BULLETIN No. 26

GEOLOGY AND GEOGRAPHY
OF THE
GALENA AND ELIZABETH QUADRANGLES

BY

ARTHUR C. TROWBRIDGE and EUGENE WESLEY SHAW

HISTORY OF DEVELOPMENT
OF
JO DAVIESS COUNTY

BY

BERNARD H. SCHOCKEL

Work in cooperation with U.S. Geological Survey

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ILLINOIS STATE GEOLOGICAL SURVEY
UNIVERSITY OF ILLINOIS
URBANA
1916
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STATE GEOLOGICAL SURVEY,
UNIVERSITY OF ILLINOIS, JAN. 6, 1916.

Gentlemen: I submit herewith a report on the Geology and Geography of the Galena and Elizabeth quadrangles by Arthur C. Trowbridge and Eugene W. Shaw and recommend that it be published as Bulletin No. 26. Chapter X, on the History of Development of Jo Daviess County, has been prepared by Bernard H. Schoekel, who assisted the authors in the field. The field work was done under the joint auspices of the U. S. Geological Survey and the Illinois Geological Survey, during the autumn of 1910. General direction of the work was vested in Professor R. D. Salisbury of the University of Chicago, Consulting Geologist of the State Survey, and Dr. David White of the U. S. Geological Survey.

At the time the work was done Mr. Trowbridge was a member of the department of geology at the University of Chicago. He is now professor of geology at the University of Iowa. Mr. Shaw is and has been a geologist on the U. S. Geological Survey. He has done a large amount of work in Illinois in cooperation with the State Survey. Mr. Shockel is now head of the department of geology and geography at the Indiana State Normal, Terre Haute.

The lead and zinc deposits of the region have been described in previous publications, and the purpose of the present report is to outline the processes that have produced the wealth of topographic forms found in the area, and to point out the human response to the physical environment.

The report will be of particular interest to residents of the region described, to teachers and students, and to all who are interested in nature studies.

Very respectfully,

FRANK W. DEWOLF, Director.
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GEOLOGY AND GEOGRAPHY OF THE GALENA AND ELIZABETH QUADRANGLES

By Arthur C. Trowbridge and Eugene Wesley Shaw

CHAPTER I—INTRODUCTION
LOCATION AND EXTENT OF AREA

A quadrangle is the unit of area chosen by the United States Geological Survey to be represented on topographic and geologic maps. It is a rectangular area of the earth's surface bounded by meridians and parallels. The area covered by this report is that of the Galena and Elizabeth quadrangles, of which topographic maps have been made by the State Geological Survey and the U. S. Geological Survey in cooperation. An additional area about one-half mile wide beyond the northern boundary of the quadrangles is included in the maps. These quadrangles are located in the extreme northwest corner of Illinois and extend to the Wisconsin line on the north and to Mississippi River and Iowa on the west, a small portion of Iowa being included in the southwestern corner of the Galena quadrangle. Each of these quadrangles measures 15 minutes of latitude by 15 minutes of longitude, a distance of approximately 18 miles north and south, and 12 miles east and west. The total area of the region, including the Iowa portion, is about 450 square miles. Its principal cities and villages are Galena, Apple River, Hanover, Elizabeth, Stockton, and Scales Mound. Warren is just east of the northeast corner of the area under consideration here (Pl. I).

The district lies in the southern part of the Driftless Area, a tract of 8,000 to 10,000 square miles in adjacent parts of Wisconsin, Minnesota, Iowa, and Illinois, which was not covered by ice and received no drift during the glacial period. The district is otherwise known as the "Galena lead and zinc district" or the "Wisconsin-Illinois lead and zinc district" or the "upper Mississippi Valley lead and zinc district," because of the existence in this area of extensive deposits of the ores of those metals.

FIELD WORK

The field work on which this report is based was done in the months of August, September, and October of 1910, and the usual field methods of geological surveys of the United States and of Illinois were employed. The authors were assisted in the field by Mr. B. H. Schoeckel.
Purposo of Bulletin

The purpose of this bulletin is threefold. It presents a description of the geologic features of the district and discusses its geologic history. One chapter is devoted to geographic influences in the development of the region. Throughout the report geologic principles and processes are treated in such a way as to enable the interested reader to study geology, so far as features belonging to that science are illustrated in the Galena and Elizabeth quadrangles.

Acknowledgments

In the collecting of field data, Mr. Shaw is largely responsible for the areas around Scales Mound, Apple River, Warren, and Elizabeth. Messrs. Trowbridge and Schockel did most of the work around Galena, Hanover, and Stockton. However, all parts of the region were at least visited by Messrs. Shaw and Trowbridge. Acknowledgments are due to Prof. U. S. Grant, Prof. G. H. Cox, and Prof. T. E. Savage for suggestions in the field, and to Professor Grant, in addition, for aid through his previous work immediately north of these quadrangles, published as the Lancaster-Mineral Point folio of the U. S. Geological Survey. Further acknowledgment is made of general field supervision by Mr. David White for the U. S. Geological Survey, and on behalf of the State Geological Survey by Prof. R. D. Salisbury, and especially to the latter for thorough criticism of the report. Lastly, but heartily, we thank the residents of the region, both in town and country, for a kindly interest in our work, for cordial hospitality, and for material aid in obtaining well records, finding outcrops, running level lines, and other assistance.
CHAPTER II—GENERAL TOPOGRAPHY

Topographic Relations

The Mississippi Basin province is one of relatively low relief and few striking topographic features. In the area south of the Ohio and Missouri rivers the surface has been shaped primarily by the erosive work of streams. North of these rivers most of the country was covered during the glacial epochs by great ice sheets, which brought great quantities of drift from the north and spread it irregularly over the land thus developing an undulating, irregularly arranged topography of slight relief. Since the glaciers melted away due to a change in climate, streams have formed valleys in the drift, at least locally, though much of the glacial topography is still preserved.

Topographically, the central and most of the northern parts of Illinois are typical of a glaciated country slightly modified by stream erosion. Elevations and depressions are arranged without definite relations to streams. Most of the area is rolling prairie land, though locally steep, sharp hills and abrupt depressions exist. In many places there are flats of various sizes that were formerly occupied by lakes which later disappeared by drying up or by being drained; in other places there are many small lakes and extensive areas of marsh land still undrained.

But surrounded by this area of glacial plains there is a region comprising 8,000 to 10,000 square miles in southwestern Wisconsin, northwestern Illinois, northeastern Iowa, and southeastern Minnesota, which is strikingly different topographically. This is known as the Driftless Area. It has been well described by Professors T. C. Chamberlin and R. D. Salisbury\(^1\) and by others. It presents greater relief, sharper contour, and better drainage than the glacial plains about it. The depressions in this area are stream valleys; the elevations, stream divides. Topographic features have a leaf-like or dendritic arrangement with respect to Mississippi River, which forms the stem and central axis of the leaf. Except in the extreme eastern portion of the Elizabeth quadrangle, the topography of the region under discussion is typical of that of the Driftless Area. Figure 1 shows its relations to the Driftless Area and to the district of the Lancaster-Mineral Point folio.\(^2\)

**Topography of the Galena and Elizabeth Quadrangles**

The area of the Galena and Elizabeth quadrangles may be separated topographically into two divisions—the Mississippi Valley, and the dissected plains east of that valley.

![Map showing relations between the Galena-Elizabeth district and the Driftless Area. The shaded area is the Galena-Elizabeth district; the white area bounded by straight, full lines is the Lancaster-Mineral Point district, previously mapped by Grant and Burchard.](image)

**PLAINS**

The entire area except the Mississippi Valley may be regarded as an irregular plain, above which rise conspicuous elevations and below which are numerous large and small valleys. This plain, because of its normal
A. Pilot Knob as seen from the south.

B. View of the general topography of the intermediate plain near Elizabeth.
position between the upland areas and valley bottom, is here termed the intermediate plain. Locally, as in the region between Apple River and Warren, and thence southeast to Stockton, this plain without conspicuous elevations and depressions forms most of the surface. In other and larger parts of the region the plain has been much dissected by erosion and its remnants are the divides between the streams.

The elevations above the general plain are of two types—isolated mounds; and larger, almost continuous, upland flats. Commonly they take the form of mounds, and are so designated in the region. They stand out conspicuously, because of their height, their steep slopes, and heavy growth of timber. A few are small, and almost mathematically conical. Such are Pilot Knob south of Galena, so named because it was a landmark for river pilots during the days of early river navigation (Pl. II, A), and an unnamed knob at the Mt. Pleasant School, 2 miles southeast of Galena. These are scores, or at most a few hundreds, of feet in diameter at the base and 100 to 200 in height.

The majority of the mounds are irregular in plan, flat on top, and not uniform in slope. They rise 100 to 200 feet above the general surface and cover areas ranging in size to one-quarter of a square mile. The lower slopes are steeper than the average slopes of the region, and those in the upper 15 or 20 feet are commonly vertical or nearly so. The flat tops cover some thousands of square feet. These mounds are confined largely to the northern parts of the area. Similar flats at about the same elevation exist farther south, but in areas too large to be called mounds. Some of the better-known mounds are Horseshoe, Dygents, Seales, Hudson, Mount Sumner, and some unnamed ones east and northeast of Galena.

These same summit areas in the southern part of the district occupy a very considerable part of the surface. They make the main stream divides and take the form of long, irregular, steep-sided, and flat-topped ridges, from which project short spurs similar in aspect to the main ridges. A glance at the topographic maps will show such features south of Elizabeth and in the south-central part of the Galena quadrangle. Where the ridges trend nearly east and west, for example, northwest of Stockton, they are commonly steeper on the north than on the south side (see topographic map, Pl. I).

Many of the ridges are several miles in length. For the most part they trend in a northeast-southwest direction, paralleling the main streams which flow southwest. Most of the main roads in the southern part of the district are located on the ridges, whereas in the northern part they run on the intermediate plain. Few houses are located on the upper plain, except in the extreme southern part of the region where its remnants are large. The mounds and ridges are invariably carved from a hard rock known as the Niagaran limestone. Because their north slopes appear very abrupt and
almost continuous when seen from the north and because of their rock formation, James Shaw,¹ and later Grant,² called their northern edge the Niagaran escarpment.

The intermediate plain on which the mounds are situated is broken by numerous valleys. The larger of these are the valleys of Sinsinawa Creek, Galena River (or Fever River), Smallpox Creek, Apple River, Rush Creek, and Plum River. They extend practically the whole length of the area in a northwest-southeast direction and are cut from 100 to 300 feet deep and from one-fourth to one-half mile wide. Since the steepness and definiteness of their side slopes depend largely on the resistance of the rock into which they are cut, these features vary considerably in different valleys and in different parts of the same valley. Converging to the main valleys are innumerable smaller ones which head in the divides on the upland plain, or in the ridges south of the Niagaran escarpment. A general view in this part of the region is shown in Plate II, B.

MISSISSIPPI VALLEY

The Mississippi Valley forms a distinct topographic unit in the southwestern portion of the district. Its bottom is a narrow, flat plain separated from the general plain of the region by a valley wall which is everywhere steep and in places vertical. The valley bottom varies in width from 1 to 5 miles. It departs from absolute flatness only by low swells and local wind-blown hills of sand, and by shallow, curved, linear depressions, or sloughs, which were once curves of the river channel. The Mississippi River flows through this flat in a sinuous, braided course of several channels enclosing islands. In time of flood practically the whole flat is under water (Pl. III, A).

The sides of the valley are steep, conspicuous, and bluff-like, except where they are formed in soft rock such as the Maquoketa shale, and even in such places they are fairly definite. The bluffs are commonly 300 to 400 feet high. They consist of hard rock outcrops especially in their upper slopes and cliffs. A typical view of the Mississippi bluffs may be seen at Galena Junction (Pl. III, B).

TOPOGRAPHIC HISTORY

It is clear that the topographic features of this district, in general and in detail, are due to erosion by running water. The mounds and areas south of the Niagaran escarpment above the general intermediate plain are interstream areas, parts of a still higher and older flat not yet destroyed by erosion. The intermediate plain is a lower area made flat by streams and

A. View over the bottom lands along Mississippi River as seen from Galena Junction.

B. Mississippi River bluffs at Galena Junction.
not since dissected. The Mississippi Valley was made by Mississippi River. All the other linear depressions of the region contain streams to which the valleys are genetically related.

**RELIEF**

The elevation of a region is its height above sea level. The relief of a surface is the vertical distance between its high and low points. Maximum relief is the distance between the highest point and the lowest point of the surface considered. Average relief is the average distance between elevations and depressions, measured vertically. Roughness involves still a different factor. Figure 2, b, shows a region of the same relief as in figure 2, a, but of greater roughness.

![Diagram](image)

**Fig. 2.** Diagrams illustrating the difference between relief and roughness; a, profile of a surface of relief ab; b, profile of a surface of the same relief as a, but of much greater roughness.

The average elevation of the region about Galena and Elizabeth is about 900 feet. This is 300 feet higher than Chicago, 500 feet higher than Mississippi River at St. Louis, about 4300 feet lower than Denver, and about 1300 feet lower than the average for all the lands of the earth. It therefore belongs to the low part of the surface of the continent.

The maximum relief of the district may be learned by reading from the topographic map the elevation of the Mississippi where it leaves the region and that of the highest mound or escarpment within it, and subtracting the former from the latter. The Mississippi leaves the area at an altitude of 580 feet; the highest point in the region is Charles Mound which reaches an altitude of 1241 feet. The maximum relief is, therefore, 661 feet. Nearly every square mile has a relief of more than 100 feet.

Apart from the relief of the region, its surface is rough in detail. A glance at the topographic map shows crowded contour lines in most parts of the area. There is relatively little flat land. Except in the east and north parts of the Elizabeth quadrangle, the courses of roads are controlled by topographic features; it would be almost impossible and certainly not
advisable to lay them out in straight lines. The region is also sufficiently rough to control the distribution of inhabitants to a certain extent. In its southern part the people live on the flat above the Niagaran escarpment or on the stream flats, cultivate the narrow upland and lowland flats and the lower gentler slopes associated with them, and use the steep upper slopes for pasture and timber. Where the intermediate plain is broad there are homes and cultivated land, and timber and pasture are obtained in the valleys. A scantly population inhabits the Mississippi River bottom land. It is, however, not to be understood that the people are distributed according to topography alone, for the location of mines, railroads, springs, and other features, are also important in determining the locations of settlements.

DRAINAGE

As intimated above the region is well drained by Mississippi River, its tributaries, and their branches. Aside from the Mississippi the main streams draining the district are Sinsinawa River, Galena River, Smallpox Creek, Apple River, and Plum River, named in their order from northwest to southeast. They are all permanent streams in their lower courses, even in the driest seasons. Apple River and Galena River are used somewhat for power. Before a dam was constructed at its mouth the latter stream was navigable as far as Galena, 3 miles above the Mississippi. All except Smallpox Creek are decidedly crooked. Apple River has a peculiar course, which can be seen on the map (Pl. I) in the vicinity of Millville. This is due to a change in drainage by which one river system was diverted into another, a subject to be discussed in Chapter V.

The main tributaries are fed by streams of a lower order, such as North Fork, Long Hollow Creek, and Fish Hollow Creek, and these in turn receive most of their water from innumerable smaller creeks heading at the main divides. Except that there are small sloughs in the east-central part of the Elizabeth quadrangle and on the Mississippi flat, the whole region is well drained.

EFFECT OF ROCK FORMATIONS ON TOPOGRAPHY

Different kinds of rocks give rise to different types of topography. Flat areas are due, at least in part, to resistant, horizontal strata. The hard dolomite forms the bluffs, cliffs and steep valley walls. The soft Maquoketa shale forms wide, open, indefinite, gentle-sided valleys. These points will be brought out as the rock formations of the region are described.
CHAPTER III—GEOLOGIC PRINCIPLES

Marine Deposition

Rock material is constantly being taken from the lands and carried to the sea. All streams carry mineral matter in solution and mud and sand in suspension, and many of them move gravel along their beds. Most of this material sooner or later reaches the ocean. Wind blows dust and sand from dry places and some of the wind-blown material comes to rest in the sea. Waves cut material from shores, and leave it in the water. Ocean waters are inhabited by animals which secrete calcium carbonate and other substances, making shells, skeletons, tests, and other forms which are left on the bottom when the animals die. Dredges bring up these materials from the bottom of shallower parts of the ocean. Many of the rocks now on the land consist of materials similar to those now depositing in the sea. Some of them contain marine shells and have structures characteristic of marine deposits. The inference is that such rocks were once deposited in the sea, much as sediments are now being deposited. The materials carried to the sea and deposited there are gravel, sand, dust, or mud, and materials dissolved in the water. Some of the latter are deposited as shells in the manner described.

The exact site of deposition of the various materials on the sea bottom is determined by several factors. Where the land is high and precipitation is abundant streams have great volume and great velocity and transport coarse materials, as gravel or sand. Along the coast of such an area the waves undercut the bases of cliffs and cause masses of rock to fall from above. In general, the higher the land, the coarser the materials deposited. If a stream carries several grades of material, the coarsest (gravel) is deposited near shore, the sand farther out, and the mud beyond the sand. Beyond the limits of deposition from the shore, shells accumulate on the bottom and form the principal part of the deposit. Where the water is shallow, the materials derived from the land are carried farther out than where the water is deep. The coarseness of material carried to the sea and the distribution of the materials on the sea bottom are therefore controlled by (1) the height of the land and its proximity to the site of deposition, (2) the depth of the water, and (3) the climate.

These things being true, geographic conditions at the time of deposition can be read from the texture of materials deposited. For instance, marine gravels mean high land nearby, and a shallow sea. Deposition of shells
alone means a clear sea. The site of deposition may have been far from shore, or if near short, the adjacent land was low.

After sediments are deposited, they are likely to be cemented. This takes place by the precipitation of materials dissolved in the water. Precipitation may take place while the sediments are being deposited or it may take place later.

The results of the deposition of fragmentary materials in the sea and their cementation are classed among sedimentary rocks. When cemented, gravel forms conglomerate, sand becomes sandstone, mud makes shale, and shells or fragments of shells essentially free from mud and sand form limestone.

Structure

At the time of deposition, beds of sediment conform in general to the surface on which they were laid down; most of them are nearly horizontal. But many of the rock strata of the earth, including those of the Galena and Elizabeth quadrangles, have been displaced from their original nearly horizontal position by movements which tilt and fold the rocks, and which are included under the general term diastrophism. The cause of these movements is in part the shrinkage of the earth. The interior is constantly losing heat and in so doing contracts. The outer part is forced to fit itself to a smaller core, and thus is made to wrinkle. Again, the materials of the inside of the earth are constantly rearranging themselves into denser and denser combinations which occupy less and less space. This may be as effective as cooling, so far as shrinkage is concerned. In adapting itself to a shrinking interior the outer part of the earth, the "crust", is shortened by lateral pressure which in extreme cases results in folds. On the tops of the upfolds tension is brought into play and the rocks are cracked. Other causes may also produce folding and tilting, but it is unnecessary to discuss them here.

Where strata are folded the upfolds are known as anticlines, and the down folds synclines. Where strata dip constantly in one direction, the structure is known as a monocline. More or less vertical cracks in rock are known as joints. Where rock is displaced on opposite sides of a plane of breaking it is said to have been faulted, and the plane of displacement is a fault (fig. 3).

Geologic History

Record of the Rocks

The rocks of any region furnish a more or less complete and accurate record of its history. The record is especially satisfactory where, as in the Galena-Elizabeth district, the rocks are sedimentary, of marine origin, contain abundant fossils, have been disturbed from their original attitudes, and are well exposed.
The determination of the relative ages of different rock strata is usually simple where they have not been much disturbed. For instance in the Galena and Elizabeth quadrangles there is a shale formation overlain and underlain by dolomite formations. Obviously the shale is older than the upper dolomite, and younger than the lower dolomite. This is according to the law of superposition. If the age of one formation is known, and if it grades into another formation above without interruption the upper bed is next younger than the lower one. If one bed lies on another with evidence of a period of erosion or a period of deformation between, the upper one is still younger than the lower, but not next younger. After the shale of this region was deposited, it was elevated above the sea level, its surface was weathered and eroded, the area was again submerged, and the upper dolomite was then laid down. The upper dolomite, therefore, does not belong to the epoch next after that in which the shale was laid down, but to some later one.

![Fig. 3. Diagrams illustrating various structural forms; a, anticline; b, syncline; c, monocline; d, fault.]

If the relative ages of two formations are known by the methods outlined above, and each contains fossils which are characteristic, the ages of these beds in regions where their relations are not clear can be determined by the fossils. For instance, in some places in this district where the upper part of the shale is limy and the lower part of the younger dolomite is shaly, the plane between them can be located most easily by finding fossils known to be characteristic of the one or the other.

The former presence or absence of seas can be determined by the presence or absence of marine deposits. Seas are known to have existed over these quadrangles in the past, because the shales and dolomites have a structure, constitution, and fossil content which are characteristically marine. If in some places the shale between the dolomite formations
is missing, it is inferred either that the sea did not cover this area while the shale was being deposited elsewhere, or that the shale once deposited was removed by erosion before the deposition of the upper dolomite.

Dates of emergences and submergences of the land can be determined if the ages of the beds are known. If the top of the a limestone is weathered and overlain with b limestone, as in figure 4, and both are marine, the events are recorded in the order of the following numbers:

5. Deposition of calcareous matter (to become b limestone).
4. Submergence
3. Weathering.
2. Emergence.
1. Deposition of calcareous matter (to become a limestone) in sea.

![Fig. 4. Diagram illustrating an erosional unconformity.](image)

The interruption between the deposition of shale and of dolomite constitutes a structure known as an erosional *unconformity*; the dolomite is *unconformable* on the shale.

If one formation has been folded as well as eroded and underlies one which is horizontal, as in figure 5, clearly there was an interval of deformation after the deposition of the lower one and before the deposition of the upper. Such a structure is known as a structural unconformity.

![Fig. 5. Diagram illustrating a structural unconformity.](image)
Changes in forms of life at the time of the deposition of sedimentary beds are revealed by differences in the fossils contained in the different strata. The top of the shale in much of the district around Galena and Elizabeth is highly fossiliferous, and the fossils are distinctive. They include forms of large size and of certain species. The lower part of the upper dolomite contains few fossils. They are all small, and the species are different from those of the shale below. The change in life took place because of a change in physical conditions, perhaps climate, depth, clearness of sea, or other factors; or because of the migration of forms to and from the region; or because in the lapse of time between the epochs of deposition of the two formations organisms underwent changes. These are some of the ways in which geological history can be read from the rocks.

**Basis for Division of Geologic Time**

Human history is divided into periods during which political, educational, industrial, or artistic conditions were similar, and different from corresponding conditions of other periods. Geologic history is divided similarly, but the subdivisions are more complex. Geologists recognize eras, periods, and epochs, eras being the greatest of the divisions and epochs the smallest. In human history lines between periods are likely to be drawn (1) at times when great events, such as wars and political changes, took place about simultaneously in different countries, or (2) when there is a break in the record. So it is with geologic history, the divisions are separated by physical events of various magnitudes which took place over local or over widely distributed areas, and which more or less influenced the existing forms of life.

Eras are separated by physical events which were most pronounced in character and extensive in distribution. For instance, using the principles outlined above, it is known that between the times of deposition of two great groups of rocks known as the Paleozoic and Mesozoic: (1) the eastern part of the North American continent emerged from the sea; (2) seas then existing in the western part of the continent shifted their positions; (3) the Appalachian Mountains were folded, and the Ouachita Mountains were uplifted; and (4) there was a marked change in life throughout the continent. Similar events are recorded by the rocks of the same groups in other continents. These great changes separate the Paleozoic and Mesozoic eras. Such great and widespread physical changes seem to have taken place periodically throughout geologic time and now serve to divide geologic history into five eras: Archeozoic, Proterozoic, Paleozoic, Mesozoic, and Cenozoic, named in order of age from the oldest to the youngest.

Between the times of great physical change, important events of less magnitude or those affecting more restricted areas occurred. These less important changes are the basis for the subdivision of eras into periods.
The ideal period would include (1) a gradual submergence of an area which had been suffering erosion, (2) the gradual deepening and clearing of the sea, recorded by a vertical change from coarse to fine sediments and finally to limestone, (3) a shallowing of the sea with a return to coarse sediments at the top, and (4) an emergence followed by erosion. These physical changes would be accompanied by changes in life. On the basis of physical and life changes as recorded in the rocks the Paleozoic era is divided into the Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Permian periods.

Periods are subdivided into epochs on the basis of changes in sedimentation, as from limestone to shale, minor changes in life, or slight and local unconformities. The Maquoketa epoch is separated from the Galena epoch in the district under discussion because (1) shale was deposited where dolomite had been in process of deposition, (2) new species of animals succeeded those which had lived before, and (3) the dolomite probably emerged from the sea and was slightly eroded before the shale was deposited.

Thus geologic time is divided into eras, periods, and epochs. The rock strata deposited during these divisions of time are known as groups, systems, series, and formations. The relation between rock and time divisions is shown thus:

<table>
<thead>
<tr>
<th>Time</th>
<th>Rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Era</td>
<td>Group</td>
</tr>
<tr>
<td>Period</td>
<td>System</td>
</tr>
<tr>
<td>Epoch</td>
<td>{ Series }</td>
</tr>
<tr>
<td></td>
<td>{ Formations }</td>
</tr>
</tbody>
</table>

We would thus speak of the Paleozoic era and Paleozoic group of rocks; the Cambrian period and the Cambrian system of rocks; the Niagaran epoch and the Niagaran series or formation. The series may be further divided into formations, each of which is usually composed of a single kind of rock.

A table of geologic time divisions follows. It shows periods for all geologic time, and epochs for those periods represented in northwestern Illinois. The Ordovician period is divided still further, since this is the period to which belong most of the rocks in the Galena and Elizabeth quadrangles.
### Geologic time divisions

<table>
<thead>
<tr>
<th>Eras</th>
<th>Periods</th>
<th>Epochs</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Recent</td>
</tr>
<tr>
<td></td>
<td>Cenozoic</td>
<td>Pleistocene</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Miocene</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eocene</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cretaceous</td>
</tr>
<tr>
<td></td>
<td>Mesozoic</td>
<td>Comanchean</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jurassic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Triassic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Permian</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pennsylvanian</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mississippian</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Devonian</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Silurian</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cayugan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Niagaran</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oswegan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cincinnati-Maquoketa</td>
</tr>
<tr>
<td></td>
<td>Paleozoic</td>
<td>Mohawkian...</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Galena</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Platteville</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Trenton)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>St. Peter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Canadian...</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prairie</td>
</tr>
<tr>
<td></td>
<td></td>
<td>du Chien</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Lower)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Magnesian</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cambrian</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suratogan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acadian</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Georgian</td>
</tr>
<tr>
<td></td>
<td>Proterozoic</td>
<td>Keweenawan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upper Huronian</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or Animikean</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle Huronian</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower Huronian</td>
</tr>
<tr>
<td></td>
<td>Archeozoic</td>
<td>Archean</td>
</tr>
</tbody>
</table>
CHAPTER IV—GEOLOGY OF GALENA AND ELIZABETH QUADRANGLES

GENERAL STATEMENT

Both consolidated and unconsolidated rocks are represented in the Galena and Elizabeth quadrangles. The hard rocks consist of limestone, dolomite, shale, and dolomitic limestone. The unconsolidated rocks are sand, clay-like material known as loess, deposits which were made in lakes, glacial drift, and stream alluvium. The cemented rocks occur in layers in the regular order of deposition. At the top the youngest dolomitic limestone (Niagaran) overlies shale and limestone (Maquoketa); this shale overlies dolomite (Galena) which in turn overlies limestone (Platteville). The unconsolidated rocks lie in irregular order on the hard rocks, and the law of superposition does not hold except with modification. The reason is as follows: After the deposition and cementation of the hard rocks, they were uplifted, tilted slightly, and dissected by streams before the deposition of the loose sediments. In places the upper dolomite and even the shale were cut through, and stream alluvium was then laid directly on the lower dolomite, at levels lower than neighboring outcrops of shale and upper dolomite (fig. 6). For the distribution of these various rocks, see Plate IV.

Fig. 6. Diagram illustrating young, unconsolidated rocks lying on eroded, hard rocks.

HARD ROCKS

The oldest rock appearing at the surface in this region is the Platteville limestone. Its equivalent in northern Illinois and southern Wisconsin is commonly called the Trenton limestone. Older rock formations beneath are known by deep-well borings, and by outerops in neighboring regions. Figure 7 represents the succession of hard rocks of the district in the form of a columnar section.
<table>
<thead>
<tr>
<th>Formation Name</th>
<th>Scale of Feet</th>
<th>Columnar Section</th>
<th>Thickness in Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niagara dolomite</td>
<td>1875</td>
<td></td>
<td>0-140</td>
</tr>
<tr>
<td>Maquoketa shale</td>
<td>1825</td>
<td></td>
<td>120-200</td>
</tr>
<tr>
<td>Galena dolomite</td>
<td>1500</td>
<td></td>
<td>240</td>
</tr>
<tr>
<td>Platteville limestone</td>
<td>1250</td>
<td></td>
<td>55</td>
</tr>
<tr>
<td>St. Peter sandstone</td>
<td>1125</td>
<td></td>
<td>35-170</td>
</tr>
<tr>
<td>Prairie du Chien</td>
<td>1000</td>
<td></td>
<td>150-250</td>
</tr>
<tr>
<td>Cambrian sandstone</td>
<td>875</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>750</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>625</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>500</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>375</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>250</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>125</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 7. Columnar section through the rocks of the Galena-Elizabeth district.
PRE-PLATTEVILLE ROCKS

In the vicinity of Baraboo, Wisconsin, the oldest rock outcropping is a hard reddish quartzite. It was laid down in the sea as sand, cemented to sandstone, and later further cemented to quartzite by the precipitation of silica from water, enlarging the sand grains and filling up the pores. The exposed parts of the quartzite are the stubs of truncated folds. The quartzite is overlain unconformably by sandstone of Cambrian age. Sediments corresponding to the quartzite may have been deposited in our region, and may or may not have been removed by erosion before the deposition of the succeeding beds.

In a great area around Camp Douglas, Wisconsin, and around Madison, Wisconsin, and between these two places, the predominant rock at the surface is a quartz sandstone, known as the Potsdam sandstone. This formation is about 1000 feet thick. Though it appears horizontal in short exposures, its beds are known to have a gentle dip to the south. This dip projected southward would bring the formation beneath the surface of the Galena and Elizabeth quadrangles.

In most parts of southwestern Wisconsin, the Potsdam sandstone is overlain conformably by a limestone known as the Lower Magnesian limestone, or Prairie du Chien formation. It is gray, buff, or slightly greenish in color, hard, compact, and fine grained, massive to thin bedded, and it contains both magnesium and calcium carbonates. It has a dip to the south similar to that of the Potsdam sandstone. Like the sandstone, it probably continues into our region and lies beneath the exposed rocks.

In southern Wisconsin, the Prairie du Chien formation is overlain generally by the St. Peter sandstone. This formation lies unconformably on the Prairie du Chien formation. It lies at the surface at Platteville, Wisconsin, where there is an outcrop at Helers bridge, which is not more than 20 miles from the north edge of the Galena quadrangle. This formation, like those below it, dips south and underlies our region. At Platteville, the sandstone is overlain conformably by the Platteville limestone, which is the oldest rock outcropping in the Galena and Elizabeth quadrangles.

Since the rocks older than those which outcrop in our region have a southerly dip in the area to the north, they should be discovered by deep borings in this region. The only borings in the district deep enough to penetrate rocks older than those which outcrop are (1) in the northeast portion of Galena, (2) the town well at Stockton, and (3) the well at the woolen mills at Hanover. The records of these wells are given below. The key to their interpretation is obtained from the Lancaster-Mineral Point district to the north, where the following section is given by Grant and Burchard:

---

34

GALENA AND ELIZABETH QUADRANGLES

Geologic section in southern Wisconsin

<table>
<thead>
<tr>
<th>Thickness Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Galena dolomite</td>
</tr>
<tr>
<td>4. Platteville limestone</td>
</tr>
<tr>
<td>3. St. Peter sandstone</td>
</tr>
<tr>
<td>2. Prairie du Chien formation</td>
</tr>
<tr>
<td>1. Potsdam sandstone</td>
</tr>
</tbody>
</table>

The well northeast of Galena is on the property of D. A. Taylor in sec. 16, T. 28 N., R. 1 E. Mr. Taylor furnished the following record:

Log of well near Galena, Illinois

<table>
<thead>
<tr>
<th>Thickness Feet</th>
<th>Depth Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Surface wash</td>
<td>25</td>
</tr>
<tr>
<td>4. Gravel</td>
<td>30</td>
</tr>
<tr>
<td>3. Limestone (water at base)</td>
<td>65</td>
</tr>
<tr>
<td>2. Sandstone</td>
<td>30</td>
</tr>
<tr>
<td>1. Dolomite</td>
<td>103</td>
</tr>
</tbody>
</table>

From a study of the surface outcrops here and the use of the key given above, it is clear that in this section No. 1 is Prairie du Chien, No. 2 St. Peter, No. 3 Platteville, and Nos. 4 and 5 surficial material of more recent age.

The log of the well at Stockton is as follows:

Log of well at Stockton, Illinois

<table>
<thead>
<tr>
<th>Thickness Feet</th>
<th>Depth Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Clay</td>
<td>53</td>
</tr>
<tr>
<td>6. Limestone</td>
<td>450</td>
</tr>
<tr>
<td>5. Shale</td>
<td>50</td>
</tr>
<tr>
<td>4. Limestone</td>
<td>50</td>
</tr>
<tr>
<td>3. Sandstone</td>
<td>125</td>
</tr>
<tr>
<td>2. Limestone</td>
<td>620</td>
</tr>
<tr>
<td>1. Sandstone</td>
<td>180</td>
</tr>
</tbody>
</table>

If this record is compared with the section given by Grant and Bur- 
chard, some serious discrepancies in thickness are found. It must be rec-
gnized that since well records are often inaccurately reported there is 
some risk in trying to correlate formations by them. If, however, cor-
relation is attempted in this case, it seems probable that No. 1 is the upper part 
of the Potsdam, No. 2 the Prairie du Chien, No. 3 the St. Peter, Nos. 4 and 
5 the Platteville, and No. 6 the Galena. The surface material at Stockton is glacial drift, and No. 7 probably consists of this drift mixed with, or over-
lying, clay from the Maquoketa shale formation. The Prairie du Chien and 
Galena formations appear to be much thicker at Stockton than at Galena 
or in the area north of this district.

The record of the Hanover well was made by examination of samples 
saved from different depths. As some intervals of over 100 feet of rock 
were not represented by a single sample, the record is by no means complete 
and the correlation is correspondingly unsatisfactory.
### Log of well at Hanover, Illinois

(Made from examination of samples)

**Surface elevation 611**

<table>
<thead>
<tr>
<th>Description of strata</th>
<th>Thickness Feet</th>
<th>Depth Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone, gray, crystalline to earthy, hard</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Like that above, only finer grained</td>
<td>18</td>
<td>78</td>
</tr>
<tr>
<td>Limestone, gray, crystalline, containing some grains of white chalky material, possibly fragments of shells</td>
<td>79</td>
<td>157</td>
</tr>
</tbody>
</table>

**Platteville—**

Very fine, powdery, gritty, yellowish-gray material containing a little brown substance; does not give limestone reaction; fine-grained, sandy when wet.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>160</td>
</tr>
</tbody>
</table>

**St. Peter—**

Quartz grains, mainly small, white, water-worn; some black material; few soft red particles, possibly feldspar.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>174</td>
</tr>
<tr>
<td></td>
<td>334</td>
</tr>
</tbody>
</table>

Like that just above, only quartz much more predominant; some black arkose material and some red specks. First flow of water which came to within five feet of surface.

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>344</td>
</tr>
</tbody>
</table>

Quartz, dominant, white, water-worn grains; green fragments of shale; few black specks; white lumps; much powder.

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<table>
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<tbody>
<tr>
<td></td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>351</td>
</tr>
</tbody>
</table>

Quartz, dominant, finer grained than in that above; some earthy particles like loam.

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<tbody>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>357</td>
</tr>
</tbody>
</table>

**Prairie du Chien—**

Like that next above.

<p>| | |</p>
<table>
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<tbody>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>361</td>
</tr>
</tbody>
</table>

Quartz, white grains; grains of black substance; brown lumps which powder like dolomite.

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<table>
<thead>
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<tbody>
<tr>
<td></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>376</td>
</tr>
</tbody>
</table>

Like that next above.

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<table>
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<tbody>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>381</td>
</tr>
</tbody>
</table>

Quartz, red, water-worn grains; some white calcareous material

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<table>
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<tr>
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<tbody>
<tr>
<td></td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>450</td>
</tr>
</tbody>
</table>

**Potsdam—**

Quartz, red and white grains, water worn; black and brown sand grains

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<thead>
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</thead>
<tbody>
<tr>
<td></td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>464</td>
</tr>
</tbody>
</table>

Sand, red, white, brown; some quartzite lumps

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<tbody>
<tr>
<td></td>
<td>6</td>
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<tr>
<td></td>
<td>470</td>
</tr>
</tbody>
</table>

Sandstone, red to brown

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<tbody>
<tr>
<td></td>
<td>13</td>
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<tr>
<td></td>
<td>483</td>
</tr>
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</table>

Like that next above, only finer

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<tbody>
<tr>
<td></td>
<td>30</td>
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<tr>
<td></td>
<td>513</td>
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</tbody>
</table>

Sand, red

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<tr>
<td></td>
<td>25</td>
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<tr>
<td></td>
<td>538</td>
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</tbody>
</table>

Quartz grains dominant, fine, water worn; some black and red particles

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<tbody>
<tr>
<td></td>
<td>2</td>
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<tr>
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<td>540</td>
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</table>

Sand, red

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<tbody>
<tr>
<td></td>
<td>16</td>
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<td></td>
<td>556</td>
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</table>

Sand, dominant, coarse, red; some black grains

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<td>4</td>
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<tr>
<td></td>
<td>560</td>
</tr>
</tbody>
</table>

Sand, fine, red; lumps of yellow sandstone

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<tbody>
<tr>
<td></td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>582</td>
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</tbody>
</table>

Sand, yellow, intermixed with some red.

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<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>587</td>
</tr>
</tbody>
</table>

Sand, white; feldspar specks

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<tbody>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>591</td>
</tr>
</tbody>
</table>

Sandstone, fine, white

<p>| | |</p>
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<th></th>
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<tbody>
<tr>
<td></td>
<td>6</td>
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<tr>
<td></td>
<td>597</td>
</tr>
</tbody>
</table>

Quartzite-like material in fragments, very hard, purple brown; yellow sandstone

<p>| | |</p>
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</thead>
<tbody>
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<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>601</td>
</tr>
</tbody>
</table>

Dull, brick-red, soft lumps that powder when rubbed leaving dark-red stain

<p>| | |</p>
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<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>615</td>
</tr>
</tbody>
</table>

Although the correlation of the formations penetrated by these three wells with those in the region north of our district is not satisfactory, still it is clear that the Potsdam sandstone, the Prairie du Chien limestone, and the St. Peter sandstone are represented below the Platteville formation. If the pre-Cambrian quartzite exists in the Galena and Elizabeth quadrangles, it has not been reached by borings.

Our state of knowledge concerning the pre-Plattville formations of the district is shown in figure 8.
Fig. 8. Diagram showing the relation of the pre-Platteville rocks of the Galena-Elizabeth district to the Platteville formation and younger rocks and to the pre-Platteville rocks of neighboring regions. The vertical scale and dip of the strata are exaggerated; locations of towns and relative thicknesses of formation are only approximately correct.
The following history is recorded by the rocks antedating those which appear at the surface:

1. In the Cambrian period a sea existed in the region, and sand was deposited in it. Either the water was shallow and the shore not far distant, or the lands were high, or both.

2. The seas cleared, and the Prairie du Chien limestone was deposited. The clearing may have been caused by a deepening of the water or by a lowering of the neighboring land, an event which would reduce the amount of sediment carried to the sea by rivers.

3. Possibly there was emergence and a short period of erosion after the deposition of the Prairie du Chien limestone. If so, it was soon followed by another submergence.

4. Sand for St. Peter sandstone was deposited in a shallow sea and was probably derived from relatively high land to the north.

The duration of the time recorded by these rocks can be only roughly estimated. It is believed that limestone is now being made at some places on the sea bottom at the rate of about one foot per century. At this rate, the Prairie du Chien formation is a record of 15,000 to 25,000 years of time. If the rate of accumulation was half as fast, the time would be doubled. Sandstone is deposited more rapidly than limestone. At 5 feet per century the 1150 feet of sandstone in the district would call for about 23,000 years. This would make the duration of time represented by the rocks in the district about 43,000 years, not counting the time represented by the erosion between the Prairie du Chien and St. Peter formations. It is probable that these figures are too small rather than too large.

**PLATTEVILLE LIMESTONE**

**DISTRIBUTION, OUTCROPS, AND THICKNESS**

Aside from a single small outcrop on Galena River, the Platteville limestone does not appear at the surface in the Galena and Elizabeth quadrangles. There are many outcrops just north of this district in the vicinity of Platteville, Wisconsin, and some knowledge of the rock can be had from them. It is penetrated in the quadrangles under discussion by wells, and undoubtedly it underlies the whole district at depths increasing to the south.

The single outcrop of the Platteville in the district is in the bottom and lower parts of the walls of the valley of Galena River. It is in the form of a narrow area one and one-half miles long, the center being 3 miles northeast of Galena. It forms the surface rock here for two reasons: (1) the formation has been elevated at this place in a slight upfold or anticline, and (2) a stream flows across the fold. As the stream cut its valley down, the overlying rocks were cut through on the axis of the fold, but have not been cut through on its sides. Hence the limestone outcrops only at the top of the fold and near the bed of the stream (fig. 9). It is not to be understood
that the bare rock appears everywhere in this strip. It is covered in some places with stream alluvium and in others by waste which has crept down the valley sides. The solid rock appears only on the lower and steeper parts of the valley walls. The best exposures are (1) on the Chicago and North Western Railway a mile south of Millbrig, and (2) a few hundred yards south of this point in the ruins of an old mill on the east side of Galena River. The formation is typically exposed in the vicinity of Platteville, Wisconsin, and may be seen in its entire thickness along Little Platte River west of that place.

Fig. 9. Diagram illustrating the conditions under which the Platteville limestone is exposed on the axis of an antcline in the valley of Galena River.

As shown by well records (Chap. IV) and the exposures at Platteville, the formation has an average thickness of about 65 feet.

**Lithologic Character**

Unlike most of the other calcareous rocks of the region, the Platteville formation is for the most part a true limestone rather than a dolomite; that is, it is chiefly calcium carbonate, rather than a combination of calcium and magnesium carbonates. Interbedded with the limestone are beds of dolomite and thin beds of shale.

A generalized section of the Platteville formation where it outcrops just north of this area is as follows:¹

<table>
<thead>
<tr>
<th>Layer Description</th>
<th>Thickness (Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Shale, blue, at some places sandy</td>
<td>1—5</td>
</tr>
<tr>
<td>2. Limestone or dolomite, thick-bedded, magnesian</td>
<td>15—25</td>
</tr>
<tr>
<td>3. Limestone, thin-bedded, brittle, fine grained</td>
<td></td>
</tr>
<tr>
<td>4. Limestone, principally in thin beds; and shale (at the top)</td>
<td>10—15</td>
</tr>
</tbody>
</table>

Two miles northwest of Platteville is a section which includes the contact of the Platteville and Galena formations.

Section of parts of Galena and Platteville formations

<table>
<thead>
<tr>
<th>Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Limestone, fine grained, dark, chocolate colored, hard, compact, massive, of conchoidal fracture, nonfossiliferous. There are 3 distinct beds. This is the glass-rock well known to miners and geologists throughout the region</td>
<td>3</td>
</tr>
<tr>
<td>2. Limestone, thin bedded, interbedded with shale near top, highly fossiliferous; the species of brachiopod Dalmanella subaequata (see Plate V, figures 1-5), being present in great numbers</td>
<td>3</td>
</tr>
<tr>
<td>3. Clay bed which marks the top of the Platteville and base of the Galena</td>
<td>7</td>
</tr>
<tr>
<td>4. Limestone, thin bedded, similar to No. 1 lithologically, but of a lighter color. Fossils characteristic of the Galena formation are abundant (at the top)</td>
<td>10</td>
</tr>
</tbody>
</table>

The best exposures of the upper part of the Platteville formation on Galena River are described below:

On the railroad a mile south of Millbrig the Platteville formation occupies the lower foot of a 16-foot exposure. Here it is a hard, compact limestone. Over this lies a bed of shale varying from 4 to 15 inches in thickness. In this shale were found fossils of Dalmanella subaequata which show evidences of having been rolled and worn (Pl. V, fig. 6). As this species occurs abundantly in the upper part of the Platteville, the finding of the fossil in the Galena formation suggests the existence of an unconformity between the Galena and Platteville formations.

The section on the east side of Galena River is as follows:

Section of parts of Galena and Platteville formations on Galena River

<table>
<thead>
<tr>
<th>Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Glass-rock, beds 1 to 1½ feet thick, compact, chocolate colored, fine grained, breaks with conchoidal fracture</td>
<td>3</td>
</tr>
<tr>
<td>2. Limestone, fossiliferous, thin bedded; resembles the glass-rock</td>
<td>13</td>
</tr>
<tr>
<td>3. Shale</td>
<td>1</td>
</tr>
<tr>
<td>4. Limestone, thin bedded, fossiliferous, enclosing lenses of dark brown, oily shale (the oil-rock)</td>
<td>14</td>
</tr>
<tr>
<td>5. Dolomite, massive (at the top)</td>
<td>2</td>
</tr>
</tbody>
</table>

In this section members 1 and 2 belong to the Platteville formation, members 4 and 5 to the Galena, and member 3 marks the plane of division between the two. Shales bearing similar relations to the Platteville and Galena formations and resembling the shale, No. 3, lithologically and faunally have been found at several places in Minnesota and Iowa. In Minnesota they have been called the "Green Shales"; in Winneshiek County, Iowa, where they reach 30 feet in thickness, Calvin calls the deposit the "Decorah shales." It would perhaps be correct to correlate Nos. 2 and 3 of the section above with the Decorah formation.

FOSSIL CONTENT

Next to the Maquoketa formation, the Platteville formation is the most highly fossiliferous of the district, but the fossils are not evenly distributed.

through it. They are abundant in members 3 and 4 of the generalized section, whereas in members 1 and 2 they are relatively rare. The part of the formation which appears at the surface in the Galena and Elizabeth quadrangles affords the following forms:

**Brachiopods**—
- Dalmanella subaequata
- Zygospira recurvirostra
- Rafinisquina alternata
- Plectambonites sericeus
- Dinorthis deflecta

**Trilobites**—
- Pterygometopus sp.
- Thaleops ovatus
- Bryozoans (sea mosses) and corals—
  - Streptelasma profundum
  - Leperditia fabulites
  - Stictoporella frondifera
  - Stictoporella angularis

Only the tails of the trilobites were found. As can be seen from Plate V the brachiopods were small animals, which secreted shells, as oysters do today. The shells consisted of two valves, held opposite by interlocking projections or teeth along a marginal hinge line. One valve was marked by a convex fold, and the other by a concave fold or sinus directly opposite. Both valves are strengthened by ribs or plications. The brachiopods lived in the sea in which the materials of the Platteville formation were deposited.

**PLATE V**

*Fossils from Galena and Platteville formations*

(All illustrations natural size)

Figures 1 to 6. Brachiopods. Although they are furnished with a mollusk-like shell, the soft parts of the organism are entirely different from those of the true mollusks.

1 and 2. **Dalmanella subaequata.** These figures show the two valves of large specimens which are abundant in the uppermost beds of the Platteville limestone.

3. **Platystrophia biforata.** This specimen was taken from the upper thin beds of the Galena dolomite, though the species occur also in the Maquoketa shale.

4. **Lingula iowensis.** This is a more primitive brachiopod than the others. Its more primitive character is indicated by its flatness, its lack of plications, and its lack of an articulate hinge between the valves of the shell. It is characteristic of the uppermost Galena beds.

5. **Zygospira recurvirostra.** A small form from the Platteville formation.

6. **Dalmanella subaequata.** A specimen similar to 1 and 2, but worn by streams or waves. It was found in the shale between the Platteville and Galena formations. The animal probably lived and left its shell on the bottom of the Platteville sea; when the sea bottom emerged, the shell was rolled about and worn before final deposition in the shale.

Figure 7. **Triptoceras lambl.** A cephalopod now extinct, but related to the chambered nautilus of today. This specimen was found with others of its family in the upper part of the Galena formation.

Figures 8 and 9. **Receptaculites oweni.** Figure 8 is a section and figure 9 a surface view of this supposed sponge. The fossils are often called “sunflower corals.” They are most commonly seen in the rock in section, as in figure 8. Two zones are recognized in the Galena formation, in which these forms are abundant, known as the “upper Receptaculites” and the “lower Receptaculites,” zones, respectively.
and when they died their shells accumulated on the bottom. The fossils in the glass-rock are probably shells of large animals deposited with those of tiny organisms which made fine-grained rock when cemented. None of these species of animals is living today.

