in the distance are composed of intrustive diabase. This topography is typical of the Minnesota coast of Lake Superior.

C. Falls of the Baptism River, 1½ miles above Highway No. 1. The 50-foot cliff over which the river plunges is composed of hard rhyolite, which is undercut along a softer flow beneath.

A

B



C

but with diabase along the lower part at places. Some of the rock has been blasted down for the road thus exposing the fresh material. The anorthosite is much darker than that found at Beaver Bay and Split Rock. Beyond this the road follows a broad terrace and the coast is less rugged than that near the Baptism River. Three beach or terrace levels may be noted from this point to Little Marais; one is a short distance above the present lake level, a second is just below the road, and the third or upper terrace is occupied by the road.

From Little Marais to the Manitou River the road follows the same level beach or terrace, and gravel deposits form a mantle over the solid rock. The coast line is regular and the country much less rugged than that to the southwest. An exceptionally well stratified sand and gravel deposit is located just at the west approach to the bridge where road material has been removed. This deposit may represent an old delta formed by the river pouring into the lake when it stood at a much higher level.

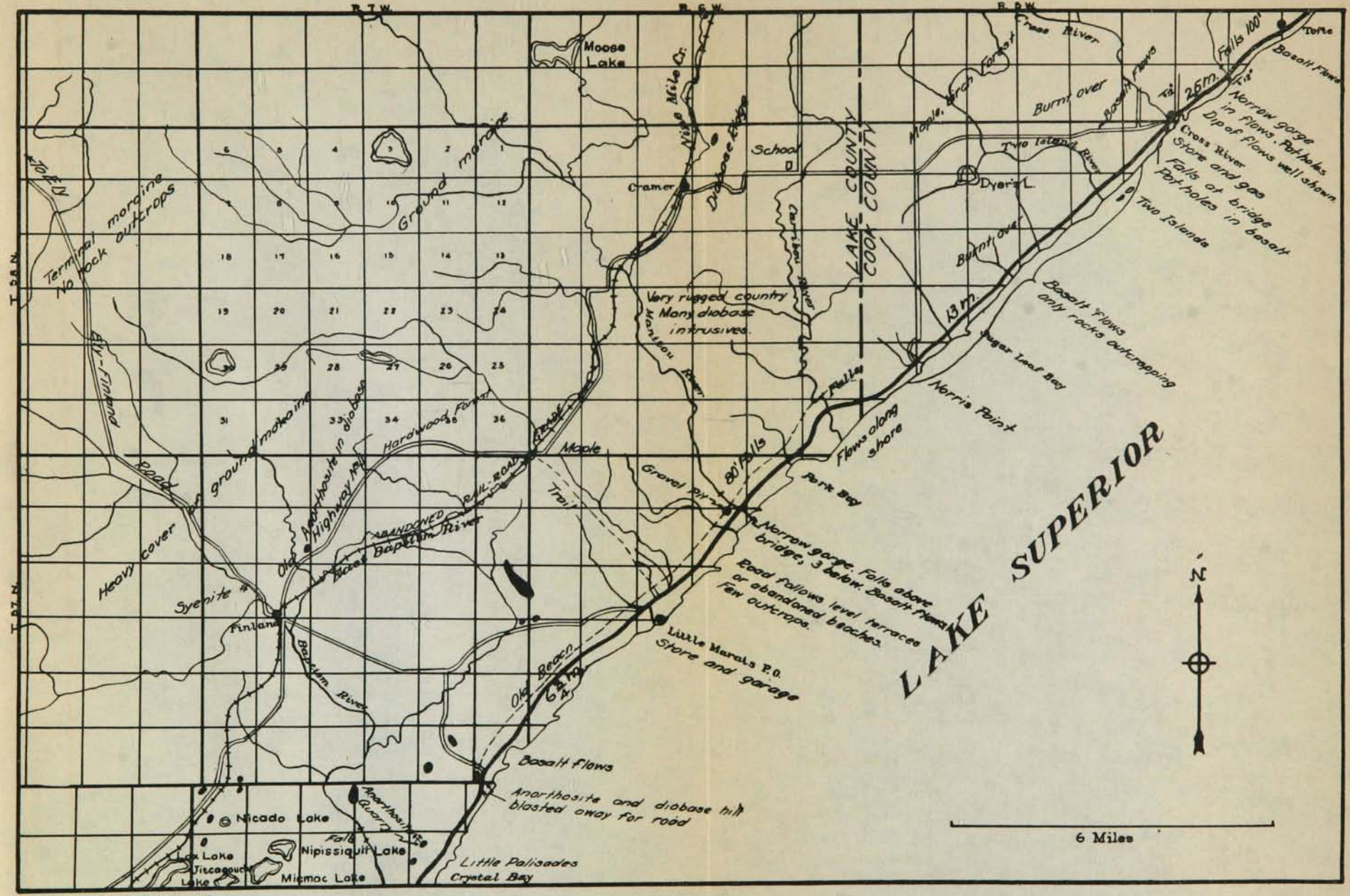
The Manitou River retains its Ojibway name which means spirit. The river has a remarkably deep and narrow gorge where the new steel bridge spans it. The cause of this gorge may be seen in the beautiful falls a short distance upstream from the bridge. The falls are not visible from the road, as there is a sharp bend in the river, but they may be reached in a few minutes by following a path along the east bank. The river makes a right angle turn and plunges over a massive basalt bed with a total fall of nearly one hundred feet. (See frontispiece.) At the base is an amygdaloidal bed several feet thick, which the stream is undercutting, thus maintaining the falls, which gradually migrate upstream leaving the narrow canyon seen between the falls and the bridge. Between the bridge and the lake, a distance of only half a mile, three more falls with a series of rapids give a total drop of several hundred feet. The last fall plunges the water directly into a small cove of Lake Superior and may be seen by passing boats. The Manitou, especially in its upper stretches, affords good trout fishing.

About half a mile northeast of the Manitou River the road descends to a lower terrace which continues at almost the same level for several miles. The gravel of the abandoned beach covers the rocks except for a few outcrops of basalt. The Caribou River emerges by a fall from the hilly inland country onto the terrace which the road follows.

COOK COUNTY

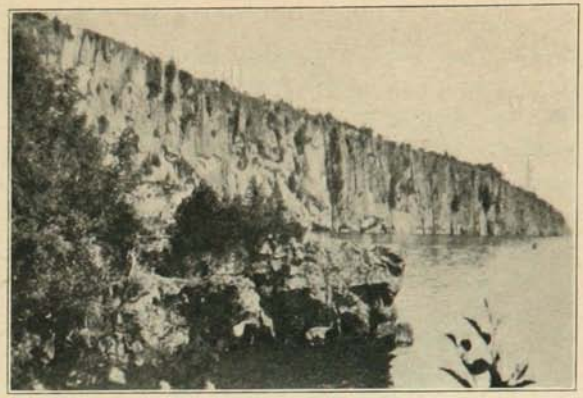
(Total area, 1680.4 square miles; covered by water 213.56 square miles)

Cook County was named in honor of Major Michael Cook, of Faribault, who was mortally wounded in the battle of Nashville, December 16, 1864. The county forms the extreme northeastern part of the state and



ROUTE MAP No. 10.

HIGHWAY NO. 1 ALONG THE NORTH SHORE OF LAKE SUPERIOR NEAR LITTLE MARIAS AND TOFTE. THE HIGHWAY IS INDICATED BY A HEAVY BLACK LINE. THE BLACK SPOTS SHOW THE LOCATION OF ANORTHOSITE HILLS.



A. THE LITTLE PALISADES. COAST OF LAKE SUPERIOR EAST OF THE MOUTH OF THE BAPTISM RIVER

B. GROUP OF WHITE PINE (PINUS STROBUS), SUPERIOR NATIONAL FOREST

C. FOREST OF SPRUCE AND BALSAM, STEWART RIVER, HIGHWAY NO. 1, NEAR TWO HARBORS

has a roughly triangular shape, being bounded on the west by Lake County, on the north by Canada, and on the southeast by Lake Superior. Its extreme length east and west is 72 miles and its width 54 miles. The county is mostly unsettled and is traversed by but few roads, the only ones of great length being Highway No. 1 along shore, and the Gunflint Trail extending from Grand Marais north and somewhat westward to Gunflint Lake. Lakes and streams are numerous and the area is one of rare beauty and charm, and is especially adapted to canoe trips, but also furnishes ideal conditions for campers traveling by auto.

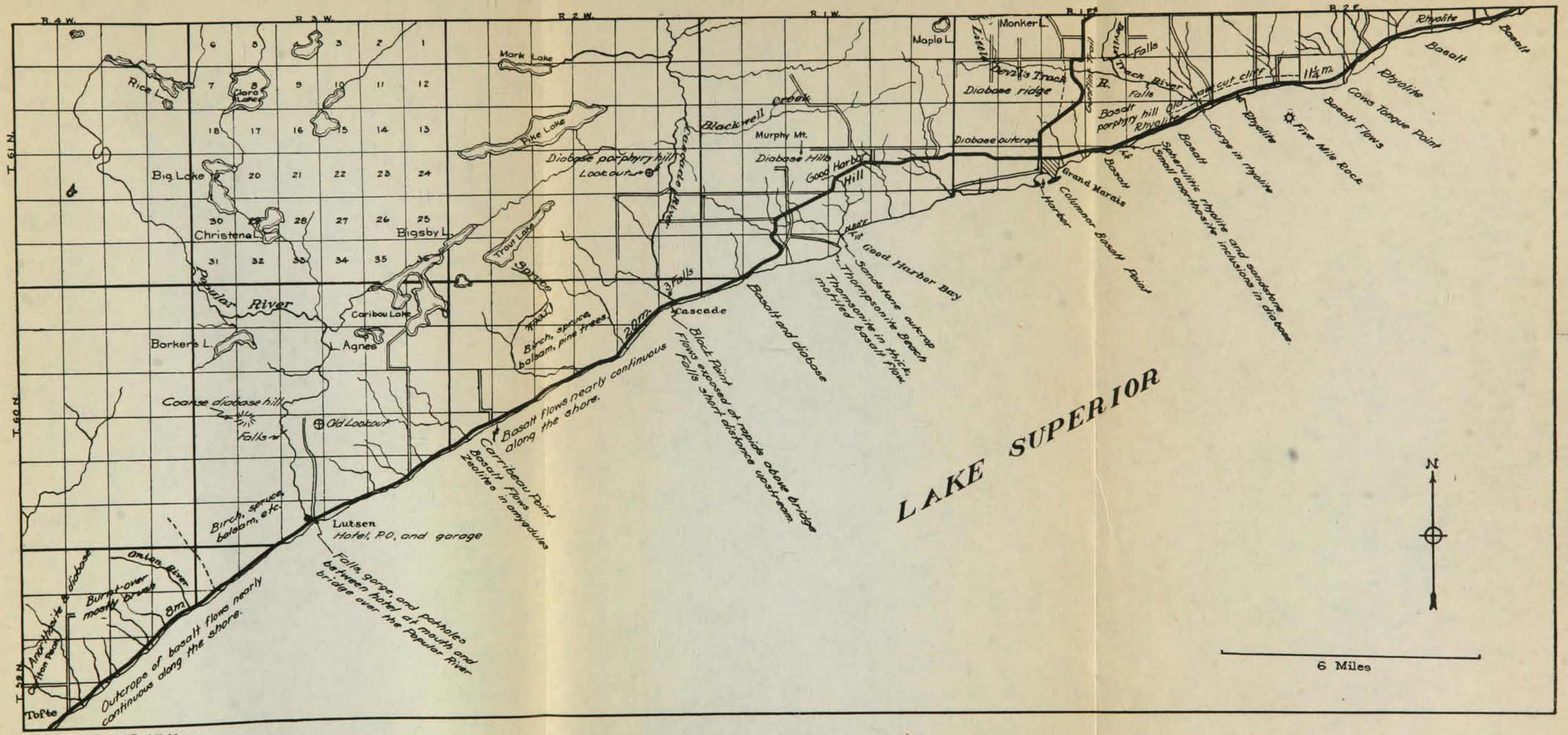
Highway No. 1 enters Cook County a short distance east of the Caribou River, where it continues on the terrace that extends from the Manitou River northeastward. The area near the shore has little relief. The three beaches or terraces are more marked here than at any other place along the coast. The road follows the intermediate beach. This section of the coast has been burnt over recently and has few trees of any size. At Two Island River the absence of a gorge is noteworthy. This is a result of the low and comparatively level land along the coast. The river receives its name from the two rocky islands near its mouth.

The lack of conspicuous hills along the coast east of Little Marais may be accounted for by the absence of the diabase intrusions such as those which stand up as prominent hills in the Beaver Bay region. No outcrops of rocks other than lava flows occur along the road northeast from Little Marais to Tofte. The road follows the shore closely to Cross River or Schroeder. The bridge over Cross River is just below a fall and cascade. Several potholes are exposed in the massive basalt flow which forms the falls. The river was given its name in 1864 by Thomas Clark, assistant state geologist, because of a cross which had been placed at its mouth in 1843 by Father Baraga, a Catholic missionary to the Indians.

Temperance River empties into Lake Superior only a little more than a mile east of the mouth of Cross River. It is one of the longer rivers of the north shore, as it starts near the west end of Brulé Lake in north central Cook County. The highway crosses the stream a short distance above its mouth, over a very narrow gorge. At the bridge are many examples of potholes which have grown together, forming the gorge. The rock consists of the usual basalt flows dipping toward the lake at an angle of about 12 degrees. The river was named by Clark in 1864. The name originated from the fact that the mouth of the river, unlike most of the other streams entering the lake, was not blocked by a bar!

Beyond the Temperance River the road continues to follow a prominent terrace or abandoned beach and the country is comparatively level, although to the east Carlton Peak looms up close to the lake.

Carlton Peak.—The name is applied to a conspicuous peak located a mile and one half inland from the lake directly behind the village of Tofte.



ROUTE MAP No. II

HIGHWAY NO. 1 ALONG THE NORTH SHORE OF LAKE SUPERIOR NEAR LUTSEN AND GRAND MARAIS. THE HIGHWAY IS INDICATED BY A HEAVY BLACK LINE.

It is composed of huge masses of anorthosite overlying, or embedded in diabase. The anorthosite is rounded off in the form peculiar to it and the peak is thus relatively flat on top. It rises 927 feet above the lake and forms one of the most conspicuous landmarks along shore, especially as it rises out of a comparatively level stretch of coast. It may be climbed with little difficulty and affords an excellent view. The foot of the peak may be reached by an auto road which extends north from the church at the east end of Tofte.

Tofte was named for a family of early settlers in the region whose name was derived from their former home in Norway. A store, garage, hotel, and a few houses comprise the village. A tourist park is maintained on the lake shore. A considerable area of cleared land around the village exposes the outlines of the main terrace on which the village is located. Just back of the group of farm buildings is an old shore line, and others may be noted up the slopes of Carlton Peak.

Tofte
Population 100

Northeast of Tofte the country is comparatively level near shore, to Onion River. Here the road enters a region, which has not been burned over recently, covered with a thick growth of birch, spruce, balsam, and other trees. The attractiveness of the country is greatly increased by this primeval covering of trees.

Lutsen is the name of a settlement centering around a resort at the mouth of the Poplar River. Between the resort and Highway No. 1, which is a short distance inland, the river flows through a gorge with many cascades and falls. Many potholes of various sizes are found near the stream level. A large one receives the water from one fall and at places others have joined to form the gorge. Footpaths follow along the gorge and make it easy of access.

From the Poplar River northeastward the road follows the main terrace and is close to the lake. The road is level and there are but few exposures of rock. The shore is a continuous outcrop of reddish basalt with many amygdaloidal beds showing excellent zeolite fillings. In the region of the Cascade River the exposures are of black massive diabase at places coarse enough to suggest an intrusive. The Cascade River is named from a series of beautiful falls found a short distance above the road, which crosses but a hundred feet above the mouth of the river.

About two miles northeast of Cascade River the road turns inland and gradually mounts to one of the higher terraces and follows this east nearly to Grand Marais. About a mile from the coast a road branches to the east, and runs south to Good Harbor Bay and Thompsonite Beach. (See Map No. 11.) This is the source of the thompsonites which are much used in Minnesota as semiprecious stones. Thompsonite is one of a group of minerals known as zeolites. Commonly these minerals assume

a radiating form and this with the hardness and desirable colors gives the thompsonites their value. The stones are found embedded in a massive diabase especially in the amygdaloidal portion near the top but are most easily gathered from the beach gravel where the diabase is broken up. Red sandstone and shale are also exposed in the bay in greater amounts than elsewhere along the Minnesota coast.

