BEDROCK GEOLOGY OF WESTERN STORY COUNTY, IOWA

by

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INTRODUCTION

Location and Area

Story county is located in the geographic center of Iowa, as shown in Figure 1. It includes Townships 82, 83, 84 and 85 North and Ranges 21, 22, 23 and 24 West and lies between 41° 50' and 42° 14' north latitude and between 93° 13' and 93° 42' west longitude. It is bounded on the north by Hamilton and Hardin counties, on the east by Marshall county, on the south by Polk and Jasper counties, and on the west by Boone county.

It contains the usual sixteen congressional townships common to interior Iowa counties and covers an area of about 576 square miles.

Physiography and General Drainage

The county is almost entirely mantled by the drift of the Des Moines Lobe and possesses the topographical forms typical of a young drift sheet. According to Fenneman and Johnson (1946), it lies within the western lake section of the Central Lowlands Province.

The topography of the area is one of gentle relief; the surface is a gently rolling pattern of swells and swales with local flats of considerable extent. Stream dissection has exerted very little influence in shaping the topography, but has produced local relief of about 100

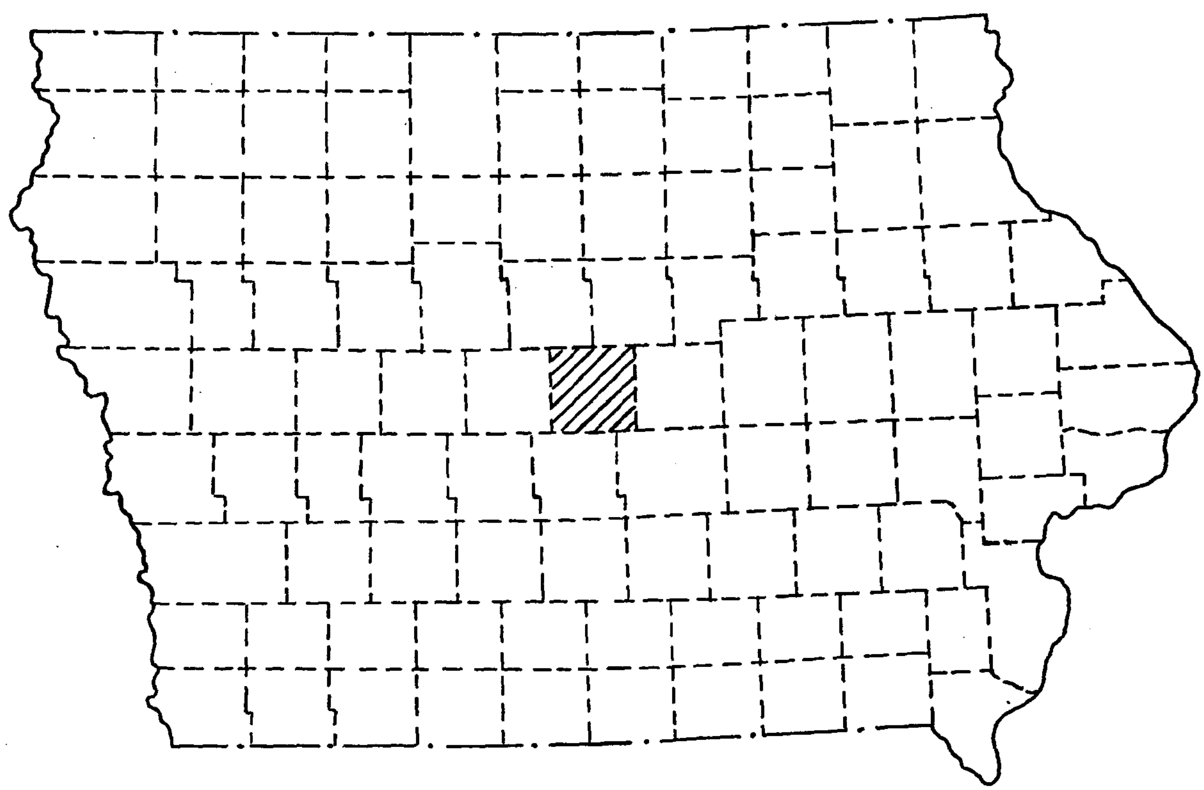

Figure 1. Index map of Iowa

feet (along the Skunk River in Milford and Franklin Townships and along Indian Creek in Indian Creek Township).

With the exception of the areas near the main streams and their larger tributaries, the county has poor natural drainage. Much of the area has been artificially drained, both by tile and ditches, to allow extensive agricultural practices.

The western portion of the county is drained by the Skunk River and its major tributaries, Kegley's Creek, Squaw Creek, Walnut Creek, and Ballard Creek to the west and Long Dick Creek and Bear Creek to the east. Indian Creek, Clear Creek and their tributaries drain the central and southeastern section, and Minerva Creek drains a small area in the northeastern part. All of these streams flow in a southeasterly direction across the county and all of them are part of the Skunk River system except Minerva Creek, which belongs to the Iowa River system. A small section in the southwestern corner of the area is drained by the Des Moines River system.

Previous Geological Investigations

The occurrence of bedrock about 3 miles northwest of Ames was noted and referred to the St. Louis formation by White (1870, pp. 259-260). The relationships of the surficial deposits were partly established by Upham (1891, pp. 298-304) and McGee (1891, pp. 336-347). In addition, McGee established the presence of the major structural flexure of the county and named it the "Skunk River anticlinal". He considered it to be one of a series of northwest-southeast trending flexures in the strata of Iowa.

Beyer (1898, pp. 157-237) made the first major investigation of the geology of Story county. He made a comprehensive report on the surface geology and verified the existence of the "Skunk River anticlinal" by correlation of the deep wells at Nevada, Iowa State College, and Boone. Beyer considered the general trend of the flexure to be northwest-southeast.

The Altamont morainic system was mapped through the northern part of the county by Leverett (1932, p. 70).

Gwynne (1940-1941, pp. 330-331) briefly discussed the ceramic shale and clay deposits and outlined the area believed to be underlain by rocks of the Des Moines series, mentioning some of the outcrops. His outline of the area underlain by these rocks corresponds very closely to that of Beyer.

Gwynne (1942, pp. 200-208), by the use of aerial photographs, mapped the minor morainic pattern of the Mankato Lobe through the area. This swell and swale topography can be seen in the field and it exerts considerable influence on the minor drainage pattern of the county.

Ruhe (1952, pp. 46-56) states that the Altamont moraine, extending across the northwestern corner of Story county, is the only representative of the Mankato Lobe in the county and that the rest of the area is mantled by the Cary drift.

Scope and Method of This Study

The purpose of the present paper is to further the investigation of the bedrock geology of Story county, especially that of its western half. It presents a detailed study of the location of bedrock exposures, their description, correlation and structure, including, also, a study of the relationship of the bedrock surface to the geomorphic features.

In order to achieve this objective, previous literature was searched, known exposures were studied, and most of the creeks in the area were walked to locate additional exposures. The information obtained from exposures was supplemented by well borings throughout the county. These well logs, which form a part of the Iowa Geological Survey records, have added much information concerning the stratigraphy and structure of the county.

GENERAL GEOLOGY

With the exception of the few places where bedrock is exposed, the county is mantled by glacial or glacio-fluvial deposits. The drift, but for a few isolated exposures, is of late Wisconsin age and may be divided into two types, end moraine and ground moraine. Sands and gravels underlie flood plains and terraces and occur locally as lenses and irregular masses in the drift. Some of these sands and gravels were deposited by streams directly associated with the glaciers, and the remainder, by post-glacial streams which derived the materials from glacial deposits.

The ground moraine surface is scalloped by a discontinuous, crescentric pattern of swells and swales. This pattern is very distinctive on aerial photographs as linear, alternating light and dark features. On the ground these are discontinuous, oriented ridges (light colored) and depressions (dark colored). This pattern is a characteristic feature of the entire Mankato Lobe and has been discussed by Gwynne (1942, pp. 200-208).

According to Beyer (1898, p. 204) there are two, possibly three, distinct terminal moraines in the county. The Gary moraine extends across the county from west to east through the two northern tiers of townships. The inner border of the Altamont moraine extends from the extreme southeastern corner of the county along a line that nearly parallels the Story-Marshall county line. The main body of the moraine lies in Marshall county. These two moraines were first named by

Chamberlin (1881-1882). He called the outermost one Altamont and the inner one Gary. Beyer used the names in this manner. However, Leverett (1922) questioned the propriety of this nomenclature and suggested renaming them. He advocated calling the outer one Bemis and the inner one Altamont, after the towns of Bemis and Altamont, South Dakota, through which they pass. Kay and Graham (1940-1941, pp. 241-242) and other writers have followed Leverett's terminology, which is now the generally accepted usage.

