THE PLEISTOCENE HISTORY OF IOWA RIVER VALLEY, NORTH AND WEST OF IOWA CITY IN JOHNSON COUNTY

BY

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OUTLINE.

THE PLEISTOCENE HISTORY OF IOWA RIVER VALLEY

Introduction.

LOCATION.

That portion of Iowa river valley to be considered is in Johnson county, Iowa.

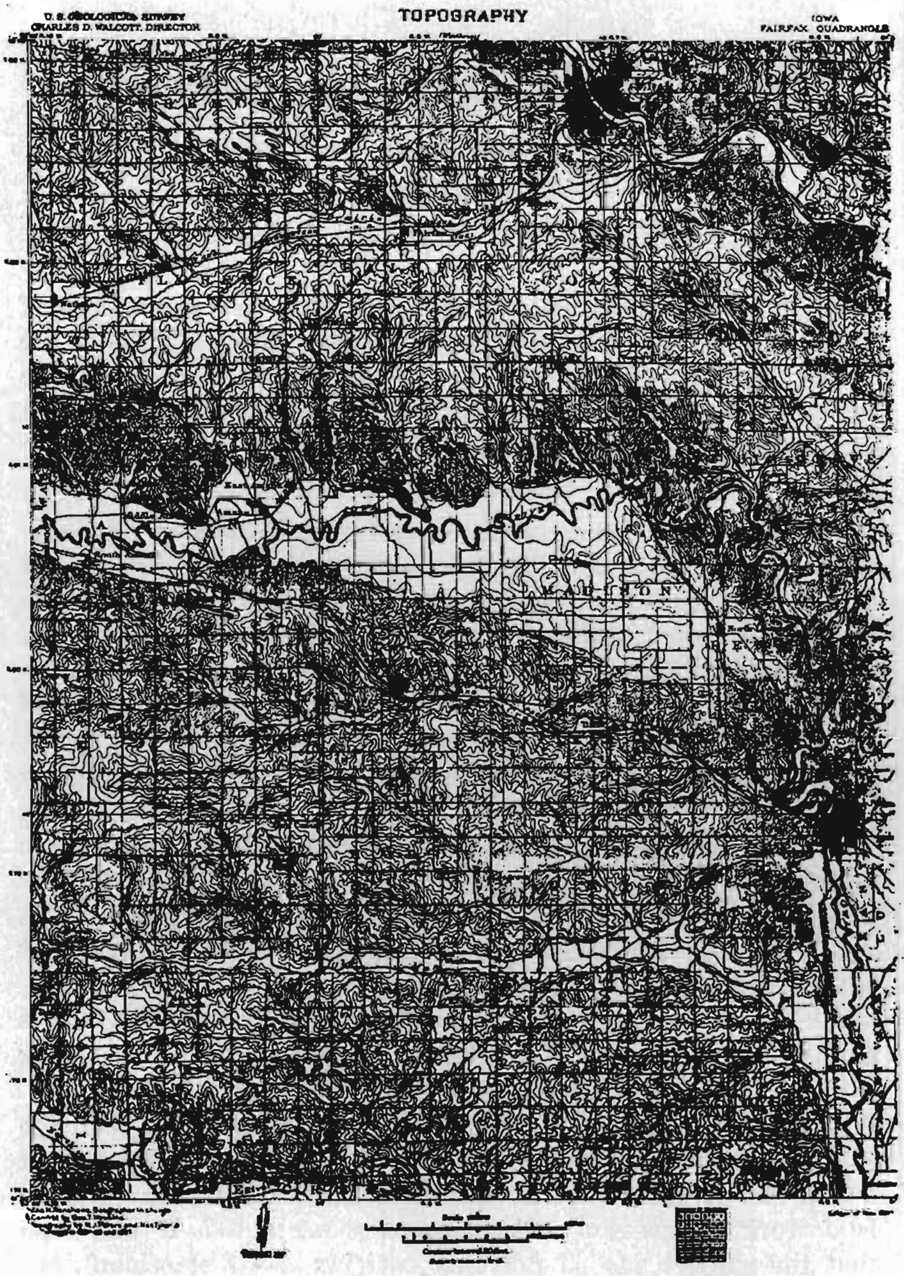
Physiographically, the region lies within the great area of Kansan drift, and also includes the North Liberty Lobe of the Iowan drift-sheet as mapped by the late Professor Calvin. The topography of this and adjacent areas is shown on the Fairfax and Stanwood topographic maps.

THE PROBLEM.

The discrepant features of the valley of Iowa river in Johnson county, as shown in Plate V, have been in the past objects of unusual interest from a physiographic and geologic standpoint. The great elbow of the stream within the county's boundaries, the gorgelike features of the great turn, the remarkable width of the valley above and below the gorge, the absence of rock in the south wall above the upper constriction to the gorge, and a similar absence in the west wall below the gorge, together with certain well records west of Iowa City showing deep glacial fill—these data had given rise to the theory that a change in drainage had occurred at some time in the history of Iowa river valley. Though this seemed to be the true explanation, yet it was held with that degree of tentativeness which is necessary when not confirmed by sufficient data.

Hence, it was with the hope of successfully working out a positive knowledge of the situation, impartial to all preceding conceptions, that the problem was undertaken.

At first, the problem was thought to involve merely a drainage change. Accordingly data were sought that would throw light on its cause, date, and the course of the old channel. But as field work progressed and evidence accumulated, it was seen that the subject needed not only revision in its statement, but amplification in order that the whole Pleistocene history of Iowa river valley might be included.



Topographic map of Fairfax Quadrangle, showing the discrepant development of the valley of Iowa river in Johnson county.

METHODS USED IN COLLECTING DATA.

The area involved in the study of relevant data includes roughly the whole of Johnson county; most of the field work, however, was done north and west of Iowa City.

Practically all of the data, excepting the well records, were collected by personal detailed investigation in the field. The river valley was carefully surveyed from Iowa City above Curtis, together with Pardieu creek, a part of Clear creek, and many of the minor tributaries. Elevations of bedrock, drift, gravel, and loess along the river were taken and many sections of materials examined. The North Liberty Plain was generally traversed with the exception of the extreme western border. One drive was taken to the southern part of the county for the purpose of studying the distribution of the loess in that direction and ascertaining its relations to the underlying surface.

Most of the well data were obtained from well drillers of experience and eight have contributed such knowledge as was relevant. They were Messrs. D. A. Jones, Henry Buck, H. A. Hemmerle, all of Iowa City; M. H. Eaton, of Shueyville; Bert Eastland, of North Liberty; Frank Novatny, of Solon; Alf. Campbell, of Oxford; and Wm. Brown, of Wellman (Washington county). In certain instances where their territory overlapped their records of depth to bedrock closely agreed.

ACKNOWLEDGMENTS.

The writer wishes to express his appreciation to Professor A. C. Trowbridge for his advisory opinions and verifications, and to Professor G. F. Kay and Mr. A. O. Thomas for helpful suggestions and encouragement. Mr. Thomas also contributed several score of well records which he had formerly collected.

PRE-PLEISTOCENE EROSION.

The Indurated Rocks.—The indurated rocks exposed along the gorge of Iowa river are Devonian limestones and isolated patches of Carboniferous sandstone and shale.

Shales, presumably of Mississippian age, are penetrated by deep wells toward the southern part of the county, and sandstones of the same general age are exposed along English river beyond the south county line.

Upon the indurated rocks, the drift rests unconformably.

Pre-Pleistocene Topography.—While it is impossible from the available well records to reconstruct the subdrift surface accurately, some knowledge concerning it can be gained from a study of well records. Approximate elevations of the rock surface can be determined by subtracting from the altitude of the well-site, as obtained from the topographic map, the distance to rock, or the depth of the well where bedrock is not reached.

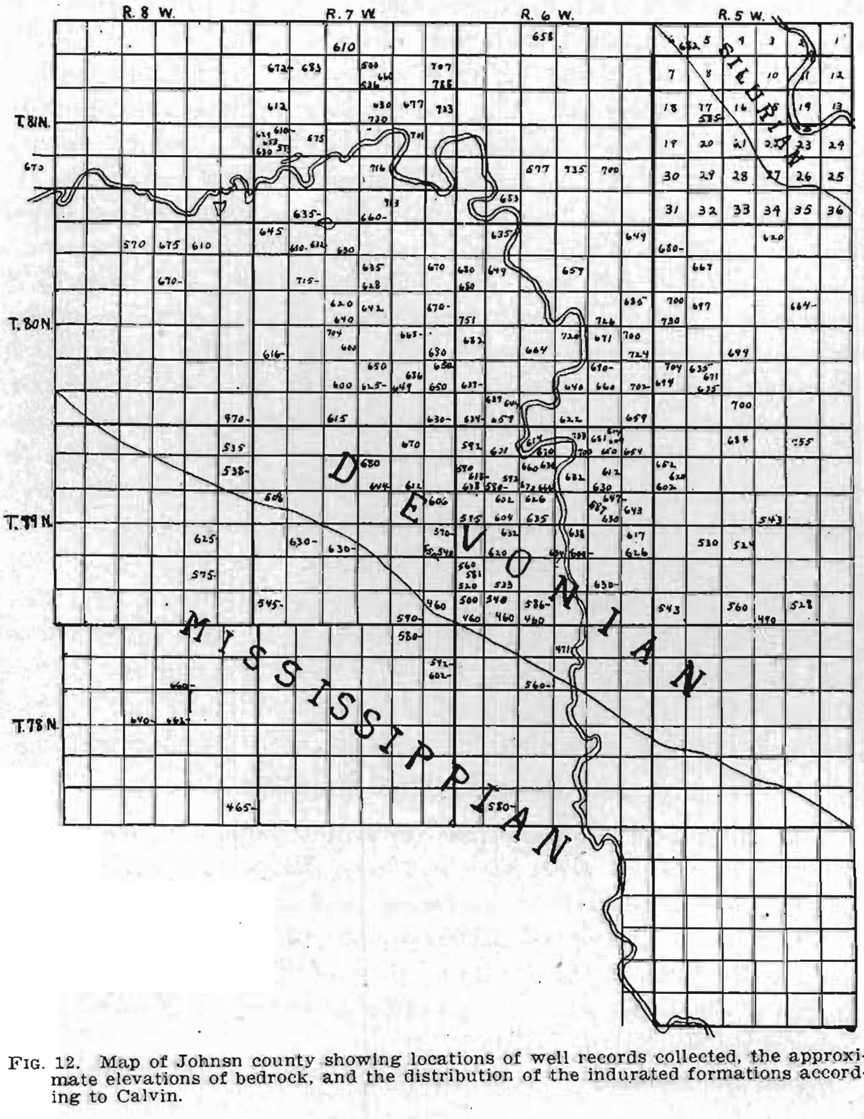


FIG. 12. Map of Johnsn county showing locations of well records collected, the approximate elevations of bedrock, and the distribution of the indurated formations according to Calvin.

These data show that the bedrock surface has marked irregularities (see figure 12). Over an irregular area in the central, northern, and northeastern parts, and along the extreme southern border of the county, bedrock is high; but between these two areas there is a northwest-southeast belt in which the bedrock surface is low. Well records, numbered 85, 86, 89, and 106, reveal bedrock as low as 460 feet above sea level.[1] Besides these, there are wells, as for instance 1, 2, 3, 83 and 104, which, though they do not penetrate rock, go down to points respectively 471 feet, 560 feet, 580 feet, 535 feet, and 545 feet above sea level.

The former group of wells penetrate shale which is perhaps the basal portion of the Kinderhook.

To the north, the bedrock surface rises on Devonian limestone and projects through the drift just north of the Rock Island trestle at Iowa City, on the west side of the river. The average elevation of the rock surface in its higher part is about 700 feet above sea level. To the south the bedrock rises on Kinderhook sandstone which overlies the basal shale. It outcrops along English river at several places:[2] (1) at Wassonville, 706 feet above sea level; (2) at Kalona, 665 feet above sea level; (3) at Riverside, 648 feet above sea level.

The distance from the outcrop at Iowa City to that at Riverside is about eleven miles. This gives an idea of the width of the buried valley. In the southwestern part of the county it seems to be even wider. Figure 12, which shows also the distribution of the indurated formations in the county, makes it evident that the north wall of the buried valley follows more or less closely the boundary between the Devonian and Mississippian formations. The lower resistance of the shale in comparison with that of the limestone on the north and the sandstone on the south undoubtedly accounts for this parallelism.

Another buried channel exists in the vicinity of Shueyville, but its relation to the large one is not clear.

It is interesting at this point to note that through the middle of the high bedrock area, as shown in figure 12, is the course of the gorge of Iowa river. On either side of the gorge, for a distance of seven to eight miles, well records show in general

[1]The logs of the wells are given in detail at the close of this paper.
[2]Bain, Iowa Geological Survey, V., p. 119.

a high rock surface. There are a few, however, that register valleys deeper than the present bed of the stream in the same latitude. This fact is significant of the partial dissection of the old divide before it was buried.

The rock surface is not necessarily wholly preglacial. If there was a long interval of erosion in the Pleistocene period preceding the heavy Kansan deposit, it is possible that bedrock was still further modified at that time.

THE PLEISTOCENE DEPOSITS.

The Pleistocene deposits of Iowa have been classified by Calvin as follows,[3] the oldest being placed at the bottom:

SERIES	STAGE
Pleistocene	Wisconsin Peorian Iowan Sangamon Illinoian Yarmouth Kansas Aftonian Nebraskan (Pre-Kansan)

Those which occur in Johnson county will be considered in the following pages.

The Nebraskan or Pre-Kansan Till and Aftonian Interglacial Deposits.

No exposures of Nebraskan till and Aftonian interglacial deposits occur within the county. The overlying drift is so heavy that if the oldest deposits are present, they can be detected only in well records. In view of the widespread distribution of known deposits over various parts of the state, it would be surprising if, among the well records collected, there were not some which strongly suggest their presence. In order better to identify them in the records, a review of their characteristics as noted by Shimek may be helpful.[4] The Nebraskan drift "con-

[3]Calvin, "Iowa Geological Section," Iowa Geological Survey, XVII, p. 192.
[4]Shimek, Iowa Geological Survey, XX, pp. 304-307.

sists chiefly of a dark blue-black joint clay which when dry is hard and brittle.....It is almost impervious to water, and when wet is very tough, tenacious, 'rubber-like,' and so difficult to work that it is the abomination of well-diggers and road-workers, being the most despised of all 'gumbos.' Scattered through this joint-clay are relatively few, usually dark colored pebbles and small bowlders."

As for the Aftonian deposits, they comprise both sand and gravel and peat and forest beds, though these do not necessarily occur together.

The well records which indicate the presence of Nebraskan and Aftonian below the thick Kansan are given below. In the records, those materials which appear to belong to the pre-Kansan deposits are italicized.

[5]Lone Tree, town-well: Soil and yellow clay, about 30 feet; blue clay, about 95 feet; *sand, about* 5 to 8 feet, *with pieces of wood and bark at top.* The driller penetrated a *bluish tough clay* below the sand for some distance, but withdrew the drill and made the sand the water bed.

[6]No. 61: Yellow clay and sand, 50 feet; blue clay, 40 feet; *hard pan,* 15 feet, to rock.

No. 65: Yellow clay, 50 feet; blue clay, 70 feet; *sand and wood,* 8 feet.

No. 84: Yellow clay, 40 feet; blue clay, 200 feet; *sand and tough clay* to rock.

No. 104: Yellow clay, 80 feet; blue clay, 100 feet; *black muck,* 5 feet.

No. 107: Yellow clay, 100 feet; coarse gravel, 3 feet; blue clay, 40 feet; *black hard pan with pebbles,* 122 feet.

No. 110: Yellow clay, 65 feet; blue clay, 65 feet, *log* at 125 feet; *gravel,* 5; *blue clay,* 25; *sand,* 5.

No. 173: Sand, 20 feet; blue clay, 118 feet; well in top of gravel, *wood came up with gravel.*

No. 178: Yellow clay, 50 feet; blue clay, 40 feet; *sand and wood,* 4 feet; *blue clay,* 86 feet; rock, 7 feet.

[5]Thomas, Iowa Geological Survey, XXI, p. 514.
[6]See records of wells following this paper for locations.

No. 181: Yellow clay, 30 feet; blue clay, 100 feet, to *gravel containing wood.*

No. 206: Yellow clay with bowlders, 30 feet; blue clay, 50 feet; *sand,* 68 feet.

No. 220: Same as No. 221.

No. 221: Yellow clay, 50 feet; blue clay, 20 feet; *sand,* 20 feet, *with red cedar log at* 85 feet; *blue clay,* 54 feet; sand, 6 feet, rock.

The presence of the wood, noted in the records, is not necessarily a true indication of Aftonian deposits. They may represent forest-growth upon that portion of the pre-Pleistocene surface evaded by the Nebraskan glacier, but advanced upon by the Kansan. Or, possibly they are remnants of forests which grew close to the edge of the Kansan ice-sheet or even upon it—as is the case to-day on the Malaspina glacier of Alaska— and were overridden or buried by a new accession to the glacier.

As for the sands, they may be deposits from the waters of the ice during a temporary retreat and then later buried by a re-advance. They may also be esker-like deposits, laid down beneath the ice.

The above interpretations might be preferred but for three opposing factors of note: (1) the kind of till underlying the sands and forests beds; (2) the mode of occurrence of the latter; and (3) their general distribution. In wells 61 and 107, the material in the bottom was distinguished from the blue clay above as "hard-pan" by two different well drillers, and in well No. 84 as "tough clay" by a third well driller. One of these drillers, especially, remarked about the difficulty of drilling through the "hard-pan." In the Lone Tree well, the driller penetrated a bluish tough clay to some distance below the wood-bearing sand, and in well No. 104, five feet of "black muck" was encountered. Of the seven wells striking wood, six encountered it in the sand or gravel layer and but one in the till, though that one was just above the gravel. Another fact indicating the presence of the Nebraskan and Aftonian deposits is the quite general distribution of the sand and wood over the county. Figure 13 illustrates this point clearly.

