

IOWA GEOLOGICAL SURVEY

IOWA CITY, IOWA

H. Garland Hershey, Director and State Geologist

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REPORT OF INVESTIGATIONS 2

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GLACIAL DRIFT IN THE "DRIFTLESS AREA"  
OF NORTHEAST IOWA

by

A. C. TROWBRIDGE

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Iowa City, Iowa

H. GARLAND HERSHEY, Director and State Geologist

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# GLACIAL DRIFT IN THE "DRIFTLESS AREA" OF NORTHEAST IOWA

A. C. TROWBRIDGE

## INTRODUCTION

The subject area of this paper is in Allamakee, Winneshiek, Clayton, Dubuque and Jackson Counties, Iowa. The west border of this area is the east border of Kansan drift and the east border is the Mississippi River. On the north the limit is the Iowa-Minnesota state line and the south limit is near Bellevue, Iowa. The total area is about 1500 square miles. See figure 1.

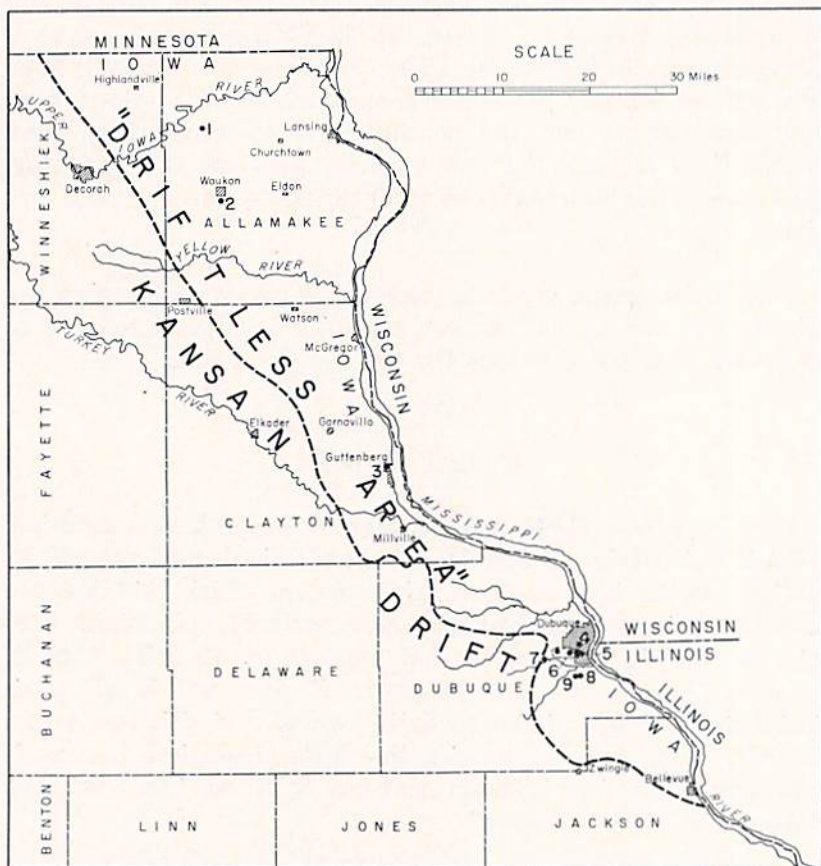


Fig. 1—Map of northeast Iowa showing the subject area and location of places mentioned in the text.



Conventionally this was known as the Iowa part of the upper Mississippi valley Driftless Area. Most of those who have had special interests in the Driftless Area have so mapped the Iowa area, although some of the early workers and most of the later ones realized that there is some glacial material here as well as in the Kansan area proper. The first known map of the Driftless Area shows that its Iowa portion was published more than 100 years ago. The subject area was a part of the Driftless Area. Later many maps of the same sort were published. About 1913 patches of upland drift were found in the subject area that indicated to some that the area had really been glaciated and should not be mapped as driftless. The Nebraskan ice sheet was thought to have extended farther east than the Kansan and reached the Mississippi River. In 1928 The Iowa Geological Survey came to agreement with this idea and mapping was changed accordingly. The new maps and interpretations were published but without the detailed data on which they were based. Now a map that shows this as Driftless Area has appeared in an international publication. Again no data are given.

The major purpose of the present paper is to present the missing data, to prove that the area has been glaciated and to demonstrate if possible that the drift is Nebraskan.

#### EARLY WORK

J. D. Whitney (1862, p. 118, fig. 2) recognized a Driftless Area in Wisconsin, Minnesota, Iowa and Illinois and mapped its western border in Iowa. The field work on which this line was based must have been done with care, for with only slight modification and in greater detail it appears on all drift maps of Iowa to the present day. However, it does not in all cases designate a division between drift-covered and driftless areas. In drift maps now in use by the Iowa Geological Survey it represents the line between Kansan drift on the west and Nebraskan drift on the east.

T. C. Chamberlin (1883, pl's. 9 and 10 and p. 268-272) appears to have used Whitney's line designating the west boundary of

the Driftless Area in Iowa. No mention was made of glacial drift within the Driftless Area as mapped.

