GEOLOGY OF HENRY COUNTY.

BY

T. E. SAVAGE.

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INTRODUCTION.

LOCATION AND AREA.

The territory of which Henry county forms a part was purchased from the Sac and Fox Indians through their chief, Black Hawk, in 1832. It was not set off as a separate county until the first session of the Wisconsin Territorial Legislature in 1836, at which time this area was included within the territory of Wisconsin.

Henry county is situated near the extreme southeastern portion of the state. It lies in the second tier of counties west from Illinois and in the second tier north from the state of Missouri. The counties of Louisa and Washington form its northern boundary. On the east the counties of Des Moines and Louisa separate it from the Mississippi river. Lee county stands between it and Missouri on the south, while Van Buren and Jefferson counties touch it on the west.

Its eastern border is but eighteen miles from the Mississippi river, and its southern boundary is about an equal distance from the Iowa and Missouri line. Henry is among the smallest counties in the state. It forms a rectangle twenty-four miles in length, north and south, and eighteen miles in width. It comprises twelve government townships which give it an area of 432 square miles.

Although among the smallest in area, this county is not among the least in attractiveness, either from the standpoint of the agriculturist, or of the geologist, or indeed, of him who appreciates the beauties of landscape expressed in its rich variety of widely stretching prairies, its forest-covered hills and rock-bound streams.

EARLIER GEOLOGICAL WORK.

Among the earliest students of geology in Iowa was Professor D. D. Owen, whose parties worked in the state during the summer of 1849. He refers to some deposits of the Coal Measures in the adjoining counties of Van Buren* and Jefferson† but no

* Owen: Geol. Surv. of Wis., Iowa and Minn., pp. 106-109.
† Ibid, p. 110.

mention is made of any points within the area under consideration.

In 1857 Mr. A. H. Worthen, under the direction of Professor James Hall, made some investigations on the geology of southeastern Iowa. During the progress of this work he visited several points in Henry county and devotes a few pages to the description of its geology.*

Dr. C. A. White, in his report on the Geological Survey of Iowa,† gives a short description of some exposures of the Coal Measures in the southeastern part of the state, but says nothing in regard to deposits of coal occurring within the borders of Henry county.

Mr. Frank Leverett, of the United States Geological Survey, has made extensive observations on the surface features of Henry county. He was the first to note the presence of the Illinoian drift sheet in southeastern Iowa, and to trace its boundary. Among his numerous publications the following contain references which bear upon the geology of the area under discussion: The Deflection of the Big Cedar Creek from its Normal Axis,‡ The Weathered Zone (Sangamon) between the Iowa Loess and the Illinoian Till Sheet,§ the Yarmouth Soil and Weathered Zone‖ and the Illinoian Glacial Lobe.¶

PHYIOGRAPHY.

TOPOGRAPHY.

The surface features of Henry county may be grouped in two distinct topographical areas. The first consists of an undulating prairie, moderately well drained, occupying the northern and northeastern portions of the county. This region belongs, for the most part, to the Kansan drift plain, but the imperfect drainage resulting from its distance from any stream of considerable size and the consequent absence of erosion renders the area wanting in the typical features of Kansan drift topography.

* Hall: Geol. of Iowa, Vol. I, pp. 218-219.
† White: Geol. Surv. of Iowa, 1870, Vol. II, pp. 271-274.
‡ The Aurora, Iowa State Agri'l. College, Nov., 1885.
§ Journal of Geology, Vol. VI, pp. 171 and 172, 1898.
‖ Proc. Iowa Acad. Sci., Vol. V, pp. 76-80. 1898.
¶ Jour. of Geology, Vol. VI, pp. 239-243, 1898.
Monograph 38, U. S. Geol. Surv., pp. 34, 38, 52, 89, 90, 93 and 97.

The level landscape is broken in the northern portion of the county by the presence of two old valleys, one-fourth to three-fourths of a mile in width and fifteen to twenty feet in depth. These depressions are abandoned channels which were eroded in the Kansan drift by temporary streams during some later ice invasion, and whose waters found other channels upon the retreat of the ice. One of these valleys enters the county from the north near the northeastern corner of Scott township. It trends towards the west, passing a short distance north of the town of Winfield. Near this village it divides; one branch bending towards the northwest leaves the county near the northeast corner of Wayne township. It continues westward at some distance north of the county line for ten or twelve miles, when it bends southward and again enters the borders of Henry in the northwest corner of Jefferson township, near the town of Coppock. This channel is occupied in the greater part of its course by the small stream of Crooked creek.

The other branch passes almost directly west from Winfield and forms a conspicuous valley across the northern portion of the county. It unites once more with the former channel near the town of Coppock above mentioned. The Burlington and Western railroad follows this valley for several miles through the central portions of Scott and Wayne townships.

Mr. Frank Leverett has shown that these were channels successively occupied by the Mississippi river when it was pushed over westward by the lobe of the Illinoian ice sheet. This lobe crossed the river from Illinois and covered a narrow portion along the border of southeastern Iowa. A small area in the southwestern part of Henry county, comprising a narrow strip along the eastern edge of New London and Baltimore townships, also owes its topography to this invasion of the Illinoian ice. The rounded ridges and irregular hills which mark the marginal moraine of this drift sheet are prominent for some distance in the township of New London, a short distance east of the town of the same name. Further south, in Baltimore township, the moraine is crossed by the Skunk river. Here it is obscured for the most part by the erosion of that river and its tributaries.

Over all of the remaining southern and southwestern portion of the county, continuing along the western side to the point where

the Skunk river enters, in the extreme northwest corner, the surface presents the erosional features so characteristic of the Kansan drift plain. It is evident that its topography has been impressed upon it by the waters of the Skunk river, the master stream of the county, together with that of its tributaries and their dendritic branches. These streams have intersected the region in all directions. During the slow moving centuries they have cut down their channels entirely through the drift and, in many cases, have carved their beds deep into the underlying limestone. As a consequence we have here a diversified landscape of hill and upland, of valley and prairie. The level plains of varying extent are separated by ravines bordered by rounded slopes, or by wider channels in which the streams flow lazily as they wander from side to side in the broad valleys which they occupy. Occasionally their waters run with heedless haste as they hurry over the stony bottom and past the rocky bluffs which at intervals confine them to a narrower channel. At numerous points along the course of these winding streams the current has been deflected against the side of a bordering bluff and the stream is chiseling wider its valley that already is much too large to be filled by its waters even in their most swollen periods. All of this area is quite perfectly drained by the ultimate branches of Big creek and Big Cedar creek which are the largest streams that pay tribute to the Skunk river within the county.

The general level of the uplands back from the river on either side is determined by the hard, evenly-bedded limestone which occurs near the upper part of the Saint Louis stage. Over the most of this area these hard layers immediately underlie the superficial deposits that cap the hills and cover the level plains. They may be seen exposed in the beds and bluffs of the streams in the townships of Tippecanoe, Center, New London, Salem and Jackson, and doubtless extend over much of the drift-concealed surface of the prairie townships. These compact beds crumble but slowly under the action of the disintegrating agencies of the atmosphere. They stand out at the top of the bold escarpment that overlooks the Skunk river at Oakland Mills. They crown the bluffs that in so many places make beautiful the banks of Big creek. They appear in the crests of the low ledges that outcrop

on either side of the broad valley along the course of Big Cedar creek in the townships of Salem and Tippecanoe. On following back to their source the tributaries of these streams one passes over the same compact layers of white limestone which usually appear in their beds as the uppermost indurated rocks of the county. The influence of these layers upon the topography of the region cannot be overlooked.

Below these compact beds for many feet the rocks are more broken and irregular. Local layers and pockets of soft sandstone and brecciated beds of limestone render the cutting of the streams down to the harder strata which lie near the base of the Saint Louis stage comparatively rapid. For this reason the tops of the hills and the level of the uplands stand thirty to forty-five feet above the beds of the larger streams, whose bordering ledges are almost vertical; the inclined bank of superficial materials sloping back to the general level of the plain above.

The hills here are most of them covered with a thin mantle of loess, but deposits of any considerable depth are very local. Over the greater part of the region the thickness is insufficient to modify the erosional features of the drift. Usually the loess is not so uniformly fine-grained in texture nor so yellow in color as it appears nearer the border of the Iowan drift, or nearer the bluffs of the Mississippi river. In a few places along the Skunk river, however, the westward facing hill slopes have received a deposit of typical loess twenty to thirty feet in thickness. In the cuts that have been made through this material the sides have a tendency to stand almost vertical, the top not sliding downward so early nor to the same extent as it is prone to do in the case of excavations made in the drift.

Besides the work of long continued erosion over this area there are a few points at which it is probable that the wind has also had a share in determining the topography. In the southwestern part of Jefferson township, about one mile east of Merrimac Mills, the level valley on the east side of Skunk river is bordered for some distance by a series of hills of sand instead of the low, talus covered ledges of limestone that usually bound the river at some distance back on either side. These hills vary in height from about twenty-five to thirty-five feet. Some of them are sev-

eral rods in length extending with their long axes east and west, almost at right angles to the river valley. The valley at this point is about one mile in width. Its surface materials are almost pure sand, and it is probable that the hills have been slowly built up by the deposit of materials gathered by the winds as they swept over this level bed of loose sand.

A few miles north of this point, in section 6 of the same township, the regular bank that guards the east side of the river is again replaced by a number of irregular hills. These, however, are composed of the finer loess material instead of sand. At this point the valley of the river is narrower and its surface materials are less sandy than at the place mentioned above, which facts probably account for the difference in the deposits. Both groups of hills are where the prevailing westerly winds sweeping across the valley would lay down their load of dust and debris on coming in contact with vegetation, or on having their velocity checked by the obstructing banks.

Near the central part of section 4, in Salem township, there are a number of interesting mounds which have attracted some local attention. They stand on the east side of the valley of Big Cedar creek, a short distance below what is known as the Bales' ford. The flood plain through which Big Cedar creek flows is at this point about three-quarters of a mile in width. The hills, six in number, stand near together, their tops reaching fifty or sixty feet above the bed of the stream. They are more nearly circular in outline than those in Jefferson township, but their longer axes also extend east and west, nearly at right angles to the valley, where the northwesterly winds would be likely to deposit their load on meeting the opposing banks. On the crest of the hills have been found the graves of some prehistoric men. Popular tradition tells that these hills are tumuli constructed by some primitive people, of sand carried by them from unknown distances, in order that here overlooking the waters their dead might have a beautiful place of burial. Be this story as it may, the hills are composed of rather fine sand of nearly uniform sized grains and so clean that the neighboring farmers often use it for purposes of masonry. They are covered with a forest of oak trees, some

of which are of large size, indicating an age of at least two hundred years.

TABLE OF ELEVATIONS.

The following table taken from aneroid determinations made by Mr. Frank Leverett, and from the table of altitudes of the Chicago, Burlington and Quincy and the Saint Louis, Keokuk and Northwestern railways, gives the height above sea level of some of the principal points in the county. The elevation given by Leverett is that of the channel of the temporary Mississippi river. That taken from the railroad records refers to the level of the top of the ties. It will be noticed that the highest point given in the county is at New London, which is situated on the edge of the Illinoian moraine.

STATION.	Altitude above Sea Level.	Authority.
Winfield	703	Leverett.
Coppock	760	Leverett.
New London	762	C., B. & Q. R. R.
Mt. Pleasant	730	C., B. & Q. R. R.
Ketcham	694½	C., B. & Q. R. R.
Rome	626½	C., B. & Q. R. R.
	675	Leverett
Oakland Mills	615	St. L., K. & N. W.
Denova	736	St. L., K. & N. W.
Salem	735	St. L., K. & N. W.
Henry and Lee county line near where it is crossed by St. L., K. & N. W. R. R	657	Leverett.

DRAINAGE.

It is a fact of common observation that the rivers of southeastern Iowa all flow in a general southeasterly direction towards the Mississippi. Now within the borders of Henry county the streams do not always follow this normal course. Even the larger streams, as the Skunk river and Big Cedar creek, which follow that direction for many miles before reaching the county, here deviate in a very marked degree from the usual southeasterly direction. This peculiar action on the part of the streams points to some exceptional conditions in the history of the county as the cause, and these must be sought within the borders of this interesting region.

The Skunk River.—The present drainage system of Henry county is comparatively simple. The Skunk river embraces the

entire area in its hydrographical basin, and together with its branching tributaries carries away all of the excess of water that falls upon the surface.

This river enters the county in the extreme northwest corner. Digressing from its general southeasterly course, at this point it makes an abrupt bend to the south. With many windings it follows for some miles along the west side of the county, at one time bending to the west of the county limits and again making a turn within its borders. In section 31 of Trenton township it makes a stronger bend to the east for a distance of three miles, returning westward as far as the village of Rome in section 5 of Tippecanoe township, and then resumes its general southeasterly course crossing the townships of Tippecanoe, Center, Jackson and Baltimore, and leaving the county in section 35 of the latter township, about one and one-half miles west from its southeast corner.

