GEOLOGY OF MARSHALL COUNTY.

BY

SAMUEL WALKER BEYER.

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CONTENTS.

INTRODUCTION.

LOCATION AND AREA.

Marshall is one of the middle tier of counties and lies between Tama and Story counties on the east and west respectively. The Iowa river makes a bold bend southward nearly to the center of the county, where it turns abruptly eastward, cleverly detaching the northeast quarter. As in the case of most of the inland counties of Iowa, Marshall comprises a rectangular area of approximately five hundred and seventy-six (576) square miles and considerably more than a third of a million acres.

PREVIOUS GEOLOGICAL WORK.

Considering the great value of the natural resources of Marshall county and the varied and abundant fauna entombed in the rocks, the literature concerning the geology of the region is extremely meager.

David Dale Owen* in his "Reconnaissance of the Carboniferous Rocks of Southern and Western Iowa," was the first geologist to visit the county in an official capacity. He traversed the county in the vicinity of the Iowa river, and incidentally called attention to the more salient geological features. J. D. Whitney† in treating of the geology of Marshall and adjoining counties records the occurrence of coal in Bangor township, and briefly describes a section exposed on Timber creek near the old road leading from Marietta to Indiantown, in which he remarks the close resemblance of the rocks to the lower Burlington limestone as exposed at its typical locality.

More than a score of years later White‡ described the exposures near Le Grand and definitely refers the formation to the Kinderhook stage of the Carboniferous system. Certain quarry products are also described, and in the same

*Geological Surv. Wisconsin, Iowa and Minnesota, p. 101-102. 1852.

†Geology of Iowa, vol. I, pp. 267-9. Albany, 1858.

‡Geology of Iowa, vol. I, pp. 197-198. Vol. II, pp. 260, 312-314 and 316. Des Moines, 1870.

report Prof. Rush Emery* reports an analysis of "Iowa marble," from the Le Grand quarries.

The crinoidal remains so abundant in certain layers at Quarry and Le Grand have received the attention of the late Charles Wachsmuth† and his co-laborer, Frank Springer, of Burlington, and others.

PHYSIOGRAPHY.

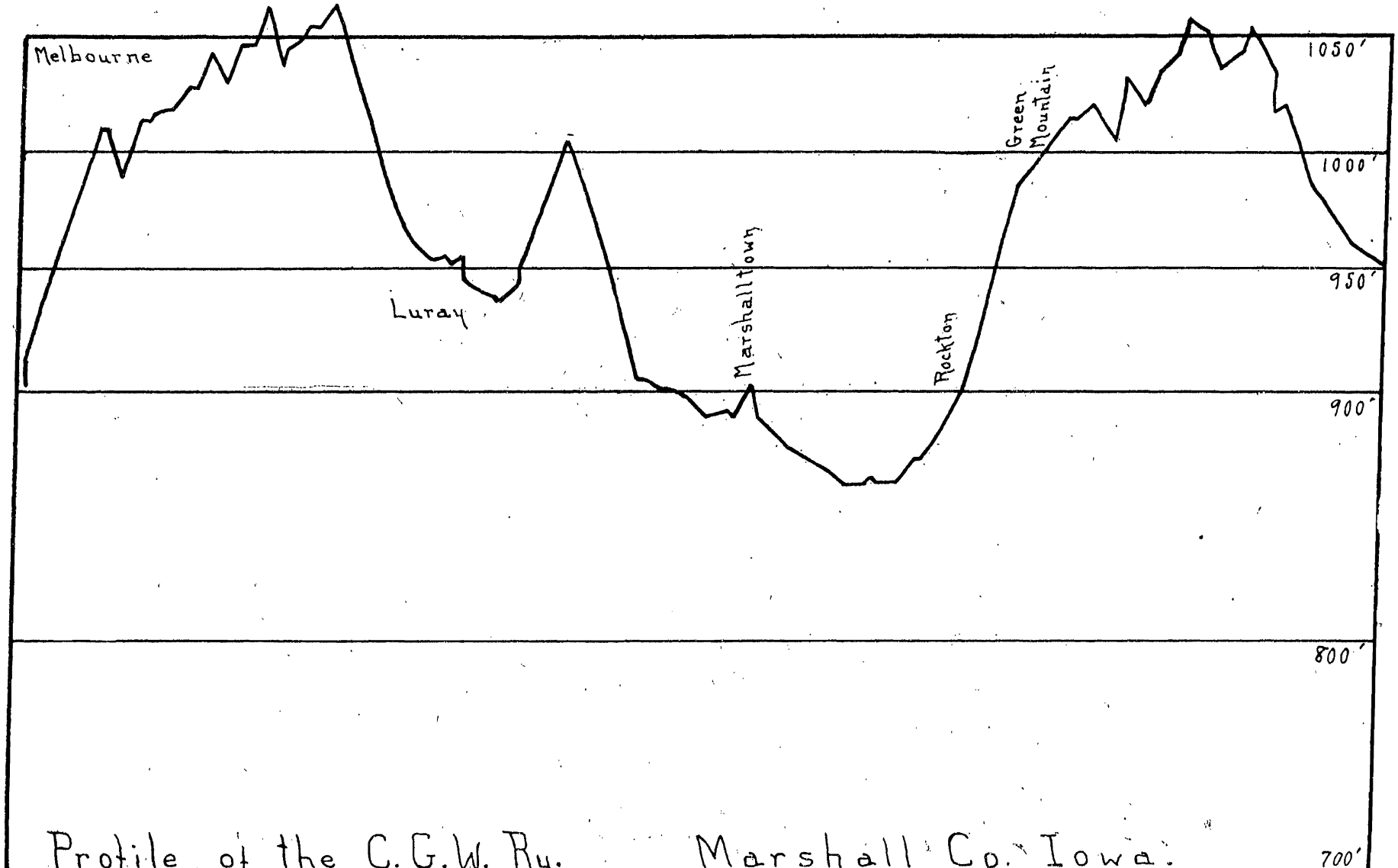
TOPOGRAPHY.

The topographic features of the county are varied. In order better to understand the more general configuration, conceive a more or less regular surface very gently inclined to the southeast. Let there be a slight depression in the position of the Iowa river, flanked on either side with parallel ridges, the crest on one side bisecting Vienna township diagonally, while a line passing through State Center, Van Cleve and Laurel marks approximately the position of the other. Spread over the surface a material which responds readily to water action, but holds with equal fidelity the vigorous carving of the spring freshet and the most delicate tracery of the summer shower; given these conditions, time and the erosive agents are the only requisites to account for the general physiography of the region.

The principal water courses have wrought out well-marked flood plains bordered by the usually gently rising uplands, all of which attest topographic maturity. The vertical interval between the lowlands and the adjoining uplands varies from 50 to 100 feet, but the altitude gradually increases towards the divides which attain an elevation of more than 200 feet above the water level in the Iowa river. Plate v shows the cross-section of the general plain. The most vigorous land forms occur in the marginal areas which intervene between the upland plain and the flood plains of the greater streams. These areas, with the flood plain, originally supported a luxuriant forest growth, but have in large part been dismantled.

* Ibid vol. II, p. 347.

† Geological Surv. Illinois, vol. VIII, pp. 157-205, and pls. xv-xvii, 1890.



Profile of the C.G.W. Ry. Marshall Co. Iowa.

While the whole county is heavily drift-laden, yet the territory readily resolves itself into three distinctive topographic areas which are coincident in a general way with the areas occupied by the Wisconsin, Iowan and Kansan drift sheets, and will be designated by the terms, drift, drift-plain and drift-loess types respectively. The first type is represented by a wedge-shaped area on the western margin of the county, whose apex is approximately at the southwest corner while its base spans little more than three miles on the north line. The characteristic features of the region are the prevalence of depressions, sloughs and "kettle holes" and eminences with kame and drumloid affinities. Drainage is imperfect and this, when taken in conjunction with the unique surface features, is indicative of topographic youth.

The second comprises an area of scarcely more than fifty square miles in the northeast corner of the county. Although the Iowan till sheet probably extended over a greater area in the county it was not competent to control the configuration of the region to the extreme limits of its attenuated margin. Away from the larger streams this territory is characterized by a monotonous, plane surface interrupted by occasional gentle swells, and as a rule it is moderately well drained, while oftentimes prairie sloughs are much in evidence. This triangular area is a fragment of the great drift-plain which extends northward far into Minnesota and comprises an area of more than seven thousand square miles in Iowa.

The drift-loess type constitutes more than four-fifths of the surface of the county. The topographic features are purely erosional and the contours are strengthened by the loess top-dressing. The upland is dissected by a plexus of small streams which gives the surface a graceful, billowy aspect, very pleasing to the eye. Sharp V-shaped valleys and convex hills are the rule in the broken areas and bear silent testimony to the instability of the surface configuration. The larger streams meander through broad valleys which are almost destitute of salient topographic features. The divides are better defined

than is usual in this type of topography. The head branches of opposing drainage systems often interlock, so sharply is the territory contested.

TABLE OF ELEVATIONS.

The following table of altitudes is compiled from the profiles of the different railroads which traverse the county.

STATION.	Altitude.	AUTHORITY.
Albion	937	I. C. Ry.
Dillon	975	I. C. Ry.
Divide, Iowa and Cedar rivers	1054	C. G. W. Ry.
Divide, Iowa river and Linn creek	952	I. C. Ry.
Divide, Iowa and Skunk rivers	1116	C. & N.-W. Ry.
Dunbar	878	C., M. & St. P. Ry.
Ferguson	909	C., M. & St. P. Ry.
Gilman	1090	I. C. Ry.
Gladbrook	954	C. G. W. Ry.
Green Mountain	1000	C. G. W. Ry.
Haverhill	1023	C., M. & St. P. Ry.
Iowa river, Chicago Great Western crossing	865	C. G. W. Ry.
Iowa river, county line	926	I. C. Ry.
Iowa river, Iowa Central crossing, south of Albion	895	I. C. Ry.
Lamoille	940	C. & N.-W. Ry.
Le Grande	940	C. & N.-W. Ry.
Linn creek, Great Western crossing southwest of of Marshalltown	905	C. G. W. Ry.
Linn creek, Great Western crossing east of Marshalltown	875	C. G. W. Ry.
Laurel	1040	I. C. Ry.
Liscomb	950	C. G. W. Ry.
Duray	885	C. & N.-W. Ry.
Marshalltown	890	I. C. Ry.
Marshalltown	900	C. G. W. Ry.
Malta	1062	I. C. Ry.
Melbourne	1045	C. G. W. Ry.
Melbourne crossing, Chicago, Milwaukee & St. Paul railway	1060 1033	C. G. W. Ry. C., M. & St. P. Ry.
Nicholson creek	896	C. G. W. Ry.
Pickering	987 1025	C., M. & St. P. Ry. I. C. Ry.
Quarry	885	C. & N.-W. Ry.
Rhodes	1015	C., M. & St P. Ry.
Rockton	880	C. G. W. Ry.
State Center	1073	C. & N.-W. Ry.
State Center Junction	1051	C., M. & St. P. Ry.
Timber creek, Iowa Central crossing	874	I. C. Ry.
Timber creek, Chicago & North-Western crossing	855	C. & N.-W. Ry.
Van Cleve	1054	I. C. Ry.

DRAINAGE.

Marshall county is well watered and for the most part is also well drained. The annual rainfall averages about thirty inches per annum, of which less than one-third is gathered up into the streams and carried to the gulf. Five-sixths of the annual "run-off" finds a convenient outlet through the Iowa and its tributaries, while small triangular areas in the southwest and northeast corners contribute their surplus waters to representatives of the Skunk and Cedar river systems respectively.

Iowa river system.—The Iowa river is the master stream in the system and in large measure establishes the grade for its numerous tributaries. It meanders through a broad alluvial

FIG 25. Le Grand gorge.

valley which averages from one to two miles in width. The river crosses the Kinderhook escarpment at two points; near its entrance into and exit from the county. At the latter place the river flows through a gorge scarcely a quarter of a mile in width. The present stream occupies a channel but little below the general level of the bottom land and extensive reaches of territory are subject to periodic inundation. Deserted channels are everywhere in evidence, and northwest of Marshalltown sand flats are common features of the

flood plain. The Iowa river has long since passed its adolescent stage, has reached maturity and is now approaching old age. The stream is not corrading its channel at any place. Excavations for bridge piers and abutments show that the country rock lies ten to fifteen feet below the present stream bed. At the Marshalltown waterworks there is an apparent exception to this. The river impinges strongly upon the south bank, and the country rock is close to the surface in the bed of the stream. Excavations for the water galleries on the north flank of the flood plain reveal the fact that the old rock bottom slopes away from the present position of the channel.

The Iowa drainage system is of the asymmetric type with the greater tributaries coming from south and west as are the Skunk and Des Moines rivers in central Iowa. Rock, Burnett and Asher creeks are the principal tributaries received from the north; while Timber, Linn, Minerva and Honey creeks are the more important branches received from the south and west. All of these have much the same general characters as does the greater stream. All are long in proportion to their volume, and all are characterized by drainage basins which are relatively narrow in proportion to their length.

The tributaries from the north are relatively of much less importance than those from the south. They have narrow flood plains or none at all, and have deposited but little alluvium save in their lower courses. Asher creek is the largest and drains an area of about fifty-four square miles. Each has cut through the drift at certain points exposing the upper member of the Kinderhook beds.

Timber creek, which enters the Iowa from the south near Quarry, collects the water from an area of 130 square miles. It comprises three principal branches which are named according to their geographic positions—North, Middle and South Timber creeks. North Timber flows almost due east, and is much the longest member, while the south branch

flows north and comprises the greatest drainage basin. All have narrow, but well marked flood plains, which follow well up far towards their sources.

The drainage basin of Linn creek is the narrowest in proportion to length of any in the county. The proportion of length to breadth is about six to one, and the valley comprises an area of about seventy square miles. Its course is almost exactly parallel to the North Timber creek, but it has not progressed as far in valley forming as the latter. The most rugged topography in the county is found in the territory traversed by Linn and the Timber creeks.

Minerva creek has its source in Hardin and Story counties. It pursues a tortuous course in a southeasterly to easterly direction, and enters the Iowa a little north of west of the town of Albion. The head waters of this stream arise in the area of the Wisconsin drift, and drain more than two-thirds of the region covered by this till sheet in the county. The lower course of the Minerva has a flood plain which, considering the volume of the stream, is quite broad. It has numerous small branches; but where its tributaries leave the Wisconsin, the valleys are sharply constricted. In the upper reaches little or no alluvium has been deposited, and there is a dearth of minor streamlets.

Honey creek has done an immense amount of work in the way of valley cutting, which as in the case of the Minerva, is out of all proportion to the size of the present stream. It has cut through the drift and exposes the coal measure shales and Lower Carboniferous limestone near Bangor. Mud creek, a prairie stream through the greater part of its course, and without the usual accompaniment of alluvial bottom land, is the principal tributary of Honey creek—the two streams joining just as they enter the flood plain of the Iowa.