Beyer's other morainal tract swings across the county from west to east through the lower two tiers of townships and fuses with the Bemis moraine (Altamont of Beyer) in the southeastern corner. He believed this moraine possessed enough individuality to deserve a name and thus called it the Walnut Creek moraine. No other mention of the Walnut Creek moraine was found in the literature. In the present work no attempt is made to trace this morainal tract but its course is marked only by a few isolated hills rising but slightly above the surrounding surface. Hills of a similar nature are common throughout Story county.

The pre-Pleistocene rocks, exposed by stream dissection and quarry operations, belong to two systems, the Pennsylvanian and the Mississippian. Bedrock outcrops in the western half of Story county are shown on Plate 1 and a complete description of each exposure may be found in the appendix. The Mississippian rocks occur as isolated exposures along the Skunk River and its tributaries where stream dissection has cut into the northeast-southwest trending, asymmetrical anticlinal flexure shown on Plate 2. The Pennsylvanian rocks are represented by outcrops along Bear and Indian

Creeks. However, the study of well sections shows that the Pennsylvanian system underlies the drift in all but a small area along the crest of the anticline and along Squaw Creek and the upper portion of the Skunk River (Plate 3).

MODERN AND PRE-PLEISTOCENE (?) DRAINAGE

Introduction

Plate 1, a detailed drainage map of western Story county, was drawn from aerial photographs loaned by the U. S. Department of Agriculture, Soil Conservation Service. All drainage identifiable on stereoscopic pairs of photographs was mapped and then verified by field checking. The bedrock contour map, Plate 4, prepared from outcrops and well logs, shows a number of pre-Pleistocene (?) drainage lines that correspond very closely to the position of the present stream valleys. The valleys on this map shall be referred to as pre-Pleistocene (?) since the well logs used made no differentiation in age and type of drift.

Modern Drainage

The present drainage is characterized by two dominant trends, one northeast-southwest and the other northwest-southeast. Most of the minor drainage tends to follow the northeast-southwest trend, corresponding very closely to the minor morainic pattern discussed by Gwynne (1942, pp. 200-208). The major streams in general have a northwest-southeast trend which is characteristic of most of the major streams in Iowa. Long Dick Creek, Bear Creek and a segment of the Skunk River, from the SW. ¼ sec. 32, T. 85 N., R. 23 W. to the NE. ¼ sec. 27,

T. 84 N., R. 24 W., follow the northeast-southwest trend. Their course, however, is probably controlled by resistant dolomite on the flank of the anticline (Plate 2).

The Skunk River valley, in Story county, is readily divisible into two sections. The first section extends from the northern boundary of the county to the NE. $\frac{1}{4}$ sec. 27, T. 84 N., R. 24 W., about 2 miles north of Ames. It is characterized by a narrow flood plain, averaging approximately a quarter of a mile in width. Exposures of bedrock are common in this section. The southern section of the valley has a broad flood plain, averaging about $1\frac{1}{2}$ miles in width. Nowhere is bedrock exposed along this section.

Beyer (1898, pp. 206-209) attributed these features of the Skunk River to three causes: (1) the southern section represents an old pre-Pleistocene channel, (2) the pre-Pleistocene river had greater volume, and (3) the upper course of the old Skunk River probably followed the present Squaw Creek channel. Present information indicates that the differences between the two sections may be attributed to the influence of the pre-Pleistocene (?) valley. The southern section follows the old valley, whereas the northern section now occupies a position east of the old valley, such that it is cut into the resistant dolomite on or near the crest of the anticline.

Pre-Pleistocene (?) Drainage

The pre-Pleistocene (?) Squaw Creek and Skunk River valleys have a bedrock relief of about 200 feet whereas the present surface has approximately 100 feet of relief. Near Ames, where the greatest bedrock control is available, the pre-Pleistocene (?) valleys of both streams have about the same depth and width. With the present information it is impossible to say which was the master stream.

The pre-Pleistocene (?) valley of the Skunk River has characteristics similar to those of the present valley. The section from the northern boundary of the county to Ames is narrow and steep sided whereas the southern section has a broad valley with gently sloping sides. This is probably due to the fact that the northern half was cut into the more resistant Mississippian rocks and most of the southern half was cut in the softer Pennsylvanian rocks.

Bedrock valleys that correspond in position to the valleys of other modern streams, such as Kegley's Creek, Bear Creek, East Indian Creek and Clear Creek, are also shown on Plate 4. In the Ames area (Plate 5) where control is best, the influence of the pre-Pleistocene (?) bedrock is quite evident on even the modern smaller streams. Thus it would seem that many of the modern streams correspond in position to pre-Pleistocene (?) valleys.

Whether this similarity in position is actually caused by bedrock control or is due to some other control will have to be determined by more detailed investigation.

STRATIGRAPHY

Introduction

In Story county the glacial drift rests directly upon both Pennsylvanian and Mississippian rocks. The Pennsylvanian, as now known from outcrops and well borings, is limited to the Cherokee group. (The Mississippian rocks known to underlie the drift are assigned to the following formations: in descending order, the St. Louis, Warsaw, Keokuk, Gilmore City and Hampton.) Although it is highly probable that the Burlington, stratigraphically between the Keokuk and the Gilmore City, also underlies the drift, no evidence of it has as yet been found. The St. Louis and the Warsaw are the only exposed Mississippian formations.

In the only previous study of the indurated rocks of this area, Beyer (1898, pp. 182-195) recognized the two systems, Pennsylvanian and Mississippian. His work deals with but a small percentage of the outcrops located in the present investigation. He shows approximately 35 feet of exposed Mississippian rock whereas the present work shows 76.5 feet. Beyer did not mention the massive Pennsylvanian sandstone unit exposed along Bear Creek (Figure 2) and he placed all the exposed Mississippian rock in the St. Louis formation, whereas some are now known to be Warsaw.

In all the literature on this area only seven outcrops are described. Although the present investigation of the bedrock exposures was limited to the western half of Story county, a total of twenty-three outcrops of

Figure 2. Massive Pennsylvanian sandstone unit exposed on the left bank of Bear Creek (W. $\frac{1}{2}$ SW. $\frac{1}{4}$, T. 85 N., R. 23 W.).

bedrock were located, described and correlated. Plate 6 shows the correlation of six selected exposures, giving the complete stratigraphic range of the exposed Mississippian and the lowermost Pennsylvanian.

Pennsylvanian

The rocks of the Pennsylvanian system are here assigned to the Cherokee group. The maximum known thickness of the group in this area occurs near Nevada in the central part of the county. The log of the Howard Richardson well in the NW. ¼ NW. ¼ SE. ¼ sec. 36, T. 84 N., R. 23 W., shows a thickness of 235 feet. The Cherokee group is of approximately the same thickness in three other wells in this vicinity.

The contact of the St. Louis formation and the Cherokee group is exposed along Bear Creek. In the following composite section, exposed from the southeast corner of section 29 to the southwest corner of section 22, T. 85 N., R. 23 W., bed number one (dolomite) is the top of the St. Louis.

		feet
6.	Drift.	
5.	Limestone, gray, fine-grained, porous, massive; containing abundant pyrite crystals; bottom contact irregular and gradational with shale below..	2.0
4.	Shale, gray-green, blocky; very calcareous, calcite nodules becoming abundant near top; containing Pennsylvanian conodonts; upper contact irregular and gradational....................................	2.25
3.	Limestone, gray, dense, glauconitic; upper layer dense with a 3 inch band of dense, gray chert in center; lower layer sandy, grading laterally into calcareous sandstone.........................	0.75
2.	Sandstone, white to buff, fine-grained, friable, well-sorted; grains rounded to subangular; cross bedding locally prominent; locally containing lenses of "conglomeratic" chert near top...	18.0

1. Dolomite, buff to light gray, fine-grained with occasional calcite rhombs........................ 1.5

The boundary between the Mississippian (St. Louis formation) and the Pennsylvanian (Cherokee group) cannot be accurately determined due to the lack of fossils. Pennsylvanian conodonts do occur, however, in the shale of bed number four. Lithologically the sandstone appears to be closely related to other Pennsylvanian sandstones known in this region. A "conglomeratic" chert zone occurs between the underlying dolomite and this sandstone unit in the section exposed about one mile downstream in the NW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 32, T. 85 N., R. 23 W. The massive sandstone unit fills an old solution cavity in the underlying St. Louis formation in an old quarry located on the right bank of the Skunk River in the SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 13, T. 84 N., R. 24 W. (Figure 3). For these reasons this sandstone was placed in the Pennsylvanian system.

