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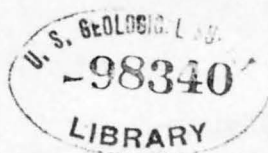
DEPARTMENT OF THE INTERIOR

MONOGRAPHS

OF THE

UNITED STATES GEOLOGICAL SURVEY

VOLUME LIII



WASHINGTON
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1915

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DEPARTMENT OF THE INTERIOR

WATER RESOURCES DIVISION

UNITED STATES GEOLOGICAL SURVEY

VOLUME III

1965



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UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

THE
PLEISTOCENE OF INDIANA AND MICHIGAN
AND THE
HISTORY OF THE GREAT LAKES

BY

FRANK LEVERETT

AND

FRANK B. TAYLOR



WASHINGTON
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1915

lobes is about 800 feet. The waters passed southward along the eastern front of the Lake Michigan lobe to Plainwell and there joined the longer line of glacial drainage just described.

With the northward extension of the reentrant angle between the Saginaw and Lake Michigan lobes, past the city of Grand Rapids, and a slight westward shrinkage of the border of the Lake Michigan lobe a line of glacial drainage with bed below the 700-foot contour, well shown on the Grand Rapids topographic sheet, was opened southward from Grand Rapids past Carlisle and Ross to Rabbit River.

With the recession of the reentrant into southwestern Montcalm and southeastern Newaygo counties the glacial drainage took a southward course between the ice lobes for a short distance and then turned into districts which had just been abandoned by the Lake Michigan lobe. (See pp. 220-221.)

INNER BORDER.

GENERAL CHARACTER.

The interval between the Charlotte morainic system and the next later moraine of the Saginaw lobe is filled principally by a till plain, whose surface is in large part very smooth and much of which is included in the Lansing, Mason, Fowlerville, and Howell quadrangles. In Ingham and Livingston counties, however, it is traversed by several eskers, which lie for the most part in shallow swampy depressions or esker troughs and which lead somewhat directly toward and terminate in the morainic system. Some of these swampy depressions are not occupied by eskers or are occupied by them for a part of their course only.

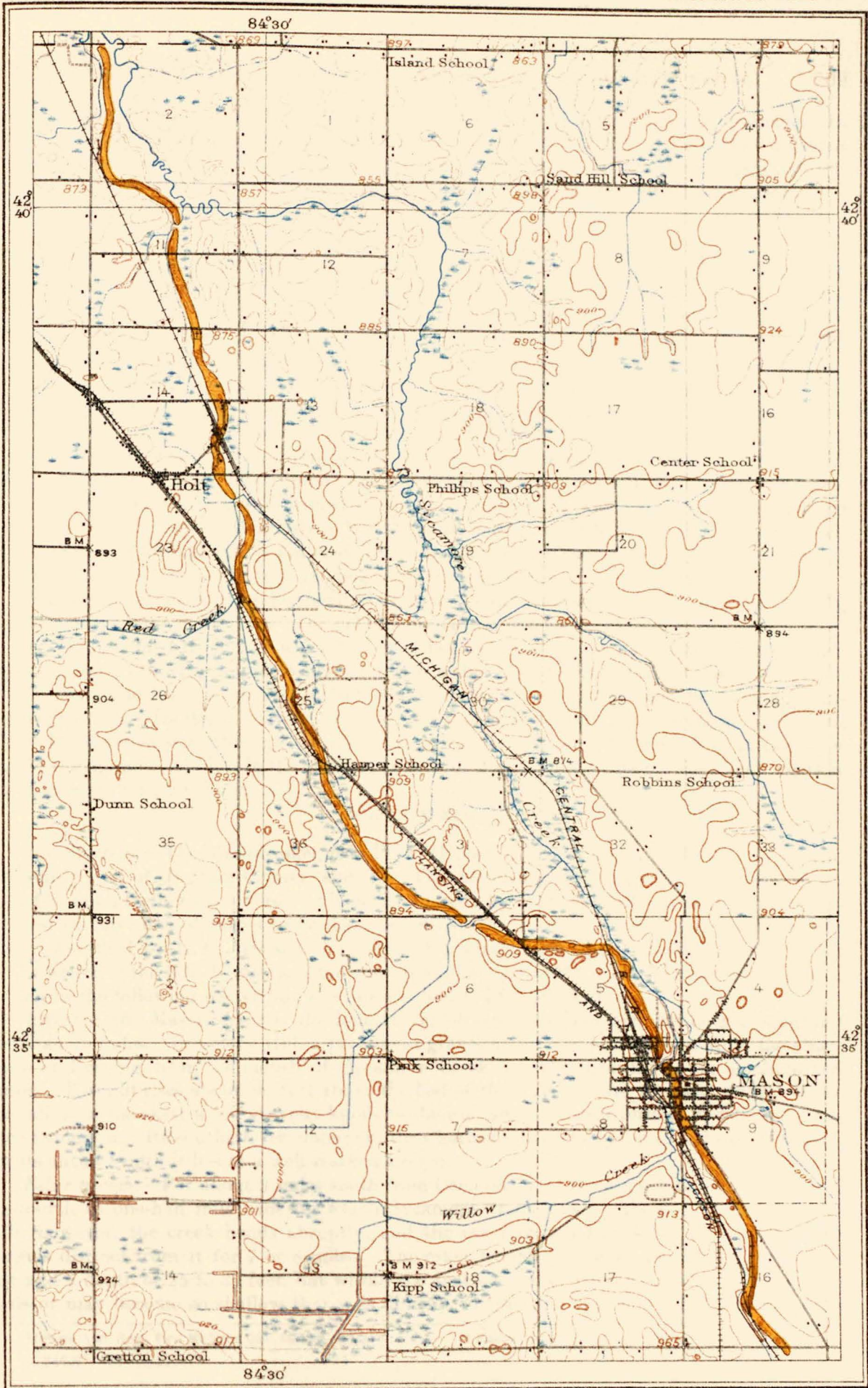
On this inner border tract there are a few very prominent knolls and some undulating strips nearly surrounded by till plains. Some of these knolls northeast of Howell are elongated in the direction of ice movement and form short chains, as is the habit with eskers, but are irregular in shape, in some places reaching a width of nearly one-fourth mile. They are clearly shown on the Howell topographic sheet in secs. 16, 17, 20, 21, 28, and 29, Oceola Township. Though composed largely of gravel and sand they are partly veneered with bowldery till. Their height is from 60 to 100 feet. The longest chain, which extends from the north part of sec. 16 southwestward into the edge of sec. 20, has a length of about $1\frac{1}{2}$ miles. The chain in secs. 21 and 28 is less than a mile in length and so also is the chain in sec. 29.