Age of the Iowa system.—The Iowa system bears the impress of age; of advanced maturity. The original topography of the county did not depart far, perhaps, from that of a plain and the present configuration is due almost wholly to erosive

forces. The limiting divides average about two hundred feet higher than the Iowa flood plain. The down cutting alone would require thousands of years, while the true enormity of the task and the vast lapse of time can only be realized when it is considered that the river valley averages from one to two miles in width. Sufficient data are not at hand definitely to determine the age of the system; but, considering the broad valleys of the Iowa and its principal tributaries, and the fact that the Kansan drift, apparently undisturbed, follows down the hillsides at least to the level of the flood plain, much lower than the outcroppings of the country rock as in the vicinity of Quarry, Le Grand and Timber creeks, it may tentatively be stated that the system, in part at least, is pre-glacial. The profoundly glaciated surface exposures at Le Grand, Timber creek and Linn creek, all located on the south flank of the present stream valleys, may also be admitted as evidence of preglacial depressions in the direction from which the ice came. It seems probable that the Iowa river, from Le Grand to the mouth of Honey creek at least, the lower courses of Timber, Minerva, Honey and perhaps Linn creeks have sought out and partially reopened their old channels. The minor streams and the upper courses of the larger tributaries are doubtless usually superimposed upon the glacial deposits and are independent of preglacial configuration. In terms of stream development the Iowa has passed its zenith and old age is slowly but surely coming on unless stream action be reinvigorated by deformation and uplift of the region. The surface inequalities have long since reached their maximum and the hills are slowly melting away to fill the valleys. The melting snows and summer showers humble the one that they may contribute to the upbuilding of the other. Man himself is a potent factor in this leveling process. The old settler can well remember the time when the waters of our streams were untarnished at the spring freshets or summer floods save by the crystal amber from our virgin prairies. At the present time after

such periods the streams flow liquid mud. The prairie grasses and forest trees were conservators of moisture and firmly held the soil in place. The processes of agriculture in subduing the prairies and denuding the forest areas have increased the "run-off" and rendered the soil easily eroded. Culture has stimulated the small streamlets to a new cycle of cutting, as is evidenced by gullied fields and roadsides. Some of these cuttings are more than ten feet in depth.

Skunk river system.—A triangular area in the southwestern part of the county drains through tributaries of the Skunk river. The hypotenuse of the triangle is approximately followed by the State Center branch of the Iowa Central railway and its area is about ninety square miles. The principal representatives of the system are Clear creek, North Skunk river and Snipe creek. All flow approximately at right angles to the general slope of the county. Clear creek and the Skunk river are wooded streams, while the Snipe is timberless. Clear creek has more deeply incised the region through which it flows than its co-workers, but none of them have done much in the way of valley formation. The valley of Snipe creek is boggy in character and suggests the fitness of its name.

The Cedar river system is feebly represented in the northeast corner of the county. The drainage from about two square miles takes this route to the "father of waters."

TERRACES.

Stream terraces are doubtfully represented in Marshall county. Timber creek, on sections 8 and 17 in Le Grand township, is accompanied by a low shelf fifteen to twenty feet above the flood plain in the streams. This bench can be identified at several other points in the various branches of this stream and is the nearest approach to a terrace found in the region.

Minerva creek, in Liberty township, sections 22 and 27, is apparently terraced. The bench is eight to ten feet above

the flood plain and is composed of Wisconsin drift. Here is the semblance of an old valley partially filled by the Wisconsin ice, and the present narrow flood plain represents the cutting since the retreat of the last ice sheet.

STRATIGRAPHY.

General Relations of Strata.

The geologic history of Marshall county is recorded in strata which belong to two distinct series separated by an enormous time break. A feeble realization of the immensity of the interval which elapsed after the completion of the first chapter and before the commencement of the last, can only be gained when we catch occasional glimpses of profoundly eroded areas and base-leveled plains.

The underlying stratified rocks belong to the Carboniferous system. Lying unconformably upon these is a thick mantle of Pleistocene deposits which effectually conceal the older rocks, save along some of the larger streams. The formations present are tabulated below.

CLASSIFICATION OF FORMATIONS.

GROUP.	SYSTEM.	SERIES.	STAGE.	SUB-STAGE.
Cenozoic.	Pleistocene.	Recent.		Alluvial.
		Glacial.	Wisconsin.	Fourth till.
			Iowan.	Loess. Third till.
			Buchanan.	
			Kansan.	Second till.
			Aftonian.	Albion gravels.
			Sub-Aftonian?	First till.

CLESSIFICATION OF FORMATIONS—*Continued.*

GROUP.	SYSTEM.	SERIES.	STAGE.	SUB-STAGE.
Paleozoic.	Carboniferous.	Upper, or Pennsylvanian.	Des Moines.	
		Lower, or Mississippian.	St. Louis.	
			Augusta.	
			Kinderhook.	Marshallt'wn shales. Le Grand beds. Hannibal shales?

The Lower Carboniferous forms an unbroken platform upon which all of the later deposits rest. The coal measures partially overlap this formation and comprise about one-half the area of the county. While the present surface slopes gently to the southeast, the underlying stratified rocks are inclined to the southwest or at right-angles to the general surface inclination. The average dip of the strata is about fifteen feet per mile in the eastern portion of the county, but the beds become almost perfectly flat to the westward.

The deeper strata have only been explored at one point,—Marshalltown. The following is the sequence of strata passed through in sinking the deep well near the city water works. The record* is based on sample drillings saved by Dr. W. S. McBride of Marshalltown.

		THICKNESS.	DEPTH.
13.	Limestone, light gray in fine sand, with many angular fragments of limpid quartz at 68 feet		70
12.	Limestone, light yellow, compact, earthy luster, three samples	45	115
11.	Limestone, brown, crystalline, cherty, at 115	30	145

* Prof. W. H. Norton kindly loaned to the writer his manuscript on the Marshalltown well, and from it the recorded descriptions and interpretations are taken almost verbatim.

		THICKNESS.	DEPTH.
10.	Shale, soft, light green, calcareous	175	320
9.	Limestone (?) no samples	145	465
8.	Limestone, hard, brown; gray and brown crystalline, rapid effervescence, samples at 465 and 560	155	620
7.	Dolomite, yellow, gypseous and cherty	55	675
6.	Limestone, magnesian, brown, samples at 675, 690 and 700, cherty at 675	95	770
5.	Dolomite, cherty and gypseous; drillings consist mostly of white and translucent chert	30	800
4.	Chert, white and translucent; samples at 800	75 (?)	875
3.	Limestone, rapid effervescence; drillings consist almost wholly of chert with some gypsum, samples at 875 and 900	15	915
2.	Dolomite, white in powder, with some chert and gypsum	10	925
1.	Shale, blue and green-gray, non-calcareous in samples, 925 to bottom of boring at	95	1,020

SUMMARY.

NO.	FORMATION.	THICKNESS —FEET.	DEPTH —FEET.
11, 12, 13.	Mississippian (Kinderhook limestone)	145	145
10.	Kinderhook (Shales)	175	320
8, 9.	Devonian	300	620
2–7.	Silurian	305	925
1.	Maquoketa penetrated	95	1,020

The sub-crystalline gray limestone and the buff magnesian limestone which attain such prominence in the exposures near Le Grand can be recognized as Nos. 13 and 10 respectively in the above section; but no trace of the equally prominent oolite and blue sandstone is to be found in the drillings. The whole assemblage of limestones above the green shale undoubtedly belong to the Kinderhook, while the taxonomic relations of the shale itself are not so clear. For the present, perhaps, it is best to follow Professor Norton and provisionally treat the formation as belonging to the Kinderhook, although latter developments may show it to be in part Devonian. Mr. C. N. Hutson, well driller, reports 260 feet of shale penetrated in sinking a well at the glucose works in the

south part of town. This heavy bed of shale does not outcrop any place in the county, nor, so far as known, any place in central Iowa, but its stratigraphic position seems to be the same as the thick shales encountered in the deep wells at Ottumwa and Sigourney* and the blue shale which outcrops at the base of the bluffs along the Mississippi river at Burington.†

The section ends in the Maquoketa shales which forms a well defined terrain throughout central Iowa, which may be taken as a standard of reference to determine the general dip of the deeper strata for this region. At Ackley and Cedar Rapids‡ this formation is reached at about 400 and 300 feet respectively above sea level. At Marshalltown the top of the shale is fifty feet below tide, while at Ames the shale rises more than 100 feet above sea level.

Standard Sections.

The best exposures are found in the vicinity of Quarry and Le Grand along the Iowa river. The Le Grand Quarry Co. in the development of their property have laid open to inspection sections which aggregate nearly two miles in length and nearly one hundred feet in vertical thickness. Other sections of less importance may be observed where the smaller streams cross the Kinderhook escarpment, as, for example, on Timber, Linn and Honey creeks, and near the towns of Albion and Bangor.

The following sequence of beds may be observed at the East quarries near Le Grand.

SECTION I.

		FEET.	INCHES.
18.	Loess, interstratified sands and silts below	16	
17.	Bowlder clay oxidized a deep brown and containing bowlders much decayed	5	10
16.	Limestone, sub-crystalline, pebbly	3	
15.	Oölite, fine-grained, with many brecciated grains	4	

* Geology of Iowa, vol. III, pp. 203-205, pl. xviii, 1893.
† Geology of Iowa, vol. I, pp. 192-193, 1870.
‡ Geology of Iowa, Vol. III, pp. 189-192 and 195-197. 1893.

		FEET.	INCHES.
14.	Limestone, gray, slightly oölitic	2	6
13.	Limestone, gray above, and yellow below	2	
12.	Limestone, buff, magnesian, rather heavily bedded, bisected by chert band about four feet from the base	9	
11.	Limestone, mixed gray, blue and buff, breaks very irregularly ("Brindle" of the quarrymen)	3	6
10.	Chert		4
9.	Limestone, soft, yellow, in thin layers and arenaceous; earthy in places	2	6
8.	Chert		4
7.	Limestone, blue, variegated to yellow-brown	6	
6.	Chert		3
5.	Fossil-breccia with lenses of crystal calcite	1	
4.	Limestone, buff, magnesian, fine even texture and massive; cherty, concretions scattered promiscuously throughout. One quitepersistent band of chert about four feet from the base	12	
3.	Limestone, blue, variegated to brown, hard, conchoidal fracture, and in heavy layers	3	6
2.	Oölite, in layers, 14, 12, 8, 9, 6, 36, 26, 24 and 42 inches in thickness	15	
1.	Sandstone, fine-grained, blue, calciferous, in part shaly (exposed)	10	

No. 1 in the above section is exposed in the quarry north of the river and appears at no other point in the county. The dip is about four degrees to the southwest, and this, with the slope of the stream, soon carries the beds below the surface. Near Indiantown, in Tama county, the base of the oolite lies more than twenty feet above the water level, while at the west quarry both oölite and sandstone have passed below the bed of the river, and No. 16 has a thickness of about twelve feet. The upper layers at Le Grand probably form the base of the section at Marshalltown. At the latter place the following series, which consist principally of shales, may be seen near the Woodbury flouring mills.

SECTION II.

		FEET.
7.	Loess, sandy	2
6.	Clays, and sands with some bowlders, variegated; highly oxidized in streaks	6
5.	Calcareous, pebbly material containing large chert concretions; the original limestone structure is almost obliterated	4
4.	Shale, ash-blue, graduating downward into arenaceous beds	6
3.	Limestone, arenaceous, impure	2
2.	Shale, dark blue, slightly sandy and concretionary and slacks rapidly on exposure; many of the fragments spotted with white flocculent material	4
1.	Limestone, brown, sub-crystalline, base	

All of the beds are more or less irregular and are cut out eastward. A continuation of the above exposure, in the form of a low ridge, runs southwestward from the mill, departing somewhat from the river, and perhaps outlining the position of an old escarpment. The ridge continues for nearly a mile, gradually wanes and passes under the drift bluff at the Soldiers' home.

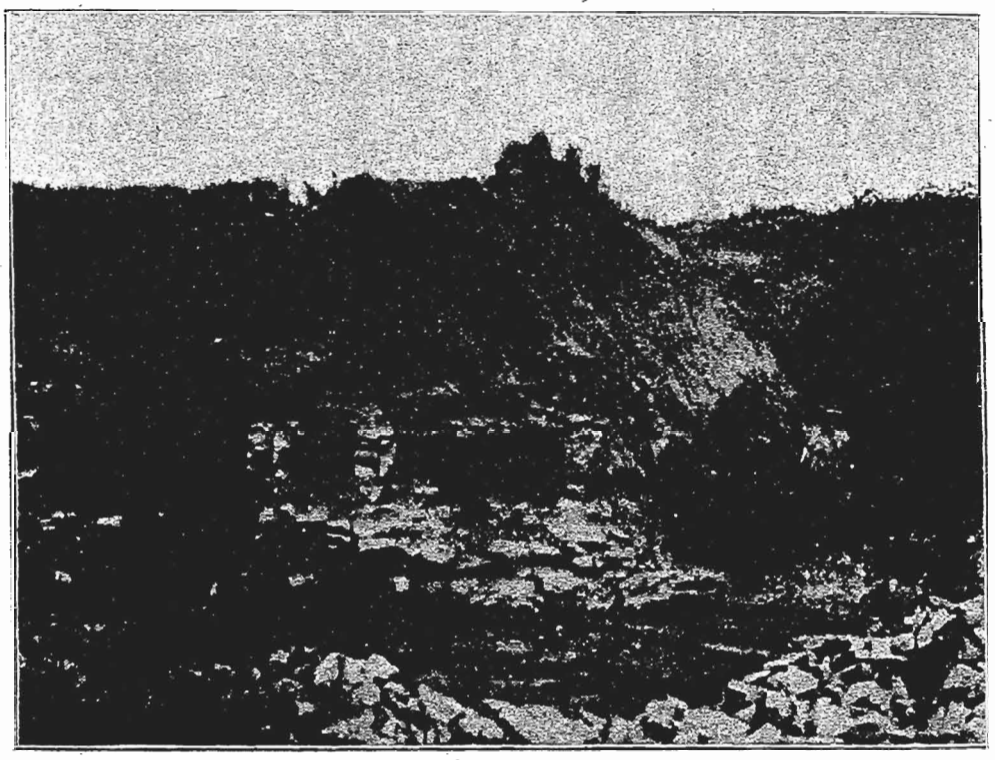


FIG. 26. The upper Le Grand beds as exposed at Rockton.

At Rockton the upper portion of section 1 is duplicated almost perfectly.

SECTION III. ROCKTON.

		FEET.
6.	Loess and soil	1–3
5.	Till, yellow (Iowan)	2–4
4.	Till, reddish-brown, sometimes blue below (Kansan)	0–3
3.	Limestone, brown, sub-crystalline, rubbly	3–5
2.	Limestone, oölitic, heavy bedded	5
1.	Limestone, gray-brown, beds thinner and slightly argillaceous	2

Two drift sheets are represented here. Numerous granitic

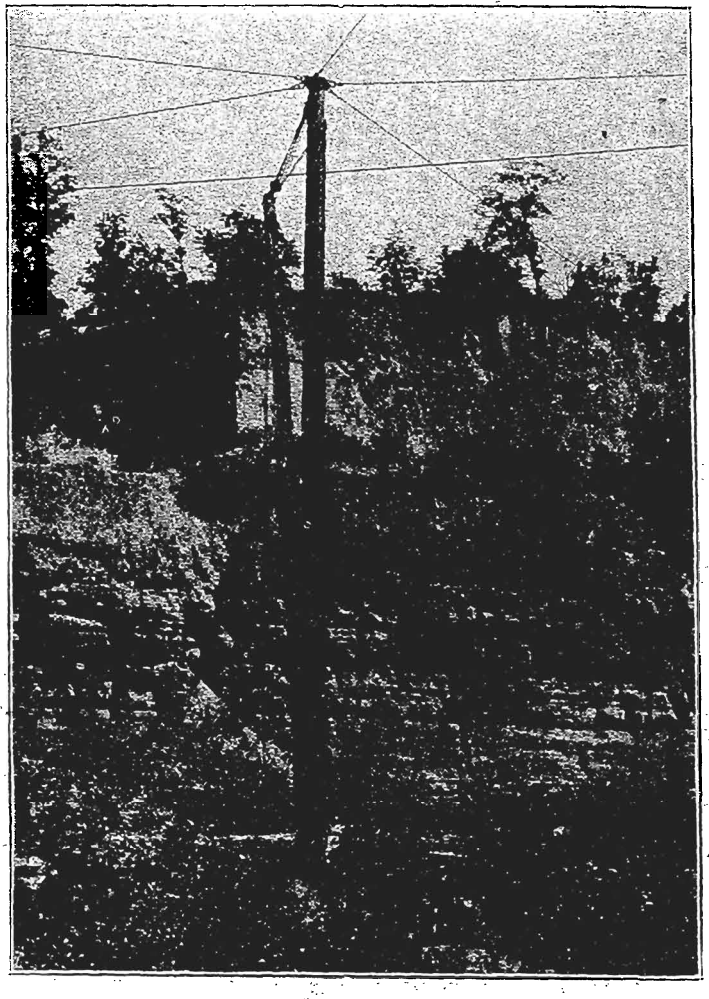


FIG. 27. The Le Grand beds as exposed on Timber creek at the I. C. Ry. crossing. The loess maintains a vertical scarp, while the Kansan till slopes.

bowlders are present in the base of the Iowan in places. Numbers 1, 2 and 3 in the above section may be referred to Nos. 14, 15 and 16 respectively in section 1.