In the western half of Story county there are also two isolated exposures of the Cherokee group whose relationship to the other Cherokee exposures cannot be accurately determined. The first, located in the big bend of the Skunk River southeast of Story City in the NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 13, T. 85 N., R. 24 W., exposes approximately 4 feet of gray to black shale. The other, along Indian Creek in the pit of the brick and tile plant just west of Nevada in the SW. $\frac{1}{4}$ SE. $\frac{1}{4}$ sec. 1, T. 83 N., R. 23 W., exposes about 39 feet of variegated and gray shales.

Mississippian

The Mississippian rocks are exposed where stream erosion has cut into the northeast-southwest trending anticline shown on Plate 2. A

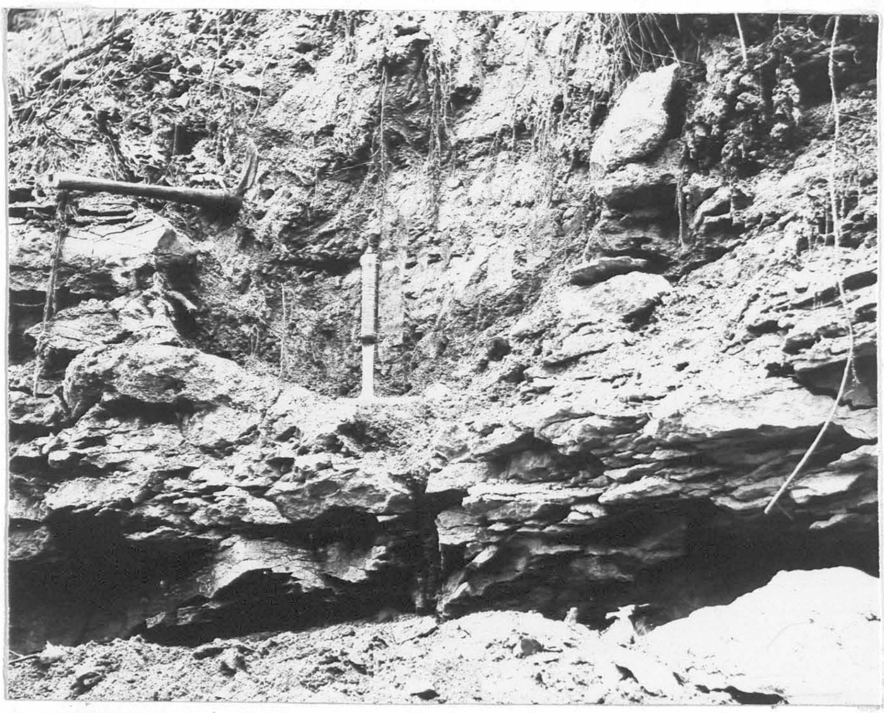

Figure 3. Pennsylvanian sandstone unit filling a solution cavity in the St. Louis formation (Mississippian) in an old quarry on the right bank of the Skunk River (SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 13, T. 84 N., R. 24 W.).

correlation of selected exposures (Plate 6) gives the total thickness of the exposed Mississippian rocks as 76.5 feet. The exposed Mississippian rocks are here assigned to two formations, in descending order, the St. Louis and the Warsaw.) The oldest formation directly underlying the till is the Hampton, found in the Joe Taylor well in the SW. ¼ NE. ¼ NE. ¼ sec. 33, T. 84 N., R. 24 W., and in the Iowa State College deep well in the NE. ¼ NE. ¼ SW. ¼ sec. 4, T. 83 N., R. 24 W. As there is no continuous exposure of the complete Mississippian section, a composite section was compiled from the selected exposures on Plate 6.

Composite Section of the St. Louis Formation
Total Thickness Exposed—28.0 to 29.0 Feet

		feet
6.	Dolomite, buff, fine-grained, heavy-bedded, concretions common; a 1 foot bed 1.5 feet below top is resistant and locally cherty; upper surface irregular and weathered................	7.5
5.	Dolomite, light gray to buff, fine-grained, dense, conchoidal fracture, fossiliferous...........	0.75
4.	Dolomite, buff to brown, fine-grained, massive, locally glauconitic; containing a few chert concretions......................................	2.0
3.	Dolomite and shale (interbedded); dolomite, gray-brown, medium-grained, containing calcite veinlets; shale, brown, calcareous, fissile.........	1.0
2.	Dolomite, brown, fine to medium-grained, massive; containing a few chert concretions. Recrystallization along joints forms veins of dense, gray dolomite. These veins form dike-like ridges on weathered surface. Lower contact irregular......................................	10.75
1.	Sandstone, light green, fine-grained, friable, with dolomitic lenses becoming more prominent near top..	6.0 to 7.0

Figure 4. An exposure of the St. Louis formation (N. ½ SW. ¼ sec. 25, T. 84 N., R. 24 W.) showing the dike-like ridges formed by dense, gray dolomite veins. These veins are characteristic of the lower 10 feet of the St. Louis dolomite.

Composite Section of the Warsaw Formation
Total Thickness Exposed--48.82 to 50.82 Feet

		feet
22.	Shale, blue-gray to green, silty, blocky, dolomitic; containing large irregular, granular, nodular masses of chert intermixed with calcite. In places it contains lenses of dolomite and locally the lower portion grades laterally into argillaceous dolomite. The shale is locally separated from overlying sandstone by a lens of brown to buff, medium-grained dolomite..............................	5.0
21.	Dolomite, buff to brown, fine to medium-grained, heavy-bedded; lens of gray shale 1.1 feet above base; upper 3 feet siliceous with nodular, irregular, granular masses of chert and calcite.....	5.5
20.	Shale, blue-gray, blocky, silty, finely disseminated pyrite present. The bottom 1 foot grades laterally into gray to buff, earthy, pyritic dolomite. Dolomite lenses locally present in rest of shale...........................	3.25
19.	Dolomite, buff to gray, fine to medium-grained; argillaceous, locally cherty...............	2.0
18.	Dolomite, brown, fine-grained; with masses of dark brown chert and calcite nodules; locally argillaceous; two beds of dark brown, brecciated-appearing, siliceous dolomite, one at base and the other 2.5 feet above base; dolomite grades laterally into shale................................	4.0
17.	Shale, brown to dark gray, blocky, with siliceous dolomite concretions throughout; two 3 inch beds of brown, siliceous, dense dolomite, one near middle and the other near top......................	2.0
16.	Dolomite, dark gray, fine to medium-grained; upper half firm and locally siliceous...............	2.15
15.	Shale, blue-gray, blocky, pyritic; top 4 inches dolomitic and locally siliceous..............	1.75
14.	Dolomite, buff to brown, medium to fine-grained; lower 2 feet argillaceous; top 1 foot resistant, saccharoidal dolomite containing crinoid stems, fish teeth and brachiopods; locally capped with lens of buff dolomitic chert.......................	3.0 to 3.5
13.	Chert, dark brown, very dense, upper surface irregular...	0.5
12.	Dolomite, brown, fine-grained, firm, with dark brown, nodular chert.............................	1.0
11.	Chert, clear, granular nodules and irregular masses mixed with calcite; pyritic; bed-like but probably masses in brown, fine-grained dolomite. It pinches and swells................................	1.0 to 1.75

		feet
10.	Dolomite, brown, fine-grained, firm; containing irregular nodules of granular, chalcedonic chert..	0.75
9.	Chert, dark brown, mottled, appearing brecciated in places. It has a 1 inch layer of brown, fine-grained dolomite on top and bottom.............	0.5 to 0.75
8.	Dolomite, gray to brown, fine-grained, pyritic; with a few chert nodules................................	0.75
7.	Shale, blue-gray to buff, blocky, silty, pyritic; dolomite lens 1 foot above base; a band of granular chert nodules 2 feet above base locally underlain by a lens of dolomite.............	3.0 to 3.5
6.	Dolomite, gray-brown, medium-grained; lower 5 inches resistant, upper 5 inches nodular, argillaceous; containing fish teeth and algae.......	0.82
5.	Dolomite, buff, fine-grained, earthy; containing lenses of coarser-grained, more resistant dolomite; discontinuous chert bed 2 feet above base. The bottom 8 inches grades into shale laterally.........	3.0
4.	Dolomite, brown, fine-grained, very shaly. On weathering it gives the appearance of shale. Upper and lower contacts irregular.................	1.0
3.	Dolomite, buff, fine-grained, argillaceous, massive; discontinuous band of dense, chalcedonic chert 1.5 feet above base. Masses of calcite appear in and around chert zone....................	2.35
2.	Shale, blue-gray, blocky, pyritic; with selenite along the partings; containing brachiopods and algae (?).....................................	5.0
1.	Dolomite, blue-gray, medium-grained, pyritic..........	0.5

Areal Distribution

The areal distribution of the Pennsylvanian and Mississippian rocks can be seen on Plate 3. The map is very generalized due to the lack of sufficient detailed information; however, enough information has been gained to necessitate a revision of Beyer's interpretation (1898, p. 238).