**STRUCTURE**

The strata of the Platteville formation dip gently south with the younger and older beds of the region. Locally, as where the formation outcrops on Galena River, this monoclinal dip is interrupted by low anticlines, synclines, and minor irregularities. Where seen, the upper part of the formation is slightly jointed, the joints being nearly vertical. The jointing may have resulted from the stretching of the rock over the anticline as it was forming, by the contraction of the rock after its emergence, or by crustal movements at any time.

**CONDITIONS AND TIME OF DEPOSITION**

From the character of the beds and from the fossils contained in them, this formation is known to have been deposited in the sea. The limestone and dolomite were laid down in clear water and result from the deposition and cementation of shell fragments. The shales were deposited as mud. They may record an uplift of the land so that rivers brought down more mud, or a shallowing of the sea, which allowed the mud from the land to be carried out to the zone where formerly limestone or dolomite were accumulating. Perhaps a change in climate resulted in increased volume and velocity for the streams, so that they were enabled to carry mud, whereas in an earlier epoch they carried only materials in solution. The existence of fossils in the shales shows that life continued in the muddy waters. Thus slight oscillations of land and sea or of climate are recorded by the rocks of the Platteville epoch.

The age of the formation as determined from the fossils and from its position between the St. Peter sandstone and the Galena dolomite is the same as that of the Platteville limestone of Wisconsin. It may be seen from the table of geologic time divisions given in Chapter III that the formation belongs to the Mohawkian series of rocks, which was deposited during the Mohawkian epoch of the Ordovician period. It is probably to be correlated with the Plattin limestone of Missouri and is a little older than the Trenton limestone of New York.

**GALENA DOLOMITE**

**GENERAL IMPORTANCE**

For several reasons the Galena formation is the most important of the district. It is the thickest formation—almost 250 feet—and, being hard and massive, it outcrops in many places and is hence very conspicuous. It has
a distinctive dolomitic character which makes it easily recognizable. Certain fossil beds within the formation are so characteristic and widely distributed as to be good "horizon markers" for the whole region. The formation is also economically important for it contains practically all the lead and zinc ore of the region, and its name is derived primarily from this fact, the lead ore being chiefly in the form of the mineral galena. The distribution of the ores is probably connected with the structure of the formation and with the occurrence of a peculiar rock at its base known as oil-rock.

**Distribution and Outcrops**

The Galena dolomite appears at the surface over a large area in the northern and central parts of the region, and more sparsely in its southern parts. To the north it is widely exposed, except where patches of Maquoketa shale and Niagaran dolomite overlie it, as on the mounds and lower divides. It underlies most of the intermediate plain, and appears in all valleys below it. To the south the formation dips under the younger strata and appears only in the deeper valleys, where the younger beds have been removed by stream erosion. On the gentler slopes even where the formation is not overlain by later, hard rocks, it is covered with a thin mantle of residual soil or other unconsolidated material, although most shallow cuts reach the solid rock. The bare rock outcrops on the walls of main valleys, in the beds of smaller streams, in quarries, and in road and railroad cuts. It appears also in the roads on the steeper hillsides where no cutting has been done, but where the wash has been sufficient to remove the soil.

The Galena dolomite appears abundantly in the following places: (1) It forms the hills and underlies the valleys in and around the city of Galena, where the rock is bare in many places. (2) It forms the bluffs along Mississippi River from the north edge of the area to Aiken, and outcrops in the lower valley slopes farther south. There is a typical bluff exposure of the formation at Galena Junction. (3) In the vicinity of Scales Mound the uppermost part of the formation outcrops in numerous railroad cuts and shallow quarries. (4) At Apple River it was encountered in several wells at a depth of 4 feet, and is exposed in quarries in the west and southwest portions of the town and in the valley walls of the streams tributary to Apple River. (5) Plate VI, A shows a typical exposure of Galena in the canyon of Apple River south of Millville, where it outcrops in many places with considerable beauty and impressiveness. (6) At Hanover the formation outcrops along Apple River below the bridge and at the pond. At Elizabeth the formation is 10 to 80 feet below the surface, and at Stockton about 60 feet below the surface.
A. Typical section of massive non-cherty and massive cherty members of the Galena dolomite on Galena River at Millville.

B. Thin-bedded dolomite in the oil-rock member of the Galena formation on Sinsinawa Creek at the bridge in sec. 4, T. 28 N., R. 1 W. (Rawlins).
LITHOLOGIC CHARACTER

*General description.*—With the exception of a slight amount of limestone, oil-rock, and shale at the base, and a few limestone layers and shaly partings near the top, the Galena formation is composed of dolomite. It is crystalline, coarse grained, and porous, and it weathers into exceedingly rough, pitted, and irregular forms. Hand specimens show small cavities, many of which are lined with dolomite or calcite crystals. Although the solid rock does not appear sandy, much of it weathers into coarse, yellow, dolomite sand. As a whole it is massive in appearance. The average thickness of the beds composing the formation is from 1 to 4 feet, but in the uppermost and lowermost portions of the formation there are thinner beds. Its middle part contains large quantities of chert as isolated nodules and discontinuous beds of nodules. Where unweathered, the dolomite is commonly light bluish gray in color, but in some places, especially in its upper part, it is gray. In its lower part the bluish color is intensified locally. On weathering, the color of the rock changes to a light yellowish gray or buff, and in its most weathered parts it has a brownish to reddish color.

The Galena formation can be divided into five members, distinguished chiefly by lithologic differences. It is not to be understood however that these divisions are all sharply marked, since almost everywhere the several members grade into one another. Nevertheless, it is usually not difficult to determine the stratigraphic position of the beds wherever a considerable thickness of rock is exposed. The divisions are here described in order, beginning at the base of the formation.

*Oil-rock member.*—In the area here discussed the base of the Galena formation outcrops only on Galena River south of Millbrig. It was seen, however, in the vicinity of Platteville, Wisconsin, and in the Vinegar Hill mine north of Galena.

As previously stated the contact of the Platteville and the Galena formations is marked by about a foot of shale. Immediately above the shale is the well-known *oil-rock* member of the Galena formation (Pl. VI, B). It occurs as thin beds or partings of a chocolate-brown, soft, bituminous shale which when touched with a match burns slowly and gives off a strongly bituminous odor, suggestive of the smell of a hot box on a railway car. This member of the formation is exposed or indicated in several sections.

1. The oil-rock is best exposed in the region on the Chicago and North Western Railway, a mile south of Millbrig. Overlying the shale are 7 feet of thin-bedded, fine-grained, light-gray beds which resemble the glass-rock of the uppermost part of the Platteville formation. These are overlain by 2½ feet of thin-bedded limestone, in which there are two seams of the oil rock. Each seam of oil-rock is one-half to one inch thick and the two are one-half to three inches apart. Above the limestone which carries oil-rock,
there are several feet more of thin limestone beds which are included in the oil-rock member.

2. At the old mill at the middle of the line between secs. 34 and 3, a mile southeast of Millbrig, is an exposure of 13 feet of thin-bedded limestone containing several irregular lenses of oil-rock. The limestone and oil-rock are similar to those exposed south of Millbrig. The limestones are highly fossiliferous.

3. Two miles a little north of west of Platteville, just outside of our area, the shale is overlain by 10 feet of thin-bedded limestone, which resembles the glass-rock lithologically, but has lighter color, thinner bedding, and more abundant fossils. There are several thin, irregular seams of oil-rock in the limestone. The lithologic similarity between the limestones associated with the oil-rock and the glass-rock in the upper Platteville is characteristic of most exposures.

4. In the bottom of a shallow, abandoned mine two miles west of Platteville, the oil-rock which is here in a single bed reaches the exceptional thickness of three feet.

5. In the south-central part of sec. 4, T. 28 N., R. 1 W. (Rawlins), at a spring on the east side of Sinsinawa Creek below the ford, is an exposure of several beds of fossiliferous, hard, crystalline limestone. The fauna includes brachiopods, gastropods, and trilobites of which the following species were recognized:

\[
\text{Fossils from the oil-rock member}
\]

- Dalmanella testudinaria
- Plectambonites serieus
- Strophomena incurvata
- Orthis tricenaria
- Bumastus trentonensis
- Ceramus pleurexanthemus
- Rafinesquina alternata
- An unidentified pelecypod

This exposure is at an elevation of 600 feet and must be, at this point, very near the base of the formation. Probably the spring is caused by the fact that the downward course of the ground water in the hill back of the outcrop is arrested by the impervious oil-rock which lies immediately below the surface, and the water passes along the top of the oil-rock until it issues at the surface.

6. In the northeast part of sec. 4, T. 28 N., R. 1 W. (Rawlins) at and upstream from the bridge across Sinsinawa Creek, limestone outcrops in the bed and on the sides of the stream. The base of the exposure has an elevation of 604 feet and its top 629 feet. The limestone is thin, irregularly bedded, and highly fossiliferous (brachiopods and trilobites). It is hard, compact, fine grained, and crystalline, gray on fresh surfaces and lighter gray where weathered. At this place no oil-rock is exposed (Pl. VI, B). The thin-bedded member here is at least 25 feet thick, and as the oil-rock horizon is probably below, the member is undoubtedly thicker. At the house
just south of the bridge on the east side of the creek a prospect hole 62 feet deep strikes rock at an elevation of 606 feet above sea. Rock in the dump is fossiliferous and thin bedded. The fossils are chiefly Dalmanella sub-aequata, with orthoceras and bryozoans. Rock resembling glass-rock also appears. As the fossils and appearance of glass-rock indicate, this shaft probably penetrated into the Platteville limestone.

It will be seen from the above sections that the oil-rock member varies from 10 feet to 25 feet or more in thickness. So far as can be seen, the oil-rock itself is confined to the lower 13 feet. It is almost invariably thicker in the stratigraphic sags than where the base of the formation is higher.

Although much work has been done and much has been written\(^1\) on the oil-rock, its exact nature and mode of origin are still somewhat problematical. However, from chemical analyses and microscopic examination its general nature has been learned. It is found to be highly carbonaceous, the carbonaceous matter constituting 40 per cent of the rock mass in some places. This carbonaceous matter was undoubtedly derived from some form of life, and it seems likely that it is entirely of vegetable origin. The rock contains innumerable yellow bodies, too small to be seen with the naked eye, that have been identified as small and simple plants called algae. Upon being heated the rock gives up a large quantity of gases showing that much of its matter volatilizes readily. The volume of the oil-rock has been reduced by the escape of gases. This loss of volume and of gas content has been thought to have had an important bearing on the deposition of the ores of the region.

The theory of the origin of the oil-rock now generally accepted is as follows: The Galena sea advanced over a region which had been weathered to a gently undulatory surface. At first, in this shallow sea algae lived abundantly, dropped to the bottom, and accumulated to a considerable thickness in the low places and to a less depth on the elevations. With the algae were deposited some shells of animals and some mud. This material was buried subsequently by thick deposits of fragments of shells making the rest of the Galena formation. Pressure and resulting volatilization have brought the organic matter to its present condition.

**Lower, massive, non-cherty member.**—The thin-bedded limestones of the oil-rock member grade up into a member of massive, non-cherty dolomite. This gradation may be seen at the exposure on Galena River a mile south of Millbrig, which shows the Platteville-Galena contact. In a general way the dolomite member varies in thickness, inversely as the thickness of the oil-rock member, and the two members together aggregate 40 to 45 feet.

Where the oil-rock member is 25 feet thick, the non-cherty, massive member is no more than 20 feet thick, and where the former is 13 feet thick, the massive member is about 30 feet thick. The massive, non-cherty member is limited above by layers containing much chert, and by a layer of rock containing abundant remains of a sponge-like animal, known as *Receptaculites oweni*. The chert nodules as a rule become abundant at, or immediately above, this fossil zone. The rock of this massive member is singularly uniform throughout the district. Its beds average 4 or 5 feet in thickness, though many are either thinner or thicker.

Probably the best exposure of this member is in the canyon of Apple River about midway between Apple River and Stockton. The section extends from 20 feet below to 20 feet above the *Receptaculites* zone, and hence includes a part of the massive, non-cherty member and a part of the one above. The rock is gray and massive, and weathers into vertical walls and impressive bluffs (Pl. VI, 4). When freshly broken, the rock is white or reddish, coarse grained, and porous. It contains much chert in irregular nodules above the zone of fossils, and in some places below that zone. The fossil zone, therefore, does not separate the two members sharply, but it occurs as a transition zone between them.

The upper part of the non-cherty member outcrops in the city of Galena and its vicinity. The *Receptaculites* zone is well exposed behind the foundry near the river in the northeast part of the city and in the back yard of the house immediately north of the foundry, where a quarry has been opened. At this place there is no chert below the fossil zone, though it appears a few feet above the fossils in the rock north of the outcrops. Just south of Galena in a cut on the Illinois Central Railroad, this member is again exposed. Its beds average 1 1/2 feet in thickness. A zone of *Receptaculites oweni* in the central part of the exposure separates the cherty and non-cherty members of the formation at an elevation of about 625 feet above sea.

**Massive, cherty member.**—The base of the massive, cherty member is 40 to 45 feet above the bottom of the formation and extends upward about 100 feet and to within 100 feet of the surface of the formation. It is a coarse-grained, porous, thick-bedded dolomite, carrying chert in layers and in nodules which range up to several inches in diameter and which occur in isolated masses and in discontinuous layers. The chert is hard, fine grained, and white to chocolate colored. It is generally known in the region as flint.

It is not to be understood that all parts of this member, considered horizontally or vertically, contain chert; some beds have none, others contain a slight amount, and still others contain large amounts. The member is limited upward by the gradual disappearance of abundant chert.

Beds belonging to the massive cherty members may be seen in many
places in the region. Some of the best exposures are: (1) in the canyon of Apple River south of Millville, (2) at many of the exposures in and around Galena, and (3) on the bluffs of the Mississippi at and near Galena Junction. At Galena Junction, the upper limit of cherts has an elevation of 676 feet above sea level. The base of the formation here is known to be at an elevation of about 536 feet. Thus the top of the cherty member lies 140 feet above the base of the formation, and 100 feet below its top.

Upper massive non-cherty member.—The cherty member just described is overlain by 70 feet of massive strata which are similar to it, except that chert is practically absent. They are coarse-grained, thick-bedded dolomites. This series of rocks, which is called the upper massive, non-cherty member, is not limited sharply either below or above, although the limits of abundant chert below it may be located within a few feet in good exposures, and the gradation zone between this member and that above it is not more than ten feet thick. About 30 feet from the base of this member, is a zone of Receptaculites oweni very similar to the zone of the same fossils in the lower massive, non-cherty member. This upper zone lies about 70 feet below the top of the Galena formation, and makes another good horizon marker.

The rocks of this member can be seen best on the upper part of the Mississippi bluffs at and north of Galena Junction. The lower slopes at this place are in the cherty member, which at an elevation from 630 to 650 feet gives place to the upper non-cherty member. It may be seen also in numerous other places in the northern part of the Galena quadrangle. Some of the more notable exposures are: (1) near the top of the bluffs in Galena (the upper Receptaculites zones appears in a shallow cut just south of the library); (2) along the road and at the bridge in the south-central part of sec. 11, T. 29 N., R. 1. E. (East Galena); (3) east of the north-south road in the village at Council Hill station; and (4) one-eighth mile southwest of Rodden on the southwest side of the Chicago Great Western Railroad.

The member is recognized by its gray to buff color, its massiveness, its lack of chert, the presence of the fossil Receptaculites, as well as by a gradation to thinner beds above.

Upper thin-bedded member.—The uppermost 30 feet of the Galena formation consists of thin beds of dolomite separated by thin, shaly, and calcareous partings. In thickness the beds range from 2 inches to 2 feet. The thicker beds are hard, buff, crystalline, coarse grained, and porous. All layers, but especially the thin calcareous ones, are more fossiliferous than most of the other parts of the formation. This member outcrops abundantly throughout the district, in shallow quarries, along roads, and stream bottoms. It can be distinguished by the fossils to be described later, by its thin beds, and its alternating shaly and calcareous portions. Fur-
other, it gives place above, to a shale that carries abundant small fossils, which will be described in connection with the Maquoketa formation.

A few characteristic exposures of this member are described below:

1. In the extreme south part of sec. 10, T. 28 N., R. 1 W. (Rawlins), 2½ miles northwest of Galena, 10 feet of the member are exposed in a quarry. The rock is thin bedded, roughly weathered, yellowish to buff, porous, semi-crystalline, sandy, and devoid of chert. Its beds average about 10 inches in thickness.

2. Between secs. 2 and 35, 3 miles northwest of Galena, is a shallow, abandoned quarry in thin-bedded, sandy, buff dolomite. The beds are apparently horizontal and average about 6 inches in thickness. Thin, irregular layers of soft, gray limestone, composed chiefly of tiny flat disks which are plates of crinoid stems, are interbedded with the dolomite 10 to 15 feet below the top of the formation. On the upper edges of the quarry are reddish residual clays containing Maquoketa fossils.

3. On the northwest side of Apple River, on the road leading northwest from the town of Apple River, is a small quarry. The highest rock in the quarry is just about at the top of the Galena formation, which furnished rock for road ballast and rough masonry. There are other quarries in the upper thin-bedded member along the railroad, and along the east-west road east and south of town. The top of the formation is found at an elevation of 993 feet on the hill cast of the cemetery.

4. At Rodden, and for 300 yards west along the Chicago Great Western Railroad tracks, the upper 30 feet of the formation is exposed. Twenty feet below the top, the beds are 2½ feet thick. They become thinner toward the top and are separated by thin partings of shaly, wavy beds containing many disks of crinoid stems. All the beds are remarkably uniform in thickness for hundreds of feet. Plentiful Maquoketa fossils were found on top of the cut at an elevation of 738 feet above sea level.

5. At and below the dam across Apple River at Hanover, the Galena dolomite is overlain at an elevation of 613 feet by Maquoketa shale, a fact which shows a lowering of the formation from Rodden to Hanover. The dolomite here is more massive than usual for this top member, some of the beds being 2 feet thick. Below the dam they are less massive, and contain shaly and calcareous partings.

6. One and one-third miles north of the hotel in Hanover, a quarry has been operated in the upper 12 feet of the Galena formation. In the overlying clay, at an altitude of 645 feet, there are many pelecypods, gastropods, brachiopods, and some peculiar phosphatic pellets belonging in the base of the next younger Maquoketa formation. The rock quarried is yellowish or buff. The beds average about 6 inches in thickness, and each bed is strikingly uniform in thickness. In general the thicker beds are near the bottom. The uppermost beds are separated by shaly partings one-half
inch thick. The thinner beds are fossiliferous, though the fossils are poorly preserved. A view of this exposure is shown in figure 10.

7. On the south side of the Chicago Great Western Railroad, 1½ miles west of Stockton, an old quarry exposes 8 feet of the top of the formation. The rock is thin bedded, and contains shaly partings. A layer 5 feet from the top is fossiliferous and contains Zygospira, Lingula, and Lingulepis.

This upper thin-bedded member is also well exposed: (8) in the valley one-half mile west of Black School; (9) in the bed of Plum River southeast of Elmoville; (10) in several cuts along the Illinois Central Railroad for 3 miles east of Apple River; (11) in a railroad cut one-third mile west of Scales Mound; and in several other places in the region.

From the foregoing descriptions of the different members, the following generalized section for the Galena formation in this region is obtained:

Generalized section of the Galena formation

<table>
<thead>
<tr>
<th>Member</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Upper thin-bedded member; thin beds of dolomite, separated by calcareous and shaly partings; beds thick in the lower part and thinner near the top; fossiliferous</td>
<td>30</td>
</tr>
<tr>
<td>4. Upper, massive, non-cherty member; coarse-grained, massive dolomite; contains upper Receptaculites zone 40 feet from top</td>
<td>70</td>
</tr>
<tr>
<td>3. Massive, cherty member; coarse-grained, porous, thick-bedded dolomite carrying nodules and layers of chert</td>
<td>100</td>
</tr>
</tbody>
</table>

Generalized sections for different parts of the region may be found in the Galena-Elizabeth folio U. S. Geol. Survey Geol. Atlas (in preparation).
2. Lower, massive, non-cherty member; dolomite beds averaging 4 to 5 feet in thickness; grades into thin beds below.......................... 20—30
1. Oil-rock member; thin-bedded limestone carrying irregular lenses of oil-rock; highly fossiliferous........................................... 13—25

240—245

FOSSIL CONTENT

The Galena formation is not abundantly fossiliferous except in its lowest member. The most important fossil zones are the lower limestones, the lower and upper Receptaculites zones, and the upper thin beds. The lower limestones on Galena River and Sinsinawa Creek afford the following forms, some of which are shown in Plate V:

Fossils from lower limestones of the Galena formation

<table>
<thead>
<tr>
<th>Dalmanella testudinaria</th>
<th>Bumastus trentonensis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plectambonites sericeus</td>
<td>Ceraurus pleurexanthemus</td>
</tr>
<tr>
<td>Strophomena incurvata</td>
<td>Thaleops ovata</td>
</tr>
<tr>
<td>Orthis tricenaria</td>
<td>Pterigometopus (species?)</td>
</tr>
<tr>
<td>Rafinesquina alternata</td>
<td>Hormatoma (species?)</td>
</tr>
<tr>
<td>Dinorthis pectinella</td>
<td>Lophospira (species?)</td>
</tr>
<tr>
<td>Vanuxemia niota</td>
<td></td>
</tr>
</tbody>
</table>

The lower Receptaculites zone lies 40 to 45 feet above the base of the formation, and the upper zone 70 feet below the top of the formation. The fossils are known popularly as "sunflower corals", because of a fancied resemblance to the central part of that flower (Pl. V). They are not corals, and are now thought to be sponges. The zones in which they lie are from 1 to 4 feet thick. It is not unusual to find 20 specimens of the Receptaculites in each of these zones within horizontal distances of 20 feet. They are disk-like forms which lie parallel with the bedding, so that they are circular where found on horizontal surfaces, and long and narrow when seen in section on vertical walls.

Elsewhere in the middle portion of the formation are found scattered fossils of gastropods, pelecypods, and brachiopods.

The upper thin beds are fossiliferous, but as a rule the fossils are poorly preserved. A large cephalopod of the genus Orthoceras is common. Linguloid brachiopods are rather abundant. A list of fossils from this horizon follows:

Fossils from upper beds of the Galena formation

<table>
<thead>
<tr>
<th>Lingula iowensis</th>
<th>Clitambonites diversa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platastrophia biforata</td>
<td>Ilaeapus</td>
</tr>
<tr>
<td>Dalmanella testudinaria</td>
<td>Orthoceras amplexamaretum</td>
</tr>
<tr>
<td>Orthis tricenaria</td>
<td>Triptoceras lambi</td>
</tr>
</tbody>
</table>

CORRELATION

No attempt is made here to correlate exactly the various members of the Galena formation with formations of similar age in other regions, though some general facts and possibilities have been learned by comparison of fossils. According to Prof. Stuart Weller\(^1\) the Galena formation is

\(^1\)Weller, Stuart, verbal statement.
probably to be correlated with the Trenton limestone of New York, and to be regarded as younger than the Kimmswick limestone of Missouri. After a study of fossils collected in the Galena-Elizabeth quadrangles and others collected from rocks of other regions, Mr. Ulrich\(^1\) makes the main central part of the Galena formation younger than the Kimmswick, and corresponding in age with the oldest of the Trenton limestone beds of New York. In this he agrees in the main with the view of Prof. Weller. Similar opinions were published by Mr. Ulrich before the present work was done.\(^2\) In addition Mr. Ulrich considers that the lower thin beds of the Galena formation are of the same age as the later Black River beds of New York, and that the upper thin beds of the Galena are considerably younger than the middle part of the formation.\(^1\) But these upper beds are conformable on the main part of the formation in the Galena-Elizabeth district, and are, therefore, regarded as a part of the Galena, and not as a separate formation.

**MINERAL CONTENT**

In the Galena formation the following minerals of economic value are found:

- Galena
- Sphalerite ("black jack" or "jack")
- Calcite
- Chert (flint)
- Pyrite
- Marcasite
- Smithsonite
- Cerusite

The galena is lead sulphide, the principal lead ore of the region; sphalerite is zinc sulphide, the principal zinc ore. Both these minerals were precipitated from ground-water solution in caverns, crevices, and other places. The lead and zinc in some form were probably present in the limestone in minute quantities when this limestone was deposited, were later dissolved, and finally concentrated in workable quantity. Calcite is calcium carbonate dissolved from limestone and dolomite by ground water and redeposited in crystalline form. Chert is a form of silica, derived probably from the shells of silica-secreting animals, such as sponges, and other forms which had lived in the sea with the animals which secreted calcium carbonate. Pyrite and marcasite are sulphides of iron. Smithsonite is carbonate of zinc and has probably resulted from the union of carbon dioxide of the air and of surface water with the zinc of sphalerite. Cerusite is carbonate of lead, formed in a similar way by the alteration of galena.

\(^1\) Ulrich, E. O., oral statement.
Where all strata are essentially horizontal and structural unconformities are wanting, erosional unconformities (Chap. III) may be present, though they may be difficult to recognize. This is especially true if the time of erosion between epochs of deposition was so short, or the land was so low, that little erosion took place.

There is some indication of an erosional unconformity at the base of the Galena dolomite. In the Wisconsin area to the north, as on Galena River in our own district, a bed of shale separates the Platteville limestone below from the Galena limestone above. This in itself records changing conditions, such as a shallowing of the sea or a rising of the nearby land. At the outcrop a mile south of Millbrig, the surface of the Platteville limestone under the shale is slightly irregular as shown in figure 11. The limestone surface has a relief of 6 inches within a foot or two. This may be a weathered surface, or its irregularity may be due to solution of the limestone under the clay bed. If the former, it indicates a period during which the underlying rock was above the sea. Within the clay itself are also some evidences of an unconformity. At its base is a thin zone of reddish, oxidized, loamy clay, which seems to have been weathered. In the main body of the clay was found a single specimen of Dalmanella subaequata that appears to have been rounded by streams on land or by waves on a beach (Pl. V, fig. 6). In either case an unconformity is suggested.

The probable sequence of events was: (1) the Platteville beds were deposited; (2) the sea withdrew; (3) the surface of the limestone was weathered, its fossils were loosened and rolled around, and a thin soil was formed; (4) the sea encroached again on the land and covered the weathered material with mud and later with limestone-making materials.

Fig. 11. Diagrammatic sketch of the Galena-Platteville contact on Galena River. The irregular upper surface of the Platteville suggests an unconformity.

The irregular upper surface of the Platteville suggests an unconformity.

STRUCTURE

Methods of investigation.—In short sections the Galena formation appears to be practically horizontal. Its general structure can be determined by estimating the elevation of the top of the formation at different points throughout the district. From the topographic map the elevation
of any point on the land surface can be read within about 20 feet. In the making of this map, the elevations of hundreds of points were ascertained and many of them were painted on posts, fences, bridges, and other places. With a hand level it is a simple matter to run lines from these "temporary bench marks" to nearby points. In this way the elevation of the top of the formation was ascertained accurately in many places. As has already been mentioned, the base of the Maquoketa formation carries characteristic fossils, chief of which are small pelecypods or oyster-like shells. These weather out and appear in roads, quarries, stream beds, gullies, and other places, and consequently may be traced up grade to their uppermost limits. The top of the Galena formation must be at about these horizons. Levels run to the upper limits of the beds of fossils, therefore, give the approximate elevations of the top of the formation at different places. Moreover, the upper and lower Receptaculites zones furnish another means of calculating the top of the Galena, for it is necessary only to add 200 feet to the elevation of the lower zone and 70 feet to that of the upper zone to obtain the desired result. The elevation of the top of the formation may be obtained more roughly by adding 100 feet to the elevation of the top of the cherty member, or 240 feet to the elevation of the oil-rock. Where the formation lies wholly below the surface, its top may be located by logs of wells which penetrate it, and its elevation obtained by leveling to the well sites, and subtracting from the result thus obtained the distance in feet to the top of the Galena formation. The results of applying these methods to the determination of the elevation of the top of the Galena formation are stated below, and in another way by means of structure contours on the map (Pl. IV).

General monoclinal dip.—In a general way the formation dips gently to the southwest at a right angle to the structure contours. Its top is highest in the northeast corner of the region. From this point west along the north border of the district the most accurately determined elevations of the top of the formation recorded in feet above sea level are as follows: 1026, 1012, 1000, 900, 895, 891, 880.

The lowest known point on the surface of the formation in these quadrangles in Illinois is at 615 feet in the southwest corner of the area, south of Blanding. A series of elevations in feet above sea level, chosen in a nearly straight line from Warren in the northeast corner of the area, to Blanding in the southwest is as follows: 1010, 970, 966, 956, 950, 946, 885, 839, 797, 740, 720, 702, 686, 646, 615. From Warren to Blanding it is 27 miles and the difference in elevations of the top of the Galena formation between the two points is 395 feet, making an average southwesterly dip of 14.7 feet per mile.

A series of points taken in a northwest-southeast line from the northwest corner of the area to its southeast corner, also recorded in feet above
sea level, is as follows: 880, 870, 864, 851, 824, 791, 803, 780, 757, 749, 681. It is seen from these figures that the fall is 199 feet in the 28 miles taken in a northwest-southeast direction. This then is not quite the direction of strike, as the line at right angles to the direction of dip is called. Nor is the strike in an east-west direction, as shown by the 146-foot rise from west to east along the north edge of the region. It is between these two directions, and the dip is south-southwest. The direction of trend of structure contours is the strike, and a direction at a right angle is the direction of dip.

At Galena the top of the formation has an elevation of 780 feet, at Scales Mound 950 feet, at Apple River 980 to 1000 feet, at Warren 1030 feet, at Stockton 943 feet, at Elmoville 694 feet, at Elizabeth 760 feet, at Hanover 613 feet, and at Blanding 615 feet.

**Minor folds.**—The general monoclinal dip of the formation is interrupted by a series of low anticlines, shallow synclines, and rather sharp monoclines. In the vicinity of these features dips are steep enough to be seen, even in short sections. On the south border of Galena a cut on the Illinois Central Railroad tracks exposes dolomite dipping 7 degrees in a direction N. 10° E. Judging from the elevations in various mines and prospect borings around the city, the oil-rock forms a local structural basin, and the outcrop described is doubtless on the south limb of the basin. Three-quarters of a mile northwest of Galena Junction, the massive cherty member dips south one foot in fifteen.

The steepest dip found in the region is between the Black Jack mine and a prospect shaft on the hill one-fourth mile west of it. The oil-rock is said to be about 190 feet lower in the mine than at the bottom of the prospect shaft, but there is some doubt of the authenticity of the record of the shaft. The following records from points immediately east of the mine were obtained through Mr. James Shannon:

**Data from vicinity of Black Jack mine**

<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
<th>Surface elevation</th>
<th>Oil-rock</th>
<th>Glass-rock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Feet</td>
<td>Feet</td>
<td>Feet</td>
</tr>
<tr>
<td>1</td>
<td>1921 feet W. and N. of house</td>
<td>623</td>
<td>179</td>
<td>444</td>
</tr>
<tr>
<td>2</td>
<td>618 feet E. of No. 1</td>
<td>652</td>
<td>170*</td>
<td>482*</td>
</tr>
</tbody>
</table>

*Calculated.

Since the vertical distance from glass-rock to oil-rock is generally about 12 feet, a westerly dip of 38 feet in 618 feet is indicated by these observations. The beds here may be on the east limb of the syncline whose axis passes through the Black Jack mine, or between it and boring No. 1 on Mr. Shannon's property.
North of Galena, Galena River runs southward from the Galena formation, over the Platteville formation, and back again over the Galena. This indicates a rise in the surface of the Platteville formation, and the rise may be a low anticline or a high place in the pre-Galena surface.

There are some suggestions of an elongate syncline whose axis is followed by Smallpox Creek. The dolomite strata incline toward the valley from the north with unusually steep dips about 30 feet to the mile. South of the creek the top of the formation is higher than it is in the valley or immediately north. Known elevations of the top of the dolomite formation in and near the valley to the north are: 772, 776, 793, 796, 806, and 813. About a mile from the valley to the south and southeast the elevations indicate a rise in the same direction: 754, 757, 773, 794, 798, 799, 816, and 814. It seems that the rather sudden fall of the beds toward the valley north of the creek is compensated by a rise of the strata south of the creek. This may account for the comparatively straight course of Smallpox Creek; whereas all the other streams of similar size in the region are notably crooked. The axis of the syncline, so far as known, is straight, and the stream seems to have adjusted its course to it.

The southerly dip of the formation is accentuated also in the southwestern part of the district along the Chicago, Burlington and Quincy Railroad tracks south of the Royal Princess mine. A quarter of a mile, south of the valley in which the mine is located, the top of the Galena has an elevation of 656 feet, the railroad being at 600 feet. Between this point and the mouth of the next valley to the south, the dip is southward 1 foot in 40. Half a mile south of this point, south of the mouth of a third valley, the top of the formation has an elevation of 638 feet and the railroad 603 feet. Beyond this the amount of dip decreases.

Plate VII, A shows an unusually steep dip of the uppermost members of the Galena formation on Apple River between the dam and the ford at Hanover. At first glance in the field the structure here looks like a syncline, but it is rather a monoclinal dip to the southwest, the river cutting the strata in a curve. Dips steeper than common and shallow folds also appear in the formation along Sinsinawa Creek and in the canyon of Apple River.

Joints and crevices.—At nearly all places where the formation is seen, it is broken by cracks which cross the strata at all possible angles and trend in various directions. As these crevices carry ore in many places, they have been of special interest to the people of the region. A crevice trending northwest-southeast is known as a "ten o'clock", because the sun shines in it at about that hour. Similarly a crevice trending northeast-southwest is a "two o'clock". These crevices are commonly a foot or two wide and are filled with loose rubbish. They are frequently encountered in wells, and drilling tools are sometimes lost in them.
A particular form or pattern of the crevices is well known to all miners, mine operators, and engineers, as "flats and pitches". In these the ore of the lower part of the formation is found. Flat-lying openings (the flats) run into more nearly vertical ones (the pitches), as shown in figure 12.

![Diagram](image)

**Fig. 12.** Diagrammatic cross-section of a series of flats and pitches (after Grant and Burchard).

*Causes of the structural features.*—The general southerly dip of the formation may be due to either one of two causes or to a combination of both. (1) The bottom of the sea in which the dolomite was deposited may have sloped in the direction of the present dip at a low angle, and the strata may have taken that dip during deposition; or (2) the strata may have been deposited horizontally, and may have been tilted later by a slight uplift of the region on the north relative to that on the south; or (3) the beds may have been deposited with a slight dip, which was accentuated by later tilting. Probably the last explanation is the true one.

Likewise, more than one view may be entertained to explain the minor folds. (1) The region may have been subjected to lateral compression, which was relieved by the slight warping of the beds. Such pressure is known to have affected other regions in the past with similar results. (2) the surface of the Platteville limestone may have been, and probably was, irregular before the Galena was deposited on it, and the upper synelines may be over the basins of the old surface, the anticlines over the elevations, and the steeper dips over the steeper slopes. But considering the low relief of that old surface, it would not seem possible that dips would have been caused in sediments 240 feet higher. (3) A third possible explanation for these folds has to do with the compression of the oil-rock. There seem to have been slight depressions in the bottom of the Galena sea, in which the algae and other material which make up the oil-rock were deposited in greater thicknesses than elsewhere. The oil-rock layer was thinned by pressure of the overlying rock, and compression took place most where the original volume had been greatest. This caused the dolomite to sink farther down over the old depressions than elsewhere, and resulted in forming synelines. This is the accepted explanation of the cause of the folds. It
A. Upper part of the Galena formation at Hanover showing the exceptionally steep dip of the beds.

B. Flats and pitches developed in a brick wall by the giving way of its support.
is seen to be a combination of an original irregular surface, irregular depositions of the oil-rock, and a corresponding varying loss in thickness of the oil-rock by compression.

Under the last idea of the origin of the synelines, obviously the flats and pitches resulted from the sinking of the beds of dolomite. When the foundation sinks away from under a portion of a brick wall which is supported at both ends, the wall breaks along a rudely arch-shaped crack which is quite similar to those now found in the Galena dolomite (Pl. VII, B). The flats and pitches are confined to the lower part of the formation where this strain would be felt most.

The crevices in the middle and upper parts of the formation are due to: (1) lateral tension or stretching of the beds over the whole region, (2) tension over the higher places of the old surface as the strata sink away on either side over the low places, (3) tension in the lower places as underlying strata sink to make the flats and pitches, (4) tension in the upfolds if the region was compressed laterally, (5) tension resulting from contraction of the rock mass as water was drained from it after the sea withdrew, or (6) a combination of all five causes. Causes No. 2 and No. 3 are probably predominant, although undoubtedly all the others may have been effective at one time or another.

THICKNESS

Throughout most of its extent in the district the Galena formation is from 240 to 245 feet thick. As shown in the detailed descriptions, its two lower members aggregate 40 to 45 feet in thickness, the cherty member is 100 feet thick, the upper massive member 70 feet, and the upper thin-bedded member 30 feet. This thickness is sufficiently uniform to allow its use in determining stratigraphic horizons. However, there seems to be evidence of variation from this in two places. In the center of sec. 10, T. 27 N., R. 1 E. (Rice) the following drill records seem to show that the formation is thinner than elsewhere:

<table>
<thead>
<tr>
<th>Surface elevation</th>
<th>Depth to oil-rock</th>
<th>Elevation of oil-rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>804</td>
<td>175</td>
<td>629</td>
</tr>
<tr>
<td>796</td>
<td>168</td>
<td>628</td>
</tr>
</tbody>
</table>

The top of the Galena formation near the drill holes is at an elevation of 745 feet, giving a thickness of 116 and 117 feet for the formation. A mile northwest of the last point, on the property of James Shannon, the top of the formation has an elevation of 754 feet. Two thousand feet east of the point where the top of the formation is located, two wells (618 feet apart) reach oil-rock at elevations of 444 and 432 feet respectively. If the rock were perfectly horizontal here, thicknesses of 310 and 322 feet would be recorded, but this is near the Black Jack mine, and the oil-rock is dip-
ping steeply westward. This would account for some feet of these unusual thicknesses.

**HISTORYRecorded in Galena Beds**

The history recorded by the rocks and fossils of the Galena formation is as follows: After the Platteville rocks had been uplifted relative to sea level, and their surface weathered and otherwise roughened, the sea advanced and submerged the whole region. The thin bed of shale at the base of the Galena formation was deposited in this sea, probably as it first advanced. Then the sea cleared, either because the water became deep, or because the margin of the sea had already gone far beyond this district, or if the land was nearby, because that land was very low. In this sea lived numerous animals which made shells for themselves from mineral matter in solution in the sea water, and dying, left their shells on the bottom. The most abundant animals were brachiopods, trilobites, and bryozoans, which secreted calcium carbonate for their shells. At certain times millions of tiny plants known as algae lived. When partially broken up, deposited, and cemented the shells made the lower limestones of the formation, and muds containing the algae made the oil-rock. Later the mud and algae ceased being deposited rapidly, and the later deposits were such that after cementation and alteration dolomite resulted. Conditions of deposition were now stable for a great length of time, as the beds deposited are very thick. Animals secreting siliceous skeletons also lived at this time and, dying, deposited their skeletons with the shells of other animals. The silica was gathered together into nodules and layers, and the cherts of the cherty members were formed. During the latter part of the epoch, the sea probably shallowed somewhat and oscillated back and forth, causing the deposition of calcareous materials in thin beds, separated by thin layers of mud where the water was shallowest. The resulting rock is the thin-bededded member at the top of the formation. At the end of the epoch, the sea may have withdrawn entirely from the region.

**Maquoketa Shale**

**Distribution and Outcrops**

Although the Maquoketa shale formation has a wide distribution in the region and is almost as thick as the Galena dolomite, it does not have so conspicuous or extensive outcrops as the latter. The shale is soft and is easily disintegrated and eroded; hence the beds are covered in places with their own debris and with loose material which lodges on the gentle slopes. In the north part of the district the formation is found sparsely in the mounds and on the lower divides; it occurs more widely in the central portion; and in the southern part it occurs abundantly beneath the Niagaran escarpment, under the intermediate plain, and in the walls and floors of valleys. It is known to be present in these locations more because the
Galena formation is seen beneath and the Niagaran above, than because the shale itself is actually visible, although close observation does usually reveal the shale or its weathered debris.

There are, however, outcrops of the Maquoketa in railroad cuts, and in the banks and beds of streams. The best exposures are: (1) in a railroad cut west of Scales Mound, (2) at the east end of the Chicago Great Western Railroad tunnel 7 miles southeast of Galena, (3) in quarries in the northwest portion of Stockton, (4) in the valley of Plum River and its tributaries, south of Elmoville, and (5) in the valley of Apple River a mile south of Hanover (fig. 13).

![fig_13](image)

**Fig. 13.** Outcrop of Maquoketa shale on Apple River below Hanover.

**Lithologic Character**

The Maquoketa formation, unlike the Galena, cannot be divided into distinct and persistent members, for there is considerable variation in its constitution in different parts of the region. It is about 80 per cent shale, the rest consisting of layers of pure limestone, sandy limestone, shaly limestone, and dolomite. The lower part of the formation is predominantly shaly, the upper part predominantly calcareous. The following divisions are applicable in a very general way:

3. At the top, a zone of massive, heavy beds of limestone, interbedded with shale; not present everywhere.

2. A middle zone of shale with sandy and calcareous layers interbedded; thickness variable.

1. At the bottom, a blue-black shale, with a few lenses of sandy limestone; thickness variable.

Even this very generalized subdivision can hardly be said to hold for the entire region. Outcrops are so few, so scattered, and so poor, and so great differences are seen in the formation from place to place, that exact subdivisions cannot be made. The formation is so largely shale, that all except its upper part, and even that locally, is recorded in well records
as "blue clay." Where a boring penetrates downward from the middle part of the formation, it reaches "hard rock" first where it strikes the top of the Galena dolomite. Where well borings pass from the Niagaran dolomite into the Maquoketa shale, the drillers record "hard rock" above, and "blue clay" below, although in certain parts of the region, as around Stockton, the lower few feet of the "hard rock" may be Maquoketa.

Descriptions of a few of the best outcrops, representing different stratigraphic horizons will serve to give a general idea of the character of the formation:

1. The lower part of the formation is well exposed in a railroad cut half a mile west of Scales Mound. The fossiliferous zones, No. 2 and No. 4, are very characteristic of the lower 10 feet of the formation.

Section of lower part of the Maquoketa near Scales Mound

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Ft.</th>
<th>In.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Clay (at top)</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>6. Shale (?), hard, laminations 1 to 3 inches thick, does not effervesce</td>
<td>6</td>
<td>.</td>
</tr>
<tr>
<td>5. Clay shale, fissile, gray, fine grained, fossiliferous (graptolites, linguline, ctendonts 1 foot from base); material breaks into thin plates</td>
<td>26</td>
<td>.</td>
</tr>
<tr>
<td>4. Ferruginous bed containing numerous pelecypods, gastropods, and a few specimens of a small orthoceras</td>
<td>11</td>
<td>.</td>
</tr>
<tr>
<td>3. Clay shale, fissile</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>2. Shale, ferruginous, carrying pelecypods, gastropods, orthocera, and numerous flat or irregular bits of fossil plants now composed of calcium phosphate</td>
<td>1</td>
<td>.</td>
</tr>
<tr>
<td>1. Galena dolomite in 1-foot beds</td>
<td>.</td>
<td>.</td>
</tr>
</tbody>
</table>

2. One and a half miles east of Scales Mound is the following section:

Section in the Maquoketa near Scales Mound

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Calcareous rock, hard, fossiliferous</td>
<td>20</td>
</tr>
<tr>
<td>3. Clay shale</td>
<td>40</td>
</tr>
<tr>
<td>2. Calcareous material, hard</td>
<td>10</td>
</tr>
<tr>
<td>1. Clay shale, blue, at base of formation</td>
<td>30</td>
</tr>
</tbody>
</table>

3. An almost complete section of the formation is laid bare in two valleys south of Elmoville. Its lower part is exposed in the wall of Plum River valley half a mile southeast of the village (Pl. VIII, A), and the upper part 2 miles south and east of the Eaton School. A complete section, made by combining these two, is as follows:

Section of the Maquoketa near Elmoville

(Contact between Niagaran and Maquoketa at an elevation of 824 feet)

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Ft.</th>
<th>In.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conglomerate, brown, fragments of fossils not more than one-eighth inch in diameter, crumbling</td>
<td>8</td>
<td>.</td>
</tr>
<tr>
<td>Limestone, coarsely crystalline, fossiliferous, reddish brown</td>
<td>1</td>
<td>.</td>
</tr>
<tr>
<td>Shale, blue, weathering to yellow clay</td>
<td>1</td>
<td>.</td>
</tr>
<tr>
<td>Limestone, highly fossiliferous; containing Maquoketa fossils</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Shale, blue, highly fossiliferous in the lower part</td>
<td>5</td>
<td>.</td>
</tr>
</tbody>
</table>
Section of the Maquoketa near Elmoville (concluded)

<table>
<thead>
<tr>
<th>Description</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone, fossiliferous</td>
<td>8</td>
</tr>
<tr>
<td>Shale, some interbedded thin, calcareous layers</td>
<td>23</td>
</tr>
<tr>
<td>Shale, interbedded half and half with layers of clay, blue and easily broken; beds average 2 inches in thickness</td>
<td>3</td>
</tr>
<tr>
<td>Limestone and shale, thin bedded, easily disintegrated</td>
<td>3</td>
</tr>
<tr>
<td>Limestone in 7-inch layers, fossiliferous, biscuit-like bryozoans in float</td>
<td>6</td>
</tr>
<tr>
<td>Shale, blue, some layers a little harder than the normal shale</td>
<td>2</td>
</tr>
<tr>
<td>Limestone, hard, crystalline, nonfossiliferous</td>
<td>3</td>
</tr>
<tr>
<td>Shale, greenish blue, nonfossiliferous</td>
<td>6</td>
</tr>
<tr>
<td>Limestone, hard, nonfossiliferous</td>
<td>2</td>
</tr>
<tr>
<td>Shale, greenish blue</td>
<td>2</td>
</tr>
<tr>
<td>Limestone, highly fossiliferous, hard</td>
<td>5</td>
</tr>
<tr>
<td>Shale, greenish blue</td>
<td>1</td>
</tr>
<tr>
<td>Loose material in stream bed</td>
<td>20</td>
</tr>
<tr>
<td>Shale, blue</td>
<td>1</td>
</tr>
<tr>
<td>Loose material</td>
<td>1</td>
</tr>
<tr>
<td>Limestone, thick, blue</td>
<td>6</td>
</tr>
<tr>
<td>Shale, blue black</td>
<td>4</td>
</tr>
<tr>
<td>Yellow, hard rock, probably somewhat calcareous</td>
<td>1</td>
</tr>
<tr>
<td>Shale, blue black, thin bedded</td>
<td>11</td>
</tr>
<tr>
<td>Limestone, hard, blue, crystalline, weathering yellow</td>
<td>3</td>
</tr>
<tr>
<td>Shale, blue black, thin bedded but more massive than that above</td>
<td>6</td>
</tr>
<tr>
<td>Limestone, dark blue, fine grained, crystalline, weathering red</td>
<td>2</td>
</tr>
<tr>
<td>Shale, dark blue, weathering to layers one-third inch thick</td>
<td>5</td>
</tr>
<tr>
<td>Shale, hard, blue, weathering red</td>
<td>2</td>
</tr>
<tr>
<td>Shale, massive, blue black, conchoidal fracture; contains iron concretions; weathered to thin, brown beds</td>
<td>1</td>
</tr>
<tr>
<td>Shale, brown, weathered to red and yellow</td>
<td>6</td>
</tr>
<tr>
<td>Not in place</td>
<td>3</td>
</tr>
<tr>
<td>Shale, blue</td>
<td>3</td>
</tr>
<tr>
<td>Shale</td>
<td>11/2</td>
</tr>
<tr>
<td>Shale, bluish black, weathers thin bedded from massive beds; conchoidal fracture</td>
<td>1</td>
</tr>
<tr>
<td>Slate rock and &quot;soapstone&quot;, bluish, soft; contains few inches of harder material</td>
<td>50</td>
</tr>
<tr>
<td>Alternating shale and limestone similar in thickness to those below</td>
<td>20</td>
</tr>
<tr>
<td>Shale</td>
<td>3</td>
</tr>
<tr>
<td>Limestone</td>
<td>1/2</td>
</tr>
<tr>
<td>Shale</td>
<td>6</td>
</tr>
<tr>
<td>Limestone</td>
<td>1/2</td>
</tr>
<tr>
<td>Shale</td>
<td>6</td>
</tr>
<tr>
<td>Limestone</td>
<td>2</td>
</tr>
<tr>
<td>Shale</td>
<td>2</td>
</tr>
<tr>
<td>Talus-covered slope; no outcrops</td>
<td>5</td>
</tr>
<tr>
<td>Limestone</td>
<td>4</td>
</tr>
<tr>
<td>Shale</td>
<td>8</td>
</tr>
<tr>
<td>Limestone</td>
<td>1/2</td>
</tr>
<tr>
<td>Shale</td>
<td>8</td>
</tr>
<tr>
<td>Limestone</td>
<td>3</td>
</tr>
<tr>
<td>Shale</td>
<td>2</td>
</tr>
<tr>
<td>Limestone</td>
<td>4</td>
</tr>
<tr>
<td>Shale</td>
<td>1</td>
</tr>
<tr>
<td>Limestone</td>
<td>11/2</td>
</tr>
<tr>
<td>Shale</td>
<td>1</td>
</tr>
<tr>
<td>Limestone, compact, argillaceous, gray</td>
<td>3</td>
</tr>
<tr>
<td>Clay shale, dark gray, chocolate colored, uniform, breaks in flattish bits with conchoidal fracture</td>
<td>8</td>
</tr>
<tr>
<td>No outcrop</td>
<td>10</td>
</tr>
<tr>
<td>Thin beds, black, loose, soft, porous; contain pelecypods, phosphatic pellets, gastropods, and orthocera</td>
<td>3</td>
</tr>
</tbody>
</table>

4. The Chicago Great Western Railroad tunnel, 7 miles southeast of Galena, is driven through Maquoketa shales. They are exposed in the open...
A. Lower part of Maquoketa shale in a gully south of Elmoville.