Grand Marais is the county seat and largest village in Cook County, and also is the largest settlement in northeastern Minnesota east of Two Harbors. The name, French for Great Marsh, was applied because of a marsh or swamp situated at the head of the bay and harbor. The harbor is the first one east of Two Harbors that is well protected. Tourist camp sites, hotels, garages, and stores provide everything the tourist may need. This is also the point where the Gunflint Trail leaves the coast on its way to Gunflint Lake on the northwest border of Cook County. (See page 88.) An excellent view of the town and harbor may be had from the hill which the trail ascends a mile out of town. The harbor at Grand Marais owes its existence to a hard columnar diabase which resisted the erosive power of the waves while the softer rock behind it was worn down. This is a fine example of the columnar structure found in certain igneous rocks. (See Plate VI A.) The structure is believed to be due to shrinkage on cooling, resulting in fractures which tend to form six-sided blocks or prisms. The best known example of this structure is the Giant's Causeway on the coast of Ireland.

Grand Marais
Population 443

From Grand Marais northeast, the road follows the upper of two abandoned beach levels and a line of bluffs to the north marks a still higher shore line. The rock along the road is a conspicuously red and dense rhyolite at places. Other types of rocks are interbedded with the rhyolite as may be seen along shore at many places. About two and a half miles east of Grand Marais is a rocky point of diabase and in the bay beyond is a dike of intrusive diabase with small anorthosite fragments. In this region the dip of the rocks varies and is locally steep indicating considerable disturbance by this intrusive. A short distance east of the point is a spherulitic rhyolite overlain by a sandstone. This interesting series of rocks may be found along shore where the old Highway No. 1 drops down to the lower beach near a group of houses. The Devil Track River flows into the lake about four miles east of Grand Marais. It is normally a small stream deeply entrenched in rhyolite flows, but in times of flood it becomes a torrent as is shown by the ruins of the large concrete bridge, wrecked in 1922. For nearly a mile beyond the river an unusually fine wave-cut cliff may be seen north of the road. This represents the last level which the lake maintained for any length of time before it dropped to its present stage. A mile northeast of Devil

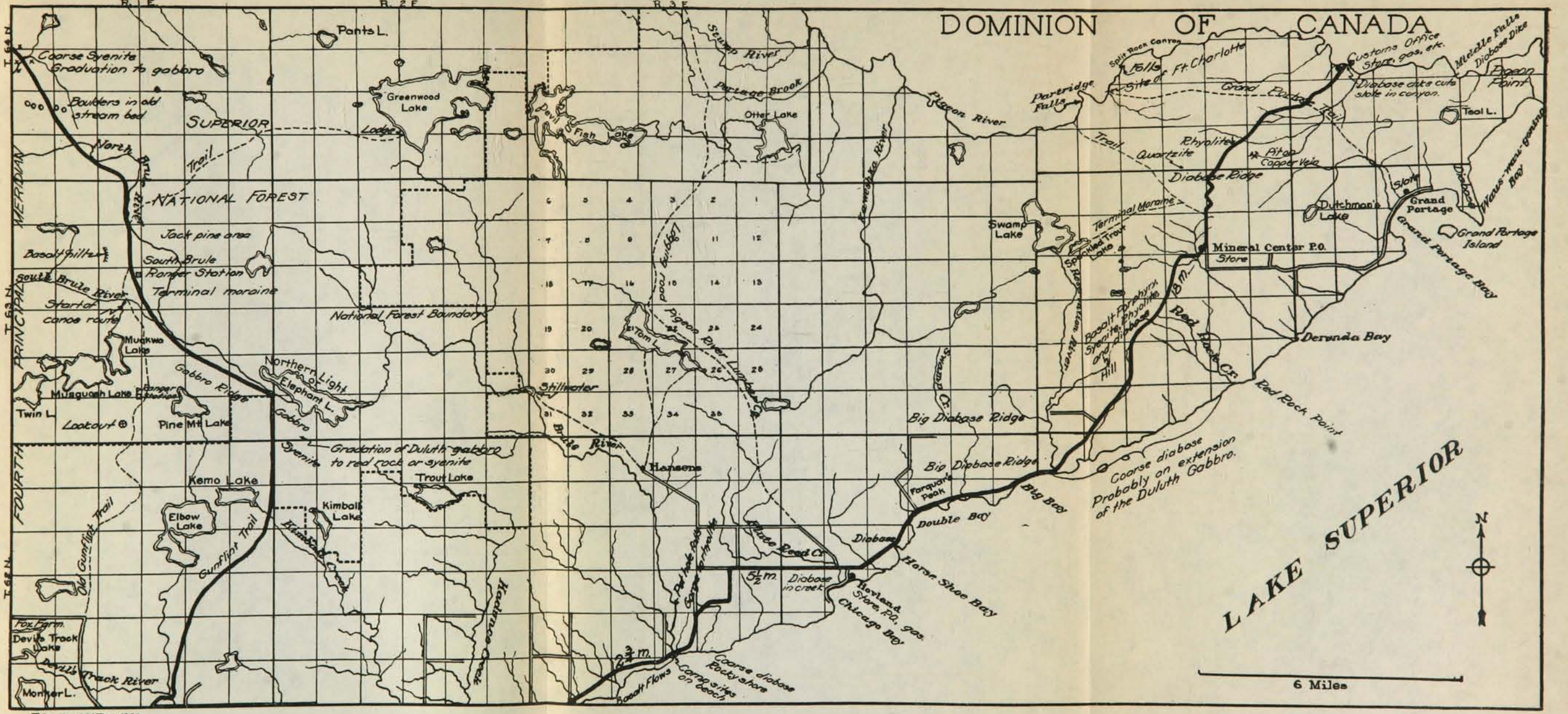
A. COLUMNAR JOINTING IN DIABASE, HARBOR AT GRAND MARAIS

B. ABANDONED SHORE LINE OF LAKE SUPERIOR, COOK COUNTY

Track River the red rocks give way to the usual basalt flows with amygdaloidal tops. These are well exposed at Cow Tongue Point. In the bay and along Kimball Creek rhyolites occur again. The rhyolites are easily broken and this probably accounts for the bay. The rhyolites continue for some distance to the east and beyond the rhyolites basalt flows extend to the Brulé River.

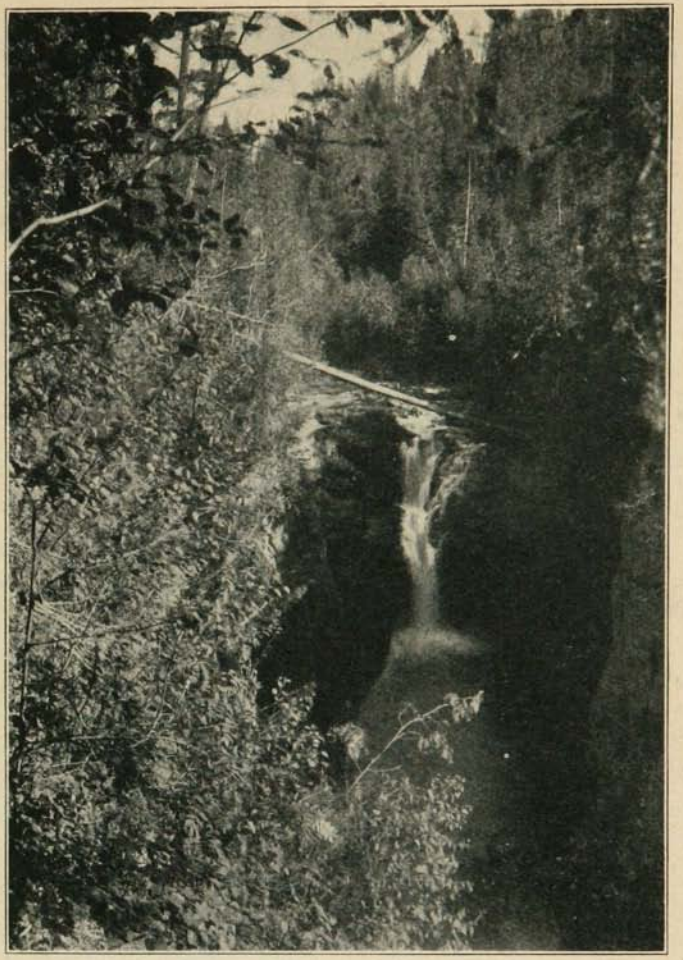
The Brulé River.—This is one of the largest streams along the Minnesota coast. The south branch has its source at the east end of Brulé Lake which, as has been previously noted, also feeds the Temperance River at its west end. This feature of two outlets is probably due to the rock basin in which the lake is located. Brulé is the French word meaning burnt, and was probably applied because of partly burned areas along the stream. The river flows in a comparatively shallow gorge where the road crosses it near the mouth; but a short distance above the bridge, high banks rise on either side and it is entrenched in a gorge hundreds of feet deep at places. For picturesque wildness the stream is not easily surpassed. A well-marked trail leads upstream from the bridge on the west side and furnishes an easy path up to the series of falls from one to one and one-half miles above the road. At the bridge are basalt flows, but upstream the gorge is entrenched mainly in rhyolites. Several cascades and one fall of about 20 feet are located along the gorge below the main fall, which is often termed the Pot Hole Falls. (See Plate VII.) This fall presents a most remarkable phenomenon. The total height is perhaps 70 feet and just above the brink the river is divided into two parts by a jutting rock mass. The eastern part, which is somewhat the smaller, plunges over the vertical cliff into the pool below, the larger part plunges into a huge pothole in the western channel just before reaching the crest of the bluff and the water disappears. Although the point where it issues cannot be seen, it must empty in the very deep pool below the falls as the river shows no diminution.

Northeast of the Brulé River the road turns inland for several miles but nears the shore again at Hovland. No outcrops are found along this stretch, but the road cuts through red, lake clay. From Hovland northeast outcrops, mostly of diabase, are abundant along the road. A big range of hills may be noted a mile or more inland. Farquar's Peak is the most conspicuous knob. This range is composed of gabbro or diabase of the type found at Duluth and Beaver Bay. Near Big Bay much rhyolite is visible along the road. On the west side of Big Bay rhyolite porphyry may be seen in contact with diabase where a rock ridge crosses the road. The diabase shows up conspicuously at the Reservation or Mesquatawanga River and eastward along the shore and road. This rock has been traced to the west and apparently is a part of the Duluth gabbro. Just beyond the river the road leaves the coast and it does not

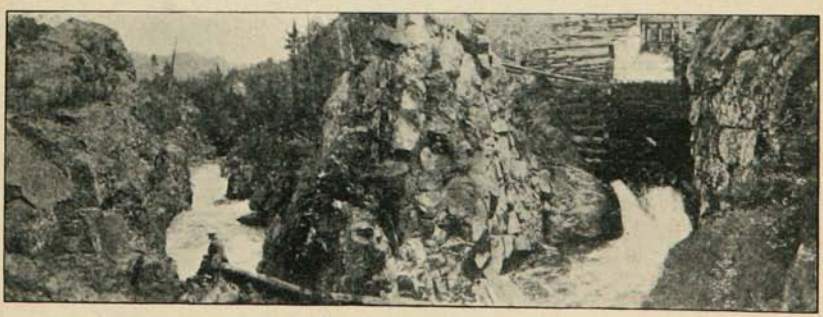


ROUTE MAP No 12

HIGHWAY NO. 1 ALONG THE NORTH SHORE OF LAKE SUPERIOR NEAR GRAND PORTAGE. THE HIGHWAY AND THE GUNFLINT TRAIL ARE INDICATED BY HEAVY BLACK LINES.



A. POT HOLE FALLS, BRULÉ RIVER, 1½ MILES ABOVE HIGHWAY NO. 1, MORE THAN HALF OF THE RIVER FLOWS INTO A MAMMOTH POT-HOLE HIDDEN BY THE FOLIAGE TO THE LEFT



B. HAIRPIN TURN IN SPLIT ROCK CANYON OF THE PIGEON RIVER

return to it again in Minnesota but crosses the Pigeon River into Canada several miles from the lake. The road ascends a long grade and is flanked by many bare gabbro hills.

About two and a half miles northeast of Reservation River the road bends around a conspicuous red hill which has exposures of a variety of rocks. Most of the main ridge near the road is basalt porphyry with large plagioclase phenocrysts often aggregated into starlike forms. The term glomeroporphyry has been applied to this type of rock. Cutting the basalt porphyry is a network of dikes. A fine-grained basalt dike cuts into the porphyry near the road on the south side. This dike is cut by red dikes. The smaller dikes which cooled quickly are rhyolite, but they were apparently formed from the same magma and at the same time as some large masses of coarse syenite near by. To the west and north the hills are composed mainly of coarse, red syenite and about 200 yards northwest of the road a gradation from syenite to coarse diabase or gabbro may be seen.

The road continues up grade nearly to Mineral Center where a more level area is settled and partly cleared. To the east are the high, practically mountainous ridges of the Grand Portage and Pigeon Point regions. These high ridges are formed by large sills and dikes of diabase intruded in the Rove slate (see page 14) which occupies an area along the border from Pigeon Point and Grand Portage Bay to Gunflint Lake. The slate is soft and has been eroded away leaving the hard, tough diabase standing high above it.

At Mineral Center a road extends south, and eastward from Highway No. 1 to the picturesque and historic village of Grand Portage which is located on Grand Portage Bay. (See Map No. 12.) This historic place has been mentioned in Chapter II as the first more or less permanent post established by white men within the area of Minnesota. Further details on the Grand Portage trail are given on the following page. The village is still the home of Indians and the surrounding area lies within a reservation which extends from the Reservation River to a line from Hat Point northwestward to the Pigeon River, a mile below the International Bridge. (See Map No. 12.) The bay is flanked by a very rugged country which adds to the scenic effect. Mount Josephine forms the divide between Grand Portage and Waus-wau-goning bays and rises to a height of 703 feet above the level of Lake Superior.

North of Mineral Center, Highway No. 1 follows the valleys and low points among the hills. This region is heavily timbered with spruce, balsam, birch, and pine, so that only occasional glimpses of the hills may be had. About five miles beyond Mineral Center and one and one-half miles from the border, the road crosses the Grand Portage trail. (See Map 12.) Brush has grown up in it now, so that it is only a footpath,

but its history is one of great interest. Highway No. 1 ends at the International Bridge over the Pigeon River. The river gorge at the bridge is mainly slate, but numerous diabase dikes cut the slate and are responsible for the several high falls along the course of the river some distance above and below the bridge. The road on the Canadian side follows roughly the course of the river and returns close to it at the Middle Falls. Beyond the Middle Falls the road angles away from the river, but a side road leads down to Pigeon Falls, the highest water fall in Minnesota. (See Figure 11.) A side trip to this point is well repaid.

THE GRAND PORTAGE[1]

The trail known as the Grand Portage crosses Highway No. 1 about a mile and a half from the Pigeon River. Long before white men visited the region, the Indians had utilized the trail as the best route connecting Lake Superior with the navigable portion of the Pigeon River. Its length is approximately nine miles. The numerous falls and rapids make the last twenty miles of the river impossible for navigation even by canoe.

The first white man to leave a record of the use of the portage was Sieur de la Verendrye, who crossed it in 1731, and referred to it as the Grand Portage. It is believed that a party of British traders visited the region in May, 1762, but due to the hostility of the Indians the occupation of the region was not permanent. By 1778 the portage was being utilized to a great extent and it was estimated that forty thousand pounds of goods were carried across every year. In 1778 the British sent a small detachment consisting of an officer and twelve soldiers to take charge of the area. The organization of the Northwest Company in 1783 opened up a period of great activity. A fort or stockade was built and several buildings were erected inside it at Grand Portage Bay. At the western end a stockade and other buildings, composing Fort Charlotte, were erected.

The land over which the portage ran became a part of the United States by virtue of the Treaty of 1783, but the British did not completely relinquish control until 1796. A new route was established by the Northwest Company with headquarters at Fort William, Ontario. This was some distance east of the mouth of the Pigeon River. From this time on the importance of the Grand Portage route decreased. By the Webster-Ashburton Treaty of 1842, it was provided that the portage should be free and open to the use of British, as well as American, citizens.