At the point where the Iowa Central railway crosses Timber creek a slightly different facies of the Kinderhook beds may be observed.

SECTION IV. TIMBER CREEK.

		FEET.
8.	Loess, sandy, below	10
7.	Bowlder clay (Kansan)	6
6.	Limestone, brown, sub-crystalline, thinly bedded, and rubbly above, heavier below	8
5.	Limestone, yellow, brittle, with occasional small caverns decorated with concretionary calcite	1½
4.	Limestone, blue, hard, brittle	2
3.	Oolite in three layers, 8, 22 and 6 inches respectively	3
2.	Limestone, gray-brown, with layers of blue, sub-crystalline limestone interbedded	6
1.	Limestone, gray-blue, close textured, soft when first exposed, weathered portion, yellow; layers vary from 6 to 18 inches, very evenly bedded, magnesian	12

The oölite in the Timber creek section is undoubtedly the equivalent of the oölite exposed at Rockton and the "upper oölite" of section 1, numbers 1–6, in the above section find their counterparts in 12–16 in the Le Grand section, with the possible exception of number 5, which was not recognized farther north. The differences in physical properties and coloration are largely, if not wholly, due to the differences in weathering. The Timber creek beds are better protected than those at Le Grand. The prevailing colors of the unweathered product are shades of blue and gray, while tones of yellow and buff are brought about through the action of weathering agencies. The hardness of the Timber creek stone increases on exposure.

SECTION V.

(Tp. 83 N., R. XVIII W., Sec. 8, Sw. qr., Se. ¼.)

		FEET.
3.	Loess	1–3
2.	Till, oxidized throughout a deep brown	2–5
1.	Sandstone, reddish-brown in heavy beds, certain layers show oblique bedding, exposed	12

The sandstone exhibits a conglomeratic facies in part. Well polished grains of sand and gravel are held in a matrix

of ferric oxide. Some of the iron oxide is often in the form of small nodules which frequently are hollow and possess the concentric structure peculiar to concretions. Throughout the beds are the impressions of the trunks and branches of trees which have retained their woody structure in a remarkable degree, although their original organic substance has been entirely replaced by mineral matter. In some instances a pulverulent ash surrounded by a highly ferruginated shield are the only remains. In one case, a central core of very

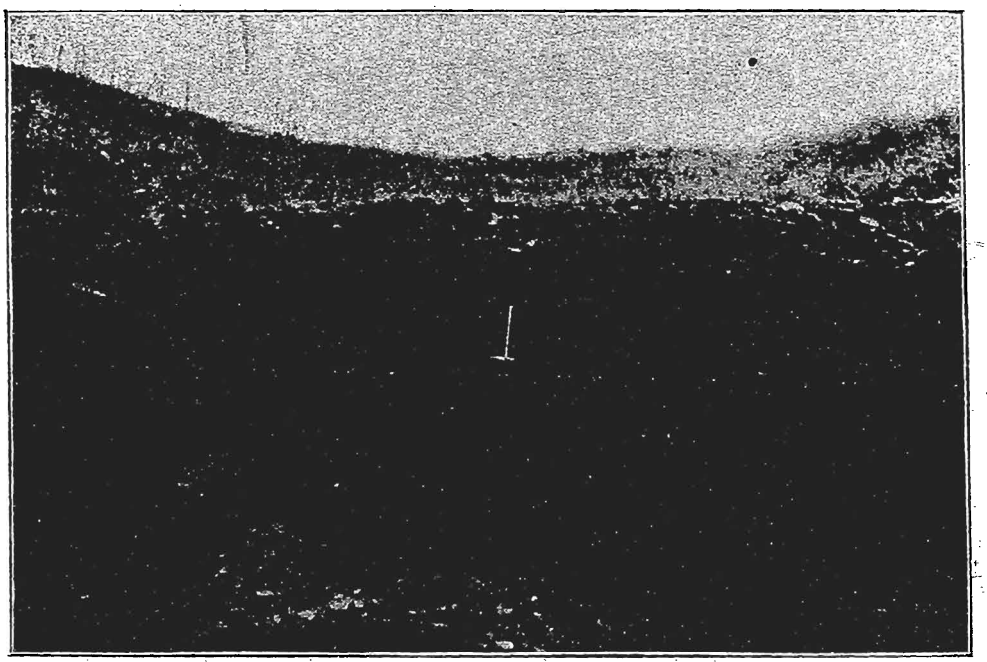


FIG. 28. Carboniferous sandstone in Timber Creek township, Sec. 8, Sw. qr., Se. ¼.

hard material, almost quartzitic, was noted; around this a zone of wood fiber, and surrounding all the concentric ferruginous shield. All of the stems were in a recumbent position. No faunal remains could be found.

Geological Formations.

CARBONIFEROUS SYSTEM.

With a few unimportant exceptions, the stratified rocks in the western half of the county are entirely concealed by the Pleistocene deposits. Rocks of the Lower Carboniferous age

have been exposed northwest of Liscomb near the Iowa river, and also east of Bangor on Honey creek. Coal measure outcroppings appear on Honey creek and along the Iowa river between Bangor and Albion.

MISSISSIPPIAN SERIES.

Owen, in his description of the Carboniferous rocks of the Iowa river definitely referred the rocks exposed near Le Grand to the Subcarboniferous. He says in part: "It was not, however, until reaching the northwest corner of Tama county that rocks of the Subcarboniferous era were seen unequivocally in place. Here, on the left bank of the Iowa, * * * both oölitic and encrinital beds of Carboniferous limestone protrude; and where the river crosses the corner of Marshall county the characteristic fossil, *Pentremites pyriformis* was found, along with *Terebratula plano-sulcata*, *Spirifer striatus* and *Productus semireticulatus*." He also calls attention to the change in the surface configuration, the beginning of a more vigorous topography, and the increased growth of timber, both of which, perhaps, are more or less independent of the country rock, but mark the transition of the drift plain into the loess-drift topography.

J. D. Whitney describes a section on Timber creek and disposes of the exposures near Indiantown and Le Grand as follows: "About one-half mile northwest of the town [Indiantown] a thin bedded, brittle limestone with a pinkish tinge is seen cropping out along the summits of the low ridges, * * * succeeded, in a descending order, by thin layers of white crystalline limestone filled with fragments of crinoidal columns. These layers contain intercalated masses of chert, and some of the beds are oölitic in structure, the whole assemblage closely resembling the outcrop of the Burlington member of the Carboniferous limestone as seen at that place. * * * In some loose masses of oölitic limestones * * * there were found specimens of Spirifer (?) ————, and an Avicula resembling *A. marionensis* Shumard."

* Geology of Iowa, Pt. 1, pp. 267-8, 1858.

White, in his discussion of the "Carboniferous System,"* describes the section at Indiantown, which is practically the same as the exposures at Le Grand, as consisting of.

		FEET.
3.	Soft irregularly bedded magnesian limestone passing up into purer and more regularly bedded limestone	40
2.	Light gray, oölitic limestone in heavy layers	15
1.	Yellowish, shaly, fine-grained sandstone	20

Continuing he says: "The characteristic fossils of the Kinderhook formation prevail throughout the whole series of beds found at Indiantown, even including the whole forty feet of No. 3. Although the upper part of No. 3 presents the lithological appearance of some parts of the Burlington limestone, yet its distinctive paleontological characters are wanting or feebly shown. The whole is therefore referred to the epoch of the Kinderhook beds, especially since the line of demarkation between the rocks of this epoch and those of the Burlington limestone is nowhere definite."

Wachsmuth and Springer,† in their chapter on the crinoids and blastoids from Le Grand, Iowa, accept White's reference of Nos. 1 and 2 in the above section, but observe that the upper part of No. 3, of the Le Grand and Indiantown sections is, in their opinion, very probably the representative in part of the Lower Burlington limestone. A specimen of *Actinocrinus proboscidialis* which is one of the most characteristic species of the Lower Burlington, is mentioned as having been found in the upper layers; and these authors suggest that the upward limit of the Kinderhook is coincident with upper limits of the magnesian limestone.

To summarize briefly, Owen and Whitney considered the Le Grand beds to be the equivalents of the encrinital formations,—the Lower Burlington limestone at Burlington, the correlation being based almost wholly on lithological resemblances. White definitely assigns the assemblage to the Kinderhook as defined by Meek and Worthen, basing his opin-

* Geology Iowa, vol. I, pp. 195-7, 1870.

† Geol. Sur. Illinois, vol. VIII, pp. 155-208, 1890.

ion on paleontologic evidence; while Wachsmuth and Springer, in their study of the echinodermatous remains in the beds, confirm White's reference, in the main, but suggest the probability of certain of the upper layers belonging to the Lower Burlington.

The present investigation affords no reason to dissent from Professor White's reference. Professor Calvin has kindly identified a series of fossils collected at Le Grand, Timber creek and Rockton, some of which were taken from the extreme uppermost strata, and he finds them to possess distinctively Kinderhook characters.

KINDERHOOK.

The Kinderhook beds in Marshall county attain a maximum thickness of nearly 150 feet.* The entire sequence may be

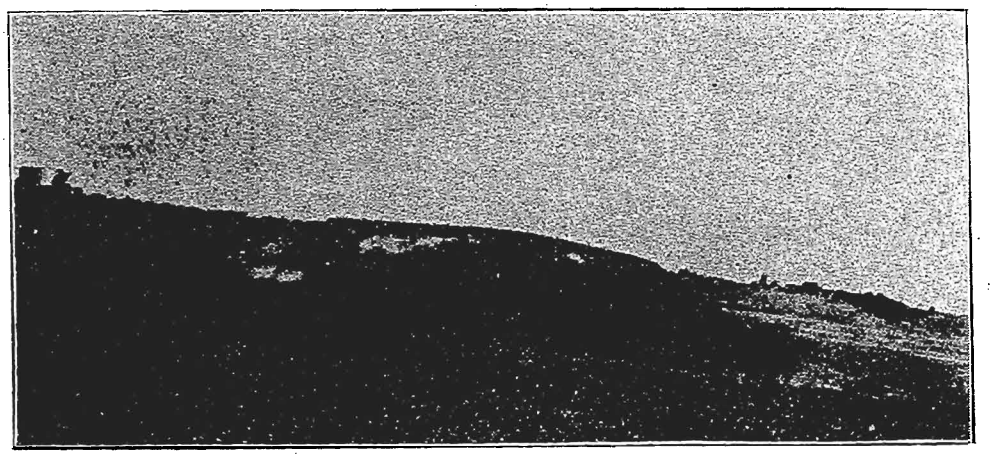


FIG. 29. Kinderhook outlier. Marshall-Tama line on the Iowa river.

observed by visiting two sections. The greater portion of the section is exposed at Le Grand, while the uppermost beds may be seen at Marshalltown.

THE LE GRAND BEDS.

The Le Grand beds comprise a total thickness of about 135 feet, as evidenced by the deep wells in Marshalltown which penetrate these deposits. Scarcely 100 feet of strata are

* The above estimate does not include the 175 feet of shale exhibited in the Marshalltown deep well, which is doubtfully referred to the Kinderhook.

exposed at the Le Grand when all of the outcrops are combined. Although the Le Grand beds constitute a strati-

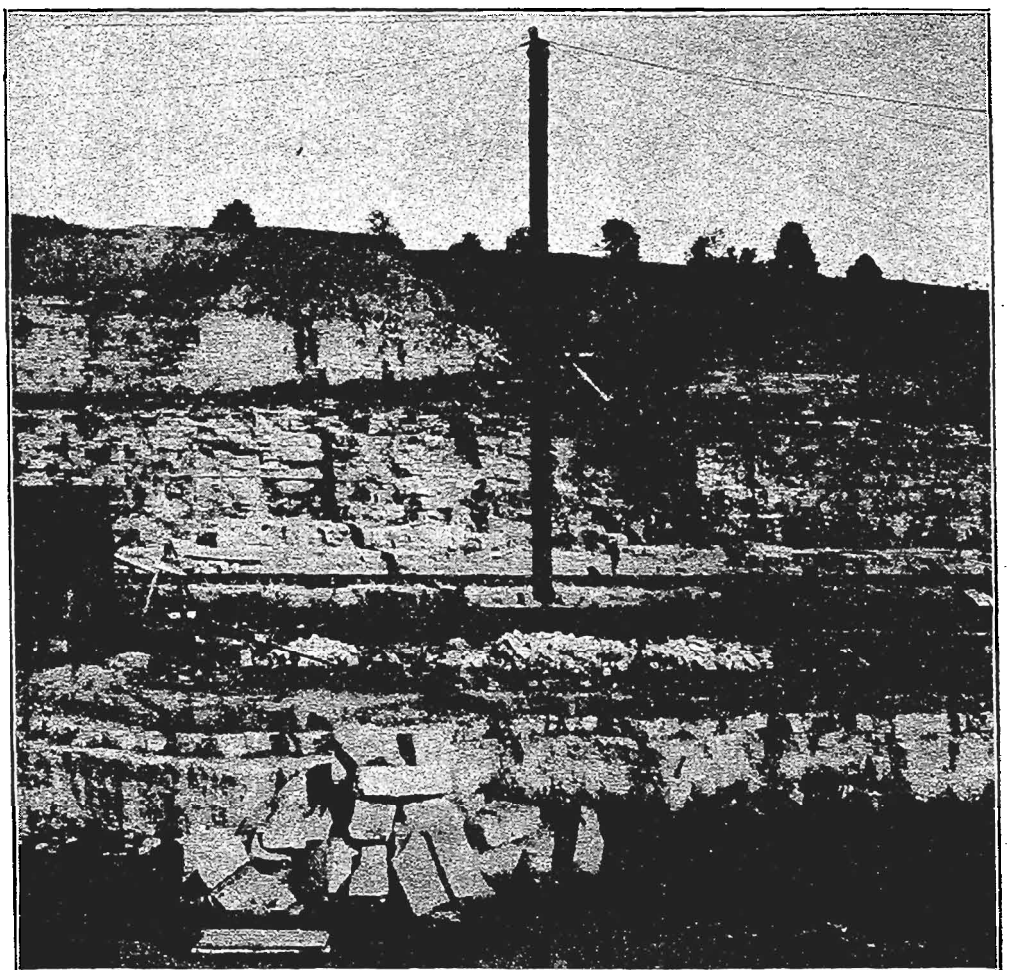


FIG. 30. Le Grand beds as exposed at southwest quarry, Le Grand. (1) Oölite, (2) Chert beds, (3) Crinoid zone, (4) Ice-planed surface of the brown and gray subcrystalline limestone.

graphic unit, for convenience of discussion they may be subdivided lithologically into four fairly well worked terrains, as follows:

		FEET.
4.	Brown and gray subcrystalline limestone	30
3.	Buff magnesian limestone, cherty below	35
2.	Gray-white oölite	15
1.	Argillaceous, blue sandstone	20

The lowest member consists of a very soft, fine-grained bluish white sandstone, slightly argillaceous above and heavy bedded below. The sandstone is exposed only at the north-

east quarry within the limits of the county. At Indiantown, about two miles east of Le Grand, the sandstone is very friable and takes on a yellowish tone due to weathering. Casts of fossils were observed.