B. Massive beds in the uppermost part of the Maquoketa shale at Stockton quarries.
part of the cut at both ends of the tunnel. At the east end of the tunnel 41 feet of fine, bluish, clay shale is exposed above the railroad tracks, under argillaceous, calcareous beds of Niagaran age.

5. A section in the extreme upper part of the formation where it is thickest is exposed in the hillside and in a quarry on the hill where the water reservoir of Stockton is located. The base of the exposed beds is 169 feet above the base of the formation half a mile southwest of the hill. At the elevation of the top of the exposure Niagaran beds outcrop on the hill west of the main quarry. A photograph of the upper portion of the Maquoketa in the quarry at Stockton is shown in Plate VIII, B. A section beginning at the top follows:

Section of the Maquoketa at Stockton

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Ft.</th>
<th>In.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Calcereous rock, thin bedded, yellow, dolomitic</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>6. Calcereous and shaly beds, thin-bedded, yellow to blue, highly fossiliferous</td>
<td>4</td>
<td>..</td>
</tr>
<tr>
<td>5. Limestone, reddish, massive, coarse grained, hard, dolomitic; fossils easily seen on weathered surfaces</td>
<td>2</td>
<td>..</td>
</tr>
<tr>
<td>4. Shale, pinching out</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>3. Limestone, massive, coarse grained, hard, crystalline; contains calcite and many fossils</td>
<td>4</td>
<td>..</td>
</tr>
<tr>
<td>2. Limestone, massive, crystalline, hard, and dolomitic; base cherty; fossils conspicuous on weathered surface</td>
<td>3</td>
<td>..</td>
</tr>
<tr>
<td>1. Calcereous beds, thin, shaly, blue, and earthy, separated by layers of blue shale; fossiliferous</td>
<td>3</td>
<td>..</td>
</tr>
</tbody>
</table>

6. A quarry in the upper Maquoketa 1 ¼ miles northwest of Stockton, exposes beds that are more than usually massive. The rock is coarse grained, light yellowish or reddish in color, and made up largely of small, white particles probably fragments of shells. Of the 13-foot exposure, all is massive except 4 to 18 inches of shale near the top, and a 3-foot bed at the top. The lower shale is variable in thickness as a result of being squeezed unequally by the overlying beds. The massive rock is jointed and broken. Both shale and massive rock are fossiliferous, though the fossils are best preserved and most easily collected in the shale.

This place and Reservoir Hill at Stockton are the only ones seen where Maquoketa formation is sufficiently hard to be quarried for building purposes. The massive member of the formation is present only where the formation is exceptionally thick (about 200 feet). It is found around Hanover, Stockton, and Scales Mound.¹

Fossil Content

The Maquoketa shale is the most fossiliferous formation outcropping in the Galena and Elizabeth quadrangles. At its base is a thin bed which came to be known in the field as the lamellibranch zone, because of the great abundance of tiny pelecypods (lamellibranches) in it. Above this zone the

¹For other sections of the Maquoketa formation and their geographic and stratigraphic relations, see the Galena-Elizabeth folio, of the U. S. Geological Survey (in preparation).
lower and middle parts of the formation are relatively nonfossiliferous. In the upper part of the formation beds of shale and of heavy limestone contain abundant fossils.

Lamellibranch zone.—The extreme base of the formation is characterized by one or two layers composed in great measure of small fossils, which are valuable aids for locating the Maquoketa-Galena contact almost everywhere in the region. Even where the bed is not exposed, the fossils weather out of the shale and are found loose on the surface. Several genera and species are represented among them. The most abundant and characteristic forms are small pelecypods of two genera, Cleidophorus and Ctenodonta. They resemble the mussels and clams of today in having two convex valves, of equal or sub-equal dimensions. Cleidophorus is the larger and more stocky of the two and has a peculiar slit or groove at the beak. Photographs of these forms are shown in natural size in Plate IX. With the pelecypods are small gastropods of the genus Liospira, bearing some resemblance to present day snails; a cephalopod, of the genus Orthoceras, the like of which does not live today; and numerous peculiar phosphatic pellets or "slugs," as they were called in the field, which are small, irregular, nodular-like masses, most of which have a peculiar depression at or near the center of one side. They may have originated in the secretions of animals or of plants like the algae.

At the exposure half a mile west of Seales Mound, a 1-inch bed of ferruginous shale, carrying all these forms, lies directly on the surface of the Galena dolomite, and four feet above the top of that formation is another 11-inch bed containing the same forms. The two fossiliferous beds are separated by about 4 feet of fissile clay shale.

At the dam at Hanover massive dolomite is overlain by 3 feet of talus and wash, and 3 feet of thin-bedded, fine-grained, arenaceous, chocolate-colored clay shales, containing egg-shaped, nodular masses of clay. Six and one-half feet above the top of the Galena is a 6-inch layer of open, porous, but resistant rock, made up largely of shells of pelecypods, gastropods, and a few large brachiopods of the genus Lingula.

Probably the best outcrop of the lamellibranch zone seen in place is in the bed of Plum River half a mile southeast of Elmoville, and 1060 feet north of the bridge. The basal beds of Maquoketa are soft, black or brown, porous, and carbonaceous. In them are abundant lamellibranches, roundish "slugs," gastropods, and orthocera. Galena dolomite is in the bed of the stream 940 feet from this outcrop and 2 feet higher, and the fossiliferous zone is overlain directly by 40 feet of shale in the east wall of the valley. From this point southward the Galena dolomite dips under the stream bed, and at the exposure just described it must lie very close to the surface.

Moreover, the lamellibranch zone may be located almost anywhere along the Galena-Maquoketa contact, in roads, stream beds, or quarries, by the
PLATE IX
Fossils from Maquoketa formation
(All illustrations natural size)

Figures 1 to 12. These are the more common species that occur in the ‘‘lamellibranch zone’’ at the base of the Maquoketa shale. Figures 1 to 3 are pelecypods, or lamellibranchs; figures 4 to 6 are brachiopods; figure 7 is a small sponge; figure 8 is a cephalopod; figures 10 to 12 are gastropods.

1. Cleidophorus neglectus.
2. Cleidophorus neglectus, cast of the inside of a shell.
3. Ctenodonta obliqua.
4. Dalmanella testudinaria.
5. Zygospira modesta.
6. Rhyconellolid shell.
7. Hindi parva.
8. Orthoceras, unnamed.
9. Slug or pellet of phosphate; contains algae.
10 and 11. Liospira micula.
12. Pleurotomaria depauperata.

Figures 13 to 24. These are fossils from the upper part of the Maquoketa shale. Figures 13, 14, 15, 16, 18, 20, 23, and 24 are brachiopods; figures 17 and 22 are bryozoans, a colonial organism related to the brachiopods, though resembling some corals in outer form. Figure 21 is the tail of a trilobite, an extinct creature which was distantly related to the present crayfish.

13. Plectamphistia sericeus.
14 and 15. Rhynchotrema perlamellosa.
16. Rafinesquina alternata.
17. Bryozoa, unfinished.
18. Rhynchotrema capax.
20. Heberella occidentalis.
22. ‘‘Biscuit bryozoan.’’
23. Orthis whifieldi.
24. Platastrophia biforata.
reddish clay and the small fossils which it yields on weathering. The list of species found in this zone is as follows:

**Fossils of the lamellibranch zone**

<table>
<thead>
<tr>
<th>Ctenodonta feconda</th>
<th>Hindia parva</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleidopus neglectus</td>
<td>Orthoceras</td>
</tr>
<tr>
<td>Ctenodonta obliqua</td>
<td>Liospira micula</td>
</tr>
<tr>
<td>Zygospira modesta</td>
<td>Hyolithes parviusculus</td>
</tr>
<tr>
<td>Dalmanella testudinaria</td>
<td>Pleurotomaria depauperata</td>
</tr>
</tbody>
</table>

**Middle barren zone.**—A large part of the middle and lower portions of the Maquoketa formation is almost without fossils. In the outcrop at Seales Mound a few graptolites were found above the lamellibranchs, and a single specimen of *Ctenodonta*. A large *Orthoceratite* (cephalopod) was found 20 feet above the base of the formation near Bellevue, Iowa. There are probably other fossils in this part of the formation, but they are relatively scarce.

**Upper fossil zone.**—In the upper part of the formation nearly all of the calcareous beds and most of the associated shales carry abundant fossils. This is especially true where the formation reaches its greatest thickness. Where it is thinnest, as at the Chicago Great Western Railroad tunnel, the calcareous beds were removed by erosion before the overlying Niagaran formation was deposited, and the shales now at the top of the formation are barren. The fossiliferous beds are most in evidence in the vicinity of Seales Mound, Stockton, Elmoville, and Hanover. The fauna consists of brachiopods, bryozoans, and trilobites including the following species:

**Fossils of the upper Maquoketa formation**

<table>
<thead>
<tr>
<th>Hebertella insculpta</th>
<th>Plectambonites sericeus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hebertella occidentalis</td>
<td>Plectorthis whitfieldi</td>
</tr>
<tr>
<td>Platastrophia biforata</td>
<td>Leptaea unicoostata</td>
</tr>
<tr>
<td>Rhynechotrema perlamellosa</td>
<td>Orthis anticoenensis</td>
</tr>
<tr>
<td>Rafinesquina alternata</td>
<td>Hyolithes parviusculus</td>
</tr>
<tr>
<td>Dalmanella testudinaria</td>
<td></td>
</tr>
</tbody>
</table>

Trilobites were found in only one place in the region. They were taken from the dump of a shallow well immediately west of Mt. Pleasant School. The base of the Niagaran here has an elevation of 966 feet and the well dump is 71 feet lower. Photographs of some of these fossils are shown in Plate IX.

A few places where these fossils may be collected are: (1) valley one mile northwest of Hanover at elevations ranging from 750 feet to 815 feet; (2) valley 2½ miles west of Hanover; (3) gully heading in extreme east part of NE. ¼ sec. 1, T. 26 N., R. 2 E. (Hanover); (4) valley heading northwest in sec. 30, T. 27 N., R. 2 E. (Elizabeth); (5) valley in extreme southwest corner of Elizabeth quadrangle, just south of boundary of area; (6) tributary valley one-half mile south of Mt. Pleasant School; (7) head of gully in north part of sec. 33, T. 27 N., R. 4 E. (Stockton); (8) quarries
GEOLOGY

in Reservoir Hill in Stockton; (9) quarry 1¼ miles northwest of Stockton; (10) in hill road 2½ miles northeast of Scales Mound; (11) a place 2 miles north of Hickory Grove School, sec. 36, T. 28 N., R. 2 E. (Guilford); (12) west and northwest of Thompson Center School in the north part of sec. 17, T. 27 N., R. 2 E. (Guilford); (13) two miles southeast of Elizabeth; and (14) in the vicinity of Derinda Center.

THICKNESS AND STRATIGRAPHIC RELATIONS

There are some evidences of an unconformity at the base of the Maquoketa shale: (1) the Galena dolomite below gives place to shale very abruptly, denoting at least a rapid change in conditions of sedimentation; (2) fossils in the base of the shale are entirely different from those just below in the dolomite, suggesting a break in the deposition; (3) the basal layer of the shale formation is rich in oxidized iron, as if the surface below had been exposed to the atmosphere before it was covered by the Maquoketa sea; (4) the lamellibranch zone includes pellets of phosphates, and phosphatic nodules, such as are commonly found just above unconformities.

These evidences of unconformity are opposed by certain features which suggest conformity: (1) chief of these is that no direct physical evidence of unconformity has been found at the contact, such as an eroded surface, a definite soil, marks of weathering on the surface of the dolomite, or a dip of the dolomite unlike that of the shale in amount or direction; (2) further, the upper member of the dolomite formation has a uniform thickness throughout the region. The upper Receptaculites zone lies everywhere about 70 feet below the top of the formation. This shows that the dolomite was not eroded much (if any) before the deposition of the shale; or, if it was eroded, material was removed equally over the whole region.

The contact is probably an unconformable one, though of such type that it is not at once apparent. The Galena sea probably withdrew, leaving the surface of the dolomite exposed. This surface was probably so low that little erosion was possible, though the surface was weathered. Then the Maquoketa sea advanced, and covered first the ferruginous earth and the phosphatic nodules which lay on the surface. An alternative view is that strong waves or ocean currents stopped sedimentation, and swept the sea floor clean, and when sedimentation was renewed conditions had so changed that mud was deposited where limestone had been in the making. This would not make an unconformity in the ordinary sense of that term.

Although at the top of the Maquoketa formation there is little direct evidence of a physical unconformity at any single exposure, the existence of such an unconformity is made clear by a comparison of the phenomena exhibited by several exposures. The evidence is as follows:

1. In the vicinity of Scales Mound, Stockton, and Hanover, the Maquoketa formation is about 200 feet thick. In these places its top is rep-
resented by massive layers of limestone alternating with shale, and carrying abundant and characteristic fossils. In many other places, as in the vicinity of the Chicago Great Western Railroad tunnel and at the mounds east of Galena, it is much thinner. A few of the thicknesses, as estimated by leveling from the lamellibranch zone to the top of the formation, are recorded in the following table to show the variability.

Observations showing variations in thickness of Maquoketa formation

<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
<th>Thickness Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>East part of sec. 10, T. 27 N., R. 1 E. (Rice)</td>
<td>209</td>
</tr>
<tr>
<td>2</td>
<td>East of Platteville, Wisconsin</td>
<td>155</td>
</tr>
<tr>
<td>3</td>
<td>Center sec. 30, T. 28 N., R. 2 E. (Guilford)</td>
<td>117</td>
</tr>
<tr>
<td>4</td>
<td>...Do</td>
<td>182</td>
</tr>
<tr>
<td>5</td>
<td>3 miles east of Galena</td>
<td>147</td>
</tr>
<tr>
<td>6</td>
<td>3½ miles northeast of Galena, and ½ mile northeast of No. 5</td>
<td>117</td>
</tr>
<tr>
<td>7</td>
<td>Chicago Great Western Railroad tunnel</td>
<td>108</td>
</tr>
<tr>
<td>8</td>
<td>Scales Mound</td>
<td>195</td>
</tr>
<tr>
<td>9</td>
<td>Elizabeth</td>
<td>155</td>
</tr>
</tbody>
</table>

From this table it is seen that the formation varies in thickness from 108 to 209 feet, and that it varies considerably in short distances, as between observations 3 and 4, and between 4 and 5. At the Chicago Great Western Railroad tunnel, and east of Galena, where the formation is thinnest, the upper fossiliferous zone is not present, but the Niagaran is underlain directly by shale. From this it is concluded that the formation has been eroded unequally. Where the upper beds have been removed, it is thin; where they have not been removed, it is thick. These conditions are shown in figure 14. This erosion took place before the deposition of the Niagaran dolomite.

![Fig. 14. Diagram illustrating the variable thickness of the Maquoketa formation and the Maquoketa-Niagaran unconformity; X, Maquoketa; Y, Niagaran; A, conditions at Stockton; B, conditions at Chicago Great Western Railroad tunnel.](image)

2. At two places at least the lower layers of Niagaran dolomite contain shale pebbles, probably derived by erosion from the formation below. This is well shown in the gully 1½ miles N. 5° E. of Pleasant Hill School,
just north of the Burke home in the NW. 1/4 sec. 1, T. 26 N., R. 2 E. (Hanover). Here a bed of limestone carrying Maquoketa fossils underlies a bed of shale, which in turn underlies thin-bedded Niagaran beds. The top of the shale is irregular and partially oxidized. At one place the oxidized shale is replaced by a 2-inch layer of dolomitic limestone which contains pebbles of black, blue, and brown rock from 1/10 to 1/30 inch in diameter. Some of the pebbles are of Maquoketa shale. They are rounded and water worn. The other known case is at the head of a valley 2 1/2 miles west of Hanover, where the base of the Niagaran limestone is slightly conglomeratic and lies on the Maquoketa with apparent unconformity.

An important unconformity is thus indicated between the Maquoketa and Niagaran formations. The Maquoketa ocean withdrew, leaving its deposits more than 100 feet above sea level, for erosion removed a thickness of at least 100 feet locally from the newly exposed formations. Later the Niagaran sea advanced over the region.

Fig. 15. Diagram illustrating how slopes are made steep by soft rock wearing out from beneath more resistant rock.

**TOPOGRAPHIC EXPRESSION**

Being generally non-resistant, the Maquoketa formation gives rise to gentle slopes. Where the formation is thin, it commonly contains no material resistant enough to make a steep slope, though a few low, inconspicuous benches occur as the result of the appearance of a layer of calcareous material at the surface. Plate X, A, shows typical topography developed by streams on the Maquoketa shale. Individual valleys developed in the shale are broad, open, and indefinite, and the slopes of the valley walls are uniform (Pl. X, B). In the vicinity of Stockton and Scales Mound where the hard upper part of the formation outcrops slopes are steeper, as at Reservoir Hill at Stockton and on the hill 2 1/2 miles northeast of Scales Mound. Where the shale is overlain by the harder Niagaran dolomite, the upper slopes of the Maquoketa are kept steep by the relatively more rapid weathering of the soft shale as compared with the dolomite above. This principle is illustrated in figure 15. Some of these slopes are seen on the mounds east, south, and southeast of Galena and over much of the southern part of the district.
A. Erosional topography on the Maquoketa shale.

B. Valley developed in the Maquoketa shale.
From the foregoing descriptions and discussion, the following geologic events can be inferred. After the deposition of the Galena dolomite, the region probably emerged from the sea for a time, the land being low. Then the district was again covered by the sea, which remained until the end of the period represented by the Maquoketa formation, when it withdrew, and another period of erosion was inaugurated. The Maquoketa sea was alternately muddy and clear, the clearness increasing toward the end of the epoch. The ripple marks in the shale at Belden School indicate that the sea was shallow, at least locally and temporarily. The sea contained abundant life as small pelecypods, gastropods, and cephalopods and minute plants abounded in the early part of the epoch, graptolites in its middle part, and brachiopods, bryozoans, and trilobites toward its end.

**Niagaran Dolomite**

**Distribution and Outcrops**

The uppermost and youngest series of hard rocks in the Galena and Elizabeth quadrangles is known as the Niagaran dolomite. It outcrops on the high mounds in the northern part of the region, forms the Niagaran escarpment in its central portion, and underlies a large part of the higher areas in its southern part. Having a wide distribution and being resistant to weathering, it outcrops abundantly. The bare rock appears as bluffs and ledges on the mounds (Pl. XII A), as small outcrops in the beds and walls of stream valleys, and in numerous quarries throughout the region.

**Lithologic Character**

The Niagaran rocks in this district, though most frequently referred to as limestones, are almost exclusively dolomites. The lower rocks are thin bedded, and locally shaly or cherty; the upper ones are massive. The lower member comprises the thin beds, and the upper the massive Niagaran.

**Thin beds.**—The character of the lowermost part of the Niagaran formation is quite different in the districts where the Maquoketa shales are thin from that which it possesses in districts where the whole of the Maquoketa formation is present. Conditions for sedimentation were different in the low places; or perhaps the low places were submerged first and sedimentation was in progress there for a time before the higher places were covered by the sea. These basin deposits are best exposed on two mounds east and northeast of Galena, where the Maquoketa is 117 to 147 feet thick and the thin beds of the Niagaran are 87 feet, and at the east end of the Great Western tunnel, where the thickness of the shale is 108 feet and that of the thin beds of the Niagaran 80 feet. Descriptions of these exposures follow.

1. The lower thin beds are exposed in two quarries in secs. 14 and 13, T. 28 N., R. 1 E. (East Galena), 3 to 3\(\frac{1}{2}\) miles in an easterly direction from
Galena. On the west end of the mound in the extreme east-central portion of sec. 14, the exposure extends from elevations of 999 feet to 1009 feet. The bedding is very regular, the thickness of the individual layers ranging from 1 to 4 inches. The rock is chiefly argillaceous limestone, but it is liberally streaked with seams of shale 1 to 1 1/2 inches thick. The limestone has an earthy appearance, and is yellowish or gray. Irregular masses of chert are scattered throughout the rock, but no fossils could be found in it. On the south end of the mound in the extreme north-central part of sec. 13 on the property of Ed. Tippet, the exposure consists of 25 feet of shaly limestone. Argillaceous beds alternate regularly with sandy shale and each averages 3 inches in thickness. After an exhaustive search two brachiopods, Atrypa marginalis and Dalmanella elegans, were found in the rock. Both these species are characteristic of the Niagaran dolomite; otherwise the section might have been mistaken for the upper part of the Maquoketa.

2. The Chicago Great Western Railroad tunnel is driven through Maquoketa shales, which are exposed in the open part of the cut at both ends of the tunnel. At its east end the section above the railroad is as follows:

Section of Niagaran and Maquoketa in Chicago Great Western tunnel

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Ft.</th>
<th>In.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Limestone, thin bedded, argillaceous</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>3. Limestone or calcareous shale, soft, slate colored, massive, argillaceous; readily breaks with conchoidal fracture into angular fragments</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>2. Sandstone, hard, in horizontal layers, one-tenth inch thick</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>1. Clay shale (Maquoketa)</td>
<td>41</td>
<td></td>
</tr>
</tbody>
</table>

No. 1 of this section is Maquoketa; Nos. 2, 3, and 4 are Niagaran as shown by the fossils, but they are abnormal lithologically. There are two fossiliferous horizons: the massive layer, No. 3, carries Orbiculoidea, Lingulae, Atrypa marginalis, and Rhynchonella (?); eight feet above the base of No. 4 is a second fossiliferous zone in which were found Atrypa marginalis, Dalmanella elegantula (brachiopods), and Calymene niagarensis (a trilobite). The three last-named species are characteristic of the Niagaran dolomite, and hence the rock at this outcrop is considered to be Niagaran in age.

3. In parts of the area where all the Maquoketa formation is present most of the lower Niagaran beds are not shaly. A section in the extreme west-central part of sec. 1, T. 26 N., R. 3 E. (Derinda), is as follows:

Section of Niagaran in sec. 1, T. 26 N., R. 3 E.

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Limestone, thin bedded, white, dolomitie</td>
<td>4</td>
</tr>
<tr>
<td>3. Limestone, massive, yellow, soft</td>
<td>1</td>
</tr>
<tr>
<td>2. Dolomite, hard, white, thin bedded, layers averaging 1 inch thick</td>
<td>4</td>
</tr>
<tr>
<td>1. Limestone, massive, soft, yellowish</td>
<td>1</td>
</tr>
</tbody>
</table>
A. Typical topography developed on the Niagaran and Maquoketa formations. The Niagaran appears on the upland in the distance; the foreground is underlain by shale.

B. Massive beds in the lower part of the Niagaran formation two miles southwest of Hanover.
4. Locally at least, the thin-bedded member contains some massive beds. On the northwest end of the isolated hill 2 miles southwest of Hanover (Pl. XI. F) the following section is exposed:

Section of Niagaran southwest of Hanover

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dolomite, very cherry, thin bedded, beds being about 6 inches thick and more or less lenticular. One-quarter of the material is chert which alternates with the dolomite; more chert at top than at bottom.</td>
<td>20</td>
</tr>
<tr>
<td>2. Limestone, dolomitic, massive, beds being about 3 feet thick; coarse grained, bould: no shale nor chert; makes fair building stone.</td>
<td>20</td>
</tr>
<tr>
<td>3. Dolomite, yellow, soft, earthy, with many shaly partings; weathers to thin beds about 7 to the inch (Pl. XI. F).</td>
<td>7</td>
</tr>
</tbody>
</table>

5. Another section is exposed in a quarry on the hill in the southeast part of Elizabeth. Here there are 29 feet of alternating, orange-colored dolomite and gray or reddish cherts. Chert is most abundant at the top. It occurs in uniformly thick layers, discontinuous layers, and nodular masses (fig. 16).

![Fig. 16. Thin beds of Niagaran dolomite containing chert nodules and interlayered with beds of chert in the southeast part of Elizabeth.](image-url)

Other places where the thin-bedded part of the Niagaran formation can be seen are: (1) one-half mile northeast of Galena; (2) in the central part of sect. 7, 24½ miles northwest of Hanover; (3) in a series of quarries 1½ miles southeast of Woodbine; (4) in a small quarry just northwest of Montrose School; (5) at a point 2 miles south and west of the Stockton Center School; (6) one-half mile south of Elsmoeville; (7) in the NW. 4/4 sec. 33, T. 27 N., R. 4 E. (Stockton); (8) one-half mile south of preceding.
outcrop on north side of ridge road; (9) in the NW. ¼ sec. 5, T. 26 N., R. 4 E. (Pleasant Valley); and (10) on a knob 2 miles northwest of Stockton.

**Massive beds.**—The tops of the mounds and the upper slopes of the Niagaran escarpment are made of massive dolomite. To one observing from a distance only, the whole series of rocks would seem to be massive because the outcrops of the massive parts are so conspicuous. The rock ranges from white to gray or buff. Where beds are visible at all they are 5 to 10 feet thick. The rock bears a resemblance to the massive Galena dolomite but differs from it in being white, more compact, more crystalline, and less earthy. It outcrops generally in cliffs or ledges, and weathers into huge blocks which fall, slide, roll, or creep down the steep slopes far over the upper Maquoketa beds. In one place a great block of this rock was found lying directly over the lamellibranch zone at the base of the Maquoketa. The material and the mode of outcrop of the member are uniform throughout this district. Its outcrops may be seen in the following places: (1) in the east-central part of sec. 14, T. 28 N., R. 1 E. (East Galena); (2) in the central part of sec. 13, T. 28 N., R. 1 E. (East Galena); (3) at the end of the mound in the south part of sec. 3, T. 27 N., R. 1. E. (Rice); (4) in the NW. ¼ sec. 30, T. 28 N., R. 2 E. (Gulford). Moreover, it forms the common basal part of the outcrops on the upper steep slopes throughout the region. It can be seen in thousands of places.

In certain places on the ridges in the central and southern parts of the region, as in sec. 6, T. 26 N., R. 4 E. (Pleasant Valley), fine white clay without chert or other fragments appears in the roads. Since it is not one of the recognized unconsolidated rocks of the region, it must be a product of the weathering of some of the Niagaran rocks. No layer which seems likely to have given rise to it was noted; perhaps there is shale in the series above the massive beds, which on account of its lack of resistance to weathering, does not outcrop.

It may be inferred from the above statements that the division of the Niagaran beds in this region is not entirely satisfactory. However, they include at least (1) a lower thin-bedded member, containing a few cherts in its lower portion and many cherts in its upper portion, and (2) an upper massive member. In the thin-bedded member at least locally are several feet of massive beds.

**Fossil content**

The Niagaran dolomite is not abundantly fossiliferous. Its lower thin beds at first sight seem to be entirely barren, but a careful examination of them discloses at least the forms in the following table, which are all small. Unless considerable time and care are taken, search for them is usually unprofitable.
Fossils of the lower thin-beded member of the Niagaran dolomite

Atypa marginalis
Dalmanella elegantula
Calymena niagarensis
Orbiculoidea
Rhynchonella?

The massive layers carry a few corals and abundant casts of a large brachiopod. The corals include "honey-comb coral" or Favosites, and "chain coral" or Halysites. The brachiopod is known as Pentamerus oblongus. It is seen most frequently in loose blocks of chert on top of the mounds or escarpments.

THICKNESS

The full thickness of the Niagaran beds is not present in this region. If there were ever younger hard rocks in the region, they have been removed by erosion. Not more than 140 feet of Niagaran rocks occur here. The thin beds aggregate about 80 feet, the massive or upper cherty beds and the doubtful shale making up the other 60 feet.

STRATIGRAPHIC RELATIONS

It was shown under the discussion of the Maquoketa shale that the Niagaran lies unconformably on the Maquoketa. No rock strata overlie the Niagaran, so that its relations to younger hard-rock formations need not be discussed. However, there was a long period of erosion before wind-blown dust and sand were laid on it.

HISTORY RECORDED BY THE NIAGARAN ROCKS

As in the Galena and Maquoketa epochs, the limestones of the Niagaran epoch record the presence of a clear, life-inhabited sea over the Galena and Elizabeth quadrangles. During the first part of the epoch conditions changed somewhat frequently, and limestone and mud were deposited alternately. Later the sea probably deepened, so that streams from the land, waves, wind, tides, and slight oscillations of level did not much affect deposition, and massive beds resulted. Still later the sea may have become muddy, because of a shallowing, a retreat of the shore line, an uplift of neighboring land, or a change in climate.

The origin of the cherts is a problem. Where silica occurs in irregular masses, small nodules, or even discontinuous layers, it may be supposed that it has resulted from the gathering together of siliceous material scattered throughout the rock. But where chert occurs in definite layers of uniform thickness, just as beds of limestone do, it seems almost necessary to suppose that the silica was deposited as a bed, just as was the limestone. Presumably the limestone consists of fragments of shells made of calcium carbonate. The chert might be regarded as a deposit of siliceous shells. It then becomes hard to conceive of an alternation of chert and limestone, such as this formation exhibits. Or, if the dolomite is formed by partial replace-
ment of limestone by magnesium carbonate, the chert layers may be considered to be limestone entirely replaced by silica. This last view also encounters obvious difficulties. For instance, why should limestone be replaced by silica, and by magnesium carbonate in alternating layers, and why should the lines of contact be sharp? Chert sometimes gathers around spicules of sponges, and it has been suggested that the chert layers are found where the original limestone contains abundant remains of sponges. The exact origin of such beds of chert is still problematical.

**Summary of History Recorded by the Hard Rocks**

From a knowledge of all the formations of hard rock in the region, its physical history can be deduced by application of the principles discussed in Chapter III. All the main events of this history are recounted below in chronological order:

1. During later Cambrian time in this region a sea existed in which sand was deposited, making the Potsdam sandstone.
2. In the early part of the Ordovician period the sea cleared, and the Prairie du Chien limestone was laid down.
3. Emergence, erosion, and later submergence followed, and the St. Peter sandstone was laid unconformably upon the Prairie du Chien limestone.
4. The sea again cleared gradually, the shells of animals became the predominating deposits, and after cementation, resulted in the Platteville limestone.
5. The Platteville formation probably emerged, its surface was weathered, and fossils were worn out and rolled about.
6. The sea again advanced over the region, stood a long time, and covered the undulatory surface with 240 feet of dolomite. This sea was clear most of the time and it contained many forms of life. It probably withdrew finally, leaving the region a low-lying area of land for a short time.
7. Again the sea advanced over the region. This time it was generally muddy, but there were occasional short intervals when it was clear, these intervals becoming longer and more frequent toward the end of the epoch. In this epoch the Maquoketa shale formation with its interbedded limestone and abundant fossils was deposited.
8. The surface again emerged and rose this time to a height great enough and remained for a time long enough to allow of the removal from some places of at least 100 feet of the shale formation.
9. The region was then submerged for at least the fifth time. The sea that covered it was alternately muddy and clear at first, but finally it cleared for the deposition of the Niagaran dolomite.
10. Further than this the history of the region is not recorded by the hard rocks. Still other seas may have advanced and given rise to deposits
of sandstone, limestone, or shale. If so, all the deposits were removed before the next recorded event, the advance of the sheet of ice from the north.

**Unconsolidated Rocks**

Aside from the hard rock formations which occur at or beneath the surface, there are in the district six other kinds of rock material more or less distinct from one another and quite different from the older rocks in that they have never been cemented. None of these materials was deposited universally over the region.

The relative ages of these deposits are not always determinable. Where they are found together, the law of superposition holds; that is, the materials on top are known to be younger than those beneath. But in general these materials are not found one above another, and in some cases, it is impossible to be sure of their relative ages except in a general way.

The unconsolidated materials of the region were formed by other agents and according to principles and laws different from those which governed the deposition of the earlier sedimentary formations, as outlined in Chapter III. They can be considered to best advantage along with discussions of the work of wind, glacier ice, lakes, and running water, which were their main depositing agents. They are, therefore, only briefly described in this place. The first five of the unconsolidated deposits are listed in roughly chronological order, No. 1 being considered the oldest, although it is understood that their exact ages are not known, and several of them may be contemporaneous, at least in part. The period of deposition of No. 6 probably overlaps all the others.

1. In the extreme eastern part of the region in the vicinity of Stockton, in a small area one mile northeast of Elmoville, and in another around Hanover is a mixture of local hard sedimentary rocks, in the form of boulders and angular fragments containing a few large and small pieces of igneous rocks which are entirely foreign to the region. This material is glacial drift, which is considered in the next chapter.

2. A yellowish earth, in texture between sand and clay, is found chiefly on the uplands in the western part of the region, and especially near Mississippi River. This is known as loess. It is a wind-deposited formation to be discussed in Chapter VI.

3. Finely laminated sands and clays taking the form of low terraces are found in the lower ends of the main valleys tributary to Mississippi Valley, such as the valleys of Sinsinawa Creek, Galena River, Smallpox Creek, and Apple River. These are terrace materials (see Chapter VIII) which are probably related in origin to glacial drift, but to drift younger than that of our immediate region.

4. On the flat bottom of Mississippi Valley and on the bluffs near the river, wind-blown sand is found. It takes the form of dunes, or isolated
patches. Most of it was blown to its present position after the material of the terraces was deposited. Dunes are still forming (see Chapter VI).

5. The bottoms of many of the valleys of the region are covered with stream alluvium. Such material is still being deposited during and after each flood.

6. Where none of the preceding deposits exist, the hard rocks are overlain almost everywhere by a mantle of loose material, clay, gravel, and soil, in some places 18 feet in thickness. This has resulted from the weathering of the hard rocks and may be called residual material. Unlike all the other rocks of the region, consolidated and loose, this material is not mapped. Should it be expressed on the map, it would cover practically all of the bed-rock formations. Though listed last, the production of some of the residual earth probably dates back as far as the oldest of the deposits of this list. Most of No. 6 is older than No. 5, much of it is older than No. 4, some of it is older than No. 3 and probably some of it is older than No. 2 and even No. 1. The listing therefore is hardly according to age so far as No. 6 is concerned.
CHAPTER V—GLACIAL GEOLOGY

GLACIAL PERIOD IN NORTH AMERICA

That part of North America north of Raritan Bay on the Atlantic coast, north of the Ohio and Missouri rivers in the interior, and north of northern Washington on the Pacific coast differs from other parts of the continent in being covered by a mantle of loose material known as drift. This drift consists of a mixture of stones and clay, the stones being of many different kinds and having almost an infinite variety of shapes. For the most part, the materials are bowlders, cobbles, sand, and clay mixed together without order. But locally the drift has been sorted by water, and clay, sand, and gravel are separated from one another in beds. In many places where solid rock appears beneath the drift, its surface is polished, scratched, and grooved, as if a solid body shod with hard tools had passed over it. These facts and many others of similar import have led all those who have given the matter serious attention to the conclusion that this part of North America was once covered by a great ice sheet, which moved from the north, eroded the surface over which it passed, and carried and deposited the drift. This is no mere hypothesis; it is supported by such a body of facts that the truth of the conclusion may be accepted as established.

In certain locations within the area covered by the ice, there are two sheets of drift separated by a zone of soil and vegetable material as thick as, or thicker than, that found at the surface of the uppermost drift today. Locally, also a drift sheet which has been deeply weathered and leached, is found underlying another sheet which is fresh and less altered. In central Illinois and Iowa, and generally in the southern part of the glaciated area, the surface of the drift has been much more modified by streams, wind, and other agents since its deposition than that in regions farther north, thus indicating that the southern drift is older than the northern.

In these ways it is known that more than one ice sheet is responsible for the drift, and that considerable periods of time elapsed between the advances of the several ice sheets. By most geologists five ice sheets (four by some) are thought to have advanced in succession from the north, and the glacial period is divided as follows:

9. Wisconsin glacial stage
   \( \{ \)
   \( \) Late Wisconsin
   \( \) Early Wisconsin
8. Peoria interglacial stage
7. Iowan glacial stage
6. Sangamon interglacial stage
5. Illinoian glacial stage
4. Yarmouth interglacial stage
3. Kansan glacial stage
2. Aftonian interglacial stage
1. Sub-Aftonian or Nebraskan glacial stage

The results of glaciation were many and great. Immense quantities of all kinds of rocks were brought from the north and deposited farther south. Basins were gouged out in the surface in a few places and valleys were filled in others. Thousands of lakes, including the Great Lakes, came into existence in the basins which were formed. The courses of many of these streams were deranged, because their valleys were filled or partly filled with drift. Surface relief was increased in some places and decreased in others. Some places were made peculiarly suitable for man, whereas others lost all chance of habitation by being buried under lakes. The glaciers are responsible for many of the details of the surface of the northern part of North America as it exists today.

Driftless Area

Almost at the center of the drift-covered portion of the United States, is a region which was avoided by each of the ice sheets in turn. It is located in southwestern Wisconsin, northwestern Illinois, northeastern Iowa, and southeastern Minnesota, and includes an area of 8,000 to 10,000 square miles.

The general topography of this region and a detailed description of the area included in the Galena and Elizabeth quadrangles was described in Chapter II. With the exception of a small amount of gravel and a few bowlders near the margin, the area contains no glacial drift; hence its name. Why this particular area should have escaped glaciation is not exactly clear. Perhaps the ice was led off to either side by the basins of lakes Superior and Michigan in such a way and to so great an extent that there was no ice left to cover the higher lands between these depressions.

Although the Driftless Area was covered by none of the ice sheets, the glaciers, nevertheless, affected the region indirectly. Where rivers flowed outward from the area, their courses were blocked by the ice, and this affected their courses within the Driftless Area. In some cases lakes were made along the edge of the ice, and in these lakes silts were laid down, deltas were deposited, and floating icebergs dropped bowlders and other fragments of rocks. Where drainage was unobstructed, water resulting from the melting of the ice flowed down the main valleys, depositing in them finely divided glacial debris which the glaciers had carried to their edges. Where there were no main valleys the water escaped by many small streams to the immediately adjoining plains, depositing drift in the form
of rude fans. Some such indirect results of the work of at least two of the ice sheets are found in the Galena and Elizabeth quadrangles.

**Effects of Glaciation in the Galena and Elizabeth Quadrangles**

**Glacial Drift**

Almost all the area of the Galena and Elizabeth quadrangles is in the Driftless Area, but some evidences of glaciation in the form of glacial drift and deranged drainage are found in the district around Hanover, in the vicinity of Stockton, and in a small area northeast of Elmoville.

**Drift Near Hanover**

Remnants of a once extensive but now much eroded and very old drift sheet are known on the west border of the Driftless Area in Iowa and Minnesota, and some of these remnants are found in the Iowa portion of the Galena quadrangle, but it has not been known until recently that this drift exists on the east side of Mississippi River in Illinois. Its occurrence east of the river was pointed out to the writers by Mr. T. D. Shipton of Hanover and his son, W. D. Shipton, now a graduate student in the State University of Iowa.

The most extensive exposure of this drift is in a ravine 1 1/2 miles west and a trifle north of Hanover where bowlders and cobble of glacial material may be seen in the rubble along the stream, in the sides of the valley, and in the beds of dry tributary ravines. It extends for a distance of several hundred yards along the stream, but was observed not to extend above an altitude of 800 feet although the head of the valley is higher than 900 feet above sea. The drift is patchy in its distribution, for several neighboring valleys, including the one next north and the one next south of the location of the drift exposure, were searched by one of the writers and found to contain none of this deposit. Mr. T. D. Shipton reports the finding of a single piece of foreign quartzite in a ravine one-half mile east of Hanover, which may or may not be the remnant of an original body of drift at this place. Although no other exposures of the drift are known east of the river as the bulletin goes to press, it is not unlikely that other patches may be discovered later.

The drift west of Hanover consists of ice-worn pieces of material foreign to this district, ranging in size from cobbles to bowlders 2 1/2 feet in diameter. Dolerite, syenite, basalt, schist, porphyry, quartzite, and at least two kinds of granite are represented. The bowlders in the banks are surrounded by clay, but this matrix is residual matter from the Maquoketa shale and Niagaran dolomite, rather than a part of the drift. None of the igneous rocks is perfectly fresh, but all show some and many show great evidence of alteration by processes of weathering since their deposition here. Even those which appear almost unaltered break easily under the hammer.
along rusty fracture planes. The dark-colored rocks are greenish in color, as is common with such rocks which have been weathered. Some of the boulders are so much altered that they can be picked to pieces in the fingers, and doubtless others have been entirely decomposed and washed away by the stream or added to the soil.

The exact age of this drift cannot be determined, but its patchy distribution and mature state of weathering suggest that it is old. It is similar in most respects to the old drift in Iowa which is either Kansan or Nebraskan in age and which may include drift deposited at both times. The drift around Hanover, therefore, may be either Kansan or Nebraskan in age, and in any case is older than the drift on the opposite side of the Driftless Area in the east edge of the Elizabeth quadrangle. Either the Nebraskan or the Kansan glacier must have advanced into this district from the north and west.

**DRIFT NEAR STOCKTON**

The region north of the east edge of Stockton and east to the east edge of the Elizabeth quadrangle for 5 miles north of Stockton is characterized on the topographic map (Pl. 1) by few and broadly curving contour lines, showing a flattish or gently rolling surface (see figure 17). This is the western margin of a great drift-covered region, which stretches far to the east, outside these quadrangles.

![Fig. 17. Topography of the glaciated area north of Stockton.](image)

Though the drift is nowhere well exposed, foreign boulders are fairly common on the surface, the road cuts afford some shallow exposures of drift
materials and drift is recorded in well borings. Almost anywhere along
the road leading north from the east edge of Stockton and in the immedi-
ately adjoining fields for 5 miles north of Stockton, careful search reveals
scattered bowlders of igneous rocks foreign to this region. These bowlders
most of which are larger than a man’s head, are popularly known in the
vicinity as niggerheads. Many of them are conspicuous because of their
dissimilarity to the rocks which occur commonly in the vicinity. The
bowlders are plentiful in the southeastern portion of Stockton and in the
fields to the southeast. Fifty were counted in a single vacant block between
the easternmost north-south street, the railroad tracks, and the east-west
street paralleling the railroad on the north side. They range from 1 to 3
feet in diameter, and consist of granites, basalts, dolomites, and quartzites.
Mr. F. D. Murphy, who lives 3 miles north of Stockton, has drawn about
150 bowlders from a 20-acre field north of his home. One of these weighs
about 2 tons (fig. 18). Bowlders are scattered rather generally over other
farms in this neighborhood.

Drift sections and well records are so scarce, that the boundary of the
drift-covered area can be best located by joining points at which the western-
most bowlders are found. The only good exposure of the drift is in the
roadside 3 miles north of Stockton. The material consists of a matrix of
stiff, compact, chocolate-colored clay, in which are inbedded numerous frag-
ments of foreign and local rocks. When wet the clay molds readily in the
hands. The bowlders are many-sided or subangular. Some are scratched
or striated by pieces of rock or grains of sand which rubbed against them
while all were being transported in the glacier. The stony matter ranges
in size from that of a pea to bowlders 1½ feet in diameter.
Because in the vicinity of Stockton a thin layer of Maquoketa shale underlies the glacial drift, and because after weathering the two are somewhat similar, the position of the base of the drift is somewhat difficult to determine from the well records. However, if the descriptions of material penetrated by the wells are accurate and detailed, the boundary can in most places be distinguished. Where the dolomite is first struck at levels lower than the normal position of the top of the formation in the vicinity, the soft upper material is regarded as glacial drift. Records of wells near Stockton which penetrate glacial drift follow:

Record of wells near Stockton which penetrate glacial drift

<table>
<thead>
<tr>
<th>No.</th>
<th>Strata penetrated</th>
<th>Thickness Feet</th>
<th>Depth Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Clay and rock fragments (drift)</td>
<td>60</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>Rock</td>
<td>22</td>
<td>82</td>
</tr>
<tr>
<td>2.</td>
<td>Gravel (drift)</td>
<td>60</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>Rock</td>
<td>22</td>
<td>82</td>
</tr>
<tr>
<td>3.</td>
<td>Clay, slate colored (drift)</td>
<td>35</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Rock</td>
<td>30</td>
<td>65</td>
</tr>
<tr>
<td>4.</td>
<td>Clay and blue clay (drift)</td>
<td>36</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Rock</td>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>5.</td>
<td>Soil, black</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clay, yellow</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clay, blue &quot;Dirty material streaked yellow, mixed</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>or white&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rock</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clay, hard, yellowish</td>
<td>7</td>
<td>53</td>
</tr>
<tr>
<td>6.</td>
<td>Soil, black, and blue clay</td>
<td>50</td>
<td>1 1/2</td>
</tr>
<tr>
<td></td>
<td>Gravel</td>
<td>51 1/2</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Clay, blue (drift)</td>
<td>63</td>
<td>63</td>
</tr>
</tbody>
</table>

From these records the drift is seen to consist chiefly of clay, with some rock fragments and some gravel. In other places quicksand is also encountered in wells. Most of the drift found in the wells is similar to that seen in the cut 3 miles northeast of Stockton. In all, 13 records of wells which penetrate through the drift to rock were obtained. The average thickness of the drift through which they pass is 49 feet. The well at the cheese factory 2 miles north of Stockton penetrates 90 feet of drift without reaching rock. Frank Leverett\(^1\) reports thicknesses of 140 to 150 feet in the area northeast of Stockton.

It is clear that one of the ice sheets which affected neighboring parts of North America advanced to the border of our region from the east but went little farther. The till (unstratified drift) was deposited by the ice itself, either because it melted and left its burden on the ground, or because the material was dragged out of its bottom during the movement of the ice over the surface. A considerable part of the drift was transported from

places far to the north and northeast of our region, no outcrop of igneous rock being known in the path taken by the ice nearer than northern Wisconsin. The shapes of the bowlders are characteristic of those carried far by ice. When in the bottom of the glacier, they were dragged along its bed, causing their lower sides to be worn smooth. Because they shifted positions in the ice occasionally, other flat planes were also worn. The scratches resulted from the grinding of the bowlders against sharp points of the bed rock or of other fragments in process of transportation, under the great pressure due to the overlying ice. Where deposited from the ice direct, materials of all textural grades were deposited together, as is seen in the road section north of Stockton. The gravel reported in one of the wells was probably deposited by water resulting from the melting of glacier ice at or near its edge. The water could not carry the coarsest bowlders and the fine clay was carried farther and deposited elsewhere, thus leaving the gravel by itself.

**DRIFT NORTH OF ELMOVILLE**

A mile northeast of Elmoville, or 5 miles south and a little west of Stockton, is a small area of glacial drift that presents some peculiar problems. It lies just above the junction of Plum River and Middle Fork of Plum River, and occupies an area of flattish topography about one-fourth to one-half of a square mile in extent (Pl. IV). This drift is entirely isolated from that at Stockton, except that a few bowlders are scattered along the drainage lines between the two areas. The valley heading in the northern area in sec. 13, T. 27 N., R. 4 E. (Stockton), contains drift bowlders as far as its mouth in sec. 35. They are large and numerous near the drift border and become smaller and scarcer toward the south. In the first half mile 6 were seen, in the next mile only 4, and in the next mile only 2. Those in the last mile were cobbles less than 4 inches in diameter. The valley tributary to Plum River from Morseville (sec. 25) also contains some foreign bowlders. Two bowlders were seen in secs. 25 and 36 and one in sec. 35. These are larger than those in the tributary described above, the smallest one being 8 inches in diameter. Except for these few scattered bowlders there is no connection between the drift north of Elmoville and that around Stockton.

The drift at Elmoville consists of bowlders, till, and gravel. The bowlders lie in the bed of Plum River which flows along the east side of this drift area. Ten foreign bowlders were counted in the bed of the stream within a distance of 100 feet. One diabase bowlder measures 3½ by 3½ by 2½ feet above ground.

The west branch of Plum River and the east branch of the Middle Fork of Plum River afford exposures of material with a peculiar structure. On Plum River near the north edge of this area of drift it consists of large, only slightly glaciated, bowlders of Galena dolomite intermingled with a
few very small pebbles of igneous rock. The dolomite fragments reach \(1\frac{1}{2}\) feet in length. Spaces between the bowlders are filled with reddish clay. A little farther south the dolomite blocks are smaller and better rounded, and the till includes chunks of soft Maquoketa shale and some foreign pebbles. On Middle Fork bowlders of foreign cobble appear as shown on Plate XII, A.