[1] Condensed from The story of Grand Portage, by Solon J. Buck, Minn. History Bull., vol. 5, p. 20, 1923.

During much of the period of great activity the Grand Portage was a footpath only and all goods were carried across in packs. In 1788 a request by the Northwest Company for a grant of land to enable it to construct a wagon road was refused, but at a somewhat later date the trail was improved so that ox carts could be used. The trail still shows the ruts formed by the wagons.

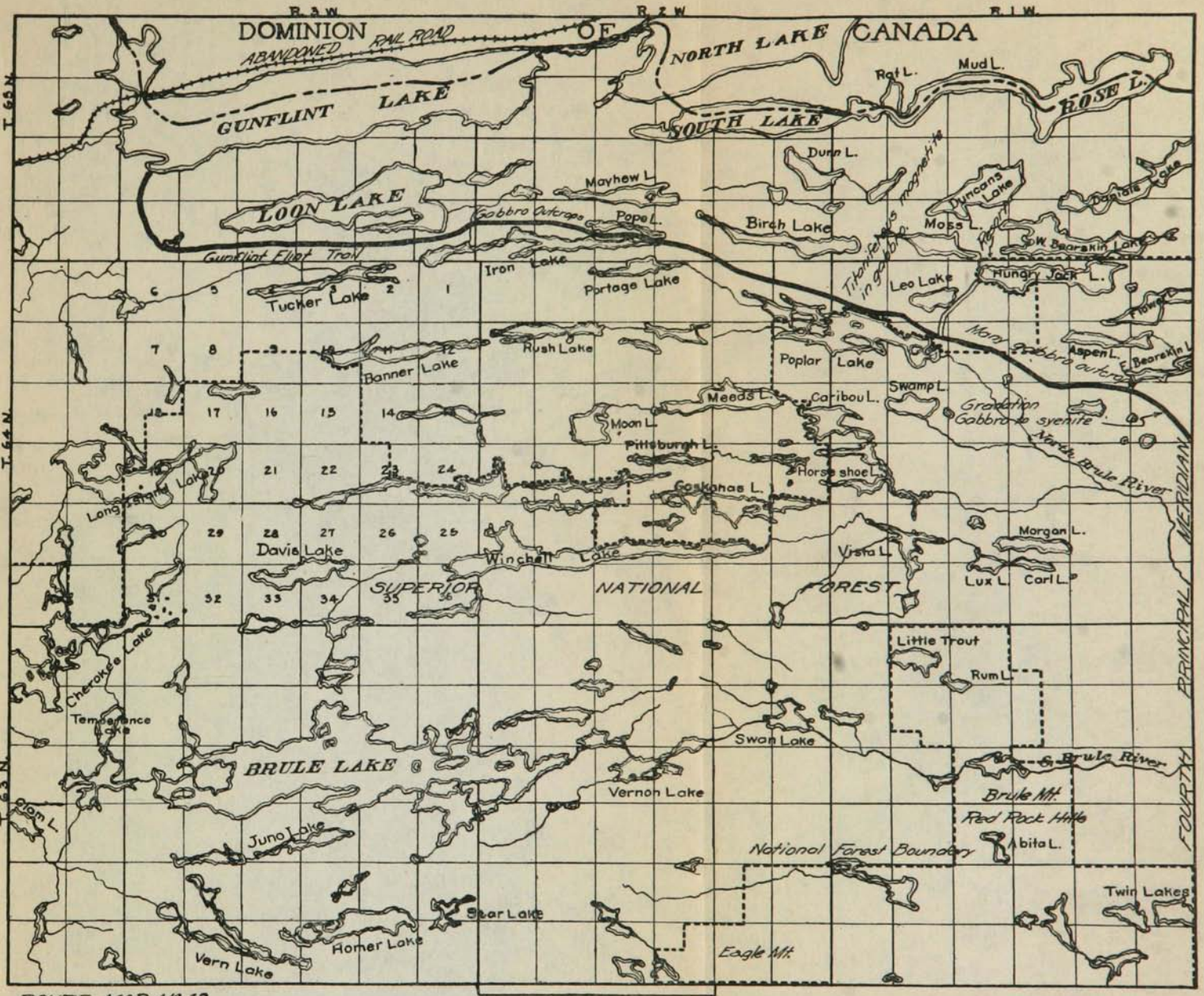
The Pigeon River in the general vicinity of Fort Charlotte is noted for its falls and deep gorge. Partridge Falls are about a mile and a half above the end of the portage and Split Rock Canyon and the Hairpin turn (see Plate VII B) are about a mile downstream from the portage. For those who enjoy a tramp, a trip over the Grand Portage Trail from the highway to the Pigeon River would make an ideal day. Sufficient time would be available for a visit to either, or possibly both, of the features mentioned above.

Route Map No. 12 shows the location of the various points mentioned above, including the Grand Portage Trail.

SIDE TRIP ON THE GUNFLINT TRAIL

As noted in the description of Grand Marais the Gunflint Trail starts at the town and follows a northerly route for twenty miles, thence runs westerly for about 20 miles more to Gunflint Lake. (See Maps 11, 12, and 13.) The auto road follows roughly the route of the old trail built when the Paulson iron mine just west of Gunflint Lake was being explored. With the exception of the first few miles the road passes through entirely unsettled country, much of which is within the Superior National Forest. (See Maps 12 and 13.) The drive is one of the most attractive found in the state. The northern half of the route touches many lakes from which canoe trips may be started. Canoes are available at Hungry Jack and Clearwater lakes. Camp sites are abundant all along the trail.

Leaving Grand Marais the road runs northward then eastward to ascend the hill at a convenient grade. A most picturesque bird's-eye view of the harbor and coast may be had from the road along the hill. About three miles from the town the road reaches the crest of the hill and drops to the valley of the Little Devil Track River in which there is a rolling area with much cleared land to the main Devil Track River. Outcrops of rhyolite and basalt flows and an intrusive diabase may be seen downstream from the bridge. The last settlement along the route is located around the small sawmill on the river. Beyond the river the road runs nearly due north for some distance over a fairly level area of gravel deposits. This is apparently the highest level of Lake Duluth (the glacial lake which occupied the Superior basin, see Figure 4, page 20), as within a mile or two glacial boulders become abundant and the gravel deposits are no longer conspicuous.



ROUTE MAP No 13.

NORTH END OF THE GUNFLINT TRAIL. THE TRAIL IS MARKED BY A HEAVY BLACK LINE.

The country has been burnt over at a comparatively recent time to a point about ten miles north of Grand Marais. Just at the north border of the burnt area is a fine group of white pines through which the highway passes. This gives some idea of what the region was like before it was devastated by logging operations and fires.

The country along this part of the road is gently sloping, but farther north large ridges appear. Twelve miles north of Grand Marais red angular blocks of syenite are abundant along the road and to the east a ridge of this type of rock is found across a swamp from the road. This continues to the prominent hill which lies between the road and Northern Light Lake. This hill is gabbro much like that at Duluth and, as at Duluth, there is a gradation from gabbro to syenite, so that it is difficult, if not impossible, to determine where to draw the line between the two. The syenite or red portion is lighter than the black basic gabbro and the separation of the two is believed to be due to the action of gravity while the rocks were still practically molten. This is one of a group of exposures that occur at intervals from the Reservation River to Duluth.

Northern Light Lake is shallow and swampy, unlike most Minnesota lakes, but it is a favorite feeding ground for moose, and the traveler who climbs the ridge above the road may be rewarded by a glimpse of one feeding on the reeds. They feed in the early evening, as a rule. The southern boundary of the Superior National Forest is marked at the road side near the lake.

At Northern Light Lake there is a change in the type of trees. South of the lake the region is covered with a second growth consisting mainly of birch and poplar, but to the north these are displaced by a thick stand of jack pines with only a little poplar and birch.

To the northward the road passes through a decidedly hilly country, but only the larger hills are composed of solid rock, as the road cuts usually show only gravel. The South Branch of the Brulé River is in a shallow valley in glacial drift at the bridge and the road continues over a hilly gravel and boulder country. A few miles farther on the North Branch of the Brulé River is entrenched in a pronounced valley in glacial drift.

Somewhat more than a mile north of the river the road passes over a very marked boulder bed. This is apparently an old stream channel and the outline of the valley may be seen on both sides of the road. Presumably the stream washed away the fine silt and pebbles, but was unable to move the large boulders which are chiefly of red syenite. Two miles north of the river is an outcrop of very coarse syenite over which the road passes and a creek exposes the same rock in its bed. The size of the individual crystals or grains of orthoclase and plagioclase feldspar as well as of augite, vary from small grains to those an inch across. This is a somewhat basic phase of the syenite and it continues in variable phases for over a mile, then grades to normal gabbro.

Some distance beyond here a road turns off to the east to East Bearskin Lake, where the United States Forest Service has provided camp sites. The main road turns more to the northwest. Outcrops of gabbro are abundant up to and beyond the point where a road branches off to the right to Hungry Jack Lake. The main road angles to the left and follows the north shore of Poplar Lake. Here is an interesting outcrop of titaniferous iron ore or magnetite in the gabbro. This may be seen in the rough blocks blasted out for the road, and north of the road is an outcrop consisting mostly of titaniferous magnetite. These iron deposits have segregated in the gabbro at many places from Poplar Lake westward for fifty miles, but are particularly abundant in the region just described. The material has no value as ore at present, as the titanium content makes it difficult to smelt. Outcrops of gabbro are nearly continuous for several miles along Poplar and Pope lakes and titaniferous magnetite may be found in several limited areas. Scattered gabbro outcrops continue to Loon Lake. Here many graywacke boulders or angular blocks indicate the presence of the Rove slate formation. (See pages 13 and 86.) This formation bounds the gabbro on the north, but it is not well exposed along the route. The road swings northward around the west end of Loon Lake and touches Gunflint Lake at its west end.

The series of lakes which have been noted are only a few of the great number in this region (see Map 13), but any of them will give the traveler an idea of their attractiveness. By canoe, scores of lakes of all sizes may be reached by routes marked and kept open by the Federal and State Forest Service. To enjoy fully this magnificent lake country this mode of travel is recommended; the thrill of gliding silently along in these surroundings under the power of one's own strokes cannot be described.

OLD HIGHWAY NO. 1, OR THE INLAND ROUTE

Previous to the construction of the new road along the lake shore from Two Harbors to Cross River, the route of Highway No. 1 turned inland at Cross River at the east end, and on the Stewart River near Two Harbors at the other end. (See page 71.) The road follows the uplands and is located at places as much as ten miles inland. Many streams offer excellent trout fishing and the country is of a somewhat different type from that close to Lake Superior. It is probable that many will wish to follow this route on the return trip and for this reason a few notes on this country are included.

From Cross River (see Route Map No. 10) the old road trends about due west nearly to the line between Cook and Lake counties. There it turns one-half mile south, then west again. For the first mile and a half the road ascends a steep grade and outcrops of basalt flows occur here and

there, while a fine view of the coast may be had to the south. The road then reaches a more nearly level country and hills cut off the view of the lake. This area along the road is burnt over to a point within a mile east of the county line. There the road passes into a partially cut-over forest, where a thick growth of maple and birch renders the country far more attractive than the burnt-over regions.

A mile west of the county line the road enters a big valley with high hills beyond. One of these hills is conspicuously white, which suggests that it is composed of anorthosite and this is found on examination to be the case. The road descends into the valley which is occupied by the Caribou River and its branches and thence turns southward to cross a big diabase ridge at a low spot. Thence it descends to the valley of one of the branches of the Manitou River. The village of Cramer is located where the road turns nearly due south. The country about Cramer is extremely rugged. High diabase ridges have been dissected by the swiftly flowing streams of the region. Beyond Cramer the road follows an irregular southwestward course to Finland and much of the way parallels the abandoned grade of the Duluth and Northern Minnesota Railway. The road crosses the Manitou River about two miles southwest of Cramer. Below the road the river has cut a deep gorge. Beyond the Manitou the road passes over a divide and runs not far from a branch of the Baptism River to Finland. Midway between Cramer and Finland the road swings northwestward away from the river and passes over a morainic hill covered with a heavy growth of hardwood. Near Finland the road swings back to the river. The rock outcrops consist mainly of diabase and basalt.

From Finland a branch road extends northwest to Ely on the Vermilion Iron Range. A good road also connects with Highway No. 1 at Little Marais.

From Finland south and westward the country is somewhat less rugged for about three miles, then becomes very rugged again and many conspicuous hills of anorthosite occur, mainly south and east of the road. They are especially numerous just east of Lax Lake. The road follows the north shore of Lax Lake, then turns south at its west end and continues nearly due south to the Beaver River two miles from Beaver Bay. The main rock of the region is the Beaver Bay diabase (see page 73), which with the anorthosite masses included in it, is responsible for the hills and ridges. Near the junction of the east and west branches of the Beaver River the road turns west and follows the gorge of the west branch. Then it gradually enters a more level country and crosses the west branch, where it flows in a shallow valley. From this point to Two Harbors the country near the road is not rugged and few outcrops are found. The road gradually seeks lower levels, and steep grades such as the one where the road turns inland at Cross River are no longer encountered.

CHAPTER VIII

FISH AND GAME ALONG HIGHWAY NO. 1[1]

THADDEUS SURBER
Game and Fish Department

SOUTH STATE LINE TO THE TWIN CITIES

The extreme southern part of Minnesota is so extensively cultivated that it is only in favored localities that fish and game still prevail in any quantities. Almost due east from Albert Lea near Spring Valley, on the many spring tributaries of the Root River, good brook trout and brown trout fishing is still to be found and this is true also of the smaller tributaries to the Whitewater River east of Rochester, which may be easily reached by a side trip from Owatonna. However, those desirous of fishing for small-mouthed bass can find good sport in the Red Cedar River near Austin; while good, big-mouthed bass fishing is found in many of the lakes around Albert Lea and to the northward of that point at Faribault. Small-mouthed bass may be obtained at certain times in the Straight River between Faribault and Owatonna, but the best fishing in that vicinity is for large-mouthed bass and pike in the many lakes to the west and northwest of Faribault, particularly Shields, French, and Tetonka lakes. It is possible to find good fishing for bass, crappies, and sunfish and, at times, for wall-eyed pike, in the Cannon River, particularly in that widening of the Cannon known as Byllesby Lake near Cannon Falls. A number of the little spring feeders of the Minnesota River about Savage and other points between Shakopee and St. Paul afford angling for brook and rainbow trout. In fact, about the only rainbow trout found in southern Minnesota occur in some of these small streams.

The game of the region south of the Twin Cities consists of bobwhite in the extreme southeastern counties of the state, with considerable numbers of prairie chickens in favored localities, but the best shooting is obtained during the fall migration of the ducks when excellent sport is furnished on the passes between many of the lakes from Albert Lea northward, particularly those lakes in the vicinity of Faribault. Cottontail rabbits and squirrels occur almost everywhere, but squirrels are more abundant in the country near the Mississippi River eastward of Highway No. 1, where the heavy timbered bluffs supply them necessary food and refuge.

[1] Most of the streams and lakes referred to will be found on the route maps (Nos. 1-13).

TWIN CITY REGION

In the vicinity of the Twin Cities, notwithstanding the tremendous drain made on the lakes, excellent fishing for bass, sunfish, and wall-eyed pike is still to be had within a few miles, notably at White Bear and Lake Minnetonka. A side trip to Stillwater can be taken and in addition to the species of fish taken in the vicinity of the Twin Cities, anglers will find good fishing for small-mouthed bass in the St. Croix River and Lake St. Croix, and will, at certain seasons, be able to procure great numbers of the white bass, one of the most beautiful of fresh water fishes.

Twin City anglers find the best of trout fishing on the Wisconsin side not far from Hudson; some of the smaller tributaries of the St. Croix abounding in brook and brown trout.

TWIN CITIES TO DULUTH

Traveling northward from the Twin Cities good fishing is to be had in almost every lake encountered along the highway but the best fishing is to be obtained by a side trip through the Chisago chain of lakes to Taylors Falls, though the fishing at Forest Lake is of the best. However, when one becomes satiated with bass and crappie fishing in the Chisago lakes he can proceed to Taylors Falls and there fish for the so-called muskellunge, and for wall-eyed pike, in the St. Croix River in that vicinity. Returning to the main highway and proceeding northward, the Snake River at Pine City, together with Cross Lake and Pokegama Lake, afford good sport for the angler, practically all the native game fishes being taken there. In this connection it is well to state that it is possible for the angler occasionally to obtain a sturgeon in Lake Pokegama.