In the upper part of its course, above described, the river flows in a valley from three-fourths to one and one-fourth miles in width. This valley on either side is bordered by low bluffs of sandstone and impure limestone, twenty to thirty feet in height. These ledges belong to the middle portion of the Saint Louis stage. The bed of the river is of mud or sand and the stream is not at present cutting its channel deeper. In this part of its course the river is evidently occupying a valley that was eroded before the visit of the Kansan ice sheet. Its bordering banks are comparatively low, and concealed both near the top and the base by drift and debris. Kansan drift may also be found in places within the valley. The above condition would indicate that here the river has appropriated a channel not of its own making, one that was formed by the waters of a preglacial stream. A short distance south of Rome, at the point where the river resumes its more easterly direction, it abandons this old valley. From this place down to the point where it leaves the county the river occupies a newer bed. Along this part of its course the channel is narrower, and the ledges that border it are higher, less covered with waste, and stand more nearly vertical. Near Rome the magnesian beds which belong to the lower portion of the Saint Louis limestone may be seen at the base of the bluffs. Proceeding further downward along its course the river has cut through succes-

sively lower beds. At Webster's mill, a few miles below Oakland, its channel is carved to a depth of twenty-five feet in the strata of the Keokuk limestone. Below this point there is a slight dipping of the layers, and at the old Boylston mill, near the northwest corner of section 25 of Jackson township, the geode shales of the Keokuk sub-stage are exposed in the south bank of the river just above the level of low water.

Seven miles below Boylston mill, and about one mile before leaving the county, the Skunk river receives from the north the waters of Mud creek. At this point deposits of the Keokuk shales stand out in a bluff to a height of twenty feet above the river. Here they are overlain by the thick layers of magnesian limestone which Professor Worthen designated as the Warsaw.

Big Cedar Creek.—Big Cedar creek, the largest tributary of the Skunk river within its area, rises in Harrison township of Mahaska county. It flows in a southeasterly direction for a distance of seventy-five miles, crossing the counties of Wapello, Jefferson and a corner of Van Buren. It enters Henry county near the northwest corner of Salem township. After making a few turns it receives the waters of Little Cedar creek near the northeast corner of section 17, of the same township. Soon after this the stream departs from its general southeasterly course and bends abruptly northward. With many windings it persists in following a northerly direction until it unites with the Skunk river a short distance below Rome. This is only eight miles from the point where the stream makes its northward turn, but in the devious journey its waters have traversed more than double that number of miles.

Throughout the whole of its northerly course Big Cedar creek flows in a wide valley bounded by low ledges, partially drift covered, or by banks of till which belong to the Kansan age. One such bluff composed of clay, containing pebbles and bowlders of various sizes overlooks the stream near the middle of the northwest quarter of section 9, Salem township. At this point the creek bends sharply to the northwest, and its current has been deflected against the bluff that borders the valley exposing a bed of drift for a depth of fifty feet down to the water's edge.

The bed of the stream lies about fifteen feet below the flood

plain which would average over three-fourths of a mile in width, but at no point in its northward journey does its waters cut down to the underlying limestones. Indeed, in many places over the flood plain wells have been put down for a depth of fifty or sixty feet without reaching the indurated rocks.

The above facts testify to a time preceding the invasion of the Kansas ice, in which for a long period the land over this area stood higher than at present. During this time the streams that drained the region cut their channels to a greater depth than they are permitted to do with the present elevation. This interval was followed by the period when the Kansan ice sheet spread its mantle of drift over all of this portion of the state, filling full and completely burying all of these old river channels. After the retreat of the ice a stream of the new drainage system established itself within the banks of the old preglacial valley. After another long period a lobe of the Illinoian ice sheet pushed over for some distance into Iowa from the eastward. This mass of ice crowded the Mississippi river out of its bed and forced it to flow for a time further west. As this temporary Mississippi passed west from Winfield around the margin of the ice, it found the channel which is at present occupied by the Skunk river and appropriated it for some distance, following it southward from Coppock as far as Rome.

Mr. Leverett has also found a wide valley excavated in the Kansan drift and partially filled with till of the Illinoian age, which turns aside from the present Skunk river channel near Augusta* in Des Moines county. This valley, which is over a mile in width, passes south from this point, meeting the Mississippi a few miles farther south than the present bed of the Skunk. Above Augusta this valley is occupied by the waters of the present Skunk river. Along the borders of Lee and Des Moines counties the river flows through a wide flood plain which is much larger than that of Big creek, and probably could not have been formed by the waters of that stream. In the northern portion of Lee county this valley comes up nearly to the level of the neighboring part of the temporary Mississippi. Leverett considers this to be the ancient bed of the Skunk river before the

* Leverett: The Illinoian Glacial Lobe, pp. 121-123.

invasion of the Illinoian ice. If the line of discharge for the Skunk river in pre-Illinoian times was down this channel, the same ice dam which caused the Mississippi to make a turn further westward around its border, would also block the drainage of the Skunk in this direction. During this period the waters of the temporary Mississippi joined with those of the Skunk river at Coppock and passed down the present Skunk river channel as far as Rome. Then owing to the blocked condition of the lower portion of the Skunk, they continued south along the lower course of the present Big Cedar creek to section 17 of Salem township. This lower course of the valley of Big Cedar was probably the line of discharge for the waters of Big and Little Cedar creeks in the pre-Illinoian times the same as at present. It is about one mile in width and is bordered by rather low and partially drift covered ledges of limestone twenty-five to thirty-five feet in height. It has every characteristic of an ancient valley and indicates a much longer period of water action than does the more southern portion of this temporary Mississippi channel known as the Grand Valley.

The presence of the Big Cedar channel probably determined the particular place where the united Skunk and Mississippi rivers should leave the valley of the Skunk. As they continued southward in the Big Cedar creek channel in the direction opposite to that of the waters which it previously carried, they would silt up the bed to a height a little above that of Big Cedar at the point where it enters this channel in Salem township.

When the Illinoian ice melted and the rivers returned to their present course, Big Cedar creek would probably continue to find the southward direction, down this old valley, the line of easiest discharge owing to the slope of the bed determined by the direction of flow of those temporary rivers. The portion of the channel between Rome and section 17 of Salem township would thus for a time have been abandoned. Upon the return of the Skunk river to its present course, a stream would probably at once be formed in the northern portion of this deserted channel, discharging its waters into the river. Finding the task of excavation in this new deposit a comparatively easy one, it soon worked its way backward to the point where Big Cedar entered this valley in Salem

township, diverting the waters of that stream once more northward, in the old direction of flow. Continuing this back erosion a short distance further southward, the bed of Little Cedar creek also would be tapped and the present course of these streams within the county established. The Grand valley would thus be left a deserted channel to tell the partial story of the changes in which it had had a share.

Big Creek.—This is the second largest stream that pays tribute to the Skunk river within the county. It drains the region to the north of the river and belongs distinctively to the central portion of this area. It also enjoys the distinction of being one of the most crooked and winding streams in the state. Big creek has its source in the trenches and small gullies eroded by the water in the eastern part of Canaan township. These smaller branches unite to form a single larger stream near the southeast corner of the township of Marion. From this point the creek winds back and forth across the southern part of Marion township, past abrupt ledges of limestone and beds of softer sandstone. Near the western part of Marion township it receives from the north the waters of Linn and Little Potomac creeks. Soon after this it turns southward and continues in just as zigzag and winding a manner to within less than two miles of the river in section 18 of Cedar township. Here it bends to the southeast and continues its devious course in a general line parallel with the Skunk river, flowing across Center and the northeast corner of Jackson townships, and emptying into the river in section 19 of the township of Baltimore. About two miles before it unites with the river, Big creek receives the waters of Brush creek, whose tributaries drain the greater part of New London township. The headwaters of Big creek are within ten miles of its mouth, and yet this winding stream has a length of more than seventy miles. It forms the principal drainage for the townships of Canaan, Marion, Center, New London, the northeast corner of Jackson and the northwest portion of Baltimore. Along its entire course it is bordered by ledges of sand and limestone. It exposes along its banks the entire thickness of the Saint Louis stage, as that stage is developed in the county, from the shaly fossiliferous layer overlying the white compact beds at the top, to the geode

shales of the Keokuk which underlie the brown magnesian beds at the base.

Big creek is a new stream. It occupies a channel of its own carving since the leveling mantle of the Kansan drift was spread over all of this area. It lies in the region embraced between the moraine of the Illinoian drift on the east and the great bend of the temporary Mississippi river on the north and west. It forms the principal drainage for the east-central portion of the county.

In its westerly course Big creek runs parallel to the old Mississippi valley across the northern portion of the county. After bending southward it continues to flow parallel with the portion of the temporary channel which passes from Coppock to Rome, and finally, after turning to the southeast it still continues parallel with the present course of the Skunk river until by a more abrupt bend its waters meet that stream in the western part of Baltimore township.

Crooked Creek.—Scott township is drained by the numerous branches which form the headwaters of Crooked creek. This stream passes out of the county near the northeast corner of Wayne township. It follows the northward flowing channel of the temporary Mississippi river, and with it returns to the borders of the county in the northwest corner of the township of Jefferson.

Numerous other small streams within this area pay tribute to the Skunk river and to Big creek and Big Cedar creek, but they are not of sufficient size to merit separate mention.

Instead of the normal stream drainage that carries off the surface water over the greater part of the area, at a few points there are developed sink holes. At these places the underlying strata are fissured, or passages have been dissolved in them, through which cracks the water finds its way downward to subterranean waterways. Such sink holes appear in the southwest portion of Tippecanoe township and, again, a few may be seen along Little Cedar creek in the western part of the township of Salem. None of these, however, are more than a few feet in diameter nor are they so numerous as to form an important feature of drainage.

STRATIGRAPHY.

General Relations of Strata.

The ancient geological history of Henry county is written on the rocks which belong to the uppermost system of the Paleozoic group, as that group of rocks is developed in the Mississippi valley. Over all of the southern and southwestern portion of the county the rocks of this system are exposed, time after time, in the beds and along the banks of the larger streams. In many places a vertical section of thirty to forty feet is laid open to observation. The northern or prairie portion of the area is deeply drift covered, and it is but rarely that a stream has carved its channel through the drift to the indurated rocks. Even here the well drill has revealed the fact that the rocks of this same age underlie the till at varying depths.

The glacial series is represented in Henry county by two distinct drift sheets, separated by a long interglacial period. These record the changes and vicissitudes of climate to which the region has been subjected in more recent times.

The relations of the different geological formations which are exposed over this area may be represented in the following table:

GROUP.	SYSTEM.	SERIES.	STAGE	SUB-STAGE.
Cenozoic.	Pleistocene.	Recent.	Alluvial.	
		Glacial.	Illinoian.	
			Yarmouth.	
			Kansan.	
Paleozoic.	Carboniferous.	Upper Carboniferous or Pennsylvanian.	Des Moines.	
		Lower Carboniferous or Mississippian.	Saint Louis.	Pella.
				Verdi.
				Springvale.
			Augusta.	Keokuk.

As will be seen from the above table we have here but one sys-

tem of indurated rocks, and of this system both the upper and the lower series are represented. The two series, however, are separated by an enormous period of time. So long indeed was it after the laying down of the lower, before the rocks of the upper series were deposited, that the surface of the former was dissected and deeply furrowed by the streams which drained the area during its earlier history. At many points the rocks of the upper series can be seen occupying the old channels that were eroded in the lower during this long interval.

Of the lower series there are present the Augusta and the Saint Louis stages, and of the upper the sandstones of the Des Moines. Of the Augusta stage in Henry county there is exposed but the upper part which is known as the Keokuk sub-stage.

Lower Carboniferous or Mississippian Series.

KEOKUK LIMESTONE.

The name Keokuk is applied to this assemblage of strata from the fact that in the bluffs of the Mississippi river at the city of Keokuk these rocks have a greater development and are better exposed than at any other point within the state.

The Keokuk limestone occupies but a limited area in Iowa. It is found only in the counties of Lee, Van Buren, Henry and Des Moines, and rapidly thins out towards the north from the city of Keokuk.

As it is exposed in Henry county the Keokuk limestone presents two distinct phases conveniently designated as the upper and the lower. The lower phase consists of about twenty-five feet of limestone, made up of layers of unequal thickness and of varying degrees of hardness. Very often these layers are interstratified with bands of rather soft bluish colored shale. The beds are fossiliferous throughout their entire thickness.

The upper phase, called the geode shales, consists of a bed of calcareous shale or marl, thirty feet in depth. Within this softer material are imbedded great numbers of siliceous geodes, whose cavities are lined with beautiful crystals of quartz or of carbonate of calcium. This bed contains no fossils. The lower phase, as it appears at Keokuk, has been described by Owen under

the name of the "Lower Archimedes Limestone"* and he refers the geode beds to another series of the Carboniferous. In his report on the Geology of Iowa,† James Hall includes both of these members in the Keokuk limestone, making the geode shales the well marked upper limit for the Keokuk, as does also Dr. C. A. White,‡ who wrote a dozen years after. The later writers on the geology of Iowa have followed the classification of Hall in this regard, and that arrangement will be adhered to in the present work.