T. C. Chamberlin and R. D. Salisbury (1886, pl. 27, p. 259; 271-277) placed the west border of the Driftless Area in Iowa along the line previously drawn by Whitney and Chamberlin. However east of this line and extending eastward for distances up to 30 miles they mapped a "pebbly border of earlier drift" and discussed it at length, thus introducing the subject of the present paper. Pebbles, cobbles and boulders of rocks foreign to this area were found in association with chert from local limestones and dolomites and small well-rounded pebbles of quartz derived locally from what is now known as the Cretaceous Windrow formation. \*Most of this material is said to occur at high topographic levels. It was recognized in all of the so-called Driftless Area of Iowa except in a few of the northeastern townships of Allamakee County and the authors conceded that it might be found there (Chamberlin and Salisbury, 1886, p. 275). The authors thought that this upland material was not deposited directly by a glacier and therefore that the subject area was driftless in the sense of not having been glaciated. It was suggested that the foreign matter might have been carried eastward from the ice front by icebergs floating in a gigantic lake. Following complete description of Kansan drift and its attenuated border they state (*ibid.*, p. 313):

"The attenuated pebble border, however, does not possess characters which we can attribute to glacial production. The exceedingly attenuated edge, the paucity of glacial clays,

\*Footnote. Chamberlin and Salisbury in some cases appear to have considered that these small quartz pebbles are of foreign derivation. They are common in the residual clays, glacial drifts, alluvium and other Pleistocene and Recent sediments of the region. Gravels and conglomerates have long been known in and near the Driftless Area of Wisconsin, Iowa and Minnesota. The best-known occurrence in Iowa is at Iron Hill just north of Waukon in Allamakee County. Early workers called them "high level gravels" and considered them of Cretaceous age. The present writer (Trowbridge, 1921, p. 121-123) considered these gravels tentatively to be associated in genesis and age with the Dodgeville peneplain, to be late Tertiary and to date the Dodgeville plain. Thwaites and Twenhofel (1921), described these sediments in detail, named them the Windrow formation and considered them Cretaceous. More recently it has been found that these gravels slope west toward known marine Cretaceous rather than south toward the Mississippi embayment. Furthermore there are surface and subsurface occurrences west of the Driftless Area that tie these gravels with the known Cretaceous. The pebbles of the Windrow gravels are practically identical in petrology, size, shape, color and high polish with those of the Cretaceous to the west. The Windrow formation is now known to be much older than the drift and other sediments that contain the pebbles and older than the upland surface in our area. The loose pebbles reworked from the Windrow formation are of local origin and in no sense to be considered glacial.



the want of notable erosion of the glacial kind at any observed point, and the several characteristics brought out in the description before given, seem to us to exclude direct glacier action. We believe the deposit was formed by the aid of floating ice in a body of water fringing an ice lobe which lay to the west."

By designating this portion of the area as the pebble or boulder border Chamberlin and Salisbury intimated that they saw nothing but pebbles and boulders and not till. Possibly this is the reason why some later workers thought this upland drift consisted of erratic pebbles and boulders only.

W J McGee (1891, p. 514) noted the presence of upland glacial material in the Driftless Area of northeast Iowa. He considered this to be Kansan drift. The upland position he explained by assuming that the glacier at and near its margin was thin, that transverse valleys were filled with sluggish or stagnant ice, that the glacier moved over this dead ice onto the uplands and deposited there conventional glacial drift including foreign erratics. The valleys McGee thought would be modified only slightly if at all by erosion or deposition. McGee apparently considered that the "Driftless Area" in Iowa did contain glacial drift and had really been glaciated.

Samuel Calvin (1894, p. 85) stated: "There is no drift properly speaking in Allamakee County". He goes on to say however that granite boulders 2-3 feet in diameter "have by some means been carried as far east as Makee township" and left on uplands. Makee township is 10 miles east of the mapped Kansan border. He says also that foreign pebbles occur to the top of Iron Hill, the highest point in the county.

Samuel Calvin and H. F. Bain (1900, p. 464-470) drew a line on the map of the surficial deposits in Dubuque County between Kansan drift and Driftless Area. They considered the discontinuous drift east of the Kansan drift border as Kansan outwash.

Samuel Calvin (1906, p. 119-126) mapped the eastern two-thirds of Winneshiek County as Kansan drift but stated that in the extreme east the drift is patchy and on the uplands. He

considered that these high patches are erosional remnants of Kansan drift and that the Kansan glacier may have covered the whole county. However the Legend of the map (*ibid.* p. 122-123) shows: "Kansan Drift, Partly driftless overlain by loess". All drift maps from Whitney's in 1862 to Martin's in 1932 (p. 9) show a small Driftless Area in eastern Winneshiek County.

A. G. Leonard (1906, p. 231-284) recognized in Clayton County Kansan drift and east of it to the Mississippi River a Driftless Area. Both are covered by loess and exposures are not plentiful. The Kansan drift is thin and discontinuous at its border. On the surficial map Kansan and "Driftless Areas" are separated by a broken line, but this line is not claimed to be accurate. There is said to be no marked difference between the topographies of the two areas. Several exposures of drift are described in the Kansan area but not one in the Driftless Area; no drift seems to have been seen there.

T. E. Savage (1906, p. 633-634) reported that the Kansan glacier probably covered the whole of Jackson County. Glacial boulders and cobbles, consisting of quartz, greenstones, and granites are widespread. On the surficial geology map no distinction is made between ordinary Kansan drift and Driftless Area at and north of Bellevue.

Ellison Orr (1907) located upland glacial drift east of the border of Kansan Drift two miles and five miles west of Waukon in Allamakee County, three miles west of McGregor in Clayton County and one half mile north of Garnavillo in Clayton County. All exposures are on high ground 400-600 feet above the Mississippi River. The drift is described as consisting of residual clay mixed with pebbles of granite and greenstone and cobbles six to eight inches in diameter. One granite boulder two feet in diameter was seen near Waukon. In the one-to-four-inch textural grade 75 percent is greenstone; in coarser grades 10 percent is granite. Orr considered that the material is true glacial till and that a lobe of an old glacier "Kansan or Sub-Aftonian" advanced eastward at least to the vicinity of Waukon, McGregor and Garnavillo.