Two wells at the southeast corner of this drift area report 40 and 60 feet respectively of "rolling stones" (gravel), some of which are so large as to be difficult for a man to carry. A small amount of gravel is present also in the east-west road crossing the south end of the area.

The glacial material in this locality was deposited by the ice itself, probably at or near its edge. The fragments of shale could not have been carried far, as they would have been ground to powder and mixed with other fine material. The lack of shaping of all the bowlders also suggests that they were not transported from great distances.

**LIMITS OF ICE INVASION**

The exact limits of the ice invasion in these quadrangles is hard to ascertain accurately. The ice reached as far west as Stockton and Elmoville, but the course of the edge of the ice between these two localities is problematical. Drift is continuous and thick over a wide area east of these quadrangles, and ice surely covered the area around Stockton. Perhaps a separate tongue of ice pushed down from the main glacier at Morseville (sec. 25) to the valley of Plum River; or perhaps the edge of the ice sheet extended from Stockton to Elmoville about along the line of the bowlders seen in the beds of the drainage lines as described above. If so, all evidences of glaciation, except bowlders, have been obliterated.

**AGE OF DRIFT**

The age of the drift in the Elizabeth quadrangle is not definitely known. It does not belong to the last or Wisconsin stage of glacialion, as its surface has been much more altered by streams, wind, and other agents than the surface of Wisconsin drift north and east of our area. From the relations of this drift to drift of known age in Wisconsin and Iowa, it is usually considered to be Illinoian, though this is by no means proved.

**VALLEY FILLING**

Whereas much the larger part of the Galena and Elizabeth quadrangles was never covered by ice, some parts of it, other than those actually glaciated, show indirect effects of the ice invasion. These take the form of fluvio-glacial (stream and ice) deposits in Mississippi Valley and fluvio-lacustrine (stream and lake) deposits in tributary valleys.
4. Glacial cobble along Middle Fork of Plum River one mile northeast of Elmoville.

B. Section through the Mississippi terrace at Aiken station.
MISSISSIPPI TERRACE

In many places between the base of the Mississippi bluffs and the river itself, patches of gravel and sand are found. They can be seen best west of Blanding, and in the neighborhood of Aiken 6 miles a little west of north. The sand is a mixture of different kinds of minerals, including quartz, feldspar, mica, limonite, hornblende, pyroxene, and others. There is a good exposure of this sand a few rods west of Aiken station on the north side of the Chicago Great Western tracks (Pl. XII, B). The gravel is composed chiefly of well-rounded pebbles of diabase, granite, and other foreign rocks, though with a slight admixture of dolomite in more angular pieces. Most of the pebbles are less than an inch in diameter, but a few are slightly larger. Besides the sand and gravel, there are also a few large ice-worn boulders scattered over the area. One, 3 feet in diameter, was seen half a mile southwest of Blanding, and several others of like size are reported on farms in the neighborhood.

A typical exposure of these terrace materials is seen three-fourths of a mile south of Blanding in the south-central part of sec. 10, in a stream bank 35 feet high. Practically all the material is coarse sand, but it contains some small pebbles of igneous rock one-half inch and less in diameter. The sand and gravel are cross bedded. Angular fragments of dolomite and cobbles of igneous rocks were seen here to an elevation of 645 feet. The material has been little weathered.

As it stands today, this material does not form a distinct physiographic feature. Its original form has been almost, if not quite, obliterated, the remnants which now exist having a topography shaped by streams and wind. However, where it occurs in low hills, careful observation and the use of the hand level show that the tops of the different patches of the deposit rise approximately to a common level. That is, the deposits today are in the form of a much-dissected terrace. The elevation of the top of the original terrace is in most places not ascertainable. At Blanding it is at least 645 feet above sea level or about 45 feet above high water stage of the river, and it appears to slope downstream slightly, corresponding to the gradient of the stream which deposited it. The thickness of the gravel and sand is not known, but it is at least more than 60 feet, for the Mississippi has not yet cut to the bottom of it, and the materials are found 60 feet above low-water mark. Leverett\(^1\) reports it to be 150 feet in depth, as recorded in wells at Dubuque and Sabula.

When traced upstream beyond the borders of the Galena-Elizabeth district these materials are found connected with glacial deposits of Wisconsin age on the Mississippi at St. Paul and with similar fluvio-glacial deposits in the valley of the Wisconsin at Prairie du Chien. During the Wisconsin glacial stage the ice sheet lay over the headwater regions of the

\(^1\)Idem, p. 565.
Mississippi and its tributaries and discharged its waters into them. The streams formed by these flowed down through the Driftless Area carrying portions of the glacial debris and depositing them in their beds, so as to produce what is known to geologists as a valley train. All the coarser material was dropped before the northern limits of our region were reached, only the sand and finer gravel having been carried farther. The large bowlders in our region were carried under exceptional conditions, probably in blocks of ice which floated down the streams from the edge of the ice to the north.

The partial filling of Mississippi Valley necessarily affected the streams which drained into it from the sides. It caused a ponding of these streams, resulting in the partial filling of the lower ends of their valleys with the local material carried by the streams themselves. These deposits in the tributary valleys are discussed later (see Chapter VIII).

HISTORY OF APPLE RIVER

As shown on the map (Pl. XIII) the upper part of the valley of Apple River has certain marked peculiarities, indicating some unusual event in its history. The field evidence is even more striking and leads to the conclusion that there has been a drainage change of considerable magnitude, and that the ice sheet is responsible for the change.

The lower portion of the valley of Apple River from a point about 12 miles above Elizabeth to its mouth (Pl. XIII, a) has the characteristic of a normal stream-made valley, with an almost uniform gradient, a width and steepness of slope varying with the hardness of rock through which the stream has cut, and with many tributaries of varying sizes and lengths, each of which joins the river with an acute angle upstream. But for 3 or 4 miles southwest of Millville (Pl. XIII a and b) the stream flows in a deep, steep-sided canyon, having almost vertical walls and very few and short tributaries. At Millville the valley divides, the West Fork of Apple River coming in almost at right angles to the canyon from the west, and the South Fork flowing in practically an opposite direction from the drift-covered region north of Stockton. Both of these streams occupy canyon-like valleys except for the headwater region of South Fork. From field data the following conclusions are drawn as to the history of the valley:

1. In their normal development by streams, valleys acquire certain characteristics by which their age can be roughly determined. A young valley usually has a high gradient, steep sides, is narrow, and has few and short tributaries. Later in its development the valley acquires a flat bottom, a low gradient, gentler slopes, and more and larger tributaries. Also, in youth most streams are straight, but they become more crooked as their development progresses. The valley of Apple River below the forks at
Topographic map of the upper part of Apple River where two drainage systems have united.
Millville (Pl. XIII, a and b) is younger than the valleys of West Fork and South Fork since it is strikingly straighter, narrower, steeper sloped, and has a much narrower flat in proportion to the size of the stream occupying it.

2. The valleys of West Fork and South Fork were originally one valley. The evidence is as follows: (a) Both valleys trend northwest-southeast and they join end on end; that is, one is the continuation of the other. (b) The valleys have about the same size and shape, and could easily have been made by the same stream. (c) Taken as a single valley, and neglecting the head of the main canyon at Millville, the valley of the South Fork-West Fork grows gradually smaller to the northwest, as if made by a single stream flowing southeast.

3. South Fork of Apple River has been reversed as determined by the following data: (a) The valley becomes gradually broader to the southeast, whereas the present stream flows in the opposite direction. (b) Several tributaries join the valley with an acute angle to the northwest, as do Clear Creek, Birch Branch, and Wolf Creek on its north side, and those designated by c, d, and e (Pl. XIII) on its south side. This fact suggests strongly that the main stream flowed southeast when the tributaries were developed. It will be noticed from the map that the waters flowing into the head of c make almost a complete circle before getting to a.

4. The valley of West Fork is normal for the valley becomes broader in the direction in which the stream is flowing, the tributaries join the main valley with acute angles upstream, and the valley is entirely proportionate in size to the stream which occupies it.

5. The southeast part of the valley of South Fork has been partially filled as evidenced by the following observations: (a) The flat bottom of the valley is very broad, as if it had been built up against the sloping valley walls. (b) The edge of the flat is broken by sharp projections from the valley walls, as if the bottom had been built up around tributary divides. (c) An abundance of peat and muck is found in the valley of Mud Run, consistent with the damming of its lower end. (d) Wells drilled in the edge of the bottom of the valley of Mud Run show a deep deposit there. (e) Wolf Creek and an isolated valley in the south part of see. 10 have courses other than they would have were they developed under present conditions of rock and slope, which suggests that the streams started on a flat surface and were let down on the present surface by cutting into the flat.

6. A pre-glacial valley filled with glacial drift is disclosed by records of wells drilled in the drift-covered area east of the present head of South Fork. Leverett\(^1\) reports a pre-glacial valley filled with drift running in an east-west direction between Stockton and Nora and lists the records of

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\(^1\)Idem, p. 566.
thirteen wells in it, showing an average depth of 95 feet, without reaching bed rock. A table of well records taken by the writers from north to south (Pl. XIII, between f and g) along and just east of the border of the Elizabeth quadrangle, is given below. In the taking of these records, the elevations of the well sites were obtained with the hand level, the depths to rock obtained from the records, and the elevations of the rock surface determined by subtracting the latter from the former.

Well records showing drift-filled valleys north of Stockton

<table>
<thead>
<tr>
<th>No.</th>
<th>Elevation of well site (Feet)</th>
<th>Depth to rock (Feet)</th>
<th>Elevation of rock surface (Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>940</td>
<td>35</td>
<td>905</td>
</tr>
<tr>
<td>2</td>
<td>970</td>
<td>29</td>
<td>950</td>
</tr>
<tr>
<td>3</td>
<td>971</td>
<td>24</td>
<td>881−</td>
</tr>
<tr>
<td>4</td>
<td>969</td>
<td>28</td>
<td>947</td>
</tr>
<tr>
<td>5</td>
<td>930</td>
<td>30</td>
<td>911</td>
</tr>
<tr>
<td>6</td>
<td>973</td>
<td>23</td>
<td>950</td>
</tr>
<tr>
<td>7</td>
<td>960</td>
<td>60</td>
<td>900</td>
</tr>
<tr>
<td>8</td>
<td>978</td>
<td>36</td>
<td>942</td>
</tr>
<tr>
<td>9</td>
<td>974</td>
<td>40</td>
<td>934</td>
</tr>
<tr>
<td>10</td>
<td>985</td>
<td>20+</td>
<td>965−</td>
</tr>
<tr>
<td>11</td>
<td>997</td>
<td>60</td>
<td>937</td>
</tr>
<tr>
<td>12</td>
<td>996</td>
<td>60</td>
<td>936</td>
</tr>
<tr>
<td>13</td>
<td>865</td>
<td>60</td>
<td>805</td>
</tr>
<tr>
<td>14</td>
<td>960</td>
<td>74</td>
<td>886</td>
</tr>
<tr>
<td>15</td>
<td>940 (?)</td>
<td>60</td>
<td>880 (?)</td>
</tr>
<tr>
<td>16</td>
<td>945</td>
<td>62</td>
<td>883</td>
</tr>
<tr>
<td>17</td>
<td>920 (?)</td>
<td>97</td>
<td>823 (?)</td>
</tr>
</tbody>
</table>

Of these records, Nos. 3, 14, and 18 show places on the rock surface distinctly lower than places on either side, suggesting that there were several east-west valleys here before glacial times. From the records at hand, the precise place of exit of West Fork-South Fork Valley from the quadrangle is not clear. Perhaps one of the valleys recorded by the wells is the buried continuation of the present valley, and the others are buried tributaries to that valley. Possibly also West Fork-South Fork Valley, with its tributaries, was tributary before glacial times to the larger valley between Stockton and Nora, reported by Leverett.

From the above facts the history of this drainage system can be deciphered. Before the advance of the glacier there were two drainage systems: (1) Apple River, including Mill Creek, Holts Branch, Coon Creek, and the present Apple River as far northeast as about sec. 18, T. 28 N., R. 4 E. (Rush) (Pl. XIII, a); and (2) the valley now occupied by West Fork and South Fork with several small tributaries. The southern system was the larger, and the water flowed southwest as it does today. The northern system drained southeast, leaving the quadrangles somewhere north of Stockton. Between the two systems a divide lay where the main canyon is now located (Pl. XIII, a to b). Into this divide a tributary stream from
each side had probably worked its head, making a gap at the site of the present gorge.

The ice sheet advanced and covered the lower portion of the northern system to a point north of Stockton. At first the ice formed a dam for the waters of the stream flowing to the southeast. The river water proper and the water furnished by the melting of the ice gave rise to a lake in the valley west of the ice margin. Later the deposits from the ice filled the old valley northeast of Stockton and remained as a dam after the ice sheet had melted from the region. In this lake the fill described above was deposited. The waters of the lake rose to the lowest point in the valley wall, which was located at the divide between the two systems or about at h on Plate XIII. The precise altitude of the lowest point is not known, but it was probably well above the floor of the present valleys. The waters from the lake in the northern valley discharged across this divide into the system flowing southwest to the Mississippi, and in so doing cut the gorge (Pl. XIII, a to b). The lake was drained when the bottom of the canyon had been cut lower than the bottom of the lake.

Thus the main canyon is younger than the valley above it, West Fork Valley is normal, and South Fork has been reversed. The field evidence of the existence of a lake in the northern system is not perfectly conclusive, but it must have followed from the damming of the stream by the ice to the southeast.

Summary

In conclusion it may be said that an ice sheet which was either the Kansan or Nebraskan entered the Galena quadrangle from the west and reached a point as far east as Hanover. Then a glacier which was probably the Illinoian advanced from the northeast to the extreme east edge of the Elizabeth quadrangle where it deposited there a mixture of foreign and local material and filled the valley of a stream flowing southeast, so as to turn its waters southwestward into the valley of Apple River. Later the Wisconsin ice sheet furnished water which flowed down Mississippi Valley through the region, depositing sand and gravel, and ponding back its tributaries. Other great continental glaciers had little effect on northwestern Illinois.
CHAPTER VI.—EFFECTS OF WIND IN GALENA AND ELIZABETH QUADRANGLES

To one who remembers how hard it is to walk against a strong wind or how far his hat can be carried by the wind, it is clear that the wind sometimes has sufficient force to carry particles of dust and grains of sand, and in exceptional cases even small pebbles. Most readers of this report have seen snow piled into drifts by the wind and may have seen sand dunes being made. In any region where finely divided material appears at the surface the wind would be expected to perform certain tasks in transporting and depositing it. Evidences of such work of the wind are seen in the region under consideration.

LOESS

DISTRIBUTION

Scattered in numerous but more or less isolated areas in the western and southern parts of the region and more sparsely in the eastern part, is a light, yellowish, loamy or clay-like substance known as loess. On the edge of the upland near the Mississippi bluffs it is almost continuous, and it can be seen there almost anywhere, particularly in gullies and where animals have burrowed into the earth. At Galena Junction the loess is piled into hills 15 or 20 feet high. Elsewhere along the bluff, as at a point a mile north of Galena Junction, Indian mounds have been built of the loess. Back from the bluffs it is seen only in isolated patches on the tops of hills, and in areas extending part or all the way down the valley slopes. Patches of typical loess were seen 2 miles east of Galena, three-fourths of a mile east of Winston on the Chicago Great Western Railroad tracks, on the upland northeast of the tunnel of the same railroad, on the ridge in sec. 22, T. 27 N., R. 1 E. (Rice), on the hills in the vicinity of Hanover, in the valley bottom 2 miles west of Galena, and in many other places. Clearly it was deposited after the surface of the region had acquired almost its present form.

LITHOLOGIC CHARACTER

The color of the loess is generally yellowish or buff. In texture it is midway between clay and sand. When wet it molds readily in the fingers like clay, but it is easily crushed to fine powder when dry; still it is loosely packed and porous. On the railroad tracks east of Winston and in sec. 36,
T. 28 N., R. 1 E. (East Galena) it has stood for several years in a vertical bank, a common characteristic of the loess of this and other regions. Its material is commonly indistinctly laminated at the base, and less commonly above. Plate XIV, A and B, shows two typical exposures. Roots growing into the loess cause the precipitation of iron around them, resulting in red, irregularly cylindrical bodies, known as pipe stems (Pl. XV). Small nodules of calcium carbonate are also abundant. Small shells of snails, similar to those living on the lands of the region today, are found rather abundantly in most exposures.

THICKNESS

The loess is thickest along the Mississippi River bluffs, and from there it thins out toward the east. At Galena Junction 42 feet of loess appear above the highest outcrop of rock, but it may not be 42 feet thick, for it may be only a mantle over a rock core of the hill. However, the loess probably attains a thickness of 30 or 40 feet along the bluff. Two miles east of Galena there are at least 10 feet of it; east of Winston 12 feet are exposed; in sec. 22, T. 27 N., R. 1 E. (Rice) it is at least 20 feet thick; and at Hanover, exposures from 8 to 10 feet in thickness were seen. The loess is recognizable in other places and doubtless exists still more generally, but in amounts too small to be recognized.

ORIGIN

Microscopic examination shows that the loess consists of a variety of minerals, such as occur in glacial drift. It is found most abundantly in and about glaciated areas and on the lee-sides of rivers which have carried and deposited glacial silts ("rock flour"). From these facts it is concluded that the glaciers were the first agents in the transportation and deposition of the material which later became loess. After the silt of the glacial waters had been deposited by Mississippi River and had become dry at times of low water, it was picked up by the wind and carried as dust to the surrounding bluffs and uplands, chiefly to the east, since the prevailing winds are from the west. Much of it was deposited on the upland at the edge of the bluff, because (1) the velocity of the wind was checked there, and (2) it was caught and held by vegetation which grew abundantly at that place. Some of the dust was carried on and deposited far beyond the valley, much as snow is carried and drifted by the wind. Probably some of the loess was blown from the surface of the glacial drift direct, and lodged on the Mississippi bluffs because abundant vegetation grew there which checked the velocity of the wind and caused deposition of the dust. How much of the loess material came from the mud flats of the river and how much from greater distances is not known.

Precisely which of the ice sheets is responsible for the loess is not
A. Loess overlying stratified terrace materials on Apple River at North Hanover.

B. Typical loess near Galena Junction.
PLATE XV

Fossils and concretions from loess and terrace material
(All illustrations natural size)

Figures 1 to 6. Fossils from the terrace deposit on Sinsinawa Creek. They are shells of land snails, though deposited in water.
   1 and 6. Pyramidula shimekii.
   2 to 5. Succinia avara.

Figures 7 to 10. Pipe stems from the terrace material east of Galena. The materials have been deposited around rootlets.

Figures 11 to 14. Nodules of calcium carbonate from the terrace material east of Galena.

Figure 14. A section of a pipe stem from the loess near Hanover, showing the hole where the rootlet was and the concentric arrangement of the material.
clear. Much loess in Iowa, associated with the so-called Iowan drift, is supposed to be correlated in time with the retreat of the Iowan ice sheet, and much of the loess of the upper Mississippi Valley has been considered by many geologists to be of that age. So far as our region is concerned, the deposition of the loess may have accompanied or followed the Iowan, Illinoian, or even perhaps the Kansan ice epochs, or a part of it may have been deposited during or after each one.

Finely divided and loosely packed as it is, loess makes excellent soil. Its varied composition allows the growth of many sorts of plants. Its porosity insures good drainage. Where it has been added to the mantle rock or where it forms the whole covering over the solid rock on the high parts of this region, the value of those parts as agricultural districts is considerably increased. Even where it has not accumulated in sufficient quantities to be recognized as loess, wind-blown dust doubtless forms a considerable part of much of the soil.

**SAND**

Wind-blown sand of two ages at least is found along the east side of Mississippi Valley.

**OLDER SAND**

On the slopes of the bluffs, and extending nearly or quite to their tops, there are dunes of sand in well-rounded forms. Between the dunes are undrained depressions covered with sod and forests where not under cultivation. Many of them hold pools of water in their lower parts. Locally, as west of Hanover, this sand extends to the tops of the bluffs, and is intimately associated with the loess. The sand in its characteristic topographic forms can be seen (1) west and southwest of Rice, (2) in an area immediately north of Blanding, and especially 1½ miles northwest of Blanding, and (3) along the slopes of Mississippi Valley where it chokes the mouths of the tributary valleys from the Edgerton School to the south edge of the quadrangle west of Hanover.

On the slopes of the bluffs the sand forms hills, between which are undrained depressions, whereas on the uplands it is scattered more or less uniformly and is closely associated with the loess. The dunes take the form of mounds, hills, and short ridges 20 to 30 feet high. One and a half miles northwest of Blanding five distinct hillocks occur within a radius of 200 feet, and within this area there are also two undrained depressions, one of which contains water even in dry seasons (Pl. XVI, A). The hills stand 30 feet above the water in the depressions.

The dune sand is exposed only in a few shallow artificial cuts, in a few wind-scoured depressions called "blow holes," and in the dumps at the mouths of animal burrows. At these places it is a white, coarse, feldspathic sand, but locally it includes material finer than sand. Water would not
A. Topography in the area of old dunes northwest of Blanding.

B. Recent dunes three and one-half miles west of Hanover.
stand in the depressions continuously if all the underlying material were loose sand.

On the bluffs east of Blanding, the sand grades horizontally into loess, and all proportions of dust and sand can be found. The dunes are made up of mixtures of fine sand and dust blown from the river bottom, probably at the time the loess was deposited. Much of the dust was carried to the top of the bluff and scattered in decreasing amount for miles to the east. Being heavier, much of the sand lodged before reaching the top of the bluff, though some was mixed with the loess deposits just at the edge of the uplands. The sand is doubtless of the same age as the loess with which it is associated. If the loess be considered to be of Iowan age, the sand is also Iowan. Without doubt, both are older than the Wisconsin drift, for dunes the sand of which came from the Wisconsin drift have a much younger appearance than the dunes under consideration. The older sand and the loess were deposited during some one or more of the earlier glacial or interglacial epochs.

YOUNGER SAND

On the Mississippi terrace, south of the Edgerton School and south of Blanding, there are dune areas in which the sand is shifting today, and where the land is waste, being covered only by sparse grasses, cottonwoods, willows, a few scrub oaks, and cactuses. Bare sand is seen along roads and in "blow holes".

This material with its characteristic topography is well exposed in the northwest part of sec. 14 and the southwest part of sec. 11, T. 26 N., R. 2 E. (Hanover). Here the relief averages 40 feet, the land is almost waste and uninhabited, crops are few and nearly worthless, and the roads follow indefinite and changing courses over the sand. (Pl. XVI, B).

The material of these dunes is purely glacial sand without admixture of dust. Most of it is coarse, and is composed of a mixture of grains of many minerals, chief among which are quartz, feldspar, mica, hornblende, pyroxene, and magnetite. The magnetite being heavy is separated on the surface of the shifting sand into black patches and streaks.

The source of the sand is made clear by its relations to the sand and gravel of the glacial terrace of Mississippi Valley. The dunes are restricted to the area once occupied by the terrace and are located among its remnants. Occasionally patches of gravel are found in the lower places among the dunes, where the sand of the terrace has been removed by the wind and has left the coarse material behind. This gravel is nowhere found above 645 feet, which was approximately the altitude of the top of the original terrace. It is clear that the dune sands have been worked out from the glacial deposits by wind; in fact, the process is still going on, as can be observed on any dry, windy day.

In the dune areas there is a constant struggle between wind and
vegetation, a struggle in which man sometimes interferes. At first only rapidly growing plants, such as cottonwoods and willows, can get a start. But in the shade of these trees pines can grow. The pines in turn deposit needles which in decaying make humus; then oaks can grow, and a permanent forest is established. This is the usual plant succession, provided the wind does not shift the soil too rapidly, and provided time enough is allowed. In some places in the region the succession is complete, in others it is hardly started, in still others it has been complete once, but man has chopped down the trees and cultivated the surface and allowed the wind to begin shifting the sand again. A few dry years may so stunt the trees and destroy the grass that the wind may start the sand again, or a series of wet seasons may cause increased growth of vegetation, which may protect the sand and prevent its being blown away until the wind gets another start after dry seasons, or until the trees are removed by man. Once formed and covered with soil, a sand dune is peculiarly protected from wash and gullying by its porosity, as the water sinks into the loose sand instead of running off over its surface.

**Conclusion**

The wind has in times past played an important part, and is still playing a part, though a minor one, in the development of the physiographic features of the Galena and Elizabeth quadrangles. Before the Wisconsin glacial epoch, it removed sand and dust from the river bottoms, and obtained dust from dry, glacial surfaces farther away, and deposited them on the side slopes of Mississippi Valley, on the edge of the upland, and generally over the country back of the edge. Beginning again in the Wisconsin glacial epoch and continuing to the present time, it has sorted over the gravel and sand of the Mississippi terrace and piled the sand into dunes, thus decreasing the value of the land for agricultural purposes.
CHAPTER VII—WORK OF GROUND WATER IN GALENA AND ELIZABETH QUADRANGLES

Principles of Ground Water

The average yearly rainfall for Illinois is 35 inches. Of this about half evaporates almost immediately, about one-fourth to one-third runs off the surface in streams, and the rest sinks into the soil and the rock beneath the soil. The last is known as ground water. From the facts (1) that many thousands of gallons of water are pumped daily from the wells in the Galena and Elizabeth quadrangles without the wells going dry; (2) that virtually all wells bored deep beneath the surface find water; (3) that springs issue from beneath the surface and flow continuously; (4) that all the soil contains water notwithstanding daily loss by evaporation; and (5) that plants are constantly taking up water through their roots and giving it forth to the air by evaporation from their leaves, it is known that there is ground water beneath the surface of this region, as beneath the surface of all lands.

The amount of ground water in a region depends upon the amount of precipitation and upon other conditions such as (1) the steepness of surface slopes, (2) the porosity of the rock underlying the surface, (3) the rate of precipitation, (4) the amount and kind of vegetation, and (5) the temperature of the air and of the water as it falls. In general, the gentler the slopes, the greater the porosity of the rock, the slower and more evenly distributed the rainfall, the more abundant the vegetation, and the lower the temperature, the more ground water there will be. However, the absorbing effect of abundant vegetation may be neutralized by the large amount of water evaporated from the leaves of the plants, and the effect of low temperature in decreasing evaporation may be overbalanced by freezing so that the precipitation takes the form of snow and the frozen ground prevents the downward percolation of surface waters. Even if a given region received no precipitation, it would acquire ground water by underground seepage from regions where water does fall.

In the Galena-Elizabeth district the precipitation is medium (about 35 inches), the slopes are steep though there is also much flat land, the dolomite formations at least are fairly porous, precipitation is somewhat evenly distributed throughout the year, the temperature is moderate, and vegetation is abundant and flourishing; hence a fair amount of ground water would be expected here. Wells and springs show that this expectation is realized.
At varying depths below the surface of this region, as below the surface of all lands, there is a plane below which the pores and cracks of the rock are entirely filled with water—the rock is saturated. This is shown by the fact that water stands in wells, or flows in as fast as it is pumped out, so that the wells never go dry. It should not be understood, however, that all standing water in wells gives the real position of the water surface, for water may stand in wells, ponds, and streams far above the real water surface, if the rock immediately below is impervious. The plane below which the rock is saturated with water is known as the ground-water surface or water level or the water table. The ground-water surface is not level nor quite parallel to the surface of the land, and hence the terms "level" or "table" are misleading. The relations between the water surface and the surface of the land above are shown in figures 19 and 23. This surface rises and falls slightly with the seasons, standing lowest in the dry seasons.

![Diagram](image)

**Fig. 19.** Diagrammatic illustration of the relation of the ground-water surface to the surface of the land. The water surface stands higher under the hills than under the valleys, but is farther beneath the surface under the hills than under the valleys.

**Solution by Ground Water**

**Crevices and Caves**

Crevices in the Galena dolomite have been briefly described in the discussion of that formation in Chapter IV. Similar features are found in the Niagaran beds, and to a less extent in the hard upper portions of the Maquoketa formation. In the region as a whole they are very numerous. They are seen commonly in the walls of valleys or on other steep slopes. Soil filtering into them causes small, elongated depressions on the upland surface. They are commonly discovered during mining operations, and well drillers sometimes lose their tools in them.

No sharp line can be drawn between crevices and caves, the caves of the region being simply enlarged crevices. The crevices are more or less irregular in shape, but have a general fissure form, their sides being verti-
mechanically. Such dioxide in three can be until in and receive to contain the waste from fairly large mining operations. Although crevices trend in almost all directions, they are most numerous in three general directions—north-south, northwest-southeast, and northeast-southwest. Many contain ore bodies.

Ground water is at least partly responsible for the smaller crevices, and it has been the chief agent in making caves from crevices. The rocks of the region are jointed; ground water seeps into the joint cracks, trickles down along these channels, and enlarges them by solution. Nearly all rocks are at least slightly soluble in water, and limestone and dolomite are more soluble than most other rocks, especially in water which is charged with carbon dioxide. The ground water in this region has more or less carbon dioxide in solution, and it gradually dissolves the rocks on the sides of the cracks along which it passes and thus widens them. Some parts of their walls are more easily dissolved than others; therefore solution takes place irregularly, and makes chambered caves. The material dissolved is carried elsewhere by the ground water and deposited as calcite which lines cavities, or remains in solution and is carried to the surface in springs, and finally to the sea in streams. As the cracks are continuously but imperceptibly enlarged by solution more and more water is drawn into them, until in some cases its velocity and volume become sufficient to carry along solid particles of rock which act as tools to wear the sides of the crack mechanically. Such mechanical wear, however, has undoubtedly been slight.

The most interesting cave of the region is known as Ice Cave. It is located in the wall of the valley of Galena River, on the west side of the Chicago and North Western Railway, three miles northeast of Galena, in the east-central part of sec. 3, T. 28 N., R. 1 E. (East Galena). All that can be seen from the outside is a small entrance to an east-west crevice, now choked by fallen stones and other debris, so that one can crawl into it only a few feet. It is rendered interesting by the fact that in August a cold wind blows out of the opening with sufficient force to carry leaves to a distance of two feet. The temperature of the issuing air is said to be 39° Fahrenheit. The wind is reported to blow outward throughout the summer, but to blow inward in the winter time. The changing wind may perhaps be explained as follows: There are doubtless other openings in the roof of the cave back on the uplands, which form entrances and exits for air and which may admit into the cave snow and ice during the winter. This may remain unmelted during the summer and keep the air in the cave cold. The temperature in the cave probably remains almost constant while outside temperatures rise and fall with the seasons. During the summer the air outside the cave is warmer than the air inside, is therefore lighter, and conse-
quently is displaced by the heavier cold air which issues from the cave. This lessens the pressure inside the cave slightly and air is drawn through the opening from above forming a complete circulation. During the winter, on the other hand, the air outside is colder and therefore denser than that inside, and a reverse circulation is started into the cave through the lower opening, and out through the passages in the roof.

This is probably the largest cave in the region, and it represents a large amount of work by ground water.

**SINK HOLES**

Shallow depressions undrained surficially are found in several places in the region. None was seen on the Galena dolomite or Maquoketa shale but all are located on the top of the Niagaran surface, most of them being in places difficult of access. They may be seen (1) on the upland about Blanding, (2) in the central part of sec. 22, T. 27 N., R. 1 E. (Rice), and (3) on top of the hill 1½ miles southeast of Woodbine. Probably there are small sinks at many other places where the Niagaran dolomite comes near to the surface.

The shape and size of the sinks vary within small limits. The many sinks along the divide in the central part of sec. 22, T. 27 N., R. 1 E. (Rice), are of two types: one consisting of elongate depressions joined end to end and trending in a northwest-southeast direction; and the other composed of almost circular but slightly elongate depressions, trending also northwest-southeast. The circular depressions average 100 feet in diameter and about 20 feet in depth. One is 25 feet deep and 50 feet across the top. Two miles south of Blanding on the ridge, at the junction of a north-south secondary road with the east-west main road, there is a symmetrical depression 50 feet in diameter and 7 feet deep. To the northwest is a second sink 75 feet in diameter and 12 to 15 feet deep. This one is slightly elongate. Still farther west is a canoe-shaped sink.

These depressions are due primarily to solution by water. The Niagaran dolomite is the most soluble formation found at the surface in the region, and hence furnishes the best conditions for sink holes. The elongate depressions are doubtless over joints and crevices widened by the solvent action of water. Into these the mantle rock gradually settles, forming the depressions at the surfaces. That a definite relation exists between the sinks and the crevices is indicated by the fact that the elongate sink holes extend in three general directions parallel with the usual directions of the crevices. Some of the more circular depressions may be formed by the caving in of underground caverns. Some parts of the dolomites are more easily dissolved than other parts, and eaves develop, which are not open at the surfaces until solution renders the roof too thin to support its own weight. When it sinks, the result at the surface is a small depression into
which flows surface water carrying clay and dissolved materials from the surface.

ORE DEPOSITION

No discussion of the work of ground water would be complete without at least mention of its relation to the ores of the region. However, as this will be discussed again in connection with the chapter on economic geology, only a brief statement concerning it will be made here.

Lead and zine ores occur chiefly in the Galena dolomite, mainly as lead sulphide (galena) and zine sulphide (sphalerite). In general the galena occurs in caves and crevices in the upper part of the formation, and more sparingly in the "flats and pitches" in its lower part. The sphalerite is confined almost entirely to this lower part of the formation, where it is associated with galena. With all the ores crystallized calcium carbonate (calcite) is abundant.

It is thought that compounds of lead and zine were distributed in very small quantities throughout the original rock formations. Ground water percolating slowly through the rock, and aided by certain chemical agents, dissolved them, flowed into the crevices and caves and pores, and deposited the ores in their present form. Deposition is favored by conditions opposite to those which aid solution previously discussed.

SPRINGS

DISTRIBUTION AND OCCURRENCE

A spring may be defined as ground water issuing at the surface in volume sufficient to cause it to flow through an opening not made by man. An immense number of springs and a very large number of seeps (water seeping from beneath the surface without appreciable flow) are found in these quadrangles. Their location may be described geographically, topographically, and stratigraphically.

They occur in greatest numbers in the southern half of the region, and much less commonly in its northern half. Those in the south are numbered by thousands, whereas those in the northern half of the region would probably not exceed one hundred.

Topographically, there is a distinct relation between valleys and springs. Practically all the springs are in valleys, the water issuing either in their bottoms or on their slopes.

The springs of the region are clearly related in their origin to certain rock formations. Probably 90 per cent of them issue from the base of the Niagaran dolomite just above the Maquoketa shale. Most of the others are in the Galena dolomite, chiefly near its base. No springs issue from the Maquoketa shale, except at or near its top. Springs are more numerous in the south half of the region because the Niagaran-Maquoketa contact comes to
the surface more generally there, and has a larger gathering ground (the Niagaran upland flat) over it than in the northern part.

**SPRINGS AT TOP OF MAQUOKETA**

In the southern part of both the quadrangles here discussed there are thousands of springs at the horizon of the Maquoketa-Niagaran contact. Most of them issue just at the contact or a few feet below the contact, but some issue from the Niagaran a few feet above the contact. Springs and farm houses are found so commonly at this stratigraphic horizon that they may be used in the field to locate the boundary between the two formations.

The explanation of springs at this horizon is as follows. The Niagaran formation outcrops on the flat upland surface, where conditions of slope and vegetation are such as to cause a relatively large amount of rain water to sink into underground channels through numerous sink holes, crevices, and caverns. The water is conducted down through the Niagaran formation with comparative ease, but the underlying Maquoketa shale is commonly neither jointed, porous, nor soluble. The descending water is, therefore, arrested at the top of the shale. It then moves most readily in the direction in which the shale slopes and issues through seeps or through rather definite channels on the surface of the shale where the dolomite is most porous, and into valleys which have been cut through the contact. The conditions giving rise to these springs are shown in figure 20.

![Diagrammatic illustration of the conditions giving rise to springs at the top of the Maquoketa shale.](image)

The abundance and occurrence of the springs and their relations to rock structure may be brought out more clearly by a detailed study of one valley such as that of the short tributary to Frish Hollow in secs. 1 and 12, T. 27 N., R. 1 E. (Rice). This stream heads in the east-central part of sec. 1, and flows southwest and south a mile and a half to the west-central part of sec. 12. A diagrammatic sketch of the conditions here is shown in figure 21. The valley contains no flowing water from its head down to a point where the valley bottom reaches the surface of the Maquoketa shale at an altitude of 860 feet above the sea. Here, however, a very cold spring of exceptionally large flow is the source of the stream. On the southeast side of the valley at the same level is another spring. In the next three-fourths mile down stream there are at least 23 other springs. Two of the three
houses on the west side of the valley are located at spots where five springs issue; elsewhere the springs are about equally abundant on each side. Below the easternmost of the two lower houses, a sticky yellowish clay appears in the valley bottoms below the springs. Here the springs are at altitudes of 780 to 800 feet. At the southernmost house one-fourth mile south of the bridge, are five springs 832 feet above sea, the base of the massive Niagaran member being at 929 feet. The horizon of the springs slopes down stream less than the gradient of the stream. The first two springs at the north end of the series are only 5 to 10 feet above the stream level; the southernmost ones are 37 feet above the stream. The northern ones are about 860 feet above sea level; the southern ones are at an elevation of about 832 feet. At the southern house, the springs are 57 feet below the base of the massive part of the Niagaran.

![Diagram](image)

**Fig. 21.** Diagrammatic illustration of the relation of springs to structure and topography in the valley in secs. 1 and 12, T. 27 N., R. 1 E. (Rice).

This valley trends almost exactly with the greatest dip of the beds; hence there is as great a tendency for water to come in from one side of the valley as from the other, and the springs are equal in number on each side. It is possible also that the present valley follows the course of a valley on the erosion surface formed on the Maquoketa before the deposition of the Niagaran, and the slope of the Maquoketa surface is toward the valley from both sides.

Although many of the streams generated by these springs have considerable volume where they flow across the Maquoketa formation, some of them disappear down valley, where they reach the surface of the Galena dolomite. Thus we may have a valley without a stream at its very head, but with a stream of considerable volume of water a little lower down, and without a stream still farther down. It may then acquire a stream again below where the valley bottom reaches the permanent ground-water surface. These conditions are made clear in figure 22. They prevail in the valley in the west part of sec. 7, T. 27 N., R. 2 E. (Elizabeth), where James Powers has 18 springs on his farm, and the owner next south has several more. All
these springs issue from the upper part of the Maquoketa. Below the top of the Galena in the valley there are no more springs. The stream formed by the outflow of the springs in the Maquoketa decreases greatly in volume when it reaches the Galena, and Mr. Powers reports that it usually dries up in the summer.

SPRINGS IN GALENA-DOLomite

From the Galena dolomite springs are much less common than from the top of the Maquoketa, and the principles which govern them are not so well understood. They are of two types.

On Sinsinawa Creek and Galena River in the northern part of the quadrangles a few springs issue from the lower part of the dolomite, evidently from the top of the relatively impervious oil-rock member and shale bed at the base of the formation (Chap. IV). On Sinsinawa Creek between the ford and the bridge in sec. 4, T. 28 N., R. 1 W., the lower thin-bedded member of the Galena dolomite outcrops, and the oil-rock and shale member must lie very close beneath the bed of the stream. The spring at the ford is doubtless due to this condition. A very similar condition holds at the spring near Ice Cave on Galena River above the Furnace School where the oil-rock and shale actually outcrop. If the other streams of the region had cut their valleys below the oil-rock and shale so generally as they have beneath the top of the Maquoketa, springs would probably have been formed in almost as great abundance along these beds at the base of the Galena as at the top of the Maquoketa.

Several large springs issue at various horizons within the Galena dolomite; as for instance, those in the south-central part of sec. 18, T. 28 N., R. 4 E. (Rush), Elizabeth quadrangle, and one southwest of the Glenn Hollow School in sec. 35, T. 28 N., R. 1 E. (East Galena), Galena quadrangle. The exact conditions which have given rise to these springs are not so clear. Probably most of them flow from crevices in the dolomite, that have been cut across by the surface streams in making their valleys.
The flow of such springs is exceptionally great, showing that large underground channels have been tapped.

**EFFECT OF SPRINGS ON MAN**

In all the southern part of the region, the springs have had a direct influence in shaping the activities of the people. A great many of the farm houses are located where the strongest springs issue; hence down the valley as the stream cuts lower and lower below the top of the Maquoketa shale, the houses stand farther and farther above the stream. Windmills are strikingly lacking in this part of the region, for water runs from the hillsides directly into watering troughs, dairy houses, and residences. This water constantly running cold and clear favors dairying as an industry among the farmers.

**EFFECT OF GROUND WATER ON STREAMS**

The close relation between streams and springs in the southern part of the district is evident. Starting at the mouth of a creek when there has been no rain for weeks, one may follow it up and find the stream becoming narrower and shallower, and the volume decreasing abruptly as the mouth of each tributary is passed. Each tributary is also seen to decrease gradually in volume toward its head which is a series of stagnant pools or, more commonly, a series of springs or seeps. From this it is perfectly evident that in the dry season at least the streams are fed entirely by ground water, and but for this supply they would be dry except after rains or during the melting of snow.

Figure 19 makes it clear that any valley cut below the ground-water surface will receive water continuously, just as a well whose bottom is below that surface cannot be pumped dry. A valley whose bottom is above the surface of ground water will contain a stream only after rains, or while snow is melting in the heads and on the sides of the valley. A stream may be below the water surface in wet seasons, and above it in the dry seasons; it will then flow in the wet season and be dry in the dry season. Such a stream is said to be *intermittent*. Hundreds of the smaller tributary streams of the quadrangles under discussion are intermittent. Many others, such as Sinsinawa Creek, Galena River, Smallpox Creek, Rush Creek, and their larger tributaries flow all the year, because their beds are below the water surface even in dry seasons.

**WELLS**

The chief source of water for domestic consumption in the region is the ground water. Though no detailed estimates have been made, it is safe to say that tens of thousands of gallons of water are pumped from the wells of the region every day. The wells are uniformly distributed, averaging
about one to every farm house. Each important town has its own deep well in which the water rises by its own pressure toward the surface of the ground, though none of the public wells flow.

Obviously the depth of permanent wells is that necessary to reach the permanent ground water surface (fig. 23), unless its bottom is on an impervious stratum of rock. In valley bottoms few of the wells are more than 25 feet deep, whereas on the upland in the rougher parts of the region, depths of several hundred feet are recorded. The reason for this is made clear by figure 19. So far as records are at hand, depths of individual wells range from 4 to 436 feet, the average of 31 wells being 129 feet.

Practically all the wells of the region are permanent. In most of the wells water stands higher in the wet season than in the dry season, and occasionally one runs dry in the dry season. The principles involved here are illustrated in figure 23. Well $x$ will contain water in the wet season but go dry in the dry season. Wells $y$ and $z$ will contain standing water all the year, in the dry season at $g$ and $h$, and in wet season at $e$ and $f$ respectively. It is thus made clear why it is unsafe to drill a well in the spring or early summer, when the ground water surface stands high. If the drilling is done in August or September when the ground water surface is at its lowest, a well which reaches a sufficient supply then will contain abundant water during all the rest of the year.

Only one flowing well was seen in the whole region. This is at the abandoned Furnace Lead Mill three miles northeast of Galena. It taps an underground body of water having sufficient "head" to bring it to the surface. The conditions giving rise to this well were not investigated in the field, and the source of the water, the origin of the pressure, and other conditions are not known. The principles involved in such wells are well understood, and may be obtained by reference to any good text book on geology or physiography.
In the district north of Galena, several wells have gone dry probably because of vigorous and long-continued pumping in nearby mines, the quantity of water pumped out having been sufficient to lower the water surface below the bottoms of the wells. Some such cases reported in 1910, however, were undoubtedly due to the extreme drought of that summer and illustrate the principle that it is desirable to drill in the driest part of the driest season available.

The economic importance of ground water can scarcely be overestimated.
CHAPTER VIII—WORK OF STREAMS IN GALENA AND ELIZABETH QUADRANGLES

Principles of Stream Erosion

Power of Water

About 35 inches of rain falls on the surface of these quadrangles each
year. Some of this sinks into the ground and some of it evaporates directly, but a large part of it runs off the surface in streams. Much of that which sinks into the ground comes back to the surface in springs, and flows off with the streams. It is safe to estimate that 10 to 15 inches either flows from the surface direct or gets into the streams through springs. The area of the two quadrangles is 576 square miles or about 16 billion square feet. If we consider that 1 foot of water flows from this surface each year, there are 16 billion cubic feet of surface water working here. A cubic foot of water weighs approximately 62$\frac{1}{2}$ pounds. The running water in the region then weighs approximately a trillion pounds. As was stated in Chapter II, the average elevation of the region is about 900 feet and Mississippi River leaves the area at an elevation of about 580 feet. This trillion pounds of water, therefore, falls on the average 320 feet within the region. Any body falling develops force and does work, the amount of force depending on its mass and the distance it falls, rather than on the rate of fall or the path taken; that is, it makes no difference, so far as the power developed is concerned, whether it falls direct or on an incline. A foot-pound is the power expended when one pound of matter falls one foot. A horse power is developed by the fall of 550 pounds through 1 foot in one second. Knowing the mass of water flowing, and the distance it falls, one may estimate the amount of power developed by it in the region as equivalent to about 18,000 horse power. The streams, therefore, would be expected to perform tasks of considerable magnitude, provided sufficient time is allowed them to work.

The amount of work actually done by a machine is not always proportional to the amount of power it uses, but it depends largely on the efficiency of the machine. Much or little of the power may be wasted. The greater part of the work of streams is to transport material from higher to lower elevations. A stream reaches its highest efficiency when it carries every grain of sand or particle of mud possible for it to carry under the conditions under which it works. It remains to be seen whether the streams of this region constitute an efficient or an inefficient machine. In order to determine this point some of the principles of stream erosion must be considered.
ELEMENTS OF EROSION

WEATHERING

Before material can be transported by streams it must be in the form of loose particles,—the smaller, the more easily transported. The processes by which it is thus prepared for transportation are known as weathering processes. (1) The temperature of the atmosphere changes frequently, and some times greatly and quickly. When the air is warm, it heats the surface rock which expands. If the temperature falls quickly, the rock contracts. These changes of volume set up strains between the interior and exterior of rocks, which result in the cracking or scaling of the outside. (2) The oxygen of the air unites chemically with certain parts of many rocks, forms new substances, and causes disintegration of the rocks. For instance, iron unites with oxygen and water (rusts) and is weakened. The union of oxygen with rock matter is known as oxidation. (3) In the same way carbon dioxide, which is always present in the air, decomposes many rock components, for instance those containing calcium, and makes carbonates. This is carbonation. Most of the carbonates are soluble, and pass off in solution in ground water, thus weakening the rock. (4) Also atmospheric moisture or ground water combines with certain rock materials to form new substances, the process being known as hydration. (5) Ground water percolating through the rocks dissolves soluble matter and thus prepares it for transportation. This process is called solution. (6) Wind picks up materials previously loosened and uses the particles as tools to loosen other particles. (7) The roots of plants growing in cracks of rocks exert a force on their sides and thus tend to break rock. This may be called the wedge work of roots. (8) In decaying, plants give off organic acids which help to decompose the surrounding rock. (9) Animals burrow into the soil, bring up fine material which is readily transported by wind and water, and by their excretions while alive, as well as by the products of their decay, perform chemical corrosion. (10) Once cracks are started or particles are loosened by the above processes, action proceeds with increasing rapidity through the force of gravity, which makes many of the cracks grow larger and causes blocks of rock to roll down slopes and break into smaller pieces. In all these ways and probably others, material is prepared for transportation by streams.

TRANSPORTATION

Much of the weathered material reaches the streams by being washed down the slopes, by being cut from the banks by the streams, or by being carried by the wind. The coarser parts, such as sand and gravel, are pushed or rolled along the stream beds by the force of the running water. The mud particles are picked up and carried in suspension, being kept
above the bottom in part by upward currents caused by irregularities in the bed of the stream. Other material is carried in solution. The total amount of debris that can be transported depends largely upon the volume and velocity of the stream, and on the amount of loose material within its reach. Perhaps the greatest cause of inefficiency of running water to lower the surface lies in the lack of facilities for carrying loose material from the places where it is weathered to the streams. The water, therefore, flows off to the sea carrying less load than it could carry if the loose material were supplied fast enough.

**Corrosion**

While in transit, weathered material performs an important work. It grinds along the bottom and sides of the stream, and in so doing wears or *abrades* the rock and helps the stream to get other material. For an illus-

![Fig. 24. Lateral cutting by Plum River.](image)

tration of a stream cutting its banks see figure 24. If the material transported is harder than the bed of the stream, it may cut deeply and rapidly (as geologic processes go). In the course of time a stream may by this method cut a deep, broad, and long valley.

**Corrosion**

The water in a stream dissolves rock material from its bed and sides, thus deepening and broadening the valley in which it flows. Many streams
contain various acids which have a chemical effect on the bed rock and render insoluble substances soluble. The chemical effects of a stream on its bed is known as *corrosion*. This is probably not so important a factor as weathering or transportation in reducing the surface of the lands, but it may compare favorably with corrosion in this respect. It is more effective upon soluble rocks than upon those that are insoluble.