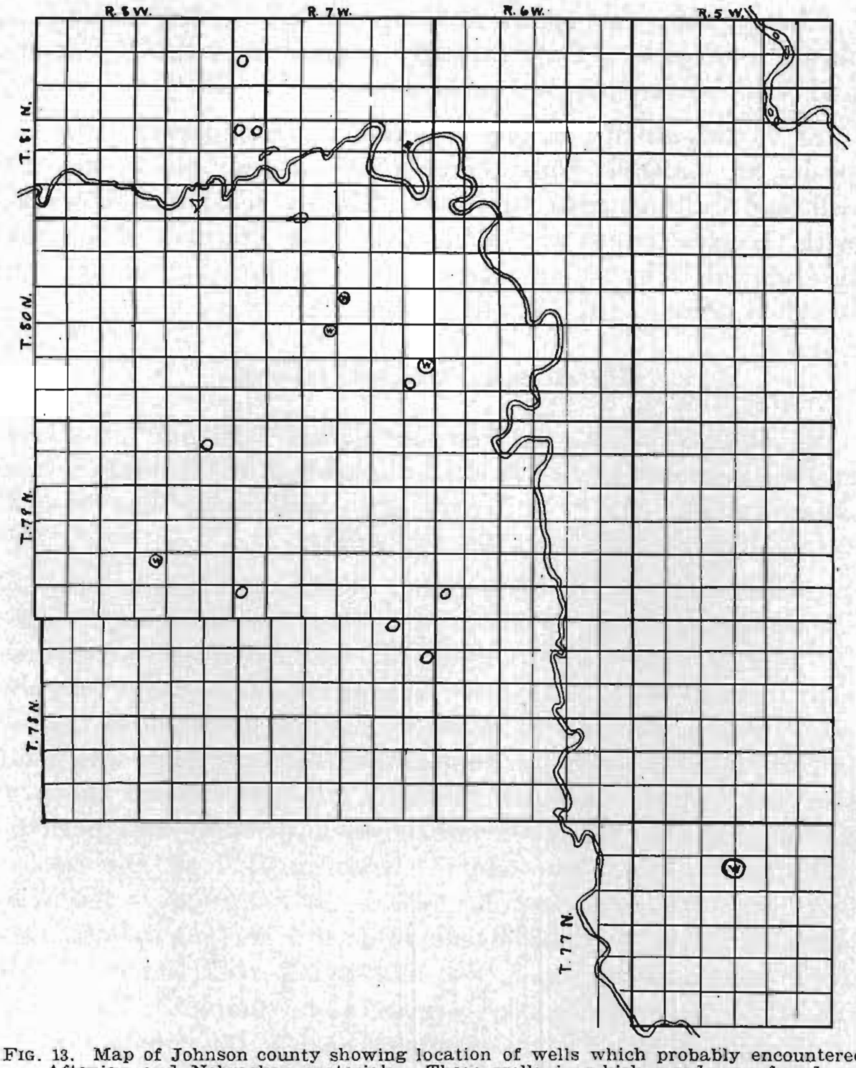


FIG. 13. Map of Johnson county showing location of wells which probably encountered Aftonian and Nebraskan materials. Those wells in which wood was found are marked by "w" within a circle.

An additional point of merit is the collection of similar records by McGee[7] in other counties in northeastern Iowa, and the occurrence of typical outcrops in areas to the south (Muscatine county) and to the southwest (Union, Harrison and Monona counties).

[7]McGee, W J, Pleistocene History of Northeastern Iowa: 11th Ann. Rept. U. S. Geol. Survey, pt. 1, pp. 514-542.

Though these evidences are not conclusive, they are by no means negligible. They strongly suggest that the Nebraskan and Aftonian deposits are present.

In so far as this county offers evidence, however, the deposits are patchy. Only thirteen well records among the 238 collected indicate their presence. This is consistent, however, with the conclusions of Calvin, that "the Aftonian was a real interglacial interval, an interval of long duration, an interval of moist climate and swollen streams."[8]

The Aftonian Erosional Interval.

In counties to the southwest, the name "Aftonian" has been applied to gravel and sand which lie between the Nebraskan and Kansan drifts, and which represent a considerable time interval between the deposition of the two drifts.[9]

Considering (1) that the sand, gravel, and wood, noted in the foregoing wells of Johnson county are Aftonian in age; (2) that the interval was long; (3) that conditions of erosion were quite ideal; (4) that thick beds of sand and gravel were derived from a till lean in pebbles; (5) that portions of the till remain, it seems probable that the original drift-sheet was not a thin one. If this was so, the drift doubtless buried the preglacial drainage lines, the minor ones at least, and perhaps the major ones of the county. Granting that the Nebraskan drift was once thick and its surface flat-lying (as is the Wisconsin), then as erosion developed on this surface the channels were superimposed upon the underlying rock-divides. This tended to make the bedrock surface more complex. The width of the buried valley in the southern part of the county may be due partly to such modifications. Figures 14 to 17 are illustrative.

Pre-Kansan Topography.—As a result of such an interval of erosion the topography finally became an erosional one, and only patches of the former drift were left upon the surface. Hence, when the Kansan ice-sheet advanced, it moved upon a

[8]Calvin, Present Phase of the Pleistocene Problem in Iowa: Bull. Geol. Soc. America, XX, p. 139.

[9]Calvin, Bull. Geol. Soc. America, XX, pp. 341-342.

rather rough topography, a topography that had developed by the superimposition of a post-Nebraskan drainage upon a pre-Nebraskan one without harmony.

The Kansan Drift.

The Kansan drift is either at or beneath the surface over the whole county excepting in stream valleys that are cut to bedrock. It lies beneath a thin younger drift in the northern part of the county, and under loess for some distance south from the borders of the new drift plain, but in the southern part of the county it comes to the surface along the hill slopes and at

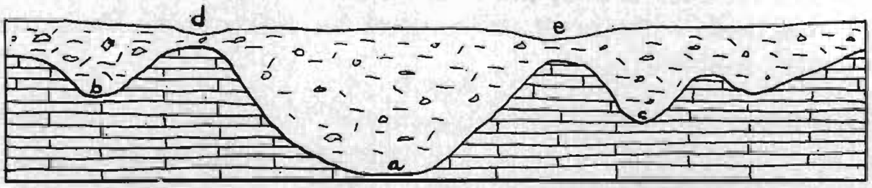


FIG. 14. Cross section of preglacial surface buried by drift: "a" the former principal drainage line, "b" and "c" two former tributaries, and "d" and "e" two incipient drainage lines on the new surface.

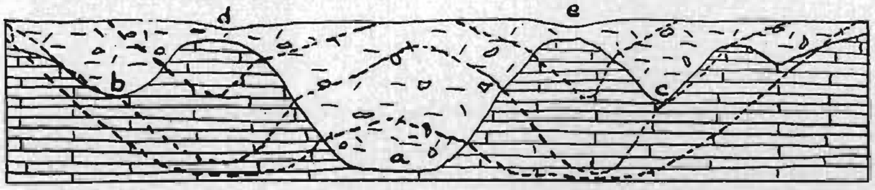


FIG. 15. Cross section showing modificafion of bedrock surface by deepening of valleys "d" and "e," and how in consequence the former valley walls might be widened and drift remnants still remain in the old valley.

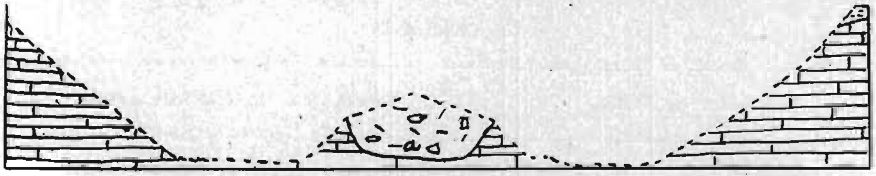


FIG. 16. Cross section of topography before incursin of a later ice-sheet. Note how it differs from the preglacial surface in Fig. 14.

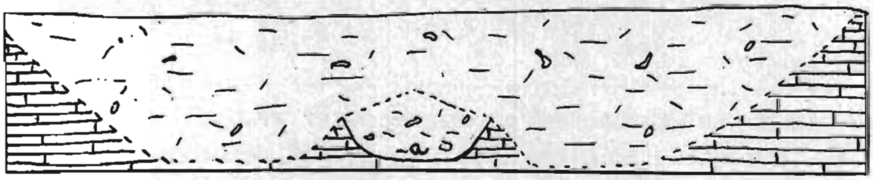


FIG. 17. Cross section showing burial by the later drift and illustrating how impossible it would be to trace out any valley that is strictly pre-Pleistocene or strictly interglacial.

the crests of divides. Alluvium and sand on the flood plains of Iowa river and of some of the minor streams also limit its exposure somewhat. But there are numerous natural exposures in the valley wall of Iowa river, a few along the smaller streams, and two artificial ones along the Cedar Rapids and Iowa City Interurban Railway.

Thickness.—The Kansan drift (including the Buchanan gravel) has a range in thickness from zero to at least 250 feet. It is thinnest where bedrock is high and thickest where bedrock is low. From the southern and west central part of the county where the rock is low, the following records in Table I are selected to show the great thickness of the Kansan, the Buchanan gravel included:

TABLE I.

No. of Well.	Thickness of Kansan Drift.
	FEET
37	162
79	197
81	190
85	250
86	250
106	250
210	224
218	228

The foregoing should be contrasted with the following typical logs in Table II, taken from the area of high bedrock:

TABLE II.

No. of Well.	Thickness of Kansan Drift.
	FEET
30	30
43	20
45	10
47	10
204	47

In the Interurban cut across the river west of Iowa City, the Kansan drift (including Buchanan gravel) is sixteen and three-fourths feet thick. From the numerous exposures of Kansan drift along the river, a similar impression is gained, namely, that the drift is thin on top of high bedrock.

From the foregoing, it is evident that the Kansan drift as deposited was thick enough to bury all previous drainage lines, and that the surface of the area immediately after the melting of the ice probably was level, undoubtedly similar to the Wisconsin area at the present time.

Kinds of Materials.—The Kansan till has two phases, the weathered and the unweathered. The upper part of the sheet is weathered to a rusty yellow, deep red, or brown color. It contains but few calcareous constituents, and much decayed material. The unweathered, forming the body of the drift sheet, is dark blue when damp and pale blue upon drying. Clay, containing small pebbles, comprises the main body of the till. Most of the pebbles in the blue clay are greenstone and limestone. Vertical jointing and polyhedral fracture are characteristic of the deposit. According to well drillers, there are not many bowlders in the blue clay, but in some of the gullies tributary to Iowa river in the Kansan area, as for instance in the ravines north of Iowa City, they are numerous. They comprise granites, dolerites, basalts, and quartzites, most of which are fresh. It is possible that these were derived from the Iowan ice-sheet by glacio-fluvial drainage. Most of the bowlders that occur above high bedrock on the valley slope are altered.

No line exists between the weathered and the unweathered portions of the Kansan. A zone marks the transition from the yellow down into the blue. This zone, however, varies in thickness at different points. In the Interurban cut across the river from Iowa City the zone of transition is about three feet thick. In contrast to this, well record No. 1 (see list of wells) shows the yellow grading into blue in a vertical distance of thirty feet.

Likewise, the thickness of the wholly oxidized portion varies. In the above mentioned cut, the yellow clay is but two feet thick, whereas in logs Nos. 62, 79, 86, and 98, it is fifteen feet, twenty feet, thirty feet, and fifty-eight feet, respectively, below the red gravel. This difference may be due to various factors: (1) the thickness of the overlying gravel; (2) the texture of the gravel; (3) the compactness of the gravel; (4) the facility with which the rain-water is drained off.

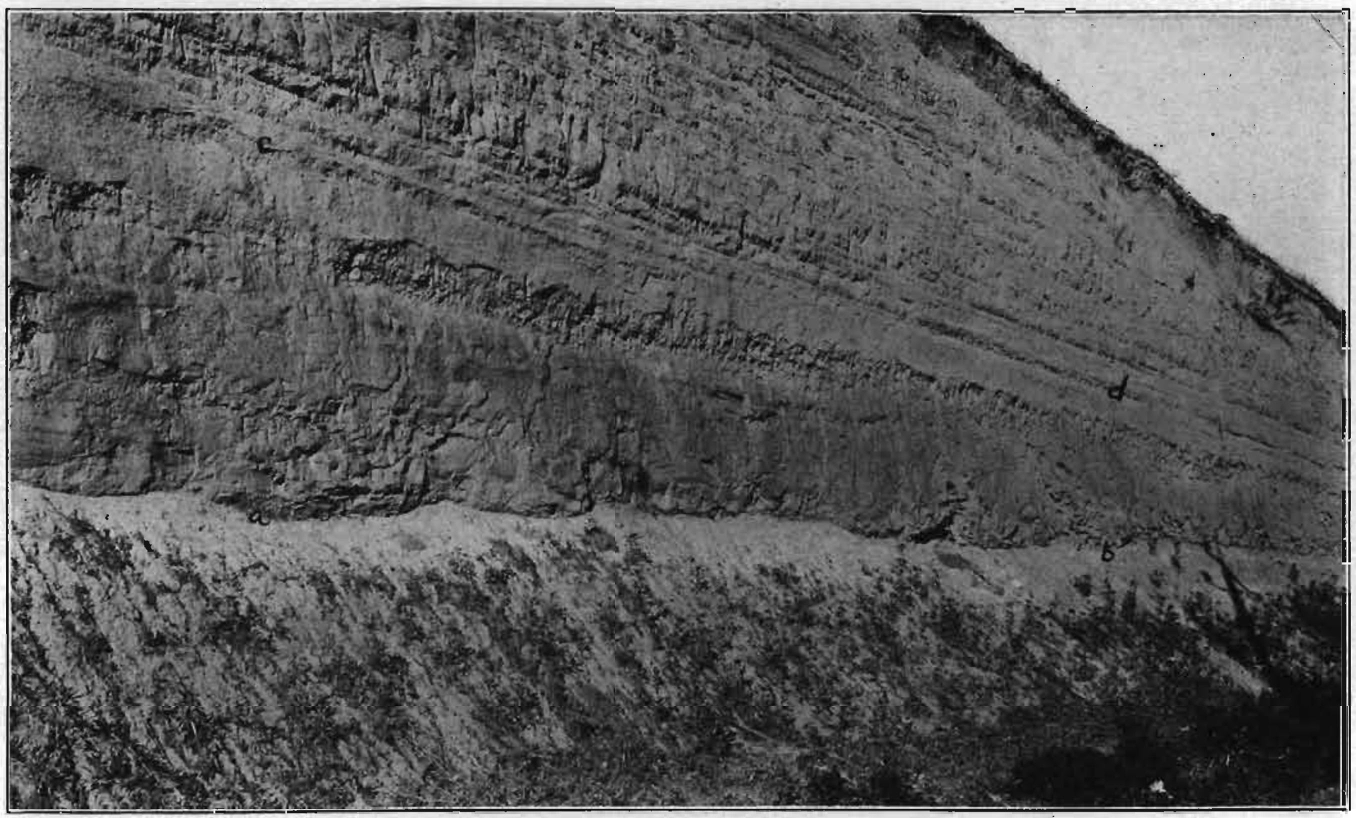
The Buchanan Gravel.—The Buchanan gravel is exposed at several places: (1) in the Interurban cut across the river from Iowa City; (2) above Saunders' northernmost sandstone quarry, three-fourths of a mile north of Iowa City; (3) one-half mile southwest of Black Springs in a ravine beside the Chicago, Rock Island & Pacific railway; (4) at Lovers Leap, one-half mile east of Coralville; (5) on the valley slope of Iowa river opposite the mouth of Rapid creek; (6) in the Interurban cut one-eighth mile north of the upper Interurban bridge.

The gravel is noted also in many of the well records following this paper as lying stratigraphically above the blue clay with yellow clay intervening.

Professor Calvin in reports of the northern counties has described two phases of the gravel: the coarse, bowldery gravel he named the upland phase, and the sand and pebbly gravel the valley phase. It was his conception that the upland phase was deposited near the edge of the ice on divides and the valley phase along drainage lines some distance from the ice.

The gravel in the Interurban cut across the river from Iowa City is quite bowldery; it, therefore, has the aspects of an upland phase. The deposit comprises four layers of stratified gravel alternated by a dark reddish, compact, sandy layer, the one near the top being more distinctly reddish and compact than the one near the bottom. In the coarse gravel beds, the range in texture is from fine sand to small bowlders eight inches in diameter. The whole mass aggregates from four to eight feet in depth and the layers pinch out from below toward the east end of the cut. The gravel is much oxidized and decayed. This extent of weathering is comparable to that of the underlying material but is strikingly more than that of the overlying loess. Upon this basis, therefore, the gravel lies conformably upon the till and unconformably below the loess. The reddish appearance of the body of gravel makes it distinguishable from the loess for some distance. See Plate VI.

In the ravine one-half mile southwest of Black Springs, near the Chicago, Rock Island & Pacific railway, there are two exposures of Buchanan gravel overlain by loess with an irregular horizon between the two. The east exposure shows from four to twelve feet of gravel lying below two to eight feet of loess.



North face of Interurban cut, across the river west of Iowa City. "a" to "b" marks the division between the Kansan drift below and Buchanan gravel, and "c" to "d" the line between the gravel and the yellow loess above.

The gravel is stratified in the lower part and one stratum shows cross-bedding. The average texture of the materials is that of coarse sand or small pebbles, although a few small bowlders six or eight inches in diameter occur. Incidentally, from this standpoint, this deposit represents Calvin's valley phase. On the other hand, it lacks only about seven feet of being as high above the river as the upland phase in the Interurban cut opposite Iowa City. The gravel has been much weathered. The upper part grades into a pale drab, sandy and silty material containing a few scattered pieces of gravel and small cobbles and showing no sign of stratification. The contact with the loess above is an irregular one, and in one place a pebbly band divides them. This irregular contact crosses the ends of some of the gravel strata and reduces the thickness of the gravel from twelve feet to four feet. Similar relations and characteristics exist in the exposure to the west. Here the gravels vary in thickness from fifteen feet to zero. The loess above bears none of the weathered aspect of the gravel. It is therefore evident that in this cut the gravel is unconformable below the loess both on the basis of contact and on the basis of weathering. See Plate VII.

The history recorded by this exposure seems to be (1) deposition of the Buchanan gravel; (2) a time interval in which the upper part of the material was altered by slopewash and burrowing animals, and the constituents became altered; (3) a period of loess deposition during which the old surface was buried.