At Hinckley a side trip should be made eastward into the State Game Refuge (it is five miles to the west boundary), not only for the purpose of seeing the deer and partridge, which occur there in such great numbers, but also to enjoy the trout fishing, which may be had in the eastern part of this refuge. Such creeks as Hay Creek, Bangs Brook (these are 24 and 20 miles, respectively, due east of Hinckley), and others, are noted trout streams and are steadily maintained as such by the state, providing good fishing for both brook and brown trout, but particularly for brook trout.

In the Kettle River, which forms the western boundary of the refuge, small-mouthed bass abound and will repay anyone for the inconvenience of a trip by boat or canoe down this river and the St. Croix back to Taylors Falls. Not only will the angler be well repaid in the small-mouth bass fishing but he will also, under favorable conditions, be able to procure a goodly number of wall-eyed pike.

Plate VIII

Common Game Fishes of Minnesota

In order from top to bottom

A. Brook trout. Speckled trout. *Salvelinus fontinalis.*

B. Rainbow trout. *Salmo irideus.*

C. Brown trout. German brown trout. *Salmo fario.*

D. Lake trout. Mackinaw trout. *Cristivomer namaycush.*

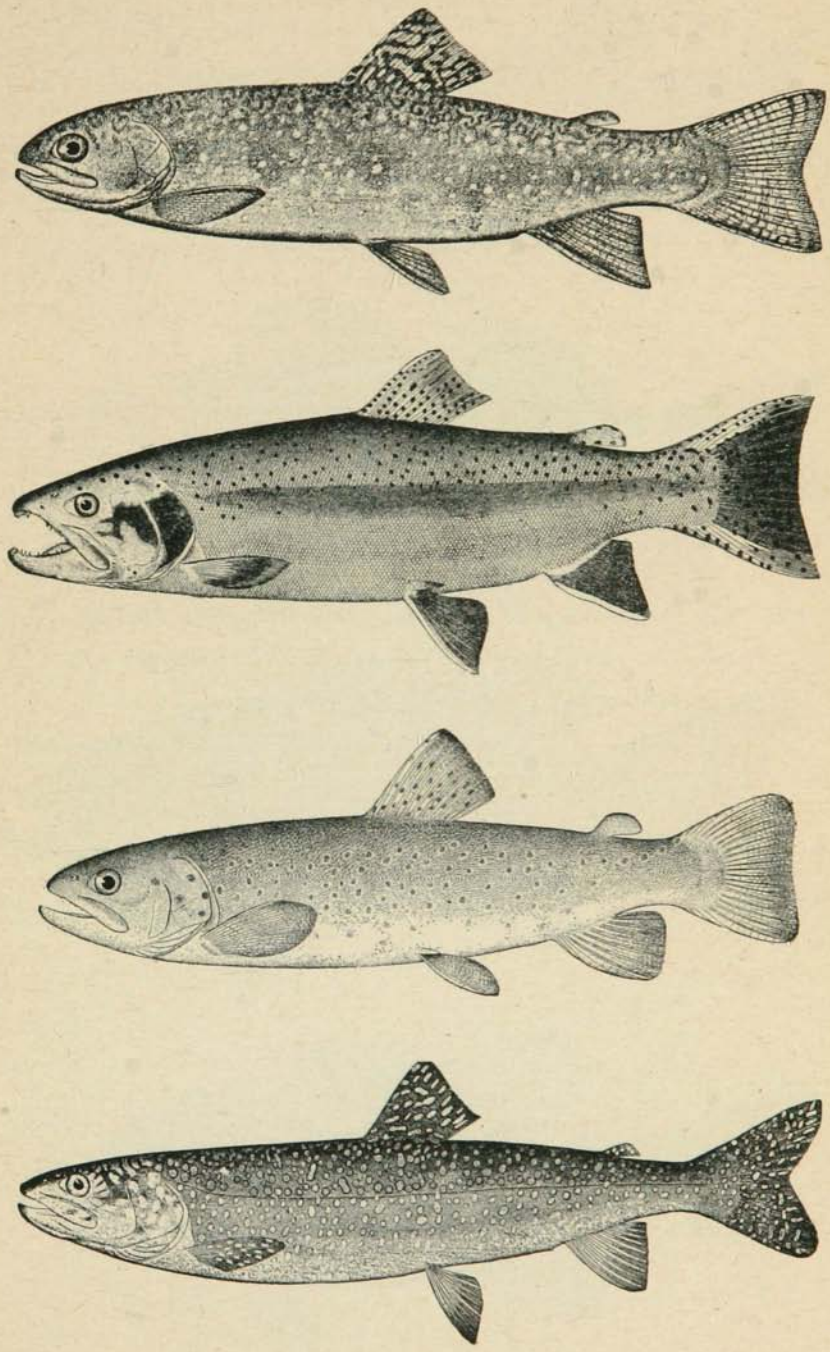


Plate IX

Common Game Fishes of Minnesota

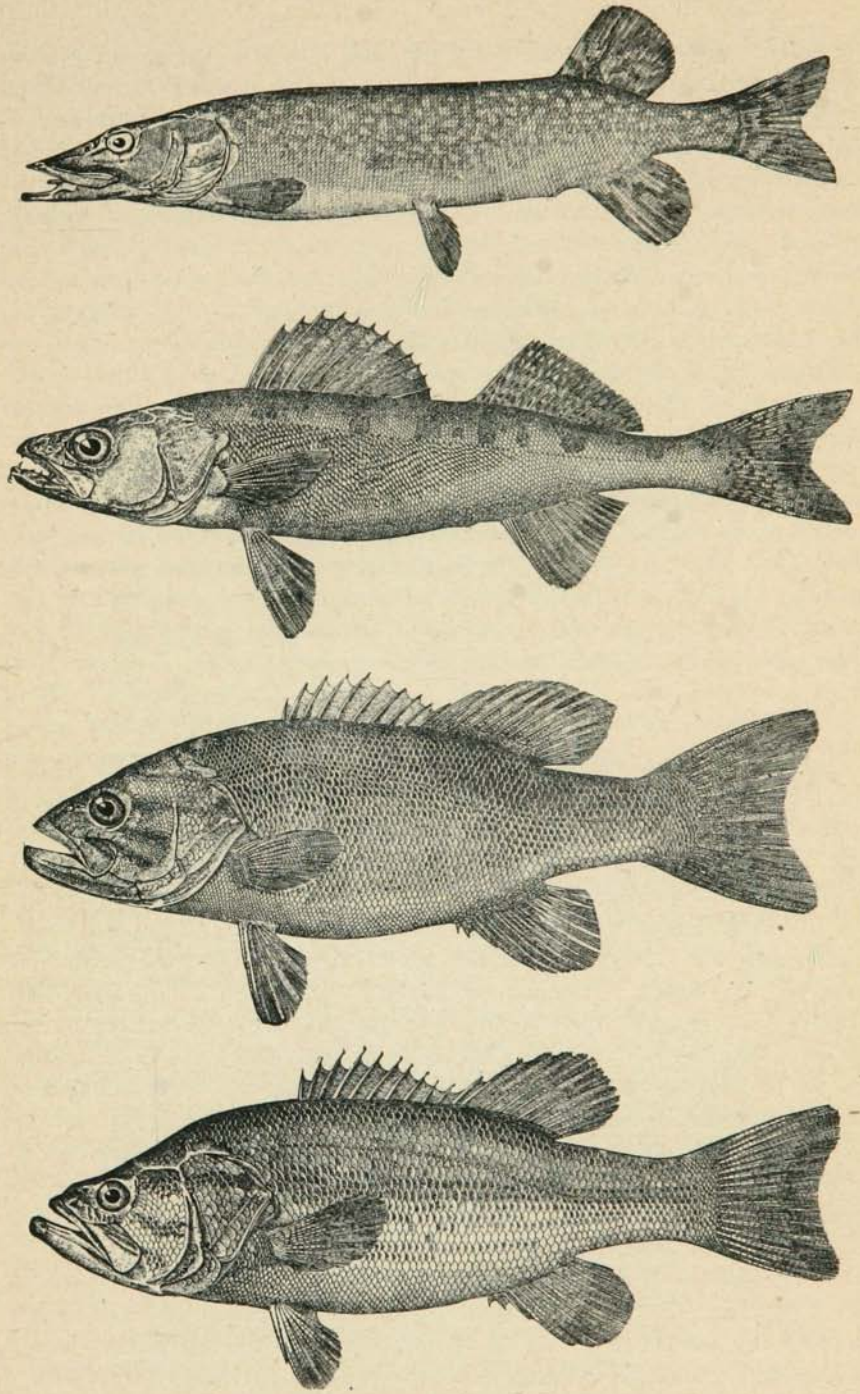
In order from top to bottom

A. Pike. Great northern pike. Northern pickerel. Jackfish. *Esox lucius.*

B. Pike-perch. Wall-eyed pike. Yellow pike. *Stizostedion vitreum.*

C. Small-mouthed bass. River bass. *Micropterus dolomieu.*

D. Large-mouthed bass. Black bass. Green bass. *Micropterus salmoides.*



In the territory between St. Paul and Hinckley there are prairie chickens and, in the timbered areas, a considerable number of partridge, or ruffed grouse, while to the northward of the Pine County Refuge in the country along the road leading from Sandstone eastward to the Wisconsin line, good deer hunting is always to be had in season. This is made possible because of the overflow from the Pine County Refuge which lies to the southward. With the exception of the pike and bass fishing in Sturgeon Lake, there is really very little fishing to be obtained in the country between Hinckley and Carlton, but to the eastward of the main highway in Pine and Carlton counties, probably more sharp-tailed grouse can be found at this time than in any other like area in the entire state of Minnesota. This country is very rolling, has been burned over repeatedly, and is now growing up in just that character of country that seems to supply these birds with the proper living conditions, and they appear literally by the thousands in this particular country, while partridge are found everywhere in the ravines and in the wooded swamps between Carlton and Duluth. A number of small spring-fed streams still support a goodly number of trout, which are being maintained by the state. Tributaries of the Moose River in Carlton County furnish excellent fishing for brook trout near the headwaters.

DULUTH AND THE NORTH SHORE OF LAKE SUPERIOR

In the vicinity of Duluth there are a number of lakes which afford good fishing for wall-eyed pike, but the streams from Duluth northeast to the Canadian border are essentially trout streams, while the lakes, unless stocked by the state or Federal government, very seldom have any bass in them. Lake fishing, therefore, is not nearly so popular as stream fishing until the deeper lakes in Cook County are reached, so that the prime consideration to the traveler is the condition of the streams north and eastward of Duluth. Streams near Duluth, or between Duluth and Two Harbors, are fished so persistently that they are not very inviting to the casual angler, but to the eastward of that city many first-class trout streams exist. It must be clearly understood, however, that the best trout fishing in any of these streams is not obtained in the immediate vicinity of the highway, but the angler, to obtain the best fishing, must penetrate two or three miles up or down stream, as the case may be, and be prepared to fight brush and mosquitoes. Results well repay the hardships of those who make these short excursions.

While all the streams crossed by the highway, with the exception of the Temperance River, afford more or less good angling for brook trout, the best streams between Two Harbors and Grand Marais are the Gooseberry, the east and west branches of the Beaver River near Beaver Bay,

the various branches of the Baptism, except the east branch at Finland, the Manitou River, and Nine Mile Creek near Cramer. On the headwaters of the Baptism and Manitou in particular, fine brook trout may be obtained, while an excursion down stream on both of these rivers will well repay the angler in the early part of the season, May and June. Passing eastward from Cramer the first stream encountered is the Caribou. Both above and below the road crossing, extending upward to the beaver dam on the headwaters, will be found good brook trout fishing. East of this the next stream encountered is the Two Island River, but this stream will have to be fished upstream for best results; the trout, while they occur in considerable numbers, are found most commonly in the upper stretches of this stream where the thickets are most dense along its banks. The next stream to be encountered is the Cross River, which both the old and new highways cross near its mouth; certain stretches of this stream provide good fishing, while other stretches do not. One of the best points at which to fish is just above and below where the Four Mile Creek empties into it from the west side, a few miles out of Schroeder. Just east of Schroeder the Temperance River is crossed but need, at the present time, be given little consideration by the casual traveler, as it is not a trout stream. However, the state has recently introduced in its waters small-mouthed bass and it is hoped that within a few years excellent fishing will be obtained for this species in this river. North and east of this comes the Onion River, a small stream which affords no fishing near its mouth, but its upper waters abound in brook trout. If one has the stamina to reach the upper waters he is usually repaid with a full creel.

The Poplar River, which enters Lake Superior at Lutsen, is fed by an enormous number of lakes and has so much dead water that during the summer months it affords no suitable waters for trout, except for two miles above Lutsen, where it is spring fed. At certain times good catches of trout, both brook and brown, are taken between Lutsen and the old mill three miles above, but this stream cannot be relied on for trout fishing. The lakes north of Lutsen furnish excellent angling for great northern pike and other fishes of that character and will repay a visit for the observation of big game which will be referred to later on. Some distance east of Lutsen and about four miles west of the Cascade, a small stream crosses the road which might be ignored by the casual as too small for consideration as a trout stream. This is known as Spruce Creek and is one of the best small streams along the north shore for brook trout, but is a very difficult stream to fish because it is small and passes through very heavy forest with dense undergrowth. The Cascade is next reached, being the last stream of any size between Two Harbors and Grand Marais. This is perhaps one of the most noted trout streams on the north shore

and affords very fine trout fishing to those who care to wade and fish the stream as it should be fished. The main highway crosses it at the mouth, but by going eastward to Good Harbor Hill schoolhouse and there taking the road back to the westward (see Map No. 11), the stream can be reached several miles above its mouth at a point where suitable camping grounds can be had, and the stream may be fished both above and below this road on the best trout waters. The upper Cascade becomes very warm during the summer and is therefore unsuitable for trout but some tributaries entering from the east, notably Blackwell or Bally Creek, and two other unnamed tributaries, abound in brook trout during the entire summer.

GUNFLINT TRAIL

At Grand Marais is opened up a vast territory of lakes to the northwestward along the Gunflint Trail, but before reaching these lakes two trout streams demand attention, both a short distance north of town. These are the Little Devils Track and Devils Track rivers. The Little Devils Track usually supplies good angling for brook trout to its source, but it is useless to expect good fishing in the Devils Track west of the Gunflint Trail because it is fed by large lakes a short distance above and these have a tendency to warm the water to such an extent that it makes the water higher up uninhabitable for trout. This is true also of the north and south branches of the Brulé which is crossed farther north. Both these streams, however, are being stocked with small-mouthed bass and it is hoped that in the near future these will prove great attractions to anglers. Nearly all of the lakes north of Grand Marais toward the Canadian border, as well as hundreds of lakes lying to the east and west, are very deep and most of them have great numbers of lake trout in their waters. If the season is a cold one these lake trout can be taken by ordinary angling in comparatively shallow water through almost all the summer, but if it is a hot season then angling at a greater depth is imperative if good catches are to be made. In all of these lakes the great northern pike abound. Being fish of superior quality, great fighters, and of great size, they afford most excellent sport to those who care to troll for them. Unfortunately no wall-eyed pike are found in any of the lakes or streams tributary to Lake Superior, but as soon as the watershed to the westward is crossed into waters flowing towards Rainy River and Hudson Bay, one finds the lakes teeming with wall-eyed pike. To reach this fishing it is necessary to take a canoe journey from the Gunflint Trail to Ely or International Falls. In the majority of these lakes whitefish are found, but these are not an angler's fish and are, therefore, given very little consideration at this time, though they are of great commercial value.