**HISTORY OF A VALLEY**

**DEVELOPMENT OF A VALLEY**

There are few, if any, large surfaces on the land, that are so smooth and so uniform in hardness that water falling on them will not concentrate into streams instead of running off in sheets. As soon as rain falls the water running over the surface starts to develop valleys. By the processes outlined above, the valley is widened, deepened, and lengthened. It is deepened by abrasion of its bed, widened by cutting on the sides of the stream (lateral planation) and by carrying away of material brought from the sides of the valley, by gravity, side wash, by the action of animals, the wind, and other agents, and lengthened by water coming in from the head. To each of these three directions of growth there is a limit. Obviously a stream can cut little deeper than the body of water into which it flows, be it the sea, a lake, or another stream. In fact, a stream cannot cut quite to the level of the water into which it flows except at or near its mouth. It cannot cut so low, at a distance above its mouth, that there is no gradient down which the stream can flow. When a stream has cut down as low as possible under the existing conditions, it is said to be at grade. A valley is made longer at its head until a permanent divide is reached between it and another valley. Similarly a valley is widened until a permanent divide is established between it and another valley.

All valleys thus have somewhat similar histories, and certain stages in their development can be recognized, just as human beings develop along certain general lines and certain stages in their development, such as childhood, middle age, and old age are easily recognized. Three stages are commonly recognized in the development of valleys, namely youth, maturity, and old age. It must be understood, however, that these terms do not apply to the actual age of a valley measured in years, but to the stage of development of the valley; that is, a valley which has approached none of its limits of growth is a young valley, a valley which has approximately reached its limits of depth, width, and length is said to be old, and a valley in a stage between youth and old age is mature.

**CHARACTER OF A YOUNG VALLEY**

When first starting its development, a valley is likely to have the following characteristics: It is (1) narrow, (2) steep sided, and (3) because
the stream has not yet reached grade it is cutting down vigorously, and the valley is narrow at the bottom, no flat having been developed. These first three characteristics may be grouped by saying that a young valley is V-shaped. In addition, (4) it usually has a high gradient, and is likely to have falls and rapids; its tributaries are few and short; and (6) the stream flows swiftly, and carries coarse material. The upper ends of most of the valleys of the Galena-Elizabeth district are young. A cross-section of a young valley is shown in figure 25, a.

![Diagrammatic cross-sections of valleys in three different stages of development; a, young valley; b, mature valley; c, old valley.](image)

**CHARACTER OF A MATURE VALLEY**

When a stream has reached grade, it ceases to cut downward, but the processes of widening continue. As the stream comes to flow more slowly, it is easily swung from side to side, and as a result it cuts laterally at a nearly constant level, forming a flat. The beginning of the development of a flat is a sign that the valley has reached its depth limit and may be taken to mark the line between youth and maturity. In addition to having a flat, a mature valley is broader than a youthful one, has gentler slopes, a relatively low gradient, and its tributaries are well developed. The stream is likely to be crooked (see figure 25, b).

**CHARACTER OF A VALLEY IN OLD AGE**

In old age a valley has practically reached its limits of change, though no valley is known in which these limits have been absolutely reached. At this stage (1) its flat is very wide, (2) the valley slopes are gentle and in-
definite, (3) the tributaries are fewer but larger than in maturity, (4) the stream is very crooked, and (5) it flows sluggishly, carrying only material in solution and very fine sediment. Figure 25, c, shows an ideal cross-section of an old valley.

**EROSIONAL HISTORY OF A LAND SURFACE**

With the first rain that falls on a newly formed land surface numerous gullies are developed. As each gully develops into a valley, and each valley passes through the three stages of growth, the whole region is changed and passes through a similar series of stages. If one stream can cut its bed down to grade and lengthen and widen its valley until the valleys made by other streams are encountered, all the streams of a region can in time reduce a land to a lower level. The time taken, or perhaps more properly the succession of events involved, in the reduction of a region from youth to base level (the theoretic lowest level to which streams could bring a region if infinite time were allowed), is known as a cycle of erosion. No cycle is ever complete, as accidents happen to disturb the process late or early in its history, but it may approach completeness more or less closely.

![Diagram](image_url)

**Fig. 26.** Diagram illustrating a region in three stages of reduction by streams. Line 1 represents a youthful stage of erosion; 2, a mature stage; 3, an old age stage or peneplain.

In *youth* a region is mostly undissected, there is much flat or flattish upland and little or none on a level with the streams; the slopes to the streams are likely to be steep, and the valleys are young. Commonly the upland plain is poorly drained. No good illustration of young topography is found in the Galena-Elizabeth quadrangles, although the district around the canyon of Apple River south of Apple River and Warren is in late youth.

Since in a cycle of erosion an upper flat is thoroughly dissected and reduced, and a new flat is made at a lower level, there is a time when most or all of the old upland flat is gone, and when the new and lower flats along the streams are not yet very extensive; that is, when the region has reached its maximum of slope. This stage is known as *maturity*. Most parts of the region under discussion are mature.

When most or all of the streams of a region have developed broad flats, and the valleys make up the whole surface; when the divides have been brought low, and most of the slopes are gentle, the streams are few and large; and when most of the region has been reduced to flatness, it is said to be in *old age*, and the surface is known as a *penepplain* (near plain). Figure 26 illustrates typical profiles of regions in youth, maturity, and old age.
EFFECTS OF UPLIFT

If at any time during a cycle of erosion, the land is uplifted, or the surface of the body of water into which the streams drain is lowered, or if there is any warping by which a portion of the land becomes relatively higher, it is obvious that new work will be given the streams to do. If such an earth movement occurs after the surface has reached the peneplain stage, the streams because of their increased velocity are enabled to cut down into the flats they had themselves developed in the old cycle. Relative uplift of the land starts a new cycle of erosion, and the *rejuvenation* of the streams.

![Fig. 27. Portion of the Pawpaw, Maryland, topographic map showing entrenched meanders of Potomac River.](image)

The results of stream erosion in the second cycle are several, some of which are seen in these quadrangles. Old peneplains come to stand above the present streams, affording even sky-lines or flat benches between the old divides and the present stream beds. Streams which have reached the advanced stage of one cycle hold their courses in the second cycle, and cut down in the old meanders; the result is a meandering stream in a young valley. These conditions constitute *entrenched meanders* (fig. 27). In the
latter part of a cycle of erosion a normal stream has a gradient low at its mouth and progressively steeper toward its head. Immediately after uplift a young valley with a steep gradient begins to develop at the mouth of the old one, and the new gradient for the whole valley is for a time gentle in its upper part and steep below, as in figure 28. This is commonly known as interrupted profile. By these and some other criteria, the second cycle can usually be detected in a region if the topography is studied carefully.

**Age of Valleys of Galena and Elizabeth Quadrangles**

**General Statement**

Valleys in various stages of development are found in these quadrangles. In general the largest streams have the oldest valleys, and the smallest ones, most of which are intermittent, occupy the youngest valleys. In general the lower parts of all the drainage systems are mature, and their headwater parts are young. This is to be expected, as the streams have developed their valleys by headward erosion, and their volumes are greatest at their mouths.

**Mississippi Valley**

The largest, deepest, and most striking valley of the region is that of Mississippi River; yet it is difficult to assign a definite erosional age to it. At the top the valley varies in breadth from two to several miles. The valley walls are everywhere steep, and in many places vertical; their height is about 150 feet. Added to these characteristics, the valley has a flat bottom which is several times the width of the river. On this flat the stream flows sluggishly, separates into several channels, and joins around islands and sand-bars of its own deposition. Its gradient is about four inches to the mile. It will be seen by referring to the list of characteristics of valleys in the three different stages of development that the valley of the Mississippi has the characteristics of all three stages, rather than of any one. Its steep walls suggest youth; its width compared to that of the stream channel suggests maturity; and the broad, flat, crooked channel, and sluggish stream seem to point to old age. The explanation of these mixed characteristics is that the valley was young or was in early maturity, and that it has been partly filled with glacial debris (fig. 29). Before the glacial period the
valley had developed to approximately its present width, had acquired a considerably greater depth, and its walls were steep. There was probably little flat. But the glacial waters filled it about half full of gravel and sand and left it with its former width and steepness of slopes, but with a broad flat bottom.

![Diagram](image)

**Fig. 29.** Diagram illustrating the manner in which a glacial fill in Mississippi Valley has given it some of the characteristics of an old valley.

**MATURE VALLEYS**

Practically all the main valleys directly tributary to the Mississippi and many of their tributaries in turn are mature. Here belong the valleys of Sinsinawa Creek and several of its tributaries; Galena River including the lower mile or two of most of its branches; Smallpox Creek as far up as

![Diagram](image)

**Fig. 30.** Diagrammatic cross-sections of mature valleys in the Galena-Elizabeth district: *a*, valley of Galena River two miles above Galena; *b*, valley of Apple River at Elizabeth. (Vertical scale is exaggerated about 6 times)
Guilford; Apple River and its many branches up to the lower end of the canyon about nine miles above Elizabeth; Big Rush Creek as far north as the Chicago Great Western Railroad; and Plum River to within three miles of Stockton. The characteristics of these valleys are shown in the diagram (fig. 30). In all of them there is a flat broader than the stream, but less than 10 times as broad. The lower part of the valley of Sinsinawa Creek is approaching old age; the flat being comparatively broad. The other valleys referred to, still have steep walls ranging from vertical cliffs where the rock is resistant to slopes of 15 to 20 degrees where the rock is less resistant. The streams have begun to meander. On the flood plain southeast of Aiken a stream has straightened its course on the flood plain (fig. 31). The gradients are about 10 feet to the mile, and much the same in each valley.

Fig. 31. Abandoned channel southeast of Aiken.

YOUNG VALLEYS

There are thousands of small valleys in the region under discussion which are steep-sided, narrow, nearly straight ravines. They have no valley flats, have gradients of 100 feet or more per mile, and have few and poorly developed tributaries. They range in size and stage of development from mere gullies to well-developed valleys. (Pl. XVII, A and B). It is unnecessary to name specific examples, for they include nearly all the valleys upstream from the mature parts referred to above. They are especially abundant in the region of the Niagaran upland in the southern part of the re-
A. A gully.

B. Well-developed young valley.
region, though they occur also in its northern part. Cross-sections of these valleys are shown in figure 32.

![Diagrammatic cross-sections of two young valleys: a, young valley near Black Jack mine, three and one half miles south of Galena; b, young valley in sec. 10, T. 28 N., R. 3 E. (Thompson), about six miles southeast of Scales Mound (Vertical scale is exaggerated about 6 times).](image)

The canyon of Apple River for five miles southwest of Millville is young. As was stated near the close of Chapter IV the reason for its youth is that the stream has been located in its present position only a relatively short time, one stream having been diverted into the valley of another during the glacial epoch. This canyon is about one-fourth mile broad at the top; it is exceptionally straight; its sides are nearly vertical in many places, and everywhere so steep as to make climbing difficult. Tributaries to the river are few, and these few are short and unbranched. The stream occupies nearly the whole bottom of its valley in the dry season, and the entire bottom in times of flood, and its gradient is about 20 feet to the mile (see figures 33 and 34).
This canyon was developed, as are all canyons, because the surface over which the stream started to flow stood considerably above base level; the stream was large and permanent; its gradient was such as to cause it to cut down rapidly; and the rock (Galena dolomite) forming its walls is of a nature to resist the processes of widening and to stand with steep slopes.

![Diagram](image)

**Fig. 34. Diagrammatic cross-section of the canyon of Apple River below Millville. (Vertical scale is exaggerated 6 times.)**

**Topographic Age of Region**

A glance at the topographic map of the region (Pl. 1) shows a great predominance of slopes over flats, the contour lines being close together over most of the area. Closer inspection shows that there are comparatively flat areas, some of them on the uplands, and some forming the bottoms of the valleys. The upper flats are those which the streams have not yet dissected in the present cycle of erosion, but which they can and will dissect in the future by the growth of their tributaries headward, and by the development of new tributaries. Such flats occupy considerable areas in T. 29 N., Rs. 2 and 3 E. and T. 28 N., R. 4 E. (Rush, Apple River, and Scales Mound), and smaller areas on the Niagaran upland in the southern part of the region. The flats on the valley bottoms represent the new level to which the whole region will be reduced, provided time is allowed without uplift. The proportions of upland flats, slopes, and valley flats are shown in the profile (fig. 35).

![Profile](image)

**Fig. 35. Typical profile taken from the topographic map in a north-south line almost through the centre of the region, the length of the profile being 16 miles. (Vertical scale is exaggerated 24 times.)**

As a whole, the region is mature, being almost in the condition of maximum slope. Certain parts are in youth, as for instance, the area in which is the canyon of Apple River in T. 29 N., R. 3 E. and T. 28 N., R. 4 E. (Rush and Apple River). Certain smaller areas in the south along the
streams, and in the west along Mississippi River, may be regarded as well advanced in maturity if not in early old age. But in general, for any extra slope made by the further dissection of the upland flat, other slopes will be reduced to flatness along the beds of the streams. The surface has never been rougher than it is, and will never become rougher.

**Development of the Flats**

**General Statement**

In Chapter II it was stated that there were flattish areas above the stream beds. At least two such areas in the region force themselves upon the attention of anyone who studies the topography with a view to its interpretation. One of these flats is everywhere underlain by Niagaran dolomite, and the other follows the Galena dolomite more or less closely. Where they have been studied in regions north of these quadrangles both flats have been considered to be old peneplains uplifted and partially dissected in later cycles of erosion. It may be profitable to describe these flattish areas with a view to determining if there is any other possible explanation of their origin.

**Niagaran Flat**

In most places where the Niagaran dolomite is found in the district its top has an even skyline as seen from a distance and a flat upper surface. The level upper surface can be well seen on the upland running over the Chicago Great Western Railroad tunnel, on the hills around Elizabeth, or almost anywhere on the upland surface. Even in the north part of the region the Niagaran-capped mounds are flat topped, and those which stand in east-west lines rise to almost a common level. It is clear that if all the valleys were filled to the tops of the mounds, the resulting surface would be nearly flat. The presumption is strong that there was once over all this area a flat which has since been dissected. Three of the mounds in the north part of the region reach elevations of 1170, 1152, and 1160 feet. In its central part the mounds and the top of the Niagaran escarpment reach elevations of 1112, 1145, 1065, and 1072 feet. In the south portion of the district considerable areas of the flat are found at 994, 964, 1027, 1004, and 1000 feet. That is, if this plain were reconstructed, it would slope south and southwest about 175 feet in 16 miles, or about 11 feet to the mile. In Wisconsin a few miles north of this district, this same flat on the Niagaran dolomite reaches elevations of 1400 feet, showing a continued rise in that direction. Reference to the discussion of structure will make it clear that the rock strata of the district, including the Niagaran dolomite, also dip southwest, and at about the same angle as the slope of the imaginary.

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plain; that is, this upland plain follows the structure of the strata within the boundaries of these quadrangles (fig. 37).

With reference to the origin of this flat there are at least four possibilities: (1) It may be an old peneplain uplifted and dissected after its formation by streams; (2) it may be a flat made by a hard layer of rock underlying its surface; (3) it may be the original sea bottom, which after emerging remained low and flat for a long time after the Niagaran epoch; or (4) it may be the result of the erosive action of ocean waves cutting back on the land, at a time subsequent to the deposition of the Niagaran dolomite and any other formations which may have been laid down on it. The correct one of these four hypotheses should be determinable by close field observation.

1. If such a flat is a dissected peneplain: (a) It is likely to have hills standing above it, which were left unreduced in the cycle of erosion that produced the peneplain; (b) the surface is likely to have some relief; (c) the thickness of the formation on which it is developed is likely to vary to a degree corresponding with the relief of the surface; (d) the surface is not likely to be parallel to underlying strata, but to rise or fall stratigraphically; (e) it would be expected to slope in one general direction, corresponding to the direction of flow of the streams that made it, unless tilting took place after its formation; (f) much of the flat might be covered with river detritus such as fine gravel, sand, and silt, similar to the materials on river-made plains today. If such a plain is not parallel to underlying strata, but lies across their bevelled edges, particularly if the strata are known to have constant thicknesses where undisturbed, it is almost certainly a result of general erosion going to a late stage; that is, it is a peneplain.

If the characteristics of the Niagaran flat within the district were compared with this set of features expected on a raised and partially dissected peneplain, they are found to correspond only partially. Concerning the flat as it is in these quadrangles: (a) No distinct hills stand above it; (b) the flat has little relief—probably no more than could have been given it by erosion following the uplift; (c) the thickness of the formation immediately under it varies slightly but not greatly in short distances; (d) its surface does not rise or fall appreciably in the stratigraphic section; (e) it does slope in a general direction and at about the angle expected for a peneplain; (f) no sand or gravel or stream alluvium was discovered on the flat within this district although stream gravel occurs on remnants of the plain in Iowa and Wisconsin. From the foregoing data within these quadrangles it is seen that this flat is not clearly a raised peneplain; neither is it clearly not a peneplain. If the flat is traced beyond the limits of this district, and is found to pass from Niagaran to Maquoketa to the north, and from Niagaran to some younger formation to the south, it will be proven a peneplain.
2. In a cycle of erosion a flat of considerable magnitude might be formed on the top of a hard layer of rock by the removal of all softer material from above, provided the streams were not able to cut through the hard formation for a long period of time. Such a plain would be essentially a peneplain, with the difference that its position would be determined by a hard stratum instead of by base level, and that it would need no uplift to start its dissection; dissection would result when the main stream had cut through the hard formation. It would have essentially the same characteristics as the true peneplain with the marked exception that it would be parallel to the layers of the rock and remain at the same stratigraphic position over wide areas.

If the Niagaran flat be tested by these criteria, again no definite conclusion can be drawn. As the flat is everywhere located on the Niagaran, lies everywhere very near the top of the massive member of that formation, about 150 feet above its base; and as it has all the other characteristics of a true peneplain, it may be said to fit the second hypothesis as well as the first.

3. Or, is the Niagaran flat the original plain which emerged from the sea at the end of the Niagaran epoch and has undergone partial dissection in a single cycle of erosion since then? A flat having had such a history should have somewhat different characteristics from one developed in either of the ways previously outlined. (a) There would be no marked hills standing above the remnants of the flat, for there were no other strata above it from which hills could be formed, and there was no period of erosion preceding the formation of the flat during which hills could be formed. (b) The thickness of the underlying formation would be expected to be uniform, except for possible differences in the amount of deposition on the bottom of the sea, or the quantity of material removed by erosion since its emergence from the sea. (c) The flat would have little or no relief, unless roughened after its emergence by streams, wind, and other agents. (d) Like the plain developed on a hard layer, the marine plain would follow the rock structure, not rising or falling appreciably with reference to the strata. (e) Any slope the flat has would be the slope of the old sea bottom, unless tilting occurred during emergence or later. (f) No river detritus should be found on this surface, but instead some material might be found which had been deposited at the shoreline as the shore receded over it. (g) In this case also, if the bottom of the old sea has been preserved as the flat, it might be expected that somewhere the old shorelines might be found as raised sea-cliffs, old beaches, and other features in places where protected from later erosion. (h) Marine fossils might be found on the surface of the flat.

Of the features referred to above, the flat under discussion has some and lacks others: (a) It has no hills above it; (b) the underlying formation
has a sufficiently uniform thickness to suggest the possibility of its being an original plain; (e) the relief of the flat is sufficient for that of an original plain but not too great; (d) the surface of the flat follows the rock structure fairly closely; (e) its slope may be that of the old sea bottom, modified perhaps by slight subsequent tilting; (f) and (h), the materials of the flat afford no evidence of its origin, because there is a complete lack in these quadrangles either of river detritus or the remains of terrestrial or marine animals; (g) even if old shorelines were preserved at the edge of the ancient sea bottom, they would be found only at the margin of the flat, and this is outside the region under discussion. But no such shore features have been reported, and in all probability none exist.

4. There remains one other hypothesis to be analyzed and tested. If this flat is the result of marine erosion, it should have most of the characters of a peneplain due to stream erosion, as outlined in 1: (a) it should have erosion remnants on its surface; (b) it might lie parallel with the strata in a general way, but not in detail; (e) it should slope in one general direction, the slope being the ocean-ward slope of the old sea bottom; (d) some of the flat might be covered with marine sediments—debris deposited on the surface after its erosion but before the recession of the sea. This plain would differ from a true peneplain in having little or no relief before dissection. In addition, a plain so made must have originally been bounded by a shoreline of some sort, and this might or might not have been preserved, if the flat was preserved. Also, as the sea cut its way over the rock surface, and the flat off shore became wider and wider, the places eroded would gradually become sites of deposition, and this debris should be found today on the flat, either cemented into hard rock or un cemented.

Again the Niagaran flat has some of these characters, but not all. So far as slope, original relief, and the uniformity of thickness of the underlying formation are concerned, the flat might be explained as a wave-cut plain, but the correspondence of the flat with the structure of the beds, the absence of near-shore marine deposits, the absence of all shorelines, and the fact that no other large plains made in this way are known, would seem to indicate that some one of the other possible explanations is more probable.

After this discussion it is apparent that the origin of the Niagaran plain is still in doubt, if only the facts discoverable in these quadrangles are allowed to bear evidence. So far as can be determined within the Galena and Elizabeth quadrangles, it is possible that the plain has had any one of the four histories, or perhaps even a combination of two of them. The fact that the flat within the Galena and Elizabeth quadrangles is so distinctly related to structure and that it shows no conclusive evidences of having been peneplaned, points toward the idea that it is an original plain or a structural plain, rather than an old peneplain or a plain of marine erosion. It seems unlikely that a peneplain would happen to be
formed closely parallel to structure over wide areas. It has been so long since the Niagaran epoch, that it appears extremely unlikely that a flat emerging from the sea at that time could have remained undestroyed until now, unless perhaps it be conceived that the surface took a position very near to sea level from the start, and held that position until uplifted in relatively recent times. So far as evidence in the immediate district is concerned the flat may be a combination of a true peneplain and a structural plain, the flat having been developed on the hard Niagaran formation at a level which was near grade for the streams of the region at the time the flat was made, or the flat may be an original marine plain and also a structural plain, the last deposit in the sea having been made into hard rock (the massive Niagaran).

But if data concerning this plain collected from districts beyond the borders of the Galena and Elizabeth quadrangles be admitted in evidence, more light is thrown on the origin of the Niagaran plain, and fairly definite conclusions can be reached. West and northwest of these quadrangles in Dubuque County, Iowa, this same plain is represented by mounds and ridges on the summits of some of which are waterworn pebbles. When traced north into Iowa, the plain is found to cut across the edges of rock formations, so that it finally comes to lie on the Platteville formation near the Minnesota line. At Waukon, Iowa, the flat appears on the Platteville formation and is there almost covered with stream-worn gravel similar to that in Dubuque County. The plain and the gravel are known at Devils Lake, Wisconsin, where the surface undoubtedly represents a peneplain.¹

The exact age of this plain is not determinable. Professor Grant regards it as of Cretaceous age in the Lancaster-Mineral Point district of Wisconsin; whereas at Devils Lake, Wisconsin, Professor Salisbury attributes it to the Pliocene. The latter interpretation seems to the writers most likely to be correct. It would seem, therefore, that although there is not sufficient evidence within the borders of the Galena and Elizabeth quadrangles to demonstrate the age and origin of the Niagaran flat, when data from beyond the borders are admitted, the conclusion is reached that the flat is a true peneplain, and that it was probably formed before but not long before the glacial period.

**GALENA FLAT**

A second flat lower than the one on the Niagaran dolomite is conspicuous in many parts of the region. As it is generally situated at the top of the Galena dolomite, it may appropriately be called the Galena flat. It is best developed and occurs in widest area and can be seen to best advantage in the district around the towns of Seales Mound, Apple River, Warren, and Stockton, where its surface is 150 feet lower than the tops of the mounds and ridges and 150 to 200 feet above the stream beds. Except

for the elevations above it and the depressions below it, the flat is a wide area of slight relief. Figure 36 is a view on this plain, showing one of the mounds standing above it. In sec. 8, T. 28 N., R. 4 E. (Rush) where

Fig. 36. Galena flat and mound upon it east of Scales Mound.

the surface has not been modified, it has a relief of less than 20 feet for a whole mile (see topographic map, Pl. 1). This is a little more level than the average but not greatly so. This flat is confined practically to the northern two-thirds of the region; it does not appear to any appreciable extent in its southern one-third and is lacking entirely along the south edge of the quadrangles. In the vicinity of Galena it appears in flattish or rounded divides midway between the uplands and the valley bottoms. By close observation traces of this flat may be seen about as far south as the Chicago Great Western Railroad tunnel in the Galena quadrangle, and to about the latitude of Stockton in the Elizabeth quadrangle. If reconstructed, this flat, like the Niagaran flat, would slope southward at a low angle.

Stratigraphically the Galena flat is located on the hard Galena dolomite or only slightly above it in the Maquoketa shale. The broad flat in the district around Scales Mound, Apple River, Warren, and Stockton is underlain directly by the upper thin beds of the Galena, or locally far from the main streams by 5 to 15 feet of Maquoketa shale. The rounded divides and narrow flats around Galena and north and south of that place are underlain by Maquoketa shale up to thicknesses of 30 feet. In the south part of the region where the Galena dolomite dips beneath the surface, the flat disappears.

In the case of the Galena flat, only three of the four above-discussed modes of origin are possible. The flat cannot be an original marine plain of deposition, because the mounds and Niagaran escarpment stand above
it; and these have been made by processes of erosion since the recession of the sea. It may however be: (1) a structural plain on the hard Galena dolomite; (2) it may represent the beginnings of a true peneplain; or (3) it is conceivable that it was carved out from the shale and dolomite above the Galena by the waves of a slowly advancing sea. In either of the first two hypotheses, streams were the agents of its formation. If a structural plain, the flat was developed by streams that flowed down the dip of the top of the hard dolomite and scoured off the softer shale. If the flat is a remnant of a true peneplain in its beginnings, it was developed by streams that had reached grade in a region that had been developed to an early peneplain stage before uplift allowed dissection in another cycle of erosion.

After analysis of the various features of this plain, the idea of marine erosion as its explanation seems to be untenable. On so extensive a flat, marine shore deposits would have surely been deposited, and no suggestions of such deposits are found on the flat. Under this hypothesis also, the mounds and ridges standing on the plain, must have been islands, headlands, and peninsulas, and their sides must have been suffering erosion by the waves which made the flat; that is, their slopes must have been shorelines of erosion. As most of these elevations stand out boldly on the plain, far from the main streams and the valleys of the present cycle of erosion, it must be considered that they are today about as they were left by the agent or agents which made them. This being the case, evidences of wave-work on their sides should be visible. But, on the contrary, the slopes of the mounds and ridges show every evidence of stream work, and they have very clearly not been eroded to their present shape by waves. Especially is this fact plain in the central and southern parts of the region where the uplands form the stream divides and have the characteristic dendritic arrangement of topographies developed by the work of streams.

The Galena flat has all the main characteristics of an incipient peneplain after uplift and partial dissection, except that in the Galena and Elizabeth quadrangles it follows the Galena dolomite with surprising closeness. (1) It is made up of extensive flat areas lying between uplands and lowlands, and in such positions flat areas are not developed except under special conditions; (2) aside from recent dissection, it has about the flatness to be expected on a peneplain; (3) distinct and striking erosional hills rise above it; (4) it slopes gently in the direction in which the present streams flow; but (5) it follows the top of the Galena rather closely and seems to disappear where that formation dips beneath the surface. However, close study of the stratigraphy in connection with this flat shows the coincidence of flat and structure to be not so striking after all. It is represented in Iowa where it cuts across the bevelled edges of the formations from the Prairie du Chien at New Albin to the Galena formation at
Work of Streams

Fig. 37. Diagram illustrating the relations of the Niagara and Galena shales to the dolomite.

rock structure of the district; a, Galena dolomite; b, Maquoketa shale; c, Niagara
Dubuque. In southwestern Wisconsin, Grant\(^1\) finds evidence of a partly dissected peneplain on the upper part of the Galena formation, which has an altitude of 1000 to 1100 feet. In the northern part of the Galena and Elizabeth quadrangles this flat lies on a few feet of Maquoketa, and the Maquoketa becomes slightly thicker under the flat to the south; that is, the flat does lie across the bevelled edges of different formations. These relationships are shown in figure 37. The Galena flat is believed by the writers to be a true but partially developed peneplain somewhat controlled by rock structure. The feature which seems at first to oppose the peneplain interpretation is the disappearance of the flat where the Galena dolomite dips beneath the surface. However, this may possibly be explained. If the peneplain were developed on the Galena formation as shown in the diagram (fig. 37), the Maquoketa shale was thickest at the southern edge of the flat. When the plain was uplifted and the streams were rejuvenated, the shale would be attacked most vigorously downstream. This being soft, its dissection would result in speedy destruction of the plain where the shale was thick; where thin or lacking, the plain would be preserved longer. Even where there was a little shale under the flat the main streams would cut through it rapidly and then would be held to slow cutting by the hard Galena dolomite. Working in the hard rock, they would not develop tributaries as promptly as they would in the soft Maquoketa farther south, and the flat would be protected. It is conceived then that the flat is a partially developed peneplain, the southern part of which after uplift has been destroyed because the underlying shale was exposed and only slightly resistant to erosion. The flat is more distinct in the central part of the district, and in the northern part it is very well preserved because of the hard dolomite near or directly under it.

No clue to the age of the Galena plain is found in the Galena and Elizabeth quadrangles, other than obvious evidence that it is younger than the Niagaran flat and older than the present valleys which have been formed below it. But there is some evidence in northeastern Iowa\(^2\) that a peneplain of the same age as the Galena flat in these quadrangles is of early Pleistocene age, and Professor Grant assigns to it a slightly earlier date in southwestern Wisconsin. The plain is believed to have been formed either during or just before the earliest stages of the Pleistocene period.

**OTHER FLATS**

In addition to the large and striking Niagaran and Galena flats there are in the district two other less noticeable groups of flat land areas. Southeast of Elizabeth, on Little and Big Rush creeks, are a few flattish benches on the walls of the valleys. They are neither large nor geograph-

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ically important. The are underlain by the upper part of the Maquoketa formation, and so far as now known, are rock terraces formed on hard and thick dolomite layers within the shale formation; but they may also be remnants of the old Galena peneplain. The second set of minor flats comprises those forming the flood plains of the present streams. The streams have reached grade, and are forming flats which will broaden and become parts of a peneplain if time is allowed before another uplift.

CONCLUSIONS

The flattish areas of the region record history following that recorded by the hard rocks. After the Niagaran rocks had been deposited, they were probably covered by younger formations. Then erosion took place, and the land was degraded to the horizon of the Niagaran dolomite. This erosion resulted, probably in late Tertiary time, in the Niagaran plain. After the formation of this plain, the land was uplifted, allowing for the dissection of the Niagaran plain and the formation at lower levels of the Galena plain. Still later, most likely in early Pleistocene times, the surface was again uplifted, and the excavation of the present valleys was begun.

STREAM TERRACES

In the lower parts of all the larger tributaries of the Mississippi, there are terraces composed of unconsolidated materials. These terraces have a distinct relation to glaciation and to the Mississippi terrace described in the chapter on glaciation.

DISTRIBUTION AND TOPOGRAPHY

These terraces are found in the lower parts of the valleys of Sinsinawa Creek, Galena River, Smallpox Creek, and Apple River. Along Sinsinawa Creek they may be traced for about four miles above its mouth, along Galena River about six miles upstream, on Smallpox Creek about five miles, and on Apple River to a point about two miles above North Hanover. They have the form of patches or elongate strips parallel with the sides of the valleys, here on one side of the stream, and there on the other, in places where they have been protected from erosion. On Sinsinawa Creek, Galena River, and Apple River, there are several strips of terrace to each mile, whereas on Smallpox Creek the remnants are less numerous. In several places on Galena River and Smallpox Creek, the terraces extend for a short distance up the tributary valleys. Near the mouths of the streams the terraces are about midway between the valley bottom and the top of the valley wall; upstream their heights above the valley bottom gradually decrease to a point where they merge into the present flood plains.
All the remnants of the terraces are limited upward by a level plane; that is, their tops are practically horizontal. Elevations were read with the hand level to the tops of many of the remnants, and from these readings it is clear that the old valley filling of which these patches of terrace are remnants formed a flat which, if reconstructed, would have been nearly horizontal in individual valleys. It was also found by comparing the altitudes of the remnants in the different valleys that the original flats in each successive tributary valley stood at a lower altitude than in the one next upstream (with reference to the Mississippi), the difference being roughly proportional to the distance between the mouths of the tributaries.

The terrace remnants are flat topped and steep sided. On Sinsinawa Creek, in secs. 9 and 16, T. 28 N., R. 1 W. (Rawlins), the terrace top is 250 feet broad and almost perfectly flat. Farther south it reaches 400 feet in width and is cultivated; farther north in the same valley it is a continuous bench 100 feet wide for half a mile. The fair grounds northeast of Galena are located on the surface of the terrace which is so flat that only one fill across a gully was necessary in making the race track. A track of a similar size could not be located on any other physiographic feature of the region without grading. The terrace is also well developed on the east side of Galena River from Galena north to sec. 15 and south to Galena Junction, where its top reaches 300 or 400 feet in width. The village of Hanover is located on the terrace of Apple River; the main street seems perfectly flat except for an almost imperceptible slope to the west. Probably the best preserved strip of terrace seen is 1 3/4 miles north of Hanover on the east side of Apple River, where it is half a mile long and half as broad. Here the valley wall on the east rises fairly sharply. No relief is visible on its top. Camp grounds and a club house are located on its streamward edge. Remnants of terraces exist also along the tributaries of Apple River (fig. 38).
MATERIALS

The material of which the terraces are composed is entirely of local origin, except just at the mouths of the streams, where it is mixed with the glacial debris of the Mississippi terrace. It consists of dolomitic sand, small bits of dolomite, and silt which has been derived from dolomite, limestone, and shale. Except at the very mouths of the streams, the terraces contain nothing that could not have been gathered, carried, and deposited by the streams which now flow past them. In texture most of the deposit is of very finely divided earthy matter, clay or silt, with a subordinate amount of fine sand. However, small bits of rock are not uncommon near the base of the deposit, and locally, as on Sinsinawa Creek, large angular bowlders of dolomite are embedded in that part of the deposit next to the valley wall. In many places small "mud balls" similar to those found in some stream bottoms today, are abundant in the exposures. They are the result of the rolling of particles of mud, bits of shell, or small pebbles along the muddy bottom, so as to accumulate mud as they go.

The character of the stratification of this material is significant of its origin. In most places the deposit is well sorted into thin horizontal beds or laminae of uniform thickmess, there being several to the inch. This is the structural characteristic of slack-water or still-water deposits. But locally, as on lower Sinsinawa Creek and Galena River above Galena, the material is sorted into irregular lenses or pockets, where cross-sections of old filled channels can be seen plainly (Pl. XVIII, A). This part of the deposit was clearly deposited by a stream on a flood plain. In many places the terrace deposit contains abundant fossils of small gastropods of at least two species, one of which lives among the vegetation on slopes of the land today, and the other of which is now extinct. These fossils are found abundantly in beds of fine sand or silt, or rolled up in mud balls in those places where the material was laid down on a flood plain.

The more exact character of this material may be best learned by its study in the field. Its best exposures are described below:

1. A quarter of a mile above the mouth of Sinsinawa Creek on the northeast side of the valley, 17 feet of the terrace deposit are exposed. Here the material consists of clay and exceedingly fine sand, both being well laminated. The sand of one bed a foot thick is as fine as hour-glass sand and is laminated in wavy lines. No pebbles appear in the exposure, but there are several lenses of rounded mud balls which are about half an inch in diameter and fossiliferous. Other layers contain many gastropods. In only the topmost five feet are the beds horizontal and continuous, below this they are cross-bedded and pockety. The depositing agent was clearly a braided stream which shifted its channel from time to time. The upper part of the deposit was doubtless laid down in slack or still water. At least one old channel is plainly visible. It was cut in a bed of brown
A. Section through terrace materials a quarter of a mile above the mouth of Sinsinawa Creek: a flood-plain deposit.

B. Section through terrace materials on Smallpox Creek: a lake deposit.
sand and then filled with gray sand and clay. Most of the cross beds dip downstream.

2. Between secs. 9 and 16, T. 28 N., R. 1 W. (Rawlins), on Sinsinawa Creek, the stream has cut the terrace from top to bottom. The material is variously colored clay and fine sand. The colors include striking reds, yellows, chocolate color, and gray. The beds are horizontal and average two or three to the inch. None of the material is as coarse as coarse sand, neither are the clays “fat” (without grit). It is typical of deposits made in relatively quiet water.

Fifty feet upstream from the cut just described, the clays are developed characteristically, except that they contain large fragments of dolomite. The cut extends across the line between the terrace deposit and the old valley wall (fig. 9). Presumably blocks of rock fell or crept from the slopes above which the material was being deposited, and worked down into the soft mud. Such large blocks are common within 100 feet of the valley wall, but not farther away. Just above this exposure, the terrace has a width of 100 feet for a large fraction of a mile along the valley wall. It has doubtless been protected from erosion by the stream, because of the bowlders in it. When the stream cut into this part of the deposit, the mixture of clay and blocks resisted erosion more successfully than the deposit without blocks farther from the valley wall on the other side of the valley, and the stream was turned to this softer side.

3. Across the street south of Grant Park in Galena, about 7 feet of laminated clay and fine sand of various colors are exposed. No fossils were seen here, and no material coarser than fine sand. Up Galena River from this point there are several other exposures in the stream banks, some of which contain abundant fossils.

4. In a gulch heading at the east-west road, 300 feet west of the sheds
at the fair grounds northeast of Galena, a 12-foot section of thin-bedded clay and fine sand is exposed in the terrace. Beds average three or four to the inch, and are practically horizontal, though some of them are slightly wavy. Here are irregular nodules of calcium carbonate. In the bottom of the cut are numerous, small, angular fragments of dolomite, representing the base on which the terrace material was laid.

Less than 1000 feet away from this cut on the side of the fair grounds next the railroad is another exposure. Here the material is yellow or purplish pink, and clayey with very little grit, and it is only crudely laminated. It contains mud balls and irregular calcareous concretions as large as 3 inches in diameter, but no fossils.

The first of these exposures shows what is evidently a still-water deposit; the second is a flood-plain deposit.

5. Terrace material is well shown on the west bank of Smallpox Creek a short distance southwest of the Black Jack mine. It consists of variously colored, laminated clay and dolomitic sand. The layers are practically horizontal, uniform, and continuous, and run four or five to the inch. Some are slightly contorted or rippled with a relief of not more than two inches. The clay is light colored, gray, drab, reddish, and brown. Some of the coarser layers are fossiliferous, the fauna consisting entirely of small gastropods. Calcareous concretions are exceedingly abundant in practically all parts of the exposure (Pl. XVIII, B).

6. On the east side of Apple River one-fourth mile southeast of North Hanover 38 feet of unconsolidated material are exposed. The lower 15 to 20 feet are bedded clay and fine sand. The sand is laminated with many horizontal and cross laminae to the inch. The upper 23 feet is loess (see Pl. XIV, A).

7. South of the south edge of the Galena quadrangle 1½ miles from Hanover is an exposure of laminated clay with about 12 laminae per inch. The sand associated with the clay is fine, dolomitic, and cross-bedded. The clay is given a peculiar aspect by numerous concretionary masses, resembling knots of wood. This seems to be in the main a standing water deposit, but there are features which indicate that at times a stream flowed over its surface.

8. In a small valley east of Rice and in the valley tributary to the Mississippi at Blanding local material is mixed with glacial debris in the terraces. Half a mile south of Rice and also 3½ miles southwest of the same village, the terrace is chiefly of light-colored, feldspathic sand containing flakes of mica, specks of iron oxide, and grains of quartz and feldspar. But embedded in this are found small bodies of dolomitic sand, and angular fragments of dolomite varying in size to slabs 10 inches long. For half a mile up from the mouth of the valley at Blanding the material of the terrace is a mixture of local fragments and feldspathic sand interbedded with
clean quartz sand in pockets, layers, and lenses. Upstream the sand is less abundant and the local fragments correspondingly more abundant.

9. Other places where the material of these terraces can be seen are: (a) between secs. 15 and 16, T. 28 N., R. 1 E. (East Galena); (b) at the bridge in SE. ¼ sec. 4, T. 28 N., R. 1 E. (East Galena); (c) one-fourth mile southwest of the Catholic Church in Hanover; and (d) one-half mile southeast of Hanover on the west side of Apple River.

**SPECIAL FEATURES**

In the description above mud balls and calcareous nodules are mentioned in several places. The origin and significance of the mud balls have been explained. The nodules are of two sorts. Most of them are small, white, very irregular, earthy masses of calcium carbonate, generally distributed throughout the clay, or concentrated roughly into bands or lenses. Some of them are pictured in Plate XV. They are sometimes called "potato concretions". When found in loess they are known as *loess kindchen* (children of the loess). The original deposit contained calcium carbonate which is soluble. Ground water dissolved this material from the clay, deposited it around small particles, and built up irregular masses. Nodules of another sort found here are known as "pipe stems". These result from the accumulation of iron compounds around rootlets. Whether the plant gives off organic gases and liquids into the surrounding ground water to cause precipitation of the iron, or whether the rootlets take up the water and simply leave the iron is not certainly known. Probably both processes operate. Pipe stems also are illustrated in Plate XV.

**ORIGIN OF THE TERRACES**

It has already been explained that the valley of Mississippi River was partly filled by glacial sand and gravel during the Wisconsin epoch of the glacial period. The present main streams tributary to the Mississippi in the Galena-Elizabeth district were in existence at that time, and they could not fail to be affected by the building up of the bed of the main stream. If a stream carries material corresponding in amount with its velocity, deposition will take place where the velocity is checked either by ponding or by a simple decrease in gradient. In the present case both ponding and decrease in gradient resulted from the filling of the main valley. Actual ponding which made lakes in the tributary valleys, took place in the tributaries which were not able to deposit as fast as did the Mississippi, and laminated material was laid down in the quiet waters of these lakes. A tributary which filled its valley as fast as the main valley was filled kept flowing into the main valley without actual ponding and deposited sediment on its flood plain. It appears that in some valleys the conditions oscillated between those producing lakes and those producing flood plains, for flood
plains and lake deposits are found closely associated in the same valleys. Probably the rate of deposition in Mississippi Valley increased and decreased with increasing and decreasing rate of melting of ice upstream at the edge of the ice sheet. During and after a period of rapid filling by the main stream lakes existed in the tributaries; when filling in the main stream became slower, the tributaries caught up and kept pace with it in building up their beds, and flood plain conditions existed for a time.

At the end of the glacial period, Mississippi Valley and the extreme lower parts of its tributary valleys were partially filled with glacial debris, and the upper portions of the tributary valleys were filled with local material up to the level of the top of the fill in Mississippi Valley. Later Mississippi River cut down into the glacial fill, and this allowed the tributaries to cut down into the fills in their own valleys, thus converting the old lake bottoms and flood plains into the present terraces. The old flat at the surface of the fills is left only in spots where they were so situated as to escape the later dissection. Neither Mississippi River nor its tributaries have yet cut to the bottom of their fills.

If the above explanation for these terraces is correct, similar terraces must have been formed during the glacial period in the thousands of other tributaries to Mississippi River from both sides, above and below the Galena-Elizabeth district, and in tributaries to other main streams like the Ohio which carried glacial waters and received glacial debris at the time of the ice invasion. Such terraces have been found in Wisconsin, in Illinois just south of this district, in Iowa, in southern Illinois, Indiana, and Kentucky, and in Pennsylvania. Many other terraces similar in origin to these could doubtless be found in valleys tributary to the main streams, south of the edge of the drift sheets.

ALLUVIUM
FLOOD PLAINS

Reference to the map (Pl. IV) will show that most of the valleys contain alluvium at least in their lower courses. The surface of this material forms the flood plains of the streams. At and near the mouths of the larger streams areas of alluvium are commonly several hundred feet broad and ten times, or more, as broad as the stream. Farther upstream and in the smaller tributaries they are commonly 100 to 200 feet broad and several times the width of the stream. On the scale of the map less than 100 feet cannot be shown, so that the upstream end of the alluvium as indicated on the map is not necessarily its upper limit in fact, but is the place where the flood plain
A. Alluvial flat.

B. Typical stream alluvium on a branch of Plum River.
becomes less than 100 feet wide. The alluvium can be seen in almost every flat-bottomed valley in the region. It is more extensive near Mississippi River than in the Elizabeth quadrangle, because the valleys near the main stream have reached a later stage of development than those farther away. The lateral boundaries of the alluvium are definite where the rock of the valley wall is dolomite, but where the country rock is Maquoketa shale the alluvium grades into the gentle slopes of the valley sides (Pl. XIX, B).

Like the terrace materials, all the alluvium in each valley is of local derivation. It consists of clay, loam, sand, and rock fragments more or less intermingled. The finer materials are commonly dark colored and contain much carbonaceous matter, the result of the disintegration and decomposition of plants. The stony matter which ranges up to 3 or 4 inches in diameter is mostly of Galena dolomite, Niagaran dolomite, or chert from the Niagaran dolomite, depending upon the courses of the depositing streams. The boulders are nowhere well rounded, though their edges have been made less sharp than they were when the pieces were first broken from the parent ledges. In structure the deposit is varied; materials of different textures occur in irregular pockets and in lenses and layers. Generally the lower part of the deposit consists largely of rock fragments, and its upper part of dark-brown or reddish clay and loam. The plane of separation between the two is fairly distinct, but it is everywhere irregular. For a better idea of the material see Plate XIX, B.

Any stream which is transporting rock material, must somewhere deposit it. The chief causes of deposition are decrease in velocity and decrease in volume. If a stream is carrying all the material it can carry with its given velocity and volume, and either of these is decreased, the stream must deposit. Velocity is checked: (1) at the mouth of the stream if it flows into standing water or into a stream more sluggish than itself; (2) along and at the head of a flood plain, where the gradient becomes gradually lower downstream; (3) at the bases of steep slopes where the gradient decreases abruptly; and (4) wherever flood waters subside and give the effect of decreasing volume, a cause which may result in deposition on a large scale.

The alluvium in this region has been, and is still being deposited, on the flood plains of the streams because of a gradual decrease in their gradients and a corresponding checking of their velocities downstream. In the head-water regions of the valleys the streams flow swiftly and with considerable volume, especially after rains, and pick up clay particles and sand which they transport in suspension. Moreover, they drag or roll along their bottoms larger fragments of rock. Arriving at the flood plains below, their velocities are checked and their carrying powers decreased. Deposition therefore takes place, the coarser material falling first and nearest the head, and the finer later and farther downstream. The material is then reworked
from time to time. It is taken up and shifted downstream in time of floods, and as the stream meanders about on its flood plain, material is removed from the outside of the curves, where the current is directed against the bank and deposited in the less swift water on the inside of the curves. In these ways the materials are intimately intermixed.

**ALLUVIAL FANS**

In addition to the deposits made by the streams on their own flood plains alluvium has been deposited locally on the flood plains of the larger streams at the mouths of their small tributaries. The material takes a fan-shaped form, the outer border of the fan spreading on the flat of the main valley and its apex extending slightly up the tributary. Few of these fans attain an area of more than a few thousand square feet. One of the fans is shown in figure 40.

![Fan at the mouth of a tributary stream one-half mile southeast of Aiken.](image)

The materials of the fans are not well exposed, but they consist of the rock waste carried by the tributary streams, at the mouths of which the fans are deposited; that is, they consist of clay, sand, and angular stones. Presumably the coarser material is at the head of the fan and the finer material in its outer part. Generally speaking, the material of the fans is not distinctly different from the alluvium on the flood plains.

The cause of the deposition of the fans is the decrease both in velocity and volume as the stream moves from its confined channel of steep gradient, to the flood plain below. The stream spreads out, the friction with its bed is increased, and there is an abrupt decrease in its velocity. Moreover, much of the water of the side stream sinks into the loose material of the fan.
The dirt and stones carried from above are thus deposited in the shape to which the stream and its distributaries spread.

**RECENT DEPOSITION AND EROSION**

Near the heads of the valleys a peculiar, but important process has given rise to striking surface features. A large number of valleys, after having been partly filled and grassed over, have been gullied. The gullies, or trenches, are present in nearly every valley in the region and range in depth to 15 feet, and in width to 25 feet or more. The sides and upper ends of the trenches are steep, generally vertical. Most of them are being enlarged by lengthening at their heads, and tributary gullies are being developed along their sides (Pl. XX, A). In some valleys the gullies are not continuous; followed down valley, they become gradually smaller and finally end in a grassed-over and undissected surface; then farther down, other gullies begin with vertical walls at their heads and sides. Some valleys are gullied throughout their whole extent, and few if any are entirely ungullied.

From the foregoing it is clear that at some time the valleys of the region were cut down below their present levels; they were then partly filled, and still later were cut into again. A definite sequence of events is discovered when the materials in the walls of the gullies are studied. Almost without exception they expose the following section (Pl. XX, B).

*Typical gully section*

<table>
<thead>
<tr>
<th>Thickness Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Grass roots, very little soil</td>
</tr>
<tr>
<td>4. Loamy clay</td>
</tr>
<tr>
<td>3. Black soil</td>
</tr>
<tr>
<td>2. Gray loam and clay</td>
</tr>
<tr>
<td>1. Rock fragments in reddish residual clay</td>
</tr>
</tbody>
</table>

From this section it is concluded that: (1) the valleys were once somewhat deeper than they now are; (2) clay and loam were washed from the bordering slopes and deposited in the valley bottoms; (3) deposition ceased for a long time, vegetation lived and died on a surface which was being neither built up nor cut down, and a thick layer of black soil accumulated; (4) other material was washed in, and the old surface was built up; and (5) dissection began again and has cut through the later fill, the soil zone, and almost through the earlier fill.