The other exposures of Buchanan gravel show the same degree of weathering as those that have been described. The distribution of the gravel is notable. Besides those places already named, the gravel was encountered in wells at various points, as follows: In No. 1 in township 78 north, range 6 west; in Nos. 37, 38, 40, 61, 62, 64, 67, 68, 79, 80, 81, and 86 in township 79 north, range 6 west; in Nos. 95, 96, 98, 106 in township 79 north, range 7 west; in No. 109 in township 79 north, range 8 west; in No. 111 in township 79 north, range 9 west; in Nos. 183, 189 in township 80 north, range 7 west. The locations of these points are shown on the accompanying map (figure 18). Evidences of even a wider distribution might have been secured had all the well drillers distinguished the materials. Neverthe-

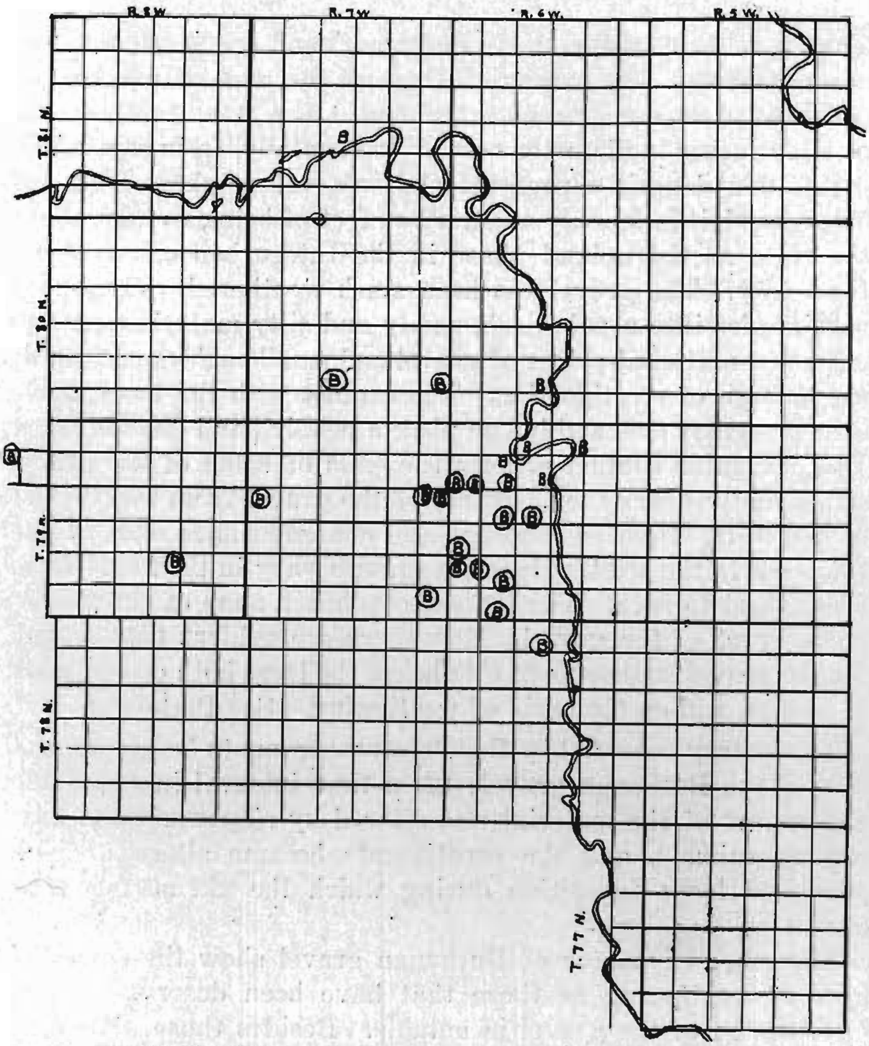


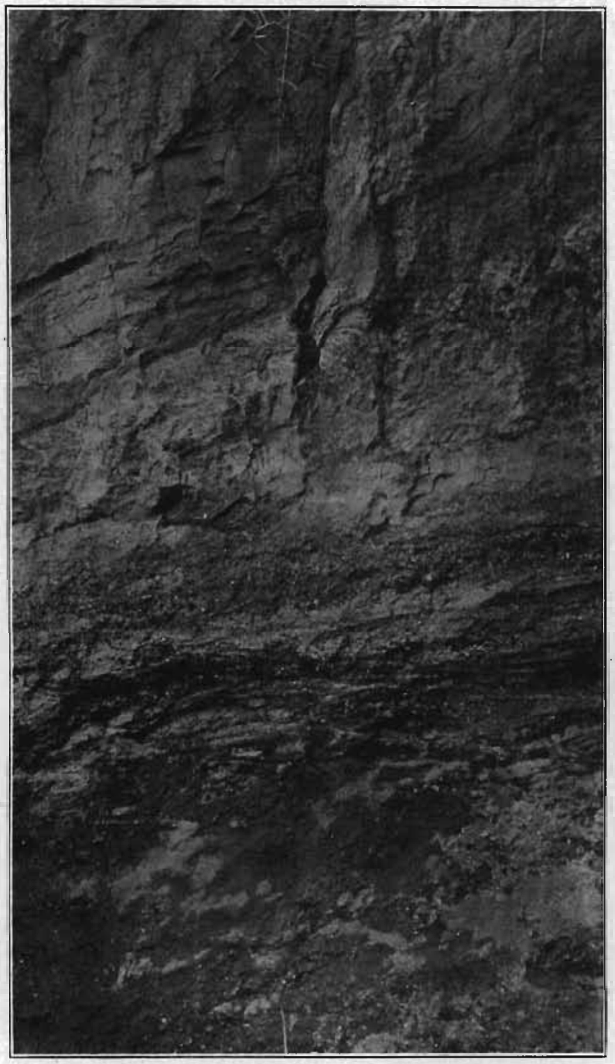
FIG. 18. Map showing distribution of Buchanan gravel in Johnson county as revealed by well records designated by "B" within a circle, and by exposures marked B.

less, the distribution herein noted is sufficiently widespread, together with their occurrence on top of the Kansan drift and apart from present drainage lines, to consider them as outwash from the retreating Kansan glacier.

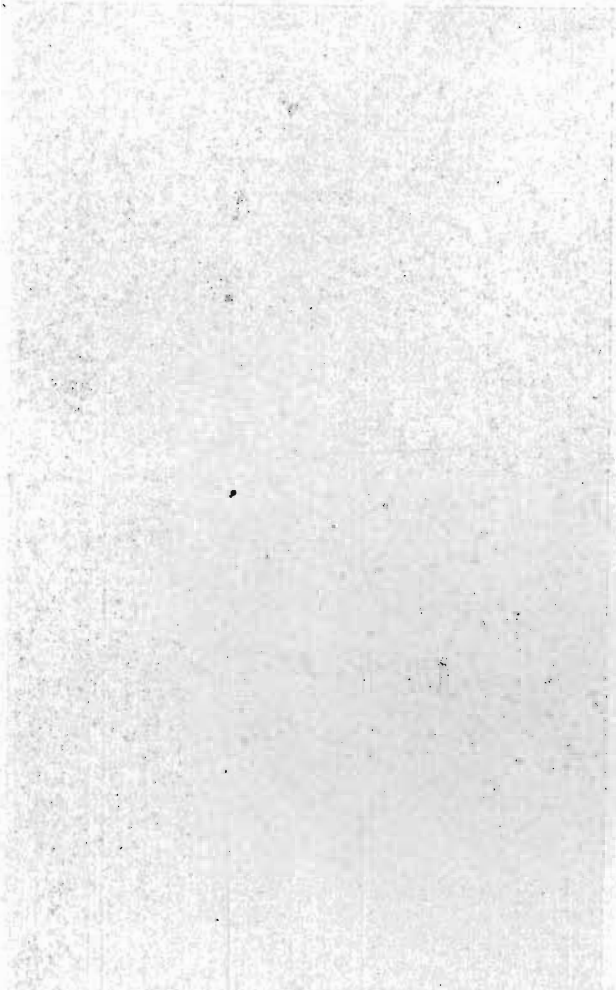
Iowan Drift.

EVIDENCES OF THE IOWAN DRIFT-SHEET.

The apparent presence of a drift-sheet in the northeast quarter of Iowa, younger than the Kansan and older than the Wis-



Cross-bedded Buchanan gravel grading up into residual material which, in turn, is overlain by yellow loess along a diagonal line, as exposed in the ravine one-half mile southwest of Black Springs.



consin, was detected by Calvin. He considered the evidence sufficient to indicate the existence of a distinct drift which he named Iowan. Lobular extensions of this drift were thought by him to reach into the northern part of Johnson county and

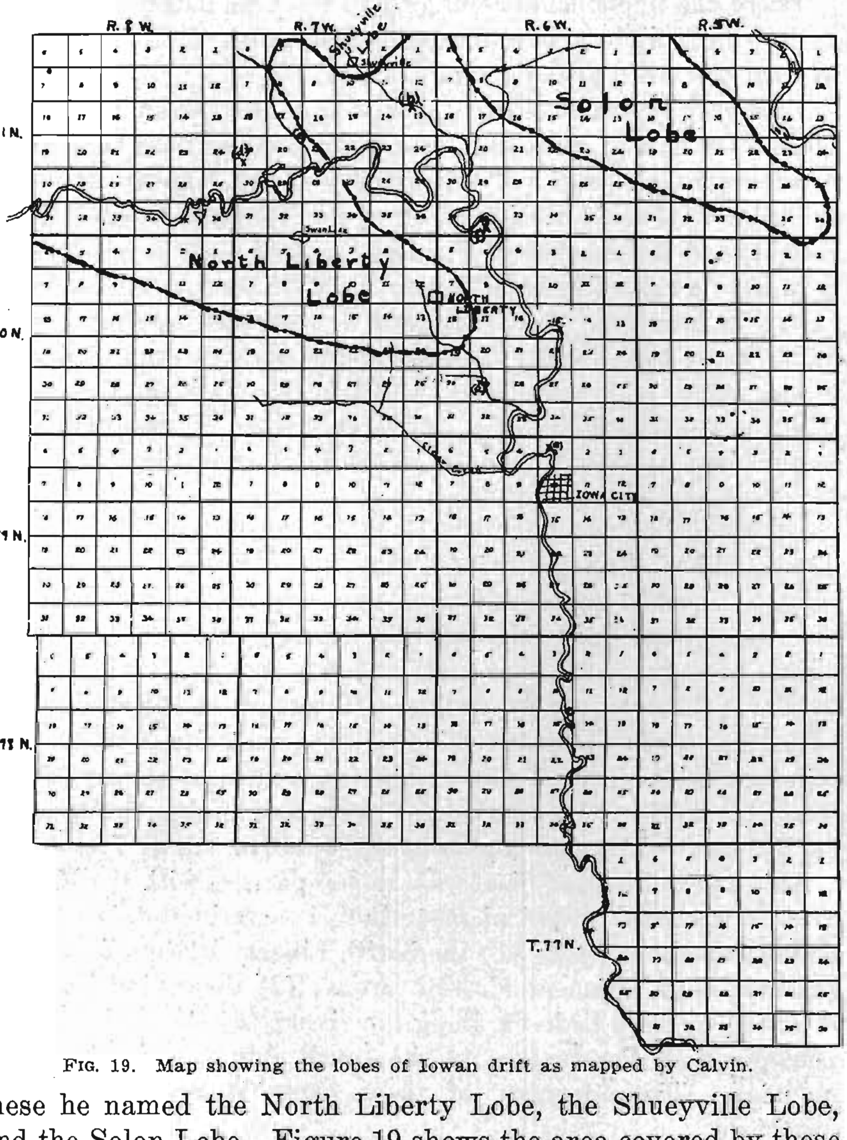


FIG. 19. Map showing the lobes of Iowan drift as mapped by Calvin.

these he named the North Liberty Lobe, the Shueyville Lobe, and the Solon Lobe. Figure 19 shows the area covered by these as mapped by Calvin.[10]

[10]Calvin, Iowa Geological Survey, VII, opp. p. 92.

In view of the fact, however, that the existence of such a drift-sheet has been called into question by Mr. Frank Leverett, of the United States Geological Survey, the evidence as shown in Johnson county will be considered.

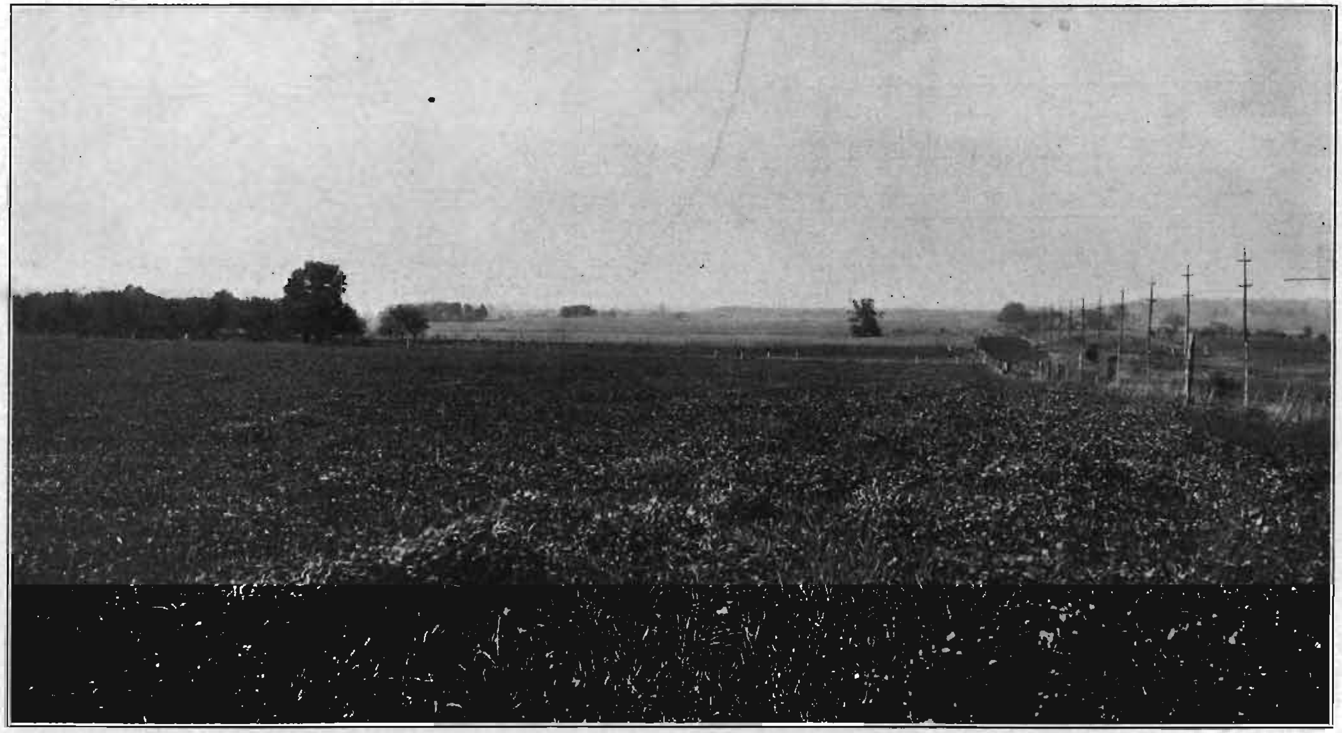
There are phenomena belonging to the area mapped as Iowan drift which, when taken together, distinguish it from the Kansan drift-sheet. These are as follows:

Topography.—The North Liberty Lobe is a gently undulating plain. Its lack of dissection offers striking contrast to the surrounding rough erosional topography of the Kansan as shown in Plates VIII and IX. Northwest of the village of North Liberty, just beyond the reaches of Pardieu creek, the surface is typically of the "swell and swale" type. Farther northwest is a topography of unrelated elevations and depressions, having a relief of not more than twenty feet nor slopes greater than twelve degrees. One depression is occupied by a small pond of water whereas the others are of a slough character. Many undrained depressions exist in the northeastern quarter of the plain, notable among which is Swan lake.

Drainage has not affected the area except near the borders. The heads of the tributaries to Pardieu creek and Clear creek have encroached somewhat upon the southeast end of the lobe, but their indentions immediately change, after crossing the border, to broad, shallow sags. This makes the surface south of North Liberty gently rolling. However, on the divides between the forks of these drainage lines, undrained depressions occur in drift. One of these is in the southwest corner of section 13, township 80 north, range 7 west, and another in the north central part of section 23, township 80 north, range 7 west.

This general lack of dissection in comparison with the Kansan area to the south might at first sight, be considered due to any one of several causes: (1) the North Liberty Plain offers lower gradient than adjacent Kansan areas; (2) dissection has been retarded by high bedrock along the river; (3) the plain may be younger than the surface to the south, due to a later glacial invasion. The adequacy of these explanations will now be considered.

(1) Nearly all the southeast one-half of the North Liberty Plain is at least 100 feet above Iowa river and in but few places



View of the North Liberty Plain.

View showing the erosional topography of the Kansan, taken near the border of the North Liberty Plain.

is the river more than one mile distant from the margin, thus making the average gradient about 100 feet per mile. The other half of the plain, toward the north, slopes toward the river with an average gradient of about thirty feet per mile. These gradients are now to be compared with those afforded by the Kansan upland to the south, where the area has been well dissected. The highest table-land along the western line of the county is 840 feet above sea level. This is 220 feet above Iowa river at the mouth of Old Man creek, fifteen miles distant. This affords a gradient of fifteen feet to the mile. In other words, the Kansan area with the mature topography has a gradient ranging from fifteen feet to eighty-five feet less per mile than the plain without dissection. It is obvious, therefore, that the difference in topography is not a matter of gradient.

(2) The bedrock along the river may have impeded the drainage of the plain and prevented dissection. If this be true, the streams that lead down to the river should give corresponding evidence. Had the streams that now lead down to the river, cut their channels through rock after the plain was made, the surface of the plain should have been lowered as the cutting took place, inasmuch as the plain is made of soft material. As a consequence, the gradient of the stream ought to be greater where it flows over bedrock than where it flows over the plain. Neither, however, is true; the streams do not have their greatest gradients where flowing over bedrock but where flowing over drift leading down to bedrock. Hence, the channels through the bedrock were made before the present plain was made, and the possibility originally considered must be ignored.

These fatal objections to the first two possible explanations add to the probability of the third, namely, later glacial invasion, as the efficient cause of difference in topography. Though windwork is in evidence along the southern edge of the plain, it is not conceivable that wind has been more than a minor modifying agent. The youthfulness of the North Liberty Plain, as contrasted with the mature Kansan surface surrounding it, can best be explained on the basis that the plain was made more recently than the Kansan plain.

Drift at the Surface.—Coextensive with the level topography of the North Liberty Lobe drift comes to the surface. At one time the plain was dotted with numerous bowlders, but with the progress of settlement they have been mostly cleared from the fields. Mr. D. A. Jones, a well driller of some twenty years' experience and a resident in this region for thirty years, remarked to the writer that bowlders were plentiful in the vicinity of North Liberty in the early days, but that now most of them have been removed. Also on the Solon lobe, between Ely and Shueyville, fences of bowlders were common thirty years ago. Even at the present time it is not unusual to see bowlders along fences or in the middle of fields.

Such conditions, however, do not exist within the area conceded to be Kansan. In addition to the coextensiveness of the drift over the North Liberty Plain, the character of the drift is different from the Kansan. The till, where exposed on the plain in the shallow Interurban cuts, is more porous, arenaceous, and distinctly yellower than the weathered Kansan, lacking in the rusty tinge that oxidation has given the latter.

Marginal Deposits of Loess.—From the border of the North Liberty Lobe and extending out in all directions for many miles are thick deposits of yellow loess that have added to the sharpness of the Kansan topography. These deposits begin right at the break between the plain of youthful topography and the area in maturity. They thin out and become finer in texture as distance increases from the plain. Such relations strongly suggest that the loess has an origin intimate in its relation to the origin of the North Liberty Plain, that perhaps it was picked up from the mud-flats on that surface during the retreat of the post-Kansan ice-sheet and deposited around the borders of the plain.