SHORE EAST OF GRAND MARAIS

Eastward of Grand Marais the first trout stream of any importance beyond the Devils Track River is Kimball Creek. The headwaters of Kimball Creek may be reached from the Gunflint Trail and fished downward, or one can walk from the main highway to the point above the falls and fish upstream, in either event with the assurance that fair catches will be made. This is also true of the next creek to the eastward, Kadunce Creek, which probably has its source in Trout Lake and is a very good stream for trout fishing above the falls. Both Kadunce and Kimball creeks may be reached by old trails, as before stated, leading in from the Gunflint Trail or by other trails leading up from Highway No. 1. After passing Kadunce Creek the next stream to be encountered is the Brulé River. As noted above the upper part of the Brulé is not suitable for trout, and attempts are now being made to stock it with small-mouthed bass, but for three or four miles above its mouth both the main stream and two or three small tributaries have a considerable number of trout, mostly brook trout, in their waters, and at times afford fairly good fishing. Passing eastward the next stream one encounters is Flute Reed Creek, which enters Lake Superior in Big Bay at Hovland. This stream has a number of tributaries, and while all are small a fair number of brook trout are found in favored pools and these at times afford fairly good fishing. Passing eastward towards the border one comes to the last trout stream of any importance at the Reservation River, which is crossed just east of Big Bay. This is one of few streams along the north shore where trout can pass upwards from Lake Superior to the headwaters without serious obstruction in the way of falls, and consequently the fishing is not only maintained from Reservation (or Swamp) Lake and Trout Lake, but is also materially assisted by migration from Lake Superior; therefore, the fishing is generally excellent throughout the season. However, the largest trout are usually caught in Trout Lake which can be reached by a blazed trail from Mile Post 30 between Big Bay and Mineral Center.

The Pigeon River on the international boundary line between Minnesota and Ontario is mainly interesting for its scenic features and not as a fish stream. Insurmountable falls at its mouth preclude the passing upward of trout from Lake Superior and it is doubted, even though it were stocked with trout, whether they could be maintained there because of the warm temperature of its waters during summer months. With the exception of the Reservation River, before mentioned, all the streams tributary to Lake Superior are inaccessible to trout from Lake Superior because of high falls at their mouths. This very fact at times creates good angling at the mouths of these rivers for such species as steelheads and brown trout and the fact that steelheads are caught about the mouths of all these

rivers demands attention from the enthusiastic angler because all realize that this one of the gamest fish which have been introduced from other sections of the United States. They are thriving in great numbers in Lake Superior and will no doubt in time become more important. During certain periods of the summer good lake trout fishing can be had in the very small bays along the north shore by trolling, notably in the bays at Grand Marais and at Grand Portage.

FIGURE 10. PIGEON FALLS

GAME ALONG THE NORTH SHORE

Game conditions north and east of Duluth in St. Louis, Lake, and Cook counties, are of as great importance as its fish life. The summer tourist by merely traveling along the road during the early part of the season will often run across deer, black bear, and moose, and if he should happen to be an enthusiastic photographer a side trip out of Cramer or Lutsen into the lake region near the Superior Game Refuge will well repay him in the chances he will have to secure pictures of moose and deer, particularly moose.

One of the most noted localities during the early summer months is the lake region which feeds the Poplar River directly north of Lutsen, and a lake to the westward of this known as Four Mile Lake on the old abandoned Duluth and Northern Minnesota Railway. It never fails to

give a photographer an opportunity to use a camera. Four Mile Lake, however, at the present time, is more or less isolated and can only be reached by a road leading north from the inland highway just east of the Caribou River, to the old railroad grade. From there it will be necessary to walk six or seven miles to the Four Mile ranger station in order to reach this moose territory. To the sportsmen the entire region has a great attraction. While the moose are now protected indefinitely, so far as hunting them is concerned, during the open season good deer hunting can be had anywhere between Two Harbors and the border. In the country north and east of Duluth, and north of Two Harbors, where it has been more or less settled and the country opened up, great numbers of sharp-tailed grouse and a few prairie chickens are found at the present time, while partridges are so numerous, even along the highway, that one often wonders where they all come from. Snowshoe rabbits are found everywhere throughout that region, but the cottontail rabbit has not as yet penetrated much beyond Duluth. It will do so when the country is more generally developed and the original forest removed.

CHAPTER IX

TREES AND PLANTS ALONG HIGHWAY NO. 1

C. OTTO ROSENDAHL AND FREDERIC K. BUTTERS

NOTE.—The figures refer to footnotes in which the common forms of plant life are listed for each type of vegetation.

That part of Minnesota lying near this highway as far north as Faribault was originally largely prairie country with scattered groves along the streams and to some extent on the uplands. It happens, however, that the course taken by Highway No. 1 lies very largely through these groves.

The country has of course been greatly modified by farming operations which have cleared away large parts of the natural woodland while at the same time the farmers have planted groves and woodlots in districts that were originally prairie. It is still possible, however, to distinguish the two types of country. The remnants of natural groves contain a great many oaks. The trees are of all ages and sizes and, where they have not been used for pastures, there is a considerable undergrowth of shrubs and native flowering herbs.[1] Planted woodlots show their origin by the regular

[1] The most common and characteristic shrubs of the groves and thickets along the highway from the southern boundary of the state to Faribault are: hazelnut—*Corylus americana*, wild plum—*Prunus americana*, choke cherry—*Prunus virginiana*, western crab apple—*Pyrus ioensis*, June berry—*Amelanchier canadense*, wild thorn—*Crataegus punctata*, glandular thorn—*Crataegus rotundifolia*, red raspberry—*Rubus strigosus*, blackberry—*Rubus alleghenicnsis*, wild rose—*Rosa blanda*, Missouri gooseberry—*Ribes gracile*, prickly gooseberry—*Ribes Cynosbati*, wild black currant—*Ribes floridum*, staghorn sumac—*Rhus typhina*, smooth sumac—*Rhus glabra*, poison ivy—*Rhus toxicodendron*, prickly ash—*Zanthoxylum americanum*, black haw—*Viburnum Lentago*, panicled dogwood—*Cornus paniculata*.

The following vines are also common: wild grape—*Vitis vulpina*, bittersweet—*Celastrus scandens*, woodbine or Virginia creeper—*Psedera quinquefolia*.

The herbaceous undergrowth is made up mostly of the following species arranged according to seasons. Spring flora: bloodroot—*Sanquinaria canadensis*, hepatica—*Hepatica acutiloba*, Dutchman's breeches—*Dicentra cucullaria*, wild ginger—*Asarum canadense*, bellwort—*Uvularia grandiflora*, meadow rue—*Thalictrum dioicum*, columbine—*Aquilegia canadensis*, jack-in-the-pulpit, *Arisaema triphyllum*, nodding wake-robin—*Trillium cernuum*, woolly blue violet—*Viola sororia*, yellow violet—*Viola pubescens*.

Summer flora: Wild crane's-bill—*Geranium maculatum*, Solomon's seal—*Polygonatum commutatum*, false Solomon's seal—*Smilacina racemosa*, *Smilacina stellata*, wild sarsaparilla—*Aralia nudicaulis*, yellow pimpernel—*Pimpinella integerrima*, sweet cicely—*Osmorhiza Claytoni*, yellow avens—*Geum strictum*, white avens—*Geum canadense*, hairy agrimony—*Agrimonia gryposepala*, showy tick-trefoil—*Desmodium canadense*, tall anemone—*Anemone virginiana*, snakeroot—*Sanicula marilandica*, American gromwell—*Lithospermum latifolium*, Virginia stickseed—*Lappula virginica*, hare figwort—*Scrophularia leporella*, Culver's-root—*Veronica virginica*, robin's plantain—*Erigeron pulchellus*, slender wild rye—*Elymus virginicus*, bottle-brush grass—*Asprella Hystrix*, panic grass—*Panicum latifolium*, brome grass—*Bromus purgans*.

Autumn flora: Stiff-haired sunflower—*Helianthus hirsutus*, wood sunflower—*Helianthus strumosus*, starved aster—*Aster lateriflorus*, arrow-leaved aster—*Aster sagittifolius*, blue wood-aster—*Aster cordifolius*, Canada goldenrod—*Solidago canadensis*, zigzag goldenrod—*Solidago latifolia*.

Roadside vegetation: Very little of the original flora remains along the roadsides on account of the natural conditions having been disturbed repeatedly. Its place has been taken by hardy and

arrangement and frequently by the uniform size of the trees. They almost never contain oaks, the commonest trees being cottonwoods, willows, and soft maples. They seldom have much undergrowth except the common introduced weeds, but in some of the older ones shrubs and flowers of the native forest have intruded. In practically no part of this region does one see any remnant of the old native upland prairie vegetation, except occasional fragments along railroad rights-of-way. In contrast to this the original vegetation of meadowlands and marshes[2] has remained almost unchanged except where drainage operations have transformed the character of the habitat.

From the southern boundary of the state as far north as Geneva Lake, the road passes through a succession of groves of the "oak-opening" type and to a considerable extent the original parklike type of landscape still persists. These groves are largely made up of scarlet oak, bur oak, American elm, and aspen. In the spring the landscape is beautified by such flowering trees and shrubs as wild plum, wild crabapple, black cherry, choke cherry, black haw, June berry, and thornapple.

Immediately to the east and southeast of Lake Geneva there was originally a vast marsh, which has been recently reclaimed by drainage operations and transformed into a very progressive farming community. In this marsh there were two small islands known respectively as Maple Island and Hickory Island. The former supports a heavy growth of hard maple, basswood, and elm such as is found much more commonly

mostly introduced weeds among which the following species are the most abundant and widespread: quack grass—*Agropyron repens*, squirreltail grass—*Hordeum jubatum*, lamb's quarters—*Chenopodium album*, pigweed—*Amaranthus retroflexus*, knot-grass—*Polygonum aviculare*, wild buckwheat—*Polygonum convolvulus*, artichoke—*Helianthus tuberosus*, common ragweed—*Ambrosia artemisiifolia*, giant ragweed—*Ambrosia trifida*, wild lettuce—*Lactuca canadensis*, prickly lettuce—*Lactuca scariola*, common plantain—*Plantago major*, nettle—*Urtica gracilis*, shepherd's-purse—*Capsella Bursa-pastoris*, pepper-grass—*Lepidium apetalum*, burdock—*Lappa minor*, bull thistle—*Cirsium lanceolatum*, field thistle—*Cirsium discolor*, cocklebur—*Xanthium canadense*, dandelion—*Taraxacum officinale* and *Taraxacum erythrospermum*.

[2] Marsh and meadow vegetation: The marsh vegetation is composed largely of sedges, bulrushes, and grasses of which the chief species are: bulrush—*Scirpus validus*, *Scirpus cyperinus*, *Scirpus atrovirens*, *Scirpus fluviatilis*, sedges—several species of *Carex* and *Cyperus*, spike rush—*Eleocharis palustris*, cotton grass—*Eriophorum*, slough grass—*Spartina Michauxii*, wild rice—*Zizania aquatica*, reed—*Phragmites communis*, together with the following: cat-tail—*Typha latifolia*, bur-reed—*Sparganium curycarpum*, water plantain—*Alisma plantago-aquatica*, arrowhead—*Sagittaria latifolia*, sweet flag—*Acorus calamus*.

The most characteristic and conspicuous plants of the moist meadows during late spring and early summer are: marsh marigold—*Caltha palustris*, saxifrage—*Saxifraga pennsylvanica*, violets—*Viola papilionacea*, blue flag—*Iris versicolor*, golden ragwort—*Senecio aureus*, water hemlock—*Cicuta maculata*, swamp milkweed—*Asclepias incarnata*, turk's-cap lily—*Lilium superbum*, Canada anemone—*Anemone canadensis*. Later in the season in the same situations appear blue vervain—*Verbena hastata*, joe-pye weed—*Eupatorium purpureum*, boneset—*Eupatorium perfoliatum*, false dragon head—*Physostegia virginiana*, turtle head—*Cheolne glabra*, sneeze weed—*Helenium autumuale*, asters—*Aster prenanthoides*, *Aster paniculatus*, *Aster punicens*, boltonia—*Boltonia asteroides*, beggar's ticks—*Bidens frondosa*, *Bidens cernua*, great lobelia—*Lobelia siphilitica*, and fringed gentian—*Gentiana crinita*.

in the central part of the state. Until the draining of the marsh it was so inaccessible that it remained practically in its original condition, but it is now being converted rapidly into farming land. The other island lying about a mile further south has been inhabited for many years, but it is still largely covered with forest made up in great part of shellbark hickory, the western outpost of this species in Minnesota.

In the vicinity of Ellendale the road passes through a region which was originally prairie but thence northward to Owatonna it traverses the groves bordering the east bank of the Straight River. In the vicinity of Owatonna black walnut occurs in several localities, the only places where it is to be seen in the vicinity of this highway.

From Owatonna to Faribault the highway runs partly through upland prairie to the west of the Straight River and partly through the belt of hardwood timber which follows that stream. This forest is denser on the east side of the river, but even along the highway it shows more diversity than the groves further south.

From Faribault to Northfield the highway traverses the southeast corner of the great forest tract known to the early settlers as the "Big Woods."[3] This was a solid forest of mixed hardwoods which extended from here westward to Mankato and northward to St. Cloud. The original timber has been largely cleared in the vicinity of the highway, but there are still to be seen individual trees of hard maple, basswood, white and red elm, and red oak. The fine growth of hard maples in the city of Northfield is particularly to be noted. In this region there was the rather unusual phenomenon of a heavy forest lying to the *westward* of the Cannon River, while to the *eastward* of this stream there were extensive open prairies beginning a mile or so back from the river banks. This phenomenon is correlated with the difference in soil and topography of the two regions—the geologically very recent glacial drift, and diversified topography to the west, and the much older and less broken country to the east.

[3] "Big Woods" vegetation. Shrubs: In addition to the shrubs already listed as characteristic of the groves and copses farther south there occur in this region: alternate-leaved dogwood—*Cornus alternifolia*, round-leaved dogwood—*Cornus circinata*, burning bush—*Euonymous atropurpureus*, Missouri gooseberry—*Ribes gracile*, iron wood—*Ostrya virginiana*, honeysuckle—*Lonicera dioica*.

Herbaceous undergrowth: Most of the woodland herbaceous plants already enumerated reappear throughout this region together with the following additions: Spring flora: dogtooth violet—*Erythronium albidum*, blue cohosh—*Caulophyllum thalictroides*, baneberry—*Actaea rubra*, blue phlox—*Phlox divaricata*, buttercup—*Ranunculus septentrionalis*, white violet—*Viola rugulosa*, bishop's cap—*Mitilla diphylla*, wild leek—*Allium tricocoum*, waterleaf—*Hydrophyllum virginicum*.

Summer vegetation: Solomon's seal—*Polygonatum commutatum*, *Polygonatum biflorum*, false Solomon's seal—*Smilacina racemosa*, black snakeroot—*Sanicula gregaria*, wild sarsaparilla—*Aralia nudicaulis*, spikenard—*Aralia racemosa*, yellow lady's slipper—*Cypripedium pubescens*, sweet cicely—*Osmorhiza Claytoni*, tick-trefoil—*Desmodium grandiflorum*, enchanter's nightshade—*Circaea lutetiana*, lop seed—*Phryma leptostachya*, maiden-hair fern—*Adiantum pedatum*, Virginia grape fern—*Botrychium virginianum*, lady fern—*Athyrium angustum*, shield fern—*Dryopteris spinulosa*.