The explanation of this series of events is not entirely clear. The first three events were probably the result of processes other than the work of man; the last two are probably due to the work of man aided by other natural processes. Before the region was inhabited, the valleys were cut and reached their approximate maximum depth under conditions then existing. When downward cutting had ceased and the streams were slug-
A. Branching gully in a pasture.

B. Typical section in the side of a gully; a, lower loam and clay; b, soil zone; c, upper loamy clay.
gish, the material washed down the slopes was greater in amount than the streams could carry off, and it accumulated in the valley bottoms until a stable gradient was established and vegetation started on the flats, slopes, and upland, and effectively stopped the wash. The oldest residents of the region tell of valley bottoms covered with a rank growth of grasses, willows, and other swamp plants before the land was much cultivated. Three causes—all the work of man—led to the renewal of deposition on the valley bottoms: (1) forests were chopped from the uplands and valley slopes, a condition that allowed the soil previously held by the roots of the trees to be washed down; (2) the cleared fields were cultivated, and the soil stirred up even on steep slopes, further aiding wash from the slopes and therefore deposition in the valleys; (3) man introduced cattle into the region, the cattle greatly reduced the grass and shrubbery on the slopes and furthered erosion still more. The result was that loose material was washed from the upland surfaces and deposited in the valleys where it covered the old soil and steepened the gradient in the valley bottoms. The cause of the later trenching is almost equally clear. By grazing the valley bottoms, where the surface materials are too shifting and the floods are too frequent for crops, vegetation was removed, so that water consequently flowed off more quickly than had previously been possible, carried away material more easily, and consequently cut gullies and trenches into the alluvial valley filling.
CHAPTER IX—ECONOMIC GEOLOGY

There are several kinds of material in the region which have an economic importance, and their location, history, value, and origin are of interest both commercially and scientifically. Although certain of them have been mentioned in previous chapters, they are mentioned again here. For a fuller and more technical statement the reader is referred to Mr. Cox’s report on the ores of the Galena district.

ORES

distribution

The district included in the Galena and Elizabeth quadrangles has long been known as a producer of lead and zinc ores. It lies in the southern part of the area variously known as the “Upper Mississippi Valley lead and zinc district”, the “Illinois-Wisconsin lead and zinc district”, and the “Galena mining district”, a region which includes northwestern Illinois, northeastern Iowa, and adjacent parts of southwestern Wisconsin.

Geographically the lead and zinc ores of the Galena-Elizabeth region are found in two main mining districts: the most important around Galena, and a smaller and less productive district around Elizabeth. Besides these, there are almost everywhere throughout the region numerous old surface workings and new prospect pits and shafts from which ore has been removed or where traces of it have been found. The Galena mining district has an irregular shape and an extent of about 16 square miles, the city of Galena being in its west-central portion. The Black Jack property on the south is usually regarded as a part of this district. The Elizabeth mining district includes 6 square miles in the vicinity of Elizabeth. A special large scale map of each district has been made, and the geology has been worked out by Prof. G. H. Cox whose results have been published separately.

The ores have a fairly distinct stratigraphic distribution. Practically all occur in the Galena dolomite, and within that formation certain horizons are more important than others as bearers of ore. Most of the present lead workings and all of the older ones are in the upper 20 or 30 feet of the formation. The zine with lead in subordinate quantities is confined practically to the lower 40 feet of the formation, from which position it has been mined extensively around Galena and to the north in Wisconsin. Its downward extent is limited sharply by the oil-rock and shale member at

2Idem.
the base of the formation. Between the lead-bearing zone above and the zinc-bearing zone beneath, the great middle portion of the formation is essentially barren. It is commonly believed by geologists and miners that the lead and zinc are closely confined to the Galena formation; but this is not absolutely true, for both the Niagaran and Maquoketa formations contain both lead and zinc sulphides locally and in small amounts. Small lumps of good ore were seen by the authors in the Maquoketa shale on the farm of Mr. Ed. Tippett, 3½ miles northeast of Galena, and also on the property of William A. Studier near Belden School in the north-central part of sec. 32, T. 28 N., R. 2 E. (Guilford). In the western part of sec. 7, T. 27 N., R. 2 E. (Elizabeth), James Powers has a prospect hole in the base of the Niagaran formation and probably penetrating the Maquoketa, from which lead ore has been taken in sufficient quantities to make one shipment.

In their distribution the ores are also distinctly related to structure. First, the main districts are where the base of the Galena and the oil-rock are bent downward into synclinal basins as at Galena and Elizabeth, Illinois, and at Platteville, Wisconsin, and the productive districts are bounded roughly by the rims of the basins. The Black Jack property south of Galena is also in a small basin. The origin and location of the ores seem to be closely related to these basins; minor structural features have influenced the exact locations of the ores within the basins. The lead in the upper part of the formation is found commonly in crevices. In the lower part of the formation, the zinc and lead ores occur in the "flats and pitches". As explained in Chapter IV, these features which have become familiar to every mining man of the district are probably the results of the compression of the oil-rock by the weight of the overlying strata, and their characteristics are as illustrated in figure 12.

The ore bodies occur as: (1) crevice fillings, (2) small cavern fillings, (3) steeply sloping flattish bodies on the pitches, (4) flat-laying bodies on the flats, (5) very irregular bodies in broken or brecciated areas near the crevices, and (6) disseminated particles through the rocks as pore-fillings. In general the lead in the upper part of the formation consists of crevice and small cavern fillings, whereas the lower deposits occupy flats and pitches. The disseminated deposits are found: (1) in thin beds of limestone or dolomite immediately overlying the oil-rock, (2) in the oil-rock itself, (3) in the basal clay bed, and (4) at the base of the glass-rock beds. The various shapes of these deposits are shown in figure 41.

**CHARACTER OF ORES**

The ores consist primarily of two minerals: *galena* (lead sulphide) and *sphalerite* (zinc sulphide) associated with which occur *marcasite* (iron sulphide), *calcite* (calcium carbonate), *barite* (barium sulphate), *smithsonite*
(zinc carbonate), and others of minor importance. Generally these minerals have a definite arrangement horizontally and vertically. Where a crevice has been filled, marcasite lies next to the walls; and sphalerite, galena, calcite, and barite in order toward the center of the deposit. Vertically there are three different zones in the Galena formation: (1) at the top, in many places near the surface of the ground, a zone containing galena in large crystals and masses; (2) a central zone, extending down to the ground-water surface or a little below, smithsonite being the important ore; (3) a lower zone which is below the water surface, essentially a zone of sphalerite. The upper zone was previously worked from the surface; the lower one is now the most important source of the ores.

![Diagram illustrating the various shapes assumed by the ore bodies.](image)

**ORIGIN OF ORES**

Not everything concerning the formation of the ores of this region is clear and agreed upon by geologists, but it is believed by all that compounds of the metals were once scattered through some one or more of the rock formations of the region, and that the metals have been concentrated by the action of ground water, which dissolved their compounds, transported them to their present position, and finally precipitated them as sulphides. It is now commonly believed that the ores were introduced into their present positions from above rather than from below—that is, that they have been concentrated by descending waters. Underlain as they are by impervious oil rock and shale, they could hardly have been carried up in solution from below as has been the case with many ore deposits.

It has long been supposed that the metals came from the Galena dolomite alone, but this is now not so certain. It is thought by Cox\(^1\) that they are more likely to have come chiefly from the Maquoketa shale. All the Paleozoic formations of the region are marine in origin, and the compounds of the metals were deposited first when the rocks were formed. The ore material was probably brought in solution from areas farther north

\(^{1}\)Cox, G. H., Econ. Geology, vol. 6, p. 449, 1911.
and precipitated in the Paleozoic sea by some means, possibly the agency of plants. It is thought that the escaping gases from the organic material lying in the bottom of the Galena sea and now making the oil-rock would have caused the deposition of the metallic compounds along with the other materials of the dolomite. It has been suggested by Cox that the carbon in the Maquoketa shales played a large part in the original deposition of the ores. This hypothesis carries with it the idea that the ore-making matter was originally scattered through the Maquoketa formation, as well as through the Galena dolomite. The presence of small amounts of ore in the Maquoketa formation separated from the oil-rock by many feet of impervious shale, makes this hypothesis seem possible. However, there is so little ore above the Galena, and it seems so improbable that the concentrating waters could get from the shale to the dolomite freely, that it is believed that the dolomite formation originally contained most of the ore materials, and that the oil-rock is most largely responsible for its deposition.

The percentage of lead and zinc required in the country rock to form the deposits of the region was very small. An estimate made for the Potosi district in Wisconsin shows that if the rock originally contained 1/1400 of 1 per cent of ore material, this would be sufficient to form all the ores of that district, even assuming that this ore material from a layer of rock only 100 feet thick had been concentrated in the deposition of the ores. It is easily conceivable that both the Galena dolomite and the Maquoketa shale originally contained this small percentage of zinc and lead.

The concentration of the material into definite ore bodies was performed by ground water, probably aided by organic matter from the oil-rock. It is supposed that the metallic substances were changed to sulphates (ZnSO₄ and PbSO₄) by the atmosphere and ground water, were dissolved by ground water, and carried downward. As stated above, the oil-rock is composed largely of organic matter, and it has decreased much in volume since its deposition by the generation and loss of gases. These gases are known to have the power of reducing oxides by the removal of oxygen. Compounds in the form of sulphates (PbSO₄ and ZnSO₄) were very likely reduced by them to sulphides (ZnS and PbS), the oxygen having been removed by union with the carbon of the oil-rock to make carbon dioxide (CO₂). Finally, the sulphides were deposited.

The deposition of the ores took place according to the ordinary laws governing deposition from solution. The sulphides of these metals are much less soluble than the sulphates; hence the change to sulphides tended to cause immediate precipitation. However, other things determined largely the places at which deposition took place abundantly. The crevices, caves, and flats and pitches formed channels in which water carrying these minerals in solution flowed downward. Where arrested in its descent by the oil-rock and shale beds, it deposited most abundantly, because it remained
longer at these places than elsewhere and consequently was for a long time subject to the action of gases escaping from the oil-rock. Possibly, however, deposition took place in the flats and pitches above the oil-rock from other causes as well. As the mineralized waters moved from the pores and smaller openings of the rock into the crevices and caverns, they underwent several physical changes: pressure was reduced, included gases escaped, evaporation took place and cooled the unevaporated water, and solutions from different sides containing slightly different substances mingled. Perhaps all these changes of conditions tended to cause deposition in the cracks, and would doubtless have caused the water to deposit the ores, even if the oil-rock had not been giving off reducing agents. The oil-rock is doubtless responsible for most of the deposition in and near the base of the formation, and probably for much of that higher up, but physical changes are regarded as important in causing deposition of galena in the upper crevices, and to a less extent in the flats and pitches below. In any event the deposits took the form of the openings in which the causes of deposition existed and operated.

Whether it be considered that the ore was first distributed in the Galena dolomite or chiefly in the Maquoketa shale, the concentration was performed by descending waters. It is clear that waters would not be descending into the Galena formation abundantly and rapidly, so long as that formation was covered by so thick a formation of impervious shale as the Maquoketa. An attempt was made in Chapter V to show that the Galena flat is a peneplain of Pleistocene age, and that the Maquoketa shale was nowhere removed from the Galena until after the Tertiary period when the Niagaran flat was intact. In any case, therefore, the ore must be regarded as Tertiary in age or later.

PROSPECTING

From a knowledge of the occurrence, distribution, and origin of the ores some idea may be obtained concerning promising prospecting grounds. The districts that in early days produced lead in large quantities close to the surface of the ground, other things being equal, are still the most favorable locations for prospecting. The chances are that a formation bearing much lead in its upper part bears ore below as well, the main difference being that below the surface of ground water there will be less galena and more sphalerite. In selecting prospecting grounds, however, one should choose a district where there is a considerable thickness of Galena dolomite beneath the surface of ground water, for this is the chief ore-bearing zone. Also a district of synclinal basin should be chosen; for instance, the shallow basin under Smallpox Creek might be profitable prospecting ground.
GALENA AND ELIZABETH QUADRANGLES

FUTURE OF THE DISTRICT

Although little mining was being done in the region in 1910, and it is likely that mining operations will be quiet for some time, there is no apparent reason why mining activity should not increase gradually, and why the region should not regain much of its previous importance as a producer of lead and zinc. There is still much ore in sight in temporarily abandoned mines which could doubtless be worked if the market price of the metals should go up, or if similar deposits in other regions, for instance in Missouri, should be worked out.

BUILDING STONE

The Niagaran and Galena formations, and locally even the Maquoketa, are used as sources of building stone. Only the hard beds are valuable for this purpose. Almost all parts of the Galena formation furnish good building stone, except the oil-rock and the cherty massive members. The former is too thin-bedded for a building stone, and it lacks uniformity. In the cherty members the chert forms an irregular impurity which renders the rock undesirable for use as well as too hard to trim. The thin-bedded member at the top of the formation is used most extensively in this region, though just to the northwest at Dubuque, greater use is made of the lower massive beds. The Niagaran formation is hard throughout, and with the exception of its cherty parts would furnish fair building stone. The rock exposed in the quarry at the southeast edge of Elizabeth is, however, usable notwithstanding its cherty character, for the chert is bedded and can generally be separated from the interbedded dolomite with little difficulty. The lower thin beds of the Niagaran are used extensively in the southern part of the region, and the massive beds to a less extent. The only part of the Maquoketa formation used for building stone is the hard upper part in the vicinity of Stockton, where two quarries have been opened in it.

Nowhere in the region are building stones quarried on a large scale; there are however numerous small quarries. The rock being plentiful and easily accessible all over the region, a new quarry is opened whenever foundations for houses are needed—that is, quarrying is done to supply a strictly local demand, for the stone is rarely carried more than a mile from the parent ledges. In the southern part of the region quarries less than fifteen feet deep and less than 100 feet in diameter are present in great numbers, almost one to each farm, practically all being in the thin beds of the Niagaran. In the northern part of the district small quarries in the Galena dolomite are to be seen along roads and near bridges, where rock has been removed for ballast and pier foundations. In the central part of the region are quarries in the uppermost Galena beds, in the lower Niagaran, and in two or three places in the upper Maquoketa. None of these quarries is worked regularly, but only when stone is needed in the immediate vicinity.
Building stone has never been shipped from the region in large amounts and probably never will be, for the surrounding districts are almost equally well supplied.

Lime

The ruins of kilns that once furnished local supplies of lime are numerous in some parts of the district. The rock most extensively burned was the middle part of the Niagaran formation, but the Galena dolomite has also been burned in a few places. At present no kilns are being operated.

Sand

Extensive deposits of clean sand are present along Mississippi River, where much of it has been blown by the wind into sand dunes. The principal sand areas are shown on the map, but there are also others that are too small to map. The sand is not being used to any appreciable extent. It could, however, be made to fill all ordinary demands for material for grading, concreting, and other purposes.

Road Materials

The rough topography of the Driftless Area and its steep grades have necessitated road improvements. Fortunately the region is well supplied with material suitable for roads—dolomite, limestone, and chert. They are furnished by quarries in the Niagaran and the Galena, chiefly in the cherty members of these series. The rock is hand broken and spread over a graded and rolled surface and over this a top dressing of gravel or finer crushed rock is sometimes added. The flood plains of the larger streams become almost impassable at times of high water, especially along the roads which lie along or across the lower courses of the main streams, and it has therefore been necessary to build substantial roads (or pikes) to a height of four or five feet above the bottom lands.

Clays

The clays of these quadrangles, although widespread and of excellent quality, have not yet been extensively used. Clay could be furnished from three sources: (1) loess and alluvium, (2) residual deposits, and (3) the Maquoketa formation. At Dubuque, Iowa, alluvium and sandy loess are used for making building brick and could probably be similarly used here in Illinois. Residual clays also could be used for brick making. The Maquoketa formation, throughout most of its horizontal and vertical extent, contains much clay and shale that could probably be used for the manufacture of ordinary clay wares, including pressed brick and tile, though it is not now being used within this area. Transportation for the clays would be easy from points along the Chicago Great Western and Illinois Central
railroads, where gravity methods of handling the material could be employed, since the shale lies higher than the tracks.

Soils

As the region is chiefly an agricultural one, the soils are its chief economic resources. The crops are the main sources of revenue for its inhabitants.

MANNER OF FORMATION

Most of the soils of the region have been made directly from the underlying rocks, mainly by processes which result in the decomposition or disintegration of the rocks and are therefore processes of weathering (Chap. VIII). The hard rocks are broken into bits by: (1) temperature changes causing differential expansion and contraction, (2) temperature changes involving the freezing of water in pores and cracks (wedge-work of ice), (3) the wedge-work of roots, (4) the blowing over of trees, (5) gravity, and other indirect processes. They are also wasted or decayed by: (6) oxidation, (7) hydration, (8) carbonation, and (9) solution. By these processes a finely divided mantle rock is formed. Then (10) the wind shifts the sand and dust over the surface, lays the rock bare in some places, and piles up the loose material in others, and as it is blown it wears other fine materials from exposed rock ledges. (11) Rain falls on the surface, runs down the slopes, makes material slightly finer by the impact of the rain drops, washes it down the slopes, leaves the hill tops and slight elevations relatively bare, and increases the depth of the mantle rock at the base of slopes and in shallow depressions. (12) Animals, such as earthworms and ants, burrow into the ground, and bring up only the finer materials like clay particles and sand and leave the coarser mantle rock and the hard rock below. In all these ways is the mantle rock prepared to become soil. Soil also results from (13) the addition of vegetable matter to the mantle rock. The decay of the dead plants causes a gradual accumulation of decomposition products known as humus. The result is a carbonaceous, loamy mantle rock which is soil. In this way most of the soils of our region have been made.

However, some of the soils have been developed entirely by the addition of organic matter to wind-deposited loess and sand. On the stream bottoms alluvium was deposited and soil has been formed from that. And in the eastern part of the region glaciers prepared and deposited the mantle rock, at the surface of which soil was developed.

CHARACTER

No technical study of the soils of the district was made in connection with this work, nor were the soils mapped, but certain differences between
them were noted in various parts of the region, where differences in the mode of origin or in the character of the underlying rocks existed. A soil survey of Jo Daviess County has been made by the Illinois Soil Survey, and to this the reader is referred for details, technical description, and analyses of the various types of soil occurring in the district.

The soils of the region may be roughly divided into several kinds. The *upland soils* have resulted, in general, from the weathering of rock in place and the addition of no great amount of vegetable matter. They are loamy clays, not very carbonaceous, and generally light colored. *Valley soils* are black and extremely carbonaceous. Their character is generally the result of wash down the slopes and transportation of fine material from the heads of the valleys, together with the accumulation of a large amount of organic matter, resulting from the decay of the luxuriant vegetation of the moist bottom lands. These soils yield large crops, especially where the surface is well drained and not subject to destructive floods. On the lower flanks of the slopes is a soil midway in location and character between upland soil and valley soil. This soil is generally thinner than the average valley soil and thicker than the upland soil of the region.

The soils can also be divided according to the character of the underlying rock from which they have been derived. Galena soil is light in weight, light colored, and sandy in texture. Partly, at least, because the Galena lies on steep slopes, so that the soil is washed off rapidly, Galena soil is thinner on the average than that over softer formations, though where the dolomite outcrops on a flat surface, the soil may be as thick as anywhere. The soil on the Niagaran upland, or the *Niagaran soil*, is markedly different from the Galena soil. Most of it is a stiff, heavy, reddish, clay soil almost impervious to water. Much of this material contains angular fragments of chert, which have resulted from the weathering of the more or less cherty beds of the formation. The limestone weathered to clay, which is only an accumulation of the impurities of the limestone, and the cherts remained in fragmentary form. The oxidation of iron compounds causes the red color. *Maquoketa soil* is stiff, heavy, clayey, and impervious to water, but it is red in only a few places, nowhere sandy, and it contains fragments of chert only on the upper slopes near the base of the Niagaran. The *loess* and *sand soils* are in most places thin, light, and loamy. *Glacial soil* around Stockton is chiefly *rock flour* and vegetable matter. The clay, consisting of particles of all rocks over which the glacier passed, is especially adapted for growing a diversity of crops. Pebbles and bowlders are mixed sparsely with the clay matrix.

**THICKNESS**

The thickness of the soil varies considerably with its position relative to topographic features. On the broad Galena flat where it is not washed off readily, it reaches its maximum thickness. On the flat Niagaran surface
and on the valley bottoms it is also thick. On slopes its thickness depends largely on the underlying rock, as that controls the steepness of the slope and the rate of production of the soil. As a whole, it is thinner on slopes than on flats, and thinner on slopes of Galena dolomite than on slopes of Maquoketa shale. On the lower parts of gentle slopes underlain by shale, the soil washes down and lodges, and a thickness almost or quite as great as that on the flats is reached. In the glaciated district the mantle rock reaches 90 feet in thickness, but the soil, deeper than most other soils of the region, is only a few feet in depth. On the upper slopes of the mounds and the Niagaran escarpment and on cliffs of the Galena dolomite in some of the valley walls there is no soil.

**USES**

The chief use of the soil is to support crops. Probably 90 per cent of the inhabitants of the region depend for their living either directly or indirectly on farm crops. The chief crops are corn, oats, and hay. Barley and wheat are of secondary importance. Corn is grown on the black soils of the valley bottoms and on the uplands, the smaller grains on the flats and gentle slopes, and hay on the slopes.

The soils of the steeper slopes, such as that at the edges of the Niagaran escarpment and on many of the abrupt valley walls, are used for timber and pasture, rather than for cultivation. This is partly because the soil is thin on the steep slopes, and if cultivated, it would wash off rapidly; the slopes are too steep for convenient cultivation; and cattle raising and dairying have become more profitable than cropping for the direct market. Most of the steep slopes and many of the gentler ones are used for pasture.

**CONSERVATION**

No complete discussion of the causes of loss and means of conservation of the soil in this region can be given here. However, a few facts are apparent which indicate some of the ways by which the soil is destroyed.

Soil is commonly lost by: (1) cutting off of timber from steep slopes, (2) cultivating too steep slopes, and (3) over-grazing steep slopes. The roots of trees and shrubs tend to hold soil on slopes, and if they are cut and grubbed up, this hold is removed, and the soil washes. It washes also because through the cutting of the vegetation, a larger proportion of rain water runs off over the surface, and less sinks into the ground. Slopes gentle enough for the soil to remain with little wash when left in grass, sometimes suffer great loss when cultivated. The rain water gets a start, and gullies are formed. Even the cultivation of a single year may leave the fields in a dangerous condition, for the wash, when once started, is difficult to stop. Plate XXI, A, shows a field in such a condition. Moreover, if too many cattle are grazed on slopes that are kept in pasture, the grass is cropped too short; heavy rains cut under it, and washing is started
A. Development of gullies in an abandoned field.

B. Pasture land losing its soil by gullying, partly because of over-pasturing.
(Pl. XXI, B). This is especially likely to happen in a dry season when there is little grass, and the cattle are compelled to graze closely.

Considerable damage has already been done by the clearing, cropping, and over-grazing of too steep slopes, and efforts should be made to stop washing that has already begun on some slopes, and to prevent it from starting on others. Much can be done in the way of stopping the wash by piling brush or other debris in the gullies, provided the material is obtained from places where its removal will cause no injury. If this does not avail, fields should be taken from cultivation and put back into grass, and then pastured lightly for a few years until the grass has a good start. If this is not sufficient to stop the wash, rapidly growing trees, like the cottonwood or the locust, can be planted especially in the gullies, and the field can gradually be put back into timber land. Then later by judicious cutting and replanting the land may be made to yield a revenue from timber instead of producing scantier and scantier crops until they become so small as to have no value.

To prevent the beginning of washing only a little care is necessary to avoid cropping and pasturing slopes that should not be utilized for these purposes. If the slope is not very steep, it can be cleared and cultivated without danger. Some slopes can safely be cleared and pastured. Others must not be cleared if the soil is to be preserved. There is very little land still uncleared in this region which could safely be cleared, with the possible exception of some valley bottoms, and some flats on the Niagaran upland. The change from cropping to pasturing, a change which is already taking place rapidly, is a considerable step toward the retention of the soil.

**Water**

Like all the surrounding territory this district receives about 35 inches of precipitation a year. This amount of water is sufficient for the growing of crops without irrigation, and the maintenance of grass for grazing. Rivers and creeks furnish water for live stock and for power for local use. The smaller streams have considerable gradients, in some places as much as 60 feet to the mile; whereas the lower parts of the large streams have an average gradient not exceeding 10 feet to the mile. There are no natural waterfalls large enough to be utilized for power. However, all the main streams have sufficient volume and velocity to furnish power for local use. Before the large mills of Minnesota were established, several small flour and grist mills in the region employed water power for grinding grain for local use as testified by abandoned mill-races. Apple River now furnishes the power for the Woolen Mills at Hanover. The Mississippi is the only navigable stream in the area. Ground water has been an economic factor of importance in connection with the area, and now plays a part in sup-
porting crops, supplying streams and springs, and furnishing water for wells.

Summary

The history of the Galena and Elizabeth quadrangles is long and diversified. During Paleozoic times the district was under the sea and it received deposits of sand, calcareous materials, and mud, which were later cemented to make the hard rocks of the region; but at certain intervals, as between the Prairie du Chien and St. Peter epochs, between the Platteville and Galena epochs, between the Galena and Maquoketa epochs, and between the Maquoketa and Niagaran epochs, the region was elevated and eroded before receiving further deposits. Finally, some time after the mid-Silurian period, and long before the Pleistocene, the region emerged from the sea for the last time, the rock strata were tilted and warped into slight folds, and atmospheric agents came to play an important part in its later life. The surface of the rocks was weathered; streams degraded the lands in two or three cycles of erosion, and brought the surface to maturity in the present cycle. Ground water dissolved out caverns, made sink holes, concentrated the ores, and escaped to the surface as springs. Glaciers advanced toward the region and twice reached its limits, deposited drift, filled the main valleys with debris, ponded back the tributary valleys, and changed the course of Apple River. Winds blew over the glacial material, sorted out the finer parts and piled them together as loess and sand dunes. Finally man came into the region, cleared the fields, built houses, towns, railroads, mined the ore, drilled wells, and found a living on the surface which had been modified in so many ways and by so many agents, until it became a suitable stage for his activity.
CHAPTER X—SETTLEMENT AND DEVELOPMENT OF JO DAVIESS COUNTY

By B. H. Schockel

INTRODUCTION

Since this chapter deals with the geographic conditions that have influenced the development of Jo Daviess County, it is less local in its treatment than the preceding ones. There will be considered, for example, the development of transportation between this and other regions, something of the settlement of the Middle West, particularly of adjacent regions, and something of the lead trade of the United States at various times. Hence many events and places outside the county must be considered.

Fig. 43. Sketch of an early mining scene in Jo Daviess County. The illustration embodies the key note to the pioneer history of the county.

Four factors have greatly influenced the development of the region: (1) Because the area borders Mississippi River, its early relations were linked by river traffic with the South. (2) Its situation west of the southern extremity of Lake Michigan and within easy reach of it (fig. 42), later led to the connection of the county with the East by railroad, lake steamer, and canal. (3) The mines near the upper Mississippi River were the first within the United States to produce large quantities of lead ore and for many years furnished most of the lead produced in this country. Because of its lead resources the region about Galena was settled comparatively early and developed along lines characteristic of mining regions (fig. 43). The rapid settlement of most of northern Illinois did not begin till about 1840 (compare Plates XXII, XXIII, XXIV, and XXV) but the Galena
region was an exception. It had a population of 450 in 1826, and Jo Daviess County was organized in 1827, whereas the rest of northern Illinois was still in undisputed possession of the Indians. In 1830 Jo Daviess County had a population of 2000. The combined population of Warren, Mercer, Bureau, Henderson, and Knox counties was less than 650. The rapid growth in the population of the region, due to the exploitation of its mineral resources, was followed by a slower but more permanent growth in consequence of the development of agriculture. (4) The mature topography of the region has greatly influenced its economic development. Agriculture has been retarded by a rough surface, much of which has a relatively thin and infertile soil which is eroded easily. To avoid excessive grades wagon roads and railroads follow sinuous valleys and remnants of uplands; this is shown strikingly by the topographic maps of the region.

Fig. 42. Map showing the relation of Jo Daviess County to the rest of the lead and zinc district on the upper Mississippi River. The dotted portion represents the lead and zinc district.

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3Bateman, Newton, and Selby, Paul: Historical Encyclopedia of Ill., p. 305.
Map showing distribution and density of population in Illinois in 1830
Map showing distribution and density of population in Illinois in 1840
Map showing distribution and density of population in Illinois in 1850
Map showing distribution and density of population in Illinois in 1860
MINING IN JO DAVIES COUNTY

MINING BY INDIANS

The date of the earliest use of the lead deposits of the upper Mississippi region is unknown. It is said that a few of the oldest mines had been worked by the Indians in a superficial way before the advent of Europeans. The French probably learned of the lead deposits from the Sioux as early as 1658. Nicolas Perrot, an Indian trader and French commandant in the West in 1690, was probably the first white man actually to see the Indian mines and may be regarded as their European discoverer. In that year the natives were mining lead ore in a small way in the vicinity of Galena, and on the west side of the Mississippi. The journals of the Jesuit explorers (Marquette, Hennepin, La Houston, and Joutel) speak of mineral wealth and Indian mining on the upper Mississippi. Hennepin's map of 1687 shows native mines near the site of Galena. In abandoned drifts the first white settlers found "buckhorns", which the Indians had used as mining tools, and from these it is inferred that a few mines probably had been operated for fully a century before the arrival of white men. There is no evidence, however, that the Indians of the upper Mississippi Valley made much use of lead before the appearance of the French. Even after the advent of Europeans, the mining methods of the natives were crude.

It is probable that the French traders and trappers taught the Indians somewhat better methods of mining and smelting the ore and of using the metal. The value of the metal was enhanced greatly by the presence of the white man, for the natives could exchange it with the traders for goods or use it with their newly acquired firearms in hunting. Under guidance

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2Radisson and Grosilliers were the first to make definite mention of this rumor.—Parrish, Randall, Historic Illinois, p. 162, 1906.
4Perrot established a small trading and military stockade on the east bank of the Mississippi opposite Dubuque and visited the mines in 1690. This establishment was only temporary. Le Sueur later visited the region in 1700 and reported: "We found both on the right and the left bank the lead mines, called to this day the mines of Nicolas Perrot, the name of the discoverer".—Parrish, Randall, Historic Ill., p. 167, 1906.
5Perrot is said to have discovered lead mines in Wisconsin in 1682.—De La Harpe, B.: Journal Historique, pp. 24, 41-47. He found the lead "hard to work, because it lay between rocks and required blasting". It had very little cross and was easily melted.—Thwaites, R. G.: Wis. Hist. Soc. Collections, vol. 13, p. 273. Some doubtfully hold Nicolet to be the discoverer of the mines in 1634.
6Joutel was in the country as early as 1657.—Harper’s Mag., vol. 32, p. 681.
7Breeze: Early History of Ill., pp. 98 and 99.
10"They only skimmed the surface as a rule."—History of Jo Daviess County, p. 836. "The savages would load the ore at the bottom of the (inclined) shaft into deerskin bags and hoist or drag it to the surface by means of long thongs of hide. The lower work was performed almost entirely by old men and squaws".—Parrish, Randall, Historic Illinois, p. 167. "Large logs would be placed on the ground and smaller pieces of wood piled around, and the ore heaped on. The fire would be set in the evening and in the morning shapeless pieces of lead would be found".—Wis. Hist. Soc. Colls., vol. 2, p. 228.
of the whites the Indians developed mining more rapidly, for they employed tools supplied by the traders, 13 but windlasses were not used, and hence the shafts were made inclined so as to afford easy means of entrance into the mines. During the eighteenth century the region was left almost entirely to the Indians and traders. 14

In 1703 De Lisle published a map in Paris which indicated Indian mining in progress on both sides of Mississippi River 15 (Galena and Dubuque). That year Cardillac, governor of Louisiana, after searching for silver, carried back some lead taken from "mines 14 miles west of the river" (Dubuque). 16 Le Guis visited the mines on Galena River in 1743 and found that one mine worked by the French and Indians had in 1741 produced 2,500 bars each weighing about 60 to 80 pounds; in 1742 the same mine produced 2,200 bars. In 1810 the Indians manufactured 400,000 pounds of lead and sold it to Canadian traders. 17 When Shaw visited Galena in 1816, he noted that the Indians had 20 furnaces in the vicinity. 18 In 1819 the famous Buck mine near Galena was being worked by the Indians. 10 Nicolas Boilvin reported to the Secretary of War in 1811 that the Sac and Foxes on the east side of the Mississippi and the Iowas on the west side had largely abandoned the chase in favor of mining. 17 In spite of these facts, however, the production of ore by the Indians was relatively small.

Early in the 18th century lead became a regular article of commerce 14 between the Indians and the trappers and traders, most of whom at first were French; later French-Canadians predominated. French traders established at Peoria purchased lead from the Indians probably as early as 1690. 20 At first temporary posts, such as those of Nicolas Perrot opposite the site of Dubuque and Le Guer (1695) on an island farther up the river, served as points of exchange, 14 but later more permanent trading posts were established at Galena. The traders paid about $2.00 in Indian supplies for 120 pounds of lead; but since the supplies were overvalued the actual

13 "They employed the hoe, shovel, pick and axe, and crow-bar." —Schoolcraft, Narrative Journal of Travels, pp. 340-358. In 1819 an eye witness described the Indian method of smelting as follows: "A hole was dug in the face of a piece of sloping ground about two feet deep and as wide at the top. This hole was shaped like a mill hopper and lined with flat stones. At the bottom of the hopper, which was 18 inches square, narrow stones were laid across gratewise. A trench was dug from the sloping ground inward to the bottom of the hopper. * * * The hopper was filled with ore and fuel. When the latter was ignited the molten lead in a few minutes fell through the stones at the bottom of the hopper and thence was discharged through the trench over the earth. The fluid mass was then poured into an awkward mold and as it cooled was called a 'plat', weighing about 70 lbs., very nearly the weight of a 'pig' of later days." —Thwaites: Wis. Hist. Soc. Collections, vol. 19, p. 281.


19 This mine was exceedingly rich. From it an enormous nugget was taken by the Indians, who wanted to send it as a present to the "Great Father" at Washington.

rate was about $.75 to $1.00 per 100 pounds. In 1815, a peck of ore was worth a peck of corn in Indian trade.

The earliest route of export of the lead was northeast to Quebec and Montreal. However, after the French lost Fort Frontenac on Lake Ontario in 1758, they ceded their possessions east of the Mississippi (except New Orleans) to Great Britain, and the lead trade naturally turned to the southern port. For example, Captain Henry Gordon says in his journal in 1776 that the French were shipping small quantities of lead to New Orleans. The French-Canadians, having lost control of the southern route after the transfer of the land west of Mississippi River to Spain in 1762 and the purchase of Louisiana by the United States in 1803, again drew some of the lead trade to the St. Lawrence; but the bulk of it continued to go down the Mississippi.

**MINING BY FRENCH**

Excited by rumors concerning fabulously rich mines of precious metal along Mississippi River, the French early organized exploring and mining expeditions to secure them. In 1693 Le Sueur reported finding "mines of lead, copper, and green and blue earth". The French government sent him and Iberville (1699) with 30 workmen to explore "the mines at the source of the Mississippi". In 1701 having come from France and ascended Mississippi River, he discovered and named "The River of the Mines" (Fever or Galena River). The party secured no ore. The next grant was given in 1712 to Crozot, who resigned the monopoly to the John Law Company of the West (the company connected with the notorious "Mississippi River Bubble"). organized in 1717. Philip Francis Renault, appointed director of the mining properties of this company, came to Louisiana in 1720 with 500 slaves (the first slaves brought into Illinois) from San Domingo and 200 artisans from Europe. His coming marks the effort on the part of the French to mine extensively. He failed to find gold or silver, and the European commercial world immediately lost interest in his expedition and in the mines of the region. He returned to France.

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24Blanchard, Rufus, Discovery of the Northwest, p. 129.
25Parrish, Randall, Historic Illinois, p. 165. In 1743, however, some was carried by horse to Kaskaskia.
29History of Jo Daviess County, p. 226.
30The name "Fever" River is said to have been derived from the Indian word, "Mah can bee" (the fever that blisters), a name given by the natives because it was there that they suffered from a disease contracted on an expedition to assist some eastern friends.—History of Jo Daviess County, p. 226. Another idea is that the name originated from the corruption of the French word "Fieble", the name of a chief once living near the river.—History of Jo Daviess County. A third suggestion is that the name comes from "Riviere aux Feves", meaning "Bean River", owing to large amounts of wild beans once found growing on the banks of the Galena.—Rudolph: Wis. Hist. Soc. Collections, vol. 15, p. 343.
31Johnson’s Universal Encyclopedia.
in 1742 with his men, having done little mining. The amount of ore sent to France as a result of these expeditions was trifling. The loss of French dominion in North America marked the official decline of French influence in the Galena region.

SPANISH AND ENGLISH INFLUENCES

Spanish influence was felt in Mississippi Valley during the last half of the 18th century, but it was of little importance in the district about Galena. The mines at Dubuque, however, were developed under Spanish rule. The first serious attempt of white men to settle in the region for the purpose of mining was in 1788 when Julien Dubuque, a French-Canadian, received permission from the Sac and Foxes, with whom he was on friendly terms, to work the lead mines undisturbed. The greater part of his operations were carried on west of the Mississippi, near the site of Dubuque; but this shrewd and energetic pioneer retained the friendship of the Indians and sent his prospectors to explore widely in the lead regions of Wisconsin, Iowa, and Illinois. They opened leads on Apple River near the site of Elizabeth, and in 1805 took ore from the old Buck and Hog mines on Fever River. When Pike visited Dubuque in 1805, the annual product of lead at that place was from 20,000 to 40,000 pounds. After Dubuque's death in 1810 the Indians, jealous of their ore, destroyed all traces of civilized life. But they continued to mine lead and to sell the product to traders who maintained a post on an island in the river. Extended legal proceedings on the part of Dubuque's heirs for the purport of securing possession of the Dubuque mines so clouded the title to the property that many early prospective miners were turned from the west side of the river to swell the numbers rushing into the Galena district.

At the close of the French and Indian War the Galena region became English territory; after the Revolutionary War the title passed into the hands of the United States. With the outbreak of the Revolutionary War and Clark's conquest of the Middle West in 1778 English influence in the lead region waned, but during the War of 1812 the Indians are said to have produced under the direction of English officers an unusual amount of lead for bullets. This war clinched American possession of the lead region and checked the already dwindling export of lead to Canada, for which trade the French-Canadians were making a determined struggle.  


29In 1805 he claimed that his mines on the west side of the Mississippi extended over a tract of land 27 or 28 leagues long and from 1 to 3 leagues broad.—Thwaites, R. G.: Wis. Hist. Soc. Collections, vol. 13, p. 283.


AMERICAN MINING EXPLORATIONS

HOSTILITY TO AMERICAN WHITES

Both the French-Canadians and the Indians were hostile to the early white American explorers and miners—the French because they desired to retain the monopoly of the lead trade; and the Indians because the American people did not commonly adopt the habits of the natives, as did the northern traders, but took permanent possession of the land, converted it into farms, cleared the woods, and thereby deprived the Indians of their heritage. French-Canadian intrigue and American aggressiveness fanned the opposition to a desultory but armed state of hostility. In 1819 a party of American traders, while attempting to negotiate with the Indians in opposition to the French-Canadian traders, were waylaid and killed. A band of boatmen was stopped on Fever River by the Indians in 1815. Geographic conditions favored the Americans, for the advance up the Mississippi was more direct than that by the Great Lakes, and the more numerous Americans finally prevailed.

GOVERNMENT CONTROL OF MINES

Official interest in the lead region was shown in 1804 when Governor Harrison bought from the Saes and Foxes a "strip of land lying contingent to the mouth of the Fever River fifteen miles square." In 1807 Congress put the mineral lands under a leasing system. The above-mentioned tract of land on Mississippi River, the exact limits of which were to be designated afterwards by the President, was ceded by the Indians to the government for mining purposes in 1816.

AMERICAN PIONEERS

The arrival of several American pioneers in the lead district has been mentioned. In 1810 Henry Schreeve came up the Mississippi to Galena. Between 1815 and 1820 Captain John Shaw made eight trips with a trading vessel between St. Louis and Prairie du Chien and claimed to have been

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35 Some of the miner-traders secured Indian protection by marrying Indian wives, as in the case of Dr. S. C. Muir, Jesse Shull, A. P. Van Metre, and Francois Bouthiller. Muir has received credit for the naming of the city of Galena.

36 Davidson, Alexander, and Struve, Bernard, A complete history of Illinois from 1673 to 1884, p. 346.

37 Laws of the United States, vol. 4, p. 127. The mineral lands were to be leased for a period of 3 to 5 years for an annual rental, instead of being sold outright. All tracts showing mineral possibilities were reserved, but they could be worked provided a rental of 1/10 to 1/16 of the product was remitted to the government. It was beneficial at first in preventing hasty sale of valuable lands. Owing to French-Canadian intrigue, Indian troubles, and the reckless character of many of the miners, great trouble was encountered in collecting the rentals, the cost of collecting sometimes exceeding the remittance, and little attention was paid to the law—History of Jo Daviess County, p. 230. In 1846 the law was repealed, and the land opened for sale.—Parrish, Randall, Historic Illinois, 1906.

38 The treaty was made with the Ottawas, Chippewas, and Pottawatomies. Even then the officials did not know the exact location of the mineral lands as is evinced by the provision of the treaty noted above.—Tawahite, R. G.: Wis. Hist. Soc. Collections, vol. 13, p. 285. All of the rest of the land lying north of a line drawn due west from the southern extremity of Lake Michigan to the Mississippi, however, was reserved to the Indians.—Pooley, W. V., Settlement of Illinois: Univ. of Wis. Bull. 220, p. 462.

In 1821 the jurisdiction of the lead district was transferred from the general land office to the War Department.

the first American to do so.\textsuperscript{40} Col. George Davenport, an agent of the American Fur Company, who was on good terms with the Sac and Foxes, sent the first recorded boat load of lead from Fever River to St. Louis in 1816.\textsuperscript{41} The advent of the first white woman into the region occurred in 1821, when F. H. January and wife built a log cabin near Galena.\textsuperscript{42} Six or eight boats, carrying possibly 100 men, made a 20-day voyage from St. Louis to Fever River in 1819\textsuperscript{43} and thereafter a steady stream of adventurers flowed into the lead district.\textsuperscript{44} Forsyth\textsuperscript{45} in 1819 and Schoolcraft\textsuperscript{46} in 1820 reported on the location of the mines.

The close of the exploring period in Jo Daviess County and the beginning of active, systematic mining on a relatively large scale was marked by the arrival of Colonel James Johnson early in 1823\textsuperscript{47} Having secured a three-year lease, he brought a force of competent workers from southern Illinois and Kentucky besides 150 slaves and a large outfit of tools and under military protection\textsuperscript{48} began to mine successfully near Galena. His example was followed by others, and the region began to pass definitely from the control of the Indians.

**IMMIGRATION OF THE MINERS**  
**RUSH OF MINERS**

Hordes of prospectors and squatters now began to swarm into the district.\textsuperscript{49} Lieutenant Thomas reported the number of American miners in Fever River diggings\textsuperscript{50} in July, 1825, as 100, and in December as 151. In the spring of 1826 the number in the vicinity of Galena was nearly 200. This increased to 400 by June and to 550 in the fall.\textsuperscript{51} In four years 'this sequestered spot literally swarmed with miners, smelters, merchants,

\textsuperscript{40}Idem.
\textsuperscript{41}Parrish, Randall, Historic Illinois, p. 170, 1906.
\textsuperscript{43}History of Jo Daviess County, p. 243.
\textsuperscript{44}Pooley, W. V., Settlement of Illinois from 1778 to 1830, p. 327.
\textsuperscript{45}Schoolcraft visited the region and reported that mining was being carried on at four points: two mines in Iowa, probably where Durango now stands, and two in Illinois on the Galena and Sinsinawa rivers, marking the beginning of mining near Galena.—Bain, H. F., Zinc and lead mines of northwestern Illinois: U. S. Geol. Survey Bull. 246, pp. 110-111, 1905.
\textsuperscript{46}Forsyth mentioned mines in the following locations (Wis. Hist. Soc. Collections, vol. 13, p. 289):  
(a) Fifteen miles up Apple Creek, a mile from the right bank.  
(b) Red Head's village, six miles above the 'Grand McCoutely' on the west bank of the Mississippi.  
(c) Four miles up Fever Creek, on both sides of that stream, flat boats being able to approach within 1/2 miles.  
(d) Six miles up Fever River.

\textsuperscript{51}Pooley, W. V., Settlement of Illinois from 1778 to 1830.
\textsuperscript{52}Parrish, Randall, Historic Illinois, pp. 171-179, 1906.
speculators, and gamblers of every description. By 1827 the workmen in the mines numbered 1600, and in 1830 some 2111 people were enumerated in Jo Daviess County (established in 1827) alone. These facts are shown graphically in figure 44.

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Fig. 44. The heavy, broken, and light lines indicate respectively the population of Jo Daviess County, Stephenson County, and of Galena, in thousands. (From U. S. Census reports, in part.)


53Census of 1830. Unofficial estimates of the number of the miners in the entire region at this time were as high as 10,000.—Fergus’ Historical Series, vol. 13, pp. 42-45.
The miners, most of them from the South but some of them from other parts of the United States and from Europe, represented various races and many types. Americans, Irish, and French predominated, though Cornish, Swiss, Canadians, and English were numerous. Southern Illinois, Missouri, and Tennessee were the chief contributors, followed by Indiana and Ohio. Among and around this medley of eager adventurers were 2,000 Saes and Foxes, whose wigwams dotted the bottoms, ravines, and hillsides.

Unlike the settlement of the rest of northern Illinois, the primary object of this immigration was not to find suitable farming land well supplied with water and timber, but the tempting inducement offered by the mineral deposits. Timber and water were found in abundance, but it is thought that had the lead been in an open, isolated prairie, the inrush would have been just as rapid. The lead district was separated from Peoria, its nearest neighbor, by 170 miles of prairie and woods through which Kellog’s Trail led (fig. 46). No trail led eastward. Furthermore, Mississippi River connected the district with the Southern States. Hence the preponderance of southern men and influence in the early history of the region is easily explained. The declining product of the lead mines of Cornwall and unsatisfactory conditions in Ireland indirectly favored the settlement of the American district. Another important cause of the inrush of miners was that the government advertised the region extensively, and favorable reports of the mining operations likewise, led capitalists to locate in the district to engage in trade and the smelting of lead.

The early influence of the South in the Galena region is seen in the adoption of a southern system of county commissioners, and in the fact that Jo Daviess County was the last county of northern Illinois to substitute for this system the New England township organization, and then only after the measure had been defeated twice at the polls. Slavery existed

54History of Jo Daviess County, p. 253.
55The Cornish immigrants from the lead mines were numerous and increased rapidly from 1830 till 1850.—Copeland, Cornish in Southwestern Wisconsin; Wis. Hist. Soc. Collections, vol. 14, p. 305.
56In 1826 a Swiss colony from the Selkirk settlement in the Red River Valley emigrated to the lead district. They were a substantial, well-to-do class and were welcome settlers, especially since they engaged in farming. They established themselves at Gratiot’s Grove, 12 miles north of Galena.—Chetlain, A. L., Recollections of seventy years, p. 6.
58Idem. So many miners emigrated from Missouri into the region, that they were nicknamed “Pukes”, it being held that Missouri was vomiting the miners into the region.
59Dr. Meeker arrived in the district in 1823 with a colony from Cincinnati.—History of Jo Daviess County, p. 242.
60Idem.
61Pooley, W. V., Settlement of Illinois from 1778 to 1830, p. 328.
63History of Jo Daviess County, p. 258.
64Adopted in 1837.
65History of Jo Daviess County, p. 345. Jo Daviess County adopted the township system in 1849.
for several years, there being 100 to 150 negro slaves in the mines in 1823.\textsuperscript{66}

Southern newspapers and ideas were quoted freely by the local press.

**DISTRIBUTION OF MINERS**

The distribution and occupations of the early settlers are shown by figure 45. Ore was the chief factor in determining the positions of the

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\textsuperscript{66}As late of 1829 the commissioners of Jo Daviess County laid a tax of .5 per cent on town lots, slaves, indentured and registered servants and other things.—Idem, p. 257.
settlements, but the distribution of timber influenced the location of smelting furnaces, as for example the furnace at Gratiot's Grove. The map also shows the distribution of the few farms of the district at this time.