Valley-train Terraces.—In valleys leading down from the North Liberty Plain, from the Shueyville Lobe, and along Iowa river from Curtis to Iowa City, are the following terraces of sand and gravel:

(1) A notable one of these occurs on the west side of the valley of Pardieu creek about one mile below the North Liberty Plain, in the west central part of section 29, township 80 north, range 6 west. The terrace is about one-fourth mile long, fifteen

feet high and from twenty-five to seventy-five yards wide. Except where dissected, it has a flat top, and is backed by a hill that rises to a height of about sixty feet above the terrace.

FIG. 20. View of the terrace in Pardieu Creek.

Several exposures in the side of the terrace show stratified sand and gravel, with a few small lenses. The sand is dominant, but gravel, ranging in size up to three inches, is mixed with the sand. They show no alteration, no oxidation and no rusting, and they are so loose that they will not stand with steep faces. In every way they have a fresh appearance.

There are no terraces on the east side of the valley.

The deposition of the sand and gravel took place, it is clear, after Pardieu creek had cut its valley. Whether the overloading took place by drainage waters from the North Liberty Plain or from a wash into the valley from the west, the significance is the same. The material is of glacial origin, and the fact that Pardieu creek was changed from an eroding stream to a depositing one for a period sufficiently long to aggrade its bed fifteen feet, and the fact that it drains from the North Liberty Lobe, are indications that Pardieu creek received a valley train from an ice-sheet after its valley was eroded.

(2) Two deposits, apparently of similar character, occur in other drainage lines leading from the North Liberty Plain. One of these is in a tributary to Clear creek, about the central part

of section 26, township 80 north, range 7 west; the other lies in a tributary leading east from the Plain to Iowa river, about one and one-half miles east of the village of North Liberty.

(3) From the Shueyville Lobe, a tributary flows southeastward through the village of Shueyville joining Hoosier creek just above its junction with Iowa river. In this tributary, on the south side, where it is crossed by a north-south road, in the northwest quarter of section 13, township 81 north, range 7 west, there is a terrace that extends for about one-eighth of a mile, and is twenty feet high and 50 to 100 yards broad. The material is not exposed in good sections, but in a side-wash and along the slopes sand is evident, suggesting that it is a sand terrace. This terrace probably has the same relation to the Shueyville Lobe that the terrace in Pardieu creek has to the North Liberty Lobe.

(4) Along the north side of the ravine running parallel with the Cedar Rapids and Iowa City Interurban from Swisher to Cou Falls, there is a benchlike feature averaging as much as thirty feet above the present stream. Apparently it has lost some of its former distinctiveness by lateral dissection. In the excavations made by the Interurban, sands, mixed with some coarse gravel, and in places cross-bedded, are exposed. This eliminates wind action and affirms deposition by running water. The material is the same in character as that in the Pardieu creek terrace and probably is of similar origin.

Three or four miles west of Cou Falls, in the southwest quarter of section 19, township 81 north, range 7 west, an intermittent creek has cut down a straight-walled channel ten feet deep into a very gently sloping area which leads up to some morainic-like hills of drift capped with loess. The materials are outwash and afford the following section:

	FEET.
3. Soil and clay, unstratified	2-4
2. Gravel parting, apparently residual	0-3
1. Sands, stratified in long lenses, yellow, medium-grained, arkose	2-4

(5) At the Helman sand-pit, situated on the north side of the bend of Iowa river just north of Iowa City and on the west side of the tributary that dissects the valley wall, is an exposure of silt, sand, and gravel, overlain by loess.

FIG. 21. View of terrace-like feature at the Helman sand-pit one mile north of Iowa City.

The site, illustrated in figure 21, resembles a remnant of a terrace. On both sides of the tributary, particularly on the east, the summit is flat-topped for some little distance back to the higher land. The uniform elevation to the west for a quarter of a mile, with higher land to the north, as shown in figure 21, still further suggests a terrace. Were it not for the break in continuity by the tributary, the semblance would undoubtedly be even more perfect.

In the bottom of the cut, to the left of the picture, as shown in Plate X, are distinct pockets and lenses of gravel, sand, and some silt, with a range in texture from very fine to pebbles the size of a walnut. The outlines of the pockets depict well the channels of rapid currents, which afterward became filled with the sand and gravel. About four feet higher in the cut, the material grades into sand and silt. The sand is quite dominant in the lower part (represented in the picture by the light streaks), in fact, so much so that the sand lenses are separated by yellow silt-partings. This relation, however, gradually changes within a height of two feet until the main lenses are no longer of sand but of silt and the partings are not of silt but of sand. In this zone, which is three feet in thickness, one terrestrial molluscan shell, characteristic of the yellow loess, was found by Professor Trowbridge. Above this where the mass is mainly silt, save for a few thin scattering lenses of sand, loess fossils are common, and their presence requires the term "loess" to be applied to the silt even though it has precisely the same appearance as the silt bands below. This loess constitutes the upper ten feet of the exposure. All of the material is arkose—unconsolidated, unstained, and unaltered.

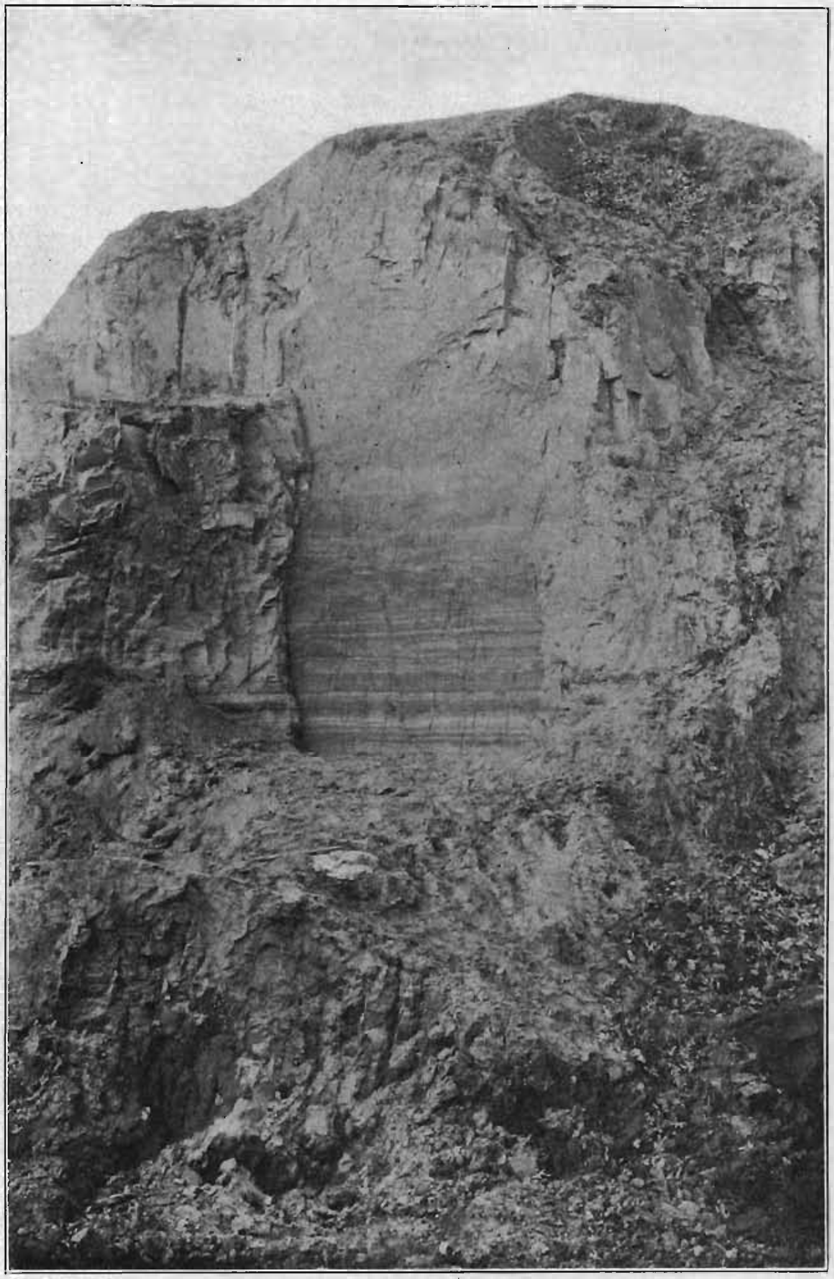
Stated briefly, there are here exposed three feet of fresh, water-laid gravel and sand at the bottom grading intimately upward through the zone of sand and silt bands into loess that is undoubtedly of wind origin.

The coarse texture of the gravel below and the pocket structure (which could not be shown in the photograph) render it impossible to refer the gravel to wind action or to deposition in still water. The material at the bottom is unquestionably a running water deposit, that at the top is clearly æolian, but no line can be drawn between them.

This deposit lies within the valley wall and hence seems to be younger than the valley. At present it is separated from Iowa river by a "second flat" one-eighth of a mile wide and by a vertical distance of twenty-four feet. Even the "second flat" appears not to be the present flood plain of the stream, although it once was, as evidenced by the channel scars on its surface.

From the foregoing, the history that can be read is as follows: Iowa river eroded its valley to a depth at least as low as the bottom of the gravel deposit. Conditions then became such that the degradational process was succeeded by aggradation. More material was given to the flowing stream than it could carry, and hence some was deposited. Inasmuch as the materials in the deposit are of glacial character and similar to those in Pardieu creek and other tributaries, and inasmuch as there must be an adequate source of these materials, it seems best to refer them to the same origin, namely, the ice-sheet that encroached upon the North Liberty Plain.

It is implying only normal glacial conditions to assume that during the maximum melting of the ice, great floods flowed forth, loaded with gravel, sand, and rock-flour, and that deposition in the stream-bed took place because of overloading or decrease in gradient. Also as the glacier disappeared, there were oscillations in the volume of water, the periods of flood-cessation af-



View showing the upper part of the aqueous sand and silt grading up into loess. Helman sand pit, one mile north of Iowa City.

fording conditions for wind-deposits, and the periods of flood-renewal causing a changing back to aqueous deposits, thus affording an alternating series in which the flood conditions grew less frequent and wind-action more prevalent until the deposit became wholly loess.

There are several other terraces along the course of the river between the one mentioned above and the upper Interurban bridge which might be mentioned, some of which are quite perfectly developed. One especially deserving of mention occurs just above the Mehaffey bridge, in the southeast quarter of section 32, township 81 north, range 6 west. It is about thirty feet high, one-fourth mile long, one-eighth mile wide at a maximum and is backed by a distinct valley-wall forty to sixty feet high. A well by the house on the east end of the terrace has the following log, as given by the digger: depth 63 feet (dug 27 feet, driven 36 feet); yellow clay, 16 feet; river sand and gravel, about 27 feet; hard-pan, 20 feet.

Structureless Ferruginous Gravel.—At the southeastern border of the North Liberty Lobe, about one-half mile north of Stewart, on a slope between the forks of a ravine tributary to Pardieu creek, is an artificial exposure of ferruginous gravel. The exposure is about ten feet long and six feet high, and is the site from which gravel has been taken for local use. Southward along the slope of one of the forks, reddish gravel outcrops in a continuous belt from the artificial exposure. Above the gravel is a thick deposit of loess, and in the stream-bed below is undoubted Kansan till. The gravel has a high textural range and the constituents are more or less rounded, and weathered. In character and position the body resembles ordinary deposits of Buchanan gravel, with certain exceptions. There are no lines of stratification, and the body contains angular fragments of both unoxidized and oxidized till, apparently Kansan.

Because of the dominance of the gravels and their rounding it seems quite clear that they show water-sorting, and, in view of their relations to the gravel outcropping continuously along the slope, that they were laid down as a Buchanan deposit and weathered in place. The lack of stratification and the angular inclusions of weathered and unweathered Kansan indicate disturbance and intimate mixing by a later ice-sheet.

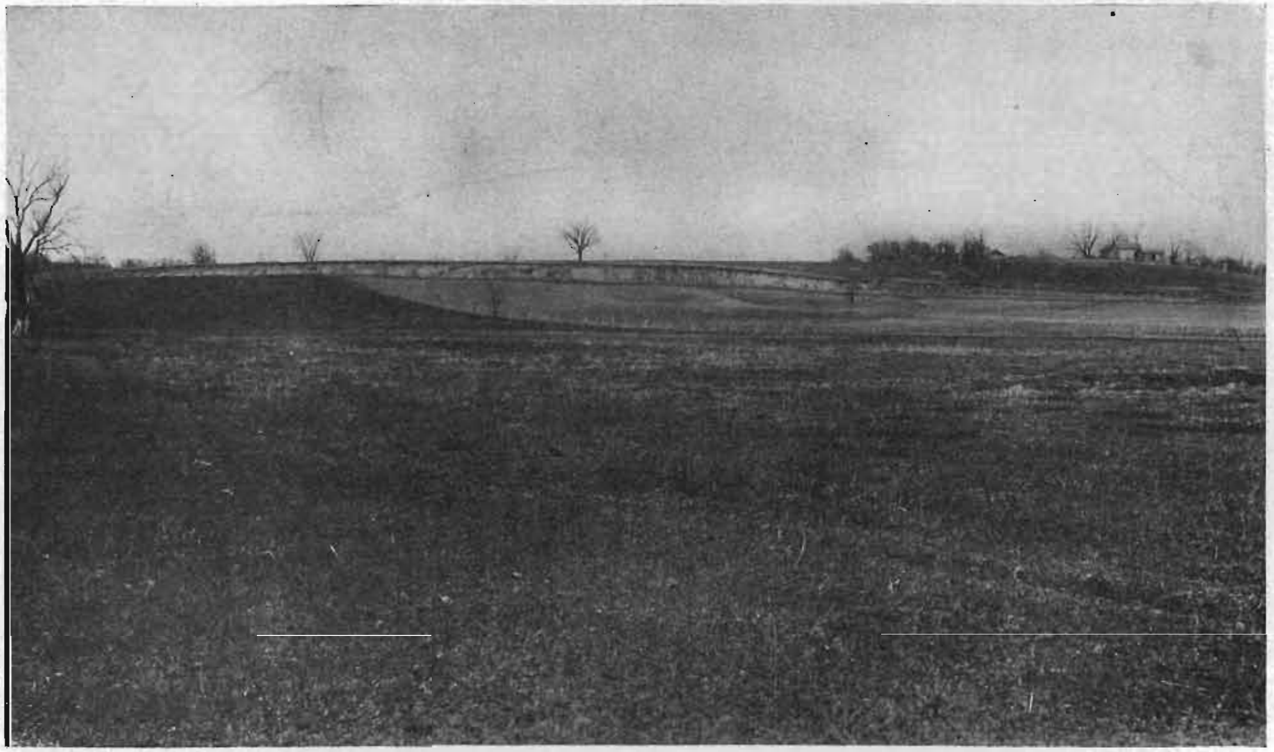
Contorted Buchanan Gravel.—An excellent exposure of folded and contorted Buchanan gravel in intimate relations to weathered and unweathered Kansan and overlain by till is shown in the first Interurban cut north of the upper Interurban bridge across Iowa river. The railroad grade here runs through the south end of a divide projecting somewhat into Iowa river valley, the summit of the divide at the surface of the cut being about thirty feet above the valley flat. The physiographic setting is shown in Plate XI. This is within the area mapped as Iowan drift by Calvin.[11]

The cut is about 250 yards long and attains a maximum depth of twenty feet. For about 120 yards, the east end is till, and for 100 yards at the west end the material is yellow, fossiliferous loess. Between these are contorted folds and rolls of Buchanan gravel in peculiar relation to the Kansan till below and overlain by two to eight feet of till. The arrangement of the materials is shown in figure 22.

The oldest material in the cut is Kansan till—blue at the bottom and grading up in places into a grayish to yellow color according to the degree of weathering. The blue drift is very clayey, contains small pebbles many of which are greenstone, and breaks with polyhedral fracture. Joints are prevalent in the yellow clay and in the upper part of the blue, but instead of being vertical they dip toward the west, which suggests that they are the result of pressure from that direction. In that case they might be regarded as slight shear-planes resulting from the same force that produced the distortion of the gravel above. Overlying this, in a peculiarly folded and contorted manner, is Buchanan gravel the textural range of which is from fine flour to bowlders one foot in diameter. The gravel exhibits the usual oxidized, weathered, and decayed character, ironstones being not uncommon and cementation by iron oxide sufficiently prevalent to have preserved stratification lines at many points.

At the west end of this section (left end of figure 22), the gravel appears in a narrow band in the lower part and rises to the east at an angle of about forty-five degrees, reaching a height of sixteen feet. From this point the gravel follows a horizontal

[11]Calvin, Iowa Geological Survey, VII, opp. p. 92.



View showing the topographic setting of the Interurban cut, one-eighth mile north of the upper Interurban bridge.

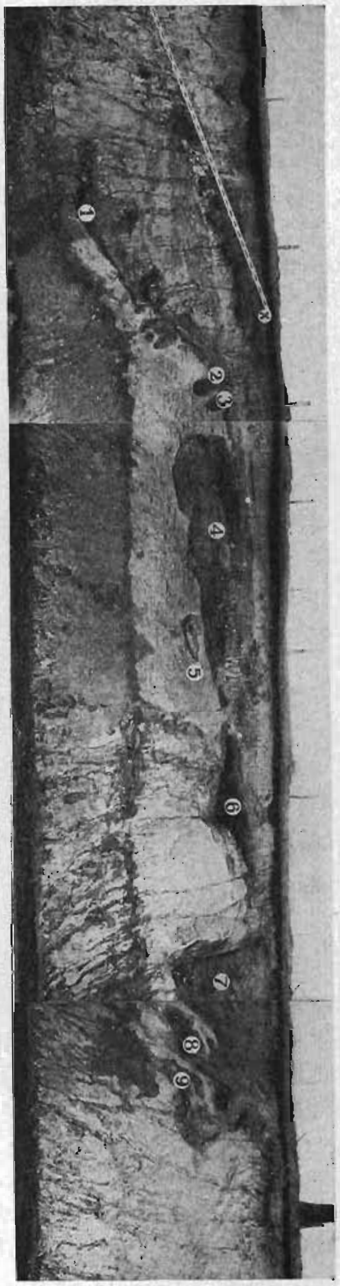


FIG. 22. View showing the folded and contorted Buchanan gravel in the first Interurban cut, one-eighth mile north of the upper Interurban bridge across Iowa river.

course eastward for about seventy-five feet and ends rather abruptly against till. In this middle portion there is a peculiar series of contortions in the gravel. Reference to the photograph shows that (2) and (3) are two small, almost perfect, synclines of the closed type; (4) is a large, elongate body twenty-seven feet long with an accumulation of small bowlders and gravel at the east end; (5) is a small elliptical roll having a nucleus of gravel with wrappings of till, all of which is surrounded by till; (6) marks a protruding compact body of gravel that has withstood slope wash; (7) is a large downward loop seven feet deep; and (8) and (9) appear as stringers projecting from the main body of the gravel into the till below. The horizontal line below the gravel is an artificial line.