U. S. Grant and E. F. Burchard (1907, fig. 1) published a map of the Driftless Area showing it to be 20 miles wide in Iowa at the Minnesota state line, five miles wide at Dubuque and crossing



the Mississippi River at Bellevue. This is almost the same line as was drawn at the west border of the Driftless Area by Whitney in 1862. In the southwest corner of the Lancaster quadrangle in Iowa there is but a thin fringe of drift and only a few scattered and fragmentary outliers of drift between this fringe and the Mississippi River. In the text (*ibid* p. 9) long quotations are taken from the Dubuque County report. The drift is Kansan and the outliers to the east are said to be Kansan outwash.

In the first 36 years of its existence beginning in 1892 the present Iowa Geological Survey published nine maps of the drift sheets of Iowa. The first of these (Bain, 1897, pl. 28, p. 466) showed the western "limit of the Driftless Area" according to Whitney (1862, p. 118, fig. 2) and Chamberlin (1883, plates 9 and 10) but in somewhat greater detail. The next three maps (Calvin, 1898, pl. 3; Calvin, 1901, pl. 2; Calvin, 1904, pl. 3) contained the conventional east border of Kansan drift but with a fringe of Kansan drift, shown by a dotted pattern, extending eastward to the Mississippi River. No Driftless Area was shown. This was obviously the Kansan and its pebbly border of Chamberlin and Salisbury (1886, pl. 23, p. 205 and pl. 27, p. 259). The following two maps (Kay, 1912, pl. 3; Lees, 1916, pl. 30) designate the Driftless Area between the Kansan border and the Mississippi River. The Iowa Geological Survey (1914, v. 24, pl. 65, and 1917, v. 26, pl. 14) twice published a drift map of Iowa in color, "compiled from publications of the Iowa Geological Survey". It shows Kansan drift and Driftless Area in northeast Iowa. The east border of Kansan drift is essentially the west border of the Driftless Area and the area between this line and the Mississippi River is driftless, as first mapped by Whitney (1862, p. 118, fig. 2). Similar to Whitney's map the Driftless Area at the Minnesota line is 30 miles wide, at Dubuque 11 miles wide and its south end is at Bellevue. Thus as late as 1917 the Iowa Geological Survey was following tradition in regard to the Driftless Area in Iowa. Another map (Lees, 1928, p. 376, fig. 1), shows "Kansan partly Nebraskan" in a pattern fading out eastward to Mississippi River. There is no line between Kansan and "Kansan that is partly Nebraskan". No Driftless Area appears on this map. This is the first map that suggests the presence of Nebraskan drift in the subject area.

L. Martin (1916, fig. 26, p. 75; and 1932, fig. 26, p. 83) published a map of the Driftless Area showing its west border in Iowa 16 miles west of Mississippi River at the Minnesota state line, one mile at McGregor, five miles at Guttenberg and ten miles at Dubuque. The size of the Driftless Area in Iowa according to this map is about 740 square miles. The data on which the line is based are unknown unless Orr's figures (1907) were used.

Shaw and Trowbridge (1916, fig. 3 and p. 7) presented a map of the Driftless Area that took into account the results of the work of A. J. Williams (1923) and others in the "Driftless Area" in Iowa. The west border of the Driftless Area was drawn along the west bluff of the Mississippi River gorge that extended from the south end of the Driftless Area at Bellevue to Guttenberg. At Guttenberg the line left the river bluff and continued north and slightly west to the Minnesota state line five miles west of Mississippi River, thus reducing the Driftless Area in Iowa from 1500 square miles of most earlier workers and the 740 square miles of Martin to approximately 160 square miles. It should be noted that this map was published in advance of completion of Williams' Ph.D. thesis (1923). Williams found patches of upland drift practically on the river bluff not far from the Minnesota line and recognized finally no Driftless Area in Iowa.

#### WORK OF A. J. WILLIAMS

In 1913 the late A. J. Williams, then a second-year graduate student at the University of Iowa, took as a Master's thesis a physiographic study of the area at and near Dubuque (Williams, 1914). Having found a considerable amount of drift in this part of the Iowa "Driftless Area", he proceeded in the following summers with similar studies in the remainder of the subject area for a Doctor's thesis. (Williams, 1923).

Williams was an industrious and careful field worker. He spent a total of about four months in the field. His work was done on foot. He covered the whole area, including upland flats, divides, and valleys. He noted more than 80 patches of glacial drift in what had been mapped as Driftless Area (fig. 2).