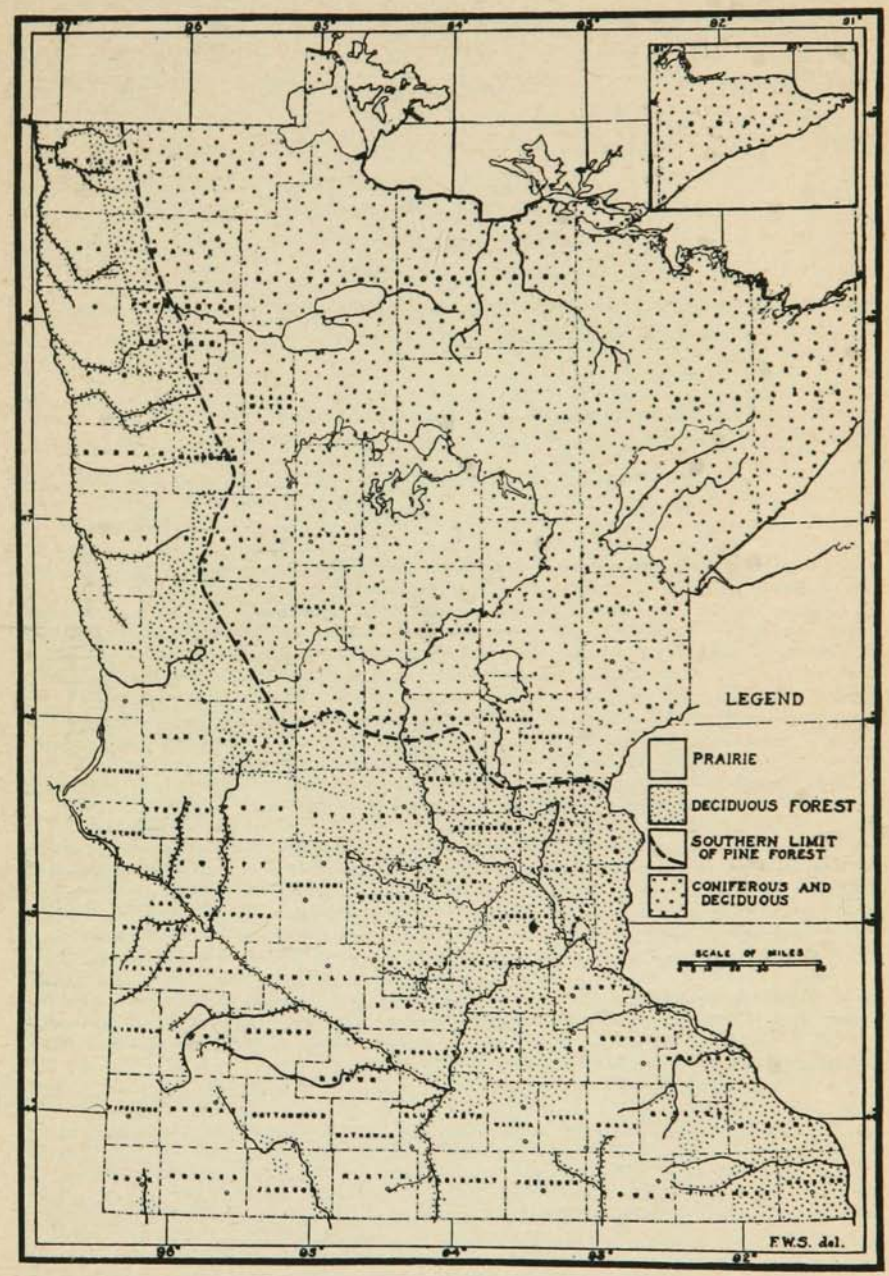


FIGURE 11. MAP OF MINNESOTA SHOWING DISTRIBUTION OF FOREST AND PRAIRIE. AFTER WARREN UPHAM AND FREDERIC K. BUTTERS

Leaving Northfield the highway almost immediately passes out of the eastern edge of the Big Woods and as soon as it turns northward away from the Cannon River it enters a tract of pure prairie which extends as far as Rosemount. Much of this is of course cultivated and has completely lost its original character, but on the sandstone knolls to the east of Castle Rock village there are still remnants of the original dry prairie vegetation.[4] Just north of Rosemount the highway passes abruptly from the prairie into a wooded district which originally extended unbroken to the Mississippi River. In contrast to the Big Woods this woodland is composed mostly of oaks and this is the first place along the highway where the white oak becomes an abundant tree.[5]

[4] Vegetation of the prairie and sandy ridges, Northfield to Rosemount. Remnants of the original prairie vegetation are found on the ungraded embankment along the roadside, on the sterile sandy ridges and particularly along the railroad right-of-way where conditions have not been disturbed.

Spring flora: pasque flower—*Anemone patens*, hoary puccoon—*Lithospermum canescens*, bird's foot violet—*Viola pedata*, prairie violet—*Viola pedatifida*, ground plum—*Astragalus caryocarpus*, lady's-tobacco—*Antennaria neglecta*, prairie crowfoot—*Ranunculus rhomboideus*, blue-eyed grass—*Sisyrinchium campestre*, purple avens—*Geum triflorum*, lousewort—*Pedicularis canadensis*, bastard toadflax—*Comandra umbellata*. Shrubs: prairie willow—*Salix humilis*, sand cherry—*Prunus pumila*.

Summer flora: hairy puccoon—*Lithospermum Gmelini*, alum root—*Heuchera hispida*, beard tongue, *Pentstemon grandiflorus*, golden meadow parsnip—*Zizia aurea*, western red lily—*Lilium philadelphicum*, larkspur—*Delphinium Penardi*, spiderwort—*Tradescantia bracteata*, anemone—*Anemone cylindrica*, spiked lobelia—*Lobelia spicata*, prairie phlox—*Phlox pilosa*, strawberry—*Fragaria virginiana*, tall cinquefoil—*Potentilla arguta*, butterfly weed—*Asclepias tuberosa*, wild bergamot—*Monarda fistulosa*, flowering spurge—*Euphorbia corollata*, purple prairie clover—*Petalostemum purpureum*, white prairie clover—*Petalostemum candidum*. Among the more common grasses are porcupine grass—*Stipa spartea*, koeleria—*Koeleria cristata*, wheat grass—*Agropyron tenerum*, June grass—*Poa pratensis*. The following shrubs are also frequent: prairie rose—*Rosa pratincola*, lead plant—*Amorpha canescens*, New Jersey tea—*Ceanothus americanus*, wolfberry—*Symphoricarpos occidentalis*.

Autumn flora: The late summer and autumn prairie vegetation is gay with asters, goldenrods, and other members of the thistle family among which the commonest species are: field goldenrod—*Solidago nemoralis*, Missouri goldenrod—*Solidago missouriensis*, Canada goldenrod—*Solidago canadensis*, stiff-leaved goldenrod—*Solidago rigida*, slender showy goldenrod—*Solidago rigidiuscula*, velvety goldenrod—*Solidago mollis*, sky-blue aster—*Aster azureus*, smooth aster—*Aster laevis*, silky aster—*Aster sericeus*, white wreath aster—*Aster multiflorus*, oxeye—*Heliopsis scabra*, black-eyed Susan—*Rudbeckia hirta*, cone flower—*Lepachys pinnata*, stiff sunflower—*Helianthus scaberrimus*, Maximilian's sunflower—*Helianthus Maximilianus*, prairie sunflower—*Helianthus petiolaris*, blazing star—*Liatris scariosa*, stiff tickseed—*Corcopsis palmata*, wild wormwood—*Artemisia caudata*, *Artemisia dracunculoides*, prairie sage—*Artemisia frigida*, Hill's thistle—*Cirsium Hillii*, western ragweed, *Ambrosia psilostachya*.

[5] Oak groves—Roesmount to St. Paul. The herbaceous vegetation is comparatively poor in the number of species, yet some of these occur in considerable abundance. The more characteristic plants in spring and early summer are: rue anemone—*Anemonella thalictroides*, wood anemone—*Anemone quinquefolia*, wild crane's-bill—*Geranium maculatum*, false lily-of-the-valley—*Maianthemum canadense*, false Solomon's seal—*Smilacina stellata*, meadow rue—*Thalictrum dioicum*, cream-colored vetchling—*Lathyrus ochroleucus*, shinleaf wintergreen—*Pyrola elliptica*, sessile-leaved bellwort—*Oakesia sessilifolia*, snakeroot—*Sanicula marilandica*, northern bedstraw—*Galium boreale*, wood sorrel—*Oxalis stricta*, hog peanut—*Amphicarpa monoica*.

These are succeeded later by: sunflowers—*Helianthus hirsutus*, *Helianthus strumosus*, Canada goldenrod—*Solidago canadensis*, early goldenrod—*Solidago juncea*, arrow-leaved aster—*Aster sagittifolius*, common blue wood-aster—*Aster cordifolius*, starved aster—*Aster lateriflorus*.

It is to be noted that from the southern boundary of the state to St. Paul there are no native evergreen trees along the route of the highway. The large specimens which are sometimes seen around old homesteads and in cemeteries were all planted by the early settlers, and the evergreen most commonly seen, the Norway spruce, is not even a native of North America. Indeed Minnesota, south of the Minnesota River, was naturally almost devoid of conifers. Red cedars, around some of the lakes and on the bluffs and some white pines in the broken country towards the Mississippi, were the only fairly common species.

On leaving St. Paul the highway traverses a region of oak groves and sandy prairie, and outposts of the northern coniferous forest are soon encountered in the form of small tamarack swamps. Around White Bear[6] and Bald Eagle lakes there are considerable belts of mixed hardwood forest but northward through Hugo the country is sandy prairie, interspersed with low marshy places. Extensive tamarack swamps can be seen to the west of Hugo.

[6] Herbaceous vegetation of the White Bear and Hugo region. Immediately north of White Bear village the road for a short distance passes through a patch of timber of the same character as the "Big Woods" with essentially the same type of undergrowth (see footnote No. 3). A short distance farther on the country becomes sandy and the land for the most part is cultivated or pastured so that the native vegetation is comparatively sparse. On embankments along the roadside or along the railroad right-of-way the following species are to be found.

Spring and early summer: pasque flower—*Anemone patens*, bird's-foot violet—*Viola pedata*, arrow-leaved violet—*Viola sagittata*, prairie violet—*Viola pedatifida*, hoary puccoon—*Lithospermum canescens*, hairy puccoon—*Lithospermum Gmelini*, lupine—*Lupinus perennis*, blue-eyed grass—*Sisyrinchium campestre*, lady's-tobacco—*Antennaria plantaginifolia*, purple avens—*Geum triflorum*, large-flowered beard tongue—*Pentstemon grandiflorus*, yellow vetchling—*Lathyrus ochroleucus*, spiderwort—*Tradescantia reflexa*, sheep sorrel—*Rumex acetosella*.

Midsummer flora: northern bedstraw—*Galium boreale*, butterfly weed—*Asclepias tuberosa*, dogbane—*Apocynum androsaemifolium*, purple prairie clover—*Petalostemum purpureum*, figwort—*Scrophularia leporella*, ground cherry—*Physalis lanceolata*, frost weed—*Helianthemum majus*, evening primrose—*Oenothera biennis*, daisy fleabane—*Erigeron ramosus*, bush clover—*Lespedeza capitata*, wild bergamot—*Monarda fistulosa*, giant hyssop—*Agastache foeniculum*.

The following grasses are also conspicuous: beard grass—*Andropogon furcatus*, nodding wild rye—*Elymus canadensis*, Indian grass—*Sorghastrum nutans*, sand dune grass—*Calamovilfa longifolia*, switch grass—*Panicum capillare*.

The following shrubs are also frequent: prairie rose—*Rosa pratincola*, dewberry—*Rubus villosus*, lead plant—*Amorpha canescens*, New Jersey tea—*Ceanothus americanus*, wolfberry—*Symphoricarpos occidentalis*.

Autumn vegetation: common sunflower—*Helianthus annus*, giant sunflower—*Helianthus grosse-serratus*, stiff-haired sunflower—*Helianthus scaberrimus*, oxeye—*Heliopsis scabra*, golden aster—*Chrysopsis villosa*, smooth aster—*Aster laevis*, sky-blue aster—*Aster azureus*, blazing star—*Liatris scariosa*, Canada goldenrod—*Solidago canadensis*, stiff-leaved goldenrod—*Solidago rigida*, showy goldenrod—*Solidago speciosa*, field goldenrod—*Solidago nemoralis*.

Roadside weeds: Throughout this sandy region the most common weeds are: ragweed—*Ambrosia artemisiifolia*, horseweed—*Erigeron canadense*, cocklebur—*Xanthium canadense*, squirreltail grass—*Hordeum jubatum*, knot-grass—*Polygonum aviculare*, sand bur—*Cenchrus tribuloides*, pepper-grass—*Lepedium apetalum*, tumbling mustard—*Sisymbrium altissimum*, cypress spurge—*Euphorbia cyparissias*, Russian thistle—*Salsola Kali*, umbrella wort—*Oxybaphus hirsutus*, carpet weed—*Mollugo verticillata*, spotted spurge—*Euphorbia maculata*, dock—*Rumex mexicanus*, bindweed—*Polygonum Convolvulus*, Canada thistle—*Cirsium arvense*, mullein—*Verbascum thapsus*, butter and eggs—*Linaria vulgaris*, bull thistle—*Cirsium lanceolatum*.

Plate X

Leaves of Common Minnesota Trees

1. Bur oak. *Quercus macrocarpa.*
2. Yellow birch. *Betula luta.*
3. Black oak. Northern pin oak. *Quercus ellipsoidalis.*
4. White oak. *Quercus alba.*
5. Paper birch. Canoe birch. *Betula papyrifera.*
6. Leaflets of American mountain ash. *Sorbus americana.*