The oölitic member is in very heavy layers and is evenly bedded. It is of a gray-white color and is only exposed in the two east quarries at Le Grand. This terrain is fossiliferous throughout. The principal forms recognized were:

Entolium circulus Shumard.

Straparollus latus Hall.

Productus sp. (?) and fish spines and plates.

The third member comprises about thirty-five feet of homogeneous, fine-grained, buff, magnesian limestone, which, lithologically and faunally, may be subdivided into three zones.

		FEET.
3.	Heavy bedded magnesian limestone; barren zone	12
2.	Arenaceous marly layers; Encrinital zone	4
1.	Chert beds { Barren zone, 12 feet / Chonetes zone, 8 feet }	20

The chert beds consist of irregularly bedded magnesian limestone, much divided by quite persistent chert bands and cherty concretions scattered promiscuously throughout the deposit. This division is almost devoid of organic remains, save in the chert bands and associated layers near the base, which are closely set with Chonetes. *Productus arcuatus* Hall, was found along with the Chonetes. The chert beds are separated from the oölite by a variegated, heavily bedded, subcrystalline brown and blue limestone, whose most characteristic organic remains are fish spines. A large spine of Ctenacanthus, similar to *C. furcicarinatus* of Newberry, was found in this layer.

The middle layers are thinly bedded and of a marly arenaceous character, forming a fit receptacle for the abundant crinoidal fauna which they contain. More than nine-tenths of the Echinodermatous remains found at this locality were confined to these shaly, marly layers, which have an aggregate

thickness of less than four feet, and may fittingly be designated the "Encrinital zone."

Wachsmuth and Springer,* the eminent authorities on the Paleozoic Pelmatozoa, have described the following species of crinoids and blastoids from the Le Grand beds:

Athinocrinus ornatissinus W. & Sp.
Athinocrinus nodobrochiatus W. & Sp.
Athinocrinus arnoldi W. & Sp.
Megistocrinus nobilis W. & Sp.
Megistocrinus parvus W. & Sp.
Batocrinus macbridei W. & Sp.
Dorycrinus immaturus W. & Sp.
Dorycrinus radiatus W. & Sp.
Dorycrinus parvibasis W. & Sp.
Rhodocrinus kirbyi W. & Sp.
Rhodocrinus nanus Meek & Worthen.
Rhodocrinus watersianus W. & Sp.
Platycrinus symmetricus W. & Sp.
Platycrinus planus Owen & Shummard?
Dichocrinus inornatus W. & Sp.
Graphiocrinus longicirrifer W. & Sp.
Scaphiocrinus elegantulus W. & Sp.
Scaphiocrinus globosus W. & Sp.
Taxocrinus fletcheri Worthen.
Taxocrinus intermedius W. & Sp.
Orophocrinus conicus W. & Sp.
Orophocrinus fusiforms W. & Sp.

In describing the mode of occurrence and former habitat and state of preservation of this most interesting assemblage of organisms, the above authors write as follows: "It appears that the Le Grand crinoids were deposited in very quiet waters, and in many cases were imbedded just as they died. They occur in nests and colonies, and genera and species are commingled indiscriminately. It is, therefore, a curious fact that while the specimens of some species are of

* Geological Surv. Illinois, vol. VIII, pp. 157-205. 1890.

pure calcareous composition and of a light color, those of others, under precisely-similar conditions, lying side by side with them, sometimes even with stems and arms intertwined, are harder and of a very dark brownish-gray color. * * * The stems are short, * * * and is worthy of note that in all our perfect specimens from Le Grand * * * taper to a fine point, giving off rootlets in all directions, and there is in no instance any indication of an attachment by the column to a solid substance * * *. Taking everything into consideration, it seems to us the numerous small rootlets, spreading in all directions lead to the conclusion that those crinoids, with but few exceptions, either lived upon a soft, oozy bottom, in which they were rooted like plants, or that the rootlets served as an anchor by which the animal attached itself to foreign bodies."

The brachiopodous fauna is represented as follows in this zone:

Spirifer biplicatus Hall.
Orthothetes crenistria Phillips.
Rhynchonella sp (?).
Spirifer sp (?).

The upper layers of the magnesian limestone consist of heavy beds two to four feet in thickness and rather evenly bedded. A chert band bisects the division near its middle, but otherwise it is quite free from siliceous matter. Fossils are rare.

The magnesian limestone is exposed in its entirety in the two east quarries at Le Grand. At the west quarry the upper two divisions only are exposed. At the Timber creek quarry the top of the upper division is but little above water and this division alone has been explored. These are the only localities where this formation appears in the county.

The uppermost Le Grand beds comprise a composite series consisting in the main of gray or brown, subcrystalline limestone, and gray oölite. This oölitic layer is near the base and is composed of four feet of typical oölite resting on two

feet and a half of shell breccia with an oölitic facies. The limestone above the oölite is hard, thinly bedded and rubbly in character. Occasionally chert bands are present, but they are less abundant than in the magnesian layers. The whole assemblage is highly fossiliferous throughout, the chief forms being:

Spirifer subrotundus Hall.
Spirifer extenuatus (?) Hall.
Spirifer biplicatus Hall.
Orthothetes crenistria Phillips.
Rhynchonella, sp (?).
Terebratula, sp (?).

Fish remains and crinoid stems are often present in abundance, but *Actinocrinus proboscidialis* Hall, is the only crinoid calyx described from these beds.

The upper division is present wherever the Le Grand beds have been recognized within the limits of the county. It plays an important role in the Kinderhook escarpment, whose position is approximately marked out by a line passing through the Le Grand, Rockton, Corrick and Liscomb quarries. The valleys of the streams which have cut into the country rock are constricted where they cross this line. This is best seen in the valley of the Iowa itself. (See Pleistocene map.) The most extreme westward outcrops may be noted on the Iowa river north of the Soldiers' Home, on North Timber creek, and on South Timber creek near Ferguson. At the last three places only the thin bedded, brown, subcrystalline limestone may be seen.

MARSHALLTOWN SHALES.

About fifteen feet of argillo-calcareous beds are exposed near the Marshalltown Flouring Mills. They consist of ash-blue to deep blue shales interbedded with argillaceous limestones. Chert nodules are present in the upper calcareous layers. After diligent search no trace of organic remains could be found. In the absence of distinctive characters these

beds may be referred conditionally to the Kinderhook. Concretions similar to those mentioned above are found along the river westward to the great bend, but not in place.

AUGUSTA.

Although Hall considers the Le Grand beds to be the equivalent of the Lower Burlington and Wachsmuth and Springer have suggested the probable equivalency of the brown subcrystalline layers at Le Grand with the same formation, yet the matter now stands pretty much as it did more than a quarter of a century ago, when White failed to find sufficient reason for the differentiation of the Lower Carboniferous in Marshall county. With the data in hand at the present time the Augusta cannot be recognized definitely within the confines of the county.

SAINT LOUIS.

In Bangor township in the Sw. qr., Sw. $\frac{1}{4}$ of Sec. 16, a heavily bedded, close-textured limestone is quarried in the bottom of Honey creek. The rock is of a dark, ash-gray color and contains some small, cherty concretions. Iron pyrites occur in bands and sheets in certain layers. The rock breaks with an uneven or hackley fracture, and some blocks give a metallic chink when struck with a hammer. No fossils could be found. Lithologically, these beds have a very close resemblance to the lithographic facies of the Saint Louis limestone as exhibited at the quarries north of Ames on the Skunk river, and at Webster City on the Boone river. The area is mapped as Kinderhook, but probably should be referred to the Saint Louis. Coal measures overlie these beds at this point.

DES MOINES STAGE.

The coal measures (Des Moines) overlap the Lower Carboniferous formation in an irregular manner and occupy nearly one-half the superficial area of the county. The general trend of the overlapping edge of the formation is east of

south, extending from the northeast corner of Bangor township to the southwest corner of Green Castle township. There are reëntrant angles where the principal streams make their exit from the measures, with the exception of Middle Timber creek; there being an extension at this point. A prolongation of the coal measures extends westward into Iowa and Liscomb townships and may have been at one time continuous with the outlier in Vienna and Taylor townships, which marks the extreme eastward limit of the Des Moines in the county. Outcroppings of the coal measures are few and unimportant, so perfect is their concealment by the glacial debris. At certain points along the Iowa river northwest of Albion on Honey creek, a thin coal seam along with carbonaceous shale may be noted. In Timber Creek township a heavily bedded, red sandstone appears along a tributary of Linn creek, near the Chicago Great Western railway on sections 8 and 9. Outcrops of the same beds may be observed near the water level on the Middle Timber in sections 26 and 34. Away from the margin there are no exposures of the Des Moines in the region. The deeper wells in the vicinity of State Center undoubtedly penetrate the coal measures, which consist largely of shales. In sinking a well for Emanuel Hepner, Tp. 85, N., R. XVII W., Sec. 30, Se. qr., Ne. ¼, the following sequence of strata was reported.

	FEET.	INCHES.
Loess and drift	120	
Sandy, shelly rock, greenish yellow	2	
Coal		6–8
Red sandstone, soft	16	
Argillaceous limestone, very hard	1	
Argillaceous shale, light, ash-color	13	
Coal, carbonaceous shale and fire clay	6	
Hard, gray limestone (penetrated)	10	

Other wells in the vicinity are reported to exhibit a similar sequence. The Hepner well seems to be near the center of the outlier and hence the maximum thickness of the measures in this region may be taken as approximately forty feet. The Des Moines is doubtless much thicker in the western portion

of the county, but at present no well authenticated records are at hand.

Here, as elsewhere in Iowa, the Des Moines stage of the Upper Carboniferous consists essentially of shales and sandstones, with occasional layers of argillaceous limestones and seams of coal, all of which are interbedded in an intricate manner. The shales predominate in Marshall county and vary structurally from massive structureless clays through clayey shales to fissile shales; texturally form the purest shales through arenaceous shales to argillaceous sandstones. Colors are equally variable from the gray-white fire clays to the jet-black carbonaceous shales.

The prevailing sandstones are in shades of red, but in other regions, where better exposed, they are found to be equally as variable in physical properties as are the shales.

So far as at present known the argillaceous limestones and coal seams are sparingly developed in this territory.

PLEISTOCENE.

With a few unimportant exceptions where the larger streams have succeeded in cutting through and exposing the older formations, the Pleistocene deposits form a continuous mantle over the entire county. They are composed essentially of bowlder clays, sands, gravels and silts, often interbedded and intermingled in a most complex manner. Bowlders are not uncommon attendants to this most heterogeneous assemblage. The average thickness of the glacial debris on the uplands in this region, is upwards of 100 feet, and the present surface features are sculptured almost wholly in this material. At certain points in the county much greater depths are attained. In Eden Tp. on the northwest quarter of section 8, 190 feet was reported; Jefferson Tp., Sw. qr. of Sec. 22, 220 feet; Marietta Tp., Sw. qr. of Sec. 25, 212 feet; Liscomb Tp., Nw. qr., Sec. 22, 260 feet; Taylor Tp., Se. qr., of Sec. 1, 300 feet, and on the Sw. qr., 400 feet of drift was penetrated. In the latter township there seems to be a rock-

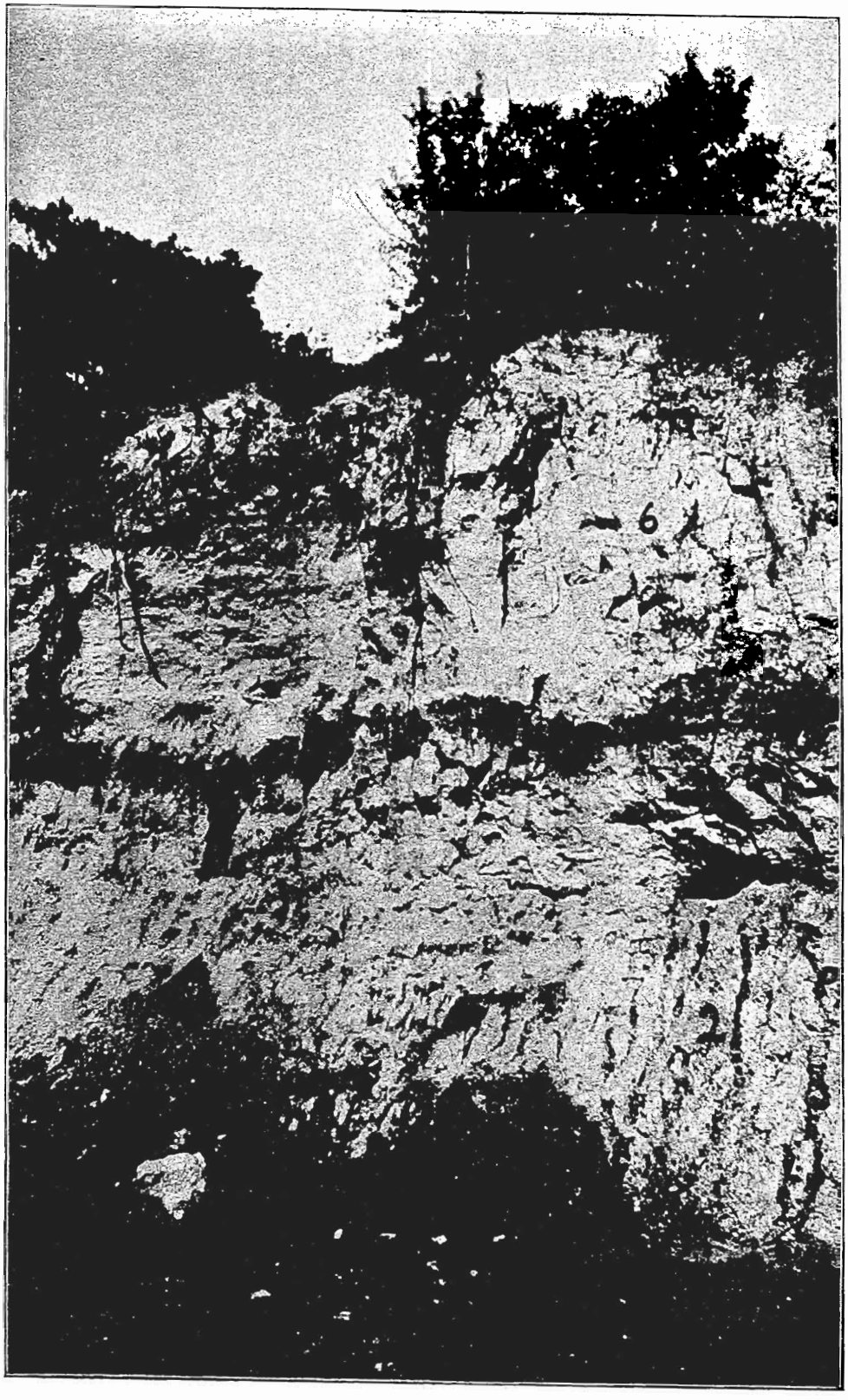
bound gorge trending northeast-southwest, bisecting sections 1 and 11, and more than a half mile in width. The southern wall of the gorge is apparently very abrupt, while the north wall rises gradually. The rock rises to seventy or eighty feet of the surface within half a mile southeast of the line of the gorge. Northward the rock is reached 190 and 180 feet below the surface on the Sw. and Nw. qrs. of section 2, respectively. The inequality of the slopes of this buried channel is analogous to that of the great majority of the Iowa streams of the present day. The south flank is almost universally the more abrupt.*

Although there are occasional hints of preglacial channels and depressions, none can be mapped definitely, and the general testimony of the drift wells is that the preglacial topography was milder than that of the present time. The type of topographic maturity. the pure plain, is suggested.

Marshall county has been subjected to at least three and perhaps four distinct ice invasions, separated by intervals of vigorous erosion and surface corrugation, or surface silting. The first two ice sheets were followed by gravel trains, while the last two were succeeded by intervals of surface silting and alluvium forming, respectively. The sequence of events may be described briefly in chronological order, and the corresponding deposits arranged stratigraphically as follows.