At (1) and around the lower part of (7), the gravel, so altered that some cobbles can be picked to pieces by the fingers, rests against the blue unweathered till, and along the lower contact of (4) and around the lenticular body (5), the edge of a knife-blade can mark the separation of the oxidized gravel from the much less oxidized till. Till that is scarcely changed lies high in the arches between (7) and (8), and between (8) and (9). It is also striking that the gravel deep in the cut is as much weathered as that near the surface.

Overlying the gravel is a yellow, blue-streaked till, two to four feet thick across the summit, and attaining a thickness of at least eight feet along the west monoclinal limb. On the western slope of this, beginning at the point (X) and lying in contact with the drift along a diagonal line (made clearer by dotting), lies yellow, fossiliferous loess which is not contorted but which shows deposition after the disturbance of the gravel. This body of loess is in the west end of the cut.

To account for such folds, rolls, and contortions of Buchanan gravel into Kansan till in such a way as is revealed here, there can be but one possible interpretation. The sharp contact of the oxidized, altered, and rotten bowldery gravel upon unchanged till at points (1) and (7) and between (7) and (8), and between (8) and (9), and the sharp break below the elongate body (4) and around the lens (5) prove that the folding took place after the gravel was weathered. If the weathering had taken place since their disturbance, there should be at least a narrow gradation-zone between the weathered and the unweathered portions. Such, however, does not occur. Besides the foregoing significant relations, the gravel is uniformly weathered at different depths, but the till is not.

The conclusion is therefore clear that an ice-sheet, capable of distorting and molding this hill of material, invaded this region after the Buchanan gravel and some of the Kansan till were much weathered.

In view of the above interpretation there are four important points embodied in this cut: (1) the Kansan drift and the Buchanan gravel record the invasion and retreat of the Kansan ice; (2) the weathering of the same represents a considerable lapse of time after the Kansan invasion; (3) the contacts record the close of that interval and the folds give identity to the presence of a later ice-sheet and its movement; (4) the yellow loess, at least in this exposure, was deposited subsequent to the advance and retreat of the later ice-sheet.

CONCLUSIONS.

In view of the positive character of this evidence, together with the foregoing corroborative phenomena, it is quite clear that a post-Kansan drift lies within the limits of the North Liberty Plain. The distinctive features that were noted preceding the last evidence—such as the topography of the North Liberty Lobe, the drift at the surface, the marginal deposits of loess, the valley-train terraces, and the structureless ferruginous gravel—add the corroborative phenomena to be expected. In this paper, therefore, the existence of the Iowan drift sheet will be considered as substantially proven.

Loess Deposits.

Two kinds of loess exist in the region. These have been identified by Professor Shimek as pre-Iowan and post-Iowan in age. The pre-Iowan differs from the post-Iowan essentially in color, the former being blue to gray, the latter yellow. A molluscan fauna is common to both.

An exposure of pre-Iowan loess occurs in the northeast part of the old brick-yards in north Iowa City and another along the north slope of Iowa river at the fork of the roads below the Iowa City Country Club.

The post-Iowan loess is the common loess found bordering the Iowan area. It is yellow in color, fine in texture, flourlike between the fingers, gritty in constitution, variably stratified, quite compact, and has the ability to stand on steep faces. Columnar structure is visible where crumbling from steep slopes has taken place. Calcareous nodules, familiarly known as "loess-kindchen," and limonite concretions, sometimes called "pipe-stems," are quite numerous. Molluscan shells have a variable distribution through the loess where the deposit is silty. Near the Iowan drift-area the loess is sandy and coarse, but assumes its characteristic texture as distance increases.

In the excavation of some of the cuts along the Interurban from Coralville to Oakdale, not less than thirty feet of loess were exposed and its base was not reached. In the cut across the river from Iowa City the loess has a maximum thickness of thirty-four feet.

Stratigraphic Relations.—There are few sections through the loess that make clear its relations to the surface below. A study of the topography of the loess where erosion has proceeded through it into the Kansan below cannot yield conclusive results. If one were to consider, on the one hand, the result of thick loess being deposited upon a flat surface and then dissected, and, on the other hand, the result of loess being deposited upon an erosional surface, the possibility of a satisfactory discrimination between the two modes of deposition would become hopeless. Slope wash and rehandling during dissection in the first case would not only conceal the relations that originally existed, but would give the same apparent relations as would exist genetically in the second case.

The exposure of loess and Buchanan gravel one-half mile southwest of Black Springs, near the Chicago, Rock Island & Pacific Railway, mentioned on p. 120, is important in this connection. The exposure shows a residual material of silt and gravel of varying thickness which grades into the Buchanan gravel below and into the loess above. The residuum has no marks of stratification and lies across the truncated ends of the gravel strata. Because of this the gravel varies in thickness from twelve feet to four feet in the east section, and from fifteen feet to zero in the west section. In some places along the contact between the residuum and the loess above, a narrow pebble band exists, and at one point some woody substances were found. In the basal portion of the loess near this contact loess fossils also were found.

The best interpretation of the above seems to be as follows: After the deposition of the gravel a period of weathering and erosion ensued which resulted in the alteration of the gravels and a partial dissection of them. Along the slopes of dissection, residual material collected by slope-wash, creep, thawing and freezing, plant growth, etc., after which the loess was deposited on the erosional surface. If this is correct, the loess is unconformable upon the material below.

Another suggestive exposure is in the quarry of the Chicago & North Western Railway in the southeastern outskirts of Cedar Rapids, just outside the region especially studied. The quarrymen have stripped back a portion of the drift and loess overlying bedrock and cut a steep face from fifteen to fifty feet high. At the point in question the loess overlies oxidized Kansan drift along a line that resembles the depression and slopes of a former drainage line. This contact is conspicuous because of the red ferretto zone. The loess above is fossiliferous and its upper surface is that of a drainage line resembling the one below. By the deposition of the loess the depression and slopes seem to have been aggraded and raised to their present position, allowing the drainage line to retain its course but with higher and higher level.

At the Interurban cut across the river from Iowa City, the loess rests upon a level surface and there is no sharp line between the Buchanan gravel below and the loess above. The oxidized character of the gravel and the unoxidized loess is in this case the only suggestion of an unconformity between them. But due to the contrast in colors the one is distinguishable from the other for some distance.

From the foregoing evidence the idea of an unconformity between the loess and the Kansan seems conclusive.

Another method of attacking the stratigraphic relations is an investigation of the loess-covered terraces along Iowa river. In the exposure of Iowan gravel and loess in the north curve of the bend of Iowa river, one mile north of Iowa City, described on pages 136 to 141, the fluvial sands grade up into the fossiliferous yellow loess and thereby prove a conformity. The loess at this point was, therefore, deposited immediately following the cessation of waters from the Iowan ice.

The terrace just above the Mehaffey bridge also is covered with loess, as the well record, hereinbefore recorded, shows sixteen feet of yellow clay. Sand and gravel underlie the loess. There are other terraces along the river, the upper parts of which, at least, are loess.

On page 146, it is pointed out that the loess overlying the distorted Buchanan gravel in the cut north of the upper Interurban bridge was deposited after the disturbance.

These facts also strongly suggest that the yellow loess is not only post-Kansan, but post-Iowan and at least the beginning of its deposition closely followed the disappearance of the Iowan ice. This assigned age is further supported by the relation of the loess to the Iowan drift-surface, since here the loess surrounds the area and encroaches upon it only along its borders.

POST-KANSAN EROSION.

Inasmuch as the Kansan drift is thick and widespread in the county and comes to the surface excepting where covered by loess or by Iowan drift, a study of post-Kansan erosion is in general a study of present drainage. The question arises, however, as to whether all of the drainage is post-Kansan or whether part of it dates back to pre-Kansan erosion.

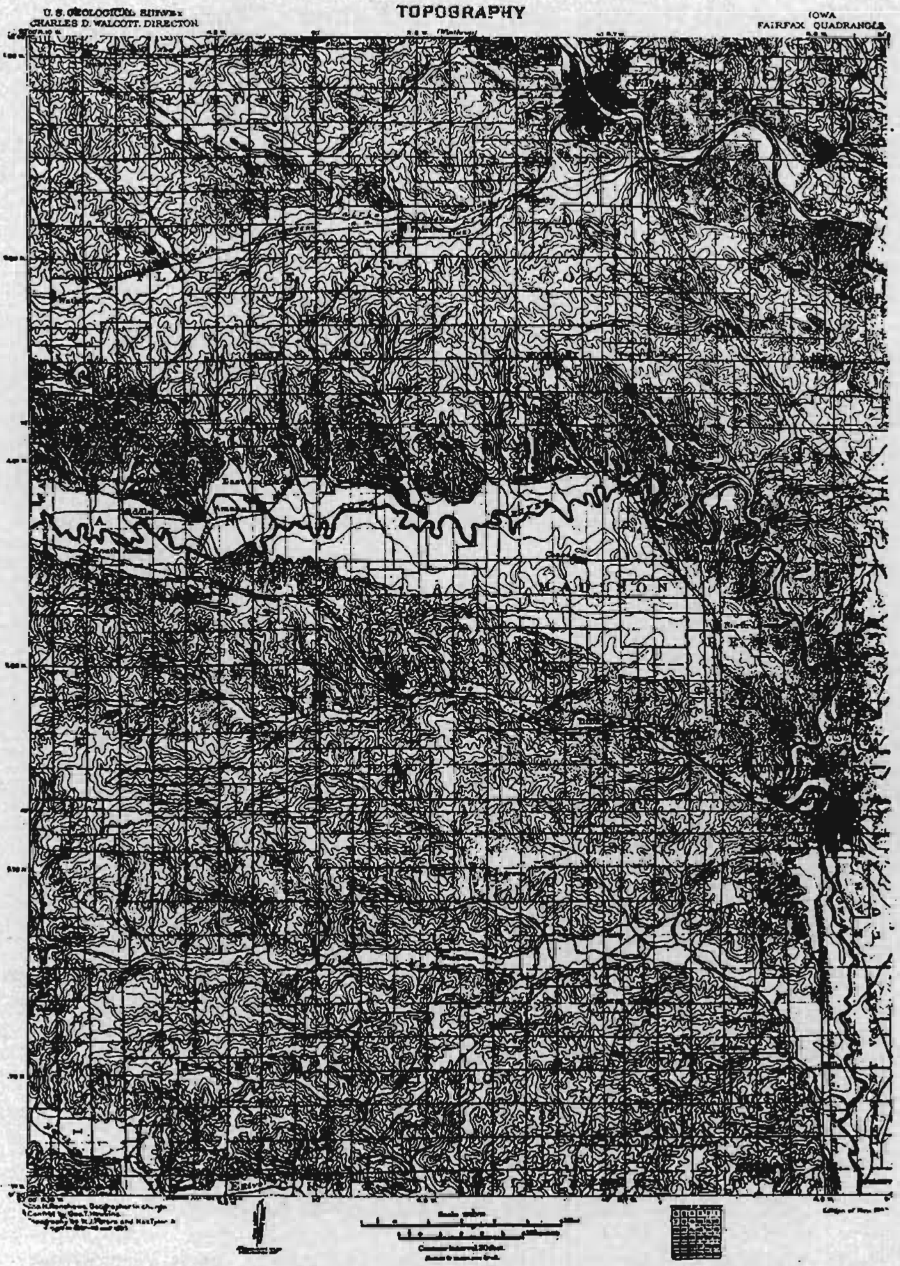
All of the tributaries of Iowa river are cut in either Kansan drift, Iowan drift, or Iowan loess, and hence are post-Kansan. Concerning this there has been no doubt. It has been thought previously, however, that Iowa river valley is in part antecedent to the Kansan invasion, and in part subsequent.[12] Conclusions bearing upon this are possible only after considering the river's features in detail.

Features of Iowa River Valley.

General Course.—Iowa river enters Johnson county five miles south from the northwest corner. For a distance of thirteen miles it pursues an eastward course, after which it changes to a southward direction, forming the notable elbow of the stream. It leaves the county near the southeast corner, the exact point being in the southern part of section 32, township 78 north, range 5 west. These and other features to be described are shown in Plate XII.

Tributaries.—Above Iowa City there are nine permanent streams from the north and east joining Iowa river on the outside of the elbow, and but two on the inside. Those on the outside of the elbow are Rapid creek, Turkey creek, Mill creek, Hoosier creek, Knapp creek, and some unnamed ones. On the

[12]Calvin, Iowa Geological Survey, VII, p. 48; Thomas, Iowa Geological Survey, XXI, p. 505.



Topographic map of Fairfax Quadrangle, showing the discrepant development of the valley of Iowa river in Johnson county.

inside are Clear creek and Pardieu creek. The scarcity of tributaries from the south and west may be due in part to a smaller drainage territory, but it is also very probable that the Iowan ice eradicated certain tributaries ~~which~~ headed westward from the river. The short tributary that joins Iowa river in the northern part of section 21, township 80 north, range 6 west, is a strong suggestion of this. It heads into the southeastern part of the Iowan drift plain for only a short distance, being but a mile in length. It is remarkable in that its lower portion is cut in thirty-five feet of limestone in spite of its being an intermittent stream. The portion toward the head is filled with Iowan drift. The tributary heading into the plain east of North Liberty is equally suggestive.

Varying Development.—Above the upper Interurban bridge at Curtis the valley has all the characteristics of old age (see Plate XIII). It is one and one-half to two and one-half miles wide and 80 to 140 feet deep, and has a valley flat many times as broad as the stream that meanders upon it. There are meander scars and oxbow lakes which represent former channels of the stream, but which have been abandoned or cut off.

In the westernmost five miles of the valley in the county, the north and south walls are of equal height, but the south wall has a gentler slope as shown in (a) of figure 23. Eastward, along

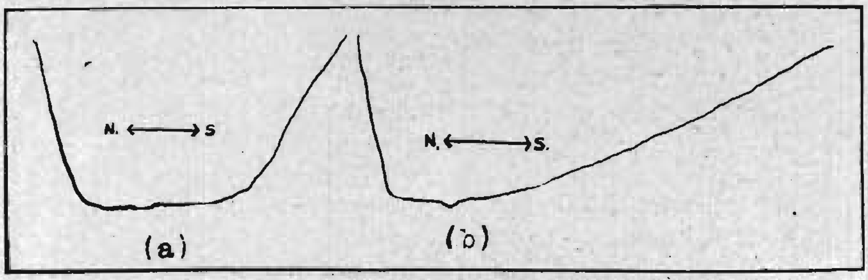
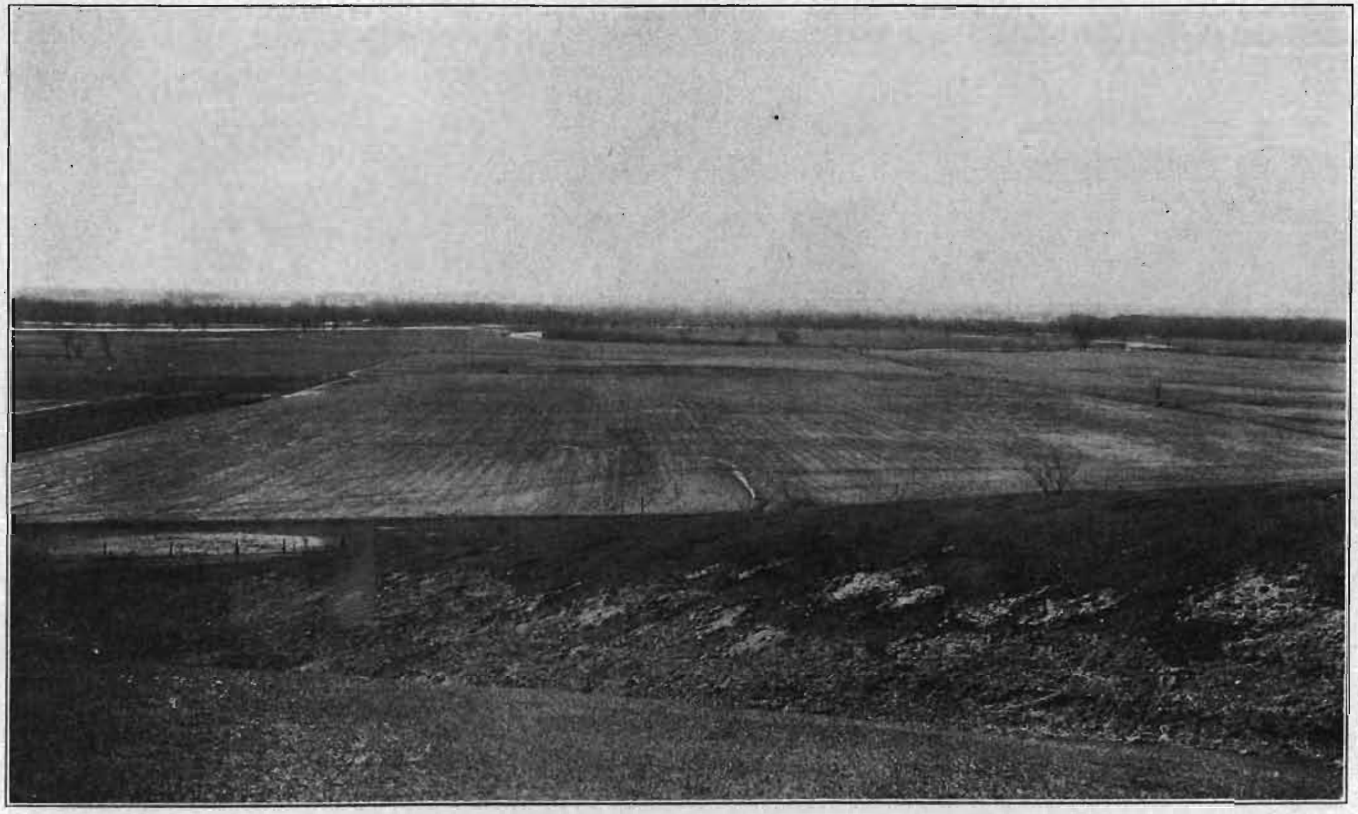


FIG. 23. (a) Cross section of valley wall four and one-half miles east from the west county line; (b) cross section four and one-half miles farther east at foot of North Liberty Lobe. In each figure the horizontal scale is one inch to a mile, and the vertical scale one-eighth inch to twenty feet.

that portion within the Iowan area, the north wall continues steep but the south wall gives way to a low, gently sloping surface that blends with the topography of the North Liberty Lobe



View across the wide segment of Iowa River Valley, above the upper Interurban bridge. The opposite valley wall is dimly visible in the distance.

(shown in (b) of figure 23). This effect is undoubtedly due to the Iowan glacier having eroded more on the south side than on the north side.

The material in the walls is drift, mainly Kansan, overlain more or less by Iowan drift and yellow loess. It is possible that in some places the Kansan is underlain by Aftonian and Nebraskan. The only place where soft material is not the sole constituent of the valley wall is at the small point which protrudes out into the valley, west of the mouth of Knapp creek. Here the lower part is rock of Carboniferous age.[13] Apart from this, rock is not exposed but lies below the level of the present stream, as shown in the last column of Tables III and IV. The data incorporated in these tables are from wells situated on the slope and on top of both walls.

