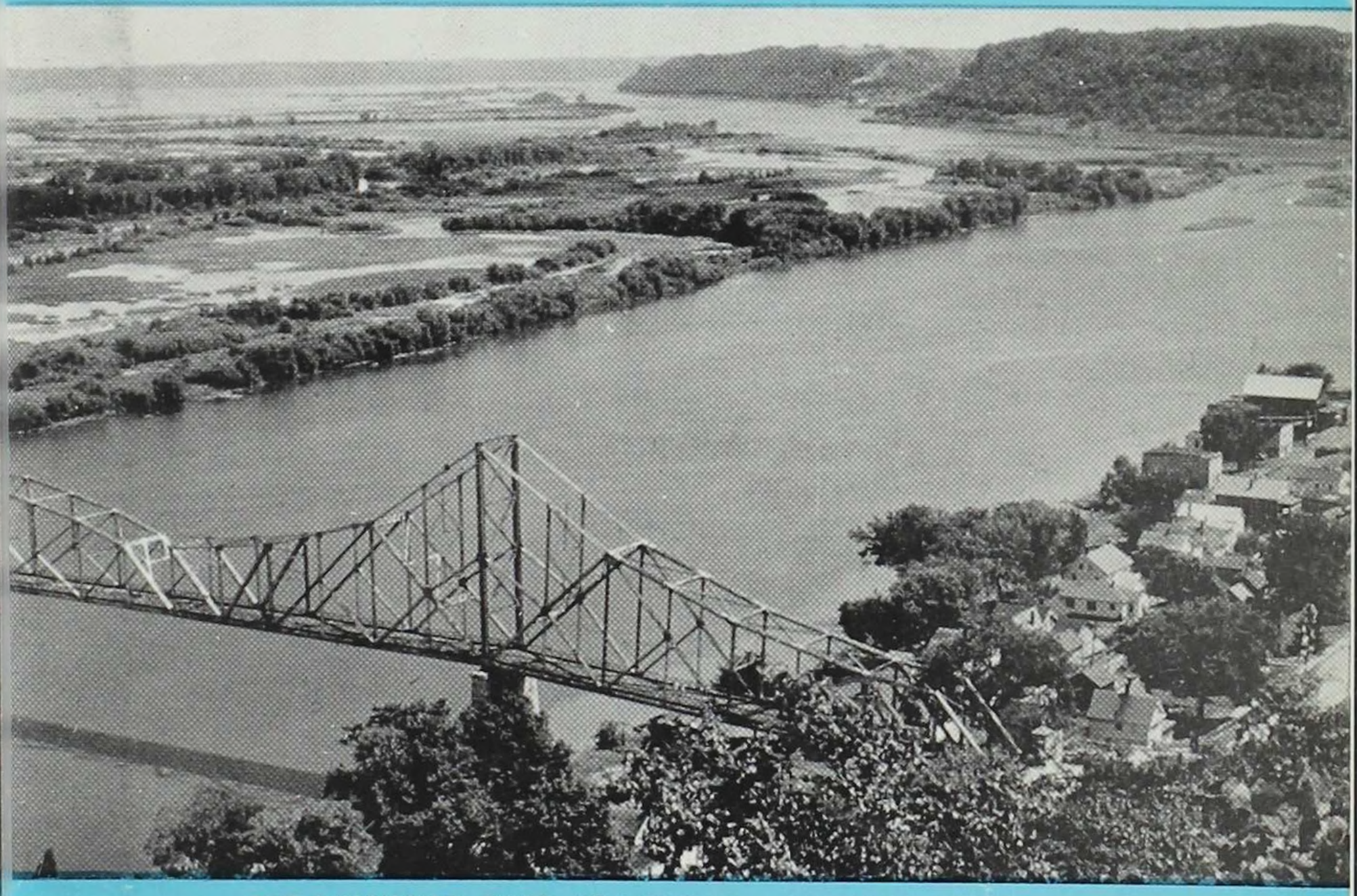
The PALIMPSEST



THE MISSISSIPPI RIVER AT LANSING — LOOKING SOUTH

The Mississippi River in Glacial Times

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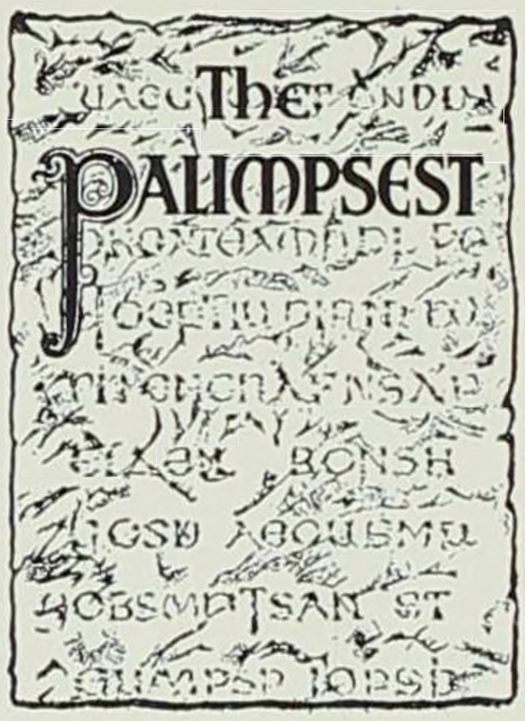

The Meaning of Palimpsest

In early times a palimpsest was a parchment or other material from which one or more writings had been erased to give room for later records. But the erasures were not always complete; and so it became the fascinating task of scholars not only to translate the later records but also to reconstruct the original writings by deciphering the dim fragments of letters partly erased and partly covered by subsequent texts.

The history of Iowa may be likened to a palimpsest which holds the record of successive generations. To decipher these records of the past, reconstruct them, and tell the stories which they contain is the task of those who write history.

Contents

Illustrations

All illustrations, unless otherwise noted, are in possession of the State Historical Society of Iowa. The picture on the back cover is a view of the lock and dam at Keokuk by Anschutz.

Author

Dr. Arthur C. Trowbridge was Professor and then Head of the Department of Geology of the State University of Iowa and is now Professor Emeritus. He served as Director of the Iowa Geological Survey from 1934 to 1947. Among other investigations, he has devoted many years to the study of the Mississippi..

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THE PALIMPSEST

EDITED BY WILLIAM J. PETERSEN

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Facts and Principles of Glaciation

Did you know that at one time the Mississippi River flowed in a course that lay west of Mason City and Iowa City? That at another time the River flowed eastward from near the present site of Clinton to the Illinois River? That at still another time it flowed into and out of a lake that occupied the lower portions of the valleys of the Iowa and Cedar rivers including the site of Iowa City? That the rapids and gorge at Keokuk are thousands of years older than the Rock Island Rapids? That these and other changes in the course of the River were caused by the advance and retreat of great glacial ice sheets?

The history of the Mississippi, especially in Iowa and adjacent Illinois and Wisconsin, can be traced through the relentless march of gigantic ice sheets.

Continental Ice Sheets

About 120 years ago it was discovered that during the most recent division of geologic time (called the Pleistocene epoch) great sheets of ice

covered large areas in northern Europe, where such ice sheets do not exist today. Features known to have been caused by ice near the ends of existing glaciers in the Swiss Alps were found to be distributed widely over the surface. Soon thereafter similar features that had been known to exist in northern United States and Canada were ascribed also to the work of glaciers. These evidences of former glaciation are so clear that what was known a century ago as the "Glacial Theory" is now considered a fact. The glaciated and unglaciated parts of North America are shown on the map on the inside back cover.

Where and when more snow falls each winter than is melted the following summer, ice that results from compaction of snow accumulates. When the mass of ice is thick enough it spreads slowly out from the area of accumulation. The rate of motion of the ice exceeds the rate of melting at the ice border, and the ice edge moves slowly forward. When and if ice motion is balanced by melting, the ice border remains stationary. If the climate then so changes that less snow falls in the area of accumulation, or the border ice melts faster, or both, melting comes to exceed motion and the ice edge retreats.

After a continental ice sheet has advanced and retreated, a *drift sheet* is left covering the surface. That part of the drift that is deposited directly from the ice is not sorted and contains

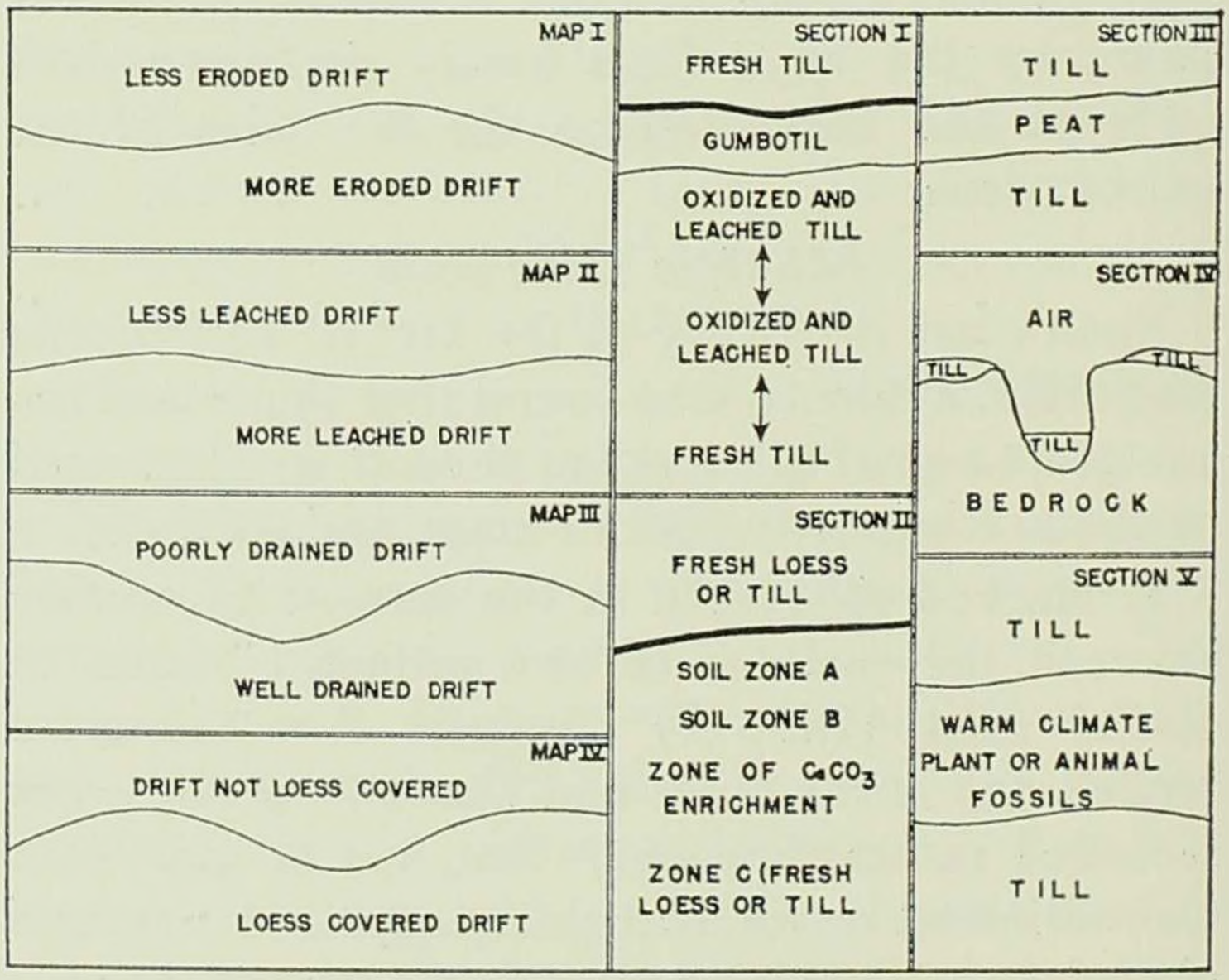
mixed boulders, cobbles, pebbles, angular rock fragments, sand, silt, and clay. This is called *till*. At and near the border of the ice sheet melt-water receives from the ice the finer portions of the glacial load and deposits material that is sorted to form layers of gravel, sand, silt, and clay. Such materials, called *outwash*, take the form of *outwash plains* or *valley trains*. *Loess* is silt that is blown by the wind from newly deposited drift surfaces and deposited on the lee sides of the source areas.

Multiple Glaciation

Soon after discovery of the fact of Pleistocene glaciation, evidence was found that there was not one great age of glaciers but several, as illustrated on the accompanying set of maps and sections.

A marked difference in the amount of erosion between the surfaces of two adjacent bodies of glacial drift (Map I) suggests that the more eroded one is the older and that two glaciers are recorded rather than one. One age of glaciation was followed by an interglacial age and a second glacial age. Similarly, the fact that the soluble materials of the southern drift (Map II) have been dissolved (leached) out to a greater degree than the northern drift indicates that the surface of the southern drift has been exposed to weathering for a longer time than the northern drift and is the older. Surfaces of newly exposed drift sheets are normally poorly drained and have

many lakes and marshes. With time such undrained depressions become connected by streams that develop valleys and finally drain the lakes and swamps. Thus, a well drained drift surface (Map III) is likely to be older than a poorly drained one. Map IV suggests that loess derived from drift has been deposited on an older drift.



Sketch maps and diagrammatic sections illustrating evidences of plural or multiple glaciation.

Similarly, and with some overlapping, the vertical sections illustrate evidences of ages of glaciation separated in time by interglacial ages. Such sections are exposed at the surface naturally — as on undercut valley walls or steep hillsides; or artificially, as in highway or railway cuts, quar-

ries, or pits. Even where there are no exposed materials, "subsurface" information may be gained from well logs, cores and cuttings, or from shallow drilling or boring for samples.

Gumbotil is thoroughly weathered till and takes a long time for its formation. In the typical section, gumbotil grades down through partially weathered till to fresh till. In Section I it is recorded that a drift sheet was deposited in one glacial age, the ice sheet retreated and there was a long time of weathering and this was followed by a second ice sheet that deposited the overlying fresh till in a new glacial age. Section II illustrates a "buried soil profile." Glacial material was deposited first and then weathered to form soil zones, after which loess, till, or other glacial material was deposited on the older soil. Again two glacial ages and an interglacial age are recorded. The peat of Section III, lying between two tills, was known as a "forest bed" by early glacial geologists. The significance of such a sequence is clear. Section IV shows an upland till deposited before the valley was cut, and a valley till that is younger than the valley. The time consumed in valley cutting is the measure of duration of an interglacial age. Section V records a glacial climate, a warm interglacial climate, and a second glacial climate.

Still another method of determining plurality or multiplicity of Pleistocene glaciation, not illus-

trated diagrammatically, is known as the radiocarbon or C-14 method. When a plant or animal dies it contains a known amount of carbon-14 but this "isotope" breaks down as it becomes older. The rate of this radioactive change is known. In about 40,000 years all of the C-14 is gone from a buried log, bone, or shell, and the material is said to be radioactively dead. By careful laboratory measurement of the C-14 content of fossil plants or animals, or of peat, the "absolute age" of the inclosing or burying glacial or interglacial material can be determined. In this way one drift sheet may be found to be about 25,000 years old and a directly overlying drift 10,000 years old. The two glacial subages are separated by an interglacial subage.

A glacial age is considered to start when the ice begins to spread and to end when the ice sheet has melted back to the center of accumulation. An interglacial age then is the time from the total disappearance of one glacier to the beginnings of the next one. In general, interglacial ages are much longer than glacial ages, and are measured in many thousands of years. Interglacial subages are much shorter. The subage glaciers retreat considerably, but not back to the source, and then readvance.