Comparison of Beyer's map with the map of this study shows the following modifications. Beyer's map shows the St. Louis as the oldest formation exposed across the anticline. Present information indicates that the St. Louis is not continuous across the structure, but has been breached by erosion so that older Mississippian formations are exposed along the crest. In addition, isolated exposures of Pennsylvanian sediments along the crest and margins of the structure somewhat modify the configuration of the Mississippian-Pennsylvanian contact near the anticline.

The older Mississippian formations are known from several wells and exposures. The Iowa State College deep well, located on the campus, and the Joe Taylor well, located in SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 33, T. 84 N., R. 24 W., penetrate the Hampton formation directly under the drift. Wells at Story City and at Roland show the drift overlying the Keokuk formation. At "Soper's Mill", in the S. $\frac{1}{2}$ SE. $\frac{1}{4}$ sec. 6, T. 84 N., R. 23 W., the Warsaw formation underlies the drift (Figure 5).

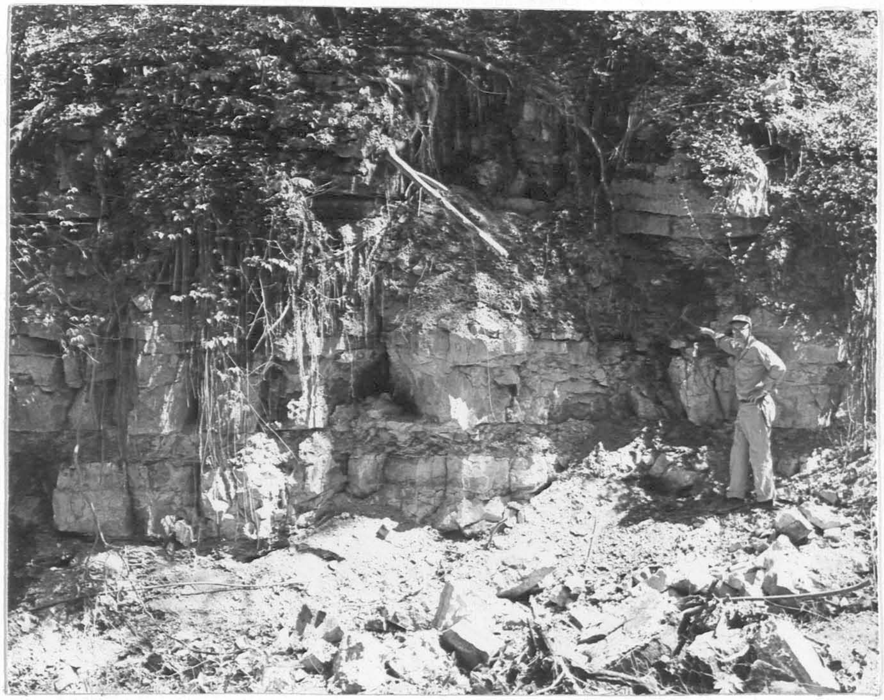

Figure 5. Exposure of the lower part of the Warsaw formation exposed on the right bank of a small tributary of the Skunk River just above "Soper's Mill" (S. ½ SE. ¼ sec. 6, T. 84 N., R. 23 W.).

STRUCTURE

Introduction

The existence of a structural flexure in Story county was first established by McGee (1891, p. 341) to explain the outcrops of Mississippian rocks exposed in the Skunk River near Ames. He considered it to be one of a series of northwest-southeast trending anticlinal flexures in the strata of Iowa and named it the "Skunk River Anticlinal".

Beyer (1898, pp. 215-216) verified the existence of this flexure by studying the strata penetrated by the deep wells at Nevada, Iowa State College, and Boone. He likewise interpreted the anticline to have a northwest-southeast trend with a dip of about 35 feet and 21 feet per mile for the southwest and northeast limbs, respectively.

Although McGee and Beyer recognized the existence of the anticlinal fold, more detailed information gained in studying additional bedrock exposures and well logs during this investigation necessitates a revision of their ideas.

Trend and Type of Folding

A structure contour map drawn on the base of the St. Louis formation (Plate 2) shows a northeast-southwest trending anticline. The eastern limb of the anticline has the steeper dip, in contrast to Beyer's interpretation, which shows the southwestern limb to have the steeper dip. The axis of this fold extends from the northwest corner of T. 83 N., R.

24 W., trending about N. 59° E., to the southeast corner of T. 84 N., R. 24 W., thence N. 31° E. to the Hamilton county line near the northeast corner of T. 85 N., R. 23 W. Thus it extends a distance of approximately 20 miles across the northwestern part of the county. Ames and Roland are located on its crest.

The crest of the anticline is marked by three domal highs with intervening saddles. For convenience these will be referred to, in this report, as Ames high, the Soper's Mill high, and the Roland high, named from southwest to northeast.

On the Ames high, the Hampton formation underlies the drift at an elevation of 835 feet in the Iowa State College deep well. The base of the St. Louis, as restored by correlation of the College well record, as taken from Beyer (1898, pp. 174-178), with the deep wells at Nevada, would rise to an elevation of 1,055 feet. The Ames high has a maximum closure of 200 feet. Dimensions of this closure are about 4½ miles by 2 miles. One limb of this high has a north-northwest dip of about 75 feet per mile and the other has a south-southeast dip of approximately 220 feet per mile.

The middle, or Soper's Mill, high is elongated N. 31° E. It has a maximum closure of 150 feet and is about 5 miles by 1½ miles. The northwest and southeast limbs of this high have, respectively, dips of approximately 55 feet and 100 feet per mile.

The Roland high trends N. 31° E. from about 1½ miles southwest of Roland to the northern boundary of the county, a distance of about 5 miles. The beds have a northwest dip of 35 feet per mile and a southeast dip of 90 feet per mile.

Most of the anticline is probably limited to Story county. The folding appears to be dying out northward and probably only a minor part is located in Hamilton county. The fact that the Ames high shows the greatest amount of folding and that there appears to have been a small disturbance in the vicinity of Madrid (Boone county) suggests the extension of the anticline southwestward into Boone county.

Other than the anticlinal flexure, four lesser structural features are shown on Plate 2. A broad, gentle high extends from the eastern edge of the county toward the center. In the southern portion of the area there is a gentle, south-plunging synclinal flexure. A small basin and a local high are indicated in T. 83 N., R. 24 W. and trend N. 45° E.

Time of Deformation

There are insufficient data, at present, to establish definitely the time of deformation in Story county. The evidence, however, appears to indicate two periods of movement.

In the Roland city well, in the SW. ¼ SW. ¼ sec. 14, T. 85 N., R. 23 W., Pennsylvanian shale rests directly on the Warsaw formation. This well, located on the crest of the anticline, is the only place in the county where the Pennsylvanian system is known to overlie a formation older than the St. Louis. The Pennsylvanian sandstone unit, in the NW. ¼ SE. ¼ sec. 32, T. 85 N., R. 23 W., is separated from the underlying St. Louis formation by a "conglomeratic" chert zone. A Pennsylvanian sandstone fills a solution cavity in the St. Louis formation in an old quarry on the right bank of the Skunk River in the SW. ¼ SW. ¼ sec. 13,

T. 84 N., R. 24 W. These facts seem sufficient to establish an interval of erosion following Mississippian deposition and before Pennsylvanian deposition.