TABLE III.

WELL RECORDS ALONG THE NORTH WALL.

No.	LOCATION	Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Depth below river[14]
	T. 81 N., R. 7 W.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
219	Steve Dean, S. W. Qr., Sec. 19....	800	177	171	629	71
221	R. L. Potter, S. part, Sec. 19......	780	165	150	630	70
223	W. B. Strang, E. part, Sec. 19....	710	140	137	573	127
224	Jos. Coufal, N. E. Qr., Sec. 20....	700	135	125	575	125
225	C. R. & I. C. Ry., at Cou Falls....	740	205	192	548	152
	T. 81 N., R. 9 W.					
234	Amana Society, Amana	720	1,640	50	670	50

[13]Calvin, Iowa Geological Survey, Vol. VII, map opp. p. 104.

[14]The datum plane for the river is taken as 700 feet above sea level, except near Amana, which is 720 feet above sea level.

TABLE IV.

WELL RECORDS ALONG THE SOUTH WALL.

No.	LOCATION	Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Depth below river
	T. 81 N., R. 7 W.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
231	C. Grabin, W. part, Sec. 27........	740	86	86	654	26
232	D. F. Gould, S. E. Qr., Sec. 32...	715	80	80	635-	65
	T. 80 N., R. 7 W.					
165	F. Cochran, N. E. Qr., Sec. 6......	720	85	75	645	55
	T. 80 N., R. 8 W.					
192	Wm. Novak, S. W. Qr., Sec. 2....	740	130	130	610	90
193	Jno. Shebetka, S. W. Qr., Sec. 3..	760	85	85	675	25
194	Jos. Tomas, S. E. Qr., Sec. 4......	740	440	170	570	130
196a	Amana Society, Homestead	868	2,224	300	568	152

By plotting the foregoing in longitudinal sections according to the direction of the river's course, and showing the elevation of the river and the elevation of bedrock, the bedrock surface will be seen to lie considerably below the bed of the stream (see figure 24).

At the upper Interurban bridge, the valley becomes restricted to a gorge in early maturity, and continues narrow and tortuous to the Rock Island trestle at Iowa City, a distance of some twenty-five miles. Not far below the head of the gorge, the river

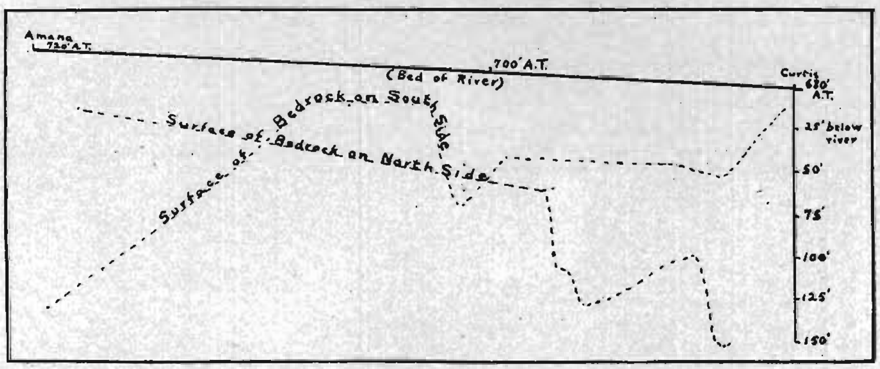


FIG. 24. Profile showing elevation of bedrock along walls of Iowa River Valley.

begins its sinuous bends and changes from an eastward to a southward direction. The valley varies from one-eighth to one-half a mile wide and from 60 to 160 feet deep. A flood plain, rarely wider than 100 yards, exists in most places but in some is totally lacking.

The stream is hemmed in by conspicuous cliffs of Devonian limestone. These are of varying height. A vertical face one-half mile above Turkey creek is ninety feet high; another on the west side of the gorge, two and one-fourth miles east of North Liberty, is seventy feet high; another of equal height occurs just below Mehaffey's bridge; and many others all along the gorge average from thirty to fifty feet in height. Overlying the rock is Kansan drift which is in turn overlain by loess. The rock, however, does not outcrop continuously, and where it is missing the drift and loess make up the valley wall from top to bottom. Where the wall on one side is of rock and the wall on the other is of soft material, the valley is asymmetrical, as shown in figure 25. This is characteristic all along the gorge and seems to be due to the lesser resistance of the soft material. And where drift is on both sides, the valley is distinctly wider than where rock occurs, as is the case four miles north of North Liberty, in the southern part of section 19 and the northern part of section 30, township 81 north, range 6 west.

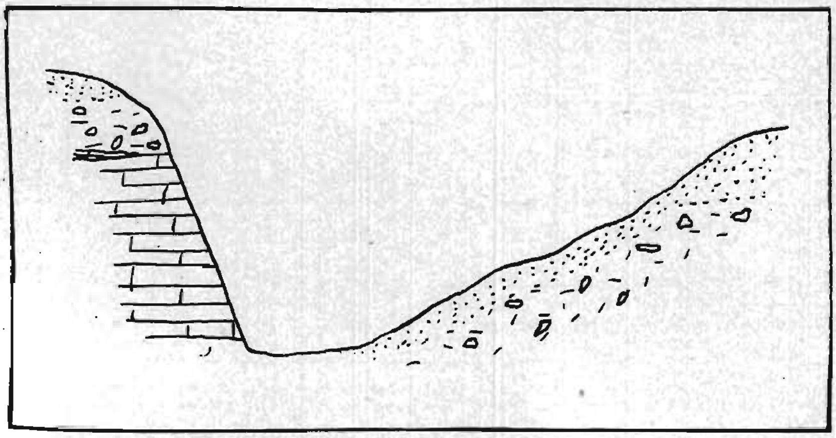


FIG. 25. Cross section of the gorge east of North Liberty at a point where rock outcrops on the side designated in the diagram but is absent in the other side.

Just below the Rock Island trestle at Iowa City, the walls diverge and the stream once more occupies a broad valley, which, in its stage of development and the materials in its walls, is similar to the old-aged portion above the upper Interurban bridge, save that the material is wholly Kansan drift and yellow loess. Bedrock lies below the river. This is indicated both by its failure to outcrop in the valley wall, and by the following tables of records taken from wells within and on top of the valley wall.

TABLE V.

WELL RECORDS ALONG THE WEST WALL.

No.	LOCATION	Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Depth below river[15]
	T. 79 N., R. 6 W.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
61	C. S. Ranck, W. part, Sec. 16....	740	250	105	635	5
62	J. P. Jones, W. part, Sec. 16.....	720	124	124	596	44
63	Henry Bird, S. part, Sec. 16.....	680	100	80	600	40
73	Jas. Paden, S. W. Qr., Sec. 22.......	660	31	26	660	6
	T. 78 N., R. 6 W.					
1	J. Glaspy, S. E. Qr., Sec. 4......	700	229	229	471-	149
2	J. Fellin, S. E. Qr., Sec. 9......	620	60	60	560-	60

TABLE VI.

WELL RECORDS ALONG THE EAST WALL.

No.	LOCATION	Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Depth below river[15]
	T. 79 N., R. 6 W.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
72	Sanders Bros., N. part, Sec. 22...	680	70	42	638	2
75	J. McCollister, S. part, Sec. 22...	640	40	40	600-	40
78	C. A. Vogt, S. part, Sec. 26......	660	30-	30	630	10

[15]The datum plane for the river is taken as 640 feet above sea level, except near wells 1 and 2, in which cases the river is 620 feet above sea level.

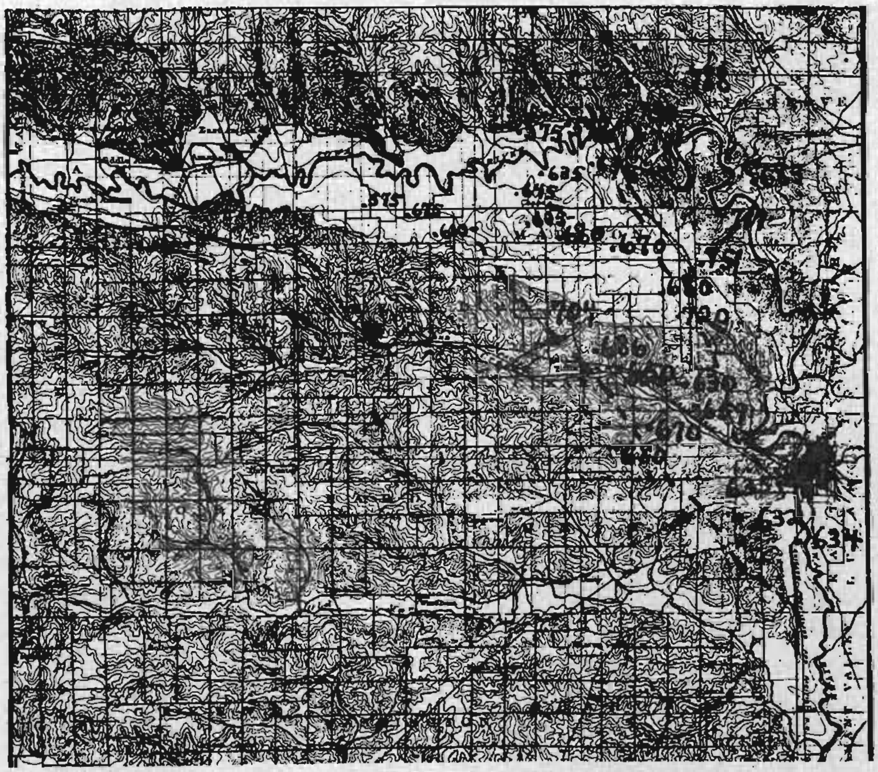


FIG. 26. Fairfax topographic map on which is marked the course of the supposed buried channel, together with elevations of bedrock in the area involved. Note that bedrock attains a higher elevation throughout the supposed old course than in the present valley, both above and below.

Cause of the Varying Development.—It is thus seen that the valley of Iowa river in Johnson county comprises three segments, two in old age and one in early maturity, the latter of which intervenes between the other two. To account for this discrepancy in development it was previously conceived that Iowa river had suffered a change in drainage.[16] It was thought that the segment which once connected the wide portions from the upper Interurban bridge to the Rock Island trestle (as marked in figure 26) lies buried beneath Kansan drift, and that because of the clogging of the channel the course of the river was deranged, forcing it to cut a new one. The gorge, therefore, was conceived to be post-Kansan in age and the wide segments pre-Kansan.

[16]Calvin, Iowa Geological Survey, VII, p. 48; Thomas, Iowa Geological Survey, XXI, p. 505.

If the above be true, it should be possible to trace the buried channel by the aid of well records. The well records in the involved area, as shown in figure 26, show, however, that no such connecting channel exists. For almost seven miles on either side of the gorge, bedrock is much higher than the bedrock below the stream in the upper segment, and there is no continuity of low bedrock surface excepting in the southern part of the county.

Hence, there could have been no change in drainage in this immediate area so far as Iowa river is concerned.

Inasmuch as it has been shown (1) that the original Kansan surface probably was level (see page 119), and (2) that the valley of Iowa river throughout its course has Kansan drift in its walls, the valley undoubtedly is wholly post-Kansan in age. The difference in valley-development is, therefore, due not to difference in age, but to some other factor or group of factors. Recalling the kinds of materials in the valley walls of the broad segments and of the gorge, it will be remembered that where the valley is wide, the materials are drift, and where narrow the material is mainly limestone. The effect of difference in materials upon the symmetry of the gorge has also been pointed out: its gentle slopes are on soft material, its steep ones on hard; and where the gorge is widest, rock is missing. Furthermore, the point of Carboniferous rock that projects into the valley of the upper segment is evidence *in situ* of the difference in degree of resistance between rock and drift.

The varying development of Iowa river valley is not due to difference in time but to difference in materials. Iowa river started originally upon the Kansan drift surface. As the stream eroded deeper it became superimposed across one area of high bedrock, while above and below, it continued to flow across drift. Due to the difference in resistance of these materials, the valley-development in drift resulted in the wide segments while that in rock resulted in the narrow gorge.

Stream Terraces.—The fact that stream terraces of Iowan age occur within the valley has been noted on pages 134 to 141. They prove that the valley is pre-Iowan in age.

Pot-holes.—At several places along both sides of the valley wall, pot-holes and eddy-scars occur at the top of bedrock. On the west side of the river at Iowa City, about twenty-five yards below Iowa Avenue bridge, there is a group of pot-holes at the top of the bedrock, thirty feet above the river. Some of them are still intact, whereas only parts of others remain. The almost perfect ones are from six to twelve inches in diameter, one to two feet deep, circular at the top and well smoothed. The remnants also exhibit the curved and smoothed surfaces.

FIG. 27. View showing the smoothed surface associated with the pot-holes at Lovers Leap.

Others equally well preserved occur at Lovers Leap, on the south side of the bend of the river one-fourth mile east of Coralville, and at a point on the west side of the river two miles east of North Liberty. The former is at the top of bedrock, thirty-four feet above the river and the latter sixty-eight feet. Much gravel is associated with the former. Figure 27 shows the smoothed surface associated with the pot-holes at Lovers Leap.

A very distinct eddy-scar occurs on top of a prominent cliff-like protrusion about one and one-fourth miles below the upper Interurban bridge at the east bend of the river. It is about eight feet long, eight to twelve inches wide and six to ten inches deep, and is somewhat sinuous as shown in figure 28. The walls are smooth, as is also the surface of the rock bordering the scar. The feature seems to have been a series of pot-holes which later

FIG. 28. A sinuous eddy-scar on top of the valley wall, one and one-fourth miles below the upper Interurban bridge at the east bend of the river.

were united. Rounded gravel and one flattened piece one and one-half inches in diameter were found in the bottom. This scar is fifty feet above the river.

There are two other places where pot-holes occur, but the preservation has not been perfect. One of these is just west of the Country Club along the top of the bedrock, forty feet above the river. The other is on top of the northeast valley wall, one mile below the upper Interurban bridge, fifty-two feet above the river. Scattered gravel occurs along the edge of the cliff.

The fact that these pot-holes are distributed all along both sides of the gorge from Iowa City to Curtis is especially significant. They undoubtedly have a connection historically with the early formation of the gorge, and represent levels at which Iowa river once flowed after it possessed a stream of sufficient permanence and currents of such velocity as to condition eddies at these places. Without doubt, flints and cherts of Buchanan gravel, which are associated with nearly all of the pot-holes, were ready tools in the carving of the limestone. Solution also may have aided.

According to this interpretation important conclusions can be drawn in regard to the amount of rock-cutting that Iowa river has done. In every case, the pot-holes are found at the top of the rock. Hence, the distance of the pot-holes above stream represents at each place the amount of cutting that has been accomplished since the pot-holes were made. Across the river at Iowa City, this amount is twenty-nine feet; at the Country Club, forty feet; at Lovers Leap, thirty-four feet; at the point east of North Liberty, sixty-eight feet; at the point one and one-fourth miles below the upper Interurban bridge, fifty feet; at the point one mile below the same bridge, fifty-two feet.

The foregoing figures do not include the thickness of the drift through which the stream cut before it reached bedrock. Nevertheless, sixty-eight feet of rock is in itself suggestive of the age of Iowa river and of the length of time since the disappearance of the Kansan ice-sheet.

The pot-holes probably were not made contemporaneously, inasmuch as those farthest upstream are not so high as those near North Liberty. But whatever their respective dates of formation they indicate that Iowa river had a high gradient in its early history.

EVENTS ATTENDING THE DEVELOPMENT OF IOWA RIVER VALLEY.

It has been shown in the foregoing data that (1) the preglacial surface was an eroded surface, made up of valleys and divides; (2) the Aftonian erosion probably added to the complexity of the bedrock surface, destroying the possibility of distinguishing pre-Pleistocene drainage lines; (3) the Kansan drift is thick and widespread and its original surface undoubtedly was a plain, covering both low and high bedrock; (4) Iowa river valley is wholly post-Kansan and pre-Iowan in age; (5) its varying development is due to difference in materials and not to change in drainage; (6) Iowa river possessed rapids at various points in its early history and perhaps small falls.

Based on these important facts the history of Iowa river is interpreted in the following pages.

At the time of the encroachment of the Kansan ice-sheet, the topography and drainage were entirely different from the

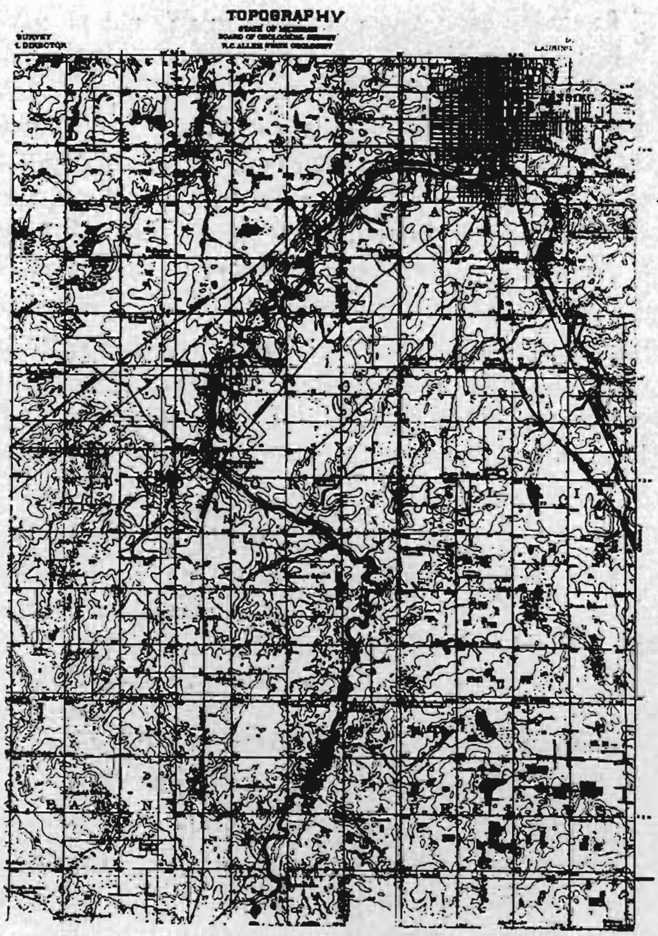


FIG. 29. Lansing (Michigan) topographic map, showing course of Grand River.

topography and drainage of the present. A wide valley crossed the southern part of the county, from west to east, and a notable rock divide lay to the northeast. This was covered by the Kansan ice, which, on melting, left drift which filled the low places and leveled off the high ones, producing a flat-lying plain. Upon this the surplus waters of the undrained depressions and surrounding areas sought the lowest outlet and ultimately established Iowa river. The course that the river now has is in general the course that marked the lowest outlet in the beginning. The great elbow represents the place where there was a change

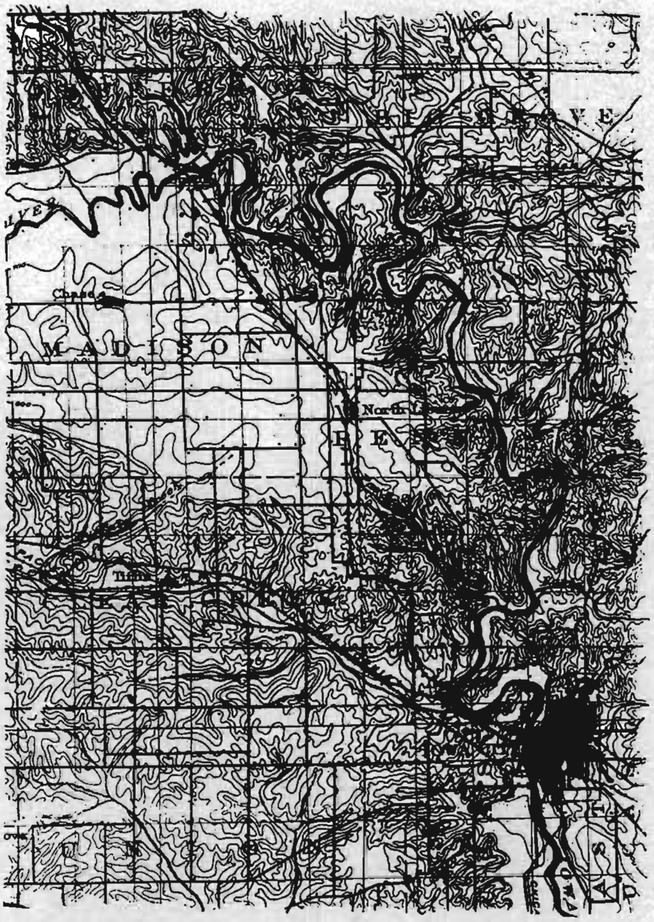


FIG. 30. Fairfax (Iowa) topographic map, showing course of Iowa River.

in slope on the original surface, and the windings of the gorge indicate the rambling of the drainage from lake to lake or around minor irregularities.