Pleistocene (Glacial) Classification

By application of such criteria and many man-years of careful field and laboratory work, it has

now been determined that during the Glacial (Pleistocene) epoch of geological history there were four glacial ages, in which great ice sheets invaded the northern portions of the Mississippi Valley, and three long interglacial ages. It is also concluded that the fourth or Wisconsin glacial age is divisible in the upper Mississippi Valley into five glacial subages, as shown on the accompanying chart.

CLASSIFICATION OF PLEISTOCENE (GLACIAL) TIME

Epoch	Age	Subage
Recent		
Pleistocene or Glacial	Wisconsin (glacial)	Mankato
		Cary
		Tazewell
		Iowan
		Farmdale
	Sangamon (interglacial)	
	Illinoian (glacial)	
	Yarmouth (interglacial)	
	Kansan (glacial)	
	Aftonian (interglacial)	
	Nebraskan (glacial)	

Absolute dates and durations of pre-Wisconsin glacial and interglacial ages cannot be determined directly, for materials containing carbon older than the Wisconsin age are radioactively dead. But the Wisconsin age began less than 40,000 years ago, and many age determinations of sub-

age drift sheets have been made. The climax of Mankato glaciation took place about 12,000 years ago. Similar figures for the other Wisconsin substages are about as follows: Cary, 14,000; Tazewell, 17,000; Iowan, 20,000; Farmdale, 26,000. From the amount of weathering and erosion that are known to have taken place during the pre-Wisconsin interglacial ages, it seems reasonable that the duration of the Sangamon may have been something like 75,000 years and that the durations of the Yarmouth and Aftonian may be measurable in hundreds of thousands of years.

Glacial Map of North America

Reference is here made again to the glacial map of North America on the inside back cover. From the Keewatin center of accumulation west of Hudson Bay and the Labrador center east of Hudson Bay the several ice sheets spread southward into Iowa and Illinois and also into states farther west, south, and east. In the middle states the line separating the glaciated and unglaciated areas follows roughly the courses of the Missouri and Ohio rivers.

It should be understood, however, that the glacial map does not represent the distribution of the ice at any one particular time. West of the Mississippi River the Kansan and Nebraskan ice sheets reached about 200 miles farther south than did younger glaciers. East of the Mississippi it was the Illinoian glacier that reached farthest

south. On the east coast and in the Dakotas the deposits of the late Wisconsin ice sheets mark the line between the glaciated and unglaciated areas.

The Driftless Area

A map of the Driftless Area (see inside back cover) shows there was no single age or subage when the Driftless Area, as its boundaries are drawn, was surrounded by ice. The drift at the west border marks the east margin of the Nebraskan ice sheet. The drift marking the east border is of Cary age. In northwestern Illinois the bordering drift was originally mapped as Illinoian but it may be Farmdale. The extreme southwestern portion of the Driftless Area in Iowa is bordered by Kansan drift. Kansan and Farmdale drifts form the north boundary. The point is that each ice sheet avoided this particular area. Glaciers one after another approached the Driftless Area but none covered it.

Why all the Pleistocene glaciers failed to cover the Driftless Area was explained by T. C. Chamberlin in the nineteenth century, and his idea is still good. An area known as the Wisconsin Highland or the Wisconsin Arch has been uplifted from time to time and has always been higher than its surroundings. The rocks are generally resistant to erosion. Less resistant sedimentary formations dip away from the highland to the west, south, and east. In Glacial times this highland was bordered on the east by the much lower

Lake Michigan basin and on the west by the Lake Superior basin. As the ice sheets spread southward, great lobes were led forward down these troughs and there was simply not enough ice between the lobes to cover the highlands.

In general it may be said that the glaciers that covered Iowa west of the Driftless Area advanced from the Keewatin center through the Lake Superior lowland and that the ice sheets that affected Illinois came down the Lake Michigan basin from the Labrador center. However, the Kansan ice sheet from the Keewatin center crossed Iowa and moved into Illinois, and the Illinoian glacier from the Labrador center moved into southeastern Iowa from Illinois.

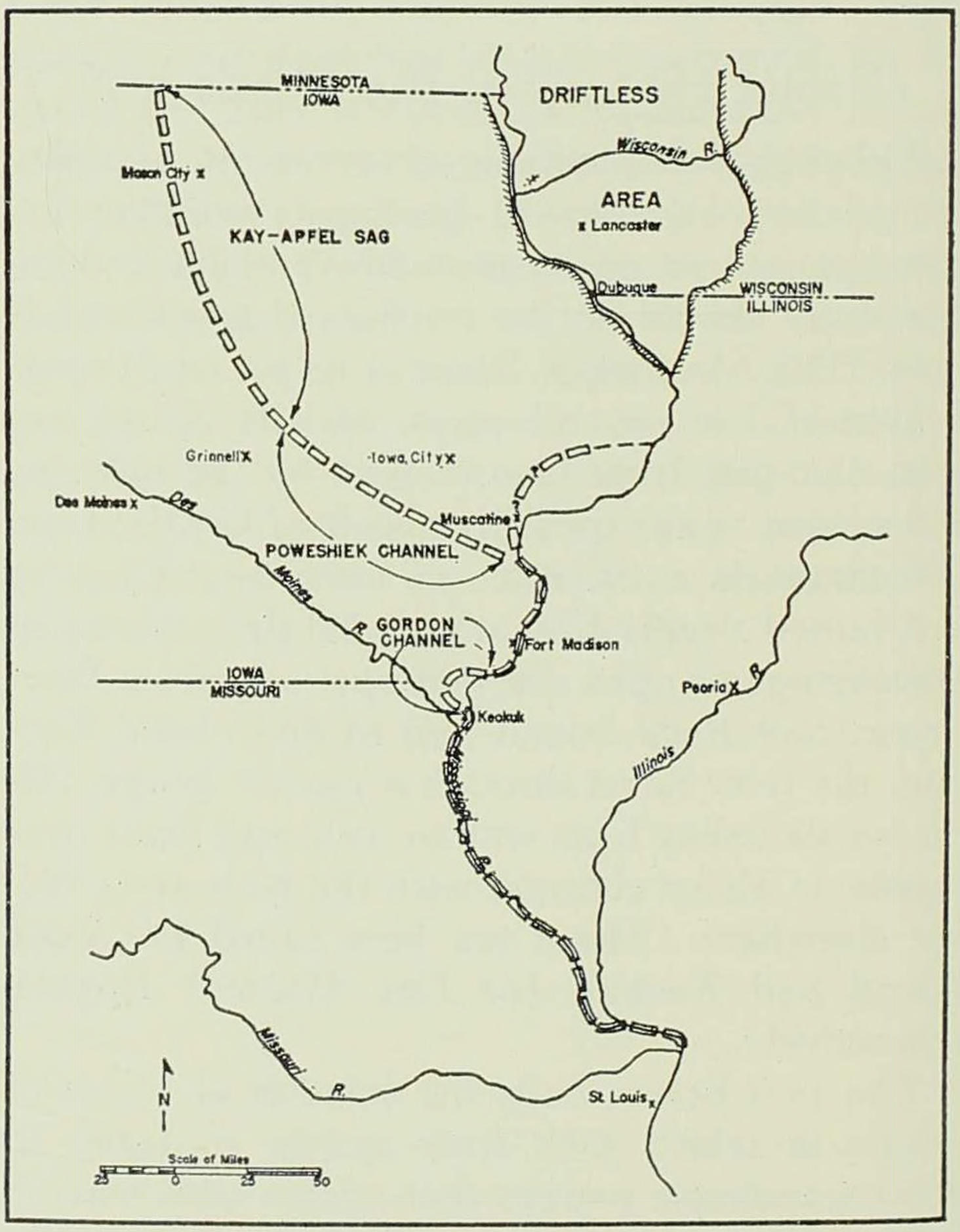
ARTHUR C. TROWBRIDGE

Glacial History of the Mississippi

Although based on the observations of many trained and experienced geologists working for many years and on large numbers of basic data, this study should not be considered as exact science. The Mississippi River in its present course is abnormal in several ways, and its course has been changed from time to time by the advance and retreat of the great ice sheets of Glacial time. Old channels exist, some of them now filled by and buried deeply beneath glacial drift of one or another age or ages. At and upstream from Davenport and Rock Island and at and above Keokuk, the river flows through a narrow gorge, fills the whole valley from wall to wall, and flows over rapids, in sharp contrast with the wide river valley elsewhere. These are here called the Rock Island and Keokuk (or Des Moines) Rapids, respectively.

The task before us is the solution of a sort of puzzle in which each river system conforms to some reasonable pattern that agrees with what is known about the ways in which rivers normally operate and with the principles of glacial action, especially as glaciers affect the courses of rivers. It is a study in preglacial, glacial, interglacial, and

postglacial drainage. In some cases this puzzle is possible of solution in more than one way.



Sketch map showing the probable course of the Mississippi River in pre-Glacial times.

The Pre-Glacial River

The probable course of the Mississippi River

before the Nebraskan ice sheet reached these latitudes is shown on the sketch map.

In 1928 George F. Kay and Earl T. Apfel described a sag or valley in the bedrock surface beneath drift, extending in a generally southeasterly direction from a position about ninety miles west of where the present Mississippi crosses the Minnesota-Iowa line. This depression contains drift of Nebraskan, Kansan, and Wisconsin ages and must have existed in pre-Nebraskan time. In 1947 a wide valley, known as the Poweshiek channel, was reported running from a place on the Kay-Apfel sag about 15 miles northeast of Grinnell easterly and southeasterly to join the present Mississippi south of Muscatine. It is buried under Nebraskan and Kansan drifts and must also be pre-Nebraskan. The valley varies in width from six to twenty miles.

Tributaries to this valley probably existed. There is some evidence of a tributary that joined the main valley southwest of Muscatine, somewhat as shown on the map. Downstream from Muscatine the present valley of the Mississippi, except for the Keokuk rapids, is wide and old-looking and is believed to have been the main line of discharge in pre-Glacial times as it is now.

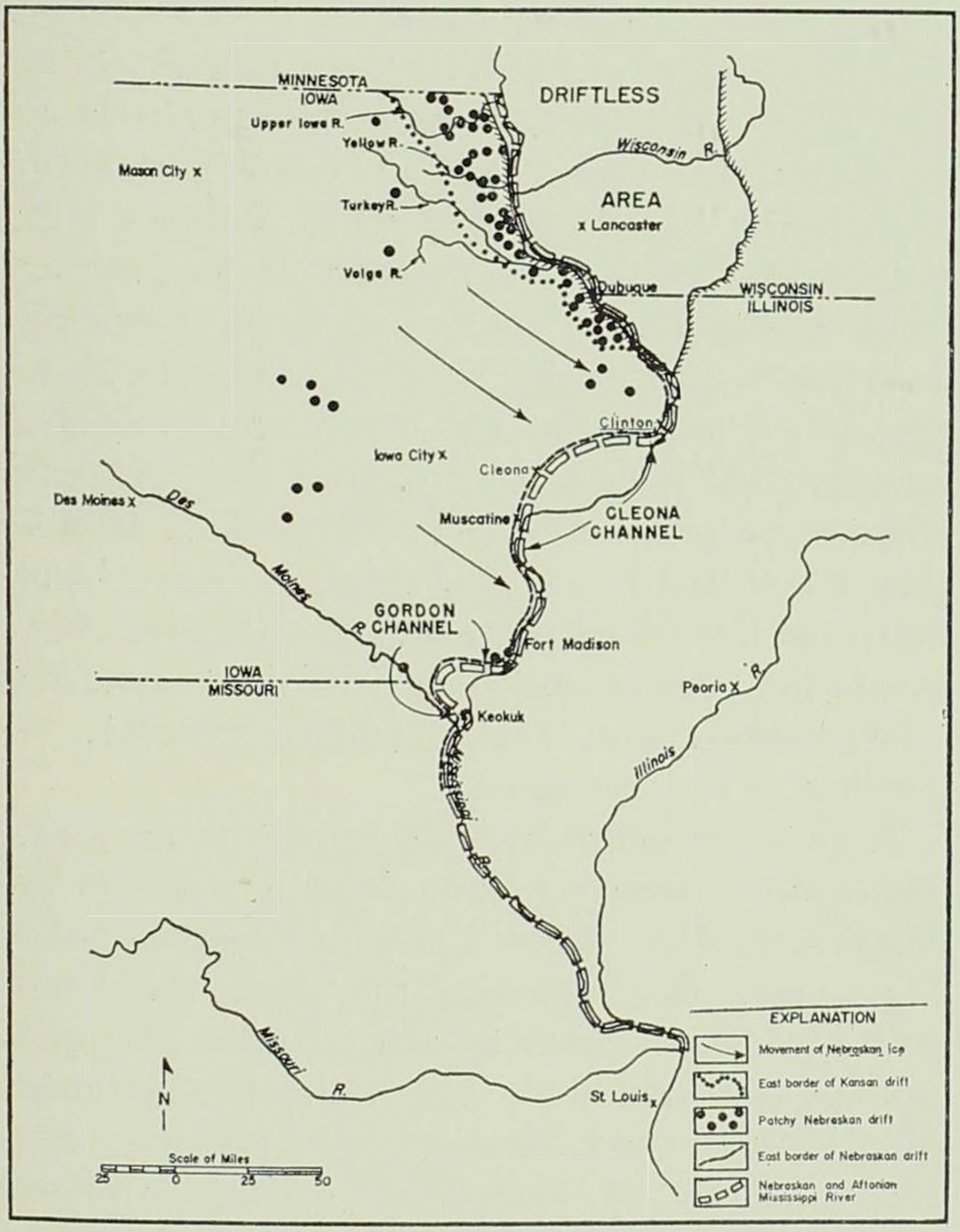
A now buried valley west of the Keokuk rapids was described by C. H. Gordon in 1895 and has more recently been called the Gordon channel. It is wider and deeper than the valley at the

rapids, which is clearly much younger. The Gordon channel is buried under Kansan drift and there is some evidence of Nebraskan drift in it. The Mississippi River in preglacial time, therefore, probably flowed through the Gordon channel.

The Nebraskan and Aftonian River

It has long been known that a small amount of drift exists in northeastern Iowa east of the east border of the Kansan drift. This part of Iowa was originally thought not to have been glaciated and was included within the Driftless Area. In studying this drift the late A. J. Williams found scores of patches of thin, much weathered and much eroded glacial drift. The drift occurs eastward to the very rim of the present Mississippi Valley, but not in Wisconsin and Illinois east of the river. The patches of drift are on the stream divides, not in the valleys, suggesting that the valleys did not exist before the advance of the Nebraskan ice. The valley of the Mississippi here is only two to three miles wide from rim to rim. Its side walls are steep and in many places vertical, forming the famous Mississippi bluffs from Bellevue, Iowa, to the Minnesota line and beyond. If it were not for a late Wisconsin fill that conceals the bottom and lower side walls, the bedrock valley would appear to be in a youthful stage of development. Indeed this part of the valley is commonly known as the Mississippi "gorge." Cer-

tainly it seems much younger than the buried valley farther west. It should be noted, however,



Sketch map showing the probable course of the Mississippi River in Nebraskan and Aftonian times.