8.	Deglaciation and erosion	Recent (Alluvium in part.)
7.	Glaciation (western margin of county)	Wisconsin till.
6.	Deglaciation and surface silting	Loess.
5.	Glaciation (northeast corner)	Iowan till.
4.	Deglaciation and vigorous erosion	Buchanan gravels.
3.	Glaciation (general)	Kansan till.
2.	Deglaciation and erosion	Aftonian gravels.
1.	Glaciation	Sub-Aftonian till.

* The writer is indebted to Mr. Harry Weatherby for the records in Taylor township. The data is based on drillers' notes or derived from a personal interviews with the respective land-owners. Such evidence must be taken with a grain of allowance. The Kinderhook shales lie scarcely 100 feet below the general rock surface and might easily be mistaken for drift clays.



DRIFT SECTION AT ALBION.

SUB-AFTONIAN.

No till sheet below the Kansan has certainly been identified in this region. At the Albion mill, about ten miles northwest of Marshalltown, the following sequence of deposits may be observed, the basal members of which are pre-Kansan, and may be the equivalent of the sub-Aftonian.

ALBION SECTION.

		FEET.
6.	Loess, stratified sand and silt below	20
5.	Yellow till, apparantly wanting in places and often represented by characteristic bowlders only. (Iowan)	0–1½
4.	Gravel, bowlders four or five inches in diameter present, granitic members often much decayed; limestone pebbles common; bowlders of Kansan adorned with pebbles noted. (Buchanan)	2
3.	Till, upper portion oxidized a deep reddish brown, the lower portion unoxidized and gray-blue in color; jointed structures prominent throughout. (Kansan)	5
2.	Sand and gravel, stratified, coarser below; oxidized in streaks and bands approximately parallel to bedding planes. (Aftonian)	10
1.	Blue till* (Sub-Aftonian)	10

At the well put down in section 7, in Warren township, for Wm. M. Wallace, the drillers' record is as follows:

	FEET.
Yellow clay (loess, Iowan and oxidized portion of Kansan)	30
Blue clay (Kansan)	40
Sand and gravel (Aftonian?)	30
Blue clay (Sub-Aftonian?)	50

The above records at least suggest the presence of the pre-Kansan till sheet, but additional data are necessary before more explicit statements can be made concerning its characteristics and distribution.

AFTONIAN.

At the base of the Albion section ten feet of stratified sand and gravels may be observed. These beds were laid down,

* Not exposed, but B. W. Sheets reports ten feet of bowlder clay penetrated in sinking the abutments for the bridge.

in large part, through the agency of running water. Many of the pebbles and small bowlders bear polished, striated or facetted surfaces, yet the granitic members are oftentimes in an advanced stage of decay. The relation of this deposit to the Kansan is unquestionable, because till of the Kansan age rests immediately upon these beds. Gravels similarly related to the Kansan have been reported from various parts of the county, and the maximum thickness attained is about thirty feet.

The presence of a well marked terrane consisting of sands and of gravels, many of the pebbles and small bowlders of which bear the unmistakable imprints of glaciation, almost necessitate a preëxistant glacier and its universal product, the till sheet. *A priori*, this fact in itself would be sufficient reason for suspecting the presence of pre-Kansan glaciation (sub-Aftonian drift sheet).

KANSAN.

The Kansan ice covered the entire area under consideration and extended far southwestward into Missouri and Kansas, receiving its name from the latter state. As a till producer this great ice sheet is without a rival, and the elements of the present topographic features are boldly outlined in the till of this sheet.

The Kansan drift is composed essentially of bowlder clays containing pockets of sand and gravel and occasional bowlders of moderate size. The coloration is almost wholly due to the state of oxidation, and the formation may be divided arbitrarily into an upper oxidized portion and a lower unoxidized portion. The oxidized zone varies in color from a bright yellow to a deep reddish brown, while the unoxidized portion assumes some shade of blue, and constitutes the blue clay, hard pan, etc., of drillers. The degree of leaching to which these beds have been subjected varies greatly, and approximately keeps pace with the process of oxidation. In the cuts along the Chicago Great Western railway on sections

8 and 17, in Timber Creek township, these facts are beautifully illustrated. The maximum thickness of Kansan till exposed here is about fifteen feet, covered with 3 to 10 feet of loëss, the latter being the thickest upon the hill flanks. Near the line of contact the till is a deep red-brown in color and thoroughly leached. Passing downward, the color becomes lighter and the leaching less perfect. The lower five feet of the partially oxidized zone is of a faded yellow color, and lime concretions similar to those found in the loess which mark the incipitent stages of leaching are very abundant.

The pebbles and bowlders consist chiefly of granites, greenstones and gneisses. In the eastern half of the county fragments of limpid quartz and cherty limestones are very common, while quartzites occur infrequently. Many of the bowlders are fractured and striated. The granites and gneisses often crumble on exposure. Fragments of coniferous wood are not uncommon inclusions in the lower portion of the formation.

The Kansan till covers the whole county save where it has been removed by erosive agencies. The thickness of the sheet varies from a few feet, where it caps the outliers of the Kinderhook to more than one hundred feet in the uplands of the south and west, with an average thickness of little less than the latter figure. The oxidized portion is usually rather more than ten feet thick.

BUCHANAN.

The retreat of the Kansan ice was closely followed by a season of vigorous erosion and a working over of the newly deposited drift. This was a time of gravel accumulation. Well rounded bowlders of Kansan till are found in these gravel beds and may be taken as evidence of the still frigid climate, for it is reasonable to presume that fragments of clay would not permit attrition and transportation unless frozen. At Albion these gravels attain a thickness of about two feet and are typically developed. They are very much

coarser at this point than those referred to the Aftonian. The gravels near Gifford are probably of the same age, but are finer textured and distinctly stratified. During the remainder, and by far the greater portion of the inter-glacial interval, the surface was profoundly eroded, oxidized and leached.

IOWAN.

The Iowan ice traversed the northeast part of Marshall county and left evidence of its visit in the form of a thin sheet of till, and a goodly sprinkling of bowlders, some of

FIG. 31. Iowan bowlder, red granite, situated two and a half miles north of Marshalltown.

which are of enormous size. Unlike the Kansan, the Iowan contributed but little bowlder clay. Exposures of Iowan till may be observed at the Albion mills, Rockton, the cuts along the wagon roads in the northwest corner of section 2, Tp. 89 N., R. XVIII W., and various places between sections 5 and 6, Tp. 84 N., R. XVII W. This drift sheet never attains more than a few feet in thickness, and over perhaps the greater portion of the area, the bowlders, many of which occur well up the hill flanks, are the only witnesses of its presence. The Iowan till is light to bright yellow in color and is imperfectly oxidized and leached. It is sandier and lacks the tough, plastic char-

acter of the Kansan. The bowlders, both great and small, are prevailingly granites, and are much fresher than those common to the older drifts.

The Iowan ice was undoubtedly thin in this region, and the extreme advance of the attenuated edge is probably approximately outlined by the Iowa river, but no bowlders were observed on the flood plain below Albion.

LOESS.

The loess is a homogeneous, siliceous silt varying from light buff to a brownish buff in color. It in some measure resembles the drift after the coarser and finer materials have been removed. The constituent particles vary in size from

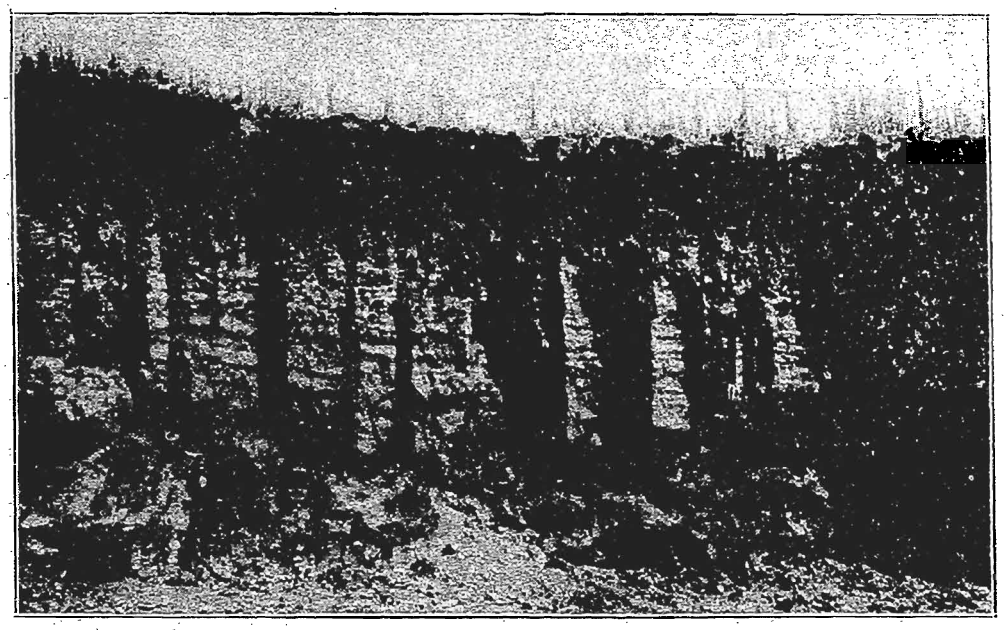


FIG. 32. Stratified loess, in clay pit of Sieg and Size, west of Marshalltown on the Iowa Central railway.

the finest silt to fine sands and usually present sharp angles. Lime concretions, *losspuppen* and *lossmanchen*, are often present in great numbers. Structurally, the deposit is uniformily massive, although in many exposures stratification lines are plainly visible. Typical loess possesses the peculiar physical property by virtue of which it tends to maintain a vertical scarp, regardless of its apparently incoherent character, and it

thereby greatly sharpens the contour lines of the regions thus clothed.

With the exception of the territory covered by the Wisconsin till and a small area near the northeast corner, the loess mantles the entire county, irrespective of altitude, save where removed by the streams. It is thickest in the vicinity of the probable margin of the Iowan ice, that is along the Iowa river, where it attains a maximum vertical measurement of upwards of twenty feet. In this region the deposit always grades downward imperceptibly into stratified sands. The loess is relatively both thicker and sandier near the greater waterways than upon the uplands. On many of the hills near the Iowa and, in a less degree, its greater tributaries, the upper silt has been removed and the sub-loessial sands comprise the present surface. This is notably true of the hills south of Albion and in Marshalltown and vicinity. The Chicago Great Western, crossing the divide between Linn and Timber creeks, lays bare some interesting facts concerning the distribution of the loess. While all of the hills are wholly loess mantled, the deposit gradually thickens from the summit to the slopes and is largely dissected out in the valleys.

The quarries near Le Grand expose from 15 to 20 feet of loess which is slightly sandy above, loess and sand interstratified in the middle, and almost pure sand at the base of the section. Loess concretions and fossils were not noted. At the clay pits west of Marshalltown, the loess is beautifully stratified throughout and becomes more siliceous below. Lime concretions occur sparingly, but no fossils were found. The above section may be considered typical for the immediate vicinity of the Iowa river. Two miles west of Marshalltown a road cut exhibits the following section.

	FEET.
Typical loess, slightly arenaceous below	6 to 8
Interstratified sand and loess, exposed	4

Fossils are abundant in the upper portion and persist in diminished numbers where lines of stratification are apparent. The principal species identified* are listed below.

* Professor Shimek kindly identified the fossils found in the loess.

Succinea avara Say, very abundant.
Succinea obliqua (Say).
Zonites shimekii Pilsbry.
Patula striatella Anthony.
Vallonia pulchella Mueller.
Zonites fulvus Draper.
Pupa muscorum Linnaeus.
Pupa alticola Ingersol.
Pupa pentadon Say.

One-half mile south of Bangor, fifteen feet of loess are exposed. The lower portion is filled with root casts, the largest of which measure an inch and a half in diameter. The matrix consists of interstratified, light colored sand and silt, the result of the removal of the iron constituents and the concretionary casts. Numerous concretions and fossils occur in the upper portion, the most common fossils observed being:

Succinea avara Say, very abundant.
Pupa pentadon Say.
Pupa muscorum Linnaeus.
Helicodiscus liaeatus Say.

About one and one-half miles north of State Center the above section is almost perfectly duplicated in all particulars. Fossils were noted in the clay pits at Rhodes and Melbourne and other points, but whenever observed, *Succinea avara* Say constituted more than one-half the specimens.

Origin of the loess.—Even since the publication of von Richthofen's "China," with the description of the Chinese loess, and the formation of the "Æolian Hypothesis" by that distinguished geologist and writer, the origin of this most anomalous deposit has been a fruitful subject for hypotheses both in this country and in Europe. It is not intended in the present discussion to espouse any particular theory, but rather to record the more salient features of the Marshall county loess and suggest their probable significance.

The stratified sub-loessial sands and interstratified sand and silt render plausible a subaqueous origin. But whether these conditions were brought about by a general depression of the surface and consequent ponding of the streams, or by drainage obstructed through the existence of an ice dam, the facts at hand do not warrant a conclusion. The general distribution of the loess, the absence of structural characters peculiar to waterlaid materials, the presence of land mollusks, some of which are now native even to arid regions, certainly lend credence to an æolian hypothesis. The angularity of the constituent particles has also been considered favorable to wind as the transporting agent. The validity of this inference is not well founded. It is an established fact that while the coarser sand grains are usually rounded through mutual attrition and impingement against obstructions, the cushioning action of the water adequately protects the finer sands and silts so that they maintain their angularity though transported great distances.

WISCONSIN.

The Wisconsin ice was represented in Iowa by a great tongue-shaped lobe, whose apex reached Des Moines, and which by a flank movement invaded the western border of Marshall county. The accompanying till sheet is second only to that of the Kansan. The upper portion of the Wisconsin till is slightly oxidized to a faint, dull yellow color and is succeeded downward by a blue bowlder clay less massive than that of the Kansan. Samples of both the oxidized and unoxidized portion effervesce freely when treated with cold, dilute hydrochloric acid. Lime balls are very abundant in many places. Bowlders are much more numerous in this region than in any of the older drift sheets, but are of smaller size than those of the Iowan age. The predominating types are gray and red granites, with less abundant quartzites and gneisses. Basic rocks are comparatively rare. The bowlders present a strikingly different aspect from those peculiar to

the subjacent Kansan, being as fresh as when they were broken from the parent ledge.

ALTAMONT MORAINE.

The limits of the Wisconsin lobe are marked in many places by a hummocky aspect of the surface with "kettle holes" and ponds liberally interspersed. This is the place where the melting glacier dumped its load of rock debris, which had been gathered during its journey from the far north and is technically known as the terminal moraine. In Marshall county

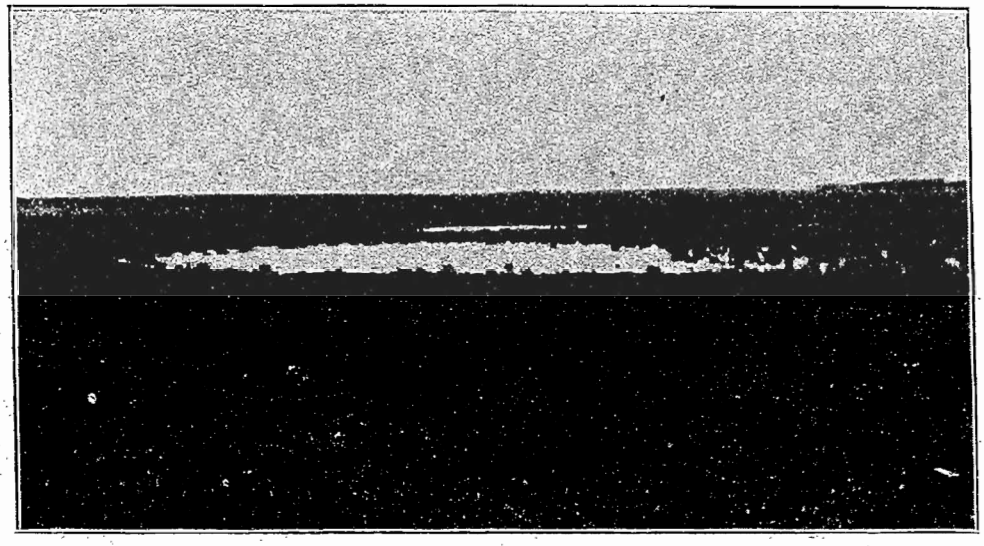


FIG. 33. Typical Wisconsin drift topography showing shallow "kettle-holes." Between State Center and St. Anthony.

the terminal moraine is but feebly developed. West of State Center is the nearest approach to a moraine in the region. Although distinctively morainic characters are but mildly expressed, the decided change in general surface configuration in passing from the older to the newer drift, facilitates the easy establishment of the boundary of the Wisconsin lobe.