Examples of streams which have chosen their courses similar to the above are to be found on the ground moraine of the Wisconsin drift. Figure 29 is a photograph of a portion of the topographic map of Lansing quadrangle, Michigan, showing the course of Grand river on the young plain. Figure 30 is a photograph of the topographic map of Fairfax quadrangle, Iowa, showing the course of Iowa river at the great elbow. The aimlessness of the two courses is strikingly similar. The loops of Iowa river might be used to illustrate how the windings of Grand river will appear if they become entrenched in bedrock.

As Iowa river channeled its course deeper through the drift, it superimposed itself upon the rock-divides in the area of high bedrock. Having established its course it could not avoid them. The drift in the segment upstream and in the segment downstream from high bedrock, being much softer than the rock, offered extraordinary conditions for variable development of the valley. The resistance of the limestone permitted the river, in the upper segment of drift, to reach grade and to widen the valley by lateral planation while the gorge was being cut. In the segment downstream from bedrock, conditions worked differently, but the result was quite similar. The river cut so much more rapidly in the drift than it did in the rock that it reached grade sooner and had time to widen that segment to an old-aged stage of development. This difference in rate of cutting also resulted in a break in gradient at the junction of

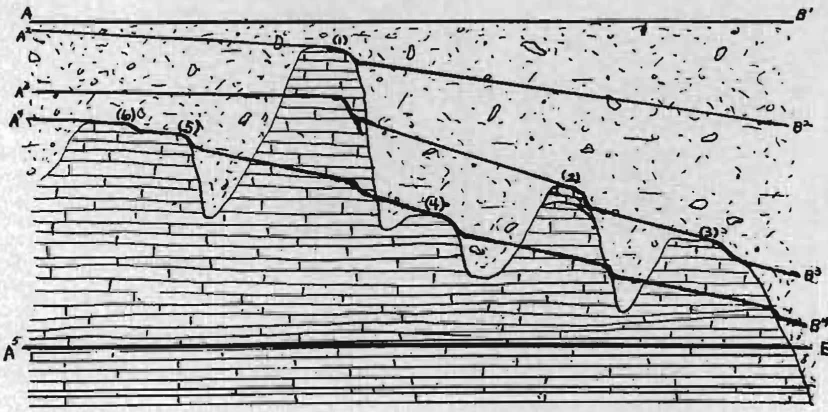


FIG. 31. Diagram illustrating progressive changes in gorge—cutting of Iowa river.

drift and rock, and rapids were developed. Even low falls may have existed. Such, however, were the conditions under which the pot-holes were made. These conditions existed first on the highest divides of the bedrock surface, which were the first ones to be reached by the stream, and other rapids developed on lower points as the stream entrenched itself more and more.

Figure 31 illustrates diagrammatically the progressive changes that characterized this period of gorge-cutting.

In the above figure A^1B^1 represents the gradient of the stream when young. A^2B^2 is the profile after the stream had reached bedrock for the first time. At (1) the profile was broken because of the resistance of the limestone, and pot-holes were formed. A^3B^3 is a later profile, after the stream had cut down to (2) and (3). At this stage Iowa river may have possessed a cascade of three rapids or falls. Pot-holes were then made at (2) and (3). A^4B^4 is the profile after all the divides, that now appear above the river, were exposed. There may or may not have been cascades at all these points, although at (4), (5), and (6) there were eddies of sufficient permanence to make pot-holes and eddy-scars. As the stream cut down from A^4B^4 it approached nearer and nearer grade. A^5B^5 represents the profile of the present stream after a cutting of at least sixty-eight feet through rock, where the rock is highest. Lateral planation within the gorge has been limited because of the limestone walls. But wherever drift occurs between the outcrops of rock it has yielded to slope wash and some planation.

Contemporaneously with the carving of the valley, tributaries developed. Some of those tributary to the gorge cut considerably into rock whereas those tributary to the wide portions of the valley are cut mainly, if not altogether in drift. The result of the development of all these has been to dissect the original Kansan plain into many valleys and divides, and so completely to change its glacial aspect to an erosional one.

Sometime after the present valley had been formed, a lobular extension of a late ice-sheet, called Iowan by Calvin, crossed Iowa river valley west of the great elbow and moved southeastward to the headwaters of Pardieu creek. It seems to have performed considerable erosion on the south valley-wall, at least an amount sufficient to blend the new drift surface with the flood plain of the river. The north side of the valley was not greatly affected erosionally, but some of the older drift was contorted and new material added. Its height and declivity perhaps was increased rather than decreased. The maximum advance of this glacier is known to have been at least six miles beyond the river, and in the course of its movement it obliterated the erosional topography of the Kansan and moulded a new plain, known as the North Liberty Plain.

From the melting of the ice Iowa river received floods of valley train material. Part of this was received directly from the ice-sheet while the rest was derived through the drainage agencies of Pardieu creek, Clear creek, Hoosier creek, and perhaps others. The load of silt, sand, and gravel being greater than the carrying power of the stream, it converted Iowa river into a stream of an aggrading or anastamosing character. The bed was built up at least twenty-four feet above the level of the present stream.

Coincident with the closing stages of melting, fine silty material was picked up from sources prepared by preceding conditions and distributed as loess over the region bordering the new drift area. These deposits ultimately increased the height of the immediate walls of the valley by at least one-half, save in certain places within the area of the young drift. This made the depth of the valley deceptively greater than the actual cutting previously accomplished by the river.

After the complete disappearance of the ice, Iowa river became once more a degrading stream. It cut through the valley train material and laterally planed it until, at the present time, only patches remain in protected places in the form of terraces. The stream again has reached grade and has developed a flat of varying width which is nowhere more than two or three times as wide as the stream.

Records of Wells in Johnson County and Adjacent Townships.

No.	Location of Well	*Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Materials
		Feet	Feet	Feet	Feet	
	T. 78 N., R. 6 W.					
1	John Glaspy, SE. ¼ sec. 4.	700	229	229+	471—	Yellow clay, 73; red sand, 3; yellow clay, 14; blue clay, 139. Graded from yellow to blue, 90-120.
2	Jno. Tellin, SE. ¼ sec. 9.	620	60	60+	560—	About all blue clay.
3	Jno. Kuebel, NW. ¼ sec. 32.	700	120	120+	580—	Yellow clay, 30; blue clay, 85; sand.
	T. 78 N., R. 7 W.					
4	J. R. Hughes, NE. ¼ sec. 2.	700	120	120+	580—	Yellow clay, 40; blue clay, 75; dirty sand to clean sand, 5.
5	R. R. Hughes, NE. ¼ sec. 12.	730	128	128+	602—	Yellow clay, 40; blue clay, 80; sand, 8.
6	W. J. Davis, NE. ¼ sec. 12.	720	128	128+	592—	Same as No. 5.
	T. 78 N., R. 8 W.					
7	Jno. Fry, SE. ¼ sec. 10.	800	140	140+	660—	Very similar to No. 8.
8	J. P. Wagner, SE. ¼ sec. 15.	800	138	138+	662—	Yellow clay, 45; blue clay, 90.
9	C. Swartzendruber, SE. ¼ sec. 16.	780	140	140+	640—	Same as No. 8.
10	J. C. Benter, NW. ¼ sec. 36.	740	275	275+	465—	
	T. 79 N., R. 5 W.					
11	Sam Bowers, NW. ¼ sec. 2.	770	117	115	655	
12	C. R. I. & P. Ry., NW. ¼ sec. 4.	800	116	116	684	
13	Ed. Balluf, NW. ¼ sec. 7.	760	213	108	652	
14	Jas. Silas, SW. ¼ sec. 7.	690	188	88	602	
15	J. T. Struble, E. part sec. 7.	720	224	100	620	Yellow and blue clays.
16	Jacob Wentz, SE. ¼ sec. 15.	760	242	217	543	
17	Frank Lord, NE. ¼ sec. 20.	730	220	200	530	

*Altitudes were determined from the Fairfax and Stanwood topographic maps.

No.	Location of Well	*Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Materials
		Feet	Feet	Feet	Feet	
18	Benj. Price, E. part sec. 21.	740	260	216	524	Yellow clay, 36; blue clay, 180; rock.
19	Jos. Bowers, NW. ¼ sec. 31.	680	317	137	543	
20	Harry Hagenbuch, NW. ¼, sec. 33.	740	226	180	560	Light blue clay, 36; sand, 1; blue clay, 20; yellow clay, 60; blue clay, 63; sand with shells, 10; hard dark blue clay, 30; coarse sand, 5; rock, 1.
21	Edw. Grier, SW. ¼ sec. 34.	730	260	240	490	Yellow clay, 36; blue clay, 180; rock.
22	Jos. Lacina, NW. ¼ sec. 35.	760	232	232	528	Yellow and blue clay.
	T. 79 N., R. 6 W.					
23	Mary Mendenhall, NE. ¼ sec. 2.	760	152	146	614	
24	Jno. Zimmerman, NE. ¼ sec. 2.	760	234	156	604	
25	Wm. Ruppert, NE. ¼ sec. 2.	800	153	146	654	Yellow clay, 96; blue clay, 50; rock.
26	L. Kessler, NW. ¼ sec. 2.	800	131	119	681	Yellow and blue clay.
27	Albert Reha, NW. ¼ sec. 2.	800	232	132	668	Yellow and blue clay.
28	D. V. Conklin, SW. ¼ sec. 2.	720	195	70	650	Yellow and blue clay.
29	Jas. Eisenhofer, NE. ¼ sec. 3.	760	174	27	733	
30	J. J. Englert, SE. ¼ sec. 3.	770	220	70	700	Yellow clay, 40; thin red sand, blue clay, 30; sandy shale, 30; limestone.
31	Mrs. Wm. Black, SE. ¼ sec. 4.	720	192	40	680	
32	Ben Hanber, SW. ¼ sec. 4.	640	126	26	614	
33	Mr. Drisdla, SW. ¼ sec. 4.	680	195	46	634	
34	Frank Awlwine, SE. ¼ sec. 5.	670	74	69	601	
35	J. K. Hemphill, E. part sec. 6.	700	108	108	592	Yellow and blue clay, gravel on top of rock.
36	J. P. Mullin, SW. ¼ sec. 7.	725	137	135	590	Yellow clay, 75; blue clay, 60; rock.
37	M. H. Clear, SW. ¼ sec. 7.	740	202	202	538	Yellow clay, 40; gravel, 10; yellow clay, 3; blue clay, 149, to rock.

No.	Location of Well	*Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Materials
		Feet	Feet	Feet	Feet	
38	S. O. Fry, SE. ¼ sec. 7.	740	122	122+	618—	Yellow clay, 40; red gravel, 10; blue clay, 50; fine sand, 20; coarse sand, 2.
39	Edw. Rohret, SW. ¼ sec. 8.	720	140	140+	580—	Yellow clay, 30; blue clay, 100; fine to coarser sand.
40	-------------- SE. ¼ sec. 8.	720	128	128	592	Yellow clay, 30; red gravel, 10, with some yellow clay below; blue clay, 88, to rock.
41	Chas. Dayton, NE. ¼ sec. 9.	700	254	64	636	Yellow clay, 54; blue clay, 10; rock.
42	Wm. Wilson, NW. ¼ sec. 9.	720	200	60	660	
43	J. U. Plank, N. part sec. 9.	720	222	50	670	Yellow clay, 30; sand and blue clay, 20, to rock.
44	Folsom Bros., SW. ¼ sec. 9.	740	224	68	672	
45	Geo. Ruppert, NE. ¼ sec. 9.	720	254	64	656	Yellow clay, 54; blue clay, 10; rock.
46	Folsom Bros., SE. ¼ sec. 9.	720	206	54	666	
47	Welch, Dunlap, Bradley and Rogers, SE. ¼ sec. 9.	720	190	40	680	Yellow clay, 30; blue clay, 10; rock.
48	Byington, Smith, Teeters, SE. part sec. 9.	720	194	40	680	Yellow clay, 30; blue clay, 10; rock.
48a	S. U. I. Hospital, Iowa City.	700	170	68	632	Yellow clay (loess), 30; sand, 38; rock.
49	Jno. Slodic, NE. ¼ sec. 11.	710	234	98	612	
50	J. J. Metzger, SE. ¼ sec. 11.	680	207	50	630	
51	Stewart Sisters, SE. ¼ sec. 11.	680	182	42	638	
52	Ed. Riley, W. part sec. 13.	680	55	37	643	
53	Chas. Lyons, NE. ¼ sec. 14.	680	76	33	647	
54	Jas. Greasel, NE. ¼ sec. 14.	680	82	51	629	
55	Cal. Williamson, SE. ¼ sec. 14.	680	71	50	630	
56	Vandenburg, SE. ¼ sec. 14.	680	39	39	641	
57	Jno. Kreg, NW. ¼ sec. 14.	680	93	93	587	
58	Frank Frauenholz, NW. ¼ sec. 14.	700	72	67	633	

No.	Location of Well	*Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Materials
		Feet	Feet	Feet	Feet	
59	F. Eggenberg, NW. ¼ sec. 16.	740	116	114	626	Yellow clay, 70; blue clay, 44.
60	A. R. Payne, NW. ¼ sec. 16.	740	116	116	624	Yellow and blue clay and gravel to rock.
61	C. S. Ranck, W. part sec. 16.	740	250	105	635	Yellow clay and sand, 50; blue clay, 40; hardpan, 15, to rock.
62	John P. Jones, W. part sec. 16.	720	124	124	596	Yellow clay, 10; red gravel, 15; yellow clay, 15; blue clay, 84.
63	Henry Bird, S. part sec. 16.	680	100	80	600	Yellow clay streaked with blue, 35; some sand, blue clay to rock.
64	Jno. Burns, S. part sec. 17.	640	276	136	604	Yellow clay, 40; red sand, 2; blue clay to rock.
65	Chas. R. Lee, NE. ¼ sec. 17.	730	156	128	602	Yellow clay, 50; blue clay, 70; sand and wood, 8.
66	Mrs. E. S. Carson, SE. ¼ sec. 18.	735	153	140	595	
67	E. S. Carson, SE. ¼ sec. 18.	740	150	150	590	Yellow clay, 10; red gravel, 12; yellow clay, 10; blue clay, 63; sand, 4; blue clay, 51, to shaly rock.
68	Mr. Miers, SW. ¼ sec. 19.	740	134	134	606	Yellow clay, 10; red gravel, 10; yellow clay, 15; blue clay, 109.
69	T. H. Morford, SW. ¼ sec. 20.	740	120	120	620	
70	W. J. Davis, SW. ¼ sec. 20.	740	120	120	620	
71	Owen Davis, NE. ¼ sec. 20.	740	108	108	632	
72	Sanders Bros., N. part sec. 22.	680	70	42	638	
73	Jas. F. Paden, SW. ¼ sec. 22.	660	31	26	634	Mostly sand and gravel.
74	Harry Holsworth, SW. ¼ sec. 22.	660	64	24	636	Mostly sand and gravel.
75	Jas. McCollister, S. part sec. 22.	640	40	40±	600±	
76	Peter Lenz, NW. ¼ sec. 24.	680	78	63	617	
77	Jos. Fuhrman, SW. ¼ sec. 24.	810	88	84	726	
78	Chas. A. Vogt. S. part sec. 26.	660	30	30+	630—	
79	J. W. Jones, S. part sec. 29.	740	207	207	533	Yellow clay, 10; red gravel, 10; yellow clay, 20; blue clay, 167.

No.	Location of Well	*Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Materials
		Feet	Feet	Feet	Feet	
80	Willard Edwards, NE. ¼ sec. 30.	760	179	179	581	Yellow clay, 10; red gravel, 10; yellow clay, 15; blue clay, 165.
81	Wm. Hastings, NW. ¼ sec. 30.	760	200	200	560	Yellow clay, 10; red gravel, 10; yellow clay, 15; blue clay, 165.
82	H. Rowland, SW. ¼ sec. 30.	760	240	240	520	
83	D. W. Jones, SW. ¼ sec. 30.	740	205	205+	535—	Yellow and blue clay.
84	S. E. Pate, N. part sec. 31.	760	400	260	500	Yellow clay, 40; blue clay, 200; sand and tough clay to rock.
85	Jos. Stover, SE. ¼ sec. 31.	720	296	260	460	Same as No. 86.
86	R. E. Jones, cent. part sec. 32.	720	306	260	460	Yellow clay, 10; red gravel, 20; yellow clay, 30; blue clay, 200; shaly rock.
87	Jas. M. Jones, NW. ¼ sec. 32.	700	400	160	540	Yellow clay, 40; blue clay, 120.
88	Matt. Howell, NW. ¼ sec. 33.	720	134	134+	586—	Yellow clay, 60; blue clay, 74.
89	Richard Peant, Sw. ¼ sec. 33.	720	410	260	460	Yellow clay, 40; blue clay, 214; sand, 6, to rock.
	T. 79 N., R. 7 W.					
90	Newman Hudson. E. part sec. 2.	770	244	100	670	Yellow clay, 80; blue clay. 20; rock.
91	John Hradek, NW. ¼ sec. 10.	780	340	100	680	
92	Geo. Wicks, SE. ¼ sec. 10.	770	126	126+	644—	Yellow and blue clay.
93	Evan Williams, SE. ¼ sec. 11.	780	318	168	612	Yellow clay, 40; blue clay, 128; rock
94	R. Williams, SE. ¼ sec. 11.	760	282	174	586	Yellow and blue clay.
95	Johnson Co. Poor Farm, NE. ¼ sec. 13.	780	182	174	606	Yellow clay, 40; red sand, 5; blue clay, 129; rock.
96	Aug. Schnare, NW. ¼ sec. 13.	740	174	174	566	Yellow clay, 40; red sand, 5; blue clay, 129 to rock.
97	Henry Schnare, NE. ¼ sec. 13.	760	187	180	580	Yellow clay, 70; blue clay to rock.
98	W. J. Seitman, NW. ¼ sec. 18.	760	390	252	508	Yellow clay, 40; red sand, 2; yellow clay, 58; blue clay, 150; rock.
99	Chas. Rohret, W. part sec. 20.	760	130	130+	630—	Yellow clay about 60; blue clay, 120.