LEAD PRODUCTION AND TRADE, 1820 TO 1830

Figure 47 shows the production of lead during this period. The Fever River mines increased their product from 335,130 pounds in 1823 to 13,343,150 pounds in 1829.67 Though two men 'raised' as much as 20,000 pounds in a single day from exceptionally rich leads, the ordinary daily amount taken by two men from the average vein did not exceed 500 pounds. Owen conservatively estimated the daily average at 150 pounds.68 Overproduction in 1828 and 1829 caused a slump during the following three years. Owen gave as factors operating against still greater mining activities: (1) the unsettled condition of the country,69 (2) the migratory habit of the settlers, (3) danger from Indians, and (4) the high wages beginning to be paid for laborers on Illinois internal improvements. However, the miners rapidly pushed beyond the boundaries of the mining reservation and settled on Indian territory.

Most of the lead went down Mississippi River to St. Louis and New Orleans, and thence to New York. The eastward overland route was unimportant at this period, though 3000 pounds was sent by wagon (fig. 46) to Chicago in 1829.70 Galena on Fever River, which was navigable a short distance above that town, became the trading center of the region. Before 1827, when steamboats began to make regular trips between St. Louis and Galena,71 most of the river traffic was carried on in flat and keel boats.72 The first shipment of lead from Galena by steamboat was made in 1822,73 but in 1828 there were 99 arrivals of steamboats and 74 of keel boats74 at

---


Comparative production of lead in the mines of Missouri and Illinois, 1823-1829

<table>
<thead>
<tr>
<th>Year</th>
<th>Missouri mines</th>
<th>Fever River mines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pounds</td>
<td>Pounds</td>
</tr>
<tr>
<td>1823</td>
<td>335,130</td>
<td>175,220</td>
</tr>
<tr>
<td>1824</td>
<td>380,500</td>
<td>664,500</td>
</tr>
<tr>
<td>1825</td>
<td>1,374,962</td>
<td>985,842</td>
</tr>
<tr>
<td>1826</td>
<td>910,380</td>
<td>5,182,180</td>
</tr>
<tr>
<td>1827</td>
<td>1,205,920</td>
<td>11,105,810</td>
</tr>
<tr>
<td>1828</td>
<td>1,198,160</td>
<td>13,343,150</td>
</tr>
</tbody>
</table>

Great Britain and Ireland produced in 1828 some 98,700,000 pounds.


68Some of the land was not in the market at all; much of the rest was held by speculators.

69This was the first team to go from Galena to Chicago with a load of lead. The route was from the mines to Ogee's ferry on Rock River, east 60 miles to a missionary establishment on the Fox River, thence northeast 40 miles to Chicago. The 200 miles were covered in 11 days.—History of Jo Daviess County, p. 456.

70Chetlain, A. L., Recollections of seventy years, p. 6.

71Besides being slow, these boats involved on the average an annual loss of 20 per cent of the cargo shipped, owing to snags, sudden storms, and other inconveniences. "Bushwhacking" consisted in pulling the boat along by grasping the bushes along shore. Sometimes the boat was towed by rope, or "cordelled." It had to be "warped" up over the rapids.—History of Jo Daviess County, p. 241.

72Niles Weekly Register, vol. 60, p. 388.

73Idem, p. 130.
this point. Galena merchants bought their goods at New York or Philadelphia, and had them shipped by way of New Orleans and the Mississippi. 

EARLY GROWTH OF GALENA

Before Galena was laid out in 1826, its site was known as "La Point."
This "outpost in the wilderness," the first city of the Northwest to organize under a charter, had one log cabin in 1822.
Four years later it boasted of 20 houses and 150 people, which numbers were increased

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[18] Chetlain, A. L., Recollections of seventy years, p. 278.
respectively to 100 houses and 800 inhabitants in 1828, and 150 houses and 900 inhabitants in 1830 (see figure 44).

With the establishment of its first trading house in 1824, it became the smelting and exporting center of the mines and the base of supplies, not only for the entire mining district, but for much of the surrounding country as well. By 1828 it had 42 stores and warehouses. There was "no other spot in America of the same size where there was one-fourth the capital or so much business done" as in Galena. The early advantages of this city were: (1) its location on the navigable Galena (or Fever) River, emptying into the Mississippi, (2) its accessibility to the surrounding mining and farming districts, such as was enjoyed by no other town in the region, and (3) the lack of good trading routes to the east.

CONDITIONS OF EARLY MINING LIFE

During this period the district was dominated by a heterogenous mining population of about 10,000 adventurers, the numbers and movements of which fluctuated with the varying success in the "diggings." Some of the conditions of life may be summarized briefly: (1) Since the mineral was near the surface, sinking the shallow shafts was "as simple a process as the common method of digging wells," and mining was carried on by individuals rather than by companies. Not till 1837 did blast furnaces succeed the rude contrivances which had smelted from 60 to 150 "pigs" per day. (2) As all the ore had to be hauled to the furnaces to be smelted and then to Galena for shipment, the teaming business became important. Figure 43 gives a good representation of early mining conditions. (3) Most of the miners were poor, and laborers received from 15 to 20 dollars per month and board. But led on by his passion the hopeful miner digging in his dark, crooked hole always

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82Letter in History of Jo Daviess County, p. 253.
84Niles Weekly Register, vol. 35, p. 120.
85Letter in History of Jo Daviess County, p. 253.
88A lot 200 yards square was allowed every two miners, with an extra lot for every additional two men employed. One man usually worked in digging the shaft, while the other hoisted the material by means of a hand windlass, a process which can be seen in operation in the district today.—Wis. Hist. Soc. Collections, vol. 11, p. 400.
89A pig weighed about 70 pounds. The ore was dumped into a rude box made by laying small logs across the ends of larger logs lying on the floor of a rough basin dug in the hillside, and covered with more wood. By setting fire to the whole and repeating the process two or three times the operator finally extracted some of the lead which was found as a lump in the ashes. This rude process was gradually improved.—Parrish, Randall, Historic Illinois, p. 164. Miners were restricted in the sale of their ore to a licensed smelter who retained 1/10 of the product for the government.
90During the late spring and early summer the farmers of northern Illinois came up to the mines to engage in hauling the ore and returned in the fall, imitating the migratory habits of the sucker fish; hence the term "Suckers" applied to Illinois inhabitants. Teams hauled lead 40 miles from Hamilton's smelting works to Galena.—Wis. Hist. Soc. Collections, vol. 15, p. 345.
91Miners' Journal, May 9, 1832.
felt sure that he was close to the ore, or at most that his "lucky strike" was not far off.  

(4) Household and personal effects were of the barest and most essential nature, since nearly everything had to come up the river from St. Louis.  

(5) For this reason, however, the few farmers in the district had a ready sale for their produce.  

(6) Surrounded by Indians, into whose territory the miners had pushed after the land in the government district had been taken up, the prospectors were in more or less constant danger of attack, as for example during the Winnebago War of 1827.  

(7) During the winter the population of Galena was increased considerably by restless river men who engaged in steamboating on the Galena and Mississippi rivers during the summer.  

(8) Social relations were primitive. The "law of honor" prevailed in personal affairs. It is said that claim jumping was infrequent, and that despite the gambling, the miners paid their debts. Unruly characters often were expelled roughly from the town.  

The inhabitants of Galena were so crowded at the base of the bluffs and shifted so frequently from place to place, "many of them dwelling in holes and clefts in the rocks," that it was difficult to say where they belonged.  

Yet in this frontier district, Latin and Greek were taught at Gratiot's Grove, and the wife of Alexander Hamilton came to visit her son, a common miner, who like the rest was wont to wade knee-deep in mud on the clay streets of Galena, in the spring months.

EXPLOITATION OF LEAD MINES

Before the close of the Black Hawk War in 1832, most of the immigrants into Jo Daviess County had come to engage in mining. Its lead resources continued to attract miners to the county till the early '50's, when the decline in the production of lead in the district and the development of mining in the districts about Lake Superior, in the Rocky Mountains, and other regions, diverted the stream of immigrant miners from Jo Daviess County to other portions of the country. There also took place a great influx of farmers into the county between 1830 and 1860.

PRODUCTION OF LEAD MINES

The slump in the output of the mines previously referred to culminated in 1832, when the production was slightly less than 5,000,000 pounds. From that year to 1845, when it reached its maximum, the output increased enormously, as shown by figure 47. In 1845, the production in round numbers

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92 "A Dutch oven and lid, a long-handled frying pan, a coffee pot, and two tin cups comprised our kitchen furniture."—Fergus' Historical Series, vol. 18, pp. 142-145.  
93 W. V., Settlement of Illinois from 1778 to 1830, p. 472. As late as 1830 but one criminal had occupied the jail for a week in three years. "Not a single case of lynch law stains the record of Jo Daviess County."—History of Jo Daviess County, p. 352.  
94 Wis. Weekly Register, vol. 65, p. 171. Erastus Kent, later connected with Beloit College, asked to be sent as a missionary to a place "so hard that no one else would take it." In 1829 he was sent to Galena.—Pub. No. 10, Hist. Soc. Ill., p. 283.  
Fig. 47.—The heavy line indicates the lead production of the mines of the upper Mississippi region in millions of pounds. The broken part of the line represents uncertainty of information. The light line indicates the lead production of the United States in thousands of tons. (Data for the upper Mississippi River region compiled chiefly from Hunt’s Merchants’ Mag., Niles’ Weekly Register, Galena Gazette, and De Bow’s Review.) As late as 1855 about nine-tenths of this lead was shipped from Galena. In 1866 about one-sixth of the total amount produced in the region came from Illinois.

was 54,500,000 pounds, worth more than $1,600,000⁶⁶ at Galena, whence it was shipped. By way of comparison, it is stated that the Missouri mines produced only about 9,000,000 pounds the next year. From 1820 to 1833 the total output of the upper Mississippi mines had been about 59,000,000 pounds⁹⁷. Between 1820 and 1845 the total production was about

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¹⁷⁷ M., A gazeteer of Illinois, p. 21, 1834.
370,000,000 pounds, and for the most productive decade, 1840 to 1850, it was more than 435,000,000 pounds. The value of the lead taken from the mines between 1821 and 1865 has been estimated at $40,000,000.\textsuperscript{28} The national importance of the mines is indicated in figure 47 which shows the total production of the United States for 1845 to be between 60,000,000 and 65,000,000 pounds and exhibits the parallelism between the production curve for the upper Mississippi mines and that of the entire country. As late as 1852, following the rapid decline in the output of the region, its production was 87 per cent of the American total.\textsuperscript{29} In 1833 England exported about 10,000,000 pounds of lead to the United States, but eight years later the direction of exchange had been reversed.\textsuperscript{30} In 1845 the United States led the world in the production of lead.\textsuperscript{31} Much of the mineral exported went to China. From these considerations it is clear that the mines of the upper Mississippi Valley were of national and international importance.

**Prices of Lead**

Lead brought $2.37 per hundred pounds at St. Louis and $4.00 at Baltimore in 1830.\textsuperscript{32} The prices fluctuated with variations in production, demand, and facilities for transportation. Despite the increasing production to 1845 and the lowering of the tariff on lead in 1846,\textsuperscript{33} the price of lead at Galena rose from $2.24 in 1842 to $5.00 in 1853. Though the total production fell from 54,500,000 pounds in 1845 to about 29,806,000 pounds in 1853, the value of the output of the latter year at Galena was $1,657,988, which was almost $50,000 more than the total for 1845. Figure 48 shows the price of lead at St. Louis from 1832 to 1858.\textsuperscript{34} With the later decline of the mines in this region prices were controlled by factors outside of the district. In 1870 the price of lead at New York was $6.25, in 1880 it was $6.10, and four years later, $4.50.

**Uses of the Lead**

That the lead of this region served the Indians and early trappers and traders in hunting and as currency (especially in the fur trade) has been noted. A large portion of the bullets used in the United States from 1830 to 1860 was manufactured from it. Shot towers were located early at St. Louis and at Hereulaneum 30 miles farther down the Mississippi, and in 1833\textsuperscript{35} the historic shot tower at Helena (Iowa County, Wisconsin) was built. Much lead was converted into sheet metal and lead piping. A lead-


\textsuperscript{30}Hunt's Merchants' Magazine, vol. 8, p. 395.

\textsuperscript{31}Niles National Register, vol. 71, p. 267.

\textsuperscript{32}Galena Advertiser, March 29, 1830.

\textsuperscript{33}Pooley, W. V., Settlement of Illinois from 1778 to 1830, p. 469. The adverse tariff legislation depressed temporarily the price of lead.

\textsuperscript{34}Hunt's Merchants' Magazine, vol. 51, p. 127.

Fig. 48.—The heavy and light lines indicate respectively the lead received at St. Louis from the Galena River and the Missouri mines in millions of pounds; and the price of lead at St. Louis in dollars per hundred pounds (1832 to 1858).

pipe factory was established at St. Louis in 1840, 106 and one at Chicago in 1855. 107 Galena had one lead-pipe and sheet-metal factory as early as 1834, 108 and three in 1860, 109 though most of the lead was shipped from the region in bulk. In 1836 a white-lead factory was established in St. Louis, and others were erected in 1860. Later, when lead began to be shipped eastward, such factories were established at Buffalo. 110

106 Idem.
109 Census reports, 1860.
DISTRIBUTION OF CHIEF MINES

Though two-thirds of the 4,000 square miles included in the area of the mines of the upper Mississippi region were in Wisconsin and but one-sixth in Illinois, the most productive part of the area lay between Dubuque, Galena, and Shullsburg (fig. 45). In 1866 Whitney estimated that one-sixth of the product of the upper Mississippi mines came from Illinois.\(^\text{111}\) In 1860 all the northern Illinois mines in operation were in Jo Daviess County. Nine-tenths of the ore then mined in Illinois came from an area inclosed by a circle having a radius of four miles and centering a little northeast of Galena.\(^\text{112}\) The chief mines in the county were (1) on Apple River, chiefly in Elizabeth Township, (2) the New California diggings in Rice Township, (3) around Galena in East Galena, West Galena, and Rawlins townships, and (4) the Council Hill and Vinegar Hill diggings.\(^\text{113}\)

TRADE ROUTES

Until the early '50's Mississippi River continued to be the chief trade route between the Galena region and the outside world. Most of the lead was collected at Galena. Thence it was shipped down the Galena and Mississippi rivers to St. Louis and New Orleans. From the latter port most of it was sent to New York City by way of the Gulf of Mexico and the Atlantic Ocean. The great bulk of the lead was consumed in the Eastern States, though some was exported from New York. At this time only a little lead was sent directly eastward from the region. Goods were imported into the county from the East, chiefly by the roundabout route to New Orleans and up Mississippi River.

MINERS AND THEIR METHODS OF MINING

In 1857 when Jo Daviess County had a population of about 26,000, only about 3,000 miners were employed about Galena.\(^\text{114}\) Somewhat before this time, therefore, the miners had ceased to dominate the county. Amongst the miners, Cornishmen, Germans, and Irish were prominent.\(^\text{115}\) The average daily wages of a miner ranged from $1.00 to $1.50, and the capitalists realized the large profits.\(^\text{116}\)

The crude log furnaces previously described were succeeded by the "reverberating furnace" which was built of stone and had an oven in which the ore was smelted. By 1866 the Scotch hearth furnace was used exclusively as it saved about 60 to 65 per cent of the metal.\(^\text{117}\) This was built

\(^{111}\)Whitney, J. D., Geology of the lead district: Geol. Survey of Ill., vol. 1, p. 157. In 1840 the Illinois product was 8,775,000 pounds, as compared to 15,129,350 pounds for Wisconsin.—Hunt's Merchants' Magazine, vol. 8, p. 384.

\(^{112}\)Whitney, J. D., Geol. Survey of Ill., vol. 1, p. 155.

\(^{113}\)Shaw, James, Economical geology of Jo Daviess County: Geol. Survey of Illinois, vol. 5, p. 45.

\(^{114}\)Hawes, G. W., Ill. State Gazeteer, 1858-59, p. 91.

\(^{115}\)Idem, 1864-65, p. 375.

\(^{116}\)Niles National Register, vol. 65, p. 171.

under a chimney 30 to 35 feet high and had a cast-iron box in which the ore was smelted. Light wood, coke, and charcoal were used as fuel.

**DECLINE IN PRODUCTION OF LEAD**

The rapid falling off in the production of lead in the region is shown graphically by figure 47, and several causes for this decline may be given: (1) The richer deposits began to give out. (2) By 1850 the shallower diggings were largely exhausted. The individual miner could not afford to buy expensive machinery for deeper mining, and there was a lack of economical machinery for pumping the water from deep shafts. (3) The discovery of gold in California in 1848 diverted from Galena the flow of mining immigrants and also lured to California many miners from the district. (4) Many of the younger miners sought their fortunes under more promising conditions in the copper fields of the Lake Superior region, and in the rich lead and silver mines of the Black Hills and the Rocky Mountains. (5) The reduction of the import duty on lead depressed temporarily the price of lead in New York from $4.25 to $3.50 per hundredweight in 30 days. A temporary drop from $3.05 to $2.50 in Galena followed. (6) Owing to lack of knowledge as to the smelting of the zinc ore found with the lead ore, the increasing abundance as mining reached greater depths caused it to become a great nuisance to the lead miner until after the later '50's. (7) The great demand for laborers in railroad construction and other internal improvements induced many men to drop mining in favor of pursuits insuring more certain returns.

Figure 47 indicates that by 1870 the lead mines of this region were no longer of national importance. After this most of the lead produced was mined only because it occurred with and above the zinc ore. In 1906 the 572 tons of lead produced in Illinois aggregated but .16 per cent of the output in the United States. In 1908 the ratio had fallen to .12 per cent. Lead mining is now merely incidental to zinc mining. The following table summarizes the lead production of the upper Mississippi region:

**Summary of the lead production of the upper Mississippi Valley region, 1821-1904**

<table>
<thead>
<tr>
<th>Years</th>
<th>Tons</th>
<th>Years</th>
<th>Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1821-31</td>
<td>23,244</td>
<td>1861-71</td>
<td>84,700</td>
</tr>
<tr>
<td>1831-41</td>
<td>55,718</td>
<td>1871-81</td>
<td>49,000</td>
</tr>
<tr>
<td>1841-51</td>
<td>215,979</td>
<td>1881-1904</td>
<td>24,000</td>
</tr>
<tr>
<td>1851-61</td>
<td>161,334</td>
<td>Total</td>
<td>611,000</td>
</tr>
</tbody>
</table>

199History of Jo Daviess County, p. 274. The town of Weston illustrates the fluctuating fortunes of the mining district. It was located about 1½ miles east and south of Elizabeth in the SW. 1/4 sec. 32, T. 27 N., R. 2 E. Rich lead mines were discovered there in 1833 and Weston soon had a population of 1000 inhabitants "and 30 saloons." The discovery of large quantities of lead in the immediate vicinity of Elizabeth, together with the discovery of gold in California, caused the depopulation of Weston. Now only two houses remain. Ill. State Geol. Survey, Bull. 16, p. 26.
200Weekly Northwestern Gazette, Aug. 14, 1846. Tariff legislation, however, had little effect in the long run.
203Strong, Moses, Geol. of Wis., vol. 2, p. 750.
EXPLOITATION OF ZINC MINES
PRODUCTION AND USES OF ZINC ORE

Though the presence of zinc ore in the upper Mississippi region was reported officially as early as 1839,124 the ore was neglected and its presence even objected to by the miners till late in the '50's. Thousands of tons lay untouched upon the surface125 or were stored away in abandoned drifts126 where it had been left after having been rudely separated from the lead ore with which it occurred. Unlike the lead, most of the zinc thus far discovered in the upper Mississippi district has been found north of Jo Daviess County.

Not until smelters which extracted the zinc with profit had been established within easy reach, did the zinc industry become important in the region. The first zinc smelter available to the region was established at La Salle, possibly in 1852,127 more probably in 1859 or 1860. The year 1859 witnessed the starting of another smelter at Mineral Point, Wisconsin; and in 1870 the Illinois Zinc Company began operations at Peru, Illinois.128 Some of the ore was shipped to Waukegan, Illinois, to be treated, some to northern Indiana, and some even as far as Charleston, West Virginia.129

It is impossible to give exactly the production of zinc in Jo Daviess County. The total amount of zinc ore produced by the mines of the upper Mississippi Valley to 1876 has been estimated at 127,000 tons.130 Since Wisconsin had produced about 115,000 tons to that date,131 the combined production of Illinois and Iowa had been about 12,000 tons. As Iowa produced very little zinc, and as none was mined in Illinois outside of Jo Daviess County, the 12,000 tons represents approximately the product of the county to 1876. The total product of the upper Mississippi mines to 1904 was about 425,000 tons of ore, worth about $10,000,000.132 From 1860 to 1900 relatively little zinc mining was done in the Galena district. In 1899 rising prices again attracted attention to the region, and since 1903

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130Strong, Moses, Geol. of Wis., vol. 2, p. 742. The product was as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Pounds</th>
<th>Year</th>
<th>Pounds</th>
<th>Year</th>
<th>Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1860</td>
<td>320,000</td>
<td>1866</td>
<td>7,373,333</td>
<td>1872</td>
<td>43,951,544</td>
</tr>
<tr>
<td>1861</td>
<td>266,000</td>
<td>1867</td>
<td>5,022,755</td>
<td>1873</td>
<td>33,628,460</td>
</tr>
<tr>
<td>1862</td>
<td>......</td>
<td>1868</td>
<td>7,380,818</td>
<td>1874</td>
<td>34,623,515</td>
</tr>
<tr>
<td>1863</td>
<td>1,120,000</td>
<td>1869</td>
<td>10,800,400</td>
<td>1875</td>
<td>32,516,400</td>
</tr>
<tr>
<td>1864</td>
<td>3,173,333</td>
<td>1870</td>
<td>11,844,697</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1865</td>
<td>4,198,200</td>
<td>1871</td>
<td>25,921,785</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

the development of zinc mining has been more rapid, especially in southern Wisconsin. In 1903 Jo Daviess County produced about 1000 tons of zinc ore. The total United States output for that year was 325,000 tons. The table below gives the recent output of metallic zinc from the mines of Illinois. Up to 1905 nearly all the zinc mined in Illinois came from Jo Daviess County but a small amount is being produced at present in southern Illinois.

**Metallic zinc mined in Illinois**

<table>
<thead>
<tr>
<th>Year</th>
<th>Production Short tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1906</td>
<td>282</td>
</tr>
<tr>
<td>1907</td>
<td>1146</td>
</tr>
<tr>
<td>1908</td>
<td>298</td>
</tr>
<tr>
<td>1909</td>
<td>675</td>
</tr>
</tbody>
</table>

**CAUSES OF SLOW DEVELOPMENT OF ZINC MINES**

The greater depth at which the zinc ore occurs, as compared with the lead ore, hindered its early mining. The metallurgy of lead is simple, whereas that of zinc is complex; therefore, as long as there was an abundant supply of the former, the zinc ore was thrown aside. The common ores carry a notable amount of iron sulphide, and can be used in ordinary zinc retorts only when mixed with richer ores. Harmful speculation accompanied the rather slow change from individual to corporation mining, a change necessitated by the great depth of the zinc mines as compared with those producing lead and by the complexity in the extraction of the metal. Recently this speculative phase seems nearly to have disappeared. The discovery of rich deposits of easily reduced zinc ore at Joplin made it unprofitable to mine the poorer ores of the upper Mississippi region, until the rise in the price of zinc in 1899. Zinc mining in Wisconsin is now more active than in Jo Daviess County. As the richer and purer deposits give out, and cause a growing demand for poorer grades of zinc carbonates and sulphides, the region probably will become much more prominent in mining than at present.

**INFLUENCE OF MINERAL PRODUCTS ON HISTORY OF REGION**

**INTERNATIONAL IMPORTANCE OF AREA**

The mineral deposits influenced greatly the development of the region. They bestowed upon it for a while local importance in the West and gave it at times international importance. Mining caused the early removal of the Indians and hastened the development of the region. These deposits also affected the region economically and socially.

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133Up to 1905 the zinc deposits of southern Illinois (Pope County) had not yielded zinc ore in commercial quantity.—U. S. Geol. Survey Bull. 246, p. 13, 1905.
136In some cases mining is yet done by individuals. Most of the corporations and companies work independently.
Glowing reports of precious metals as well as of other metals to be found in the region excited early the cupidity of foreign nations. It was only after repeated unsuccessful expeditions into the district that the French and Spanish gave up the hope of securing enormous wealth in it, and left its development to the French-Canadians and the Americans. Because of the lead product of the district, the United States exported lead in 1841 and ranked first in its production in 1845.

LOCAL IMPORTANCE IN WEST

The lead trade was a factor in the early development of St. Louis, New Orleans, and Buffalo. The manufacture of lead in these cities was an industry of some importance. Mineral Point, Dubuque, and Galena within the region owed their early development to the lead. Subsequently Mineral Point, La Salle, Peru, and other places, profited by the establishment of zinc smelters. The location of the mineral deposits undoubtedly intensified the contest between Illinois and Wisconsin over their common boundary.137

REMOVAL OF INDIANS AND EARLY DEVELOPMENT OF REGION

The lead brought the whites into early contact with the Indians, gave the latter a commodity for trade, and introduced them to powder and bullets for hunting and warfare. The eagerness of the whites for the mineral wealth caused them to crowd out of the government reservation into the mineral lands owned by the red men. This resulted in friction and finally in warfare. The outcome of the war was the removal of Indian influence from the region. Compared to the rest of northern Illinois this region received an early start. Mining began when all Illinois contained only a few hundred whites.

PHASES OF DEVELOPMENT

There was first a mining followed by an agricultural phase in the development of the region, each phase attended with the distinguishing characteristics and finally a blending of these types of development. The lead early attracted capital to the district for mining, smelting, and trading purposes. The miners offered a local market to the farmers.138 Though mining increased the value of farm produce, its development destroyed the agricultural value of lands immediately about the shafts and pits.139 Fur-

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137According to Article V of the Ordinance of 1787 the northern boundary of Illinois should have been a line due west from the southern extremity of Lake Michigan (lat. 41° 31' 7" N.). In order to give that State a lake frontage and thereby secure closer relations between Illinois and the North and East in case of a contest between the North and South, or Southwest, the northern boundary of Illinois was made 42° 30' N., thereby adding to its area the northern tier of 14 counties. Serious objection to the measure was aroused both within the territory of Wisconsin and in Jo Daviess County, which lasted till the territory became a State. The heavy State debt of Illinois was an added factor to the objection from the lead interests in Jo Daviess County.—Wis. Hist. Soc. Collections, vol. 11, p. 495; Annals of Congress (1818) vol. 2, p. 1677; History of Jo Daviess County, p. 224; Miners’ Journal, Oct. 23, 1828.

138Farmers from as far away as Rock River always had a ready sale for their produce.—Chetlain, A. L.: Recollections of seventy years, p. 27.

139Barber and Howe, Our whole country, vol. 1.
thermore, it took from the farms many laborers who were sorely needed in early days.

**ECONOMIC AND SOCIAL INFLUENCES**

The opportunities afforded by the region attracted many business men—bankers, merchants, politicians, and lawyers. But the ores also attracted adventurers from far and near, and caused the introduction of slaves into the State.

The miners refused to sell their lead for paper money during the early mining period, and as a result, English gold flowed into the region. The panics of 1837 and 1857 are said to have been felt less severely here than in many other places. At times the lead served both the miners and Indians as currency. On the other hand, the element of chance in mining increased the evils of speculation to an even greater extent than elsewhere along the American frontier during the period of rapid settlement. Speculation in zinc mines was a cause of their slow development between 1880 and 1900.

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**Footnotes:**

140 Among some of the lawyers who "got their start" in this region were the following:
- Thomas Ford, at one time governor of Illinois.
- Jesse B. Thompson, once a member of the U. S. Supreme Court.
- Benjamin Wells, at one time lieutenant governor of Illinois.
- T. C. Brown, once a member of the Supreme Court of Illinois.
- Thomas Drummond, who was District Judge for the Northern District of Illinois.
- Gen. U. S. Grant was a citizen of Galena.

141 Chetlain, A. L. Recollections of seventy years, pp. 27 and 48.

As shown by figure 50 the rise and decline in population was rapid for the townships which produced much lead, and gradual for those which produced no lead. In 1870 the percentage of foreign born in the lead-producing sections was 35.5, as compared to 18.2 in other portions of the county. Data have been advanced implying that the lead-producing townships are less valuable for farming purposes than the non-mining townships, and that where there has been any decline in productivity, the rate has been greater in the mining communities.

![Graph showing population change](image)

Fig. 50. The heavy, dark line shows the change of population per square mile in townships where lead was found abundantly; the broken heavy line, where some lead was found; and the light line, where no lead was found. Figures refer to thousands of inhabitants (data from Palmer).

The following table, showing valuation of personal and real property per capita in the mining and non-mining townships, implies the superiority

<table>
<thead>
<tr>
<th>Items</th>
<th>Townships</th>
<th>Per capita value in 1885</th>
<th>Per capita value in 1895</th>
<th>Change in value</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural products</td>
<td>Lead-producing group</td>
<td>$54.8</td>
<td>$52.8</td>
<td>$2.8</td>
<td>—3.6</td>
</tr>
<tr>
<td></td>
<td>Non-mining group</td>
<td>80.4</td>
<td>77.4</td>
<td></td>
<td>—3.7</td>
</tr>
<tr>
<td>Live stock</td>
<td>Lead-producing group</td>
<td>94.9</td>
<td>69.5</td>
<td>—25.4</td>
<td>—26.8</td>
</tr>
<tr>
<td></td>
<td>Non-mining group</td>
<td>121.3</td>
<td>98.9</td>
<td></td>
<td>—18.4</td>
</tr>
<tr>
<td>Farming implements</td>
<td>Lead-producing group</td>
<td>10.2</td>
<td>7.1</td>
<td>—3.1</td>
<td>—30.4</td>
</tr>
<tr>
<td></td>
<td>Non-mining group</td>
<td>14.0</td>
<td>11.3</td>
<td></td>
<td>—19.3</td>
</tr>
<tr>
<td>Dairy produce</td>
<td>Lead-producing group</td>
<td>8.7</td>
<td>12.5</td>
<td>$4.8</td>
<td>+43.7</td>
</tr>
<tr>
<td></td>
<td>Non-mining group</td>
<td>9.4</td>
<td>16.0</td>
<td></td>
<td>+70.2</td>
</tr>
</tbody>
</table>


145 Based partly on data from Palmer, Loc. cit.:
of the latter, as does the accompanying table of general land values.\textsuperscript{146} It is probable that the townships producing much lead, since underlain immediately by the resistant Galena limestone, are more rugged than the others. On the other hand, most limestone is covered with good soil.

\textit{Valuation of personal and real property per capita in Jo Daviess County}

<table>
<thead>
<tr>
<th>Townships</th>
<th>1860</th>
<th>1870</th>
<th>1880</th>
<th>1890</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining group</td>
<td>$124.54</td>
<td>$102.57</td>
<td>$120.66</td>
<td>$102.24</td>
</tr>
<tr>
<td>Non-mining group</td>
<td>135.45</td>
<td>142.04</td>
<td>214.13</td>
<td>195.77</td>
</tr>
</tbody>
</table>

\textit{Average value of all land per acre in Jo Daviess County}

<table>
<thead>
<tr>
<th>Townships</th>
<th>1880</th>
<th>1885</th>
<th>1890</th>
<th>1895</th>
<th>1898</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining group</td>
<td>$6.69</td>
<td>$7.30</td>
<td>$5.91</td>
<td>$5.74</td>
<td>$5.18</td>
</tr>
<tr>
<td>Non-mining group</td>
<td>7.80</td>
<td>8.65</td>
<td>7.01</td>
<td>7.24</td>
<td>7.33</td>
</tr>
</tbody>
</table>

The vote of the mining townships ordinarily has been Democratic, and that of the non-mining communities Republican,\textsuperscript{147} probably because many of the miners came from the South and many of the farmers from New England. It is claimed that "the greater the importance of lead mining in early days, the more marked the decline and stagnation in the economic life of the later period."\textsuperscript{148} Again, it is maintained that the mining townships, with better soil, are growing in population at a slower rate than the non-mining sections of the region, and that during years of decline the decrease has been greater in the lead-producing communities. It is held that the inhabitants of the lead townships have been slow to adjust themselves to changing economic conditions.\textsuperscript{149} In Jo Daviess County it would be difficult to say to what extent the results noted are due to the presence of the ore and to what extent they should be attributed to the rugged topography and to other factors not mentioned here. The data given above, however, seem to imply in some ways the economic inferiority of the mining to the non-mining townships.

\textbf{Development of Agriculture in Jo Daviess County}

To the close of the Black Hawk War of 1832 farming had been relatively unimportant in the lead district, most of the immigrants being interested primarily in mining. Between 1830 and 1860 many farmers came, not mostly from the South as did most of the early miners, but largely from the Middle and Eastern States, especially from New England and New York.\textsuperscript{150}

\textsuperscript{146}These figures are not absolutely correct, since (1) the area of the townships has varied somewhat, and (2) they are based on values assessed in taxation. The comparison between the two groups is fairly accurate, however. The table is based on data from Trans. Wis. Acad. of Sci., Arts and Letters, vol. 13, pp. 215, 256, 257.


IMMIGRATION OF FARMERS

CAUSES OF IMMIGRATION

Chief among the causes for this movement were: (1) unfavorable economic conditions in New England and other parts of the East, (2) the northward crowding of settlers from southern Illinois, (3) the attraction of cheap farming land, (4) the lead mines, (5) the Black Hawk War, and (6) improved methods of transportation.

1. Because of its isolated position with reference to the interior, its rough topography, excellent supply of timber, and its proximity to, and good harbors on, the Atlantic, New England previously had sought prosperity chiefly in shipbuilding, fishing, and the carrying trades. Rigid climatic and poor soil conditions had also influenced the development of sea interests. But with (a) the decline of her shipping, (b) the substitution in many places of sheep and cattle raising for agriculture, (c) the complete occupation of the more fertile valleys, (d) the increasing agricultural competition of the more productive western fields, and (e) the displacement of native workers in many mills by foreign immigrants, New England in the decade 1820-1830 began to pour tens of thousands of emigrants into the more promising western lands. This emigration later was given added impetus by the financial panic of 1837. The attractive conditions on the frontier also caused large numbers to go into the West from New York and the Southern States where economic discontent was current.

2. Southern Illinois was settled earlier than the northern part of the State mainly for four reasons: (a) Most of the early immigration into the State was from the land-hungry South, especially Kentucky and Tennessee; (b) the most important waterways available for transportation from older settlements, especially the Cumberland, Tennessee, and Ohio rivers, focused on the southern border of the State; (c) before the opening of the Erie Canal immigration from the East was comparatively slow; and (d) the northern part of the State was occupied by Indians longer than its southern part. By 1840, settlers from southern Illinois had begun to push into the northern tier of counties. The immigrants from the southern to the northern part of the State were, however, fewer than those from the east.

3. Having abandoned its early policy of selling the public lands primarily for revenue, the Federal government reduced the price of lands in the Middle West from $2.00 per acre in 1786 to $1.25 per acre in 1820. The minimum size of the farms permitted to be taken up also had been reduced from 640 to 80 acres. The preemption law gave the "squatter" the first right of purchase when the lands should be opened for sale. Immigrant farmers into Jo Daviess County took advantage of these provisions.


\[126\] Idem, pp. 64-67.

especially since the prairie lands were found to be interspersed with groves of timber. 154

4. To the inducement of the virgin farm lands was added the attraction of the rich mineral deposits.

Though the Black Hawk War temporarily drove many of the settlers of northern Illinois south and east of Illinois River, 155 it greatly stimulated later immigration into the Galena district (and all the northern counties as well) since, because of it, the region became well known to the settlers, who advertised the advantages of the region widely, as did the glowing descriptions of eastern newspapers and pamphlets. 156 Furthermore, the war resulted in the removal of the powerful Sacs and Foxes beyond the Mississippi, and hence brought serious danger from the Indians to an end.

Principal Routes to Galena District

Before the opening of the Erie Canal in 1825, the journey from New England over the Appalachian Mountains to the West by sea, by river, or by turnpike was slow, difficult, and expensive. 157 Before the construction of the canal it cost $100, and it took 20 days, to send a ton of freight from Buffalo to New York City. But after the completion of the canal, which followed the low Hudson-Mohawk passageway into the interior, the figures fell rapidly to $15 and $25 and 8 days. Later the rates were reduced even more. The rate from Ohio to the seaboard fell in some cases to one-tenth of the earlier rate. 158 The route of the canal, since it became a busy line of travel and traffic, acted as a powerful bond of union between the East and what was then the West.

Of still greater importance to the settlement of northern Illinois was the development of steam navigation on the Great Lakes, for it was “the great pervading power which influenced the settlement of northern Illinois and built up this portion of the State with astonishing rapidity and which gave the northern character to its population.” 159 Beginning with three sailing vessels in 1831 and one steamboat in 1832, the arrivals of lake vessels at Chicago increased rapidly to 456 in 1836. 160 In 1839 the first regular line of steamboats was established between Buffalo and Chicago. By 1848 there were 400 vessels, including more than 64 steamers, navigating the lakes 161 In 1845 steamboats carried 97,736 passengers from Buffalo west-

154 Possibly one-fifth of the whole mining tract was in timber.—Miners' Jour., Sept. 13, 1828. Another estimate was one-tenth.—Wis. Hist. Soc. Collections, vol. 11, p. 400. Timber was of great importance to the settlers for fuel and building purposes. For a long time prairies were thought to be infertile. For these and other reasons the prairies were avoided by early settlers.


157 Barrows, H. H., idem, p. 68.


161 Niles Weekly Register, vol. 5, p. 274.
ward, of whom 20,244 landed at Chicago.\textsuperscript{162} Immigration into the West was made easy and cheap, since the time of travel from Buffalo to Chicago was reduced from two weeks, to two days and two nights, while cabin fare fell from $20 to $6 and $8. It was easy also to carry household goods, farming implements, stock, and other items.

From Chicago the route of most of the immigrants into the Galena district was overland. The first wagon road from Chicago to Galena was constructed in 1833,\textsuperscript{163} though wagon trips between the two localities had been made as early as 1829. A map in Mitchell’s “Illinois in 1837” indicates a road between the two places. In 1839, Frink and Bingham’s stage line from Chicago to Galena advertised that it would carry passengers for $12.50 each, and make the journey of 160 miles in two days.\textsuperscript{164} This stage line was the chief of the overland routes from Chicago to the Mississippi.\textsuperscript{165} Schooners drawn by oxen or mules often were used by immigrants not depending on the stage line.

Immigrants could also cross the Appalachian Mountains and reach Galena by way of the Ohio and Mississippi rivers. After the completion of the Illinois and Michigan Canal in 1848, settlers could travel by water from Chicago to the Mississippi and up to the lead region. These roundabout routes were less important than the direct overland route from Chicago to Galena.

The final factor in the settlement of the county was the connection of Galena with Chicago by railroad in 1855.\textsuperscript{166} With this excellent means of transportation at hand the last few thousands of pioneers rapidly took up most of the unoccupied lands of the county.

**Numbers and Sources of Immigrants**

As early as 1828 “farmers were daily settling in the vicinity” of Galena,\textsuperscript{167} and before the Black Hawk War a few people had settled along the Chicago-Galena route in secluded ravines.\textsuperscript{168} It was not till after the close of that war, however, that the immigration of farmers became great. The magnitude and rate of the inflow is suggested by figure 44. The panic of 1837 checked the influx temporarily, but by 1839 immigrants were again crowding into the region. It was estimated that in the fall of 1839 the farmers paid between $300,000 and $400,000 in “proving up” their pre-emption rights.\textsuperscript{169}

Whence the settlers came has already been touched upon. The large foreign element in the population and the preponderance of settlers from

\textsuperscript{162}Albach, Annals of the West, pp. 958-959.
\textsuperscript{163}History of Jo Daviess County, p. 456.
\textsuperscript{164}Northwestern Gazette and Galena Advertiser, Jan. 16, 1836
\textsuperscript{165}Pooley, W. V., Settlement of Illinois from 1778 to 1830, pp. 438-439.
\textsuperscript{166}Chicago Daily Journal, Jan. 21, 1856.
\textsuperscript{167}Miners’ Journal, Oct. 25, 1828.
\textsuperscript{168}Hoffman, C. F., A winter in the West.
\textsuperscript{169}Niles Weekly Register, vol. 57, p. 204.
the east is indicated in the following table showing the sources of some of the early settlers; but too much reliance cannot be put on so scant data:

<table>
<thead>
<tr>
<th>State</th>
<th>Number of settlers</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York</td>
<td>12</td>
</tr>
<tr>
<td>New England</td>
<td>8</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>11</td>
</tr>
<tr>
<td>Maryland</td>
<td>7</td>
</tr>
<tr>
<td>Ohio</td>
<td>6</td>
</tr>
<tr>
<td>Illinois</td>
<td>3</td>
</tr>
<tr>
<td>Missouri</td>
<td>2</td>
</tr>
<tr>
<td>Kentucky</td>
<td>1</td>
</tr>
<tr>
<td>Virginia</td>
<td>1</td>
</tr>
<tr>
<td>Delaware</td>
<td>1</td>
</tr>
<tr>
<td>Foreign (mostly Irish, English, and German)</td>
<td>21</td>
</tr>
<tr>
<td>Total</td>
<td>73</td>
</tr>
</tbody>
</table>

DISTRIBUTION OF EARLY POPULATION

That the lead deposits were still the controlling factor in the distribution of the population is shown by the fact that in 1840 the lead-producing townships, excluding the city of Galena, had an average population of 15.3 per square mile and including that city, of 37 per square mile, whereas the remaining townships averaged only 6.3 inhabitants per square mile. As late as 1860 the strictly lead-producing townships (fig. 50) excluding Galena had an average population of 44 per square mile, whereas the purely agricultural townships averaged but 34 for the same unit area.

An adequate supply of drinking water influenced the location of many farms. It was difficult for early settlers to sink the necessarily deep wells on the Niagaran limestone ridges. Many crumbling log houses are found where springs issued at the contact of the Maquoketa shale with the Niagaran limestone (fig. 18). All smelting furnaces were located near a water course, from which water was led in pipes to wash the ore that was placed in troughs.

CONDITIONS OF PIONEER LIFE

DISADVANTAGES OF DRIFTLESS AREA

The development of Jo Daviess County has been influenced as much by its mature topography as by its mineral deposits. Since much of the county is dissected, the soil is thin and easily washed. This is especially true on the steep slopes of the resistant limestone; the gentler slopes of the softer shales afford the soil better lodgment. Furthermore, the soil in the

170 Extract from "Old Settlers Journal" in History of Jo Daviess County, p. 371. These people were present at an "Old Settlers Reunion" held at Galena.


172 The chief lead-producing townships were: East Galena, Council Hill, Scales Mound, Rice, Vinegar Hill, Rawlins, West Galena. The purely agricultural sections were: Dunleith, Rush, Nora Wards Grove, Berreman, Hanover, Derinda, Pleasant Valley.—Palmer, idem.
Driftless Area has not been enriched by the deposition of glacial material.\textsuperscript{173} Since many of the farms of this district are partly on slopes, farmers have not been able to use machinery to the best advantage. The heavy grades of the much-washed roads have been an added source of expense to the farmer and miner in drawing produce to market. Every person who moves about or ships goods in the county pays a toll of time and money to the steep-graded, circuitous roads and railroads.\textsuperscript{174} The dissection of the country, however, exposed the mineral deposits and made them accessible to the miner. For a more detailed discussion of the influence of topography and soils upon the region in later days the reader is referred to the discussion of agriculture.

**EARLY SUPPLY OF TIMBER**

From about one-tenth to one-fifth of the entire mining region was originally in timber, most of which was in groves along stream courses.\textsuperscript{175} Though it consisted mainly of hardwood,\textsuperscript{176} very little of the timber was fit for large buildings, except that in the largest groves along the bluffs of the Mississippi. The scarcity of timber in northern Illinois enhanced its value to the farmer for fuel and building purposes, and to the early miner for smelting, especially since there were no coal deposits within easy reach. For a long time the settlers of Illinois remained near the timber and avoided the prairies.\textsuperscript{177} The local supply of timber evidently was not enough for both farming and mining purposes, for as early as 1848 Galena imported five million feet of lumber, and two and one-half million shingles, besides laths, cordwood, and other small timber. More than half of that amount was imported in 1842.\textsuperscript{178} The immigrants early learned to supplement the slender supply of timber by using the abundant limestone of the region in their building operations.

**EARLY AGRICULTURAL CONDITIONS**

In the pioneer period from one-third to one-half of the county was fit for farming.\textsuperscript{179} The southern tier of townships was early described as uneven, with some prairie land, and the western and northwestern portions as generally timbered, hilly, rocky, and characterized in many places by bluffs. The same writer spoke of the uneven and partly timbered central

\textsuperscript{173}Glacial deposition does not always enrich the soil. The factors involved are the character of the preglacial topography, the nature of the residual soil depending on the kind of bed-rock outcropping in the region, and the kind of material which the glacier has deposited. Some of the large farms on the gentle slopes of the Maquoketa shales in the region support well-to-do owners. Even here, however, the number of people supported per acre is not as great as in adjoining Stephenson County, where glacial deposition prevailed.

\textsuperscript{174}Great expense was encountered in the construction of the Illinois Central Railroad between Freeport and Galena.—Flint, Railroads of the U. S.


\textsuperscript{176}Miners' Journal, Sept. 13, 1828.

\textsuperscript{177}History of Carroll County, p. 253; Pooley, W. V., Settlement of Illinois, p. 639.


townships, and the warm, deep, prairie soil of the east and the northeast.\(^{180}\)

In 1850 some 198,150 acres within the county were classed as farm land. Of this farm land 60,311 acres (30 per cent) were classed as improved and 137,839 acres as unimproved. By 1860, 256,910 acres had become farm land and 119,993 acres (47 per cent) were held to be improved.\(^{181}\) The average value of farm land in 1850 was $6.60 per acre as compared to $36 forty years later. The value of machinery used per farm acre at these dates was $0.48 and $1.04.

Agriculture first became important in the region in 1829, partly as a result of a depression in mining due to an over-production in lead.\(^{182}\) By 1840, 876 farmers were in the county and 617 miners.\(^{183}\) In 1842 the region began exporting breadstuffs.\(^{184}\) Corn was the leading agricultural product of pioneer days, some 2500 acres having been planted to that cereal in 1829. Corn did not require complete clearing of the land, as it was cultivated easily, had a long harvest, gave a large yield, and was easily stored and prepared for consumption, besides being available for food for both man and beast. Oats, next in importance to corn, was raised in the region ‘‘in large quantities’’ by 1828.\(^{185}\) Wheat (first exported from the district in 1847)\(^{186}\) was an important cereal. Much hay and large quantities of potatoes, as well as some rye, barley, and a little flax, were raised. The grass on the prairies and steep slopes was available for pasturage, and this led to the development of dairying. Galena was an important meat-shipping center, since the farmers found it profitable to convert their bulky corn into meat before sending it to market.\(^{187}\) Stock often was driven many miles to Galena to be slaughtered.

Owing to the cheapness and roughness of the land and the inexperience\(^{188}\) and carelessness of many of the immigrants, farming methods were wasteful with reference to soil fertility. Rotation of crops was not usually practiced.\(^{189}\) Yet from his point of view the settler succeeded; he derived much from the soil with the least possible expenditure of labor. In a small way many farmers prospected and mined on their farms during fall and winter.

\(^{180}\)History of Jo Daviess County, p. 817.

\(^{181}\)Census reports for 1850 and 1860.

\(^{182}\)Galena Advertiser, Sept. 21, 1829.

\(^{183}\)Compendium of the 6th Census, p. 83.


\(^{185}\)Miners' Journal, Sept. 20, 1828.

\(^{186}\)Niles Weekly Register, vol. 60, p. 304.

\(^{187}\)Chicago Daily Journal, Dec. 27, 1856; Ill. State Gazeteer, 1864-5, p. 375. In 1850 Jo Daviess County had 3,951 milch cows, 3,637 other cattle, 5,817 sheep and 13,912 swine. The total value of live stock was $239,584. The value of animals slaughtered that year was $44,957. The county produced 207,288 bushels of wheat, 220,650 bushels of corn, 250,386 bushels of oats, 658 bushels of rye, and 20,029 tons of hay.—U. S. Census, 1850.

\(^{188}\)"One of the neighbors came and told us it was time to attend to our fields, and offered to show us how to plant corn."—Rudolf; Wis. Hist. Soc. Collections, vol. 15, p. 353.