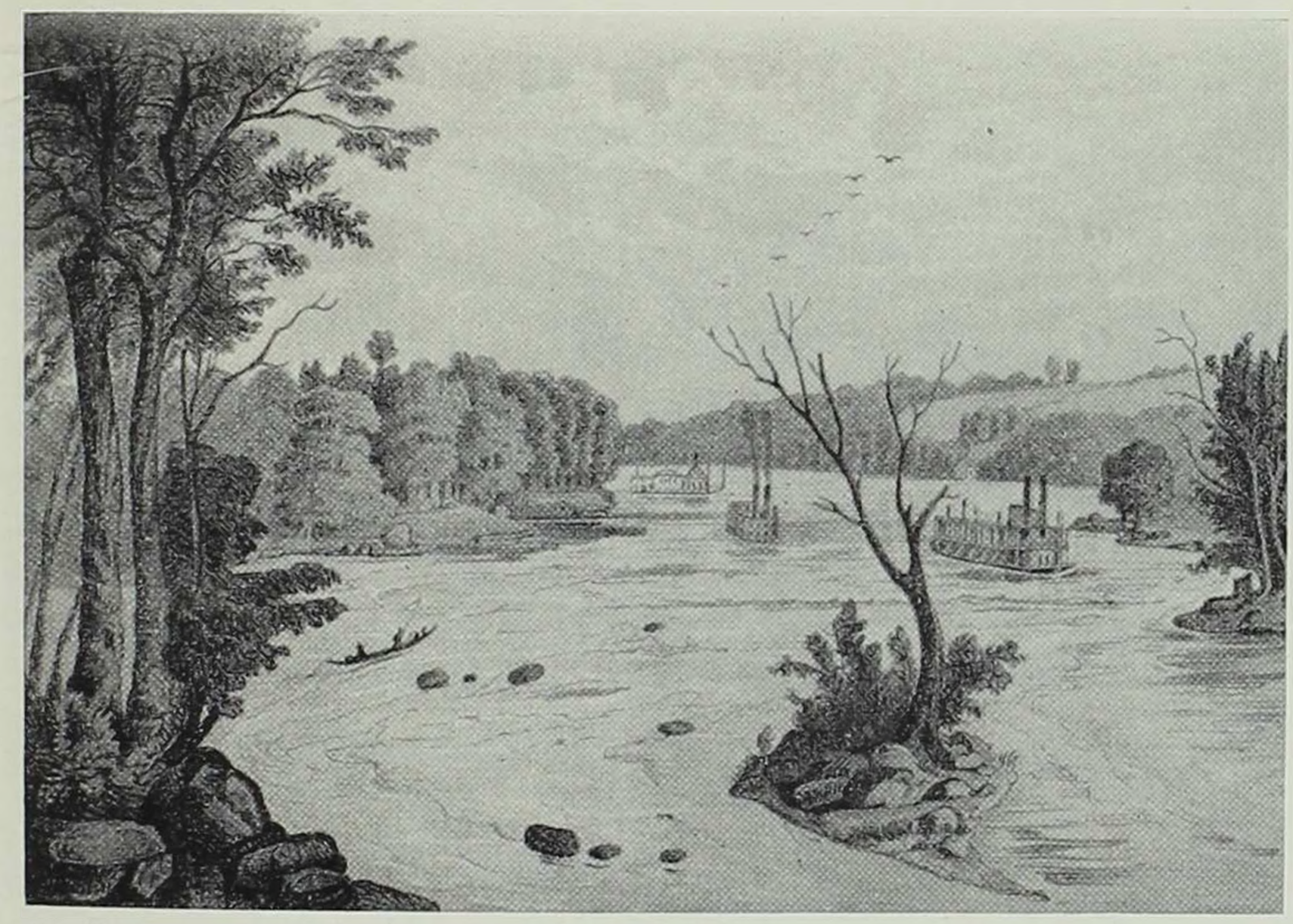
that this part of the valley was cut in more resistant rock than the western valley, which may ac-

count, at least in part, for its more youthful appearance.

Not only does this part of the river valley appear much more youthful than the Kay-Apfel sag and the Poweshiek channel, but it is entirely out of adjustment both topographically and stratigraphically. If left to themselves without interference by other agents, such as glaciers, streams tend to adjust their courses so as to flow along lines that were from the start lower than their surroundings, and along the outcropping edges of non-resistant layers of rock. But the rim of the Mississippi gorge in the Driftless Area is more than a hundred feet higher than any bedrock surface near the Kay-Apfel sag. Also the river flows across the axes of anticlines (upfolds), synclines (downfolds), and faults (displacements), regardless of rock resistances.

A valley in bedrock, wide enough to have carried a large river, extends from a point on the Mississippi River below Clinton to the river below Muscatine, thus bypassing the Rock Island rapids. This was known to early glacial geologists as the Cleona channel. This valley is now buried under Kansan and Illinoian drift, and may contain remnants of Nebraskan drift. It follows roughly the valley designated on the pre-Glacial map as a possible tributary of the Poweshiek channel.

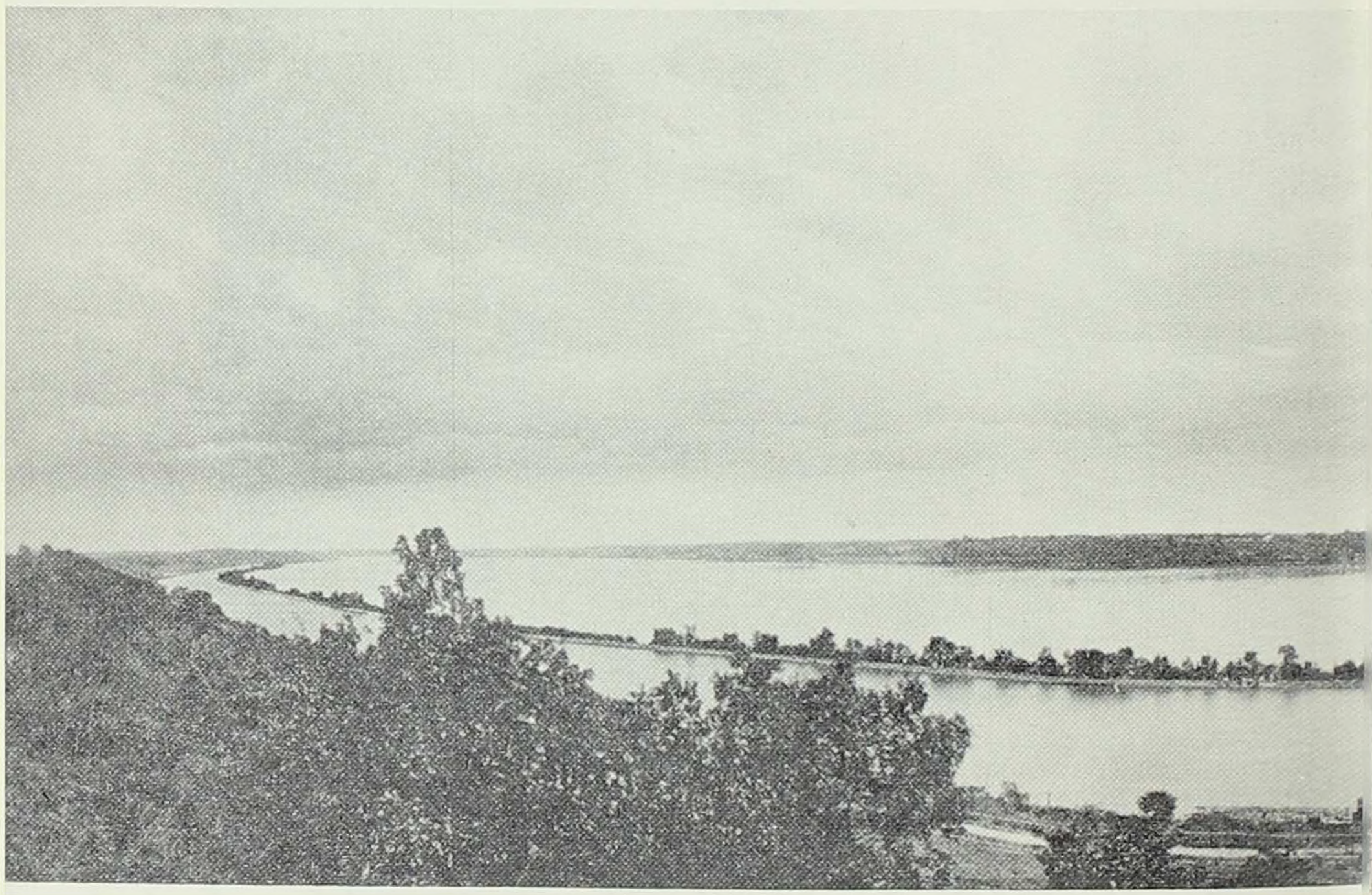
In Iowa, Nebraskan drift occurs, either at the



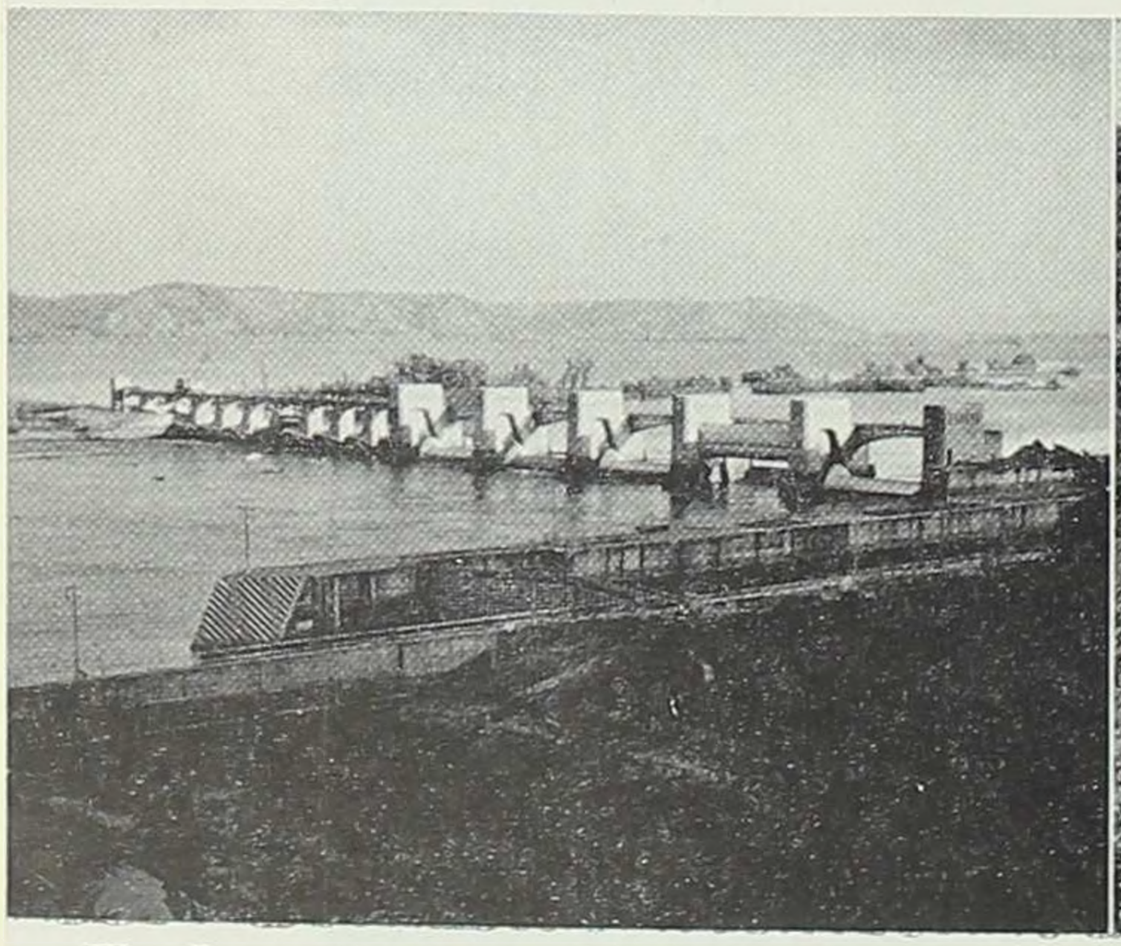
Steamboats descending Rock Island (Upper) rapids in the 1840's. The river here flows on bedrock and extends from wall to wall of its valley. These rapids were started in early Wisconsin times about seventeen to twenty thousand years ago.

Paintings from Henry Lewis' *Das Illustrierte Mississippithal*

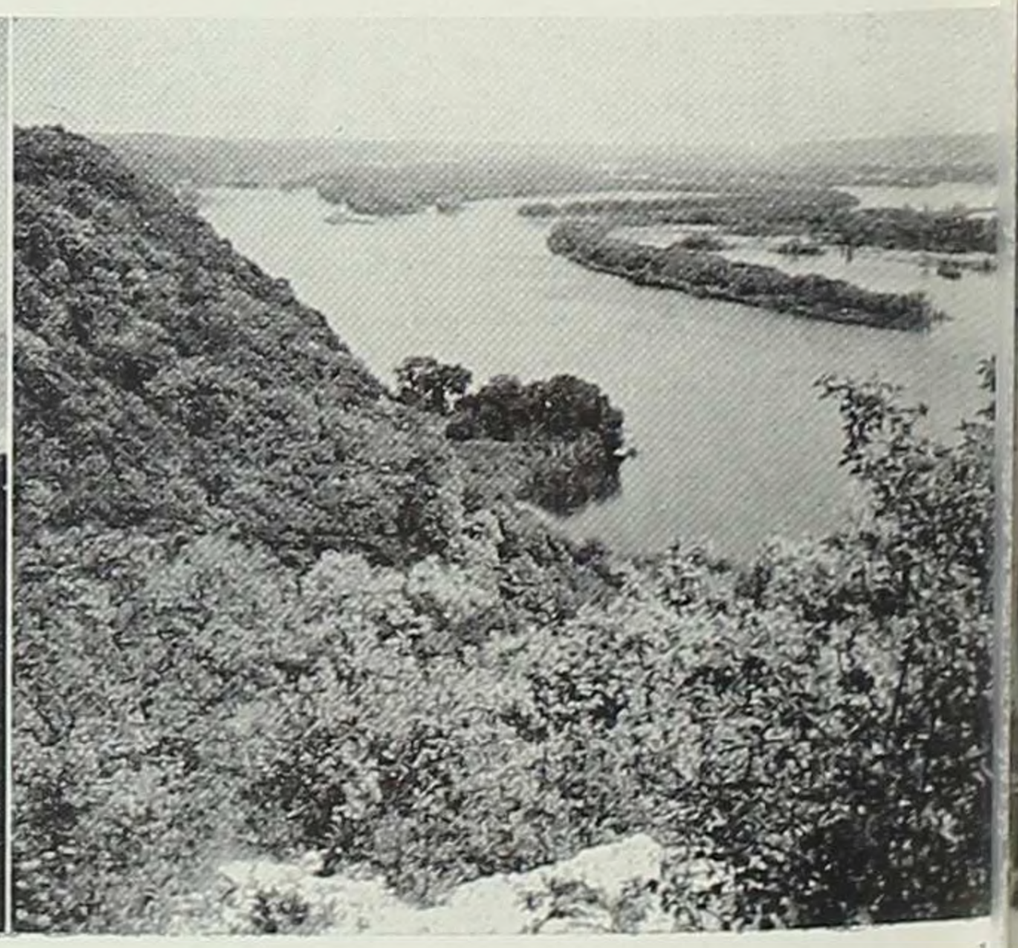
Wide, shallow, flat-bottomed valley of Mississippi River below Muscatine.