No.	Location of Well	*Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Materials
		Feet	Feet	Feet	Feet	
100	J. R. Breese, SW. ¼ sec. 21.	720	90	90+	630—	
101	John Lloyd, SW. ¼ sec. 24.	750	100	100+	650—	Yellow and blue clay.
102	Anna Zingula, NE. ¼ sec. 24.	740	170	170+	570—	Yellow and blue clay.
103	W. E. Hastings, SE. ¼ sec. 24.	760	220	220	540	
104	Wm. Buck, NW. ¼ sec. 31.	730	185	185+	545—	Yellow clay, 80; blue clay, 100; black muck, 5.
105	A. A. Rarick, SE. ¼ sec. 35.	670	80	80+	590—	Yellow clay, 20; blue clay to sand.
106	Julius Tudor, NW. ¼ sec. 36.	720	260	260	460	Yellow clay, 10; red gravel. 10; yellow clay, 15; blue clay, 225.
	T. 79 N., R. 8 W.					
107	Jos. Springmeyer, SW. ¼ sec. 1.	800	265	265+	535—	Yellow clay, 100; coarse gravel, 3; blue clay, 40; black hardpan with pebbles, 122.
108	Wm. Quinlon, NE. ¼ sec. 12.	800	262	262+	538—	Yellow clay. 125; gravel, 5; yellow clay, 10; blue clay, 75; sand, 57.
109	J. Frichly, NE. ¼ sec. 22.	780	155	155+	625—	Yellow clay, 50; gravel, 5; blue clay, 95; sand, 5; log at 135 (walnut).
110	Jno. O'Brien, NE. ¼ sec. 27.	740	165	165+	575—	Yellow clay, 65; blue clay, 65; log at 125; gravel, 5; blue clay, 25; sand 5.
	T. 79 N., R. 9 W.					
111	Charley Frost, NE. ¼ sec. 11.	880	165	165+	715—	Yellow clay, 100; sand, 10; blue clay, 50; sand, 5.
	T. 80 N., R. 5 W.					
112	Jas. Peters, NW ¼ sec. 3.	820	202	200	620	Yellow clay, 40; sand, 2; yellow clay, 70; blue clay, 88; rock.
113	G. C. Rossler, SW. ¼ sec. 6.	820	140	140+	680—	
114	Sam Spinden, NW. ¼ sec. 8.	810	217	143	667	
115	Fred Zimmerman, N. part sec. 14.	820	156	156	664—	Yellow clay, 39; red sand, 1; yellow clay, 10; yellow-blue clay, 20; blue clay, 80; sand, 6.

No.	Location of Well	*Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Materials
		Feet	Feet	Feet	Feet	
116	Chas. Dvorsky, NW. ¼ sec 17.	830	128	123	697	
117	Lucy Hempstead, NE. ¼ sec. 18.	820	128	120	700	
118	J. J. Krall, S. part sec. 18.	820	217	90	730	
119	Sam Bowers, SE. ¼ sec. 21.	780	87	81	699	
120	Michael Donovan. NE. ¼ sec. 29.	780	130	109	671	
121	Frank Kobela, SE. ¼ sec. 29.	760	127	125	635	Yellow and blue clay.
122	Sullivan Estate, NE. ¼ sec. 29.	760	90	70	690	
123	Ed. Dvorsky, NE. ¼ sec. 30.	670	79	67	703	
124	Jos. Swaner, W. part sec. 30.	720	78	26	694	
125	Jerome Earnest, NW. ¼ sec. 33.	780	163	80	700	
	T. 80 N., R. 6 W.					
126	Jos. Dvorsky, NW. ¼ sec. 1.	780	229	131	649	
127	Anton Slaby, NE. ¼ sec. 5.	720	120	85	635	Yellow clay, 30; blue clay, 55; rock.
128	J. W. Andrle, W. part sec. 7.	760	236	80	680	Yellow clay, 20; blue clay, 60.
129	T. E. Murphy, SW. ¼ sec. 7.	770	248	90	680	Yellow clay, 20; blue clay, 70.
130	R. H. Alt, NW. ¼ sec. 8.	780	131+	131	649	Yellow clay, 40 to blue clay.
131	Jas. Shimma, NE. ¼ sec. 10.	790	231	131	659	
132	Geo. Suatos, NW ¼ sec. 13.	800	115	115	685	
133	Vincent Rounner, SE. ¼ sec. 14.	790	207	64	726	
134	Albert Krall, SE. ¼ sec. 14.	790	211	81	709	
135	Jno. Zeller, SW. ¼ sec. 18.	770	200	19	751	Yellow clay to rock.
136	Sam Green, SW. ¼ sec. 18.	740	200	19	721	Black loam, 3; yellow clay, 16, to rock.
137	M. Bowman, NE. ¼ sec. 19.	780	288	98	682	High knoll.
138	Besdek Bros., SE. ¼ sec. 20.	780	116	116	664	Yellow clay, 30; sand, 10; blue clay to rock.

No.	Location of Well	*Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Materials
		Feet	Feet	Feet	Feet	
139	Anton Linder, NW. ¼ sec. 26.	770	80	80+	690—	Sandy yellow clay, 20; blue clay, 60, to gravel.
140	Geo. Gressel, NE. ¼ sec. 22.	710	219	77	633	
141	Chas. Plashel, NW. ¼ sec. 23.	750	218	74	676	
142	Jas. Hotka, cent. part sec. 23.	760	108	108+	652—	
143	Frank Kott, NW. ¼ sec. 24.	800	85	80	720	
144	Chas. Dvorsky, NW. ¼ sec. 24.	800	100	100	700	
145	Mrs. Dohrer, SE. ¼ sec. 24.	800	146	76	724	
146	Albert Hemmer, SE. ¼ sec. 25.	730	128	28	702	
147	Vincent Anton, SE. ¼ sec. 26.	740	224	80	660	
148	Jno. Sedlacek, SE. ¼ sec. 26.	740	95	95	645	
149	Jas. Sedlacek, SE. ¼ sec. 26.	730	118	79	651	
150	Wm. Vogt, W. part sec. 26.	700	111	111	589	
151	Henry Eicher, E. part sec. 27.	720	188	80	640	
152	Jno. Dolmage, SE. ¼ sec. 30.	760	123	123+	637—	Yellow clay, 40; blue clay, 83, to sand.
153	Jno. Hemphill, SE. ¼ sec. 31.	760	126	126+	634—	
154	Jos. Kile, NW. ¼ sec. 32.	660	121	121+	639-	Yellow clay, 71; blue clay, 50; sand.
155	---- Kile, NE. ¼ sec. 32.	760	120	116	644	
156	Jno. Williams, SE. ¼ sec. 32.	760	256	101	659	
157	Jno. Eicher, SE. ¼ sec. 34.	760	243	138	622	
158	Homer Johnson, SE. ¼ sec. 34.	760	120	115	645	
159	Wm. Ruppert, SW. ¼ sec. 35.	720	156	151	569	Yellow clay, 100; blue clay, 51; rock.
160	A. Greasel, SW. ¼ sec. 36.	720	219	61	659	
	T. 80 N., R. 7 W.					
161	F. D. Myers, SE. ¼ sec. 4.	760	150	80	680	Yellow clay, 40; blue clay, 40.

No.	Location of Well	*Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Materials
		Feet	Feet	Feet	Feet	
162	M. F. Snavely, SE. ¼ sec. 5.	750	118	118+	632—	Yellow clay, 25; blue clay, 90; gravel, 3.
163	W. J. Davis, S. part sec. 5.	720	128	128+	592—	Yellow clay, 40; blue clay, 80; sand, 8.
164	W. W. Muskgrove, SW. ¼ sec. 5.	750	120	120+	630—	Yellow clay and sand, 30; blue clay, 90.
165	Fred Cochran, NE. ¼ sec. 6.	720	85	75	645	Yellow sand, 30; blue clay and sand, 45; rock.
166	T. M. Thompson, cent. part sec. 8.	780	65	65+	715—	All sand.
167	M. M. Snavely, NE. ¼ sec. 8.	750	115	115+	635—	Yellow clay and blue clay to sand.
168	Jos. Lininger, NW. ¼ sec. 10.	770	278	135	635	Yellow clay, 25; blue clay, 110; rock.
169	Geo. Hoover, N. part sec. 10.	770	262	142	628	Loam and blue clay.
170	H. Lininger, SW. ¼ sec. 10.	780	90	90+	690—	Loam and blue clay; ends in sand.
171	Alex. Morland, NW. ¼ sec. 12.	760	233	90	670	Black loam, 5; yellow clay, 20; blue clay, 65; rock.
172	J. Bridensteine, NW. ¼ sec. 13.	730	90	90+	670—	Black loam, 5; yellow clay, 25; blue clay, 34; layered sand, 26.
173	Paul D. Dodt, NW. ¼ sec. 15.	780	138	138+	642—	Sand, 20; blue clay to gravel, 118; wood came up with gravel.
174	J. C. Bowman, SE. ¼ sec. 16.	760	312	120	640	
175	M. A. Stoner, NE. ¼ sec. 16.	780	160	160	620	
176	J. D. Colony, SW. ¼ sec. 19.	760	144	144+	616—	Yellow and blue clay.
177	Caroline Dodt, NW. ¼ sec. 21.	780	210	76	704	Black soil, 5; yellow clay, 25; blue clay, 40; hard sand, 6; soft blue clay with shells, 134; soapstone.
178	W. B. Brown, E. part sec. 21.	780	187	180	600	Yellow clay, 50; blue clay, 40; sand with some wood, 4; blue clay, 86; rock.
179	Jas. Swaner, NE. ¼ sec. 23.	780	112	112+	668—	Yellow clay, 30; blue clay, 82, to gravel.
180	Chas. E. Colony, SW. ¼ sec. 24.	780	100	100	680	To rock.
181	Jno. A. Koser, NE. ¼ sec. 25.	780	130	130+	650—	Yellow clay, 30; blue clay to gravel containing wood, 100.
182	State Sanatorium, SE. ¼ sec. 25.	800	380	150	650	Yellow clay, 70; blue clay, 80, with sand.

No.	Location of Well	*Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Materials
		Feet	Feet	Feet	Feet	
183	State Sanatorium, SE. ¼ sec. 25.	800	350	150	650	Yellow clay, 40 (bowlders at bottom); red gravel and clay mixed, 12; yellow clay, 20; blue clay, 44; ledge of rock, 6; sand and gravel with lots of bowlders, 28; rock.
184	Gaugh, SW. ¼ sec. 25.	800	156	140	660	Yellow and blue clay, 100; dirty sand, 40.
185	Anthony Klein, E. part sec. 26.	780	96	94	686	Sandy loam, 5; yellow clay, 20; blue clay, 69; rock.
186	Ed. Craig, SW. ¼ sec. 26.	700	100	51	649	Yellow clay, 20; red sand, 1; blue clay, 30; hard shaly rock, 3; soapstone to "iron rock," 46.
187	J. J. Craig, NE. ¼ sec. 27.	750	213	100	650	
188	Edw. Craig, SE. ¼ sec. 27.	690	65	65+	625—	
189	Jno. Falkner, cent. part sec. 28.	750	310	150	600	Yellow clay, 40; gravel, 10; blue clay, 90; sand, 10; rock.
190	Rich. Reeve, SW. ¼ sec. 33.	800	195	185	615	Sand, 40; blue clay, 145; rock (well on hill).
191	Walter Cox, SW. ¼ sec. 36.	680	50	50+	630—	Drive well.
	T. 80 N., R. 8 W.					
192	Wm. Novak, SW. ¼ sec. 2.	740	130	130+	610—	Sand, 40; yellow clay, 40; blue clay, 50.
193	Jno. Shebetka, SW. ¼ sec. 3.	760	85	85	675	Sand, 30; yellow clay, 30; blue clay, 10; sand, 15.
194	Jos. Tomas, SW. ¼ sec. 4.	740	440	170	570	Yellow sand and clay, 90; blue clay, 80; limestone.
195	Thos. Tranter, SW. ¼ sec. 10.	860	190	190+	670—	Yellow clay, 90; blue clay, 96; sand, 4.
196	M. Pitlock, SW. ¼ sec. 36.	770	300	300+	470—	Yellow clay, 100; blue clay, 150; sand, 50.
	T. 80 N., R. 9 W.					
196a	Amana Society, SW. ¼ sec. 3.	868	2,224	300	568	
	T. 81 N., R. 5 W.					

No.	Location of Well	*Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Materials
		Feet	Feet	Feet	Feet	
197	W. Verba, E. part sec. 6.	830	160	132	682	Reddish clay, 20; blue clay and yellow sandy clay and red clay, 98; black soil, 2; brownish clay and yellow clay to rock.
198	Jno. A. Hemck, SE. ¼ sec. 17.	820	235	235+	585—	Yellow sandy clay, blue clay to 145; yellow sandy clay to 200; sand, 35.
	T. 81 N., R. 6 W.					
199	J. Pesarek, NE. ¼ sec. 4.	730	158	72	658	Loam, yellow clay, blue clay, sand on rock. Log at 60.
200	Jas. A. Ulch, NE. ¼ sec. 25.	760	282	60	700	
201	Mrs. M. Kessler, N. part sec. 26.	740	120	5	735	
202	Jacob Kessler, NW. ¼ sec. 26.	740	78	11	729	
203	Zeidchek, NW. ¼ sec. 28.	720	143	143	577	Yellow clay, 40; blue clay, 100; sand, 3, to rock.
204	L. W. Mehaffey, NE. ¼ sec. 32.	750	100	67	683	Yellow clay, 20; blue clay, 47; rock.
	T. 81 N., R. 7 W.					
205	H. H. Hanson, SW. ¼ sec. 4.	760	160	150	610	Yellow clay, 40; blue clay, 110, to rock.
206	Wm. Pudil, NW. ¼ sec. 7.	820	148	148+	672—	Yellow clay with bowlders, 30; blue clay, 50; sand, 68.
207	C. R. & I. C., NW. ¼ sec. 8.	800	140	117	683	Yellow clay, 30; blue clay, 87.
208	J. E. Bowersox, NW. ¼ sec. 10.	840	345	340	500	
209	Frank Novstny, N. part sec. 10.	840	285	285+	555—	
210	J. C. Baylor, SW. ¼ sec. 10.	820	294	284	536	Yellow clay, 60; dirty sand, 6; blue clay and sand, 134; sand, 10; blue clay, 74, to rock.
211	J. K. Fordice, E. part sec. 10.	840	185	180	660	
212	Frank Chalonpka, NW. ¼ sec. 12.	840	148	133	707	Yellow clay (bowlders), 30; sand, 3; blue clay, 100, to rock.
213	Frank Novstny, SW. ¼ sec. 12.	800	74	12	788	Yellow clay, 12.
214	Anna Becicka, NE. ¼ sec. 13.	800	77	77	723	Yellow clay, 20; blue clay, 57, including thin gravel bed.

No.	Location of Well	*Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Materials
		Feet	Feet	Feet	Feet	
215	Frank Holub, NW. ¼ sec. 14.	840	170	163	677	
216	Jos. Kivonek, E. part sec. 15.	820	195	190	630	Yellow clay, 45; blue clay, 145.
217	Jos. Turecek, SE. ¼ sec. 15.	800	80	70	730	Yellow clay, 20; blue clay, 50.
218	C. Michalek, NE. ¼ sec. 18.	840	346	228	612	Blue clay, 228.
219	Steve Dean, SW. ¼ sec. 19.	800	177	171	629	
220	John Sawford, SW. ¼ sec. 19.	800	157	147	629	Same as No. 221.
221	R. L. Potter, S. part sec. 19.	780	165	150	630	Yellow clay, 50; blue clay, 20; sand, 20, with red cedar log at 85; blue clay, 54; sand, 6; rock.
222	W. B. Strang, E. part sec. 19.	760	150	150+	610—	
223	W. B. Strang, (at barn) E. part sec. 19.	710	140	137	573	
224	Jos. Coufal, NE. ¼ sec. 20.	700	135	125	575	
225	C. R. & I. C. (Cou Falls).	740	205	192	548	Yellow clay, 40; sand, 15; blue clay, 137.
226	King Tooby, NE. ¼ sec. 21.	780	80	70	710	Mostly yellow clay, some blue.
227	Mike Petracek, NW. ¼ sec. 23.	720	265	19	701	
228	C. R. & I. C. (Mid. River Park).	740	184	27	713	Yellow clay to rock.
229	M. Herdlika, NE. ¼ sec. 27.	740	156	24	716	High ridge, water rose within 36 ft. of top.
230	Flora Meyers, NW. ¼ sec. 27.	710	184	50	660	Sand, 50.
231	C. Grabin, W. part sec. 27.	740	86	86	654	
232	D. F. Gould, SE. ¼ sec. 32.	71	80	80+	635—	Sand, 30; blue clay, 50.
233	Alex. Reinhardt, SW. ¼ sec. 34.	700	90	40	660	Mainly sand.
	T. 81 N., R. 9 W.					
234	Amana Society NW. ¼ sec. 25.	720	1640	50	670	
	T. 82 N., R. 7 W.					

No.	Location of Well	*Altitude of site above sea level	Depth	Depth to rock	Altitude of rock above sea level	Materials
		Feet	Feet	Feet	Feet	
234	Jos. Benesh, SW. ¼ sec. 32.	840	212	112	728	Yellow clay, 50; blue clay, 62, to rock.
235	Jno. Benesh, S. part sec. 32.	840	98	98	742	Yellow clay, 20 (bowlders); blue clay, 50; sand, 28, to rock.
236	David Silver, SE. ¼ sec. 32.	820	172	166	656	
237	Jno. Lopata, SE. ¼ sec. 33.	820	105	105	715	Blue clay, 100; sand, 5.
238	Jos. Witrowsex, NW. ¼ sec. 35.	740	162	160	580	