GLACIAL SCORINGS.

The salient portions of the Kinderhook at Le Grand and Timber Creek, and the coal measure sandstone on section 8, Tp. 83 N., R. XVIII W., have been deeply planed and striated by the great ice sheets which traversed these regions. The

surface in all cases faces north, and all of the points are situated on the south bank of the Iowa river and the tributaries mentioned. No examples of rock scoring could be found on the opposite side of the flood plain. This may be considered additional evidence as to the preglacial character of the principal waterways. The northern slopes are protected by an accumulation of talus, while the southern flanks have been scraped clean of the rock debris and profoundly planed owing to a change in the gradient. The scorings and finer striæ were hermetically sealed by a layer of impervious blue clay and their state of preservation approaches perfection. At Le Grand the striæ trend south, 24° east; at Timber Creek they trend south, 25° east; at Sec. 8, Tp. 83 N., R. XVIII W., south, 20° east.

ALLUVIUM.

The alluvium is an important deposit in Marshall county. All of the principal streams on the older drift sheets flow through alluvial bottoms, while the Iowa river traverses a belt of this deposit which averages more than a mile in width. Most of the deposits which are mapped as alluvium are not wholly riverlaid material, but rather a mixture of loess and fluviatile deposits. Many of the streams have been alluvium making since the retreat of the Kansan ice. Northeast of Marshalltown on the broad bottomland of the Iowa, the finer debris has been removed in large part and extensive sand flats result.

Geological Structure.

The Kinderhook beds constitute a conformable series but are overlain unconformably by the Des Moines series. After the deposition of the Lower Carboniferous rocks, the general upward movement of the continent brought the whole of Marshall county above the level of the great Mediterranean sea to the southwest. Then followed an extended interval of denudation. The youthful surface was set upon by the erosive agents and dissected by streams until the physiography of the region was as strongly characterized as is the

IOWA GEOLOGICAL SURVEY

MAP OF THE SUPERFICIAL DEPOSITS OF MARSHALL COUNTY, IOWA.

BY

S. W. BEYER.

1897.

Tp. 85 N.

Tp. 84 N.

Tp. 83 N.

Tp. 82 N.

LIBERTY

BANGOR

LISCOMB

VIENNA

IOWA

TAYLOR

MINERVA

MARIETTA

MARION

LINN

STATECENTRE

TIMBER CREEK

LE GRAND

WASHINGTON

IOGAN

EDEN

JEFFERSON

GREEN CASTLE

Bangor

St. Anthony

Clemens

Bromley

Minerva

ALBION

Green Mountain

MARIETTA

Rockton

MARSHALLTOWN

La Moille

STATE CENTRE

Quarry

LE GRAND

Luray

Malta

Dillon

MELBOURNE

Haverhill

Ferguson

Pickering

Dunbar

RHODES

Laurel

GILMAN

LEGEND

GEOLOGICAL FORMATIONS.

- ALLUVIUM.
- WISCONSIN DRIFT.
- IOWAN LOESS.
- IOWAN DRIFT. IN PART LOESS COVERED.
- KANSAN DRIFT. LOESS COVERED.

INDUSTRIES.

- QUARRIES.
- COAL SHAFTS. ABANDONED.
- CLAY WORKS.
- MILL.
- ARTESIAN WELL.

R. XX W. R. XIX W. R. XVIII W. R. XVII W.

Photo-Lith. by A. HOEN & CO. Balto., Md.

present configuration. This was followed by a season of depression until the valleys were submerged, and finally perhaps, the whole surface of the county was near or below sea level and received contributions of sands, silts and clays, with some vegetable debris, which were lain down unconformably upon the older rocks. The deposits were compacted into sandstones, shales and coal seams, and constitute the coal measure series. The irregularity of the outline of the present Carboniferous deposits is due to the irregularities of the preëxisting surface. This period of deposition was closed by reëlevation the surface which was profoundly eroded through an immense interval of time; through, perhaps, the whole Mesozoic and the greater portion of the Cenozoic eras. The Pleistocene deposits lie unconformably upon all of the Paleozoic rocks and each drift sheet rests unconformably upon its predecessor. Although the surface may have oscillated up and down many times, the movement was continental and the strata are consequently approximately parallel.

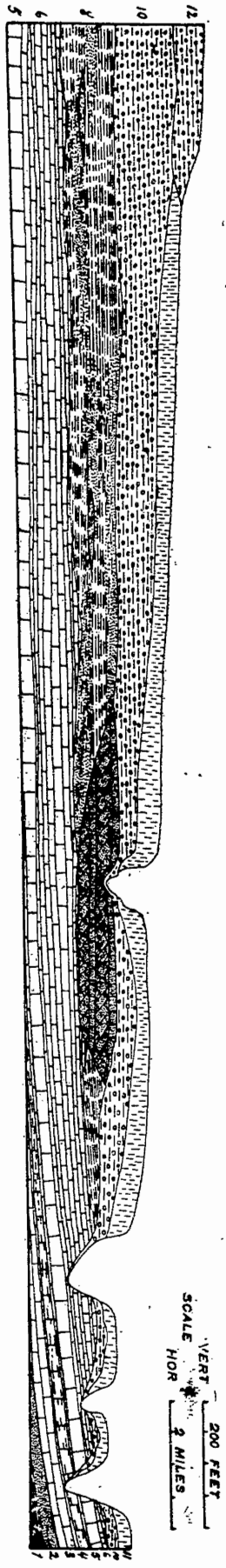


FIG. 34. Le Grand-State Center section. 1, Hannibal shales (?); 2, blue sandstone; 3, oölite; 4, chert beds; 5, magnesian limestone; 6, gray and brown limestone; 7, Marshalltown shales; 8, coal measure shale and sandstone; 9, coal measure sandstone; 10, Kansan till; 11, loess; 12, Wisconsin till. Numbers 2-6 make up the Le Grand beds.

ECONOMIC PRODUCTS.

Building Stone.

As has been said, the stratified rocks belong wholly to the Paleozoic era; and the Mississippian and Pennsylvanian series underlie about equal areas in the

county. The former consists essentially of limestones. The principal outcrops where quarry operations have been carried on are in the vicinity of Quarry and Le Grand, along the Kinderkook escarpment, and and on Timber creek. The Pennsylvanian series consists chiefly of shales, and a dull red sandstone is the only stone worthy of mention in this connection.

KINDERHOOK.

The most valuable quarry products in the county are derived from the basal member of the Mississippian series. In the southeastern portion of the state there are extensive outcrops of rocks of Kinderhook age, which consist chiefly of shales. In central Iowa, and in Marshall county in particular, the Kinderhook beds take on a calcareous facies and afford some of the best building stone to be found in the state. These beds are the more valuable because of their availability. The principal outcrops are located near the main lines of the Chicago & Northwestern and Iowa Central railways. The overlying glacial deposits are comparatively thin and may be removed at a minimum expense. The principal layers sought are the oölite and magnesian limestone, but the entire series is utilized.

LE GRAND QUARRY COMPANY.

The pioneer in the quarry industry, as well as the largest company operating in the county at the present time, is the Le Grand Quarry Co. with their central office in Marshalltown. The company owns and operates quarries at Quarry, Rockton and Timber Creek.

Quarry.—Three quarries are connected with the C. & N.-W. Ry. by branch lines at this point. Active operations were begun as early as 1860, when a limited quantity of building stone and lime was produced. Two years later the railway tracks were extended into the quarries, and the company has maintained a steady growth since. The manufacture of lime was discontinued some years ago.

The quarry plant is provided throughout with the most approved machinery. The equipment consists of steam crusher, gang mills, steam drills, derricks, lathes and planers; and quarrying and stone working is carried on most expeditiously and according to modern methods. The Le Grand beds in their entirety have been exploited to some extent, though the position of the blue sandstone renders it almost unavailable at present. (See Le Grand section.) The oölite and upper magnesian limestone layers afford the most valuable products, although the chert beds and rubbly limestone, along with the debris consequent to quarry operations, are worked up into riprap, concrete, ballast, etc., and constitute an important source of revenue to the company.

The chief building stones put upon the market are known commercially as oölite limestone, Iowa marble, Iowa caen stone and blue limestone.

The basal blue sandstone has not been sufficiently explored and tested to such an extent as to allow its merits as a building stone to be stated definitely. Small quantities of the stone have been removed from the east quarries, and certain blocks are now being tested as pavers in the streets of Marshalltown with some promise of satisfactory results.

There are two grades of oölitic limestones. The lower layer measures three and one-half feet in thickness and is coarse grained. The upper twelve feet is finer textured and consists of layers of the following thicknesses, respectively, from below upwards: 24, 26, 36, 6, 9, 8, 12 and 14 inches. The oölite is quarried only at the two east quarries, the dip of the beds and the slope of the river carrying the layers below the bed of the stream before the west quarry is reached. Formerly, the coarse, heavy basal layer was used for constructional purposes, but of recent years experience has demonstrated that it suffers disintegration when exposed for a season to atmospheric conditions. The fine-grained layers are close, even-textured and stand the test of time well. This is not only shown in artificial structures where the

blocks have maintained their angularity against sunshine and storm for upwards of a quarter of a century, but better still in the natural exposures where these layers stand out in bold relief. The oölite is composed of small, rounded, concretionary calcareous grains imbedded in a semi-crystalline matrix of cementing material of the same composition. Many of the concretions contain small angular siliceous grains. The unaltered rock is of a gray-blue color, while the weathered portion assumes a yellowish hue. Certain of the layers are highly fossiliferous and as the rock takes a high polish the beautiful effects are much enhanced, and this variety is known commercially as fossilite marble. Such slabs need to be collected with some care, for small grains of iron pyrites are often present and produce black stains when subject to moisture.

The upper portion of the magnesian limestone furnishes both the Iowa "marble" and the Iowa "caen stone," the former containing a higher percentage of $MgCO_3$. The Iowa marble occurs in heavy beds from two to three and a half feet in thickness. The slightly weathered portions are plain, light buff in color, while the weathered layers are of a a deeper color and beautifully veined with iron oxide. The stone receives a high polish, but like other limestones does not retain it when exposed to atmospheric agencies. It is very desirable for panelling and all parts of inlaid work when kept dry, aside from its qualifications as a first class building stone.

The caen stone is similar in color to the marble, but is softer, more tenacious and of lower specific gravity. It is especially adapted for carvings and molding.

A ledge of blue limestone lies between the chert beds and the oölite and also immediately above the chert beds. This limestone is very hard, compact and somewhat irregularly bedded, which renders quarrying and working rather difficult. The stone is used to some extent as a coursing stone and is very durable, but its untractable character renders its production expensive and it is mainly used as ballast.

The brown subcrystalline limestone with its interstratified oölitic layers affords some coursing stone and would be considered desirable for foundations in regions where building stone is scarce, but by far the greater quantity is transported to the crusher.

Rockton.—Active quarry operations have not been carried on at this point for several years. The beds worked comprise the brown subcrystalline limestone with the interbedded oölitic layers and the upper layers of the magnesian limestone. The characteristics of the beds exposed here are similar to their equivalents at Quarry. The upper oolite is perhaps heavier bedded and more important than at the last mentioned place.

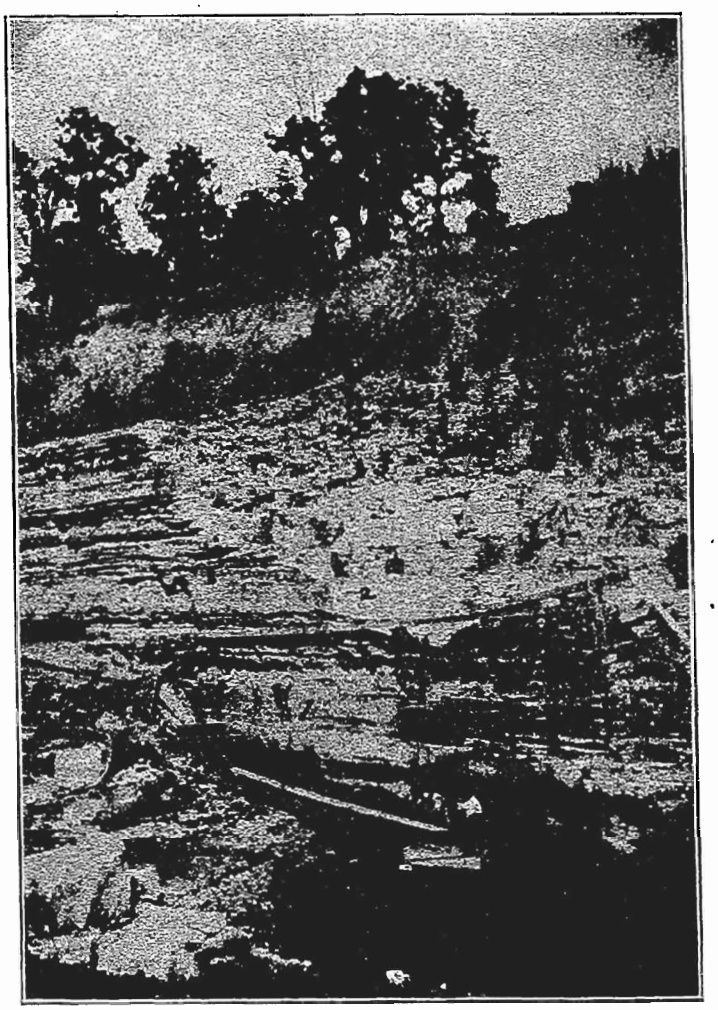


FIG. 35. The Le Grand beds as exposed on Timber creek at the Iowa Central railway crossing. The section is, in part, along the line of a natural fissure and illustrates the differential weathering of the beds. 1, Blue limestone; 3, upper oölite; 3, brown and gray subcrystalline limestone.