Typical Exposures.—Exposures of the rocks of this age are found only in the southern portion of the county. They outcrop in the bed of the streams or appear for a few feet in height along their banks. They form the surface rocks at only a few points, and in such places seem to appear in the anticlines of gentle folds.

One of the best exposures of the lower phase of the Keokuk limestone within the area is seen along a small stream that flows into the Skunk river from the south, a short distance above Webster's mill, in section 4 of Jackson township. On following down the bed of this stream from a spring, about one and a half miles above its mouth, one first passes over layers of brown, magnesian limestone which contain the fossil *Lithostrotion canadense,* Cast. The presence of this fossil marks a definite horizon near the base of the Saint Louis stage wherever in the county these rocks may be exposed. About one-half mile from the spring there is an abrupt change in the character of the rocks. The brown magnesian limestone gives place to light gray crinoidal layers which contain numerous fossils. An exposure in a low bluff at this point shows the following section:

		FEET.	INCHES.
5.	Clay, reddish in color, containing an abundance of gravel	4	
4.	Brown, magnesian limestone, non-fossiliferous	2	
3.	Layer of light gray crinoidal limestone containing the spiral axes of *Archimedes*, *Zaphrentis dalei* and *Spirifer suborbicularis*		8
2.	Thin layer of yellowish, fine-grained limestone which contains large fish teeth		3
1.	Bed of rather soft, bluish gray shale		10

* Owen: Geol. Surv. Wis., Iowa and Minn., pp. 91–96. 1852.
† Hall: Geol. Iowa, Vol. I, pt. 1, pp. 94–96. 1858.
‡ White: Geol. Iowa, Vol. I, pp. 210–212. 1870.

In the above section number 5 is Kansan drift, leached and iron stained. The reddish color is due to the oxidization of its iron from the form of ferrous carbonate or oxide to the ferric condition of the oxide. Number 4 belongs to the lower portion of the Saint Louis stage. It is fine-grained and dolomitic, reacting but slowly with cold hydrochloric acid, and contains no fossils. Number 3 is a gray limestone, containing numerous fragments of crinoid stems, together with the remains of *Archimedes owenanus* Hall, and numerous other Fenestelloid Bryozoans, a large undetermined species of Zaphrentis, besides *Zaphrentis dalei, Spirifer suborbicularis,* and an undetermined form of Spiriferina. This layer belongs to the Keokuk sub-stage and marks the contact between the Saint Louis and the Keokuk limestone at this place. Number 2 is a very narrow layer, weathering to a yellowish color, and containing large teeth belonging to the Selachian type of fishes, among which the following are conspicuous:

Sandalodus lævissimus N. & W.
Deltodus spatulatus N. & W.
Deltodus occidentalis Leidy.

The lower member of the section is a soft shale in which there are but few fossils preserved. Continuing down the stream from this point the following succession of layers is passed over:

		FEET.	INCHES.
12.	Layer of very fossiliferous crinoidal limestone containing Bryozoa, Zaphrentis and Spirifer		4
11.	Layer of soft, bluish gray shale	1	4
10.	Thinly bedded limestone, weathering into thin shaly fragments and containing numerous imperfect fossils	4	2
9.	Bed of shale similar to number 11 above	1	6
8.	Gray, fossiliferous limestone, coarsely granular		10
7.	Layer of shale resembling numbers 11 and 9 above	2	
6.	Gray, shaly limestone, weathering easily, and crowded with fossils. *Platyceras equilaterale, Spirifer keokuk, S. tenuicostatus* and *Phillipsia* sp.		11
5.	Shaly beds containing numerous Bryozoans and Brachiopods, a narrow band near the top crowded with small fish teeth	3	

		FEET.	INCHES.
4.	Crinoidal limestone in narrow layers which weather into thin fragments, alternating with thin shaly bands. *Productus punctatus, Spirifer neglectus, S. pseudolineatus Derbya keokuk* and *Dielasma formosa* are abundant throughout this member..	2	6
3.	Layer composed very largely of nodules of chert with limestone filling the interspaces		10
2.	Thin layer of crinoidal limestone containing numerous Producti and Spirifers....		6
1.	Alternating layers of shale and harder limestone with few fossils, to water's edge	7	

Number 12 of the above beds contains numerous fossils, conspicuous among which appear fragments of a small *Archimedes, Zaphrentis dalei, Spirifer keokuk* of typical form, and *Spiriferina* sp. The shale bands both above and below this member erode very rapidly leaving it standing out prominently in the banks.

Number 6 is crowded with organic remains among which the following are very common. *Zaphrentis varsoviensis, Z. centralis, Glyptopora elegans, Actinotrypa peculiaris, Camarophoria subtrigona, Spirifer tenuicostatus, S. keokuk, Spiriferina,* sp., *Athyris cf. hirsuta, Platyceras equilaterale* and Phillipsia resembling *Phillipsia portlocki.* Near the upper part of the following member, number 5, is a narrow band four inches in thickness which contains great numbers of fish teeth, including species of Orodus, Cladodus, Pœcilodus, Chomatodus, Helodus and Deltodus. The teeth are so thickly crowded in this narrow layer that they give to it a dark, mottled appearance which contrasts strongly with the bluish gray of the preceding and the succeeding beds. Numbers 2, 3 and 4 are all very fossiliferous, containing *Zaphrentis dalei, Z. centralis,* an undetermined species of Zaphrentis larger than either of the above, *Derbya keokuk, Productus punctatus, P. setigerus, Productus* sp. *Dielasma turgida, D. formosa, Spirifer tenuicostatus, S. pseudolineatus, S. keokuk, S. suborbicularis, S. neglecta, Syringothyris textus, Athyris planosulcata (?) and Myalina keokuk.*

The assemblage of fossils given above are characteristic of the

Keokuk limestone and indicate that geological horizon at this place.

There is here exposed along the stream and in the bluff a thickness of twenty-seven feet of the lower phase of the Keokuk limestone. The contact of the Saint Louis and the Keokuk is plainly marked and well exposed, but the bed of geode shales which overlies this limestone further south is entirely wanting at this point. The Archimedes bearing phase here succeeds the lower member of the Saint Louis stage without a trace of geode development.

THE GEODE SHALES.

In section 22 of Baltimore township there is exposed in the east bank of Mud creek a bed of geode bearing shales thirty feet in thickness. The shale is calcareous, grayish blue in color and so

FIG. 44. Exposure of Keokuk limestone on Mud creek, Baltimore township.

soft that it crumbles rapidly on exposure to the weather, thus releasing the numerous rounded or irregularly shaped nodules which it contains. These concretions are usually siliceous and are generally hollow. The cavities are lined with quartz in the

form of bright, transparent crystals, or of waxy white or gray chalcedony, or they are studded with clear colorless crystals of carbonate of calcium. Very often there is found in a cavity, besides the principal mineral which lines it, single crystals of lead or zinc sulphide, or of iron pyrites, or again if the geode is of quartz it may contain a large crystal of calcite. Great quantities of these geodes have weathered out of the bluff and line the bed of the stream from this point to its junction with the Skunk river a mile below. Mud creek has attained not a small degree of local celebrity on account of the number and perfection and the beauty of its geodes. Ornamental mounds of these concretions, their exposed cavities studded with shining crystals, may be seen on the lawns of the lovers of beauty even to the farthest limits of the county.

On passing still further up the creek the harder limestone beds of the lower phase are encountered. Three-quarters of a mile above the geode bluff a low ledge on the west side of the stream rises twelve feet above the water's edge, but it is overlain by no

FIG. 45. Geodes along the bed of Mud creek, near Lowell, Iowa. The Geode shales occur in the base of the bluff, which shows near the center of the picture.

geode shales, nor do any geodes appear in the bed of the creek between the two points, not at any point further up the stream. The section here exposed shows hard layers of limestone alternating with softer bands of shale, but it was impossible to correlate the different layers with those exposed near Webster's mill with any degree of certainty. Many of the fossils contained in these beds are identical with those of the Webster's mill section, which would indicate that these rocks also belong to the lower phase of the Keokuk limestone, but whether they occur above or below those exposed in Jackson township, or whether they represent a slightly different development of the same beds was not fully determined. The similarity of the fossils in the two exposures would make the latter view seem the more probable. The geode bearing shale outcrops again below this point in the bank of Mud creek at the west end of the wagon bridge which crosses that stream about one mile east of Lowell. At this point the underlying rocks are not exposed but the shales are covered by a bluff of brown, magnesian limestone thirty feet in height. Once more these beds appear a few feet above low water in the south bank of Skunk river near the old Boylston mill, and again they are seen in a bank on the farm owned by Mr. Armour, a few miles east from the latter exposure. These are the only places where the rocks belonging to the Keokuk sub-stage are known to outcrop within the county, and, as may be seen, they are confined to the southern portion. They appear at no definite level, nor are they exposed over any continuous area. The geode bearing phase was probably developed but locally over this region, as the above exposures mark the northern margin of those shales within the state. The rocks of the lower phase of the Keokuk limestone probably owe their appearance near the surface at points widely separated and at different levels, to the gentle folding of the strata over this area. The following is a general section of the rocks of the Keokuk sub-stage as they are developed within the county:

		FEET.
4.	Beds of rather soft, calcareous shale becoming harder near the basal portion, containing numerous geodes throughout its entire thickness	30
3.	Layers of crinoidal limestone alternating with bands of shale. The harder layers containing teeth of Sandalodus and Deltodus, besides the fossils *Archimedes owenanus*, *Zaphrentis dalei*, and *Spirifer keokuk*..	10
2.	Beds of soft, fissile limestone interlaid with thicker beds of shale. Near the top of this member is a narrow layer of limestone crowded with teeth of Cladodus, Orodus, Chomatodus and Pœcilodus. Great numbers of the following forms are present throughout the beds. *Spirifer tenuicostatus*, *Athyris*, *Platyceras* and *Phillipsia*	6
1.	Layers of hard limestone containing numerous chert nodules near the central portion. Fossils abundant, including *Derbya*, *Productus*, *Dielasma*, *Spirifer*, *Athyris* and *Myalina*	11

The fauna of the Keokuk limestone is of general interest on account of both the number and the variety of its forms. The following list of the more common species will convey some idea of the types which peopled the waters of those old Carboniferous seas.

Palœacis obtusus M. & W.
Zaphrentis varsoviensis Worthen.
Z. centralis E. & H.
Z. dalei E. & H.
Actinotrypa peculiaris Rom.
Glyptopora elegans Prout.
Drymopora sp.
Derbya keokuk Hall.
Productus punctatus Martin.
P. setigerus Hall.
Productus sp.
Camarophoria subtrigona M. & W.
Dielasma turgida Hall.

D. formosa Hall.
Spiriferina sp.
Spirifer logani Hall.
S. keokuk Hall.
S. tenuicostatus Hall.
S. suborbicularis Hall.
S. pseudolineata Hall.
S. neglectus Hall.
Syringothyris textus Hall.
Athyris (Seminula) hirsuta (?) Hall.
Athyris (Seminula) planosulcata (?) Phillips.
Myalina keokuk Worthen.
Phillipsia portlocki (?) M. & W.
Sandalodus lævissimus N. & W.
Orodus ornatissimus N. & W.
Cladodus magnificus Tuomey.
Cladodus sp.
Deltodus spatulatus N. & W.
D. occidentalis (?) Leidy.
Pœcilodus rugosus N. & W.
Chomatodus sp.
Helodus sp.

The Warsaw shales and limestones described by Gordon* in Van Buren county, and by Keyes† in Lee, are entirely absent in Henry. The brown magnesian limestone, which occurs at the base of the Saint Louis stage, immediately overlies the Keokuk wherever the contact between those beds is seen.

THE SAINT LOUIS LIMESTONE.

The rocks of the Saint Louis stage immediately underlie the drift over all of this region, except in the very limited areas, above described, where the rocks of the Keokuk sub-stage appear at the surface, or where the Saint Louis limestone is overlain by the sandstone of the Upper Carboniferous series. The strata of the Saint Louis are composed of limestones, sandstones and shales. They present three distinctly marked phases or divis-

* Iowa Geol. Surv., Vol. IV, p. 213.
† Iowa Geol. Surv., Vol. III, p. 344.

ions which can be readily recognized by their lithological characters wherever these rocks are exposed. The divisions may be referred to as the lower, middle and upper beds.

The first or lower phase consists of magnesian limestones, usually occurring in massive layers. They are rather fine-grained in texture, yellowish brown in color, and dolomitic in character, showing but slight action when treated with cold hydrochloric acid. These beds are characterized by the presence of the coral *Lithostrotion canadense* Cast., in its closely growing, massive form and silicified condition. In some places they contain casts and impressions of other fossils in abundance but these are usually too imperfectly preserved for identification. The thickness of this division varies from over thirty feet in the southeastern corner of the county, near Lowell, to less than fifteen feet further north and west. In the western portion of the county these layers become somewhat sandy in composition but even here the magnesian character still predominates and the yellowish brown appearance is maintained.