Whether this post-Mississippian erosion interval is the result of flexing of the anticline is difficult to establish; however, I am unable to identify any Pennsylvanian unit of the Nevada well as extending over the flexure. The inability to trace a Pennsylvanian unit across the flexure suggests a local control of Pennsylvanian sedimentation. The disconformity separating Mississippian and Pennsylvanian as well as the character of the Pennsylvanian sediments suggests late Mississippian flexing which may have extended into the Pennsylvanian.

An earlier movement is indicated from a comparison of the Iowa State College and the Nevada deep wells. The elevation of the top of the St. Peter sandstone (Ordovician) is -490 feet in the College well and -867 feet in the Nevada well. Thus, in the College well this sandstone is 377 feet higher than in the Nevada well. By comparison, the base of the St. Louis is only 332 feet higher than its equivalent in the Nevada well (723 feet elevation at Nevada, 1,055 feet elevation at the College). This difference in thickness of the interval between the top of the St. Peter and the base of the St. Louis suggests the absence or thinning of intervening units on the structure. Either of these would require structural movements between the Ordovician and the Mississippian periods. Available data do not indicate that any unit is missing nor do they permit analysis of thinning.

SUMMARY

This is an investigation of the bedrock geology of Story county with special emphasis on the stratigraphy, structure and drainage. Information was obtained from the bedrock exposures in the western half of the county and well borings throughout the county. A detailed drainage map of western Story county was prepared from aerial photographs.

The indurated rocks underlying the drift of the Des Moines Lobe belong to the two systems, Pennsylvanian and Mississippian. The outcrops of the Pennsylvanian are limited to a few isolated exposures. However, data obtained from well logs indicate that it underlies the drift in all but a small area along the crest of the northeast-southwest trending anticline extending across the northwest corner of the county. The Pennsylvanian rocks are assigned to the Cherokee group. The Mississippian rocks known to underlie the drift are assigned to the following formations: in descending order, the St. Louis, Warsaw, Keokuk, Gilmore City and Hampton. Although it is highly probable that the Burlington, stratigraphically between the Keokuk and the Gilmore City, also underlies the drift, no evidence of it has as yet been found. The St. Louis and the Warsaw are the only exposed Mississippian formations. They outcrop in northwestern Story county where the Skunk River and its tributaries have cut into the anticlinal flexure.

The major structure is a northeast-southwest trending, asymmetrical anticline, with the steeper dip to the east. Within Story county it extends from the Boone county line, in the northwest corner of T. 83 N.,

R. 24 W., to the Hamilton county line near the northeast corner of T. 85 N., R. 23 W. Its crest is marked by three highs with intervening saddles. Present evidence seems to indicate two periods of movement, the first, post-Mississippian-pre-Pennsylvanian, and the other, at an earlier date.

The pre-Pleistocene (?) drainage lines appear to have exerted considerable influence on the location of many of the modern streams. The pre-Pleistocene (?) and the present Skunk River valley within the county are remarkably similar; however, the northern portion of the modern stream has been displaced to the east. Most of the minor drainage lines are closely related to the northeast-southwest trending minor moraines.

SUGGESTIONS FOR FUTURE STUDY

During the field investigation connected with this work, various features were observed which, due to time limitations, could not be adequately examined. A solution of the problems which they present would lead to a better understanding of the geological history of the county.

A unique area in the northwestern part of Story county is the Story City flat. This is a broad, till-covered, poorly drained region containing artesian wells. Detailed study of this area should be undertaken to determine its origin, as well as the relationship of its boundary to the contact of the Mississippian-Pennsylvanian rock systems. The source of the artesian water needs also to be explained and whether or not it is related to the local pockets or lenses of sand and gravel within the till exposed along the Skunk River.

Although no eskers have ever been reported in this area, there is a curious esker-like ridge entering the county near the center of T. 85 N., R. 23 W., and extending southeast past Roland. This ridge is associated with a broad, gentle valley which, when traced southeastward, appears to branch into three parts. Investigation by borings should be made to ascertain the exact nature of this ridge and its relationship to the Pleistocene drainage.

Another problem to be studied concerns the sand and gravel deposits that occur on the southwestern flank of many of the prominent northwest-southeast trending ridges in the ground moraine. Where seen, this sand graded from coarser at the base to finer at the top. These deposits should be examined to establish the control of their location and whether they are of water or wind origin.

A study of the minor morainic pattern as discussed by Gwynne (1942, pp. 200-208) suggests an examination to determine the original relief of these features. A series of borings made along the ridges and troughs should give an accurate check on the amount of modification of the relief by colluviation.

An analysis should be made of the loess, or loess-like, deposits within the county. Some of these appear to have an alluvial section over them while others are overlain by drift. A study should be made to locate more of these deposits and to establish their age and origin.

An investigation of the bedrock geology in Boone and Hamilton counties should be made in order to determine the extent of the "Skunk River" anticline. This work would also help to ascertain a more exact age of flexing.

The abundant siliceous deposits in the Mississippian rocks of this area, especially in the Warsaw formation, present another field for additional study. Some of these deposits are dense and dark, while others are nodular, granular, and chalcedonic. The latter contain a variety of minerals, such as calcite, pyrite, marcasite, sphalerite, etc. Most of these deposits appear to be secondary accumulations; however, a detailed mineralogical examination of these rocks should give a better understanding of their composition, and of the conditions under which they were formed.

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APPENDIX: DESCRIPTIONS OF BEDROCK EXPOSURES

SECTION EXPOSED ALONG ONION CREEK IN THE SW. ¼ NE. ¼ SEC. 32, T. 84 N., R. 24 W.

	feet
7. Drift.	
Mississippian system	
6. Dolomite, buff, fine-grained, earthy, heavy-bedded to massive; containing scattered chert and calcite nodules that become more numerous toward top; top 1 foot rubbly and badly weathered...........	6.0
5. Dolomite, light gray to buff, fine-grained, very dense, sublithographic; containing fenestelloid bryozoans..	0.65
4. Dolomite, brown to buff, fine-grained, firm, slightly porous; containing calcite rhombs and veins..........	1.75
3. Dolomite and shale, interbedded; dolomite, light gray, fine-grained, dense; shale, gray-brown, fissile to blocky. This unit contains many fenestelloid bryozoans..	2.65
2. Dolomite, brown, medium to fine-grained. Recrystallization along joints forms veins of dense, gray dolomite. Lower 4 feet dense, firm, with occasional chert and calcite nodules; middle 4 feet fine-grained, firm, resistant. Top 2 feet contains resistant nodular fragments of gray dolomite that stand out on weathering..	10.0
1. Sandstone, light green to buff, fine-grained, well-sorted; containing dolomitic lenses near top; 6 to 8 inch bed of medium to coarse-grained, pyritic, brown dolomite 5.5 feet below top............ exposed	7.0
total thickness exposed.......	28.05

SECTION EXPOSED ALONG A SMALL STREAM ON THE OLSON PROPERTY IN THE N. ½ SW. ¼ SEC. 25, T. 84 N., R. 24 W.

18. Drift.	
Mississippian system	
17. Dolomite, buff, fine-grained, medium to heavy-bedded; top 1.5 feet weathered to flaggy rubble..................	4.5

		feet
16.	Dolomite, gray to buff, fine-grained, dense; containing fenestelloid bryozoa, syringoporid corals, Lingula sp. and Spirifer keokuk....................................	1.0
15.	Dolomite, brown to gray, fine to medium-grained, heavy-bedded; containing a few chert and calcite concretions..	2.0
14.	Dolomite and shale, interbedded; dolomite, brown, fine-grained, with calcite veins; shale, gray-brown, fissile, calcareous....................................	1.0
13.	Dolomite, brown, fine to medium-grained, massive. Recrystallization along joints forms veins of dense, gray dolomite. These veins form dike-like ridges on weathered surface. Upper 2 feet contains dark gray, concretionary masses of dense dolomite..................	10.5
12.	Sandstone, light green, very fine-grained, well-sorted friable; containing dolomitic lenses especially near top..	6.5
11.	Shale, blue-gray, calcareous, glauconitic; containing large, irregular, granular masses of chert containing calcite. The exposure is very poor and it is difficult to determine the top of this unit......................	5.0
10.	Dolomite, gray to brown, fine to medium-grained; containing brecciated appearing, irregular, granular masses of gray to clear chert containing calcite. Upper 1 foot almost a bed of granular chert. Upper surface rough and irregular............................	2.5
9.	Chert, brown, dense, mixed with dolomite. This bed pinches and swells....................................	0.65
8.	Dolomite, dark gray to brown, medium to fine-grained, slightly porous....................................	0.8
7.	Shale, blue-gray, blocky, calcareous, glauconitic near top; top 0.5 foot grades laterally into a light gray, glauconitic, fine-grained dolomite.....................	1.25
6.	Dolomite, gray to brown, brecciated, very siliceous.......	0.65
5.	Shale, blue-gray, blocky, calcareous, glauconitic; containing Lingula; 4 inch bed of brown, medium-grained dolomite 3 feet above base.....................	5.0
4.	Dolomite, brown, medium-grained; lower part irregular and containing irregular nodules of chert; upper bed hard, siliceous....................................	1.0
3.	Shale, blue-gray, blocky, dolomitic......................	0.75
2.	Dolomite, brown, medium-grained, porous; containing small nodules of dark brown chert......................	0.65
1.	Shale, blue-gray, silty, blocky....................exposed	0.82
	total thickness exposed.......	44.57

SECTION EXPOSED IN COOK'S QUARRY
IN THE SW. ¼ SW. ¼ NW. ¼ SEC. 24, T. 84 N., R. 24 W.