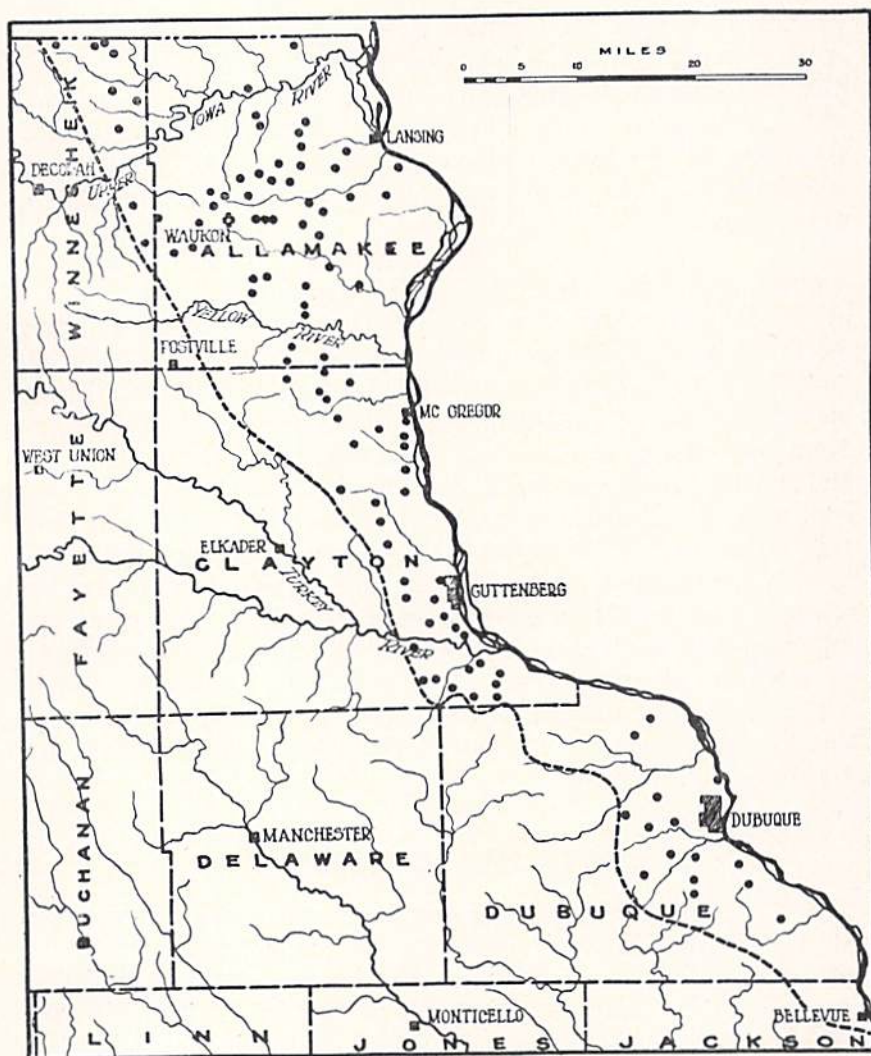


Fig. 2—Map by A. J. Williams (1923, fig. 7) showing some of the patches of upland drift, published by Kay and Apfel (1928, fig. 32, p. 155).

Following Trowbridge (1914, p. 207-208; 1915, p. 76 and 1921, p. 60-127) Williams recognized a summit plain, the Dodgeville peneplain, and about 180 feet lower but still hundreds of feet above drainage the Lancaster peneplain of Grant and Burchard (1907, p. 10). The drift Williams observed and recorded is only a



few feet below, at or above the Lancaster peneplain.

There is such a sameness in the exposures of drift mapped by Williams both in sequence and composition that only a few typical ones are located and described. In all the exposures that are deep enough weathered bedrock is at the base, overlain by brown or red clay that differs from the residual clay of the region only in containing foreign pebbles, cobbles and boulders, in addition to angular local chert pieces and small, rounded quartz pebbles out of the Cretaceous Windrow formation. This member is overlain by Wisconsin loess.

Not all of the exposures mapped by Williams were located by section, township and range but some by direction and distance from cities or towns. Many of the locations cannot even be recognized with certainty on figure 2. The present writer has done the best he could to find locations but does not claim accuracy in all cases. After all, few if any of Williams exposures are now open and exact locations as of 40 years ago now afford little help.

As will be seen the elevations of exposures have considerable value. Having only the old 1/125000 topographic maps, Williams gave few elevations and in some cases those he did give were only approximate. Now that more modern maps are available some of the missing elevations have been supplied and others corrected. The U. S. Geological Survey (Clayton, Garnavillo, Guttenberg and Zwingle) 7½ minute quadrangle sheets have been especially helpful. In some instances the 1/250000 NK series maps have been consulted. The writer has rewritten Williams' notes and made some additions and corrections but has not changed the basic data.

A few of Williams' exposures are described below. They are numbered from north to south.

1. Two and three quarters miles north of Highlandville and 2½ miles from the Minnesota line (W. central Sec. 15, T. 100 N., R. 7 W., Winneshiek Co.) reddish sandy clay with many small quartz pebbles from the Windrow gravels and some igneous rocks up to several inches in diameter were exposed. The location is 18 miles west of the Mississippi River. The elevation is about 1140 feet.

2. Reddish brown till consisting of clay, many quartz pebbles and much igneous material was exposed  $2\frac{1}{2}$  miles southwest of Churchtown (N. W.  $\frac{1}{4}$  sec. 1, T. 98 N., R. 4 W., Allamakee Co.). One quartzite boulder two feet in diameter was noted. Beneath the till a little sandstone and weathered limestone occurred and above it loess. The location is 12 miles east of Kansan drift and 14 miles west of the Mississippi River at an elevation of about 1200 feet.
  
3. One mile west of Elon (now Eldon) (near center sec. 32, T. 98 N., R. 4 W., Allamakee Co.) reddish brown till containing angular chert, quartz pebbles and badly decayed igneous rocks were exposed. The location is 16 miles west of the Mississippi River and nine miles east of the Kansan drift border at an elevation of about 1240 feet, which is about 600 feet above the Mississippi River.
  
4. Forty rods east of a road crossing  $2\frac{1}{2}$  miles southeast of Waukon (middle of line of secs. 4 and 5, T. 97 N., R. 5 W., Allamakee Co.) there was an exposure of thin till over weathered limestone. The till consists of brown clay, much local chert and some small quartz pebbles with many pebbles of decayed igneous rocks up to four inches in diameter scattered through the deposit. Above the till a few feet of loess-like material and soil occurs.
  
5. Three and a half miles southeast of Watson (S. W.  $\frac{1}{4}$ , sec. 12 T. 95 N., R. 4 W., Clayton Co.) a roadside exposure just below the upland plain shows residual clay with chert pieces up to  $2\frac{1}{2}$  inches in diameter and smaller quartz pebbles. One badly decayed granite pebble and a few quartzite pebbles were seen. The clay is overlain by five to eight feet of loess.
  