This division includes the upper member of the Warsaw limestone as defined by Hall,* and corresponds with the arenaceo-magnesian beds of Gordon in Van Buren† county, and to the Springvale beds of Bain in the counties of Keokuk‡ and Washington.§

The second or middle division is recognized by the extreme variableness of its beds and its generally disturbed condition. It consists of irregular layers of sandstones and shales with an occasional bed of brecciated limestone near the upper portion. It is a record of a time of great disturbance and of rapidly changing conditions. It is for the most part a deposit near the margin of some troubled sea. The presence of local layers which thin out rapidly within a short distance, the pockets of sand and shale, the numerous lenticular beds, and the general irregular appearance of the strata indicate a vigorous wave action. The ripple marks which are beautifully preserved in the sandstone at numerous points, and the local development of oolitic limestone testify to the close proximity of an old shore line. The brecciated phase

* Hall: Geol. of Iowa. Vol. I, pt. 1, p. 97. 1858.
† Iowa Geol. Surv. Vol. IV, p. 215.
‡ Ibid, Vol IV, p. 277.
§ Ibid, Vol. V, p. 148.

is usually represented by a bed of shattered limestone of variable

FIG. 46. Irregular beds of the Verdi division of the Saint Louis limestone, near Oakland Mills, Iowa.

thickness. It occurs only near the upper portion of the division and is usually associated with nodules of chert. The brecciated character is not so pronounced over this area as it is in the neighboring counties of Van Buren and Lee. It seldom attains any great thickness and at some points it is altogether wanting. Throughout much the greater portion this division consists of sandstones interstratified with an occasional bed of shale or a thin stratum of limestone. The latter is often oolitic in character. Near the central portion there occurs a band of flint, twelve to twenty inches in thickness, which is persistent over wide areas at this horizon, and forms one of the distinguishing features of the division.

The entire thickness of the deposits which constitute the middle phase of the Saint Louis limestone would average about thirty feet, but at a few localities they reach a depth of fifty, and are throughout almost wholly barren of organic remains. This division immediately overlies the magnesian beds above described

and is followed by the regular layers of white, compact limestone. It corresponds with the arenaceous portion referred to by White* in discussing the Saint Louis limestone. It is the equivalent of the Brecciated Limestone of Gordon† and Keyes‡ and of the Verdi beds of Bain§ in the present series of the Iowa Geological Survey reports.

The upper division of the Saint Louis stage records a more stable condition of this portion of the earth's crust during the period of its deposition. Its rock materials were laid down in deeper waters and in the lower portion consist of uniformly bedded, light gray limestones, very compact, and containing numerous fossils in the shaly bands between the layers. These beds grade upward into a softer, somewhat shaly deposit which weathers rapidly, and contains an abundance of fossils in a good state of preservation. The strata of this division have been thrown into gentle folds, but the disturbance was not sufficient to cause more than a slight flexure of the beds. This phase, as developed in Henry county, reaches a maximum thickness of twenty feet. It is distinguished by the compact, light colored limestones arranged in regular layers and containing the fossils *Rhynchonella (Pugnax) ottumwa, Dielasma turgida, Spirifer keokuk* and *Allorisma marionensis.* It corresponds with the gray flag-like limestone referred to by Keyes in the Des Moines county report, and with the compact and granular limestone of Gordon in Van Buren, and with the Pella beds of Bain in the counties of Keokuk and Washington described in the reports above cited. Inasmuch as Mr. Bain has consistently applied names to these three divisions as they appear in the neighboring counties of Keokuk and Washington where the rocks of this stage attained a development somewhat similar to that reached in Henry county, it is thought best for the sake of uniformity in nomenclature to adhere to the names proposed by him for these divisions. In accordance with this plan the lower, middle and upper phases of the rocks of the Saint Louis stage will be designated as the Springvale, Verdi and Pella beds respectively.

The Springvale division takes its name from Springvale mills,

* White: Geol. Surv. of Iowa, Vol. I, p. 216. 1870.
† Gordon: Iowa Geol. Surv., Vol. IV, p. 216
‡ Keyes: Iowa Geol. Surv., Vol. III, pp. 348-349.
§ Bain: Iowa Geol. Surv , Vol. IV, p 279 and Vol. V, pp. 149-150.

in the western part of Keokuk county, where the rocks of this phase are well developed. The Verdi quarries, from which the name of the middle division was taken, are found in the southern part of Washington county. The Pella beds owe their name to the fact that rocks of this phase are well exposed near the town of Pella, in Marion county.

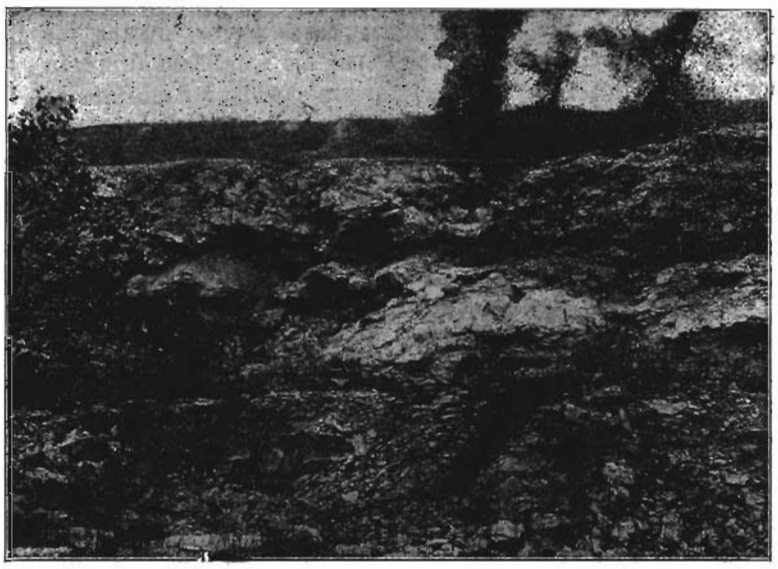


FIG. 47. Exposure of the middle portion of the Saint Louis limestone, at the old Winter's quarry near Mt. Pleasant, Iowa.

The characte ristics of the rocks of the Saint Louis stage as a whole, together with those which distinguish each of the divisions, will be best understood by the consideration of the following exposures.

The old Winter's quarry, which is located in the south bank of a small stream emptying into Big creek from the north, near the railroad bridge in the Se. ¼ of section 17, Center township, shows the following section:

		FEET.
12.	Reddish brown clay, containing gravel and small bowlders	4
11.	Soft, shaly limestone of gray color, weathering into thin fragments and containing numerous remains of *Productus marginocinctus*, *Rhynchonella ottumwa*. *Dielasma turgida*, *Spirifer keokuk*, *Athyris subquadrata* and *Allorisma marionensis*	6
10.	Fine-grained, compact limestone of light gray color, layers ten to twenty inches in thickness, containing *Productus tenuicostus*	5
9.	Evenly bedded, gray limestone in layers two to eight inches in thickness containing the fossils *Rhynchonella ottumwa*, *Dielasma turgida* and *Spirifer keokuk*	6
8.	Narrow layers of light gray flag-stones, two to four inches in thickness. Fossils similar to number 9 above	1
7.	Undulating layers of fine-grained limestone, one to three feet in thickness, containing but few fossils	8
6.	Fine-grained, brecciated, gray limestone, non-fossiliferous, in places much shattered	5
5.	Layer consisting of lentils and irregular beds of sandstones and shales	6
4.	Beds of light colored, arenaceous limestones in places flexed and often brecciated	6
3.	Layer of flint in the form of a band rather than that of nodules	1½
2.	Impure limestone, yellowish in color, the upper portion in thin layers, the lower a single bed three feet in thickness	4
1.	Laminated beds, one to three inches in thickness, consisting of brown, magnesian layers above, thin layers of oölitic limestone in the central portion and arenaceo-magnesian limestone below	5

In the above section number 1 contains numerous silicified coralla of the fossil *Lithostrotion canadense* in the closely growing form. The upper surface of this member is here exposed over an area of several square rods. It presents numerous rounded elevations two to four feet in height and ten to twenty feet in diameter.

These elevations appear as if some force from below had pushed the strata vertically upward at those points. Many of the layers, both of numbers 1 and 2, show beautiful ripple marks which are exposed over an area several square feet in extent. This ripple marked sandstone as well as the bands of oolite which appear in the first member plainly tell us that this was the site of an ancient beach at the time these rock materials were laid down. Number 3 is a layer of almost pure flint. A few rods west of this place, across the railroad track, there is exposed in corresponding beds a second band of chert, two feet in thickness, about four feet above the first. It is not surprising that the fossil *Lithostrotion canadense* always occurs in a silicified condition when the rocks of this horizon contained silica in such quantities as to make possible the deposit of these bands so closely overlying the beds in which that coral is found. The heavy layers of numbers 1 and 2 in the above section, composed of magnesian and arenaceo-magnesian limestone, and containing the fossil Lithostrotion as here found, represent the

FIG. 48. Exposure of limestone in Parkins' quarry, showing the even layers of the Pella sub-stage.

Springvale beds. The broken and irregular layers of sandstones and shales together with the brecciated or oolitic beds of limestone, embracing numbers 3 to 7 inclusive, belong to the Verdi phase; while numbers 8, 9, 10 and 11, consisting of hard, fine-grained, evenly bedded limestone and containing numerous fos-

sils, as given above, constitute the Pella beds as they are developed within the county.

In a quarry belonging to Mr. Levi Parkins, on the south bank of Little Cedar creek, near the southwest corner of section 22, Salem township, the following succession of layers may be seen:

		FEET.
6.	Reddish colored clay, in the lower portion containing gravel and small bowlders...	4
5.	White, compact, fine-grained limestone, in layers eight to twelve inches in thickness, and containing the fossils, *Rhynchonella ottumwa*, *Dielasma turgida*, *Spirifer keokuk* and *Allorisma marionensis*.....	3
4.	Fine-grained limestone similar to number 5, layers three to seven inches in thickness and separated one from another by a clayey seam of one-half to one and one-half inches. These seams contain many fossils similar to number 5.....	9
3.	Irregular layers of yellowish colored impure limestone, one and one-half to two and one-half feet in thickness, non-fossiliferous and containing numerous nodules of chert	6
2.	Layers of oölitic limestone, the grains of rather large size	½
1.	Arenaceous limestone in layers varying from two or three inches to one foot in thickness, exposed to the water's edge..	3 ½

In the above section number 6 is the reddish colored, oxidized clay of Kansan drift. The upper portion, to the depth of about one foot, is of fine-grained material and contains no gravel. It has probably been deposited in part by the wind, and again a part of it may have been slowly pushed downward from the higher land by the slow action of the rain. Numbers 4 and 5 consist of fine-grained, compact layers of light colored limestone. The beds are similar in character throughout, and represent a period of continuous deposition under uniformly quiet conditions. In the upper member the layers have a somewhat greater thickness than in the lower and with less conspicuous shaly partings between them. These two members present the distinctive characters of the Pella beds both with respect to their lithological

characters and the fossils which they contain. They yield the following species in abundance: *Zaphrentis pellaensis, Productus marginocinctus, P. tenuicostus, P. ovatus, Rhynchonella (Pugnax) ottumwa, Dielasma turgida, Spirifer keokuk* and *Allorisma marionensis.* The first four of the above list are limited to the upper member, while the rest persist throughout the layers of both. These two members correspond to numbers 8, 9 and the lower part of 10 of the Winter's quarry exposure.

Numbers 1, 2 and 3 in the above section contain but few fossils. They represent the Verdi beds, but at this point the development is somewhat different from that of the corresponding phase at Winter's quarry, on Big creek. So changeable, indeed, were the conditions during the deposition of the materials of the Verdi division that at no two points separated by even one mile is there found the same succession of layers. Number 3 contains numerous nodules of chert, varying in size from a few inches to two or three feet in diameter. These nodules are imbedded in a rather fine-grained, impure limestone. Layer number 2 is a narrow band of oolite. The development of oolitic limestone is not uncommon in this division of the rocks of the Saint Louis stage. Very often it occurs in layers much thicker than that of number 2 above. The sandstone of number 1 is here exposed at the surface near the level of the water, and presents beautiful ripple marks which may be traced continuously for a distance of seventy-five feet.

About three miles southeast of the Parkins' quarry, in section 35 of Salem township, the following layers outcrop in the south bank of Little Cedar creek near the Henry and Lee county line:

		FEET.
3.	Reddish brown clay, containing gravel....	6
2.	Two layers of fine-grained, yellowish gray limestone, each about sixteen inches in thickness and containing numerous forms of Bryozoa, *Productus tenuicostus*, *P. ovatus*, *Rhynchonella ottumwa*, *Dielasma turgida* and *Spirifer keokuk*.....	2 ⅔
1.	Layers of light gray limestone, three to eight inches in thickness, containing numerous individuals of *Rhynchonella ottumwa*, *Dielasma turgida*, *Spirifer keokuk* and *Allorisma marionensis*.....	5

In the above section number 2 corresponds with the lower por-

tion of number 10 of the Winter's quarry section, and it immediately overlies number 5, of Parkins' quarry. Number 3 corresponds with number 9 of the Winter's quarry beds, and with the upper five feet of the Parkins' quarry exposure.