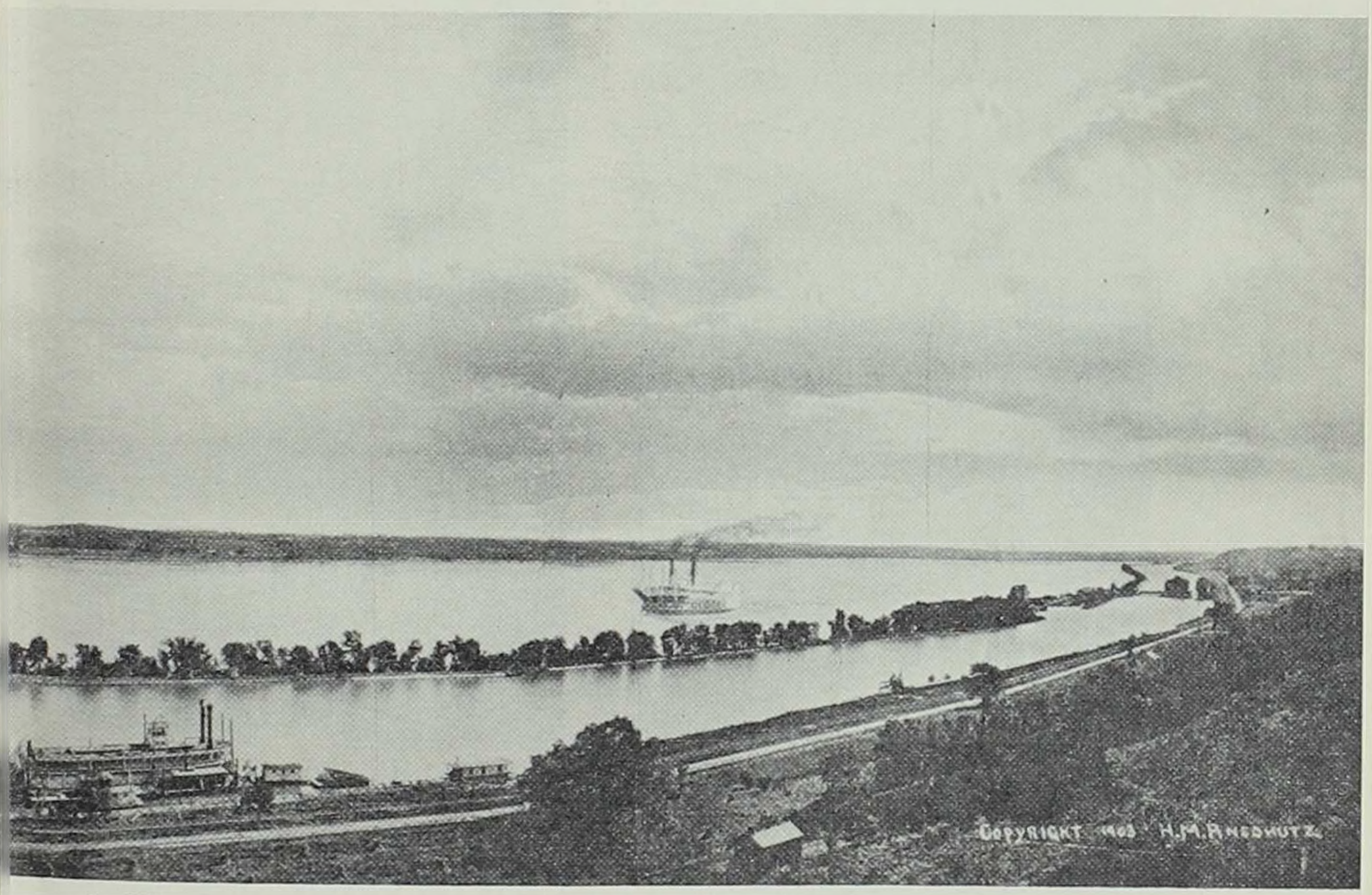
Keokuk (Des Moines, Lower) rapids, showing Des Moines system and date back to the Yarmouth age more than a hundred



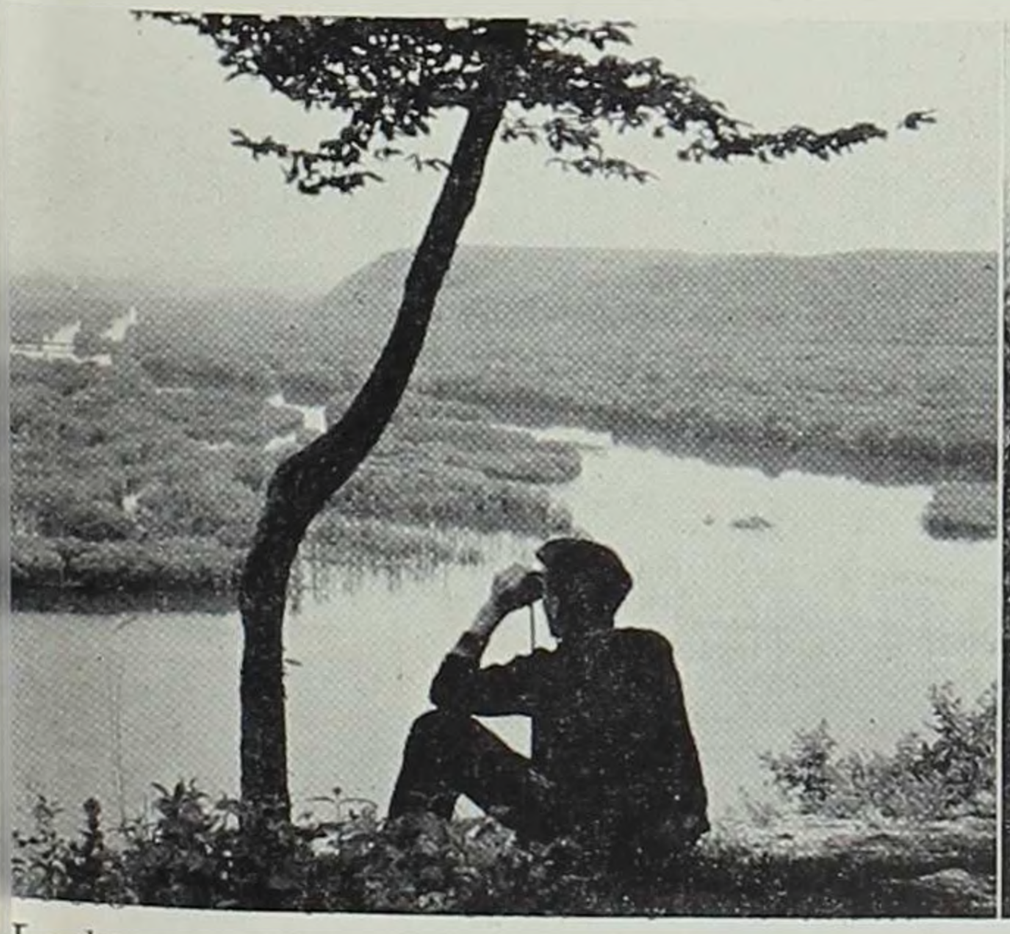
The Lynxville dam and lock looking westward toward Iowa bluffs in the distance.



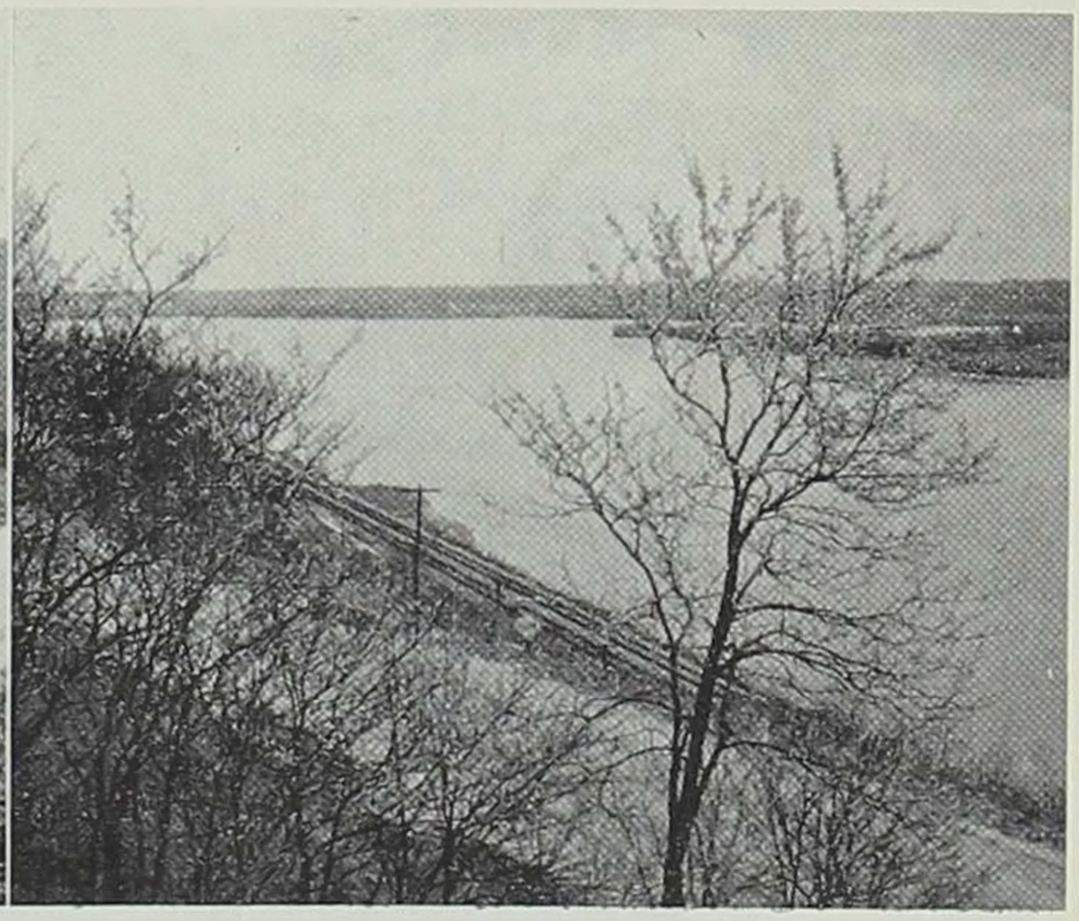
Looking north from Pike's Peak toward McGregor, showing river bluff and valley bottom.



s canal. These rapids were started by the Cedar-Iowa-Skunk
nd years ago.

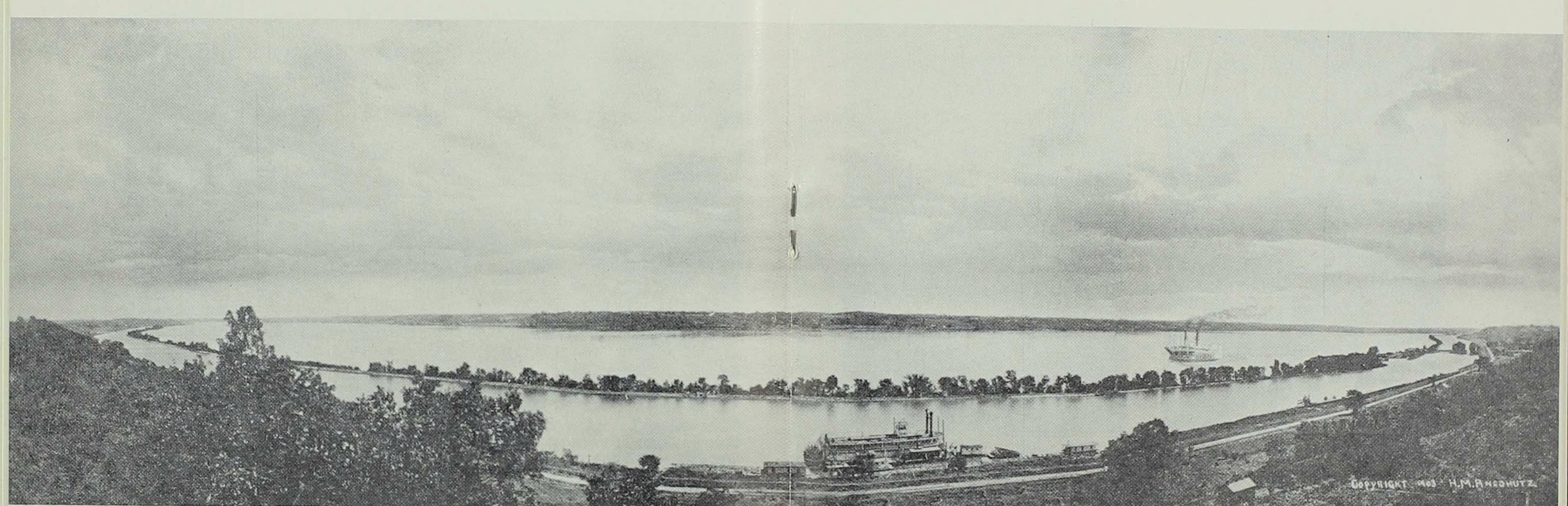


Looking east from Pike's Peak showing the Mississippi and Wisconsin rivers at their junction.

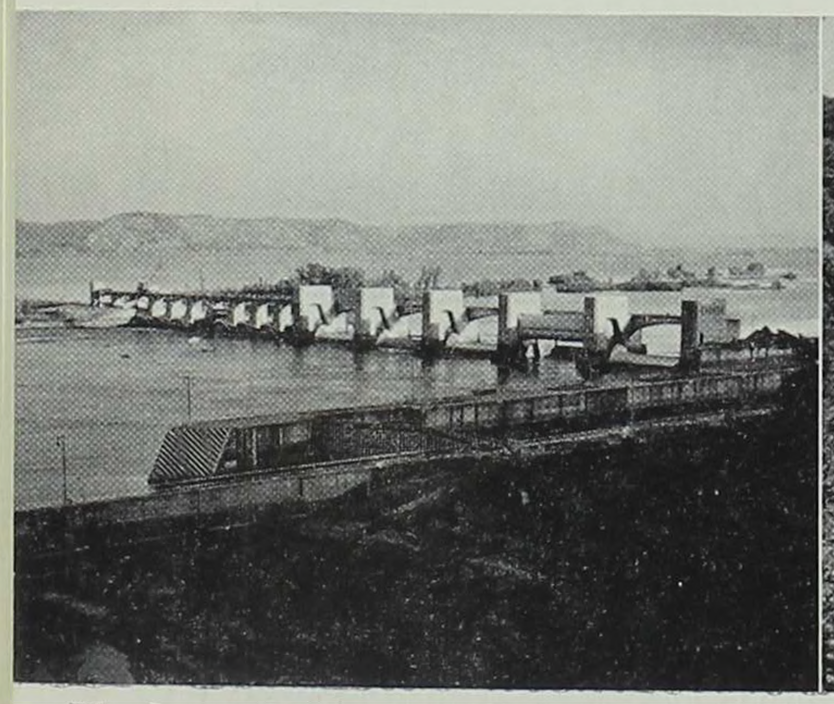


The narrow Mississippi valley above Muscatine. The river between Princeton and Muscatine came into existence at the same time.