8.	Drift.	feet
Pennsylvanian system		
7.	Sandstone, white to buff, fine-grained, well-sorted, clean, grains subangular to subrounded; top 3 inches shows secondary enrichment of calcite from drift above.........	4.0
Mississippian system		
6.	Dolomite, buff to brown, fine to medium-grained, heavy-bedded, becoming flaggy near top; containing chert nodules especially near top..............................	8.0
5.	Dolomite, gray-brown, fine-grained; dense; containing fenestelloid bryozoa..................................	1.0
4.	Dolomite, buff, fine-grained; containing a few calcite rhombs and chert nodules..............................	2.0
3.	Dolomite and shale, interbedded; dolomite, gray, medium-grained; shale, brown, fissile....................	0.5 to 0.75
2.	Dolomite, brown to gray, fine to medium-grained, massive, with a few chert nodules; recrystallization common along joints......................................	11.0
1.	Sandstone, light green, calcareous, very fine-grained, well-sorted......................................exposed	0.5
	total thickness exposed......	27.0 to 27.25

SECTION EXPOSED ALONG A SMALL STREAM IN THE
NE. ¼ SEC. 24, T. 84 N., R. 24 W.

		feet
3.	Drift.	
Mississippian system		
2.	Dolomite and shale, interbedded; dolomite, brown, medium-grained; with calcite veins; shale, brown, fissile, calcareous......................................	1.0
1.	Dolomite, brown to buff, fine to medium-grained; upper 2 feet contains gray, resistant dolomite nodules that stand out on weathering. Recrystallization along joints forms veins of dense, gray dolomite. These veins form dike-like ridges on weathered surface.. exposed	10.0
	total thickness exposed.......	11.0

SECTION EXPOSED ALONG THE SKUNK RIVER
AT THE OLD HANNUM'S MILL SITE
IN THE SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ SW. $\frac{1}{4}$ SEC. 23, T. 84 N., R. 24 W.

	feet
4. Soil.	
Mississippian system	
3. Dolomite, buff to gray, medium to heavy-bedded; containing scattered chert nodules and dense limestone concretions. When weathered the dolomite turns a yellow buff and contains abundant dendrites...........	8.2
2. Shale, brown, fissile, dolomitic, exposure poor and thickness difficult to determine........................	0.4
1. Dolomite, gray, medium-grained, massive to heavy-bedded; breaks into flaggy fragments on weathering; recrystallized lenses and nodules, especially in upper 2 feet....................................exposed	3.0
total thickness exposed.......	11.6

SECTION EXPOSED ALONG THE RIGHT BANK OF THE SKUNK RIVER
IN THE NE. $\frac{1}{4}$ NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ SEC. 23, T. 84 N., R. 24 W.

	feet
2. Drift and river silt.	
Mississippian system	
1. Dolomite, buff, fine-grained, massive; containing scattered calcite rhombs..........................exposed	4.25

SECTION EXPOSED ALONG THE EDGE OF A TERRACE
ON THE RIGHT BANK OF THE SKUNK RIVER
IN THE SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ SEC. 23, T. 84 N., R. 24 W.

	feet
2. Soil	
Mississippian system	
1. Dolomite, gray buff, fine-grained, heavy-bedded..exposed	3.0

SECTION EXPOSED IN AN OLD QUARRY ON THE RIGHT BANK OF THE SKUNK RIVER IN THE SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ SEC. 13, T. 84 N., R. 24 W.

	feet
6. Drift.	
Pennsylvanian system	
5. Sandstone, yellow-green, fine-grained, well-sorted, friable. In one place this sandstone fills a solution cavity, 1.5 feet deep and 3 feet across, in the underlying St. Louis dolomite........................	5.0 to 6.0
Mississippian system	
4. Dolomite, buff, fine-grained, massive to heavy-bedded, containing scattered chert nodules that become more prominent near top. Near top, a bed 1.5 feet thick is very resistant and locally contains abundant chert nodules. Top weathered and irregular....	7.5
3. Dolomite, light gray to buff, fine-grained, very dense; containing fenestelloid bryozoans.................	1.0
2. Dolomite and shale, interbedded, irregular; dolomite, gray, fine-grained; shale, gray-brown, calcareous, fissile..	0.5 to 1.0
1. Dolomite, brown, fine to medium-grained, massive, resistant; containing scattered calcite rhombs and chert nodules; seems to have some recrystallization along fractures.................................exposed	4.0
total thickness exposed.......	18.0 to 19.5

SECTION EXPOSED ALONG TWO FORKS OF A SMALL STREAM IN THE NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ SEC. 18, T. 84 N., R. 23 W.

	feet
22. Drift.	
Mississippian system	
21. Sandstone, light green, very fine-grained, well-sorted, friable; containing dolomitic stringers........	3.0
20. Shale, blue-gray to green, silty, blocky, calcareous; containing irregular masses and nodules of granular, hackly, clear to blue chert mixed with calcite; locally has 4 to 7 inches of medium-grained, brown dolomite at top..	5.0
19. Dolomite, buff to brown, fine to medium-grained, heavy-bedded; upper 3 feet contains abundant nodular, irregular, hackly, clear to gray chert masses. Lens of dark brown, dense chert feather-edge to 10 inches thick 1.5 feet above base.............................	5.0

		feet
18.	Shale, blue-gray, glauconitic, blocky; containing a few fish teeth. The upper part of this unit grades laterally into a gray, glauconitic, siliceous dolomite..	1.25
17.	Shale, gray, silty, chippy, very glauconitic, pyritic. Up the west branch, this unit contains 2 lenses of gray siliceous dolomite about 4 inches thick............	2.0
16.	Dolomite, brown, fine to medium-grained, heavy-bedded, locally cherty; locally a lens of gray shale occurs under the upper bed........................	1.0
15.	Dolomite, light gray, fine-grained, earthy, glauconitic, slightly porous.......................................	0.75
14.	Dolomite, buff to brown, fine-grained; containing lens of dark brown chert near top...........................	1.0
13.	Shale, blue-gray, chippy, silty, dolomitic; thickens laterally at the expense of the overlying dolomite and contains large masses of granular white to clear chert..	0.75 to 1.75
12.	Shale, gray to brown, blocky, silty; containing a few irregular nodules of granular chert mixed with calcite. This unit contains several thin beds of dolomite and dark brown chert which pinch and swell.....	6.0
11.	Dolomite, brown, medium to coarse-grained; lower 2 feet argillaceous; top 1 foot coarser, resistant dolomite, stained by iron oxide, containing fragments of crinoid stems, fish teeth, and brachiopods. This unit is locally capped by a lens of buff chert, containing small particles and veinlets of white chalcedonic chert....................................	3.5
10.	Chert, dark brown, locally containing small particles and veinlets of white chalcedonic chert; upper surface irregular.....................................	0.5
9.	Dolomite, brown, fine-grained; containing local nodules of dark brown chert...........................	1.0
8.	Chert, clear, granular, irregular masses; containing calcite, marcasite, pyrite, sphalerite, etc.; appears bed-like but probably masses in brown, fine-grained dolomite.....................................	1.0
7.	Dolomite, brown, fine-grained, firm; containing irregular masses of granular, chalcedonic chert........	0.75
6.	Chert, dark brown, mottled, appears brecciated locally. It has a 1 inch layer of brown, fine-grained dolomite on top and bottom......................................	0.5
5.	Dolomite, gray, fine-grained; containing pyrite crystals and chert nodules....................................	0.7
4.	Shale, blue-gray, blocky, calcareous, silty, pyritic; containing an earthy dolomite lens 1 foot above base and a band of granular, chalcedonic chert nodules 2 feet above base. A brown, fine-grained dolomite lens is locally present under the nodule band..............	3.5

	feet
3. Dolomite, brown, medium-grained, medium-bedded; locally containing dark brown chert nodules..................	1.5 to 2.0
2. Shale, blue-gray, blocky, calcareous, silty; containing dolomite lenses and concretions......................	0.7
1. Dolomite, gray, fine-grained; containing small veins and concretions of chalcedonic chert..........exposed	0.3
total thickness exposed......	39.7 to 41.7