6. An exposure was seen two miles south and southwest of McGregor (N. W.  $\frac{1}{4}$  sec. 9, T. 94 N., R. 3 W., Clayton Co.). This is two miles from the Mississippi River and 430 feet above it. Decayed limestone is overlain by clay that contains much local chert, some Windrow pebbles, and decayed igneous rocks up to six inches in diameter.



7. About 30 feet below the top of the bluff overlooking Guttenberg (S. W. sec. 29, T. 93 N., R. 2 W., Clayton Co.) two feet of reddish brown till occurs overlain by thick loess. The till contains many pieces of chert, small quartz pebbles and badly decayed igneous rocks.

8. An exposure of drift occurred two miles south by southwest of Millville (north center sec. 28, T. 91 N., R. 2 W., Clayton Co.) seven miles west of Mississippi River, three miles east of the Kansan border and about 475 feet above river level. Many small badly-decayed pebbles of igneous rocks, Windrow pebbles, jaspillites and quartzites occur in the clay matrix.

9. Two and one half miles west of the courthouse in Dubuque (S. W.  $\frac{1}{4}$ , sec. 22, T. 89 N., R. 2 E., Dubuque Co.) four to six feet of glacial till was exposed. It consists principally of red to brown sticky clay that contains many Windrow gravel pebbles and many dark igneous rocks up to six inches in diameter. One pebble is distinctly striated.

10. Overlooking the Mississippi River south of 17th street and west of Cox street in Dubuque there was a quarry in Dubuque dolomite overlain by a few inches of Maquoketa shale carrying depauperate fossils of the basal Maquoketa overlain by residual clay. Mixed with the clay were large quantities of local chert, quartz pebbles and igneous rocks. One granodiorite six inches in diameter was noted.

11. An exposure of till occurred on the brink of the Mississippi River bluff (north part S. E.  $\frac{1}{4}$  sec. 1, T. 89 N., R. 2 E., Dubuque Co.). The till is within 65 feet below the highest part of the loess-covered upland surface and about 400 feet above the river. The best exposure was in the head of a gully just south of a farmhouse. Numerous pebbles of quartz and igneous rocks are imbedded in red sticky clay overlain by loess and soil. Igneous pebbles are abundant and consist of granites and greenstones up to two inches in diameter. They are subangular and many are decomposed.



12. Ten miles south of Dubuque and one mile north of Buncombe (now Zwingle) (S. E. sec. 26, T. 87 N., R. 2 E., Dubuque Co.) there was an exposure of dark brown till with decayed pebbles and cobbles up to six inches in diameter, covered by gray loess. The elevation is about 1020 feet and about 420 feet above the Mississippi River 13 miles to the east.

Because Williams found significant differences between this drift and the Kansan drift to the west and because the patches of drift were on the upland whereas the Kansan drift occupies both uplands and valleys he concluded that the upland drift is Nebraskan. In this the present writer concurred. This matter will be discussed further after deposits exposed since Williams field work was done have been described.

In 1915 after Williams' Masters thesis (1914) had been submitted and most of his field work for the Doctor's thesis (1923) had been finished but before completion of the Doctor's thesis a field conference was arranged by the present writer. Participants were W. C. Alden, Frank Leverett, R. D. Salisbury, A. J. Williams and A. C. Trowbridge. At the end of two days in the field it was agreed that the drift east of the Kansan border is till deposited by a glacier and that it is an upland drift. It was recognized also that the Kansan drift occurs both on the uplands and in the valleys. The basic facts as presented by Williams and Trowbridge were accepted but their interpretation that the older drift antedates the valleys was not, or at least it was held in abeyance.

After Williams Doctor's thesis was completed (1923) and submitted, though not published, Kay and Apfel (1928, fig. 32 and pl. 2; fig. 2 of this paper) published Williams' map showing the locations of some of the patches of upland drift in the area and in the text (p. 156) accepted the conclusions of Williams and Trowbridge that this drift is Nebraskan. From that time to the present Nebraskan drift has been mapped by the Iowa Geological Survey in the whole of the area under discussion and no driftless area is recognized in Iowa. (See Kay and Apfel, 1928, pl. 34, Kay and Graham, 1943, fig. 1 and Iowa Geological Survey, 1955).

## ADDITIONAL WORK

During the last 50 years the present writer has visited northeast Iowa many times with student classes, on field conferences, with individuals, and alone and has found exposures not seen by Williams. The more important of these are described here.

Summer field courses in the subject area in 1913 and 1914 resulted in the location of about 40 exposures of drift east of the Kansan drift border and west of Mississippi River. Some of these may be duplicates, however.

Fourteen exposures of this drift were at and near Waukon in Allamakee County. They range in elevation from 1130 to 1250 feet, and 495-616 feet above the Mississippi River. A pebble count at a quarry in the southeast part of Waukon resulted as follows:

		Amount			
Lithology	%	Lithology	%	Lithology	%
Limestone	2	Felsite	4	Dolerite	16
Jasper	2	Rhyolite	2	Quartz	16
Dolomite	4	Chert	8	Quartzite	14
Sandstone	2	Granite	14	Syenite	4

Summary: Foreign 74%: Igneous rocks decayed 100%. A 10-inch boulder of quartzite and a 6x10 inch boulder of granite were seen.

Other exposures were scattered over the area west of Mississippi River from Lansing to Dubuque. Igneous and other foreign rocks include basalt, quartzite, dolerite, granite, gneiss, syenite and felsite. Elevations vary from 1140 feet in the latitude of Lansing to 820 feet near Dubuque.