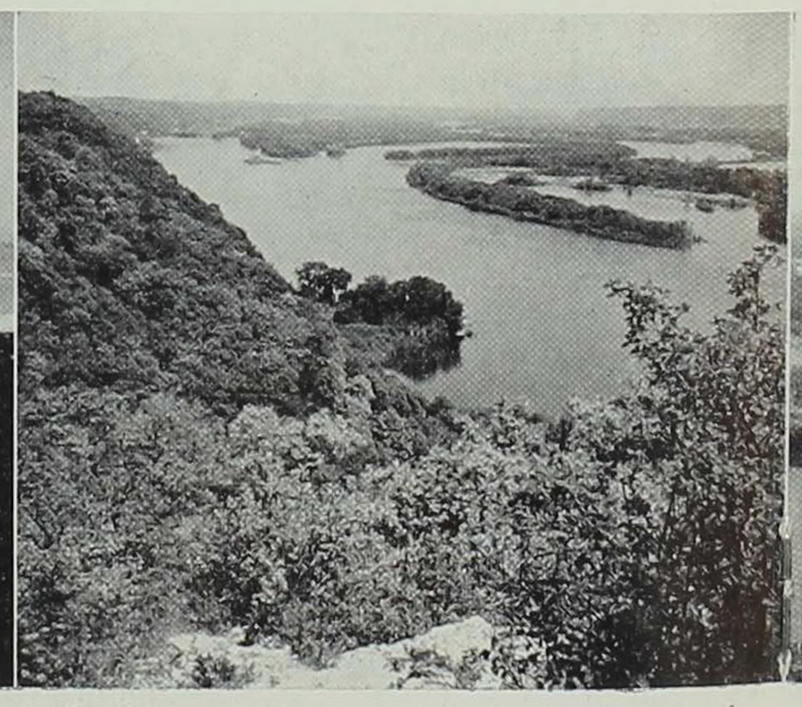
All four photos by Kent



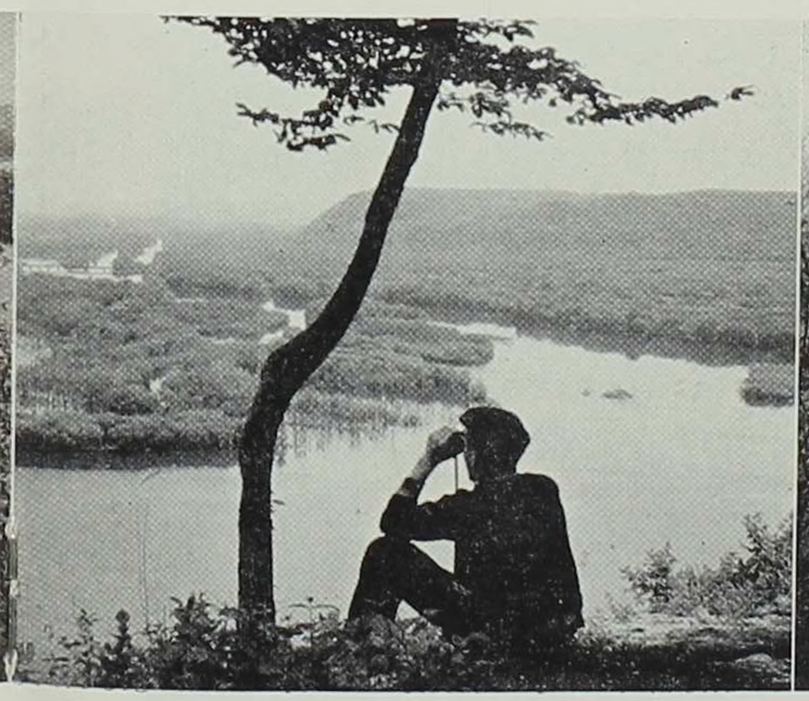
Keokuk (Des Moines, Lower) rapids, showing Des Moines Rapids canal. These rapids were started by the Cedar-Iowa-Skunk system and date back to the Yarmouth age more than a hundred thousand years ago.



The Lynxville dam and lock looking westward toward Iowa bluffs in the distance.



Looking north from Pike's Peak toward McGregor, showing river bluff and valley bottom.



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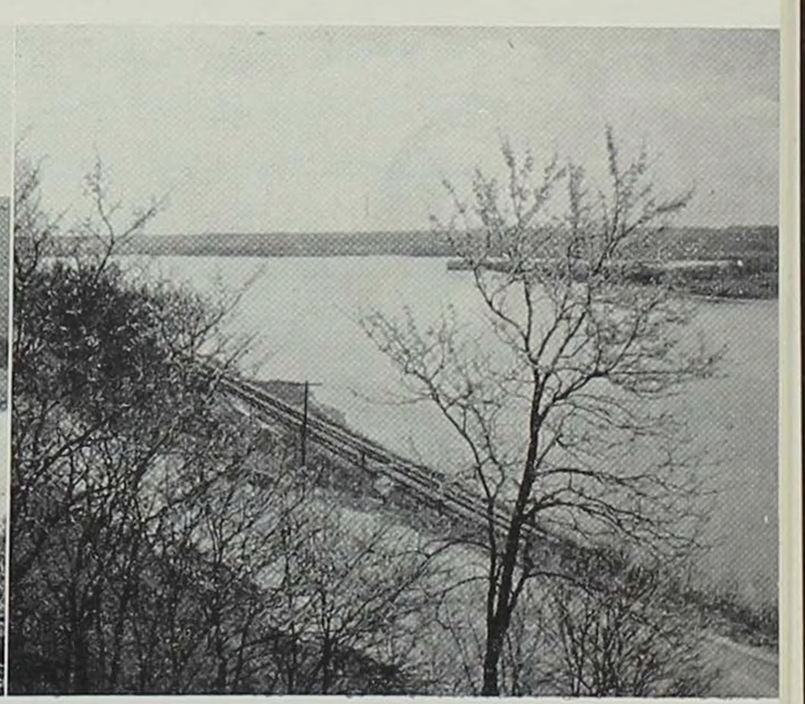
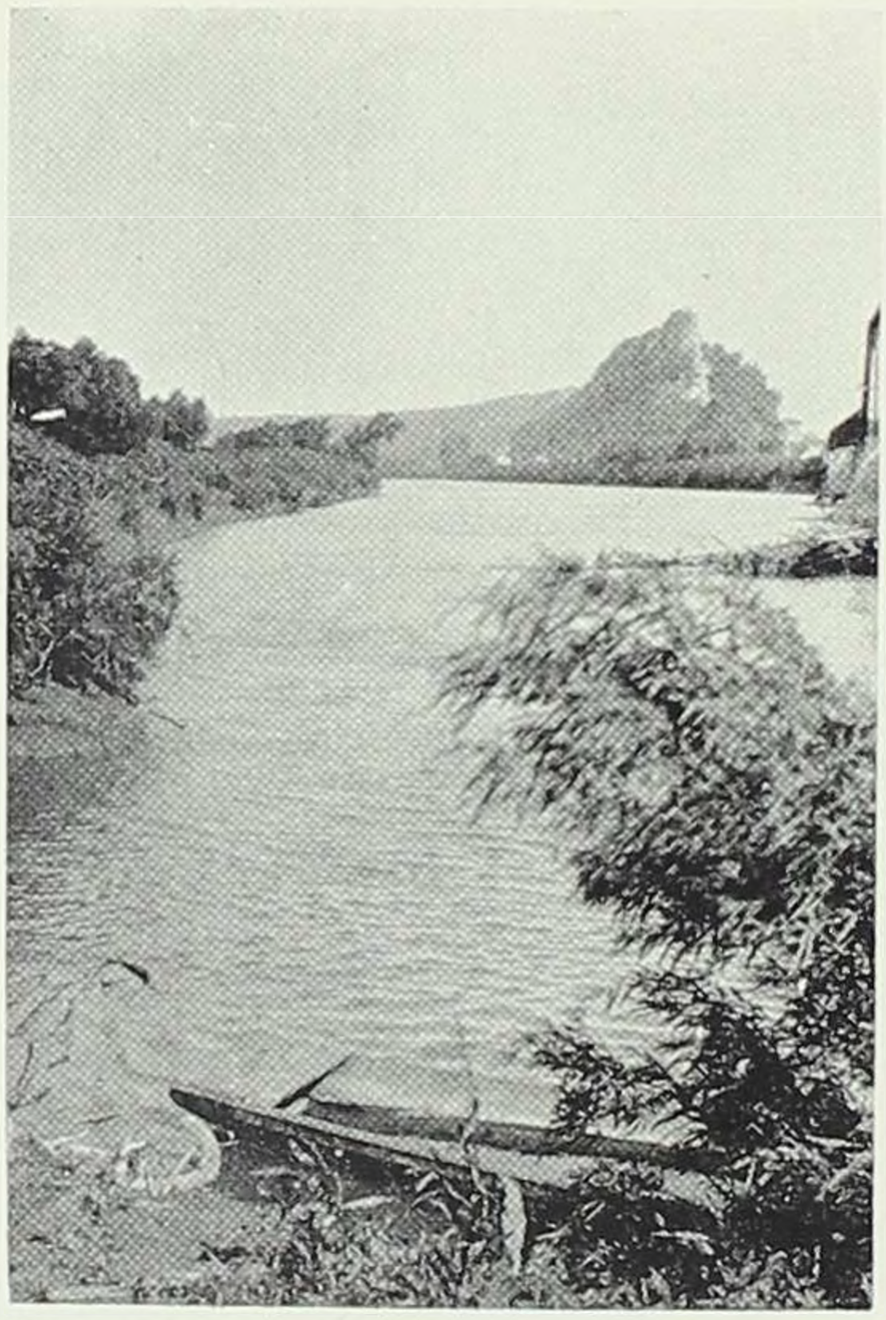
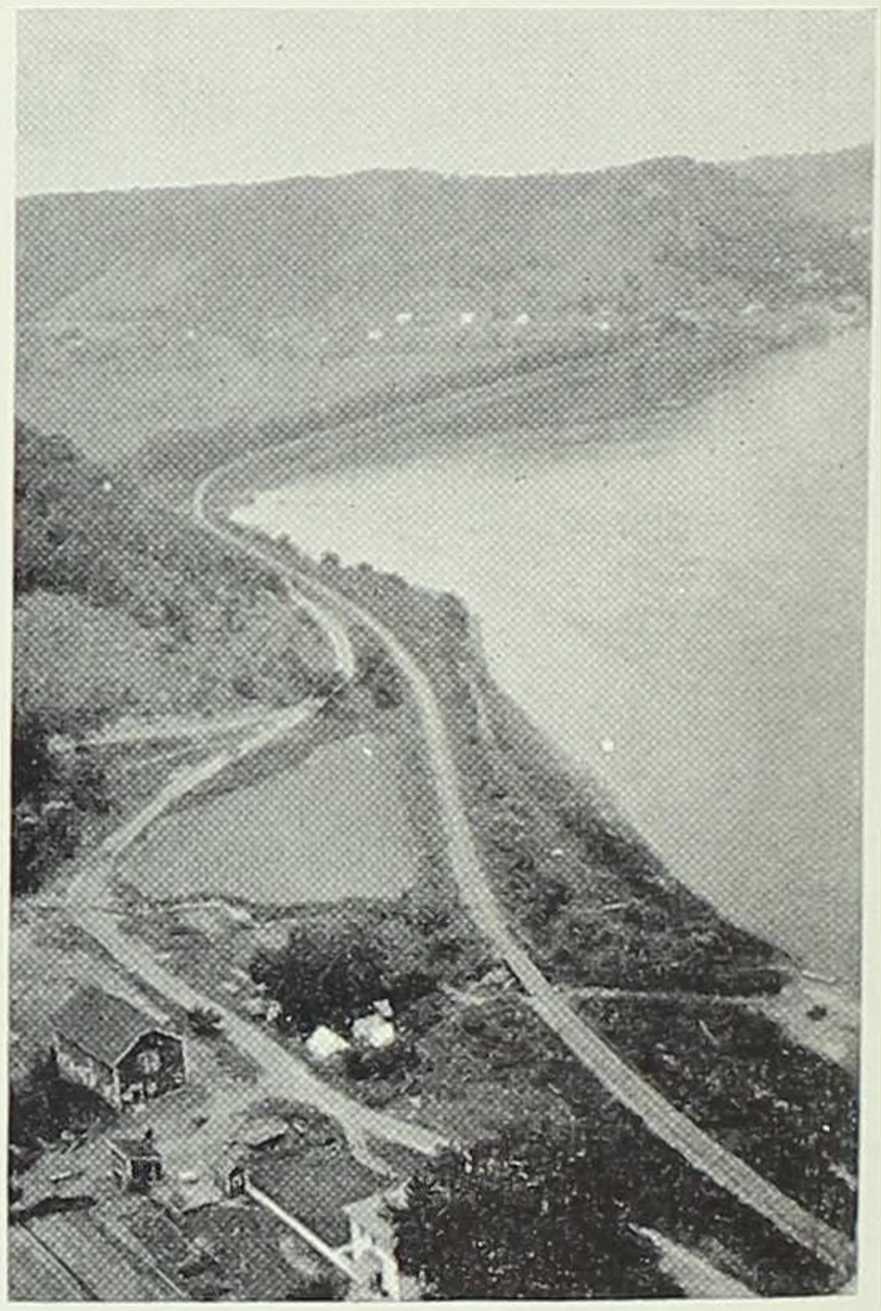


The narrow Mississippi valley above Muscatine. The river between Princeton and Muscatine came into existence at the same time.

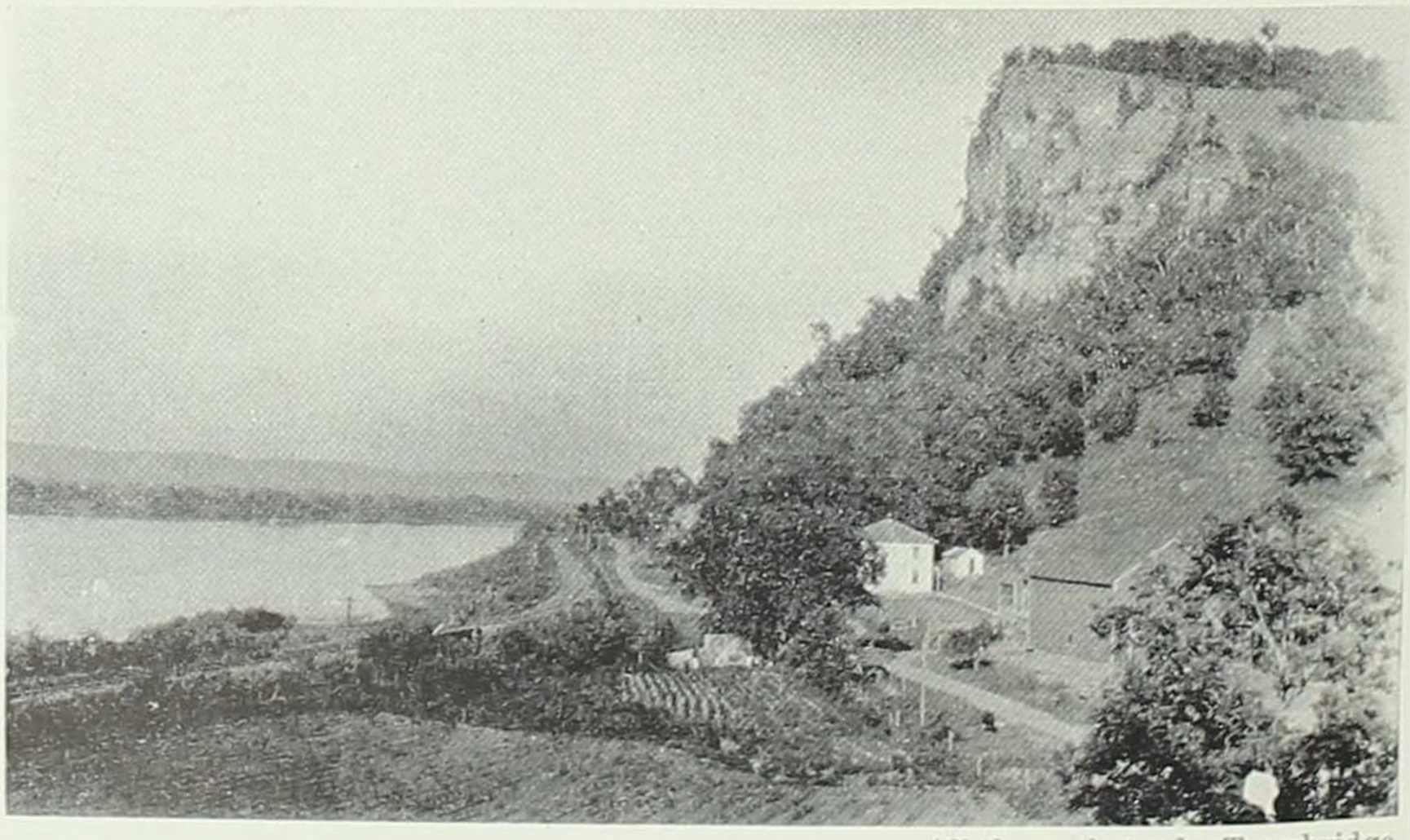
All four photos by Kent



The Turkey River near its junction with the Mississippi. The distant bluff apparently was developed after the Nebraskan glacier and was not reached by any younger glacier.