SECTION EXPOSED ALONG A SMALL STREAM ON THE MC FARLAND PROPERTY
IN THE SE. ¼ SW. ¼ SE. ¼ SEC. 7, T. 84 N., R. 23 W.

	feet
2. Drift.	
Mississippian system	
1. Dolomite, brown to buff, fine to medium-grained, massive to heavy-bedded, occasional chert nodules and calcite concretions. Recrystallization along joints forms veins of dense, gray dolomite. These veins form dike-like ridges on weathered surface. The top portion has weathered to a buff, flaggy rubble...............exposed	7.5

SECTION EXPOSED ALONG A SMALL TRIBUTARY TO THE SKUNK RIVER
JUST ABOVE "SOPER'S MILL"
IN THE S. ½ SE. ¼ SEC. 6, T. 84 N., R. 23 W.

	feet
23. Drift.	
Mississippian system	
22. Shale, blue gray, blocky. The exposure is poor and exact relationship difficult to determine..............	1.5
21. Dolomite, brown to buff, fine to medium-grained, earthy; containing much clear, hackly, granular, pyritic chert in irregular masses and nodules with intermixed calcite................................	1.5
20. Dolomite, buff, fine-grained, earthy; locally containing small masses and nodules of dark brown chert. The bottom 9 inches is dark brown, dense chert............	2.5
19. Dolomite, buff to brown, medium to fine-grained, laminated, massive; containing a few siliceous concretions..	1.5
18. Shale, blue-gray, blocky, pyritic; 4 inch bed of cherty, brown, dense dolomite 8 inches below top..............	3.0

		feet
17.	Dolomite, buff, fine-grained, earthy, with scattered calcite and siliceous concretions	2.0
16.	Dolomite, brown, fine-grained, with masses of dark brown chert and calcite concretions; argillaceous locally; small shale parting 15 inches above base; two beds of dark brown siliceous dolomite, one at base and other near top	4.0
15.	Shale, dark gray to brown, blocky; containing a few siliceous dolomite concretions; 3 inch bed of siliceous, brown dolomite at base and another near middle	2.0
14.	Dolomite, upper bed brown, fine-grained, locally siliceous; with occasional chert nodules; lower bed dark gray, medium-grained, firm	2.25
13.	Shale, blue gray, blocky; locally siliceous; containing a few crystals of pyrite	1.75
12.	Dolomite, brown, medium to coarse-grained, clastic, with a few chert nodules; containing crinoid stems, fragments of brachiopods, and fish plates	2.0
11.	Chert, buff to brown, dense, dolomitic; locally containing small particles and veinlets of white chalcedonic chert	0.75
10.	Dolomite, brown, fine-grained, earthy	1.0
9.	Chert, clear to white, granular, irregular masses; containing calcite, pyrite, sphalerite, etc.; appears bed-like but probably masses in brown, fine-grained dolomite	2.75
8.	Chert, brown, dense, hard; bounded on top and bottom by 2.5 inches of dolomite	0.82
7.	Shale, buff to gray, silty, blocky; containing a band of chert and dolomite nodules 1.5 feet above base	3.0
6.	Dolomite, gray to brown, medium-grained, dirty; upper 5 inches nodular, clastic, containing fish teeth, crinoids and algae	0.82
5.	Dolomite, buff, fine to medium-grained, earthy, slightly porous, containing nodules and lenticular masses of coarser, more calcareous dolomite that stand out on weathering. A discontinuous, dark brown chert bed 2 feet above base ranges in thickness from feather-edge to 5 inches	3.0
4.	Dolomite, brown, medium-grained, argillaceous; weathers to give appearance of shale	1.0
3.	Dolomite, buff, fine-grained, argillaceous; containing a discontinuous chert bed 1.5 feet above base; masses of calcite occur in and around chert zone	2.35
2.	Shale, blue gray, blocky, pyritic; selenite crystals common along partings; containing brachiopods and algae (?)	5.0
1.	Dolomite, gray, medium-grained, pyritic, argillaceous.... exposed	0.5
	total thickness exposed	44.99

SECTION EXPOSED ON THE LEFT BANK OF THE SKUNK RIVER
JUST BELOW THE MOUTH OF BEAR CREEK
IN THE NW. ¼ NE. ¼ SE. ¼ SEC. 6, T. 84 N., R. 23 W.

		feet
2.	River sand and silt.	
Mississippian system		
1.	Sandstone, light green, fine-grained, well-sorted, friable; containing a white, chalcedonic chert mass 1.5 feet thick capped by a dolomitic lens 2 feet below top....................exposed	5.0

SECTION EXPOSED ON THE LEFT BANK OF BEAR CREEK
JUST ABOVE ITS MOUTH
IN THE NE. ¼ NE. ¼ SE. ¼ SEC. 6, T. 84 N., R. 23 W.

		feet
6.	River sand.	
Mississippian system		
5.	Shale, blue-gray, blocky, calcareous; containing a few calcite nodules....................	1.5
4.	Dolomite, buff to light brown, fine-grained, laminated; containing abundant chert nodules....................	0.66
3.	Shale, gray, very silty, calcareous. This unit grades downward into a brown dolomite....................	0.5
2.	Dolomite, brown, medium-grained, porous....................	0.5
1.	Dolomite, brown, fine-grained; containing lenses and nodules of blue-white chalcedonic chert..........exposed	0.66
	total thickness exposed.......	3.82

SECTION EXPOSED ALONG A SMALL TRIBUTARY TO BEAR CREEK
IN THE NE. ¼ NW. ¼ NE. ¼ SEC. 5, T. 84 N., R. 23 W.

		feet
6.	Drift.	
Mississippian system		
5.	Dolomite, buff, medium-bedded; containing veins and nodules of calcite, weathers to a flaggy rubble.........	4.0
4.	Dolomite, gray to buff, fine-grained, dense; containing fenestelloid bryozoa and brachiopods....................	0.66
3.	Dolomite, buff, fine-grained, slightly argillaceous.......	2.0
2.	Dolomite and shale, interbedded; dolomite, buff, fine-grained; shale, gray, fissile. This unit contains brachiopods and fenestelloid bryozoa....................	1.0

		feet
1.	Dolomite, brown, fine to medium-grained; containing scattered calcite rhombs; containing recrystallized joints..exposed	2.25
	total thickness exposed.......	9.91

SECTION EXPOSED ALONG A SMALL STREAM AND ITS TRIBUTARIES IN THE CENTER OF THE W. ½ SEC. 5, T. 84 N., R. 23 W.

		feet
17.	Drift.	
Mississippian system		
16.	Dolomite, buff, fine to medium-grained, massive, slightly porous; bottom 4 feet fine-grained, resistant. Recrystallization is common along joints.................	7.5
15.	Sandstone, light green, well-sorted, clean, fine-grained, grains subrounded to subangular; containing dolomite lenses, especially near top..............................	7.0
14.	Shale, blue gray, blocky to chippy, calcareous; containing 6 inches of brown dolomite 2 feet below top. Large, granular, chalcedonic chert masses are common...........	4.5
13.	Dolomite, brown to gray, medium-grained; containing abundant, irregular nodules of chert that give it a brecciated appearance in places. It locally contains shaly units...	2.5
12.	Dolomite, gray, fine-grained, glauconitic.................	1.0
11.	Shale, gray-green, chippy, glauconitic; containing dolomite lenses and grading upward into dolomite........	1.25
10.	Dolomite, gray to buff, fine-grained, dense; containing cherty concretions that tend to stand out on weathering..	1.0
9.	Shale, blue-gray, blocky, calcareous; containing a thin, siliceous dolomite lens near middle and large, irregular masses of chalcedonic chert scattered throughout..	2.0
8.	Dolomite, brown, fine-grained, lower part argillaceous. This unit contains a brown, dense chert bed near base and is siliceous toward top.............................	4.0
7.	Shale, gray, blocky, calcareous; containing 3 inches of siliceous dolomite 1 foot above base....................	2.25
6.	Dolomite, gray to brown, medium-grained, argillaceous, locally siliceous....................................	2.5
5.	Shale, buff to gray, blocky, pyritic; dolomitic near top. It contains scattered chert nodules and a lens of medium-grained, brown dolomite near center.............	3.5

		feet
4.	Dolomite, buff to brown, medium-grained; lower 1.5 feet, buff, argillaceous; upper 1 foot, coarser-grained, clastic, resistant, containing fragments of crinoid stems and brachiopods. This unit is locally capped by a lens of buff chert, containing small particles and veinlets of white chalcedonic chert......	2.5
3.	Chert, brown, dense, locally containing small particles and veinlets of white chalcedonic chert; upper surface irregular....................................	0.75
2.	Dolomite, brown, fine-grained, with local masses of chert..	1.0
1.	Chert, white to light blue, granular, irregular masses; containing calcite, pyrite, etc. It appears to be in a fine-grained, brown dolomite.................exposed	1.0
	total thickness exposed......	44.25