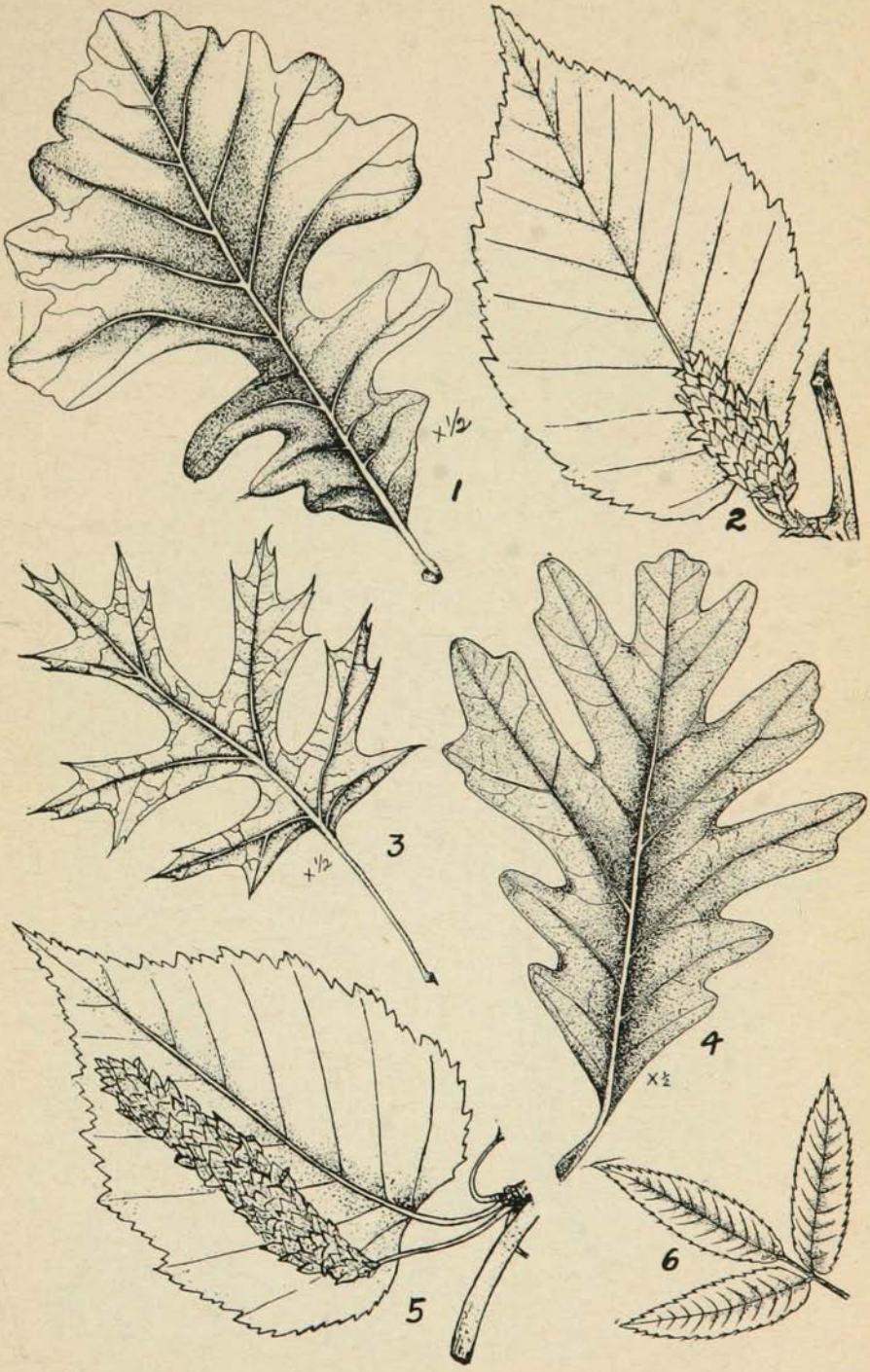

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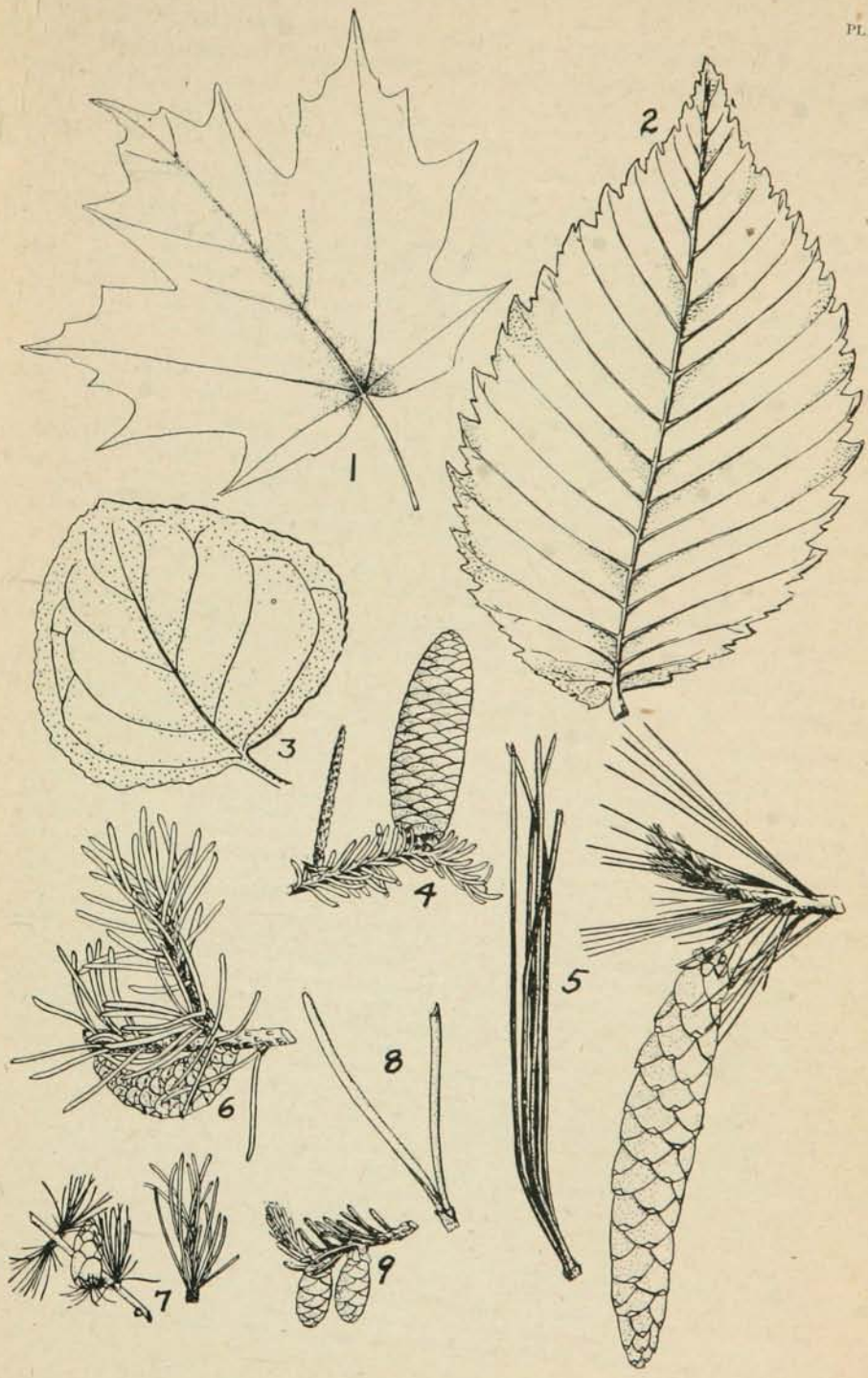
Plate XI

Leaves of Common Minnesota Trees

1. Sugar maple. Hard maple. *Acer saccharum.*
2. White elm. *Ulmus americana.*
3. Aspen. Quaking ash. *Populus tremuloides.*
4. Balsam fir. Balsam. *Abies balsama.*
5. White pine. *Pinus strobus.*
6. Jack pine. *Pinus banksiana.*
7. Tamarack. American larch. *Larix larcina.*
8. Leaf showing two fascicles of the jack pine.
9. Black spruce. *Picea mariana.*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North of Forest Lake the country becomes more sandy but is here covered[7] with a sparse growth of small scrubby oak. In marked con-

[7] From Forest Lake to Pine City. In the drier situations essentially the same types of herbaceous plants are encountered as farther south. Moist meadows, streams and ponds are more frequent and a different flora inhabits such situations.

Moist meadows. Spring and early summer: marsh marigold—*Caltha palustris,* sweet violet—*Viola pallens,* lance-leaved violet—*Viola lanceolata,* blue meadow violet—*Viola papilionacea,* holy grass—*Hierochloe odorata,* cotton grass—*Eriophorum viridi-carinatum,* meadow parsnip—*Zizia aurea,* painted cup (red and orange colored)—*Castilleja coccinea,* swamp saxifrage—*Saxifraga pennsylvanica,* star grass—*Hypoxis hirsuta,* marsh buttercup—*Ranunculus septentrionalis.*

Midsummer: blue flag—*Iris versicolor,* water hemlock—*Cicuta maculata,* turk's-cap lily—*Lilium superbum,* swamp milkweed—*Asclepias incarnata,* bulbous cress—*Cardamine bulbosa,* yellow water cress—*Radicula palustris,* meadow rue—*Thalictrum dasycarpum,* Canada anemone—*Anemone canadensis,* long-leaved stichwort—*Stellaria longifolia,* persicaria—*Polygonum pennsylvanicum,* great water dock—*Rumex britannica,* marsh cinquefoil—*Potentilla palustris,* purple milkwort—*Polygala sanguinea,* northern willow-herb—*Epilobium adenocaulon,* Virginia goat's-beard—*Krigia amplexicauli,* skullcap—*Scutellaria galericulata,* golden ragwort—*Senecio aureus,* tufted loosestrife—*Lysimachia thyrsiflora.*

The bulk of the vegetation of these meadows is made up of numerous species of sedges *(Carex),* rushes *(Juncus),* bulrushes *(Scirpus),* together with several grasses of which the principal species are fowl meadow grass—*Poa triflora,* nerved manna grass—*Glyceria nervata,* reed meadow grass—*Glyceria grandis,* rough hair-grass—*Agrostis hyemalis,* blue joint—*Calamagrostis canadensis,* marsh muhlenbergia—*Muhlenbergia racemosa,* and reed canary grass—*Phalaris arundinacea.*

Autumn flora: boneset—*Eupatorium perfoliatum,* blazing star—*Liatris pycnostachya,* willow aster—*Aster salicifolius,* panicled aster—*Aster paniculatus,* rush aster—*Aster junceus,* bog goldenrod—*Solidago uliginosa,* late goldenrod—*Solidago serotina,* giant sunflower—*Helianthus giganteus,* bur marigold—*Bidens laevis,* tall tickseed—*Bidens trichosperma,* swamp thistle—*Cirsium muticum,* gerardia—*Gerardia paupercula,* great lobelia—*Lobelia siphilitica,* marsh bell-flower—*Campanula aparanoides.*

Woods: South of Pine City the road crosses the line marking the southern limit of once continuous coniferous forest. Although the original forest has mainly disappeared, many of the herbaceous plants belonging to this type of forest are still to be found throughout the area. Among the more conspicuous upland woods species are: Large flowered wake-robin—*Trillium grandiflorum,* bunchberry—*Cornus canadensis,* yellow Clintonia—*Clintonia borealis,* twisted stalk—*Streptopus longipes,* round-lobed hepatica—*Hepatica americana,* sessile-leaved bellwort—*Oakesia sessilifolia,* wild sarsaparilla—*Aralia nudicaulis,* shinleaf wintergreen—*Pyrola secunda* and *Pyrola elliptica,* twin flower—*Linnaea borealis,* wood strawberry—*Fragaria americana.* The shrubby undergrowth consists mainly of: bush honeysuckle—*Diervilla Lonicera,* blueberry—*Vaccinium pennsylvanicum,* red raspberry—*Rubus strigosus,* beaked hazelnut—*Corylus rostrata,* pin cherry—*Prunus pennsylvanica,* honeysuckle—*Lonicera dioica,* snowberry—*Symphoricarpos racemosus,* June berry—*Amelanchier spicata,* downy arrowood—*Viburnum pubescens.*

Along roadside ditches, borders of moist meadows and in the swamps the characteristic shrubs are: dwarf birch—*Betula pumila,* red osier dogwood—*Cornus stolonifera,* shining willow—*Salix lucida,* pussy willow—*Salix discolor,* slender willow—*Salix petiolaris,* hoary willow—*Salix candida,* hoary alder—*Alnus incana,* high-bush cranberry—*Viburnum americanum,* dwarf alder—*Rhamnus alnifolia,* swamp red currant—*Ribes triste,* northern gooseberry—*Ribes oxyacanthoides,* dwarf raspberry—*Rubus triflorus,* black chokeberry—*Pyrus melanocarpa,* swamp fly honeysuckle—*Lonicera oblongifolia,* Labrador tea—*Ledum groenlandicum,* leatherleaf—*Chamaedaphne calyculata,* swamp laurel—*Kalmia polifolia,* wild rosemary—*Andromeda glaucophylla,* cranberry—*Vaccinium Oxycoccus,* creeping snowberry—*Chiogenes hispidula.*

The interesting herbaceous vegetation of the spruce-tamarack swamps, so characteristic of northeastern Minnesota still persists in the remnants of such swamps which are passed now and then from Hinckley northward towards Duluth. The more striking species of these habitats are: showy lady's slipper—*Cypripedium hirsutum,* mocassin flower—*Cypripedium acaule,* pitcher plant—*Sarracenia purpurea,* sundew—*Drosera rotundifolia,* grass pink—*Callopogon pulchellus,* round-leaved orchis—*Habenaria orbiculata,* rein orchis—*Habenaria hyperborea,* coralroot—*Corallorhiza trifida,* twayblade—*Listera cordata,* yellow Clintonia—*Clintonia borealis,* false lily-of-the-valley—*Maianthemum canadense,* bishop's cap—*Mitella nuda,* goldthread—*Coptis trifolia,* bog wintergreen—*Pyrola uliginosa,* sweet white violet—*Viola incognita,* one-flowered wintergreen—*Moneses uniflora,* star flower—*Trientalis americana,* oak fern—*Dryopteris Linnaeana,* marsh shield fern—*Dryopteris thelypteris,* crested shield fern—*Dryopteris cristata,* cinnamon fern—*Osmunda cinnamomea.*

trast to this rather sterile region is the district of rich soil and heavy forest lying a few miles to the eastward. A short side trip to the Chisago lakes and Taylors Falls takes one very quickly into some of the richest forest and lake land of the state.

Beyond Wyoming the same sandy country continues unabated until a few miles south of Pine City, where the heavy clay ridges carry a much finer type of forest. Here first appear large white pines scattered among the deciduous trees. Immediately north of Pine City, however, these signs of the northern woods completely disappear. This region was originally heavy pine forest but the Hinckley fire of 1894 destroyed the forest so completely that there are no remnants of the original vegetation and no more pines are seen until one reaches the Kettle River north of Sandstone. The country not now farmed has grown up to a second growth consisting mainly of aspen, white birch, and some oak interspersed with extensive open swamps or meadows. Owing to the considerable time since the destruction of the original forest much of the second growth has reached larger size than in the more recently burned-over districts further north.

After crossing the Kettle River[8] nine miles north of Sandstone, the highway traverses for a short distance a relatively unburned district which indicates the original type of vegetation of much of this region. Owing to the sandy nature of the country the principal trees are jack pine and Norway pine mingled with white birch and aspen. Along the road are considerable clumps of sweet fern. From here up to Carlton the country has been very extensively and repeatedly burned and the upland is largely covered with second growth of birch and aspen in various stages of development, much of it scarcely more than thickets. Throughout this area there are extensive swamps sometimes filled with tamarack mingled with spruce and fir and sometimes, where the fires have been severe, merely covered with tangled thickets of willows and alders.

At Carlton the climatic influence of Lake Superior begins to be definitely felt, and there are also several changes in the appearance of the vegetation due to the outcropping of hard rock. On the rocky ridges one

[8] In the vicinity of the Kettle River a flora typical of jack pine forests is encountered. The characteristic shrubby species are: blueberry—*Vaccinium pennsylvanicum*, sweet fern—*Myrica asplenifolia*, trailing arbutus—*Epigaea repens*, wintergreen—*Gaultheria procumbens*, bearberry—*Arctostaphylos Uva-Ursi*, snowberry—*Symphoricarpos racemosus*, hairy honeysuckle—*Lonicera hirsuta*, bush honeysuckle—*Diervilla Lonicera*, pipsissewa—*Chimaphila umbellata*.

The most common herbaceous plants are: bunchberry—*Cornus canadensis*, twin flower—*Linnaea borealis*, partridge berry—*Mitchella repens*, lady's tobacco—*Antennaria canadensis*, wood anemone—*Anemone quinquefolia*, large-leaved aster—*Aster macrophyllus*, clubmoss—*Lycopodium calvatum*, bracken fern—*Pteridium aquilinum*, northern bedstraw—*Galium boreale*, cow wheat—*Melampyron lineare*, shinleaf wintergreen—*Pyrola secunda*, mountain rice—*Oryzopsis asperifolia*, oat grass—*Danthonia spicata*.

frequently sees white spruce and white cedar while certain plants characteristic of the Lake Superior region appear in the undergrowth.[9] One of the most conspicuous of these is the flowering raspberry, a shrub with maple-like leaves and large white flowers. The fruit which is bright red and much flatter than the ordinary raspberry is edible but remarkably tasteless. In this vicinity blueberries are also abundant.

At the village of Thomson the highway enters the western extremity of Jay Cooke Park which embraces the rugged country of the lower valley of the St. Louis River. A short side trip down through the park reveals a rich and interesting vegetation on account of the great diversity of habitats. Although the chief elements belong to the northern coniferous forest there are a number of species more characteristic of the regions farther south, such as the staghorn sumac, the green ash, the ninebark among woody plants, and tall cinquefoil, alum root, daisy fleabane, and heal-all among the herbs. In the crevices of the rocky ledges grow in great profusion harebell, houstonia, violets, dwarf evening primrose, and the three-toothed cinquefoil. Most of the evergreen trees of the region occur within the park including the three native species of pine, and many kinds of broad-leaved trees are common such as birch, aspen, balsam poplar, alder, ash, and willows.

East of Duluth the influence of Lake Superior is fully felt. In general, vegetation is from a month to six weeks later in developing than it is around the Twin Cities and it has everywhere a very northern aspect. Two species of mountain ash form a conspicuous part of the forest growth with their large clusters of white flowers about July first, and their red berries in autumn. One of the most abundant trees is the white birch which here reaches great size. Of evergreens the white spruce, the jack

[9] On the rocky ledges in the vicinity of Thomson and along the St. Louis River in Jay Cooke Park the following species occur frequently: Shrubs: white-flowering raspberry—*Rubus parviflorus*, ninebark—*Physocarpus opulifolius*, blueberry—*Vaccinium pennsylvanicum*, June berry—*Amelanchier spicata*, pin cherry—*Prunus pennsylvanica*, beaked hazelnut—*Corylus rostrata*, green alder—*Alnus crispa*, bush honeysuckle—*Diervilla Lonicera*, red-berried elder—*Sambucus racemosa*, arrowwood—*Viburnum pubescens*, prickly rose—*Rosa acicularis*.

Herbs: pink corydalis—*Corydalis sempervirens*, harebell—*Campanula rotundifolia*, violet—*Viola arenaria*, three-toothed cinquefoil—*Potentilla tridentata*, Houstonia—*Houstonia longifolia*, dwarf evening primrose—*Oenothera pumila*, alum root—*Heuchera hispida*, heal-all—*Prunella vulgaris*, yarrow—*Achillea millefolium*, daisy fleabane—*Erigeron philadelphicus*.