Looking north toward Lansing and Mount Hosmer showing road and railroad track skirting the Mississippi.



All three photos by Trowbridge

Bluff and river south of Lansing. The photo at the right, above, was taken from this bluff.

surface or buried under younger drift, eastward to but not beyond a line drawn on the map to represent the course of the Mississippi River in Nebraskan time. Reports of Nebraskan drift at a few localities in Illinois fail to prove to this writer that the Nebraskan ice sheet from the Keewatin center advanced far, if at all, into Illinois.

It seems likely, therefore, that the Mississippi River, in the course designated on the map, followed the east border of the Nebraskan ice sheet. Such a river is known as an "ice-border stream." The Nebraskan ice covered the old western channel upstream from Muscatine and forced the river to take a course along the ice border, where the bedrock surface was higher and more complex structurally.

It appears that the Poweshiek channel was not completely filled by Nebraskan drift and that a tributary to the main stream occupied it in Aftonian times. If the Cleona and Gordon channels were pre-Nebraskan, they also were not completely obliterated by Nebraskan ice and became parts of the course of the main river.

It seems likely, therefore, that during the Nebraskan and Aftonian ages, the Mississippi River entered Iowa from the north where it does now and followed roughly the east border of the Nebraskan ice through the Driftless Area and the Cleona and Gordon channels and on to the south, about as mapped.

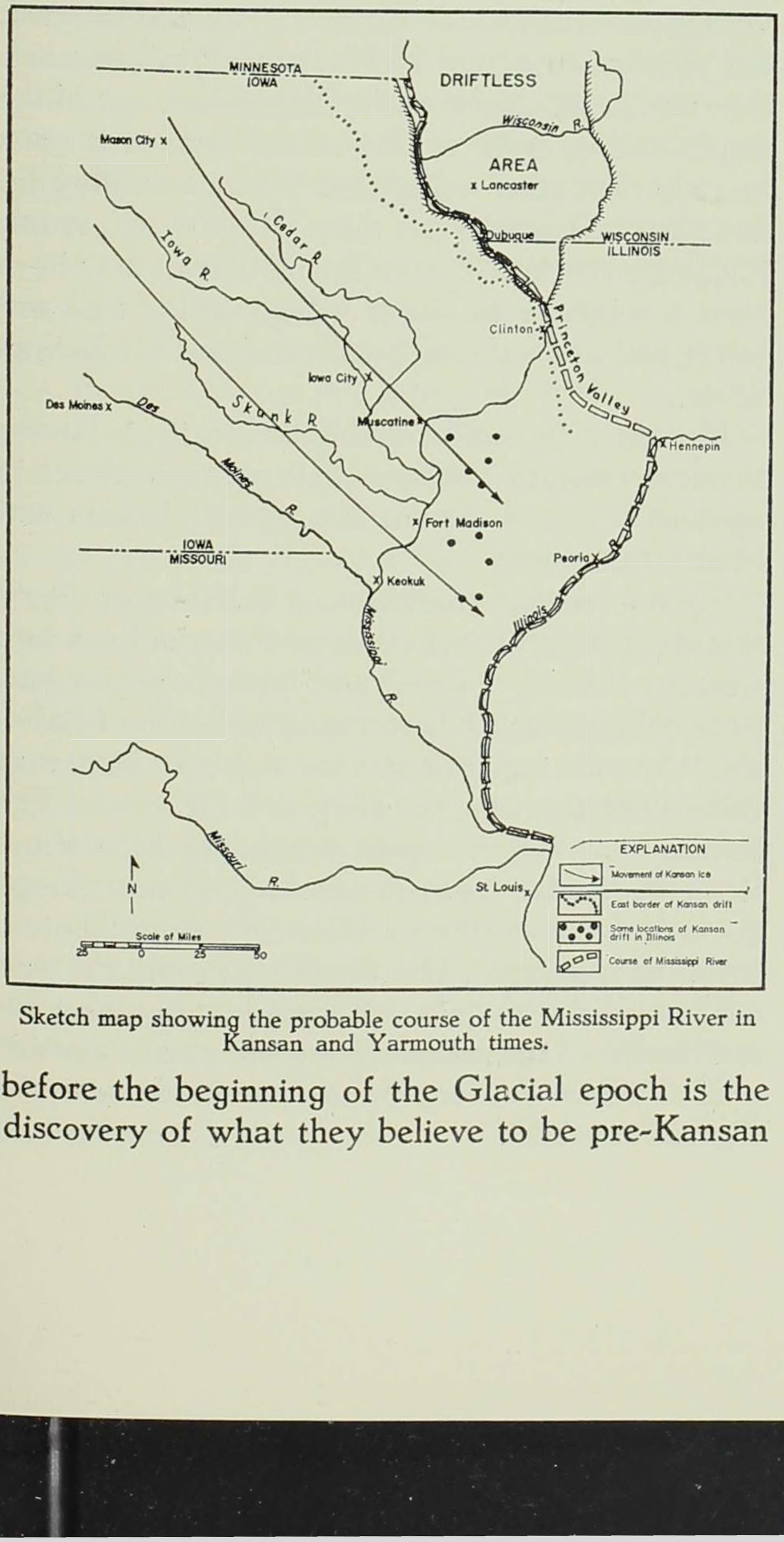
It must have been during the Aftonian age that the Upper Iowa, Yellow, Turkey, and Volga rivers started to excavate their valleys, for the Kansan drift, unlike the Nebraskan drift, occurs down in these valleys as well as on the divides.

The Kansan and Yarmouth River

The existence of a buried river channel connecting the Mississippi and Illinois river valleys was known to the very early workers in Iowa and Illinois. It was then thought to be and is still considered by some of the Pleistocene geologists of Illinois to be of pre-Pleistocene age. J. A. Udden, former professor of geology at Augustana College at Rock Island, who worked on both the Iowa and Illinois Geological Surveys, was uncertain whether the pre-Glacial Mississippi turned eastward below Clinton and cut this connecting valley or flowed southward through the Cleona and Gordon channels. Certainly no river could have so divided and flowed through both these channels at the same time. Rivers so distribute only on their deltas. The existence of the Kay-Apfel sag and the Poweshiek channel were not then known.

More recently this old channel connecting the present Mississippi and Illinois river valleys has been mapped in detail by J. C. Frye and by the late Leland Horberg. Horberg called this the Princeton valley. It varies in width from three to eight miles and averages perhaps five miles wide.

One reason for the belief of Horberg and other geologists of Illinois that Princeton valley existed



Sketch map showing the probable course of the Mississippi River in Kansan and Yarmouth times.

before the beginning of the Glacial epoch is the discovery of what they believe to be pre-Kansan

sands and gravels buried under younger drift and lying in Princeton valley and other rock-bound valleys in central and eastern Illinois. However, the absence of actual Nebraskan till in these valleys and some doubt of the Nebraskan age of the sands and gravels in the valleys makes it seem more likely to this writer that Princeton valley did not exist before Kansan time. If there was a valley along this line in pre-Glacial time, it may have been a tributary to larger valleys to the east and south and not a through-valley of the Mississippi River.

Kansan drift, unlike Nebraskan drift, is known to occur beneath Illinoian drift at many places in western Illinois between the present Illinois and Mississippi rivers.

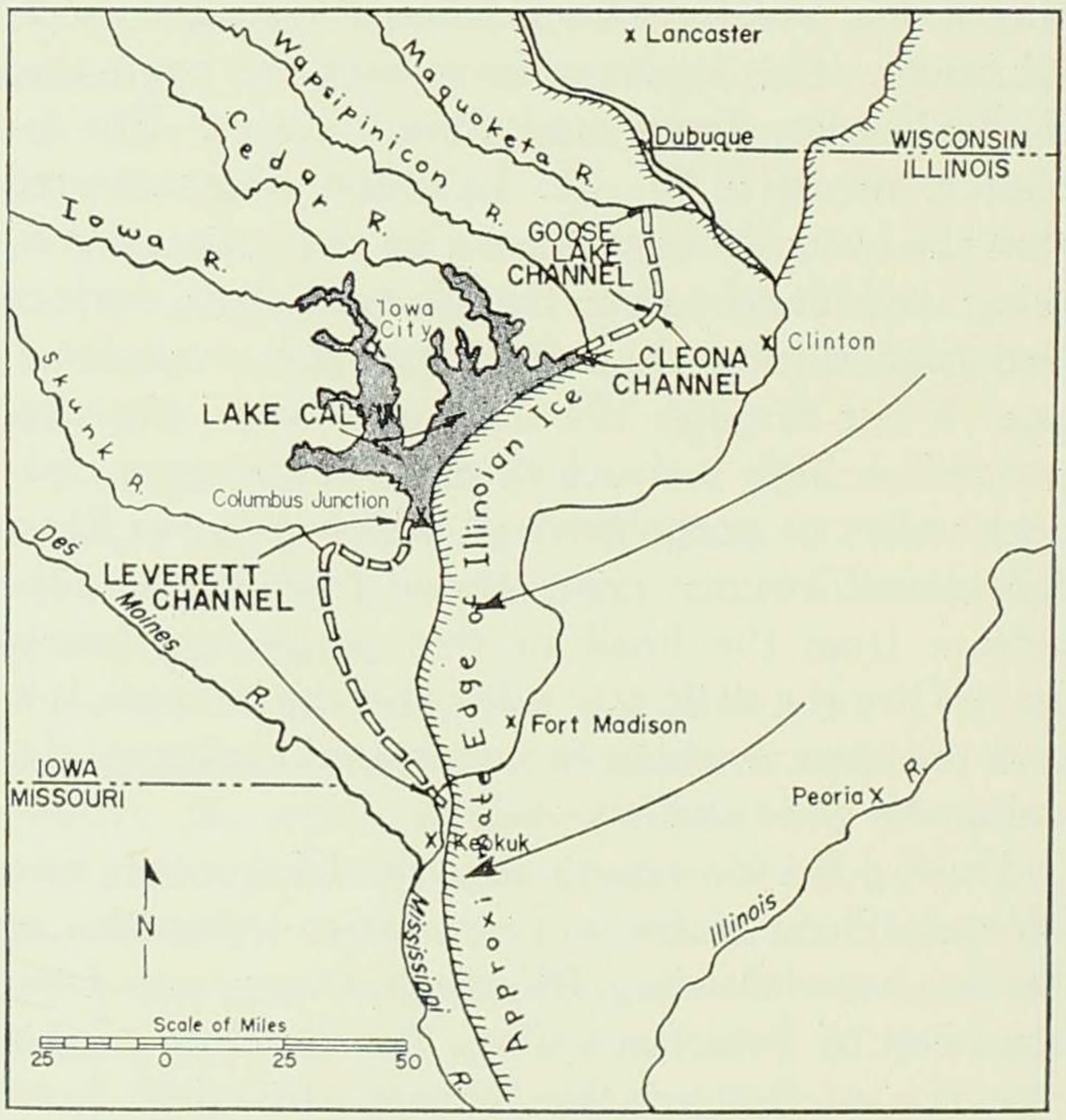
To this writer, therefore, it seems more likely that the Kansan ice sheet moved across Iowa into western Illinois, covered and buried the previous river valley below Clinton and forced the Mississippi into an eastern course through Princeton valley and the Illinois valley and on south. The Kansan ice did not quite reach the Mississippi River in the Driftless Area, and did not change the river's course there. However, from Clinton, Iowa, to Hennepin, Illinois, and on south the new course could well have followed roughly the eastern border of the Kansan ice sheet and be considered as an ice-border stream with reference to the Kansan ice sheet.

The Kansan drift is so thick and so generally distributed in central and southern Iowa as to lead to the belief that it buried and obliterated all previous drainage lines there, leaving a nearly flat surface on which a new drainage system was established. This seems to have been the beginning of the Cedar, Iowa, and Skunk rivers. For instance, in 1916 M. M. Leighton demonstrated that the Iowa River was born by the connection of lakes and swamps on the Kansan drift surface and that, during the long Yarmouth interglacial age, it cut through the drift and was "superimposed" on high bedrock to make the narrow bedrock valley or gorge through which the river flows for almost twenty miles above Iowa City. Upstream from the head of this gorge and below Iowa City the drift was thick and the bedrock low and the river working in nonresistant material developed a wide shallow valley.

During the Yarmouth Age the Maquoketa and Wapsipinicon rivers were doubless tributaries of the eastward-flowing Mississippi upstream from the head of Princton valley. By the close of this age the surface of the Kansan drift had been much eroded. The Gordon channel had been filled and buried. The Cedar, Iowa, and Skunk rivers joined and must have flowed south over the Keokuk rapids to join the Mississippi of that time where the Illinois now joins the Mississippi. The Keokuk rapids date back to the Yarmouth Age.

Illinoian Drainage

From this point in the history of the Mississippi River the evidence of change is clearer. There is less uncertainty and less difference of opinion.



Sketch map showing drainage in Illinoian time.

Unlike Nebraskan and Kansan, the Illinoian glacier crossed Illinois and entered Iowa from the northeast and east. The western border of its deposited drift, marking the west edge of the ice sheet, is shown on the map.