SECTION EXPOSED FOR ABOUT ½ MILE ALONG A SMALL TRIBUTARY TO BEAR CREEK IN THE NE. ¼ SE. ¼ SEC. 32 AND IN THE SW. ¼ NW. ¼ SEC. 33, T. 85 N., R. 23 W.

		feet
7.	Drift.	
Pennsylvanian system		
6.	Sandstone, white to buff, fine-grained; well-sorted, friable; containing calcareous lenses..................	1.5
Mississippian system		
5.	Dolomite, buff, fine-grained, heavy-bedded; containing scattered calcite concretions..........................	6.0
4.	Dolomite, light gray, fine-grained, dense; containing fenestelloid bryozoa, brachiopods, and syringoporid corals...	1.0
3.	Dolomite, brown, fine-grained, massive; containing calcite veinlets....................................	2.0
2.	Dolomite and shale, interbedded; dolomite, light gray, fine-grained; shale, brown, fissile. This unit contains fenestelloid bryozoa..........................	1.0 to 1.5
1.	Dolomite, brown, medium to fine-grained, massive. Recrystallization along joints forms veins of dense, gray dolomite. These veins form dike-like ridges on weathered surface............................exposed	7.5
	total thickness exposed.....	19.0 to 19.5

SECTION EXPOSED ALONG THE LEFT BANK OF BEAR CREEK
IN THE SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ SE. $\frac{1}{4}$ SEC. 32, T. 85 N., R. 23 W.

	feet
6. Drift.	
Pennsylvanian system	
5. Sandstone, buff to white, fine-grained, well-sorted, grains subrounded to subangular, friable. It has an irregular, "conglomeratic" chert zone at base.......	10.1
Mississippian system	
4. Dolomite, buff, fine-grained, medium-bedded; containing chert nodules in upper part..............................	7.3
3. Dolomite, gray, fine-grained, dense; containing fenestelloid bryozoa..................................	0.8
2. Dolomite, buff, fine-grained, massive; containing scattered calcite rhombs..............................	1.5
1. Dolomite and shale, interbedded; dolomite, gray, fine-grained, calcareous; shale, brown, fissile; containing fenestelloid bryozoa...........................exposed	0.7
total thickness exposed.......	20.4

SECTION EXPOSED ON THE RIGHT BANK OF BEAR CREEK
IN THE NE. $\frac{1}{4}$ SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ SEC. 32, T. 85 N., R. 23 W.

	feet
2. Drift.	
Mississippian system	
1. Dolomite, buff, fine-grained, heavy-bedded; exposure poor and badly weathered........................exposed	3.4

SECTION EXPOSED ALONG BEAR CREEK
IN THE SE. $\frac{1}{4}$ SE. $\frac{1}{4}$ SEC. 29, AND W. $\frac{1}{2}$ SEC. 28, T. 85 N., R. 23 W.

	feet
6. Drift	
Pennsylvanian system	
5. Limestone, gray, medium-grained, porous; containing abundant pyrite crystals and calcite rhombs; bottom contact gradational..................................	1.5
4. Shale, gray-green, blocky, very calcareous; containing limestone nodules; containing Pennsylvanian conodonts..	2.25

	feet
3. Limestone, light brown to gray, fine-grained, dense, locally siliceous; bottom contact gradational..........	0.75
2. Sandstone, buff to white, well-sorted, friable, cross-bedding prominent locally, grains rounded to subangular; containing well-cemented lenses. Locally it contains an iron-stained chert lens 1 foot thick near top.......	18.0
Mississippian system	
1. Dolomite, buff, fine-grained, with a few calcite concretions....................................exposed	1.5
total thickness exposed.......	24.0

EXPOSURE ALONG BEAR CREEK
IN THE NE. ¼ SEC. 28, T. 85 N., R. 23 W.

	feet
5. Drift.	
Pennsylvanian system	
4. Limestone, gray, medium-grained, porous, massive; containing abundant calcite rhombs and pyrite crystals; gradational bottom contact...................	1.75
3. Shale, gray-green, blocky, very calcareous; containing limestone nodules......................................	2.25
2. Limestone, gray to light brown, fine-grained, arenaceous; containing a siliceous lens near center....	0.75 to 1.0
1. Sandstone, white to buff, fine-grained, well-sorted, friable; grains subrounded to subangular; locally containing well-cemented lenses...............exposed	9.5
total thickness exposed.....	14.25 to 14.5

SECTION EXPOSED ALONG BEAR CREEK
IN THE SW. ¼ SEC. 22, T. 85 N., R. 23 W.

	feet
5. Drift.	
Pennsylvanian system	
4. Limestone, light gray, massive, medium-grained, porous; containing abundant pyrite crystals....................	2.0
3. Shale, green, chippy, very calcareous; containing lenses and nodules of limestone................................	1.3
2. Limestone, gray to light brown, fine-grained, dense, arenaceous, locally siliceous..........................	0.65

	feet
1. Sandstone, buff to white, fine-grained, well-sorted, friable; cross-bedding present but not prominent; containing well-cemented lenses..................exposed	12.0
total thickness exposed........	15.95

SECTION EXPOSED ON THE LEFT BANK OF THE SKUNK RIVER ON THE SOUTH SIDE OF THE BIG BEND BELOW STORY CITY IN THE NE. ¼ NE. ¼ SE. ¼ SEC. 13, T. 85 N., R. 24 W.

	feet
2. River sand and silt.	
Pennsylvanian system	
1. Shale, gray to black, blocky, clayey, soapy, slightly calcareous; containing streaks of black carbonaceous shale; ironstone concretions abundant near top...exposed	3.75

SECTION EXPOSED IN THE PIT OF THE BRICK AND TILE PLANT AT THE WEST EDGE OF NEVADA, IOWA, ALONG THE RIGHT BANK OF WEST INDIAN CREEK IN THE SW. ¼ SE. ¼ SEC. 1, T. 83 N., R. 23 W.

	feet
9. Drift.	
Pennsylvanian system	
8. Shale, yellow and/or gray or purple; massive. This unit grades up into till and may constitute part of the till..	2.0
7. Shale, laminated gray, green, red, and purple, argillaceous and micaceous; becomes increasingly red at top; calcareous nodules in lowest 2 feet; locally hematite nodules with diameters up to 2 inches.........	10.0
6. Shale, dark gray, argillaceous, soapy, fissile; fossil (?) impressions that may be clay or limonite pellets; containing pelecypod (Mytiola ?), gastropod (Bellerophon ?) and brachiopod (Lingula) in top 1 foot..	3.0
5. Shale, carbonaceous, massive, locally even appears coaly; weathers into thin plates; abundant nodules and lenses of phosphate; plant remains scarce; locally fiberous calcite and phosphate (?) at top.....	0.6
4. Shale, gray, argillaceous, slightly pyritic and limonitic, weathers into angular blocks; laminae not seen; becomes carbonaceous toward top............	2.4

		feet
3.	Shale, predominantly gray, but with local areas of purple, maroon, etc.; containing small amounts of mica and silt; massive, nodular, slickensided, weathers to angular blocks..............................	11.5
2.	Shale, maroon, massive, nodular, micaceous, silty; containing small, gray or purple masses throughout; contact gradational to unit above......................	6.6
1.	Shale, poorly exposed at base of pit, but probably shale that is similar to unit directly above....exposed	3.0
	total thickness exposed.......	39.1