In the Nw. ¼ of section 20, of Jackson township, on the farm owned by Mr. Ed. Masden, there is exposed in a ravine the following layers:

		FEET.
3.	Gray, shaly beds, very fossiliferous, containing in abundance *Zaphrentis pallaensis*, *Rhynchonella ottumwa*, *Dielasma turgida*, *Spirifer keokuk* and *Athyris subquadrata*	2
2.	Thicker, fine-grained layers, harder than the above and containing fewer fossils..	3
1.	Evenly bedded layers of light gray limestone, the seams between the layers crowded with the fossils *Rhynchonella ottumwa*, *Dielasma turgida*, *Spirifer keokuk* and *Allorisma marionensis*...	5

The above layers also represent the upper portion of the Pella beds. Number 3 corresponds with the lower part of number 11

FIG. 49. View showing the slightly folded layers of the upper beds of Saint Louis limestone, Baltimore township.

of the Winter's quarry section. Number 2 is the equivalent of number 10 in the same exposure and of number 2 of the section near the Henry and Lee county line. Number 1 corresponds with number 1 of the latter section, with the upper portion of the Parkins' quarry section, and with number 9 of the beds at Winter's quarry. At this place the layers, which in the other exposures above cited, have a horizontal position, are inclined at an angle of nearly 45°. The exposure is in the arch of a fold, the beds sloping off in two directions.

In the eastern part of section 6, Baltimore township, there is exposed in the banks of Brush creek, just north of the wagon road and west of the bridge, the following succession of layers:

		FEET.	INCHES.
9.	Clay, containing gravel and small bowlders	6	
8.	Bands of shale alternating with narrow layers of limestone; the entire series weathering rapidly and containing numerous fossils, among which the following are conspicuous: *Zaphrentis pellaensis*, *Productus marginocinctus*, *Rhynchonella ottumwa*, *Dielasma, turgida*, *Spirifer keokuk*, *Athyris subquadrata*, and *Allorisma marionensis*	4	
7.	Layers of fine-grained, evenly bedded, white limestone, varying in thickness from two to twelve inches, the shaly partings between the layers one to two inches in thickness and crowded with fossils	9	
6.	Layer of very compact, fine-grained limestone		10
5.	Flagstone layer of fine-grained, light gray limestone		6
4.	Narrow flagstone layer		3
3.	Hard, fine-grained, bluish colored limestone		4
2.	Bed of soft sandstone, presenting numerous beautiful examples of cross bedding	12	
1.	A bluff of disturbed beds of sandstones and shales, much broken and very irregular, exposed about one and one-half miles further down the creek	45	

In the above section numbers 1 and 2 represent the Verdi beds in their characteristic disturbed and shattered condition, and

yield no fossils. Number 1 consists, for the most part, of sandstones interbedded with lentils and pockets of shale, and occasional masses of brecciated limestone. In the lower portion were found small deposits of impure coal or carbonaceous material two to four feet in length and one to two inches in thickness. The layers at this point are too changeable and discontinuous to be correlated with those of any known exposures of the Verdi beds. Number 2 is a more uniform deposit than the preceding, but is only a local development. Numbers 3 to 8 inclusive embrace all of the members of the Pella beds in their normal condition. At this place also these layers are slightly flexed, as may be seen in the accompanying photograph, but the strata are not inclined at so great an angle as they are in the exposure on the farm of Mr. Masden, in Jackson township.

In the east bank of the Skunk river, about one mile above the old Millspaugh mill, in section 30 of Trenton township, the following succession of layers may be seen:

		FEET.	INCHES.
7.	Bed of fine-grained impure limestone, somewhat brecciated and carrying no fossils	3	
6.	Bed of brownish colored shale	3	
5.	Layer made up of flint nodules, their interstices filled with limestone.....		8
4.	Layer of arenaceous limestone which often resembles oölite		10
3.	Layer of variable sandstone in places hard and coarsely granular and again within a short distance it may be soft and fine-grained	2	6
2.	Bed of arenaceous limestone with grains of sand one-fourth of an inch in diameter, among which are imbedded several small fragments of chert	4	
1.	Beds of dark gray, coarsely granular limestone in layers four to sixteen inches in thickness, containing numerous fragments of crinoid remains, and other fossils in an imperfect condition, among which forms of Bryozoa, a species of Dielasma, and Spirifer are abundant....	6	

Sections similar to the above might be multiplied in every ravine over this portion of the county. The exposure represents

the rocks of the lower part of the Verdi division, and the members are the equivalent of numbers 2 to 5 inclusive of Winter's quarry.

Near the central part of section 6, Center township, a very instructive section is exposed on the east bank of Big creek. This may be called the Center township exposure, and shows the following beds:

		FEET.	INCHES.
9.	Yellowish brown clay containing gravels..	2	
8.	Bed of light gray, fine-grained, non-fossiliferous limestone in layers eight to sixteen inches in thickness	3	6
7.	Narrow band of clayey marl crowded with the casts of a fossil which somewhat resembles a species of Athyris		4
6.	Layer of hard gray limestone without fossils	2	6
5.	Bed of light colored sandstone, rather loose and incoherent throughout	8	
4.	Layer of granular limestone, light gray in color, and containing no fossils.....	1	8
3.	Bed of fine-grained, yellowish brown, magnesian limestone, in layers four to sixteen inches in thickness; non-fossiliferous	10	
2.	Bed of light gray, brecciated limestone, mostly fine-grained and in places much shattered and broken	15	
1.	Bed of brown, impure limestone in layers eight to twenty inches in thickness, containing silicified coralla of *Lithostrotion canadense*	4	

In the above exposure number 1 represents the upper portion of the Springvale division of the Saint Louis stage.

Mr. Bain says* that in Washington county the shaly character of the Springvale beds becomes the more prominent, and the diagnostic fossil, *Lithostrotion canadense,* is rarely found, while to the west the division is more generally represented by brown, earthy limestones. As will appear in the sections of the Saint Louis limestone in Henry county, the Springvale division consists of brown, magnesian limestone which becomes somewhat arenaceous in places, but at no point, except at the isolated exposure

* Bain: Iowa Geol. Surv., Vol. V, p. 148.

near Winfield, does the shaly character above mentioned become conspicuous. The deevlopment of the rocks of this phase is similar to that found in Van Buren county by Mr. Gorden*, and the horizon is always distinguished by the presence of the fossil *Lithostrotion canadense,* which usually occurs in its massive form and silicified condition.

Numbers 2 to 8 inclusive belong to the Verdi beds. The successive layers are much more regular at this point than they are in the exposure of the corresponding phase in Baltimore township. The former beds also contain a much larger proportion of limestone.

Number 7 of the above section is continuous over the entire northeastern portion of the county and furnishes a valuable means of correlating the layers of this division in exposures so widely separated that the arrangement and the degree of disturbance and the lithological characters of the rocks present a very different appearance.

In the northern part of section 3 of Jefferson township, near the Henry and Washington county line, there are exposed the following layers which may be designated as the Jefferson township section:

		FEET.	INCHES.
7.	Clay containing gravel and small bowlders	4	
6.	Layers of light gray limestone, two to four inches in thickness, checked with numerous water passages and containing no fossils	3	
5.	Bed of fine-grained sandstone, light gray in color, in places loose and incoherent..	1	4
4.	Layers of light gray limestone ten to fifteen inches in thickness, without fossils, and containing numerous nodules of chert	5	
3.	Band of clayey marl crowded thickly with the casts of a fossil which somewhat resembles a species of Athyris		4
2.	Bed of gray, fine-grained limestone, somewhat brecciated and containing no fossils	3	
1.	Bed of soft, light colored, fine-grained sandstone, exposed to the water's edge..	1	

About ten rods from this exposure, in the bank of the same

* Gordon: Iowa Geol. Surv., Vol. IV., p. 215.

stream, the following layers outcrop in such a position as to indicate that they immediately overlie number 7 of the above section, but they do not appear in any other known exposure within the area.

		FEET.
3.	Bed of shattered, light gray limestone, containing no fossils	3
2.	Loose, fine-grained, light colored sandstone	4
1.	Brown arenaceo-magnesian limestone, containing no fossils	4

About two miles west of Wayland, in Jefferson township, the following layers appear in the bank of a small stream:

		FEET.	INCHES.
6.	Bed of brown sandstone, rather hard and coarsely granular	4	
5.	Layer of white, fine-grained, non-fossiliferous limestone	1	2
4.	Soft, fine-grained sandstone	12	
3.	Layers of light colored limestone, eight to ten inches in thickness, containing no fossils	1	6
2.	Band of clay or marl containing very numerous casts of a fossil which somewhat resembles a species of Athyris		4
1.	Layers of light gray, non-fossiliferous limestone down to the level of the stream	2	

In the latter section, number 1 corresponds with number 2 of the Jefferson township section, and with number 6 of the Center township exposure. The narrow band of clay, number 2, is crowded with the remains of a small brachiopod. The shells became filled by infiltration of calcite and later the shell substance was removed, so there is left only the casts, which are in such a crystallized condition as to render the determination of the fossil very difficult. A few of the most perfect specimens, on being ground and polished, show the laterally directed spiralia with the particular manner in which they are united, resembling those of the genus Athyris. This layer is readily recognized as the equivalent of number 3 of the Jefferson township section, and of number 7 of that of Center township. Number 3 corresponds with number 4 of the Jefferson township exposure, and with number 8

of the Center township section. Number 4 represents number 5 of the Jefferson township exposure, but it does not attain nearly the thickness of the latter, while number 5 of the above section is the equivalent of number 6 of the exposure in Jefferson township. All of the members of the two latter sections belong to the Verdi beds, but their layers cannot be correlated with those of the corresponding phase in the Winter's quarry section, nor with those of any exposure that is found in the eastern portion of the county.

About one mile east of Lowell, in Baltimore township, the bed and banks of a stream, on the north side of the wagon road, show the following section:

		FEET.
7.	Reddish colored clay, containing gravel...	6
6.	Layer of impure limestone, rusty brown in color and bearing no fossils.....	2
5.	Layer of brown magnesian limestone, similar to number 4 below	4
4.	Layer of magnesian limestone containing traces of fossils in the form of casts. The weathered surface of the layer shows obscure lamination planes	3½
3.	Bed of brown magnesian limestone in layers three to seven inches in thickness and containing imperfect impressions of Brachiopods and Fenestelloid Bryozoa..	8
2.	Fine-grained magnesian limestone, brown in color, the layers one to three feet in thickness	10
1.	Bed of variable limestone, partially talus covered and concealed down to the geode bearing shales of the Keokuk sub-stage..	9

The rocks embraced in the section given above belong to the Springvale beds of the Saint Louis stage. They probably correspond with the Warsaw limestone as described by Mr. Worthen in Hall's Iowa Report*, but none of the spiral axes of the fossil Archimedes, which Worthen found conspicuous in the rocks of that group, were found in this exposure. All of the fossils that occur in these layers are in the form of casts, either of the external or the internal portion of the skeleton, and are too imperfect and fragmentary for satisfactory identification. The coral *Lithostrotion canadense,* so characteristic of this horizon over the

* Hall: Geology of Iowa, Vol I, part i, p. 97. 1858.

county, was not seen *in situ* in any of the above layers, but it is frequently encountered in the bed of the neighboring streams where it has weathered out from their banks at a corresponding horizon.

The rocks of this division have here attained the greatest development of any exposure found within the county. They reach a depth of over thirty-five feet, while the average thickness of the beds of this phase would not exceed twenty-five feet.

As above described, the rocks at this place are uniformly fine-grained and dolomitic in character. They are very durable and furnish a splendid quality of stone for foundation work and heavy masonry. It is from these layers that the stone used in the construction of the piers of the wagon bridge across the Skunk river at Lowell was taken. Owing to the oxidation of the particles of iron that are disseminated through these rocks, they usually assume a yellowish brown color when long exposed to the air. This fact renders their use objectionable for purposes in which a fine appearance is especially desired.