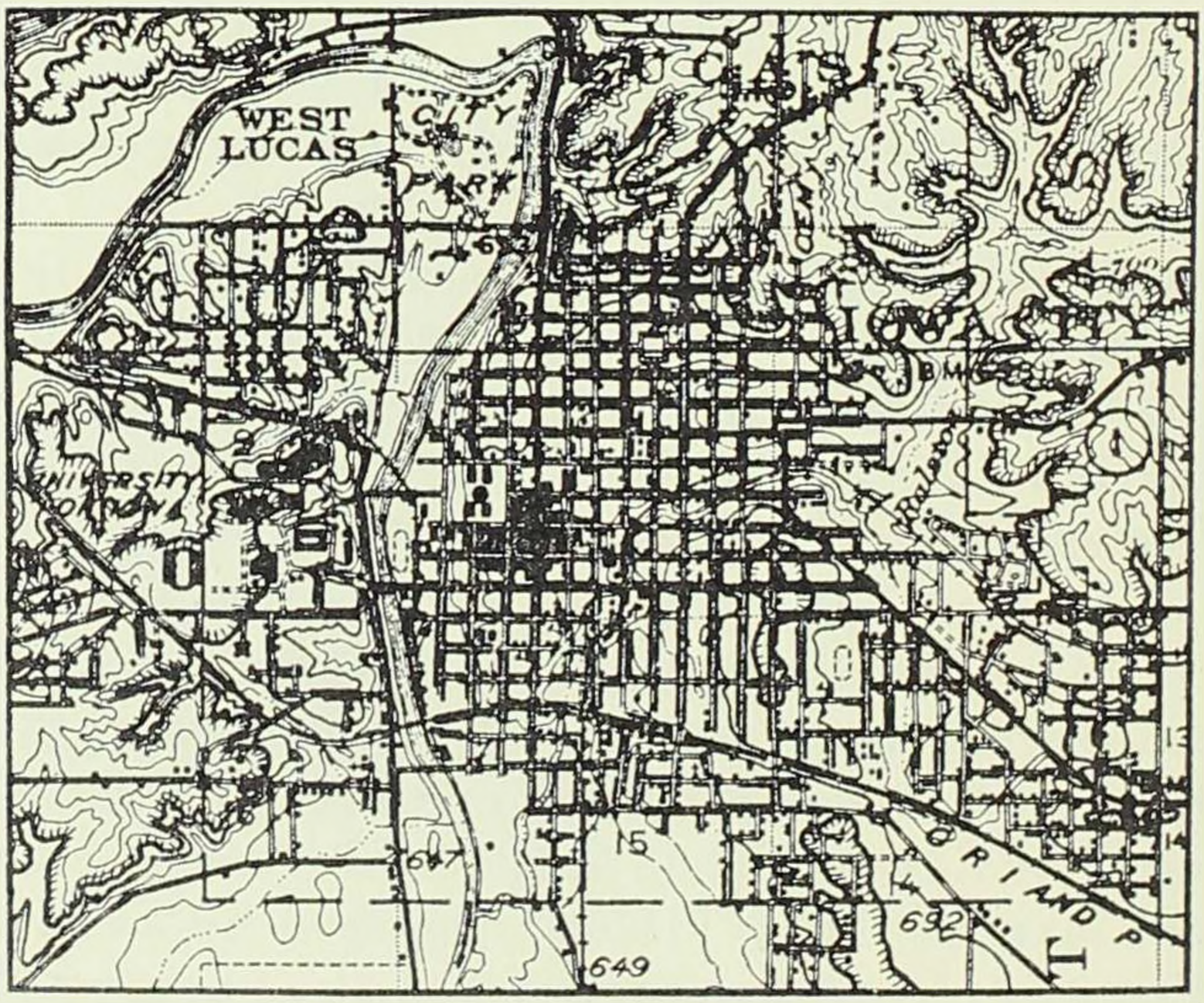
With the advance of the ice edge the Princeton valley was blocked and also the Mississippi River itself near Clinton. Waters of the resulting lake backed up the Maquoketa River and spilled over a low divide to the Wapsipinicon River. These waters eroded out a channel that is today open and visible. At the old divide there is now a shallow lake called Goose Lake and nearby is the town of Goose Lake. The old waterway is called the Goose Lake channel.

The Wapsipinicon was also blocked, and the water backed up to a divide and flowed over into the Cedar River valley along the northern part of the old Cleona channel. This spillway is also known as the Cleona channel.

The Cedar and Iowa rivers were blocked directly by the Illinoian ice. The result was Lake Calvin, so named by Udden in 1899, because the former existence of the lake had been first recognized by Samuel Calvin in 1874. The basin of the old lake was later (1920) described by W. H. Schoewe. The lake covered an area of about 325 square miles, or 208,000 acres. Arms of the lake extended far up the valleys of the Cedar, Iowa, and English river valleys. The lower parts of other tributary valleys were also drowned. The lake extended along the ice edge for almost fifty miles. At its maximum extent the level of the lake was approximately 720 feet above sea level.

Study of the accompanying map indicates that

much of the area of Iowa City was covered by the water of Lake Calvin. The water was sixty to seventy feet deep over the Iowa River floodplain, including the lower part of the City Park and the sites of the Iowa Memorial Union, the University Library, and the airport, and ten to twenty feet



Topographic map showing the approximate position of the shoreline of Lake Calvin at Iowa City. The lake shoreline is shown by the irregular hachured line.

deep over the Pentacrest campus and the main business district of Iowa City. West of the river and north of the Interurban railway three low islands existed. Relatively large areas stood above lake level south of the Interurban on the west side and east of the river in the northeast

part of the city. Parts of two blocks at and near the President's home are located on what was a small low island in Lake Calvin. Summit Street was a narrow low island. The site of the Iowa City high school stood forty to fifty feet above the lake. A low peninsula projected into the southeast part of the city from higher land to the south.

The lake had an outlet known as the Leverett channel. From its head at Columbus Junction this outlet followed a crooked course to the south and joined the present Mississippi about at Fort Madison. The water from the Leverett channel must have discharged over the Keokuk rapids and flowed on to the south.

So the main event of the Illinoian age was the displacement of the Mississippi River from its eastward Kansan and Yarmouth course to a southerly course through Goose Lake and Cleona channels to Lake Calvin and out of Lake Calvin through Leverett channel to the present river near Fort Madison. From here the water must have drained across the Keokuk rapids and flowed on to the south.

Evidences of such a history are the open Goose Lake, the Cleona and Leverett channels, wide flats and laminated sands, silts and clays on the bottom of the basin, and nearly straight bluffs that resulted from erosional wave action at many places on the west side of the basin. One of these

erosional shorelines may be seen west of the Iowa City airport and on south to Indian Lookout. The reader should be warned, however, that the old channels were neither deep nor sharply defined originally and that they have been modified more recently by erosion and deposition of streams. The Leverett channel is especially hard to find in the field, because it is crossed by the deep young valleys of the Skunk River and the post-Illinoian tributaries of the Mississippi and Skunk rivers. The most conspicuous evidences of the earlier existence of a lake are the wide flat lowlands and the west shore bluffs. Of course there are no shore features on the east side of the old lake, for the lake waters were confined on this side by the Illinoian ice itself.

Mississippi River in Sangamon Time

When the edge of the Illinoian glacier had retreated to a position east of the Illinois River, the Mississippi resumed its old eastward course through Princeton valley and down the Illinois. The Goose Lake and Cleona channels were abandoned. The level of Lake Calvin was lowered as the ice edge receded eastward, and its outlet, the Leverett channel, was abandoned. The Cedar and Iowa rivers joined then as now and soon cut the existing valley through Illinoian drift and flowed southward as before. The Skunk River also reopened its lower valley and joined the Cedar-Iowa drainage at the head of Keokuk rapids.

A map showing Sangamon drainage lines, therefore, would be practically identical with the one showing Yarmouth conditions and need not be repeated.

Early Wisconsin History

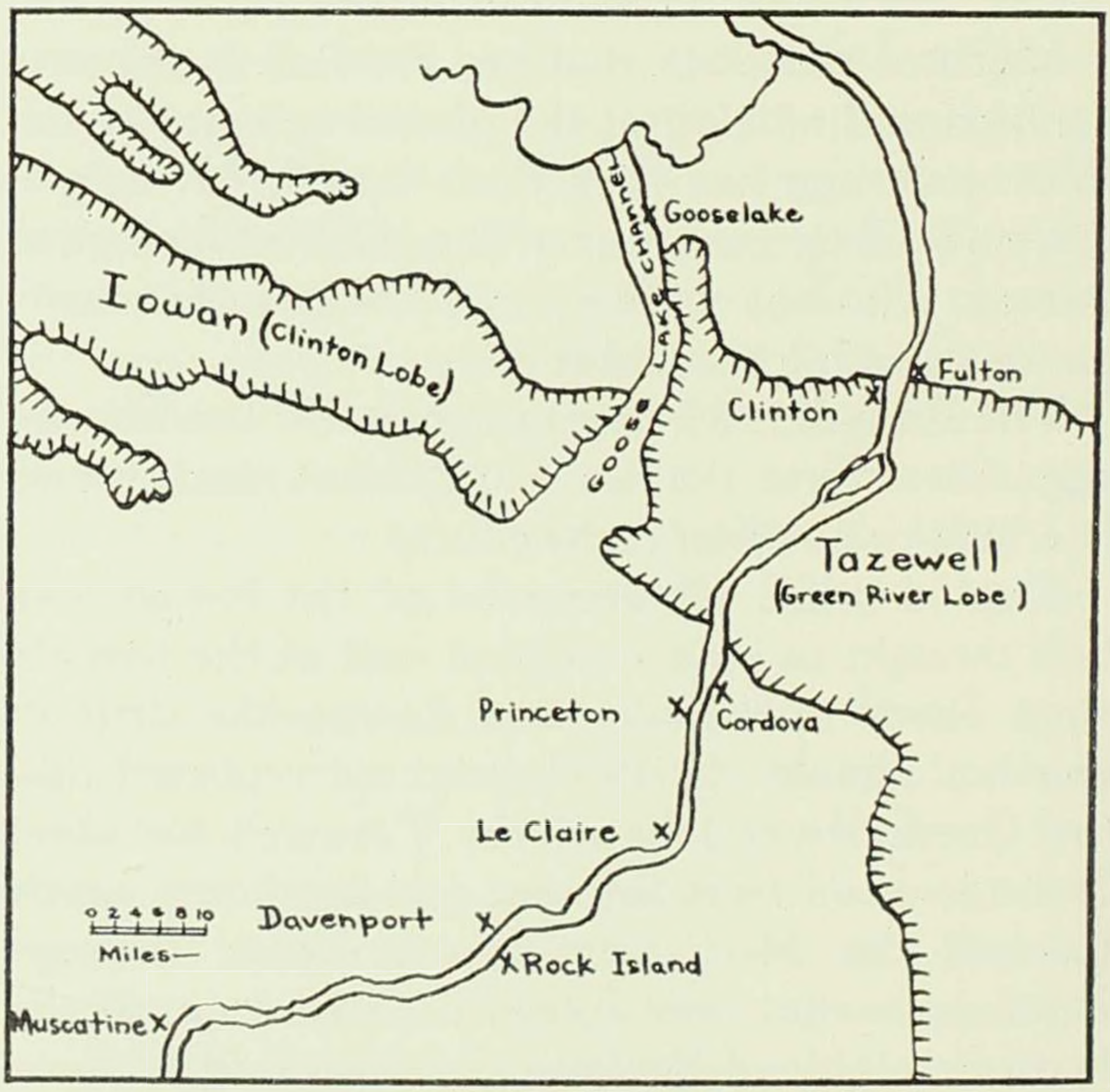
Much of the work that has resulted in the recognition and naming of the glacial subages of the Wisconsin age has been done by M. M. Leighton, now Chief Emeritus of the Illinois Geological Survey, who has done a large amount of investigation in both Iowa and Illinois.

The Farmdale ice sheet approached the Mississippi River from the east but did not reach it and had little or no effect on its course.

The so-called Clinton lobe of the Iowan was first thought to have extended east of the Mississippi River to include some Iowan-like drift in western Illinois. In 1923 Leighton reported that the Green River lobe of the Tazewell ice sheet had advanced from the east and northeast, again blocked the Mississippi in its course through Princeton valley, and forced the river to cross the bedrock highland between Cordova and Muscatine, thus starting the Rock Island rapids.

In 1954 Paul Shaffer, working in cooperation with the Illinois and Iowa Geological Surveys, published a report and map showing that the Green River lobe had actually crossed the river into Iowa. The ice blocked the river between Princeton, Iowa, and Fulton, Illinois, and made

Lake Savanna above Fulton. This temporary lake backed up the Maquoketa River valley and spilled over the divide into the valley of the Wapsipinicon, thus reopening for a short time the



Sketch map showing borders of Iowan and Tazewell drifts in eastern Iowa and western Illinois and the relations of these ice sheets to the course of the Mississippi River. (Modified slightly and redrawn from Shaffer, 1954.)

Goose Lake channel. Shaffer suggested that the Clinton lobe of the Iowan and the Green River lobe of the Tazewell may have been contemporaneous. This idea is not so radical as it might

seem, for it has been known for some time that the Iowan and Tazewell drifts are not greatly different in age. The two lobes did not quite meet and permitted drainage through Goose Lake channel to pass between them. When the ice receded to the west and east, Lake Savanna was drained, Goose Lake channel was again abandoned, and the present course of the Mississippi was established.

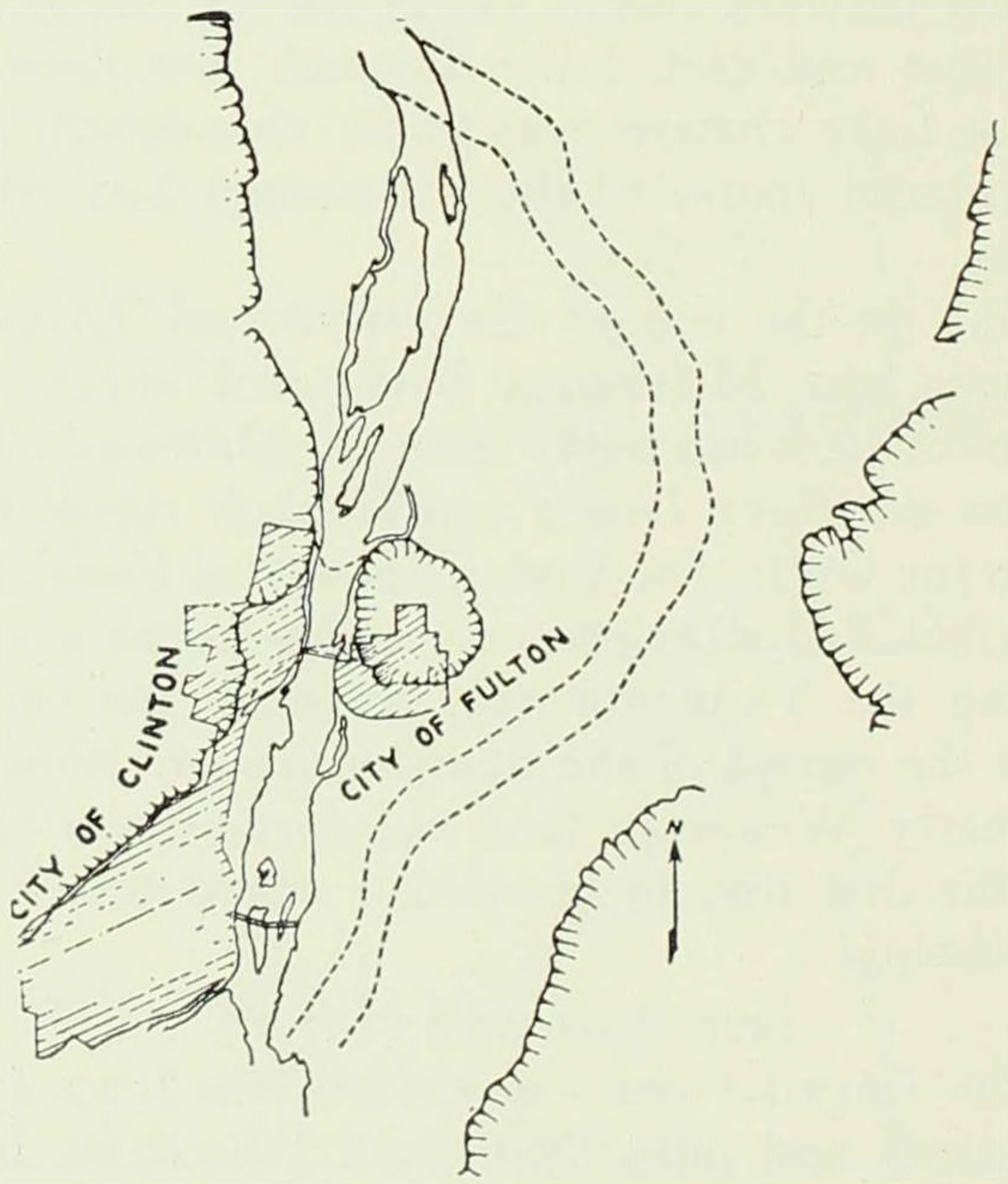
Thus at the end of the Iowan and Tazewell subages, the Mississippi River had almost the same course it has today from the Minnesota line, across the Rock Island and Keokuk rapids and on to the Gulf. The Cedar, Iowa, and Skunk rivers, that had developed an independent system during the Yarmouth age, resumed this course after the retreat of the Illinoian glacier. Now, in the early Wisconsin time, the three rivers came for the first time to be normal tributaries of the Mississippi.