Timber Creek.—The Le Grand Quarry Co. has been developing rapidly their quarry interests at this point during the past few years. A side track is laid in from the Iowa Central railway and the plant is well equipped with modern machinery. The beds operated are the same as those at Quarry from

the magnesian limestone upwards. As has been mentioned, the magnesian limestone differs in color from its homologue at Quarry and Rockton. At the latter places shades of buff prevail, while at the Timber Creek quarries the chief beds are a gray-blue with occasional layers in part light yellow. The fact is emphasized that the predominating color in the unaltered Le Grand beds is a gray-blue, which is changed to tones of buff and yellow through weathering agencies. Here, as in

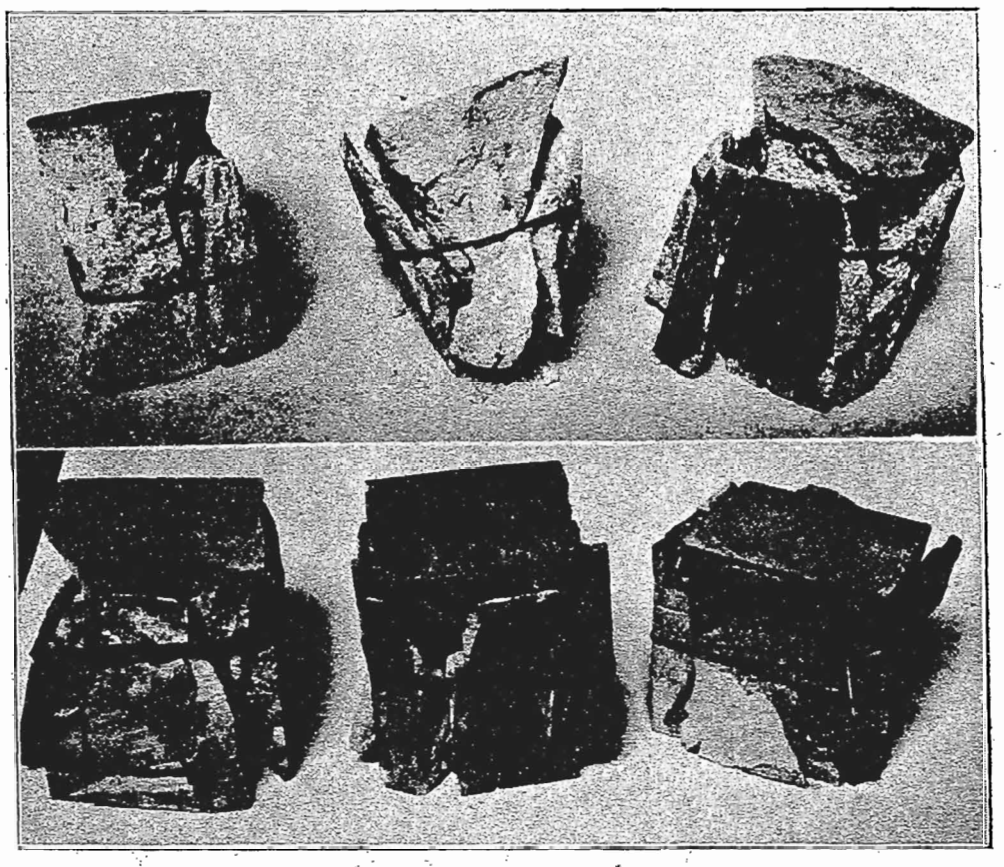


FIG. 36. Characteristic fractures of Le Grand building stone. Upper row, oölite; lower row, magnesian limestone.

other places, the magnesian layers succumb less readily to disintegrating forces than the associated beds.

The upper oölite and brown subcrystalline limestone are of more importance here than at the exposures along the Iowa river.

The Le Grand Quarry Co. employ on an average 200 men during the working season, and the daily output is about a train load.

TESTS OF THE LE GRAND STONE.*

The principal varieties of the Le Grand stone were subjected to three series of tests, viz:

1. Strength and ratio of absorption to determine the compactness of the stone, and hence its ability to withstand the atmospheric agencies.

2. Freezing and thawing alternately, and carefully noting the loss in weight and strength; and hence determining the tendency of the stone to disintegrate or weaken under the action of frost.

3. Chemical analysis to determine the relative amounts of desirable and deleterious constituents present.

In previous investigations on building stones, rectangular blocks of various sizes and shapes have been employed. The consensus of opinion of the highest authorities on the subject at the present time favor the two-inch cube as possessing the most convenient dimensions and giving the most satisfactory results. In the present investigation the two-inch cube was adopted. Great care was exercised in their preparation in order to guard against the production of incipient fractures through the impact of tools, and thereby lessening the strength. The blocks were sawed out approximately with the diamond saw, and then reduced to the proper dimensions by grinding. The results are tabulated in the subjoined tables.

*The mechanical tests were made in large part by Messrs. G. W. Zorn and J. W. Elliott under the personal supervision of Prof. A. Marston, in the Dept. of Civil Engineering of the Iowa Agricultural College. The chemical analyses were made for the survey by Prof. G. E. Patrick.

TABLE I.

MECHANICAL* TESTS.

	KIND OF STONE.	Height of cube.	Surface dimensions.	Area.	BREAKING LOAD IN LBS.		LOAD PER SQUARE INCH.		REMARKS.
					Spalling began.	Failure.	Spalling began.	Failure.	
	†Oölite, fine grained, northeast quarry	2.03	1.98x1.99	3.94	-------	46,680	-----	11,600	Failure accomp'n'd by much shattering.
4	do heavy bedded	2 02	2.00x2.00	4.00	47,500	53,800	11,875	13,450	do
5	do " "	1.97	2.00x1.98	3.96	54,000	59,300	13,636	14,900	do
6	do thinly bedded	1.96	1.96x1 96	3.84	39,400	39,400	10,260	10,260	do
22	Oölite, light, southeast quarry	2.05	2.00x2 04	4.08	42,000	52,000	10,280	12,740	do
23	do	1.97	2.00x2.00	4.00	57,000	57,000	14,250	14,250	do
43	do heavy bedded	2.00	2 00x2.00	4.00	38,000	53,000	9,500	13,250	do
	†Iowa marble, plain, west quarry	1.98	1.98x1.97	3.90	-------	47,120	-------	12,080	All samples of the Iowa marble broke in such a way as to show much elasticity.
16	do	2.00	2.02x2.04	4.12	60,500	63,300	14,685	15,120	
	†Iowa marble, colored	2.00	2.02x2.01	4.06	-------	37,060	-------	9,128	
27	Blue limestone, northeast quarry	2 00	2.02x2.02	4.08	-------	-------	-------	-------	63,000 lbs. applied, no effect.
24	do	1.99	2 00x2.02	4.04	-------	-------	-------	-------	63,000 lbs. applied, no effect.
11	Fossiliferous limestone, northeast qr.	2.00	2.00x2.00	4.00	42,000	-------	10,500	-------	Sustained 65,800 lbs. without further rupture.
12	do	2.00	2.00x2.00	4 00	63,300	-------	1,582	-------	Beyond capacity of machine to crush.
15	do southeast quarry	1.99	2.00x2 00	4.00	43,700	-------	10,925	-------	Sustained 65,800 lbs. without further rupture.
26	do	2.00	2.00x2.02	4.04	58,300	66,400	14,430	16,435	
28	do west quarry	1.97	2.00x1.98	3.96	38,700	38,700	9,773	9,773	
33	Blue limestone, Timber Creek	1.98	1.98x2.00	3.96	28,000	34,500	7,070	8,712	
34	do	2.00	1.98x2.00	3.96	29,000	33,200	7,320	8,383	

*An Olsen testing machine was used in making these tests. The specimens were placed between two steel plates, the upper being fixed, while the lower was free to oscillate in a hemispherical protuberance, which fitted accurately in a well lubricated socket, thus distributing the pressure equally when the parallelism of the cube faces was imperfect. The load was applied at a uniform rate.

†Tests made under the direction of Prof. G. W. Bissell, Dept. of Mechanical Engineering, I. A. C.

TABLE II.

FREEZING TESTS.*

Number.	KIND OF STONE.	Height of cube.	Surface dimensions.	Area.	BREAKING LOAD IN LBS.		LOAD PER SQUARE INCH.		Loss in weight in per cent.	REMARKS.
					Spalling began.	Failure.	Spalling began.	Failure.		
20	Oölite, fine grained, northeast quarry	2.05	2.00x2 08	4 16	55,700	56,400	13,390	13,558	0.0014	Loud report.
21	do	2.08	2.00x2.08	4.16	26,000	-------	6,250	14,280	0.0013	Sustained 59,400 lbs. Very slight spall at 26,000 lbs.
38	Oölite, fine grained, southeast quarry	1.99	1 97x2.00	3.94	50,000	60,000	12,690	15,230	-------	Loud report and cube much shattered.
44	do	2.00	2.00x1.96	3.92	34,000	55,700	8,673	14,210	-------	do
46	do	2.02	1 97x1.97	3.88	50,000	56,500	12,890	14,560	-------	do
19	Iowa marble, west quarry	1.96	2 02x2.02	4 08	50,000	56,500	12,255	13,850	0.0007	Broke with a loud report.
17	do	1.92	2.00x2.00	4.00	42,600	52,700	10,650	13,175	0.0008	do
18	do	2.00	2 04x2 02	4.12	38,000	51,700	9,225	12,550	0 0009	do
14	Blue limestone, northeast quarry	2 00	1.98x1 97	3.90	-------	-------	-------	15,360†	-------	59,400 lbs. applied without effect.
3	Fossiliferous limestone, northeast qr.	2.00	2.00x2.02	4.08	-------	-------	-------	14,560†	-------	59,400 lbs. applied without effect.
2	do	1.98	1.97x2.00	3.94	55,600	-------	14,035	14,900†	-------	59,400 lbs. sustained.
29	Fossiliferous limestone, west quarry	1.98	2.04x2 02	4 12	35,900	40,000	8,715	9,710	-------	Weak report.
30	do	1.97	1.99x1.96	3.91	30,500	35,000	7,800	8,950	-------	do
32	Blue limestone, Timber Creek	2 00	2 04x2.01	4 10	28,000	36,300	6,830	8,850	-------	Slight report.‡
45	do	1.96	1.98x1 96	3 88	32,700	32,700	-------	8,430	-------	

*The cubes were placed in distilled water until completely saturated, after which the specimens were encased in cotton batting saturated with distilled water and placed in wooden trays, eight by eight inches and two inches deep, provided with wire bottoms. The trays after being securely packed were placed in the refrigerator and kept at a temperature of from 17° to 19° F. for forty-eight hours. Then they were removed from the refrigerator and subjected to a temperature of 70° F. for twenty-four hours. This process was repeated six times. The specimens were afterwards subjected to refrigeration and thawing ten times; but the conditions were less constant than in the first six. In the latter series the minimum temperatures ranged from 21° to 32° F.

†The above table shows that the blocks suffered no appreciable loss in weight or strength during the investigation. It is highly probable that lower temperatures would have given very different results.

‡In spite of the apparent weakness, low specific gravity and rather high percentage of absorption, the quarry face along natural fissures shows this stone to be one of the most durable quarried in the county. (See figure 36.)

TABLE III.

ABSORPTION AND SPECIFIC GRAVITY TESTS.

Number.	NAME OF STONE	LOSS OF QUARRY WATER THROUGH DRYING—WT. IN GS.			WATER ABSORBED AFTER IMMERSION, EXPRESSED IN PERCENTAGES, OVER DRY WEIGHTS.				Specific gravity.	Weight per cubic foot in lbs.	REMARKS.
		0 hours.	1 hour.	5 hours.	1 hour.	3 hours.	24 hours.	144 hours.			
20	Oölite, fine grained, northeast quarry	350.90	350.70	350.58	0.85	1.59	2.66	2.75			
21	do	348 91	348.79	348 63	1.56	3 26	3.95	4.05			
38	Oölite, south quarry	335 03	334.99	334.97	1.20	1.50	2 50	2.61			
44	do	333 90	333.79	333.63	0.71	1 85	2.11	2.20			
46	do	326.90	326.30	325.63	1.50	1.96	2.55	2.64	Average, 2.57 lbs.	160.5 lbs.	
19	Iowa marble, west quarry	323.10	327.70	322.47	2 33	3.02	3.60	3.87	2.54	153.2	Average.
17	do	309.40	309.00	308.01	1.81	2.43	3.31	3.57	------	------	
18	do	320 90	319.20	318.20	2.31	3.06	3.97	4.37	------	-----	
10	Blue limestone, northeast quarry	348.70	348.21	348.19	0.48	0.86	1.86	2.02	2.77	173.0	
3	Fossiliferous limestone, northeast quarry	344.00	343.78	343.52	0.72	1.01	1.72	1.79	2.60	162.5	
2	do	353.86	353 40	353.20	0.22	0 50	0.70	0.77	------	------	
30	Fossiliferous limestone, west quarry	311.00	310.90	310.87	0.06	0.84	1.65	1.79	-----	------	
29	do	340.91	340.46	340.38	0 22	0 84	1.64	1.79	-----	------	
32	Blue limestone, Timber Creek	320.76	320.36	320.00	2 03	3.01	3 17	3.36	2.30	144.0	
45	do	285 74	285.36	285.15	4.00	4.67	5.41	5.65	------	------	

TABLE IV.

CHEMICAL ANALYSES OF LE GRAND STONE.

CONSTITUENTS.	Fine grained oölite.	Blue limestone.	Iowa caen stone.	Iowa marble, plain.	Iowa marble, colored.	Stratified limestone.
Hygroscopic water (loss at 100° C.)	0.03	0 09	0.06	0.04	0 06	0.04
Combined water (expelled by ignition)	0.13	0.21	0.15	0.19	0.12	0.12
Silica and insoluble	0.77	0.96	1.24	0.80	0.89	1.22
Carbonic acid, CO_2	43.62	43.30	43.79	44.85	44.76	43.85
Alumina, Al_2O_3	0.05	0.07	0.18	0.14	0.15	0.14
Iron, Fe_2O_3	None	None	0.15	0.15	0.31	0.26
Iron, Fe O	0.09	0.27	0.09	0.19	0.10	0.09
Lime, Ca O	55.05	54.85	50.56	45.42	45.39	50.42
Magnesia, Mg O	0 28	0.28	3.70	8.21	8.28	3.96
Manganese oxide (Calc. as Mn O)	-------	0.08	-------	-------	-------	Trace
Phosphoric acid	-------	-------	Trace	Trace	-------	-------
Totals	100.02	100.11	99 92	99.99	100.06	100.10

PROBABLE COMBINATIONS.

Water	0.16	0.30	0.21	0.23	0.18	0.16
Calcium carbonate, Ca Co_3	98.30	97.95	90.28	81.11	81.05	90.04
Magnesium carbonate, Mg Co_3	0.59	0.38	7.77	17.24	17.39	8 08
Silica and silicates, Alumina, iron, oxide, etc.	0.95	1.37	1.74	1 42	1.38	1.72
Totals	100.00	100.00	100.00	100.00	100.00	100.00

CORRICK QUARRY.

(TP. 84 N., R. XVII W., SEC. 7, NW. QR. Nw. ¼.)

This quarry is operated intermittently to supply the local demand. The layers worked correspond to the upper oölite at Quarry and are only used for foundation work and rough masonry in the immediate vicinity. Some quarrying has been done on section 36, Nw. qr., Ne. ¼, of the same township and range. About eight feet of rubbly limestone rests upon the upper oölitic layers. The section here exposed bears a very close similarity to the beds exposed at Rockton.

The upper layers of the Le Grand beds have been worked to some extent at different times on South Timber creek near Ferguson, on Little Asher creek, Tp. 85 N., R. XVIII W., Sec. 24, and northwest of Liscomb on the Iowa river. In all

cases the stone was for local consumption, and then only for the roughest grades of masonry.

SAINT LOUIS LIMESTONE.

CHAPIN QUARRY.

James Spear operates a quarry on land owned by O. B. Chapin of Union. The stone produced is a close textured, ash-gray limestone, which exhibits a hackly fracture and contains small siliceous concretions, with little iron pyrites in streaks and patches. The quarry is operated only to supply the local demand, but the product is apparently a durable stone.

DES MOINES.

The coal measures in Marshall consist chiefly of shales. A heavy bedded sandstone appears in Timber Creek township, and has been developed to a limited extent. Quarries have been opened on sections 8 and 9, and a considerable quantity of stone suitable for the roughest grade of masonry has been quarried. The sandstone is dark, reddish brown in color, and apparently durable. At present only the upper layers have been explored. The lower layers are more evenly bedded and give promise of a stone suitable for building and trimming.

Clay Industries.

The Paleozoic strata afford little material which is available for the manufacture of clay products. The Hannibal shales of the Kinderhook are too deeply covered to be utilized in this region, while the argillaceous layers exposed at Marshalltown are of doubtful utility. The latter deposits were tested experimentally a few years ago. A sample of the yellow-gray argillaceous marl was made into brick. The color of the burned article was not very different from that of the raw material, and when subjected to the heat given brick for paving streets, no shrinking nor altering of shape was perceptible, and to all appearance there was an entire absence of fusion. On the other hand the pavers were

completely vitrified on certain of the faces. It was hoped that the experiment would prove the manufacture of paving brick possible, but the burned article was left porous and too soft for such a purpose. The manufacture of superior fire brick is demonstrated as a possibility, but the limited extent of the deposit renders its profitable utilization doubtful. The coal measure shales are almost wholly concealed by the glacial debris, and no deposits of economic importance are known within the confines of the county.