Twenty miles directly north of the Lowell exposure, and separated from it by almost the length of the county, there is an interesting quarry in the Se. ¼ of section 4 of Scott township, about one mile northeast of the town of Winfield. At this place an exposure just north of the road on land owned by Mr. G. W. Wilson shows the following succession of layers:

		FEET.
5.	Clay of a reddish brown color containing gravel	5
4.	Bed of fine-grained, fissile limestone, light gray in color, the layers one to three inches in thickness, and containing but few fossils	4
3.	Bed of rather soft, fine-grained sandstone.	6½
2.	Bed of bluish gray limestone, the layers three to eight inches in thickness near the top, but increasing to as much as twelve inches near the base. The layers are separated by shaly partings which contain numerous fossils	10
1.	Yellowish brown magnesian limestone perforated with irregularly shaped cavities to the base of the exposure	2

Number 1 in the above section is of a stronger yellow color than

the magnesian limestone usually met with over the county. It is less compact and contains a greater number of cavities which resemble water worn passages. No traces of fossils were found in the rocks of this member. Number 2 is a bed of gray limestone. The narrower layers are somewhat shaly and weather easily into thin fragments, but the thicker portions are compact and durable. The shaly bands are very fossiliferous, among which the following forms are abundant:

Zaphrentis spinulosa E. & H.
Lithostrotion canadense var. proliferum Hall.
Syringopora sp. undt.
Archaeocidaris sp., spines and plates.
Fenestella, sp.
Dielasma formosa? Hall.
Spirifer keokuk Hall.
Eumetria marcyi Shumard.
Athyris subquadrata? Hall.

Number 3 is a bed of somewhat incoherent yellowish brown

FIG. 50. Exposure of Saint Louis limestone near Winfield, Iowa. The lower layers contain the loosely growing form of Lithostrotion,

sand which contains a small amount of calcareous matter. This bed is succeeded rather abruptly by layers of fine-grained limestone which contain but few fossils as compared with number 2 below. It consists of narrow layers of compact, light colored stone, which bear no bands of softer shaly material between them, as do the layers of limestone of the lower member.

The group of strata found here is different from that of any other exposure in the county so far as known. The assemblage of fossils which they contain is also unlike that found in the rocks at any other point over the area. Professor Stuart Weller, of the University of Chicago, to whom the fossils of these beds were submitted, regards them as indicating a Saint Louis fauna.

The presence of *Lithostrotion canadense* would suggest the Springvale horizon, but this coral, which here occurs in abundance, is at this place never silicified and is always either in a simple or very loosely growing form. It is usually even more loose and independent in its manner of growth than the species *L. proliferum* as figured and described by Hall* in his Iowa report. At every other point over the county where this fossil occurs, it is the closely growing massive form that is found, and its calcareous matter has always been replaced by silica. Further north, in Washington county, Mr. Bain found the rocks of the Springvale division to consist largely of limestones and shales† with scant development of the magnesian phase which predominates further west and south. He speaks of finding a few fossils in these rocks, but does not state the particular forms that were collected.

It seems probable that towards the margin of the Saint Louis limestone the rocks of the lower division loose the massive, magnesian character which they present further to the south and west; and that in the shallower waters the deposits were thinner layers of limestones interstratified with beds of shale. Under these conditions for some reason the coral Lithostrotion did not thrive so vigorously as it did in the deeper waters at a greater distance from the margin. As a consequence it remained either simple or very loosely branching in its mode of growth. The conditions were not so favorable, either, for the ready passage

* Hall: Geology of Iowa. Vol. I, pt. 2, p. 668, plate XXIV, fig. 6.
† Bain: Iowa Geol. Surv., Vol. V, p. 148.

of percolating waters, or for the charging of those waters with silica, as in the beds found in the southern portion of the county, hence the fossils here are all in their natural calcareous condition.

This isolated outcrop is separated from all other rock exposures by several miles of drift-covered prairie. The nearest rocks that appear at the surface are found about seven miles northeast of this point in Louisa county. Here, in a quarry worked by Mr. John Wasson, in the south bank of Long creek, are exposed the crinoidal layers of the Burlington limestones. About the same distance east from Winfield, near Morning Sun, rock exposures along Honey creek also reveal layers of crinoidal limestone, which contain numerous fossil forms characteristic of the Burlington sub-stage. Towards the south there are no rocks encountered short of the upper layers of the Saint Louis limestone ten miles distant; while the rocks first met with towards the west from the Winfield exposure occur in the northern part of Wayne township and belong to the Verdi phase of the Saint Louis.

In view of the evidence furnished by the fossils, and from the slight lithological resemblance of these rocks to those of the Springvale division as developed further north, nearer the margin of the Saint Louis limestone, and considering the fact that this exposure lies some miles nearer the margin of the deposits of this stage than any other exposure within the county, the most probable interpretation would seem to be that the rocks which appear in the quarry near Winfield belong to the Springvale division of the Saint Louis stage, and that they were deposited contemporaneously with those exposed in the section given from near Lowell.

From a comparison of the sections given above a general section of the rocks of the Saint Louis stage, as they are developed within the county, showing the lithological characters and the maximum thickness of the strata of each of the divisions, may be constructed as follows:

		FEET.
11.	Rather soft, bluish gray shale, very fossiliferous, containing *Zaphrentis pallaensis*, *Productus marginocinctus*, *Rhynchonella ottumwa*, *Dielasma turgida*, *Spirifer keokuk*, *Athyris subquadrata* and *Allorisma marionensis*	6
10.	Fine-grained, compact, ash-colored limestone in layers twelve to twenty inches in thickness, containing *Productus tenuicostus* and *P. ovatus*	5
9.	Compact, gray colored limestone evenly bedded, the layers three to eight inches in thickness, the partings of shale between the layers containing numerous individuals of *Rhynchonella ottumwa*, *Dielasma turgida* and *Spirifer keokuk*..	7
8.	Layer of very hard, fine-grained, light gray limestone	1
7.	Three flagstone layers, six, three and five inches in thickness respectively, clay seams separating the layers containing numerous fossils similar to No. 9 above	1 ½
6.	Layers of fine-grained, light colored limestone two to three feet in thickness, containing but few fossils	8
5.	Brecciated bed of fine-grained, gray, non-fossiliferous limestone	5
4.	Irregular bed of sandstone and shale intermingled in places with narrow layers of oolitic or impure limestone.....	12
3.	Band of chert in the form of a solid layer of flint	1 ½
2.	Disturbed beds of limestone, sandstone and shale, much broken and very irregular..	19
1.	Impure limestone, usually dolomitic, yellowish brown in color, the layers varying from a few inches to four feet in thickness, containing the casts of a few fossils, but especially bearing the silicified coralla of Lithostrotion	35

As will be seen from the above section, the rocks of the Saint Louis stage here have a maximum thickness of one hundred feet. Numbers 7 to 11 inclusive represent the Pella beds with an aggregate thickness of twenty feet. The shaly bed at the top has been eroded over the greater part of the area. The character of the rocks and the uniformly regular arrangement of the layers.

in this division are constant all over the county wherever these rocks are exposed.

Numbers 2 to 6 inclusive constitute the Verdi division with a maximum thickness of forty-five feet. The beds are usually very much broken and exceedingly variable as regards their lithology, their arrangement and the degree of disturbance.

Number 1 belongs to the Springvale division, attaining at one point a depth of thirty-five feet. The rocks are usually a brown magnesian limestone, in rather thick layers, and yield but few fossils besides the diagnostic coral *Lithostrotion canadense,* Cast.

The beds exposed in the quarry near Winfield differ from the typical deposits of the Springvale division with respect to the general character of the rocks and the fossils which they contain. Their stratigraphical position is not certainly known, but they are thought to represent a different phase of development of the same division.

The fauna of the Saint Louis is much less rich in the variety of its forms than that of the Keokuk limestone, but it is not excelled in the abundance of individuals. The Pella beds are preeminently the fossil bearing phase. The layers of the Verdi division seldom yield any forms whatever. The Springvale phase is more prolific. Including the beds of the Winfield exposure, this division furnishes a goodly number of species, some of which occur in great abundance. The following is the list of the fossils of the Saint Louis limestone as found in Henry county:

Zaphrentis pellaensis Worthen.
Zaphrentis spinulosa Ed. and H.
Lithostrotion canadense Cast.
Lithostrotion canadense var. proliferum Hall.
Syringopora, sp.
Chaetetes, sp.
Archaeocidaris, sp.
Fonestella, sp.
Productus marginocinctus Prout.
Productus tenuicostus Hall.
Productus ovatus Hall.
Dielasma turgida Hall.
Dielasma formosa Hall.
Spirifer keokuk Hall.

Eumetria marcyi Shumard.
Athyris subquadrata Hall.
Athyris, sp.
Allorisma mariunensis White.
Rhynchonella ottumwa White.

Upper Carboniferous or Pennsylvanian Series.

The deposition of the rock materials of the Saint Louis stage was brought to a close by a crustal movement which carried this portion of the state above the sea. Succeeding this elevation for a long interval the area was a land surface, subjected to all the weathering influences of the atmosphere and the erosional effects of meteoric waters that prevail over land areas at the present time. As the land rose higher the streams wore deeper their valleys in the hard layers of the Saint Louis limestone until in some places they reached a depth of at least ninety feet, and probably much greater. At the close of this long period of elevation there was a subsidence which once more buried the region beneath the waters and initiated the deposits of the Upper Carboniferous series.

Numerous exposures of the rocks of this series are found over the southern and western portions of the county. These deposits consist for the most part of beds of yellowish or brown colored sandstone. However, the occurrence of narrow seams of soft, earthy coal with accompanying bands of shale is not infrequent in the townships of Salem, Tippecanoe and Trenton. All of the materials belong to the Des Moines stage of the series. They were probably spread over the entire area and may originally have covered this portion of the state to a depth of many feet. The very long period that again intervened between the laying down of the Upper Carboniferous rock materials and the invasion of the first ice sheet, which buried them deeply out of the reach of erosion, sufficed to allow most of the region to be entirely denuded of its sandstones. Only such portions of these rocks were preserved as were deposited in old stream channels that were carved in the beds of Saint Louis limestone prior to the deposit of the Upper Carboniferous materials.

At no point within Henry county are the Des Moines sandstones

exposed where the eroded edges of the layers of Saint Louis limestone do not outcrop in a horizontal position at a higher level than the bed of sandstone, either immediately adjacent or only a short distance away.

The consideration of a few typical sections will make clear the character of these deposits and the relations which they sustain to the older limestones of the Saint Louis. Many of the present streams have found and established themselves within old valleys which were cut into the Saint Louis limestone and were afterward filled with the sandstones of the Upper Carboniferous. Finding it easier to carve their beds in the soft sandstone than in the harder limestone, which forms the surface rock over the greater part of the area, the streams have frequently exposed along their beds and on their banks these sandstones of the Coal Measures. A small ravine in section 5 of Salem township shows numerous outcrops of the materials of the Des Moines stage, of which the following is a representative section:

		FEET.
3.	Gravels and bowlder clay of the Kansan drift	3½
2.	Layer of soft sandstone grading downward into a narrow band of shale	4
1.	Bed of impure, earthy coal, rather soft and crumbling easily, the layers one to three inches in thickness	3

A few rods further down the stream there is an outcrop in which the coal is a better quality. The bed is three and one-half feet in thickness, and the layers vary from one to four inches. The coal is much harder and contains less earthy matter than that of the above section. This coal band is immediately overlain by about six feet of bowlder clay, both the sandstones and the shales having been removed.

Twenty rods north of this latter exposure, the edges of evenly bedded layers of fine-grained, white, fossiliferous limestone outcrop on the hillside twenty-five feet above the level of the band of coal.

In the banks of a stream about one-half mile west of the house of Mr. Wm. Spray, near the central portion of section 32, Tippecanoe township, the sandstones, shale and coal of the Des Moines stage are exposed. The coal at this point is of about the same

FIG, 51. An exposure of coal in section 5 of Salem township. The coal bed is immediately overlain by drift.

quality as that in the last mentioned exposure. The seam is overlain by a narrow band of shale, ten inches in thickness, and this in turn is succeeded by about four feet of soft sandstone. The layer of coal is about three feet in thickness and was formerly worked for a distance of two or three hundred feet back into the hill. A few years ago before any railroads passed through the smaller towns of the county, affording to every locality such favorable shipping advantages, a great quantity of coal was mined from these deposits at numerous points over the southern and western portions of the area. At present, however, but little is being taken out, owing to the low price of the superior quality of coal that is brought by the railroads within easy reach of the consumer.

A few rods below Mr. Spray's house a quarry has been opened in the fossiliferous layers of white limestone several feet higher up in the hillside than are found the later deposits of the Coal Measures.

On the farm of Mr. C. Hallowell, in the northern part of section 3, Salem township, a stream has cut its channel through a bed of sandstone to a depth of twelve feet. Underlying this sandstone there is a bed of shale a few inches in thickness down to the water's edge. There is no trace of a coal seam appearing at this place. In the sandstone are found very beautiful and abundant remains of coal plants, among which are conspicuous the impressions of Lepidodendra with their oblong leaf scars arranged in spiral lines around the stem, the fluted surface of fragments of Sigillariæ with their leaf scars disposed in vertical series, and broad parallel veined leaves which resemble those of Cordaites. In this deposit was also found a cast of a large spore bearing spike, Lepidostrobus, five inches in length and nearly one inch in width, in which were borne the spores of some of these old fashioned plants related to Lepidodendron. At one point the stream has cut for several feet beneath an overhanging ledge and laid open to view the impression of a log twenty feet in length.