Late Wisconsin History

The Cary ice sheet advanced into Iowa from the north and into Illinois and Wisconsin from the east but did not reach the Mississippi River from either direction. Sand and gravel were washed down the Wisconsin River and deposited but had no effect on the course of the Mississippi.

The edge of the Mankato glacier stood across the valley of the Mississippi at St. Paul and discharged great quantities of water and gravel,

sand and silt down the river. In this way a great valley train was deposited in the main valley. As the bottom of the main valley was built up, the tributaries also were forced to deposit and the



Sketch map showing how the Mississippi River changed its course so as to leave a portion of the Iowa bluff on the east side of the river in Illinois.

lower portions of their valleys were also partly filled. The fill in the main valley is of foreign glacial melt-water origin, but that in the tributary valleys is of local derivation.

As the Mankato ice retreated, deposition of the valley train became slower and slower and ceased entirely when the divide between the Mississippi and northern drainage was uncovered. Still more recently the fill was eroded, and surfaces of the main valley train and of local deposits in the tributary valleys were eroded to form terraces.

At a late date in its history, the Mississippi River is known to have served as an outlet for Lake Agassiz. This giant lake in Canada, the Dakotas, and Minnesota was for a time larger than all of the present-day Great Lakes.

One minor change in the course of the Mississippi River remains to be mentioned. This has to do with the sharp hill at Fulton, Illinois, across the river from North Clinton, Iowa. This hill was originally an eastward extension of the west bluff of the valley, and the river was east of it, as shown on the map. There must have been a low divide (a "col") behind the end of this projecting bluff. As the Mankato fill became thicker and thicker, its surface was built up until the river bottom became as high as the col and the river took a straight course west of the hill. The river has held this course and has deepened its valley so as to leave the Fulton hill east of the river. In this way a small area was subtracted from what is now Iowa and added to what is now Illinois.

General Summary

So it appears that the course of the Mississippi

River has been changed several times and in important ways by the several glacial invasions of the Pleistocene epoch.

First the river was forced from its western pre-Glacial position by the Nebraskan glacier to take a course along the east side of Iowa. It probably flowed through the Cleona and Gordon channels.

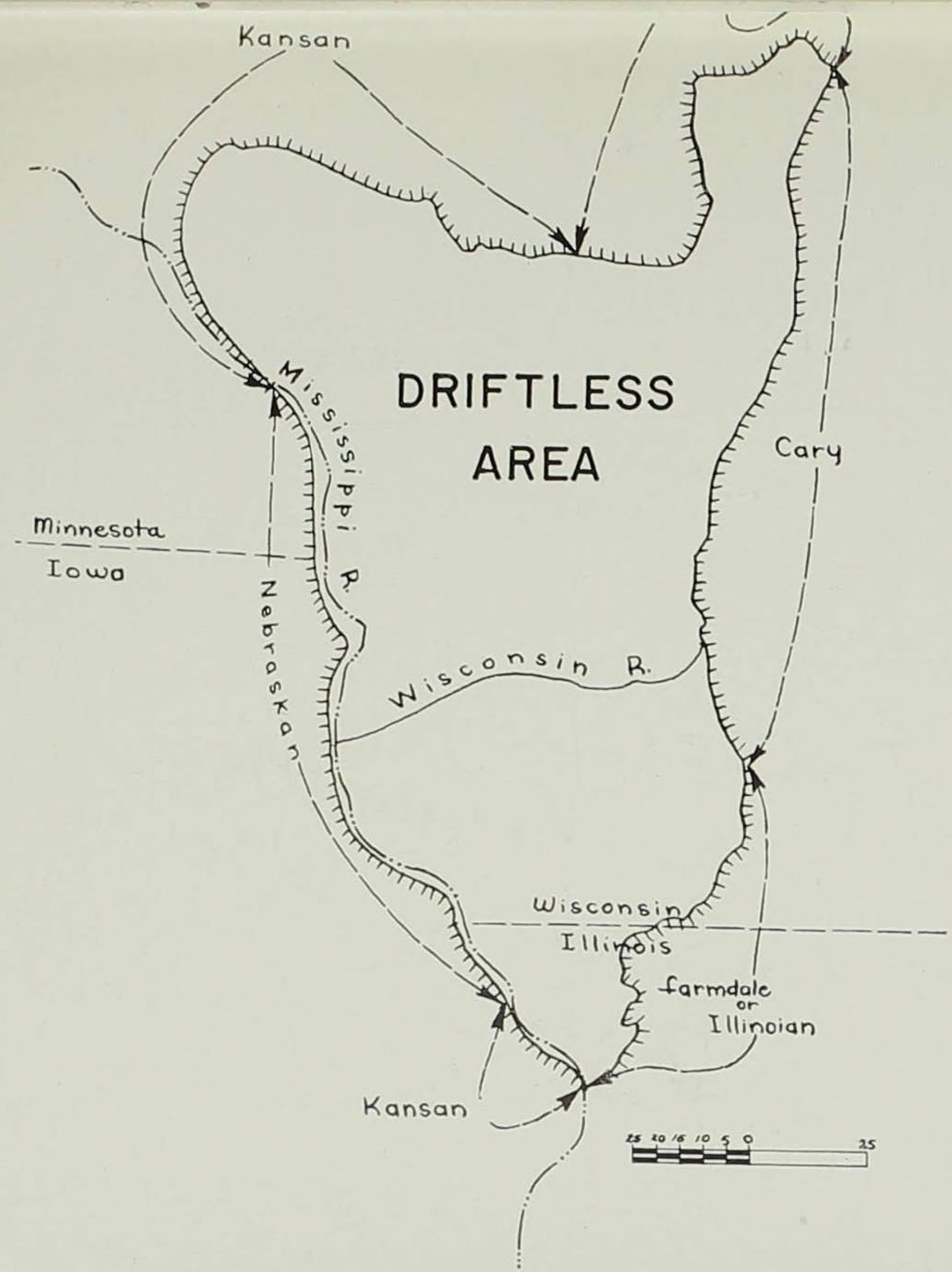
The Kansan ice sheet blocked this course and caused the river to flow eastward through Princeton valley to the Illinois River valley and on south. In the Yarmouth age the Cedar, Iowa, and Skunk joined and started the Keokuk rapids.

The Illinoian ice blocked Princeton Valley temporarily and formed Lake Calvin with its inlets and outlet. With the retreat of the Illinoian ice, the Mississippi River returned to its previous course eastward, and the Cedar, Iowa, and Skunk resumed flow across the Keokuk rapids.

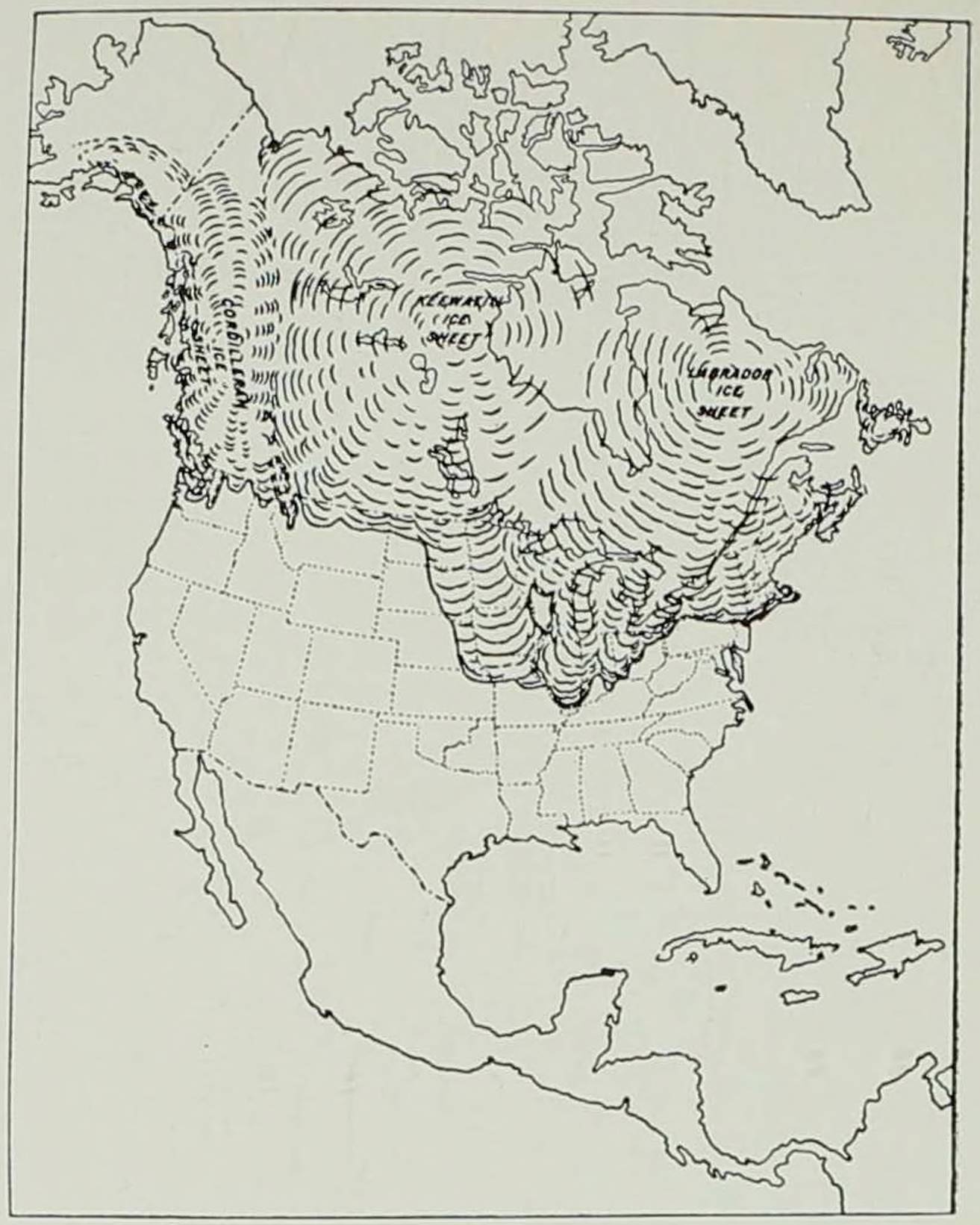
The Iowan and Tazewell glaciers, advancing from both sides of the Driftless Area, perhaps contemporaneously, blocked Princeton valley first by ice and finally by drift. This created Lake Savanna and the Mississippi took its present course across the Rock Island and Keokuk rapids.

The Mankato ice sheet partly filled the valley by depositing a great valley train and leaving a wide floodplain. Still later the river and its tributaries eroded slightly and turned the surface of the valley train into a series of terraces.

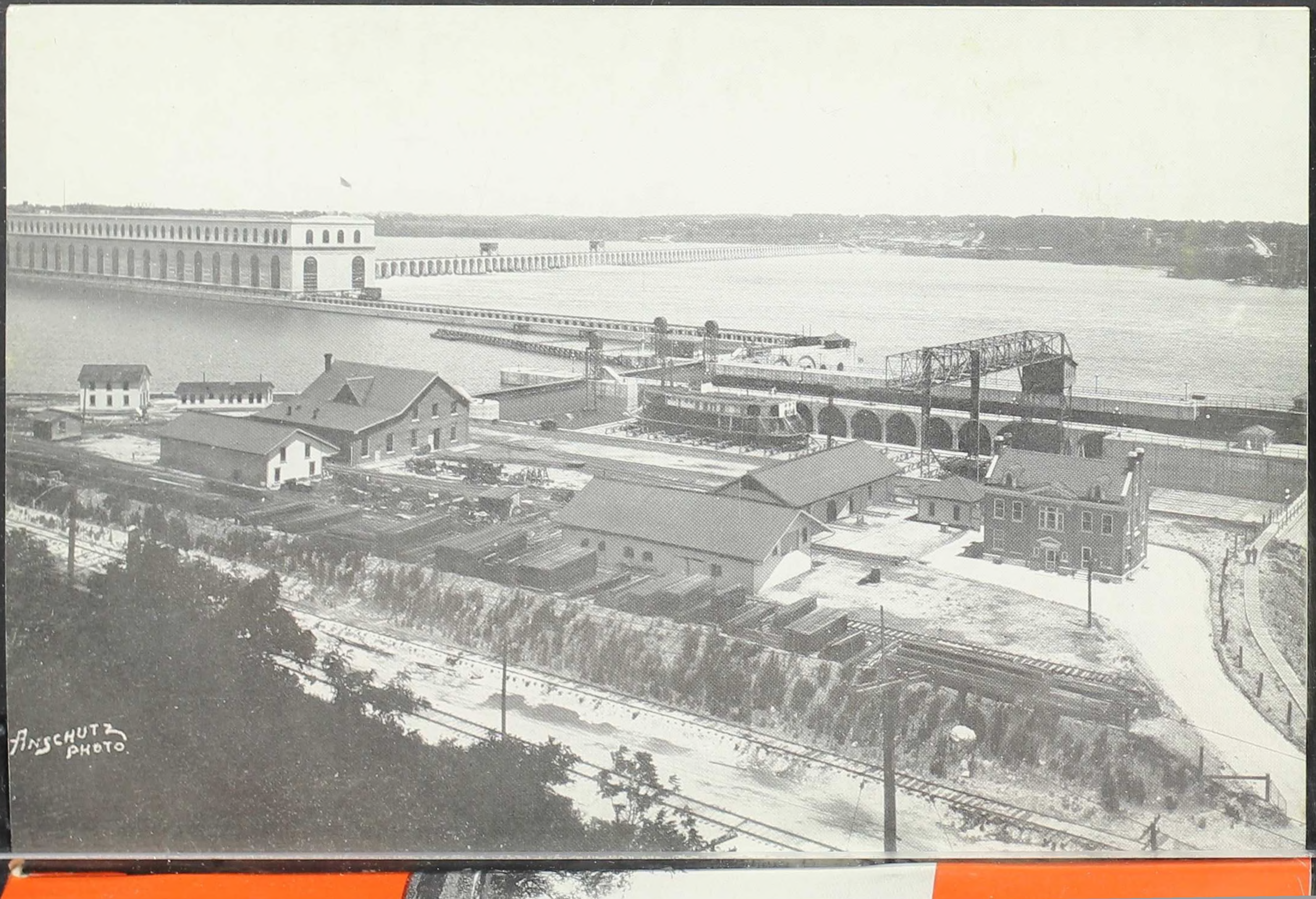
ARTHUR C. TROWBRIDGE



The Driftless Area



Glacial Map of North America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