Other more recently studied exposures are numbered from 1 to 9 on figure 1.

1. In early June 1956, C. N. Brown, H. G. Hershey, M. M. Leighton and A. C. Trowbridge participated in a field conference in northeast Iowa. Several exposures of upland till were seen east of the Kansan drift border. One was located on State Highway 13 at Hanover Church 7 miles



north and 2 miles west of Waukon (N. W.  $\frac{1}{4}$  N. W.  $\frac{1}{4}$  sec. 26, T. 99 N., R. 6 W., Allamakee Co.). A profile traverse is shown below:

Feature	Distance along road miles	Elevation feet
Summit surface	0.00	1218
Intermediate surface	0.81	1076
Intermediate surface	0.19	1076
Drift	0.10	1042
Bridge across Upper Iowa River	3.65	690

The drift is 176 feet lower than the summit surface, 34 feet lower than the flat intermediate surface and 381 feet above the Upper Iowa River bridge 3.65 miles away. This is a quite normal position for the drift east of the Kansan drift border.

The drift consists of small pebbles that seem to be the end product of weathering and erosion of a very old drift. The pebbles identified by Donald Biggs, petrographer of the Illinois State Geological Survey (Personal communication from M. M. Leighton) are as follows: Two basalts, one amygdaloidal felsite, one igneous rock that is probably granite, three graywackes (probably Precambrian), one sandstone or graywacke, three cherts, two siltstones, one quartzite, and two quartz.

2. Gravel of which some of the pebbles are foreign to this area occurs in a limestone quarry 0.9 mile south of the C. M. & S. P. railway station at Waukon on the west side of State Highway 13 (N. E.  $\frac{1}{4}$ , N. W.  $\frac{1}{4}$ , sec. 6, T. 97 N., R. 5 W., Allamakee Co). This gravel was located and studied in 1940. The gravel occurs in a horizontal layer one foot thick, six feet above the quarry floor and 20 feet below the rim. There is a sink 500 feet southwest of the quarry. The sink is 15-20 feet deep. Its bottom is 35 feet higher than the gravel in the quarry. The general summit surface between the quarry and Waukon is about 1250 feet A. T. and the gravel 105 feet lower. Clearly the gravel is in an extension of a cave below this or another of the numerous sinks in the vicinity. A summary of analyses of the



gravel made in the sedimentation laboratories of the University of Iowa is as follows:

Size, m.m.	No.	Composition	No.
64-32	4	Igneous	14
32-16	28	Quartz	12
16-8	36	Quartzite	16
8-4	3	Chert	28
4-2	1		
Shape	No.		
Angular	13		
Subangular	21		
Subround	23		
Fairly round	15		
Round	1		

This is gravel, not till, but it doubtless was derived from till, the sorting apparently having been done on the way from sink to cave. The unusual degree of rounding may be explained in the same way. In any case it is glacial drift far east of the Kansan drift. And its location and elevation relative to upland plains is the same as the many other drift locations known in this neighborhood (p. 15).

3. Another occurrence of glacial drift in caves first came to light in the Mississippi River bluff at Guttenberg in about 1935. U. S. Highway 52 extends from the upland south of Guttenberg down a valley to the town on a low terrace. From here the highway climbs the bluff diagonally to the upland north of town. This part of the highway has been made by cutting a notch in Ordovician limestone. In the making of the long cut two caves were exposed and both contain glacial pebbles. The location is in S. W.  $\frac{1}{4}$ , S. W.  $\frac{1}{4}$ , sec. 29, T. 99 N., R. 2 W., Clayton Co. About 800 feet west of Highway 52 there is a sink.

Approximate elevations are as follows:

general loess covered upland	1195-1225
rim of sink	1140-1160
bottom of sink	1118
bottom of gravel in upper cave	834
bottom of gravel in lower cave	822
Rail at C.M. & S.P. depot at Guttenberg	620.61

Results of analyses made in University Sedimentation laboratories follows:

Size m.m.	No.	Composition	No.
128-64	1	igneous	19
64-32	9	quartz	6
32-16	36	quartzite	7
16-8	12	chert	12
8-4	4	sandstone	13
		siltstone-clay	5
		hematite-limonite	1
			<u>63</u>
Shape	No.		
Angular	7		
Subangular	28		
Subround	13		
Fairly round	10		
Round	1		
Faceted	14		

These gravels are about 40 per cent foreign. Again they are more rounded than most, perhaps due to travel in underground streams from sink to cave.

4. For a few years before and after 1940 drift was exposed on the Loras College campus at 15th and Cox Streets in Dubuque. The location is at about 770 feet A. T., 126 feet above the U. S. P. B. M. in the corner of the old Post Office building at 9th and Locust Streets, 160 feet above Mississippi River level, and 85 feet lower than the general loess-covered upland surface a block west at Alta Vista and Loras Avenues. This exposure is lower than most of the patches of upland drift at Dubuque. However it was on a steep slope between the upper and lower campus and may have come down the slope from its original position. In fact it must have come down at least 30 feet for the small fossils belong 30 feet higher at this place. This exposure was permanently covered later by the building of concrete walls. Foreign material was mixed with clay from the Maquoketa formation, depauperate fossils from the basal beds of the Maquoketa and chert from Silurian dolomites that have been eroded away. This



exposure may duplicate No. 10 of Williams (p. 13).