\(^{189}\)Johnston, W. J., History of Stephenson County, p. 99. But in 1855 and 1868 respectively, agricultural and horticultural societies were organized in Jo Daviess County.—History of Jo Daviess County, pp. 423 and 431.
Mills

The region was fortunate in having abundant mill sites,\textsuperscript{190} since two of the most pressing needs of the pioneer settlers were saw mills and grist mills. Without the latter the settler had to pound and grind his grain. For this purpose it was placed in a shallow depression burned in the top of a hardwood log and ground with a rude, iron-capped club.\textsuperscript{191} The first saw mill in the county was established in 1827, and the first grist mill a year later.\textsuperscript{192} This mill was run by water power and was situated near the northern edge of Galena. The map of 1829 (fig. 45) gives the location of the early smelters, and of Craig's and Loramier's mills. In 1857 Galena had three saw mills and a steam flour mill.\textsuperscript{193} Ruins of old mills still exist just northeast of Galena, on Galena River a few miles above the city, also at the site of Millbrig a few miles farther up, and at Millville at the forks of Apple River. The water power at Hanover was used at an early date to grind wheat and corn; but as late as 1841 flour was hauled by wagon from Milwaukee to Galena, where it sold for $7.00 a barrel.\textsuperscript{194}

Early Privations

Isolated in the northwest corner of the State, and dependent for supplies upon St. Louis and New Orleans, the early settlers had only the bare necessities of life. Rude huts of rough-hewn logs or saplings, less often of stone, were the rule. Some were covered with bark, others with rough slabs. Clapboard doors, clay chimneys, puncheon floors of logs and slabs rudely smoothed, chairs made of logs and tables of roughly split wood, were in harmony with the home-spun garments, and the rough exterior of the pioneers. Wild game could be brought down in the woods, and all the streams abounded in fish.\textsuperscript{195} Because of the extensive lead trade which the region enjoyed, with St. Louis and New Orleans as well as with New York indirectly, the conveniences of civilized life probably appeared relatively early in the district.

Social Relations

The agricultural pioneers of northern Illinois differed from those of the southern part of the State in that the former were primarily farmers, whereas the latter belonged to the hunter-farmer type. The thrifty New Englanders and easterners brought their customs and educational and religious ideals with them. Despite their primitive surroundings, many of the settlers travelled frequently in their section of the country and always

\textsuperscript{190}Miners' Journal, Sept. 14, 1828.
\textsuperscript{191}Johnston, W. J., History of Stephenson County.
\textsuperscript{192}History of Jo Daviess County, p. 251. The hopper of this mill held about a peck and the building sheltering it was a dry-goods box.
\textsuperscript{193}Hawe's Ill. State Gazetteer, 1858-59, p. 91.
\textsuperscript{194}Stewart: Pub. Hist. Lib. of Ill., No. 8, p. 121.
\textsuperscript{195}Galena Advertiser, Oct. 15, 1829.
were ready to pass common-sense judgments on what they saw.\textsuperscript{196} Even the poorest settler was received with blunt frankness and hearty hospitality, provided he did not criticise the manners of the people nor complain of the disadvantages of the new country.\textsuperscript{197}

**AGRICULTURE THE DOMINANT INDUSTRY**

**IMPORTANCE OF AGRICULTURE**

In 1870 the value of the agricultural products of Jo Daviess County was almost three times that of the lead produced by all the upper Mississippi River mines in 1873. Exact figures are not available, but the agricultural products outvalued the mineral "raised" in the county certainly as early as 1860, probably as early as 1855, and possibly even earlier. It will be remembered that in 1840 the farmers outnumbered the miners 876 to 617,\textsuperscript{198} and that the region began to produce a surplus of breadstuffs in 1842.\textsuperscript{199} Agriculture had become the dominant industry in the county.

Corn, oats, and wheat continued to be the chief cereals, and potatoes the chief vegetable. Hay was an important crop. Owing to the ruggedness of the topography, stock raising, and particularly dairying, had become relatively more important.

In general the agricultural products were those of pioneer days produced on a larger scale. For details concerning the products the reader is referred to the United States Census Reports of 1860 to 1910.

**AGRICULTURE IN THE DRIFTLESS AREA**

Except on its eastern edge, Jo Daviess County is devoid of glacial deposits. Stephenson County to the east has a gently undulating surface and a deep soil, very heterogeneous in composition. Both topography and soil are a result principally of glacial deposition. Like Jo Daviess County, Stephenson County is dominantly agricultural. The tables\textsuperscript{200} below show that Stephenson County has had: (1) the greater amount of improved, and (2) the smaller amount of unimproved, farm land per square mile, (3) a greater value for its agricultural machinery per farm-acre, and (4) higher priced land, which (5) has produced more per farm-acre. Furthermore, Stephenson County has an increasing population which is more dense than that of Jo Daviess County. For years the population of the latter has been slightly decreasing.\textsuperscript{201} These figures imply that Stephenson County has been able to sustain a larger population per unit area than Jo Daviess County, but it does not follow that some of the better farms of the latter

\textsuperscript{198}Compendium of the 6th Census, p. 83.
\textsuperscript{199}Hunt's Merchants' Magazine, vol. 8, p. 83.
\textsuperscript{200}U. S. Census reports.
\textsuperscript{201}This may be due in part to the decline in the mining industry.
county have not been as productive as those of Stephenson County; nor does it follow that all glaciated land is better than unglaciated land. The pre-glacial topography, the topography and composition of the drift, and the character of the bed rock all enter into the problem. In general, however, it is safe to say that glacial deposition has enriched materially the north-central part of the United States.

Comparison of farm values in Jo Daviess and Stephenson counties

<table>
<thead>
<tr>
<th>Year</th>
<th>County</th>
<th>Value of farm land per acre</th>
<th>Per cent of farm land improved</th>
<th>Value of farm machinery per acre of farm land</th>
<th>Agricultural products per farm acre</th>
<th>Population per square mile</th>
<th>Improved acres per square mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>1850</td>
<td>Jo Daviess</td>
<td>$6.70</td>
<td>30.4</td>
<td>$.48</td>
<td>. . .</td>
<td>28.2</td>
<td>91.9</td>
</tr>
<tr>
<td></td>
<td>Stephenson</td>
<td>9.40</td>
<td>37.4</td>
<td>.53</td>
<td>. . .</td>
<td>20.9</td>
<td>135.2</td>
</tr>
<tr>
<td>1860</td>
<td>Jo Daviess</td>
<td>18.50</td>
<td>46.7</td>
<td>.87</td>
<td>. . .</td>
<td>41.4</td>
<td>182.9</td>
</tr>
<tr>
<td></td>
<td>Stephenson</td>
<td>23.50</td>
<td>70.3</td>
<td>1.02</td>
<td>. . .</td>
<td>45.1</td>
<td>376.6</td>
</tr>
<tr>
<td>1870</td>
<td>Jo Daviess</td>
<td>31.00</td>
<td>55.2</td>
<td>2.05</td>
<td>$8.90</td>
<td>42.4</td>
<td>238.6</td>
</tr>
<tr>
<td></td>
<td>Stephenson</td>
<td>46.90</td>
<td>81.7</td>
<td>1.66</td>
<td>10.00</td>
<td>54.9</td>
<td>457.4</td>
</tr>
<tr>
<td>1880</td>
<td>Jo Daviess</td>
<td>28.20</td>
<td>67.5</td>
<td>.95</td>
<td>4.90</td>
<td>41.9</td>
<td>356.0</td>
</tr>
<tr>
<td></td>
<td>Stephenson</td>
<td>43.80</td>
<td>88.4</td>
<td>1.54</td>
<td>7.44</td>
<td>57.4</td>
<td>553.4</td>
</tr>
<tr>
<td>1890</td>
<td>Jo Daviess</td>
<td>36.00</td>
<td>68.5</td>
<td>1.04</td>
<td>4.50</td>
<td>38.3</td>
<td>364.6</td>
</tr>
<tr>
<td></td>
<td>Stephenson</td>
<td>53.40</td>
<td>89.9</td>
<td>1.59</td>
<td>6.70</td>
<td>56.1</td>
<td>535.5</td>
</tr>
<tr>
<td>1900</td>
<td>Jo Daviess</td>
<td>. . .</td>
<td>67.7</td>
<td>1.15</td>
<td>. . .</td>
<td>37.4</td>
<td>376.8</td>
</tr>
<tr>
<td></td>
<td>Stephenson</td>
<td>. . .</td>
<td>87.7</td>
<td>1.85</td>
<td>. . .</td>
<td>62.7</td>
<td>549.6</td>
</tr>
</tbody>
</table>

HISTORY OF LAND VALUES

In 1850 the average value of farm land in Jo Daviess County was $6.60 per acre. In 1900 the figures had risen to $36.00. Exact values for 1910 are not yet available, but it is estimated from data given by land owners in various parts of the county that the present average is between $50.00 and $70.00 per acre, probably nearer the former. Among the factors which have influenced the value of land in this county from time to time are: (1) the available supply of fertile, free land; (2) the supply of agricultural products in relation to the demand for them; (3) the supply of labor and of capital; (4) accessibility to market; (5) improvements on the land; (6) the mineral content of the farm; and (7) its state of cultivation. Lack of space permits a fuller statement of the last factor only.

METHODS OF CULTIVATION

Farm values in the county will be affected more and more by the methods of agriculture used in it. In pioneer days the soil was virgin and land was plentiful, hence wasteful methods of cultivation prevailed. Such precautions as rotation of crops, guarding against soil wash, systematic application of manure and fertilizer, selection of the best grain for plant-
ing, and other conservational methods were almost unheard of. Many farmers ploughed when they saw their neighbors ploughing, and planted without greater thought. As a result, some of the land has become unproductive and much of it has deteriorated in fertility. If land values in the county are to be increased, or even maintained, up-to-date methods of restoring and preserving the fertility of the soil must be adopted generally. Land values in the region probably will rise with better methods of tillage, and adjustment of crops to the climate and to the various types of topography and soil. Many steep slopes are being preserved from excessive wash, and their soils enriched by being converted into pasture lands, a process which is increasing the value of such lands. Should the steeper limestone slopes be sown to alfalfa, their value would doubtless increase. The reforesting of the steepest slopes would have a similar effect. Some 500 farmers in Wisconsin recently have succeeded in doubling their corn crops, mainly by the scientific selection of seeds for planting. By these and related processes the land value of Jo Daviess County could be increased.

PRESENT LAND VALUES

The influence of topography, soil, and accessibility to market is reflected in the present value of land in various parts of the county. In the vicinity of Elizabeth and Galena, where the maturely dissected, resistant Galena limestone presents a rough topography, land sometimes sells as low as $40.00 per acre, which also is true of the broken upland of the Niagaran limestone in the south and southeast parts of the county. Some of the bluffs and sandy bottoms along Mississippi River have sold recently for $25.00 to $30.00 per acre. Near Stockton the rough Niagaran limestone ridges are said to command $60.00 to $75.00 per acre, whereas the gentler Maquoketa slopes are worth $100.00. In this vicinity $160.00 per acre is paid for land on the flattish upland covered by glacial deposits. One parcel of this land is said to have sold for $300.00 per acre. The above figures are not exact and are given only to suggest the general situation. For example, some land about Galena sells for $80.00 to $100.00 per acre. The best land in the vicinity of Elizabeth is said to be worth $85.00 per acre, and the average near $75.00. About $100.00 is the highest price now paid for farm land in the vicinity of Hanover. Factors other than those named above help to determine land values in the county; but in a general way the above figures illustrate the variations which are found in the different geographic divisions of the county.

MANUFACTURING IN JO DAVIESS COUNTY

The early development of grist mills and saw mills run by water power has already been discussed under the subject "Mills." By 1858 Galena had become the chief manufacturing center of the county. Besides saw
mills, brick kilns, and lime kilns, the city had seven breweries, three leather finishing houses, three soap and candle factories, and two iron foundries, as well as wagon shops, lumber yards, and pottery plants. Few of the other towns did much manufacturing. Elizabeth and Hanover had small woolen mills in 1864, and Warren a plow factory. In 1860 lead smelting and the making of flour and meal were by far the most important manufactures of the county, as shown by the following summary:

Manufactures of Jo Daviess County in 1860

<table>
<thead>
<tr>
<th>Products</th>
<th>Number of establishments</th>
<th>Hands employed</th>
<th>Value of products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour and meat</td>
<td>11</td>
<td>27</td>
<td>$272,979</td>
</tr>
<tr>
<td>Lead smelting</td>
<td>5</td>
<td>39</td>
<td>254,900</td>
</tr>
<tr>
<td>Agricultural implements</td>
<td>4</td>
<td>41</td>
<td>55,710</td>
</tr>
<tr>
<td>Carriages</td>
<td>9</td>
<td>32</td>
<td>41,515</td>
</tr>
<tr>
<td>Clothing</td>
<td>2</td>
<td>45</td>
<td>37,000</td>
</tr>
<tr>
<td>Provisions, pork, etc.</td>
<td>2</td>
<td>11</td>
<td>35,711</td>
</tr>
</tbody>
</table>

The general development of manufactures within the county in later years is summarized in the table below. By 1880 the slaughtering and meat-packing industry had reached a value of $553,589, as against $139,657 for the flour and grist-mill products, its nearest competitor. The meat-packing industry probably was stimulated by the growth of stock raising and dairying in the county, an adjustment to the rough topography. Most of the meat-packing and slaughtering business of the county has now been absorbed by Chicago. Clothing, lumber, agricultural implements, soaps, and candles followed in this order after grist-mill products. By 1880 the gross value of the manufactured products of the county equalled that of its agricultural products, due partly to the low prices of the latter; but in 1890 the value of agricultural products was more than twice as great as that of manufactured goods.

Growth of manufacturing in Jo Daviess County

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of manufacturing establishments</th>
<th>Wage earners (employees)</th>
<th>Capital invested</th>
<th>Gross value of products</th>
</tr>
</thead>
<tbody>
<tr>
<td>1860</td>
<td>69</td>
<td>266</td>
<td>$830,375</td>
<td>$620,860</td>
</tr>
<tr>
<td>1870</td>
<td>133</td>
<td>786</td>
<td>$1,695,299</td>
<td>$1,252,515</td>
</tr>
<tr>
<td>1880</td>
<td>194</td>
<td>925</td>
<td>$1,695,299</td>
<td>$1,790,197</td>
</tr>
<tr>
<td>1890</td>
<td>113</td>
<td>757</td>
<td>$816,756</td>
<td>$979,225</td>
</tr>
<tr>
<td>1900</td>
<td>194</td>
<td>526</td>
<td>$1,036,498</td>
<td>$1,071,353</td>
</tr>
</tbody>
</table>

Growth of Towns and Trade

Problem of Transportation

The securing of good transportation was always one of the greatest problems on the American frontier. The possession of great mineral...
wealth made this especially important for the Galena district. The ore was taken to the smelting centers, and the lead hauled to Galena over steep, winding roads to be exported. Hence a demand arose early for good roads, a demand difficult to meet, since the country was newly settled and rough.

**EARLY ROADS**

Figure 46 shows the location of the early roads within the region. In 1837 there was a good road from Galena to Gratiot's Grove. Work on a plank road which was to extend from Galena into Wisconsin was begun in 1857, but it was converted into a turnpike in 1868. Efforts to reach the outside world overland began in 1825, when Kellogg made his trail from Peoria to Galena; it crossed Rock River near Dixon. In 1826 the Bolles Trail crossed Rock River where the Illinois Central Railroad bridge now is.

Some 200 teams forded the river at Dixon in 1829. It has been noted that the first wagonload of lead was hauled to Chicago in 1829. In 1831 the Galena stage left St. Louis once a week. In 1837 stages left Galena for Peoria three times a week, each passenger paying a fare of $12.00 for the 160 miles; however, this service soon became daily. Roads connected Belmont and Dodgeville with Galena, and Galena with Savanna in 1837. As trade routes, however, these roads were far inferior to the Galena and Mississippi rivers.

**SUPREMACY OF STEAMBOAT ON GALENA RIVER**

In a general way the years 1835-55 marked the period of the supremacy of the steamboat on Galena River. The arrival at Galena of the first steamboat in 1822, and the establishment of regular traffic in 1827, have already been noted. In 1835 the number of arrivals of steamers at Galena was more than 150, and in 1837 the number had increased to 350. The decade 1840 to 1850 marked the period of greatest traffic on the river. Boats from Galena touched at all important points between St. Paul and New Orleans. The advent of the railroad at Galena in 1855 heralded the decline of steamboat transportation. The following table shows something of the importance of this traffic on Galena River at that time.

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205 History of Jo Daviess County, pp. 533-534.
206 Davidson, Alexander, and Struve, Bernard, A complete history of Illinois from 1673 to 1884, p. 351.
209 Illinois Blue Book, 1900, p. 141.
211 Niles Weekly Register, vol. 63, p. 388.
## SETTLEMENT AND DEVELOPMENT

### Arrivals of steamboats at Galena, 1828-1848

<table>
<thead>
<tr>
<th>Year</th>
<th>1828</th>
<th>1830</th>
<th>1835</th>
<th>1836</th>
<th>1837</th>
<th>1838</th>
<th>1839</th>
<th>1840</th>
<th>1841</th>
<th>1842</th>
<th>1843</th>
<th>1848</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrivals</td>
<td>99</td>
<td>50</td>
<td>153</td>
<td>152</td>
<td>350</td>
<td>308</td>
<td>375</td>
<td>300</td>
<td>350</td>
<td>350</td>
<td>340</td>
<td>268</td>
</tr>
</tbody>
</table>

Compared to flatboat, keelboat, and wagon transportation, steamboat traffic had the advantages of speed, safety, certainty, and cheapness. Before the advent of the steamboat on Mississippi River, those who reached St. Louis and New Orleans with their produce early in the season could get a fair price; later comers were likely to find a glutted market. The return upstream, if made with the boat, was hard and slow. In 1810 it took 120 days to go by flatboat from New Orleans to St. Louis. In 1860 the distance was regularly made in three days by steamboat. In 1815 the freight on 100 pounds of cloth from New Orleans to St. Louis was $5.00; in 1860 it was about 10 cents, if sent in large quantities. The transportation rate on sugar upstream from Louisiana fell to one-fifteenth of what it had been previously. Freight on Ohio River steamboats in 1841 was as low as 1/2 cent per ton-mile as compared with 11/2 cents on canals (exclusive of toll), 21/2 cents by railroad, and 15 to 20 cents on common turnpikes.

### PREDOMINANCE OF SOUTHERN TRADE

Until about 1850 to 1855 Mississippi River was the only good trade route open to the Galena district. There was no inducement to trade north or west. Eastward a hundred miles of land to be traversed by slow wagons lay between Galena and Lake Michigan. To the southeast were vast prairies only partly settled; hence the region faced south. Between 1812 and 1850 nearly all the lead shipped from the mines of the upper Mississippi as well as other produce went down Mississippi River. From New Orleans most of it went to New York, from which port some of it was exported. The receipts of lead at St. Louis, most of which came from the mines of the upper Mississippi, are shown in figure 48. A comparison of the graph showing the production of these mines (fig. 47) with the following table of lead shipped from the Galena (Fever) River mines to St. Louis, will indicate the dependence of the Galena district upon the Mississippi as an outlet during this period. Most of the mining and other supplies for the region consumed two months in transit from

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214 Flint, Recollections of the last ten years in the Mississippi Valley, p. 247.
217 Mainly bacon, pork, lard, beef, butter, cheese, corn, flour, whiskey, cider, and vinegar.
220 They consisted largely of manufactured goods and refined food stuffs. Sugar, rice, and molasses came from the south.
New York and other eastern cities, by way of the Gulf of Mexico and Mississippi River.

*Shipments of lead from the Galena district to St. Louis, 1839-1853*

<table>
<thead>
<tr>
<th>Year</th>
<th>Pounds shipped</th>
</tr>
</thead>
<tbody>
<tr>
<td>1839</td>
<td>26,250,000</td>
</tr>
<tr>
<td>1840</td>
<td>24,600,000</td>
</tr>
<tr>
<td>1841</td>
<td>32,438,000</td>
</tr>
<tr>
<td>1842</td>
<td>26,395,000</td>
</tr>
<tr>
<td>1843</td>
<td>40,890,000</td>
</tr>
<tr>
<td>1844</td>
<td>43,533,000</td>
</tr>
</tbody>
</table>

*Value of the lead.*

**Importance of Geographic Position of Galena**

Due to her exclusive shipping facilities, Galena grew rapidly with the development of the lead and agricultural resources of the region and remained the dominant city\(^{221}\) of the district. In 1840 to 1855 the "Lead Mine" city was held to be the most important metropolis of the northwest.\(^{222}\) Often 12 to 15 steamboats were seen at her wharves at one time unloading merchandise and general supplies, and taking on cargoes of lead and agricultural products,\(^{223}\) and daily lines of steamboats were in operation to St. Louis and to St. Paul.\(^{224}\) As a distributing center Galena depended almost entirely on wholesale business. In the early '50's the city had 20 and possibly 40 wholesale houses;\(^{225}\) and there were smaller industries such as implement and lead factories, mills, foundries, and breweries. In 1841 Erastus Kent, one of the founders of Beloit College, wrote that Galena was doing more business than any other place in Illinois or the territory of Wisconsin.\(^{226}\) In 1836, when the State Legislature decided to build a railroad from Chicago to Galena, it named the road the "Galena and Chicago Union", thereby indicating the relative importance of the two towns at that time.

As early as 1837 Savanna was competing with Galena for the trade of Stephenson County, but Savanna was too far south seriously to threaten the supremacy of Galena in the lead region. Dubuque, situated in the midst of the Iowa mines, became a serious rival to Galena in the early '50's, when it began to develop manufactures. Though Dubuque was founded only a few years after Galena, it held a subordinate position for 25 years.\(^{227}\)

\(^{221}\)Ill. State Gazetteer, 1864-65, p. 375.


\(^{223}\)In 1857 the agricultural exports of Galena consisted of 226,000 bushels of wheat, 200,000 bushels of potatoes, 20,000 bbls. of flour, and 34,000 lbs. of salted meat. Hawe, Ill. State Gazetteer, 1858-59, p. 91.

\(^{224}\)Ill. State Gazetteer, 1864-65, p. 375.

\(^{225}\)Chetlain, A. L., Recollections of seventy years.


\(^{227}\)At the time of the Civil War, Dubuque had passed her rival.
GROWING COMPETITION OF GREAT LAKES AND THE EAST FOR TRADE OF REGION

ATTEMPTS TO ESTABLISH AN OUTLET AT GREEN BAY

As early as 1822 some 12,000 pounds of lead were shipped by keel boat up Wisconsin River to about the site of Portage, where the cargo was hauled a short distance to the headwaters of Fox River, down which it was taken to Green Bay. Thence it was sent by lake to Detroit, and on to the east. Many attempts to use this route and much advertising of it followed, but the *Detroit Gazette* in 1829 shrewdly objected that this route was inadequate to compete successfully with Mississippi River.

**OVERLAND TRADE WITH MILWAUKEE**

Of more significance was the hauling of lead by oxen from Mineral Point, Wisconsin, to Milwaukee, begun in 1839. In 1841 from 20 to 30 teams arrived weekly at Milwaukee with lead and returned to the lead district with lumber, salt and merchandise. That year the lead, shot, and copper exported from Milwaukee amounted to 1,768,175 pounds. About 1,900,000 pounds of lead and 2,500 kegs of shot were exported the next year, and about 1,000,000 pounds in 1843. During 1843 New York reduced the toll on lead passing through the Erie Canal to favor its eastward shipment. It cost only about three-fourths as much and took only about two-thirds as long, to send the lead to New York via Milwaukee as by the way of New Orleans. This was especially true during the low-water stages of Mississippi River. Obviously, however, the wagon route could not compete in the long run with the river, and most of the lead continued to go down to St. Louis from Galena.

**WAGON ROADS TO CHICAGO**

Though the hauling of lead by wagon to Chicago was not as important as that to Milwaukee, the demand for a direct connection with Chicago and the east and a consequent release from the uncertainties of the round-about Mississippi River route steadily grew stronger, till in 1836 the Legislature of Illinois determined to build the Galena and Chicago Union Railroad between those places. Work on this road, however, was not begun till 1848. While the railroad was being pushed slowly northwest from

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228 In 1840-50 Wisconsin undertook to canalize Wisconsin and Fox rivers. The work was completed by a private corporation in 1853, and taken over by the U. S. government in 1872. The portion through Wisconsin River was poorly done, and abandoned in 1887; but the part between Portage and Green Bay is still in use.—Rept. of the Commissioner of Corporations, “Transportation in the U. S.,” 1909, p. 290.

229 Galena Advertiser, Sept. 28, 1829.


234 McLeod, History of Wisconsin, p. 216.


236 Flint, Railroads of the U. S., p. 258.

237 Porter, The west from the census of 1880, p. 187.
Chicago toward Galena, wagons from the lead district hauled mineral to the terminus of the railroad for shipment to Chicago.

INFLUENCE OF ILLINOIS AND MICHIGAN CANAL

When the Illinois and Michigan Canal was opened in 1848, Chicago was connected with Mississippi River by way of Illinois river. This route from Galena to Chicago was roundabout but that it diverted eastward some of the south-bound lead can be inferred from the table in the discussion "Methods of Cultivation," and from the complaint in De Bow's Review that the "canal has not only swept the whole produce along the line of Illinois River to the east, but is drawing the products of the upper Mississippi through the same channel." The canal was an important factor in the early growth of Chicago, the growing importance of which as a market tended in the '50's to draw the trade of Jo Daviess County eastward.

ADVENT OF RAILROAD

Freeport was reached by the Galena and Chicago Union Railroad in 1852. By January, 1855, the Galena branch of the Illinois Central Railroad extended from Galena to Freeport, thereby finally connecting the former city by rail with Chicago. The Galena and Chicago Union Railroad was the first railroad built out from Chicago, and the second in the State. It was successful from the outset, declaring a dividend of 15 per cent in 1851 from net earnings.

The railroad was the final factor in the settlement of Jo Daviess County. Even before its completion settlers crowded into the northwestern part of the State and "squatted" along its projected course. With its arrival the last rush of settlers into northern Illinois took place. During the earlier pioneer period there had been three successive waves of immigrants: (1) the hunter-farmers, who first came and who loved plenty of "elbow" room, (2) the restless early immigrant who supplemented his scanty farming with a few head of cattle, and who in turn moved on to make room for (3) the substantial settler who came to stay. The first type had disappeared before the coming of the railroad. With the ready means of transportation afforded by the railroad the last two types were now merged into one.

The table below shows the advantage in transportation offered by the railroad over the ordinary road in 1840. Jo Daviess County now began to enjoy this advantage.

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240Chicago Daily Journal, Jan. 21, 1856.
Net proceeds from sale of grain delivered at various distances from place where harvested

<table>
<thead>
<tr>
<th>Value per ton at farm</th>
<th>Delivered by railroad</th>
<th>Delivered by road</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wheat</td>
<td>Corn</td>
</tr>
<tr>
<td>Delivered 50 miles</td>
<td>$49.50</td>
<td>$24.75</td>
</tr>
<tr>
<td>Delivered 150 miles</td>
<td>48.75</td>
<td>24.00</td>
</tr>
<tr>
<td>Delivered 200 miles</td>
<td>47.25</td>
<td>22.50</td>
</tr>
<tr>
<td>Delivered 250 miles</td>
<td>45.00</td>
<td>20.25</td>
</tr>
<tr>
<td>Delivered 350 miles</td>
<td>44.55</td>
<td>19.80</td>
</tr>
</tbody>
</table>

DECREASE OF RIVER COMMERCE

With the advent of the railroad, a fast and certain trade route to the East, the several disadvantages of the Mississippi River route became more clearly marked. (1) The rapids of the upper Mississippi were a constant source of delay and loss and necessitated the "warping" of the lead over them in flatboats during low water.241 (2) The winter ice restricted the shipping season to nine months and in many years to eight.242 (3) Water so low as to interfere seriously with navigation was almost certain to be encountered at some time during the summer.243 (4) There was the added cost of reshipment at St. Louis and New Orleans.244 (5) All river trade was more or less uncertain. This was especially true of the Mississippi in view of its winding and shifting channel, unimproved in many places. De Bow’s Review characterized even the Ohio River as "dry all summer and frozen all winter."245 In 1860 hardly 2 per cent of the grain shipped from the northwest went down Mississippi River. (6) The loss by boiler explosions and in other ways was considerable. (7) In general commerce trended eastward, whereas the rivers extended southward. (8) River transportation was slow.246 The river-gulf-ocean route to New York was 4000 miles long, more than twice the length of the railroad route between Chicago and New York open after 1853. (9) Furthermore, the river monopoly permitted the steamboat owners to raise the rates on shipments near the close of the shipping season and thereby to compel shippers to pay the higher rate or keep the lead in storage at Galena over the following winter.247

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241 "Neither law nor gospel can pass the rapids of the Mississippi."—Letter in History of Jo Daviess County, p. 256.
244 St. Louis was the port of exchange between the traffic of the upper and lower Mississippi. One cent per pig was charged for receiving and forwarding the lead at St. Louis; one and one-half cents for effecting a sale; and four cents for a month’s storage.—Niles Weekly Register, vol. 68, p. 102.
246 Goods were two months in transit from Philadelphia to Galena. Merchants at Galena replenished their stock of goods but twice a year and hence it was impossible to anticipate the demands of the shifting population and rapidly to fill orders for goods, the stock of which had been exhausted temporarily.—Chaplain, A. L., Recollections of seventy years, p. 47.
247 Niles Weekly Register, vol. 60, p. 256.
Added to the above disadvantages of river transportation as compared to railroad traffic, was a gradual decline in the navigability of Galena River. In the '30's small steamers at times could run one or two miles above Galena.\textsuperscript{248} At that time the river was navigable to large steamboats as far up as Galena, except during very low stages of water. The river began to deposit silt, however, and make the main channel shallower and more tortuous. Steamboat navigation gradually became impossible above Galena, and difficult to Galena except during stages of high water in the Mississippi. "During low water it was a most arduous and slow undertaking to bring boats up to that city and often quite impossible."\textsuperscript{249} During the summer of 1863 navigation of Galena River was entirely suspended because of low water,\textsuperscript{250} and by that year the stream had become of little importance as a factor in transportation.

The chief cause of the silting of the river was increased soil wash due to the clearing and careless cultivation of the steep slopes in its drainage area. In 1865 the Illinois State Gazeteer recognized the cause partly when it said that "since the completion of the Illinois Central Railroad the river has been so filled with deposits of soil washed from the bluffs on both sides, broken by the picks of the miners, that now it is not navigable except when water in Mississippi River is very high."\textsuperscript{251} The operations of miners and the building of the railroad embankment along the stream doubtless exposed a considerable amount of loose material to erosion, but the chief cause of the filling of the streams was the spread of agriculture.

Primarily because of the above conditions, river transportation between the lead district and the South declined rapidly. The year 1855, marking the entrance of the railroad into Galena, is taken as ending the period of steamboat supremacy on Galena River, though as early as 1849 many of the 572 boats then on the tributaries of the Mississippi were being run at a loss.\textsuperscript{252} A comparison of figures 47 and 48 indicates that the receipts of lead at St. Louis from the Missouri and upper Mississippi River mines for 1857, were about 14,000,000 pounds, whereas the production in the latter region alone was between 25,000,000 and 30,000,000 pounds. The receipts at New Orleans in 1856 (1,300,000 pounds) were one-tenth of what they had been in 1846,\textsuperscript{253} and in the same decade the shipments of lead into St. Louis declined more than half.\textsuperscript{254} These rates of decline were greater than that of the lead production in the mines of

\textsuperscript{248} In June, 1836, Captain Girdon ran his steamer up the now insignificant creek called Meeker's Branch to Gear's Furnace, where he took a load of lead on board.—History of Jo Daviess County, p. 477.


\textsuperscript{250} Ill. State Gazeteer, 1864-65, p. 375.

\textsuperscript{251} History of Jo Daviess County, p. 448; Ill. State Gazeteer, 1864-65, p. 375 .


\textsuperscript{254} Hunt's Merchants' Magazine, vol. 34, p. 361.
the upper Mississippi. St. Louis received but 2,610,000 pounds from these mines in 1865, and but 1,596,000 pounds in 1872. 255

It should be remembered, however, that the Galena and Mississippi rivers were of great service to Galena in securing low railroad freight rates, even after the loss of the major part of this trade. The competing railroads were forced to establish their charges near enough to the river rates so that shippers would prefer land transportation. This influence of the water route doubtless saved the district many thousands of dollars. 256

**EASTWARD DIVERSION OF TRADE**

That the region was now facing east can be seen in the increased lead receipts at Chicago, nearly all of which to 1867 came from the mines of the upper Mississippi. The Galena and Chicago Union Railroad shipped more than 4,000,000 pounds of lead to Chicago in 1854. The table below gives some conception of the early lead transportation to that city. 257 That

<table>
<thead>
<tr>
<th>Year</th>
<th>By lake</th>
<th>By Illinois and Michigan Canal</th>
<th>By railroad</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pounds</td>
<td>Pounds</td>
<td>Pounds</td>
</tr>
<tr>
<td>1851</td>
<td>1,375,827 lbs.</td>
<td>1,007</td>
<td></td>
</tr>
<tr>
<td>1852</td>
<td>5,147 kegs and 364 rolls</td>
<td>640,027</td>
<td>715,300</td>
</tr>
<tr>
<td>1853</td>
<td>108,150 lbs.</td>
<td>1,286,604</td>
<td>1,589,009</td>
</tr>
<tr>
<td>1854</td>
<td>140,000 lbs.</td>
<td>35,463</td>
<td>4,071,065</td>
</tr>
</tbody>
</table>

the railroad now began to carry eastward not only the mineral products but also the agricultural exports of the northwestern part of the State is implied in the following table of the traffic carried eastward from northern Illinois in 1853 by the Galena and Chicago Union Railroad. 258

**Eastern traffic of Galena and Chicago Union Railroad in 1853**

<table>
<thead>
<tr>
<th>Article</th>
<th>Amount</th>
<th>Article</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>512,344 bu.</td>
<td>Animals</td>
<td>401 carloads</td>
</tr>
<tr>
<td>Flour</td>
<td>39,661 bbis</td>
<td>Wool</td>
<td>247,370 lbs.</td>
</tr>
<tr>
<td>Oats</td>
<td>640,604 bu.</td>
<td>Mill stuffs</td>
<td>1,217,020 lbs.</td>
</tr>
<tr>
<td>Corn</td>
<td>469,859 bu.</td>
<td>Whiskey</td>
<td>6,937 bbis.</td>
</tr>
<tr>
<td>Barley</td>
<td>102,389 bu.</td>
<td>Lumber</td>
<td>1,176,870 ft.</td>
</tr>
<tr>
<td>Potatoes</td>
<td>12,304 bu.</td>
<td>Milk</td>
<td>3,808 gals.</td>
</tr>
<tr>
<td>Pork</td>
<td>9,795,600 lbs.</td>
<td>Butter</td>
<td>932,820 lbs.</td>
</tr>
<tr>
<td>Lead</td>
<td>893,390 lbs.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Most of the bulky produce which was shipped eastward from Chicago went by lake to Buffalo, 259 and from there to New York via the Erie Canal

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257 Western Journal and Civilian, vol. 10, p. 51; vol. 12, p. 125; and vol. 15, p. 59.
258 Johnston, W. J., History of Stephenson County, p. 73.
and Hudson River. The lighter and the more perishable goods soon went by rail from Chicago to New York. Obviously the imports into the Galena region now came largely from the East rather than from the South as before.

**Effects of Eastward Diversion**

Among the more important results of this change of front brought about by the railroads were the following: (1) Agriculture was helped by the better facilities for transportation, and this in turn reacted favorably on the other industries of the region. (2) This region, as a part of what was then the Northwest, at last was bound firmly to the Eastern and Northeastern States by trade relations, which were cemented more closely because the railroad facilitated the immigration of easterners into the district. (3) The opening of the eastern outlet averted any difficulties which might have arisen during the Civil War in relation to the exportation of the lead. (4) Furthermore, the Northwest was able to send a vast amount of food stuffs to the Eastern States during the war and to receive manufactured products from the eastern factories. (5) This diversion, together with the decline in the production of the Galena lead mines, initiated the slow decline of that city which is shown in a general way by figure 44. As the emporium of the region, Galena had depended for her supremacy almost entirely on her wholesale trade. Freeport, Warren, Apple River, Scales Mound, and Mineral Point now were situated nearly as advantageously as Galena with reference to the railroad, and all absorbed some of her trade, as did also Chicago and Milwaukee. As a result, Galena came out of the financial depression of 1857, not the metropolis of the northwestern part of the State and of much of the mining territory of Wisconsin, but merely as the leading city in Jo Daviess County. The decline in the importance of Galena also tended to decrease the importance of Jo Daviess County as the center of mining activities.

**Existing and Future Conditions**

**Mining Activities**

At present mining activities in the upper Mississippi region are directed mainly toward the zinc ores, as most of the known lead deposits have been exhausted. Zinc mining in Wisconsin is more active than in Jo Daviess County. One reason is that the Galena limestone, near the base of which most of the zinc ore has been found, is exposed at the surface over a larger area in Wisconsin than in Jo Daviess County, where in many places it is covered by the Maquoketa shale and Niagaran limestone. Furthermore, the top part of the Galena limestone formation is

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260 Chetlain, A. L., Recollections of seventy years, p. 47.

261 In the '50's Galena had from 20 to 40 wholesale houses; in 1900 she had about five.—Idem, p. 279.
exposed chiefly in Jo Daviess County, and the lower portion in Wisconsin. Hence, in general, prospecting for zinc is more difficult and expensive in Jo Daviess County than farther north, and mining is somewhat more costly. But partly because in the Illinois district the zinc ore is usually found below the level of ground water, near the base of the Galena formation in areas where formerly large bodies of lead ore were taken from the old upper workings, it is the opinion of many mining men that the entire "region contains large reserves of zinc ore of good grade, and the mines in Illinois (Jo Daviess County) may be expected to yield their due proportion to systematic prospecting and mining." 262

AGRICULTURAL CONDITIONS

Agriculture continues to be the most important industry in Jo Daviess County. Corn, oats, barley, rye, and wheat, named in the order of their importance, were the leading cereal crops in 1899. The amount of corn produced was about 1\(\frac{1}{2}\) times that of oats, and about one-half of the total cereal crop. Stock raising and dairying are important. In 1899 about 1\(\frac{3}{4}\) million dollars were received for the stock and dairy products of the county. 263

MANUFACTURING OUTLOOK

The outlook for an extensive development of manufacturing in the county is not promising. Some water power could be developed on the large streams.

TRADE RELATIONS

When Jo Daviess County passed from its mineral to its agricultural phase of development, and when the railroad replaced Mississippi River as the leading trade route, trade was distributed more evenly over the county. Stockton and Warren, as agricultural centers with good railroad facilities, are becoming serious rivals of Galena as leading trade centers. The relative importance of these two towns will probably increase, though the recently renewed mining activities of the county will, if continued, tend to arrest the relative decline of Galena.

Should the Deep Waterway project from Chicago to the Gulf of Mexico materialize, the Hennepin Canal, 264 constructed in 1907 from Mississippi River at the mouth of Rock River to Hennepin on Illinois River, would give Galena and the county a somewhat roundabout water route to Chicago, and would affect freight rates favorably. If the upper Mississippi should also be improved and Galena River be cleaned out to

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263 See Census Reports for detailed accounts of the agricultural products of the county.

its former depth,\textsuperscript{265} the county would enjoy again the advantage of the southern route. The completion of the Panama Canal doubtless will increase the importance of Mississippi River, though this southern route probably never will be as important to Galena as in the days of the St. Louis lead trade.

\section*{Conservation of Natural Resources} \hfill

\subsection*{General Statement} 

\begin{quote}
Early in the history of the United States a movement began toward the conservation of its natural resources.\textsuperscript{266} By 1890 its frontier had practically disappeared, and since that time the Government no longer has had a great Public Domain of fertile land, upon which homeseekers could settle at will, under the Homestead Act of 1862. The movement for conservation, stimulated to some extent by the passing of the frontier, has grown steadily and it has now assumed important proportions. The country is beginning to "take stock" of its natural assets, with a view to serving the best interests of this generation and of all those to follow. Conservation in this sense means such use of the natural resources of the United States as will result in a practicable maximum of efficiency and a feasible minimum of waste. Only some of the more important phases with respect to Jo Daviess County are taken up in the following discussion.
\end{quote}

\section*{Mineral Resources} 

The chief sources of loss in the production of lead in the Galena district have been in (1) the mining of the ore, (2) the processes of concentration (the removal of dross from the ore to compact the valuable part previous to smelting), and (3) the process of smelting.

1. No definite figures can be given concerning the loss incurred in the mining of the ore. But in view of the crude methods used by the Indians and early miners, the amount must have been large. Since the abandoned shafts and "diggings" cannot be reworked profitably, the ore left in them is lost, for the present at least. In southeastern Missouri, under the best practice, not less than 15 per cent of the ore is now left in the mines, and this is said to be less than the average amount.\textsuperscript{267} Doubtless 20 per cent of the lead ore has been left in the mines of the Galena region.

2. Under modern conditions the loss incurred in the concentration of

\begin{footnotesize}
\begin{itemize}
\item\textsuperscript{265}Galena River is now too full of deposits to be navigable for large boats. It is improved by a lock and dam at its mouth. For the year ending June, 1907, it was open for navigation 235 days, during 56 of which it was flooded by the backwater of Mississippi River. That year 3,131 boats passed through the lock, carrying 12,540 passengers, but only 4,128 tons of merchandise. During 1906, 4,245 tons of merchandise passed through the locks, but a ghostly remnant of the enormous traffic which once went up and down Fever River.—Rept., Chief of Engineers, U. S. Army, p. 1431.
\item\textsuperscript{266}In 1785 the commissioners of Maryland and Virginia were called together to discuss the regulation of the waters of the Potomac. An indirect result was the Constitution. Isolated instances of the movement date back even farther than this.
\item\textsuperscript{267}Van Hise, C. R., Conservation of natural resources in the United States, p. 80.
\end{itemize}
\end{footnotesize}
lead ore is about 15 per cent. Perhaps the average loss in concentration in the Galena district has been 20 per cent.

3. The early log furnaces, some of which were used as late as 1860, extracted only 30 to 40 per cent of the lead from the concentrated ore. The crude methods of the Indians and early miners caused even greater losses. The Scotch hearth process which replaced the log furnace, extracted from 60 to 68 per cent of the metal in the first smelting. By a second treatment some additional metal was obtained.\(^{268}\) It is estimated conservatively that 25 per cent of the metal was lost in the process of smelting. According to these estimates the total loss of the original lead in the mines has been more than 50 per cent. Since about $50,000,000 was received for the lead produced, the total loss must have been more than $50,000,000, without taking account of the loss of money incurred by the operators because of poor management.

In this country at present the average loss in concentrating lead ore is about 15 per cent. About 5 per cent of the concentrated ore is lost in the processes of smelting and refining.\(^{269}\) Manifestly, under the economic conditions of the past, it was impossible to recover all of the lead mined. But if the tailings left from the process of concentration of the ore and the residue resulting from the smelting of it had been stored away, it is probable that with modern methods and under existing economic conditions the stored materials could have been reworked with profit. For this reason, should mining of lead ore again become important in the region, it is urged that the tailings be preserved.

The waste of zinc in the region probably has been relatively greater than that of lead. In the '60's and '70's the total loss must have exceeded 50 per cent of the ore taken from the mines. In this country current losses in the concentration of zinc ore average about 30 to 35 per cent.\(^{270}\) The additional average loss in smelting is about 20 per cent of the assay value of the ore.\(^{271}\) In Jo Daviess County, after the ore has been concentrated mechanically, and before it can be smelted, in many cases it must be treated to free it from the iron sulphide present. This is accomplished usually by "roasting" and magnetic concentration, and it involves a loss of 10 to 25 per cent of the ore treated. In this country the total loss of metal during the transference of the zinc from ore in the mines to metal in the hands of the producer is rarely less than 40 per cent; usually it

\(^{270}\) In one instance the loss in concentration in the region has been reduced to about 15 per cent. This exception indicates what may be accomplished.—Bain, H. F., Zinc and lead deposits of the upper Mississippi Valley: U. S. Geol. Survey Bull. 294, p. 146, 1906.
is more. There is much room for improvement in the industry.\textsuperscript{272} About $10,000,000 worth of zinc had been sold from the mines of the upper Mississippi before the year 1905. The total average loss of zinc which has been incurred in its production may be estimated conservatively as 40 per cent of the ore taken from the mines. Stated in terms of dollars and cents, this means a total loss of more than $6,500,000. To this sum must be added an unknown, but probably large, amount represented by the zinc ore thrown away as useless by the early miners of lead.

Waste in the production of zinc in the region can be reduced greatly, especially by (1) the storage of tailings, (2) improvements in the concentration and smelting plants, (3) reasonable reduction in the heavy rates of royalties now exacted, and (4) utilization of by-products. (1) At present some of the tailings are used for roads, concrete work, and in other industries. In view of the experience of the past, and particularly in view of the present high per cent of loss in the production of zinc, the storage of tailings is urged, voluntary at first, obligatory if necessary. The time will come when they can be reworked with profit. (2) The concentrating and smelting plants should be improved as rapidly as practicable. (3) To aid in the clean mining and handling of the ore, it probably would be desirable in many cases to reduce the heavy royalties now exacted by the mine owners.\textsuperscript{273} (4) Attention also should be directed toward recovering certain by-products. It is well known that by saving the sulphur and making it into sulphuric acid the iron sulphide becomes a source of revenue rather than a loss.\textsuperscript{274} The marcasite which occurs in the region sells for $3.00 to $6.00 a ton, when clean.\textsuperscript{275} It is thought that reforms along the lines indicated would increase the productivity of the region and probably add to the profits of the operators and land owners.\textsuperscript{276}

\textsuperscript{272}Following is a table of losses of zinc in the Wisconsin district of the mining region.—Hotchkiss, Report of the State Conservation Commission of Wisconsin, 1911.

\begin{tabular}{lrr}
\hline
\textbf{Zinc in ground before mining} & \textbf{Per cent} & \textbf{Per cent of original}

\hline
\textbf{Zinc in ground before mining} & \textbf{of loss} & \textbf{zinc in ore remaining}

\textbf{Loss in mining} & 13.4 & 86.6

\textbf{Loss in milling} & 18.9 & 70.2

\textbf{Loss in magnetic separation} & 14.4 & 60.1

\textbf{Loss in transportation} & .5 & 59.8

\textbf{Loss in smelting} & 1.40 & 51.4

\textbf{Total loss of original zinc 48.6 per cent.} & & \\
\hline
\end{tabular}

\textsuperscript{273}The royalties now exacted vary from 10 to 15 per cent of the gross output of the concentrates.—Bain, H. F.: U. S. Geol. Survey Bull. 294, p. 146. Sometimes the person who makes the first lease transfers to another party for a royalty of 5 per cent or more.


\textsuperscript{275}Processes for the recovery of this mineral have not yet reached a satisfactory stage.

\textsuperscript{276}As far as practicable, zinc and lead should be used only for the purposes which they are fitted to serve best. In all other cases it is desirable that other more abundant materials be substituted. From the standpoint of conservation, for example, it is not desirable to use lead and zinc in the manufacture of paint, since the mineral in that form can be used but once.

The adoption of more efficient and saving methods of production probably would cause some rise in the prices of the finished products. It is only just that the public, as well as the producer, should bear part of the burden in the conserving of the resources of the country.
AGRICULTURAL RESOURCES

The conservation of the agricultural resources of the county is of greater importance than that of its mineral resources. The chief sources of loss in the production of agricultural goods in the county are: (1) soil erosion, (2) depletion of the mineral elements of the soil necessary to plant growth, (3) development of toxic effects in the soil, (4) injurious bacteria in the soil, (5) plant and animal diseases, (6) ravages of insect pests, (7) poor methods of agriculture, and (8) lack of scientific education by many. These matters, however, have been so thoroughly discussed in the publications of the United States Department of Agriculture and of the Agricultural Experiment Stations of the various states that no further reference to them need be made here.

Summary

The chief points discussed in this chapter may be summarized as follows: (1) Geological processes determined the location of mineral deposits within the region and their exposure at the surface. (2) Because of these mineral deposits, Jo Daviess County was settled earlier than the other counties of northern Illinois. (3) The early history of the county is a history of the development of its mineral resources. As contrasted with the adjoining agricultural counties, its early settlement was rapid and its early population extremely heterogenous. The region at first produced lead only. All supplies had to be imported. (4) Because of its location with reference to the Galena and Mississippi rivers, the region at first faced south, and hence its early population and early institutions took on a somewhat southern aspect. (5) Galena, having a good location at the head of navigation for large boats on Galena River, and being in the midst of rich mines, became the emporium of the county and of the entire mining region of the upper Mississippi River. (6) The Hudson River, Erie Canal, and Great Lakes route between Buffalo and Chicago directed a large portion of the eastern and New England emigrants toward the region of the upper Mississippi. Most of these settlers took up agriculture. (7) Hence the region underwent a second, more gradual, and more substantial development, in agriculture. The farming element gradually dominated the region, and impressed upon it New England and eastern institutions which were modified, however, by the new conditions. (8) With the advent of the railroad into the county, its trade was diverted eastward, and the Mississippi River route declined in importance. This eastward facing of the region bound it more firmly with the eastern and northeastern parts of the country. (9) With the decline of river traffic and of mining and with the increasing competition of the new agricultural centers enjoying railroad facilities equal to those of Galena, that city began to decline slowly. (10) Being situated in the Driftless Area having a rugged topo-
ography, the region has been handicapped somewhat in transportation and agriculture. Stock raising has therefore gained in relative importance. Chiefly because of the influence of the rugged topography and the decline of mining, but partly for other reasons, the county has suffered a gradual decline in population since 1880. Primarily for geological and geographical reasons, the county has not developed extensive manufactures. (12) The future economic development of the county depends chiefly on its agricultural resources and subordinately on the development of its zinc mines. There are good opportunities in the county for a more efficient and conservative use of its natural resources. From the foregoing it is clear that geographical and geological factors have affected greatly the development of Jo Daviess County.
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