In striking contrast to the limited supply of raw material accessible in the Carboniferous series, the Pleistocene deposits are wholly inexhaustible. As has been said the Pleistocene covers the entire county and at nearly every point in such quantity and character as to enable a brick factory to be founded thereon. The material utilized at the present time belongs wholly to the loessial type.

The loess of Marshall county is ordinarily of the common variety. It has a maximum thickness of not less than twenty or twenty-five feet. Certain areas are exceptionally siliceous, and when dry appear as beds of loose sand. The clays are suitable for the manufacture of drain tile, for making common brick by any method, and for making stock and ornamental brick by the dry-press method. The products always have an excellent color and when properly burned their porosity is not so great as to be objectionable. At present clay manufactories are in operation at not less than six localities.

MARSHALLTOWN.

Anson Company Brick & Tile Works.—This is one of the largest plants of the county. It is situated in the southern part of the city, where operations were begun nearly fifteen years ago. It has grown from a small hand yard to a factory with a large output of both common brick and drain tile. A Penfield, No. 15 D with the corrugated crusher, has been used for several seasons. The crusher is required only for the dry clay. Closed sheds are used for drying the product, and

three large clamp kilns for burning. This latter process takes up nearly two weeks. Common brick and tile from 3's to 8's constitute the output. Some loss is experienced through checking which takes place upon the evaporation of the uncombined water.

Sieg & Size operate two yards, one about two and the other about one mile west of Marshalltown, near the Iowa Central track. The one on the south side began operation about forty years ago. The material at each yard is typical loess in a bank from six to twenty-five feet deep; clayey in upper part but more argillaceous below. Certain sections of the the formation in the vicinity are too sandy for brick making purposes. At the south pit the fine sands and silts are beautifully interstratified. An Eagle soft-mud machine is in use at each plant. The brick are dried on pallets in roofed sheds, and no checking occurs if the proper mixture of materials is secured. Three clamp kilns with a total capacity of 200,000 brick are employed for burning. This process takes up only eight days. In addition to these two plants the firm has also a hand yard which is operated in case of an unusual demand.

The G. H. Kohr brick and tile yard is just east of the city limits on the lowland. The raw material, consisting of rather strong modified loess, is treated by a Brewer machine. The newly moulded ware is placed in a closed dry-shed, and little or no checking occurs. Only a single clamp kiln is in use.

MELBOURNE.

The Wulke Factory is located at the crossing of the railroads. There are seven feet of yellow, overlying one-third as much gray, short loess, while a two inch band of ochre separates the two colors. The total thickness of the formation is twelve feet, and under it is blue drift clay. The raw material is drawn up to and run through the pug-mill, then through an auger of the Decatur Leader manufacture and moulded by a machine of the same make. Closed sheds heated with exhaust steam enable drying of the product to be carried on quite

successfully. Three down-draft kilns serve to hold the tile, and the brick are burned in cased kilns. The character of both kinds of the output is very creditable.

RHODES.

A. Harmon now operates a brick plant for the production of brick and drain tile along the right of way of the Chicago, Milwaukee & St. Paul railway. Loess to a depth of ten feet is taken and treated by a "Plymouth" machine. The lower portion of the section utilized is of a bluish color, followed by ocherous layers and finally grading upward into typical loess. Fossils are abundant throughout, but loess concretions are absent, although limey patches may be observed near the base. The color of the well burned product is a cherry red. Considerable loss is sustained through checking. The burning capacity is limited to two small round kilns.

BROMLEY.

Just south of the station at this point is the plant of the Bromley Brick and Tile works. An H. Brewer machine is in operation. The clay is run through the mill, afterwards placed in sheds tightly closed until the mud becomes "set;" otherwise much loss is occasioned through checking. The kiln capacity is 43,000 three-inch tile. Burning can be accomplished in four days. The loess comes from the top of the gradual slope about a half mile south of the railroad. At the bank the top soil is removed and the clay is used to a depth of six feet, below which it becames too sandy. Lower on the slope the character of the formation is decidedly different and is almost entirely sand.

GILMAN.

The Gilman Brick and Tile Works is a new plant situated in the extreme southeast corner of Marshall county and has a large territory adjacent to furnish a market for the products. The raw material is nothing more than modified prairie loess

taken to a depth of several feet. It is strong and the moisture is freed with some difficulty, necessitating artificial heat. A two story shed has been erected, and before long the equipment of the plant will be quite adequate for a large business.

Small plants have been operated intermittently in the vicinity of State Center and Quarry. Hand made brick is the sole product.

Lime.

About a quarter of a century ago lime-burning was carried on to a limited extent. The oölitic beds were chiefly used for this purpose and the manufactured product was of acceptable quality. As transportation facilities improved, lime produced from the older Paleozoic rocks sharpened the competition to such an extent that the manufacture of lime in Marshall county was abandoned.

Building Sand.

The sand flats along the Iowa river between Marshalltown and Albion, and the sand bars in the principal streams, furnish an inexhaustible supply of good building sand. The subloessial sands are widely distributed over the county and often attain a considerable thickness. At Marshalltown there are five to ten feet of siliceous material at the base of the loess. The southwestern half of the county is deeply covered with loess and drift, but it is meagerly supplied with the more arenaceous deposits.

Moulding sands.—The sub-loessial layers afford an abundance of material suitable for moulder's use.

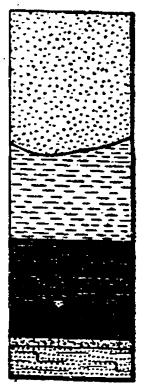
Road Materials.

Outliers of the Kinderhook in the eastern portion of the county furnish an abundance of road materials. The larger stream channels afford large quanties of sand and gravel suitable for road work. In the western half of the county materials for the improvement of the roads are almost entirely wanting.

Coal.

Marshall is one of the marginal counties of the Iowa coal field. The coal measures occupy one-half of the district, underlying the western and southwestern portion especially. The coal pockets also doubtless occur in different parts of the area. The records from a number of wells in southwestern Vienna and northeastern Taylor townships record the presence of coal measure strata in that region which constitute the easternmost outlier of the Des Moines in the county. Four miles southwest of Marshalltown a coal measure sandstone outcrops along the Chicago Great Western railway. In both of these localities coal in economic quantities is not known to be present.

The principal locality where coal has been mined in Marshall county is on the Iowa river at a place called Mormon Ridge, three miles northwest from Albion. (Tp. 88 N., R. XI W., Sec. 34, Sw. qr. Se. ¼.) A shaft fifty feet deep was sunk a few years ago and was known as the Mormon Ridge mine. The coal was three feet in thickness. The sequence of layers is as follows:



		FEET.	INCHES.
6.	Sand	20	
5.	Clay, light colored	3	
4.	Shale, dark colored, fissile	2	
3.	Coal	3	
2.	Fire clay		4
1.	Sandstone, exposed	1	

FIG. 37. Coal at Mormon Ridge mine near Albion.

At one time fourteen men were employed. The shaft was operated but a brief period for the reason that only three feet of shale intervened in the roof between the coal and a thick stratum of water-bearing sand. The water gave so much trouble that the mine was abandoned after being operated

about a year. Not more than 100 tons of coal were taken out. A few years later another company leased the property and attempted to work the coal, but owing to the defective pumps made little progress. This mine has been abandoned.

On the north side of Mormon Ridge, on the northwest quarter of the same section, James Hall* states that a limited amount of coal had been removed previous to his visit in 1857, although the shaft was abandoned at that time. Evidence of former prospect holes may still be seen around the base of the hill, but no exact data concerning the coal measures could be obtained.

In a drill hole put down one mile northwest of the Mormon shaft, on the farm of W. C. Ruddick (Tp. 85, N., R. XIX W., Sec. 28, Sw. qr., Sw. ¼), a bed of black shale with some coal was encountered at a depth of 118 feet. The seam was reported to be several feet in thickness and immediately underlain by a thin layer of fire clay.

Some years ago a shaft was sunk on the farm now owned by Americus Dakin on Minerva creek, five miles west of Bangor (Tp. 89, N., R. XX W., Sec. 9, Se. qr., Se. ¼). Coal was found here, but to what extent is not definitely known.

At the present time Marshall is not a coal producing county. Future prospecting will doubtless reveal isolated pockets of coal of economic importance, but with the data at hand, it is hardly reasonable to expect that coal will be produced in commercial quantities within the limits of the county.

Soils.

Marshall is preëminently an agricultural county and the soils greatly outrank in economic importance all of the other geological formations put together. The soils readily fall into four fairly well defined types. The drift, which is composed of glacial debris; the loess, composed of silt and very fine sand; the drift-loess, a combination of the first two, and the alluvium, an admixture of sand and silt in varying proportions. The origin of the soil types has been discussed

* Geology of Iowa, Vol. I, p. 269, 1858.

already under the various divisions of the Pleistocene. The drift soil is coextensive with the Wisconsin drift sheet. This soil contains a high percentage of clay and in many places the processes of agriculture are handicapped by the large number of small to medium sized bowlders. This type is highly productive when well drained, but cold and heavy when not properly ventilated.

The typical loess soil is confined to the immediate proximity of the larger drainage lines. This type prevails in Linn, Timber Creek and western Le Grand townships. It is subject to excessive wash during rainy seasons, and, unless very sandy, it bakes when drying. In productiveness this soil type ranks lowest.

The drift-loess soil comprises by far the greatest area in Marshall county. It is a happy combination of the soils and fine sands of the loess with the glacial debris of the Iowan and Kansan drift sheets. The drift-loess is an open, porous soil allowing the easy penetration of the most delicate rootlets, yet firm enough to support the most vigorous forage plants. It is easily tilled and is a conservator of moisture. It is to this type that Marshall owes her prestige as an agricultural county.

The alluvium flanks the principal streams, and when not too sandy it compares favorably in productiveness with the drift and drift-loess types. When unprotected by levees large tracts of these lands are subject to periodic inundations.

Water Supply.

The larger water courses furnish an ample water supply to the areas through which they flow. The smaller streams are usually dry through a considerable portion of the summer and autumn months. Shallow wells from 40 to 150 feet in depth have proved adequate for domestic purposes until the recent extended dry period, when it was found necessary, in many cases, to go deeper. At present most of the "stock wells" draw their water supply from the glacial sands and gravels

near the base of the drift or from the sandy layers of the Kinderhook. The older water-bearing horizons of the Paleozoic have not been explored in the region, but the Saint Peter and Saint Croix sandstones may be reached at about 1,300 and 1,800 feet, respectively. At Ames and Boone, the Saint Peter sandstone affords about 10,000 gallons per day, while the Saint Croix yields about 200,000 gallons.

West of Rhodes, just out of the corporation, is an artesian well which yields about 2,000 gallons per hour. The water is slightly mineral and is not utilized at present, save as a wayside watering place. The well is about sixty feet in depth and appears to be wholly in the drift.

The Marshalltown water works draw water from the gravel beds of the Iowa river. The water filters through the river sand and is collected into numerous galleries from which it is pumped. The supply is barely adequate for ordinary purposes, while in cases of fire the Iowa river must be drawn on. As several other large cities in the state obtain their water supply in much the same manner as outlined above, it is deemed fitting to append some of the results obtained from a sanitary study of the water. It is a well known fact that the spread of contagious diseases is often contingent on the source of our potable waters and "sewage contamination" is an altogether too common a phrase in our board of health reports treating of epidemics.

BACTERIALOGICAL STUDY OF THE MARSHALLTOWN WATER SUPPLY.

Prof. L. H. Pammel kindly furnished the following abstract of results. The work was done in a large part under his personal supervision.

Mr. G. L. Steelsmith* made an examination of the Marshalltown water supply during the summer and fall of 1896. Dr. Walter H. Haines, of Chicago, had previously made an examination, the results of which are as follows.

		GERMS PER C. C.
No. 1.	Across the river from water works	25
No. 2.	Bunce well	190
No 3.	River water	2,240

*Marshalltown Evening Times-Republican, April 23, 1896.

The statement is here made that the maximum number according to Koch of Berlin, and the Franklands of London, is 100 germs per C. C. The maximum number has, however, sometimes been placed at 1,000, and some authors place the number at 3,000. An absolute fixed standard cannot be made, except that 1,000 germs per C. C. is more nearly the maximum in a large number of our river waters. The quanity of organisms is dependent upon the quantity of organic matter present. The important point in connection with a bacterialogical analysis is the quality rather than the quantity. A single organism of *Bacillus coli-communis* or *B. typhi-abdominalis* is sufficient to indicate sewage contamination.

Mr. Steelsmith's determinations are as follows.

		GERMS PER C. C
No. 1.	June 7th, water from river above mill dam	2,170
No. 2.	June 7th, water from hydrant, Dr. Meghill's office	1,800
No. 3.	June 7th, water from pumping station	1,200
No. 4.	June 7th, water from sixteen hydrants, average	1,900
No. 5.	Sept. 9th, water from six hydrants, average	2,040

So far as the number from streams is concerned, the above would not be considered excessive or necessarily injurious, since water taken from the Croton reservoir, New York, contained 5,000 to 15,000 germs per C. C.; water from the Spree, which furnishes Berlin with water, contains, according to Frankel, 6,140 germs per C. C.; but this number increased to over 245,000 below the city. Water from the Mississippi at La Crosse, Wisconsin, during the spring months contained 3,000 germs per C. C. In all streams there are extraordinary fluctuations so far as quantity is concerned. These fluctuations are due to the amount of soil carried from the surrounding country. The great number found in the Iowa river last summer must be associated with the frequent rains. Numerous investigators have shown that during the autumn and winter, germs are far less numerous than during the spring and summer months, and yet the former seasons are the periods of most frequent occurence of typhoid fever.

Of the germs found in the hydrant water of Marshalltown, but one was regarded as suspicious. It agreed quite closely with the morphological and physiological characters given for *Bacillus coli-communis* and proved to be pathogenic for rabbits. The relation of this organism to sewage contamination can no longer be questioned, as this Bacillus is an inhabitant of the human intestines and it is only natural that it should find its way to the river.

The results of this investigation go to show that the water which has filtered through the river sands is safe and wholesome, but that the water drawn from the river direct may be at the peril of the public health.

Water Power.

The Iowa river furnishes an abundance of water power, the average gradient being about three feet per mile and the flow fairly constant. Flouring mills are in active operation at Albion, Marshalltown and Le Grand respectively. A head of six feet is obtained at Albion and six and one-half feet at each of the other two localities. All of the mills can be run on full time and at full capacity save during periods of very high or very low water. From fifty to eighty horse power is available at each point. The flow of water in the smaller streams is too small and inconstant to merit attention in this connection. Mills of small capacity on Timber creek were formerly operated intermittently. None are active at the present time.

ACKNOWLEDGMENTS.

In the preparation of the present report the representative of the survey received much encouragement and friendly assistance from many citizens of the county. Thanks are especially due to Dr. W. S. McBride of Marshalltown, and the officials of the Le Grand Quarry Co., who have been untiring in their efforts to facilitate the investigation. The notes of Mr. E. H. Lonsdale on the clay industry have been used freely, and the writer has been the recipient of many courtesies from the different members of the Survey.

IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF MARSHALL COUNTY. IOWA.

BY

S.W. BEYER.

1897.

Tp. 85 N.

Tp. 84 N.

Tp. 83 N.

Tp. 82 N.

R. XX W.

R. XIX W.

R. XVIII W.

R. XVII W.

LEGEND

GEOLOGICAL FORMATIONS

DES MOINES.

KINDERHOOK.

INDUSTRIES.

COAL MINES. ABANDONED.

CLAY WORKS.

QUARRIES.

ARTESIAN WELL.

Photo-Lith by A. HUEN & CO., Baltic, Wis.