Analyses of the drift pebbles resulted as follows:

Size m.m.	No.	Composition	No.
128-64	1	igneous	5
64-32	1	quartz	3
32-16	10	quartzite	6
16-8	11	chert	11
8-4	3	sandstone	1
		hematite-limonite	1
Shape	No.		
angular	5		
subangular	10		
subround	10		
fairly round	4		
round	0		
faceted (glacial)	4		

5. In about 1962 Leighton and Bretz (Personal communication from M. M. Leighton) studied a temporary exposure, a short distance west of St. Joseph School in Dubuque (N. E.  $\frac{1}{4}$  S. W.  $\frac{1}{4}$  sec. 26 T. 89 N., R. 2 E., Dubuque Co.). It showed:

	feet
Loess	15
Bedded silt, almost thin bedded enough to be called laminated	8
Much weathered Nebraskan till, resistant pebbles predominating	3-4
Residual zone	1
Bedrock	

Elevation of the till, estimated from Dubuque South Quadrangle topographic map, 830 feet A. T.

6. The relocation of U. S. Highway 20 west from Dubuque about 1940 opened up several exposures of drift near the western city limits. One was 0.3 mile east of the city limits, another 0.3 mile west of the city limits and another 1.6 miles west of the city limits (secs. 26, 27, 28, T. 89 N., R. 2 E., Dubuque Co.). These exposures were slightly beneath

the general level of stream divides at elevations of 825, 825 and 870 feet A. T. and 225, 225 and 270 feet above Mississippi River level. The sections exposed are similar. At the base 5-7 feet of the lower beds of the Maquoketa shale are overlain by 2-4 feet of reddish glacial drift and this in turn by 6-12 feet of loess. Rocky pieces from the drift 0.3 mile east of the western city limits were analyzed with results as follows:

Size	No.	Composition	No.
64-32	7	igneous	38
32-16	32	quartz	5
16-8	30	quartzite	16
8-4	14	chert	21
4-2	1	sandstone	2
		siltstone-clay	1
		conglomerate	1

Shape	No.
angular	30
subangular	30
subround	17
fairly round	7
round	0
faceted	12

7. Still farther west a long cut was made for Highway 20 when it was widened in the summer of 1959. This was seen first by Frye, Willman and Leonard (personal communication from John C. Frye) and several times by C. N. Brown and A. C. Trowbridge in the summer of 1960 and later. This cut is in the N. W.  $\frac{1}{4}$  sec. 32, T. 89 N., R. 2 E., Dubuque Co. It is  $3\frac{3}{4}$  miles west of the Dubuque city limits,  $5\frac{1}{2}$  miles west of the Mississippi River and  $4\frac{1}{2}$  miles east of the Kansan drift border as mapped by Williams and the Iowa Geological Survey. It is an upland drift. In the northeast part of the cut 20 feet of till is exposed; the lower part is calcareous. At two or three places in the middle portion of the cut either low hills of the directly underlying Maquoketa shale occur beneath till or blocks of the shale have been broken off and incorporated in the till. In the southwest part of the cut there is again thick drift



but here it consists of stratified sand and gravel and not till. In this cut the drift is overlain by loess up to 17 feet thick.

The question arises as to whether this drift is Kansan or Nebraskan. Because the Nebraskan and Kansan Keewatin ice sheets moved from the same center and over the same rock formations their tills are separately almost indistinguishable petrographically (Willman, Glass and Frye, 1963, p. 3, 13, 17, fig. 4, Tables 1, 2, 4, 5.). Mineral analyses of fine sands and X-ray analysis of clays do not tell us whether the till in question is Nebraskan or Kansan. If the till is Kansan the line representing the border of the Kansan drift area should be moved eastward so as to include it. However there are differences of other sorts between this drift and the upland drift which is the main subject of this paper. Not one of the many exposures described above as Nebraskan drift is stratified, or calcareous (with a single exception) or as thick as the drift in this exposure. On the other hand it is similar in all respects to other exposures of Kansan drift. The section west of Dubuque can therefore be considered Kansan and the line designating the east border of Kansan drift has been changed accordingly on figure 1. Unfortunately this excellent section is now covered.

8. Exposures of glacial till have been more or less open for several years near the junction of Highways 151 and 61 with Highways 52 and 67, 0.70 mile south of the south edge of the city of Dubuque and 0.1 mile south of Rockdale (N. E.  $\frac{1}{4}$ , S. W.  $\frac{1}{4}$  sec. 1, T. 88 N., R. 2 E., Dubuque Co.). The road junction is at 726 A. T. Just north of the junction on the east side of the combined highways the following section was seen:

	feet	inches
6. leached loess	8	
5. unleached loess	5	
4. leached loess (Farmdale)	2	
3. geest, angular chert and glacial pebbles mixed; leached	1-2	
2. Maquoketa shale and dolomite		6-8
1. Dubuque dolomite	10	

No. 3 of this section is similar in all respects to the many patches of upland drift located by Williams and others. Here it is about 740 feet A. T. and 170 feet above the Mississippi River.

9. At the same general location and about the same elevation as No. 8 Frye (personal communication) reported another exposure containing under the loess 13 feet of till the upper 11 feet of which is leached and much weathered and the lower two feet calcareous. The tills in exposures 8 and 9 are some 80 feet lower than the tills at exposures 5 and 6 farther west, suggesting the possibility that the surface on which the Nebraskan drift was deposited sloped eastward toward a pre-Nebraskan valley.

#### RECENT U. S. GEOLOGICAL SURVEY PUBLICATIONS

The Iowa portion of the Dubuque North Quadrangle (Whitlow and Brown, 1963, p. 155) lies in the attenuated pebble drift zone described 80 years ago by Chamberlin and Salisbury (1886, p. 275). However, only one exposure of glacial material not before recorded was noted by authors (*ibid*, 1963, p. 156). This exposure was in extreme northwest corner of the quadrangle (N. E.  $\frac{1}{4}$  sec. 8, T. 90 N., R. 2 E., Dubuque Co.). The material is not described but is called "glacial debris". The elevation in this quarter section and within the quadrangle ranges from 800 to 870 feet.