The most abundant and conspicuous plant within the city limits of Duluth, covering vacant lots, the low ground along the harbor, and the rocky slopes to the summits and beyond is the meadow buttercup—*Ranunculus acris*. This plant is naturalized from Europe and thrives exceedingly well in the acid soil and cool air of the locality. The blooming season lasts for many weeks but is at its height in the latter part of June and early July when the slopes are a mass of bright yellow. The ragweeds, both the common and the giant forms occur in vacant lots and along roadsides in many parts of Duluth but do not occur along the north shore.

pine, and the balsam fir are now the most abundant species.[10] All the way from Duluth to the border the greater part of the original forest has been destroyed by fire at one time or another, but portions of the original vegetation are preserved, sometimes in the deep ravines and gorges of streams, sometimes on peninsulas and islands in the lake.[11] Three of

[10] The vegetation of the north shore, except for a number of introduced species belongs to the element known in America as the *northeastern coniferous forest.* On account of the uniformly cool climate which obtains throughout the summer a few far northern or arctic species have become established in the immediate vicinity of the lake. Because of the interest which this region has for the traveler a somewhat comprehensive list of the species occurring mostly within sight of the highway is appended.

Trees: white pine—*Pinus Strobus,* Norway pine—*Pinus resinosa,* jack pine—*Pinus Banksiana,* white spruce—*Picea canadensis,* black spruce—*Picea mariana,* white cedar—*Thuja occidentalis,* tamarack—*Larix laricina,* balsam fir—*Abies balsamea,* white birch—*Betula papyrifera,* yellow birch—*Betula lutea,* aspen—*Populus tremuloides,* balsam poplar—*Populus balsamifera,* black ash—*Fraxinus nigra,* green ash—*Fraxinus pennsylvanica,* red maple—*Acer rubrum,* sugar maple—*Acer saccharum* (rare), white elm—*Ulmus americana* (rare).

Shrubs: yew—*Taxus canadensis,* mountain ash—*Sorbus sitchensis,* American mountain ash—*Sorbus americana,* choke cherry—*Prunus virginiana,* pin cherry—*Prunus pennsylvanica,* ninebark—*Physocarpus opulifolius* var. *intermedius,* June berry—*Amelanchier spicata, Amelanchier oligocarpa,* white-flowered raspberry—*Rubus perviflorus,* red raspberry—*Rubus strigosus,* prickly rose—*Rosa acicularis,* beaked hazelnut—*Corylus rostrata,* dwarf birch—*Betula pumila,* sweet gale—*Myrica gale,* mountain maple—*Acer spicatum,* pussy willow—*Salix discolor,* Bailey's dogwood—*Cornus Baileyi,* red osier dogwood—*Cornus stolonifera,* Labrador tea—*Ledum groenlandicum,* leatherleaf—*Chamaedaphne calyculata,* blueberry—*Vaccinium pennsylvanicum, Vaccinium canadense,* small cranberry—*Vaccinium Oxycoccus,* American cranberry—*Vaccinium macrocarpon,* bush honeysuckle—*Diervilla Lonicera,* hairy honeysuckle—*Lonicera hirsuta,* American fly honeysuckle—*Lonicera canadensis,* speckled alder—*Alnus incana,* green alder—*Alnus crispa,* red-berried elder—*Sambucus racemosa,* squashberry—*Viburnum pauciflorum,* smooth gooseberry—*Ribes oxyacanthoides, Ribes saxosum,* swamp black currant—*Ribes lacustre,* swamp red currant—*Ribes triste,* skunk currant—*Ribes prostratum,* northern black currant—*Ribes hudsonianum.*

Herbaceous vegetation. (a) General upland forest: large-leaved aster—*Aster macrophyllus,* yellow Clintonia—*Clintonia borealis,* wild sarsaparilla—*Aralia nudicaulis,* twin flower—*Linnaea borealis,* star flower—*Trientalis americana,* false lily-of-the-valley—*Maianthemum canadense,* bishop's cap—*Mitella nuda,* bunchberry—*Cornus canadensis,* sweet-scented bedstraw—*Galium triflorum,* enchanter's nightshade—*Circaea alpina,* lungwort—*Mertensia paniculata,* club moss—*Lycopodium clavatum,* stiff club moss—*Lycopodium annotinum,* ground pine—*Lycopodium obscurum,* shinleaf—*Pyrola chlorantha,* colt's foot—*Petasites palmata,* spurred gentian—*Halenia deflexa,* wood strawberry—*Fragaria americana,* wood anemone—*Anemone quinquefolia,* dwarf raspberry—*Rubus triflorus.*

(b) On moist shady ledges of river gorges and along stream beds: baneberry—*Actaea rubra,* columbine—*Aquilegia canadensis,* twisted stalk—*Streptopus longipes, Streptopus amplexifolius,* blue violet—*Viola cucullaria,* sweet white violet—*Viola pallens,* lady fern—*Athyrium angustum,* brittle fern—*Cystopteris fragilis,* long beech fern—*Dryopteris Phegopteris,* rusty woodsia—*Woodsia ilvensis,* bishop's cap—*Mitella nuda.* A number of shade-loving grasses and sedges also occur in these habitats.

(c) On slopes, ridges and generally rocky open situations: fire weed—*Epilobium angustifolium,* everlasting—*Anaphalis margaritacea,* dogbane—*Apocynum androsaemifolium,* fringed black bindweed—*Polygonum cilinode,* blue vetch—*Vicia americana,* figwort—*Scrophularia leporella,* common polypody—*Polypodium vulgare,* yellow wood parsnip—*Zizia cordata,* oat grass—*Danthonia spicata,* June grass—*Poa pratensis,* melic grass—*Melica striata,* strawberry—*Fragaria americana,* bracken fern—*Pteridium aquilinum,* bristly sarsaparilla—*Aralia hispida.*

[11] Rocky Peninsula at Grand Marais. A number of species of infrequent or rare occurrence in Minnesota are found on this rocky point, viz.: mountain cranberry—*Vaccinium Vitis-Idaca,* primrose—*Primula mistassinica,* butterwort—*Pinguicula vulgaris,* false asphodel—*Tofieldia palustris,* shrubby cinquefoil—*Potentilla fruticosa,* three-toothed cinquefoil—*Potentilla tridentata,* tufted bulrush—*Scirpus caespitosus,* sedge—*Carex Halleri.*

the most conspicuous shrubs of this region are the mountain maple, the beaked hazelnut, and Bailey's dogwood. The common red raspberry and the bush honeysuckle are also extremely abundant in all burnt over tracts. After midsummer these same areas are adorned with the showy pink-purple spikes of the fireweed and the red fruit clusters of the bunchberry. Some distance beyond Hovland the highway passes through an extensive muskeg, a peat swamp covered with a shrubby vegetation consisting of plants of the heath family with here and there stunted tamarack and black spruce trees. The chief heaths in this muskeg are Labrador tea and leatherleaf, and in early July, when the former is in blossom, it presents a very beautiful sight. While muskegs are rather rare close to the lake shore they are an exceedingly common feature of the country lying further back beyond the crests of the hills. Thus the roads running from Duluth to the Iron Range pass through an almost continuous stretch of muskegs.

As the road ascends on to the high ground towards Mineral Center it enters a strip of exceedingly barren country. The original forest and most of the soil has been entirely destroyed by fire and as yet the only cover is a sparse growth of birch, aspen, pin cherry, jack pine, willows, raspberry bushes, and alders, with a scanty undergrowth of herbaceous plants. Just before reaching Mineral Center a range of low hills covered with heavy forest may be seen to the northward. The forest on these hills is a type very unusual for this part of the state being an almost pure growth of hard maple, with the corresponding undergrowth resembling that found in the deciduous forest farther south. This maple forest has been much used by the Indians as a source of maple sugar. North of Mineral Center extensive cedar-spruce swamps are encountered which for the most part have been untouched by fires. In fact this district up to the international boundary and beyond is either unburned or burned so long ago that the second growth has had opportunity to develop into a respectable forest, and it gives some idea of what all the region from Duluth eastward must once have been.

GLOSSARY

GLOSSARY OF GEOLOGIC TERMS

Agate. A banded or variegated chalcedonic quartz (SiO_2). Usually formed by deposition in layers.

Alluvium. Sediment deposited by streams.

Amygdaloid. A cellular igneous rock, usually formed at the top of a lava flow, whose cavities have been filled with minerals deposited from water solutions; the fillings are called amygdules. Basalt is the most common amygdaloidal rock

Anorthosite. A granular igneous rock composed mainly of labradorite feldspar; closely allied to gabbro and diabase in origin.

Basalt. A dense igneous rock of very dark color, whose fabric is so fine that the grains cannot be perceived with the eye, or, if seen, cannot be recognized. The basalts are of stony, but not of glassy, texture. The color varies from grayish black, greenish, to pure black. Basalts are most often formed by the solidification of lava flows.

Calcite. A common mineral consisting of calcium carbonate ($CaCO_3$). It is the chief constituent of limestone and marble, and is often found in veins and in altered rock. It is usually white to colorless, soft, and has rhombohedral cleavage.

Cleavage. A tendency of a mineral or rock to part along closely spaced parallel surfaces or planes.

Conglomerate. A rock formed from rounded pebbles, usually with more or less sand, mud, etc. A consolidated gravel.

Diabase. A heavy, dark, intrusive rock having the same composition as basalt, but on account of its slower cooling, it has a more crystalline texture. It corresponds closely in origin and composition with gabbro, but differs in texture. The plagioclase crystals are lath shaped and are embedded in olivine and augite.

Dike. A mass of igneous rock that has solidified in a fissure or crack in the earth's crust. Usually applied to a mass that cuts across the beds. (See Sill.)

Dolomite. Similar to limestone, but consists of calcium-magnesium carbonate [$(Ca\ Mg)\ CO_3$].

Drift (glacial drift). The rock fragments—soil, gravel, and silt—carried by a glacier. Drift includes the unassorted material known as till and deposits made by streams flowing from the glacier.

Extrusive rocks. See Igneous rocks.

Fault. A fracture in the earth's crust accompanied by movement of the rock on one side of the break past that on the other.

Feldspar. Aluminous silicates of potassium, sodium, or calcium. The main varieties are orthoclase, which is a potassium aluminum silicate, and plagioclase, which consists of nearly all possible mixtures of sodium and calcium aluminum silicates. They are the most abundant minerals found in igneous rocks and vary in color from white to red or dark, possess two cleavages, and are hard as steel.

Felsite. A light-colored dense rock composed mainly of feldspar, often with quartz, in which the crystallization is usually imperfect or obscure, giving a close-grained texture with conchoidal fracture and a flinty aspect.

Formation. A rock layer, or series of continuously deposited layers grouped together, regarded by the geologists as a unit for purposes of description and mapping. A formation is usually named from some place where it is exposed in its typical character, for example, St. Peter sandstone.

Fossil. The whole or any part of an animal or plant that has been preserved in the rocks or the impression left by an animal or plant. (See Plate I.) This preservation is invariably accompanied by a change in substance, and from some impressions the original substance has all been removed.

Gabbro. Dark gray to black granular igneous rock consisting chiefly of plagioclase and pyroxene. Gabbros are always formed by solidification of magma beneath the surface and that results in the granular texture. They correspond closely in chemical composition to the basalts and diabases.

Glacier. The moving part of an ice sheet which is formed by the packing of snow on land. The glacier moves forward by forces from within developed chiefly by the weight of the ice.

Granite. A crystalline igneous rock that has solidified slowly deep within the earth. Usually light colored and consists of feldspar, quartz, hornblende or mica, and lesser amounts of other minerals.

Graywacke. Sandstone-like rock of a prevailing gray color which, in addition to quartz and feldspar, contains fragments of many other minerals and rocks.

Ground moraine. All of the drift deposited beneath the advancing ice, and all deposited from the base of the ice when it melts.

Igneous rocks. Rocks formed by the cooling and solidification of a hot liquid material known as magma, that has originated at unknown depths within the earth. Those that have solidified beneath the surface are known as intrusive rocks. Those that have flowed out over the surface are known as effusive rocks, extrusive rocks, or lavas. The term volcanic rocks includes not only lavas, but bombs, pumice, tuff, volcanic ash, and other fragmental material thrown out from volcanoes.

Intrusive rocks. See Igneous rocks.

Joints. Fractures or fissures in rocks along which there has been little or no movement.

Limestone. A sedimentary rock composed of calcium carbonate ($CaCO_3$). Deposited mainly in the ocean by chemical and organic means. The calcium is carried to the ocean in solution in river waters.

Magma. Hot liquid material within the earth which on cooling crystallizes to form igneous rocks. During the cooling certain gases and liquids are probably given off. Those magmas that reach the surface form lavas.

Magnetite. Iron ore, iron oxide (Fe_3O_4), black, heavy, and strongly magnetite. Titaniferous magnetite is magnetite plus more or less ilmenite, and iron-titanium oxide ($FeTiO_3$).

Metamorphism. Any considerable change in rocks effected in the earth by heat, pressure, solutions, or gases. A common cause of the metamorphism is the intrusion into them of igneous rocks. Rocks that have been greatly changed in minerals or texture are termed metamorphic

Outcrop. That part of a rock that appears at the surface. The appearance of a rock at the surface or its projection above the soil.

Outwash plain. The broad sheet of débris spread out in front of a terminal moraine by the numerous streams which flow out from an ice sheet or glacier.

Phenocrysts. The large mineral crystals of a porphyry.

Porphyry. Any igneous rock in which certain crystal constituents are distinctly larger than the other constituents.

Quartz. A common mineral consisting of silica (SiO_2). It is hard, usually colorless, has no cleavage. Ordinarily sand and sandstone as well as quartzite are composed chiefly of this mineral.

Quartzite. A rock composed of sand grains cemented by silica into an extremely hard mass. The bond of the cement is normally so strong that the sand grains split when the rock is broken.

Rhyolite. Those dense igneous rocks of light color which correspond in composition to the granite. The rhyolite corresponds in texture to the basalts. They often form from lava flows but also from intrusions near the surface.

Sandstone. A sedimentary rock composed of grains of sand cemented together usually by silica, calcite, or iron oxide.

Sedimentary rocks. Rocks formed by the accumulation of sediment in water (aqueous deposits) or from air (eolian deposits). The sediment may consist of rock fragments or particles of various sizes (conglomerate, sand stone, shale); of remains or products of animals or plants (certain limestones and coal); of the product of chemical action or evaporation (salt, gypsum, etc.); or of mixtures of these materials. A characteristic feature of sedimentary deposits is a layered structure known as bedding or stratification. Each layer is a bed or stratum. Sedimentary beds as deposited lie flat or nearly flat except when they have been tilted by earth movements.

Shale. A sedimentary rock consisting of hardened thin layers of fine mud.

Sill. A mass of igneous rock intruded or forced between the layers of other rocks.

Slate. A rock that by pressure within the earth has acquired the property of splitting smoothly into thin plates. Slates are usually derived from shales and the cleavage is smoother and more regular than the splitting of schist along its grain.

Stratification. See Sedimentary rocks.

Strike. The direction along which an inclined rock layer would meet the earth's surface if that surface were level. The outcrop of a bed on a plain is coincident with its strike.

Syenite. A granular rock composed chiefly of feldspar and differing from granite mainly in the absence of quartz.

Syncline. An inverted arch or fold of bedded or layered rock. Suggestive in form of a canoe.

Terminal moraine. Thick accumulation of drift made at the end of a glacier or at the edge of an ice sheet, especially where its end or edge remained stationary, or nearly so, for a considerable time.

Terrace. A steplike bench on a hillside. Most terraces along rivers are remnants of valley bottoms formed when the streams flowed at higher levels. Other terraces have been formed by waves. Some terraces have been cut in solid rocks, others have been built up of sand and gravel, and still others have been partly cut and partly built up.

Thomsonite. One of a group of minerals known as the zeolites. It is a complex hydrous aluminum silicate of sodium and calcium. It usually has a radiating structure with variable colors which gives it an attractive pattern when polished. Occurs in cavities in amygdaloidal basalt, especially in the Lake Superior region.

Topography. The configuration of the earth's surface, or of a section of the surface, including its relief, the position of its streams, lakes, roads, cities, and so on.

Trap. A general term for igneous rocks of the darker basaltic type.

Unconformity. A break in the regular succession of sedimentary rocks, indicated by the fact that one bed rests on the eroded surface of one or more beds which may have a distinctly different dip from the bed above. An unconformity may indicate that the beds below it have at some time been raised above the sea, and have been eroded. In some places beds thousands of feet thick have been washed away before the land again became submerged and the first bed above the surface of unconformity was deposited. If beds of rock may be regarded as leaves in a volume of geologic history, an unconformity marks a gap in the record.

Weathering. The group of processes, such as the chemical action of air and rain water and of plants and bacteria, and the mechanical action of changes in temperature, whereby rocks on exposure change in character, decay, and finally crumble into soil.

INDEX