On following up along the bed of a small tributary which joins

FIG. 52. Saint Louis limestone outcropping in the crest of hill above the level of the Upper Carboniferous sandstone, Rock creek, Iowa.

the former stream about five rods south of the exposure, the layers of the Pella beds in their normal arrangement and succession are passed over.

Along Rock creek, in the Sw. ¼ of the Sw. ¼ of Sec. 18, Salem township, at a point where the stream makes an abrupt turn to the north, there is exposed in a bluff about fifteen feet of the Coal Measure sandstone. At the top of this bluff there is an offset about eight feet in width back to a ledge of Saint Louis limestone which rises to a height of seven feet above the sandstone. This ledge of limestone represents the east wall of an old valley in which the sandstone was laid down. Many other out-

FIG. 53. Exposure along Rock creek in section 18, Salem township, showing the sandstones of the Coal Measures abutting against a ledge of Saint Louis limestone.

liers of the Des Moines sandstone occur over the county wherever the indurated rocks reach the surface, but they do not differ in any essential way from those described.

Pleistocene System.

After the elevation which closed the Upper Carboniferous epoch, the surface of the area which comprises Henry county remained permanently above the sea. During the whole of the succeeding geological era and through the greater part of the next following it was subjected to the wasting effects of the agents of erosion. During this enormous interval deep river valleys and stream channels were carved in this surface, forming a dendritic drainage system similar to, but much deeper than that which dissects the surface today. In the early part of the Pleistocene period ice sheets moved down from the north and covered with their mantle of superficial materials all of this portion of the state. These deposits were laid down unconformably over the eroded surface of the Carboniferous rocks, burying them to a depth which in places reached at least 175 feet.

The glacial series is represented in Henry county by two distinct drift sheets known as the Kansan and the Illinoian, besides the later deposits of loess and alluvium.

KANSAN DRIFT.

All of the drift exposed at the surface in Henry county, except a narrow strip along the eastern edge of the townships of New London and Baltimore, belongs to the Kansan stage. The Kansan is the second drift sheet which overspread the greater portion of Iowa. It has a wider extension than the first, or pre-Kansan, and so has concealed the latter from observation, except in a few favored places, where excavation or erosion has revealed its presence. The pre-Kansan drift was probably spread over all of this region, but there are no natural sections in which it is exposed within Henry county. At different points the wells which have been put down in the drift encounter a layer of sand, or a soil horizon, occupying a zone between two beds of bowlder clay. This soil horizon was once a land surface and represents the interval between the retreat of the pre-Kansan ice and the invasion of the Kansan. The beds of sand were laid down along the channels of the streams at the margin of the melting ice. These sand beds were covered by the drift brought down by the Kansan ice

sheet. They form water bearing layers at no great distance below the surface, and are the chief source of the water supply for the shallow wells.

The Kansan drift, where exposed in a thick bed, is a bluish clay containing numerous small bowlders varying in size from one or two to ten or twelve inches in diameter. Occasionally bowlders two to four feet in diameter are found and one was seen as much as ten feet across. The larger bowlders are usually reddish gray granites, but many of the smaller ones are of dark colored, fine-grained trap known as greenstone. Many of them present beautifully glaciated surfaces, showing that during some portion of their long journey they had been carried along in the ground moraine. Fragments of limestone are also frequently found imbedded in the clay.

The surface of the Kansan drift where it is exposed in the ravines along the roadsides is leached of all of its calcareous matter. It usually has a red or reddish brown color for a depth of from one to three feet, grading downward through yellow to the typical bluish color of the unchanged drift. This red color near the surface is due to a change in the form of the iron which is contained in the clay. The ferrous oxide or carbonate of the blue clay has been changed to the form of limonite, or hematite, where long exposed to the oxidizing influences of the atmosphere.

BUCHANAN GRAVELS.

At various places over Henry county there is exposed above the Kansan drift a bed of interstratified sand and gravels. The deposit is not uniform in depth, nor is it continuous over wide areas. The pebbles are usually small, rarely exceeding three inches in diameter, and are generally rounded and much waterworn. These materials were deposited soon after the drift was spread out, before any change had taken place in its surface. They record the action of swift and variable currents in streams which carried a large volume of water. The stratification is very irregular, finer sand and coarser gravels not being sorted so perfectly as is usually the case with waterlaid materials. The beds were probably laid down along the channels of the streams which carried away the waters which resulted from the melting of the Kansan ice.

ILLINOIAN DRIFT.

The Illinoian drift in Henry county is represented by a portion of the terminal moraine which can be traced for several miles along the eastern border of the townships of Baltimore and New London. It is even more plainly developed south of this near the town of West Point, in Lee county. From this place, with a trend a little east of north, it passes as a conspicuous line of hills across Pleasant Ridge township. These ridges form so prominent a feature of the topography that they suggested for the township its name. The moraine enters Henry county about one and one-half miles west from the southeast corner of the township of Baltimore. It continues in a northward and slightly eastward direction along the east side of Baltimore township, keeping within a distance of from one to two miles of its border. On entering New London township the line of ridges bends slightly towards

FIG. 54. Illinoian moraine showing the low, rounded character of the hills. East of New London, Iowa.

the northwest for a few miles, passing about one-fourth of a mile to the east of the town of New London. Then bending once more towards the northeast, it crosses the county line a short distance north of the center of New London township. It continues north and a little east along the western margin of Washington town-

ship, in Des Moines county. This conspicuous line of hills overlooks Canaan township along its entire eastern border. It then bends further eastward and is soon lost to sight from the limits of Henry county.

The rounded ridges of morainic material have a width of from one to one and a half miles. In Henry county they are best marked on the level land which lies between the broken country bordering the Skunk river and the hills near the headwaters of Mud creek, and again on the prairie north of the latter hills to the point where they pass out of the county in section 13 of New London township.

This moraine marks the western extension of the Illinoian drift over this area. It is much more conspicuous and well defined than is the distinction between the materials carried by the Kansan and the Illinoian ice sheets. Red jasper bowlders, which are not found in the former, are not infrequent in the latter, but the majority of the granite and greenstone bowlders which occur in one resemble in every way those found in the other. The ferretto character of the oxidized surface of the clay and gravels is common to both, as is also the fact that to a few feet in depth the surface materials of both drift sheets are leached of their calcareous matter.

THE LOESS.

The loess is usually a yellowish, uniformly fine-grained deposit whose constituent particles resemble very fine silt. This material forms a mantle over the surface of the entire area except where removed by streams. Its characteristic color is obscured over the prairie portions owing to the presence of the greater amount of carbonaceous matter in the surface soil, but the fine-grained texture and the absence of pebbles or bowlders are still maintained. Over the greater portion of the region it is light gray in color and only a few inches in depth, but at a few points it attains a thickness of several feet.

In making some recent improvements in the road-bed of the Chicago, Burlington and Quincy railway, cuts have been made through some of the hills in the vicinity of Rome, which yield instructive facts relative to the development of the loess over this

FIG. 55, Deposit of loess overlying Kansan drift, near Rome, Iowa. 1. Drift. 2. Loess.

area. The following section is exposed in the Se. ¼ of section 4, Tippecanoe township, on the east bank of the Skunk river:

		FEET.
2.	Fine-grained, typical loess, light yellow in color and very rich in fossils	25
1.	Reddish colored clay, with pebbles and bowlders of granite and masses of limestone intermingled	8

In the eastern part of section 3 of the same township, a new cut shows the following beds:

		FEET.
3.	Light yellow, fine-grained loess	10
2.	Bed of interstratified sand and gravels	12
1.	Bluish colored till	6

In the sections given above the surface of the Kansan drift shows a reddish, oxidized band which conforms to the contour of the hill. The thickest portion of the loess is on the crest and the westward slope of the hill, and the thinnest portion of the oxidized band lies immediately below the deepest deposits of loess. In the first section some traces of stratification appear in

the loess, the lines, however, are not horizontal but conform in some measure to the slope.

The term "bluff material" is especially applicable to the loess in Henry county, as the thick deposits are found only on the hills along the east bank of Skunk river. It is only these thick beds that carry fossils. The numerous fossil forms which occur here in the loess mostly belong to the genera Succinea, Zonites, Mesodon and Pupa. The loess was evidently a later deposit than the drift, as is shown by the eroded and oxidized surface of the latter underlying the thick beds of the former.

The origin of the loess and the manner of its deposition are questions which as yet scientists have been unable satisfactorily to explain. There are two hypotheses given which might account for the condition of the drift and the presence of the overlyin loess as here exposed. One is that for a long period succeeding the Kansan ice invasion the drift was exposed at the surface and subjected to erosion and to the oxidizing influences of the atmosphere. After this long interval a downward movement of the crust brought this portion of the state near the base level, so that the slow moving water of the expanded rivers carried and deposited only the finest silt over the surface of the drift.

The second explanation is that this fine-grained material was carried by the wind and slowly laid down on the crest and sides of the hills and in the valleys and over the prairies; wherever vegetation or leeward slopes or obstructions of any kind would catch and conceal from the air these fine particles of dust. According to the latter view, the erosion of the drift and the oxidizing of its surface went on contemporaneously with the deposit of loess. The extreme slowness of the deposition of the materials by the wind would suffice for the changes in the surface of the drift to have reached their present depth before the covering of loess would be sufficient to protect it from the further action of the atmosphere. The latter view would seem to best explain the relation between the drift and the loess and the condition of both as they appear in Henry county.

ALLUVIUM.

The waters of Skunk river and Big Cedar creek flow through a broad valley which within Henry county would average about

one mile in width. The surface of the greater portion of this flood plain has received a rich deposit of loose sediment consisting of sand and finer particles of soil. Big creek also in all of the lower part of its course flows through a rich alluvial plain. In places along the Skunk river this material is composed of beds of sand, and along the margins of the valley of all of the streams the true river laid deposit is more or less mixed with the downwash of the loess and clay from the hills. Over the greater portion of these plains the sediment is a true alluvium, which responds generously to cultivation and ranks among the most productive farm lands of the county.

Alluvial deposits occupy areas of varying extent at numerous points along many of the smaller streams. Wherever their channels have been extended sidewise and narrow bottom lands formed these fluviatile materials have been laid down.

Deformations.

The rocks of Henry county have been subjected to strains of lateral pressure sufficient in many places to produce a slight folding of the strata. There are evidences of this appearing in the outcrops of Keokuk limestone, where these rocks are exposed at the surface at different levels and at isolated points widely separated from one another. The strata of the Keokuk, however, in the limited areas which are exposed, seem to lie horizontal and it is possible that the absence of these rocks at the same level over intervening areas may be due entirely to erosion rather than to any folding of the strata.

Slight deformations occur at numerous points in the Verdi beds of the Saint Louis stage. The most of these are of a local nature, due usually to the intercalation of layers of sand or shale, or to the rapid thinning out of some of the beds in this very variable deposit.

The layers of the Pella division show some marked examples of folding. The disturbance in these beds, however, did not reach a very great depth, never involving the underlying rocks of the Verdi. The strains were not sufficient to cause any fractures or dislocations of the strata over the area, but resulted in the gentle flexing of the layers, as described under the discussion of the

Pella beds in the present report. The axes of the folds trend nearly in an east and west direction, their vertical height not exceeding five feet in the places where they were well exposed.

Unconformities.

The rocks of Henry county present several instances of unconformity. There are indications that the Saint Louis limestone was laid down unconformably upon the underlying beds of the Keokuk. The presence of the former overlying the hard limestone phase of the latter at Webster's mill, while on Mud creek the same rocks of Saint Louis age rest upon the deposit of Geode shales, would seem to indicate the erosion of these shales in the former exposure before the Saint Louis beds were laid down. The outcrop of the Keokuk rocks at different levels while in the intervening areas the same level is occupied by the Saint Louis deposits, would also be an evidence of unconformity. There is a possibility, however, that here near the margin of the Geode shales, those deposits thinned out locally, and that this bed was never laid down over the surface of the region of Webster's mill. It is possible, also, that a slight folding of the strata might account for the presence at the surface of the Keokuk limestone at different levels. However, since those layers wherever exposed have a horizontal position, and since the Saint Louis rocks are known to rest unconformably upon those of the Augusta further to the north and west, it is probable that over this area also the same relations prevail.

A second unconformity occurs between the rocks of the Saint Louis stage and the overlying sandstones of the Des Moines. In multiplied instances these sandstones may be seen occupying the old valleys carved in the rocks of the Saint Louis during the long interval that elapsed between the laying down of the latter and the deposit of the former. During this interval the land over Henry county stood higher than at present, as is shown by the fact that in many places the present streams which follow those old valleys have not yet cut their channels through the beds of Upper Carboniferous sandstone. The oldest drift sheet of the glacial series deposited its materials over the eroded surface of

indurated rocks, and the till of each of the succeeding ice sheets was laid down unconformably upon that of the preceding.

ECONOMIC PRODUCTS.

Soils.

The soils of Henry county must always constitute its greatest source of wealth, and in this respect this favored region is excelled by few areas of equal size within the state.