Nearly all of the Dubuque South Quadrangle (Brown and Whitlow 1960) is in Iowa and again the Iowa portion is in the attenuated zone of Chamberlin and Salisbury (1886, p. 275). Till is said to occur on most of the uplands in the Iowa portion and is located at 52 places (Brown and Whitlow, 1960, p. 45 and pl. 2) in natural or artificial exposures or in U. S. Geological Survey drillings. Elevations are not given but all are said to be on uplands. Faceted and striated glacial erratics have been eroded from the till. The till is bouldery clay with many chert and quartz pebbles and many varieties of igneous and metamorphic rocks. Two or three of the occurrences of till in the southwest corner of plate 2 (*ibid* 1960) may be in the area of Kansan drift and of Kansan age.



In Dubuque city the till is reported to be eight feet thick in the underpass at Grandview Avenue and highways 151, 61, 52 and 67 (near center of east  $\frac{1}{2}$ , sec. 36, T. 89 N., R. 2 E., Dubuque Co.), at elevations 825 feet and 225 above the Mississippi River; at least 14 feet thick on Pennsylvania Avenue at the north edge of sec. 27, T. 89 N., R. 2 E.; and 20 feet thick near the center of S. E.  $\frac{1}{4}$ , sec. 32, T. 89 N., R. 2 E. Glacial deposits in the southwestern part of the quadrangle and in secs. 12, 13 and 18, T. 88 N., R. 2 E., consist of ferruginous gravelly sand containing many cobbles.

And now appears the drift map of Iowa by Wright and Ruhe (1965, fig. 1, p. 30) showing the whole subject area as Driftless Area. From the foregoing it is clear that the author of the present paper does not support the Wright-Ruhe mapping that goes back to Whitney (1862, p. 118, fig. 2).

### CONCLUSIONS

From the foregoing it is concluded that the area between the east border of Kansan drift and the Mississippi River is not truly driftless and has been glaciated and that there is no Driftless Area in Iowa.

The more than 100 known occurrences of glacial drift are till and not outwash (Calvin and Bain, 1900, p. 468-470 and this paper, p. 6). The material is unstratified. Kansan outwash is known in the form of gravel-covered rock terraces in major valleys heading in Kansan drift (Alden and Leighton, 1917, p. 131) but hundreds of feet lower than the upland drift of this paper.

The till was not carried and deposited by floating ice in a lake (Chamberlin and Salisbury, 1885, p. 275-278 and this paper p. 5, 6). No such lake could have existed. In fact this idea was suggested very early when the loess was not understood, was never followed up by its authors and has never been considered favorably by others.

McGee's idea (1891, p. 514 and this report, p. 6) that the upland drift was deposited by the Kansan ice that overrode stagnated ice in the deep transverse valleys is scarcely tenable.

For one thing the valleys are not transverse but in general parallel with Kansan ice movement.

Whether the upland till is Kansan or Nebraskan is a more difficult question. The two ice sheets were so closely similar in size, shape, and lithologic sources that no means have been found of distinguishing between their tills petrographically. Both tills have been maturely weathered where not too thick. In the area of study there is little or no stratified material in the patchy upland drift but much in the adjacent Kansan drift; the eastern upland drift is, with a few possible exceptions, thoroughly leached whereas the Kansan drift is in many places calcareous in the lower portion. It must be admitted, however, that this could be due to the fact that the upland drift is thin and entirely leached whereas the known Kansan is thick enough locally to have remained unleached in its lower portion.

The main reason given for the belief that the till east of the Kansan drift border is pre-Kansan is that no till occurs on bottoms, terraces or slopes of the valleys, whereas the Kansan till west of the border occupies upland surfaces and valleys alike. In fact exposures of Kansan drift are more numerous in the valleys than on the highlands, the drift on the divides being mostly covered by thick loess. (See Trowbridge 1915, p. 76, 1921, p. 123-125; Williams 1923, p. 87-88, 101, 102-103; Kay and Apfel 1931, p. 154-157). This still appears to the writer to be the most likely explanation of the strictly upland position of the drift east of the Kansan border and the upland and valley position of the Kansan drift. The writer holds that there are two drifts here, Nebraskan east of the Kansan border and Kansan west of it.

Objections to this idea by Leverett, Thwaites, Leighton, and others (personal communications) are based chiefly on the time element. The writer is also concerned about this. If the eastern upland drift antedated the valleys and the Kansan drift postdated them the Pleistocene epoch and especially the Aftonian interglacial interval would seem to have been longer than usually supposed. The development of the drainage system and the cutting of the Mississippi valley and its tributaries would have required much time. But no way is known of determining the relative rates of erosion in the area of this



report and of weathering in southern Iowa where the ages of Nebraskan and Kansan drifts have been estimated previously (Kay, 1931, p. 454-466.). Even at best, estimates of both rates of erosion and rates of weathering are subject to large possible errors.

As suggested on page 22 drainage lines may have been developed and erosion of valleys started before the Nebraskan ice advanced. When the Mississippi River took its present position as the master stream the area was high and later there was at least one major uplift. Gradients must have been high, falls and rapids existed and sapping must have been prevalent. The formations eroded were not very resistant. Erosional tools were plentiful. Erosion may have taken place at an unusually rapid rate. It might be noted also that as the main valley includes the "deep stage" at Dubuque the total erosion time may have and probably did include Yarmouth as well as Aftonian. Thus it appears to the writer that time might not constitute a fatal objection to the conclusions reached.

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