Over all of the prairie surface the soil is dark colored, rich and deep, containing an abundance of carbonaceous material. The land usually has sufficient slope to permit a tolerably free surface drainage, although in the townships of Wayne, Scott, Canaan, and the northern portion of Marion and New London, the farms are mostly underdrained by means of tile which removes the excess of water from the soil and keeps the surface porous in the seasons of great rainfall.

Extensive prairie areas are also found in the townships of Jefferson and Salem over the divides which separate the principal water courses. Bordering the main streams and their larger tributaries, the land is much broken; the hill-slopes are covered with a yellowish loess clay which originally supported a heavy growth of timber.

These slopes in many places have been denuded of their forests, but the clayey soil, which too often has been put under the plow, is the least productive land of the county. It is a great mistake ever to have attempted to crop these clayey hillsides. They should have been left for the perpetuation of our fast vanishing forest areas, or in lieu of that, they are far more profitable as pasture lands than for purposes of tillage. If the ground remains undisturbed, the native blue grass rapidly covers the surface and prevents further wash after the forests have been removed.

A third type of soil is the rich alluvium which is found along the valleys of all of the larger streams. When not too sandy, this soil ranks second to none in its productiveness and ease of cultivation.

Coal.

In Professor Hall's report on the Geology of Iowa* in 1858, Mr. Worthen says: "Several outliers of coal occur in Henry county on the east side of Skunk river and Big Cedar creek; but none of them have as yet yielded a profitable coal seam, nor is it probable they ever will." In another place he states, "The only coal lands that promise anything like a profitable coal seam are those lying west of Skunk river and Cedar creek."

During the earlier history of the county large quantities of coal were annually taken from the Coal Measure deposits of the latter area mentioned by Mr. Worthen. The more important mines were opened in the western portion of the townships of Salem and Tippecanoe. These coal beds are all very local over this area, as is seen from the position occupied by the deposits of the Des Moines stage. The seams are narrow and the quality of the coal rather inferior. None of these coal deposits have been worked within the county for a number of years. It is possible that as the supply of fuel becomes more scarce and its cost is increased, the work of getting out coal from these beds may be resumed, and the Coal Measures may yet be a source of wealth to the people of the county.

Building Stone.

Stone suitable for common foundation work and general masonry is found in abundance over all portions of the county in which the indurated rocks are exposed. The hard layers of the Keokuk limestone would furnish an abundant supply of building material, but so far as known there are no quarries opened in these beds within the area. The Springvale division of the Saint Louis stage yields a very durable stone. It is dolomitic in character and so is less readily acted upon by the acids of the atmosphere and weathers more slowly than the common limestone. These layers are quarried at various points in Baltimore township and to some extent in the townships of Center and Jackson.

The compact layers of the Pella beds furnish a good quality of stone and are so generally distributed that they constitute the

* Hall, Geology of Iowa, pp. 211–214. 1858.

most important source of building stone in the county. They lend themselves readily to the work of the quarryman, and can be taken out in regular blocks of convenient size for handling, and for laying in a wall. They are hard and fine-grained, with usually a thin shaly band between the layers; but they prove a durable stone when placed horizontally, in the same position which they occupy in the ledge.

The thinner layers of the Pella beds furnish a good quality of flagstone which can be taken out in almost any dimensions desired. There are some layers three to five inches in thickness near the lower portion of these beds, which are designated as the "flagstone layers" by the quarrymen. These are underlain by still thinner layers called "cellar flags," which are suitable for use in places where they will be subjected to no great amount of weight or wear. Above the flagstone layers, a short distance below the middle of these beds, there is a layer ten inches in thickness, which is used by Mr. C. E. Magers of New London for monuments in cemetery work. The stone is fine-grained and very compact, taking a good polish and proves very durable, comparing favorably with the well known Bedford limestone for monumental purposes.

At the present time there is no rock material shipped out of the county, but each portion of the area finds an abundant supply for its local needs at no great distance away.

Lime.

Materials for the burning of lime occur in all of the beds which furnish building stone. The dolomitic ledges of the Springvale division, where they contain little sand or earthy matter, yield lime of the best quality. The white limestone of the Pella beds and the hard layers of the Kookuk would also furnish as good a grade of lime as is usually made from the pure limestone materials. A few years ago all of the lime that was used for local purposes was burned within the county; but at present the better quality of material is supplied through the railroads cheaper than it can be made in the small kilns and by the primitive methods of burning which were employed.

Sand.

Sand suitable for building purposes is found in great abundance at a number of places in the county.

The soft sandstone beds of the Verdi division of the Saint Louis are sometimes used. The best deposits occur at various points along the flood plain of the Skunk river and of Big Cedar and Big creeks, where almost unlimited quantities can be obtained. The wind formed hills of sand which occur in Jefferson township are also an important source of supply. Very little of this material is met with over the northeastern portion of the county.

Clay.

The beds of the Upper Carboniferous series in a few places afford some materials suitable for the manufacture of the finer grade of clay goods, but they are too thin and cover too small an area to be a very important source of supply. They are not at present worked at any point within the county.

The deposits of the Pleistocene furnish an unlimited amount of raw material suitable for the manufacture of the common, coarser kinds of clay products, such as construction brick and drain tile. These deposits cover the entire surface of the county and make possible the burning of brick and tile at almost every locality over the area. Almost every small village has its brick kiln which is supplied with inexpensive machinery and is not worked continuously, a supply being burned as often as the demand requires. The brick and tile are made from the loess clay which covers the drift in some places to a depth of several feet.

Turley Brothers.—In the southeastern part of Baltimore township is located the pottery works of Turley Brothers, where a few men are employed during the summer months in the manufacture of the coarser articles of earthenware, such as crocks, jars and jugs of various kinds. There is no modern machinery employed at this place, but the work is almost all done by hand. The market is mostly local, the products being hauled by wagons to the neighboring towns. The clay which is used comes from drift which is probably of Illinoian age. It is light colored, con-

taining but little sand or pebbles and is somewhat greasy to the feel.

Winfield Brick and Tile Co.—At the town of Winfield there is a brick and tile factory operated by Mr. Beecher Pierce. The clay is furnished by the loess which is exposed in the pit to a depth of about eight feet. It is underlain by a bed of sand and gravels. This clay contains a lower percentage of iron than that used at New London which gives to the products a somewhat yellowish color. The ware is very hard, ringing well when struck with a hammer. The plant includes the main factory building, a drying house, eighty by thirty feet, three round, down draft kilns, and a Brewer & Company tile machine. It has a capacity of from 2,500 to 10,000 tile per day. Ten men are employed from April 1st to January 1st of each year. Home trade is the main market, the wares being distributed over a radius of ten or twelve miles.

New London Brick and Tile Works.—Brick and tile are manufactured at New London, Iowa, by Mr. C. E. Magers. The factory was established in 1891 and employs fifteen men throughout the year. The plant embraces two round, down draft kilns, a steam drier and a main building 90 by 120 feet containing two stories, which give 15,000 square feet of floor room. The combined output of tile and brick has a value of about $10,000 annually. The clay is taken from a bank of loess ten feet in depth. The market is largely local, a part of the products also being sent to different points in the neighboring counties of Lee and Des Moines.

Water Supply.

The waters of Skunk river and of Big Cedar and Big creeks continue to flow throughout the year, furnishing an excellent water supply to the areas through which they pass. The most of the smaller streams are usually dry during a portion of the summer months. Wells sunk in the superficial deposits furnish an abundant supply of pure water at a depth ranging from thirty to two hundred feet. No deep wells penetrating the indurated rocks have been put down within the county except one at Mount Pleasant,

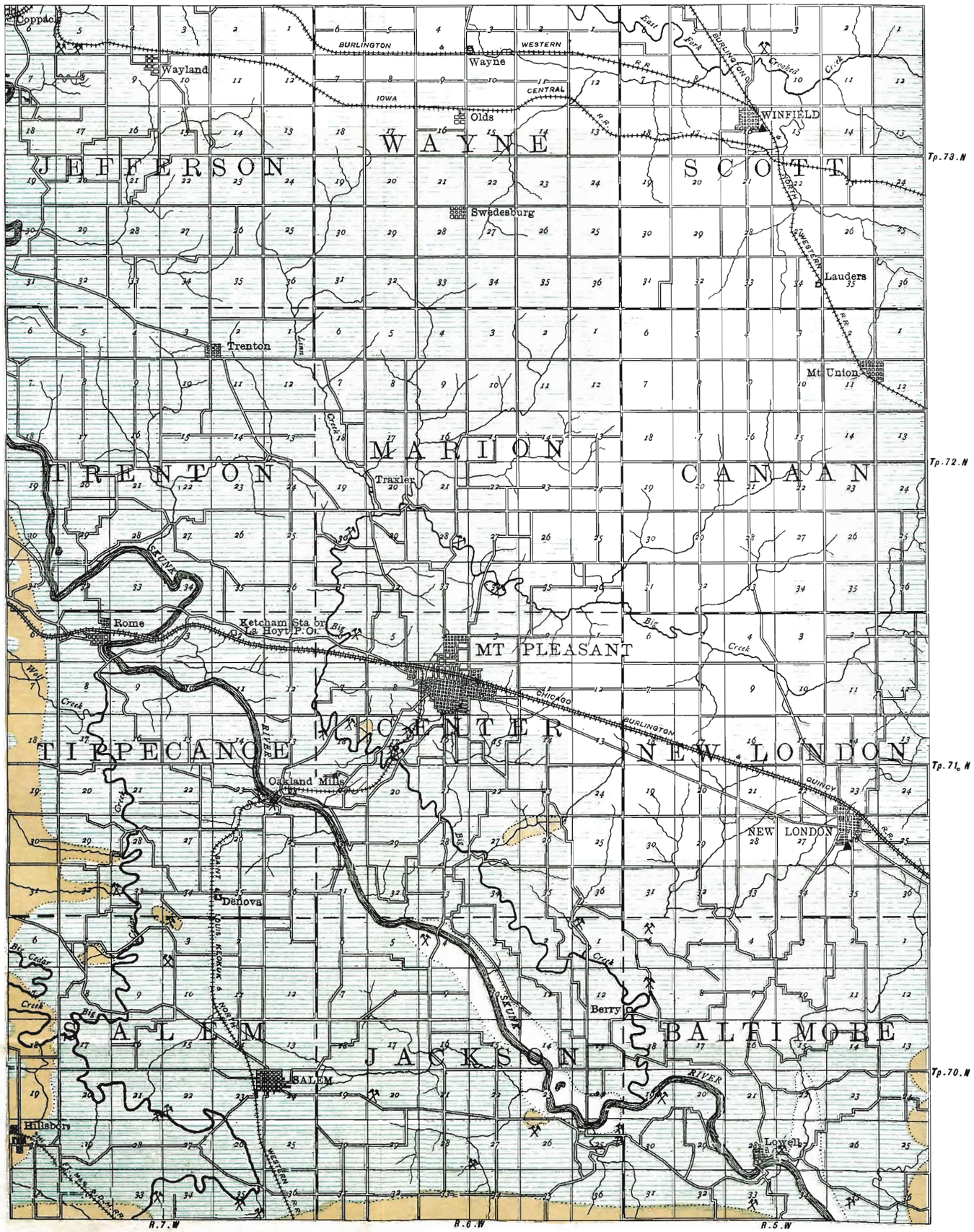
which is on the grounds of the State Hospital for the Insane. This well has a depth of 1,125 feet, and obtains its water supply from the porous sandstone of the Saint Peter stage.

Water Power.

The Skunk river furnishes abundant water power except during the periods of long continued drouth. This power is utilized by flouring mills at three different points along its course. Merrimac mill is located near the southwest corner of Jefferson township. Oakland mill is near the eastern border of Tippecanoe township, and the Lowell mill is at the village of Lowell, in the southern part of the township of Baltimore. All of these mills run continuously, and are provided also with steam power, which they use during periods of low water.

ACKNOWLEDGMENTS.

In the preparation of the foregoing report, the writer has received valuable information and kindly assistance from many persons. Thanks are especially due to Mr. Frank Leverett, of the U. S. Geological Survey, from whose work the facts relative to the superficial deposits of the county were largely drawn; to Professor Stuart Weller, who kindly identified some difficult invertebrate fossils; to Dr. C. R. Eastman, who named the fishes of the Keokuk limestone; and to Professor Samuel Calvin, whose instruction made possible whatever merit this report may possess. The writer is also indebted to Mr. J. A. Rice, Mr. D. L. Savage and many other citizens of the county who helped to make the prosecution of the field work an enjoyable task. To all of the above the author tends his hearty thanks.



IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF HENRY COUNTY, IOWA.

BY

T.E. SAVAGE.

1902.

Scale 1/126000

1 ½ 0 1 2 3 4 5 Miles.

1 ½ 0 1 2 3 4 5 Kilometers

LEGEND

GEOLOGICAL FORMATIONS

DES MOINES (Coal Measures)

SAINT LOUIS

KEOKUK

INDUSTRIES

QUARRIES

CLAY WORKS

DRAWN BY F.C. TATE

IOWA LITHO. CO.