A rather conspicuous undulating strip about a mile wide with swells 10 to 30 feet high runs east and west through northern Barry and Eaton counties a few miles south of Grand River, Roxana being on it. In places it is nearly in contact with the Charlotte morainic system and in places is separated from it by a till plain 2 to 5 miles wide, and it appears to merge at both ends in that morainic system. Farther east in northwestern Ingham County an undulating strip leads from the Charlotte morainic system at the bluff of Grand River northeastward past Holt to the Cedar Valley east of Okemos. The knolls in it are, however, low and scattered and parts of the strip are difficult to differentiate from the bordering till plains. These strips have in places some resemblance to the slender and in places ill-defined members of the next morainic system, and may perhaps belong with that system.

The surface of this inner-border tract is generally plane, but wells indicate that the underlying bedrock surface is very uneven, the depth to rock ranging from 20 feet or less to about 200 feet.

DISTRIBUTION OF ESKERS.

As already indicated, small eskers a fraction of a mile in length are found in many of the transverse depressions which characterize this morainic system from the vicinity of Hastings eastward across Eaton, Ingham, and Livingston counties. Other longer eskers or esker systems lead from the inner border district southward into the morainic system. These long eskers lie in valleys or troughs throughout much of their courses in the till plain as well as in the moraine. These valleys or troughs are in places nearly as narrow as the esker ridge, but commonly they are several times as wide. Some of the depressions are occupied for only a portion of their length by an esker; the association of esker ridge and trough is, however, so close as



Base from U. S. G. S. Lansing and Mason atlas sheets

A. HORN & CO. BALTIMORE

MAP SHOWING ESKERS NEAR MASON, MICHIGAN



Contour interval 20 feet.
Datum is mean sea level.

to render it probable that they owe their origin to the same agency—subglacial drainage. In a few places two eskers unite to form a single ridge. (See pp. 211–212.) All eskers of sufficient length are represented on the glacial map and will be considered in turn from Charlotte eastward. Eskers only a fraction of a mile in length will be passed over with a mere mention.

CHARLOTTE ESKER.

This esker, which has its terminus at the eastern edge of the city of Charlotte, is about 9 miles in length. Its northern end is in sec. 3, Benton Township, on the north side of the Thornapple River valley. The river passes across its line in the edge of secs. 10 and 15. The esker follows up the south fork of Thornapple River to the Grand Trunk Railway, about $1\frac{1}{2}$ miles southwest of Pottersville. Thus far the esker is represented by short ridges separated by gaps nearly as long as the separate ridges, but from the railway southward, across sec. 34, Benton Township, it is more nearly continuous as a low winding ridge 15 to 20 feet in height and 90 to 100 yards in width at its base. A few short spurs lead from it to the border of the trough in which it lies. In Eaton Township it is well developed in the north part of sec. 4; for the next mile southward it is much interrupted; and after this it is again continuous for a mile or more. Its southern terminus is a well-defined fan-shaped sandy delta which covers about 3 square miles immediately east of Charlotte. Wells in this delta penetrate a fine gravel with much sand intermixed throughout its entire depth to the underlying sandstone. The sandstone has an uneven surface, the depth to it ranging from 16 to 60 feet.

Slight excavations in the esker near its north and south ends show it to be composed mainly of gravel of medium coarseness. The pebbles are largely sandstone of local derivation.

The well-defined trough, in which the esker lies from its head to its southern end, shows a slight descent to the Thornapple Valley and then a slight rise to the delta at Charlotte. At its lowest part its altitude is about 850 feet above sea level, and at the esker fan it is approximately 900 feet. Its depth is from 10 to 20 feet and its width from one-eighth to one-fourth mile. It passes entirely through the Charlotte morainic belt, the esker fan being at the outer edge of the moraine, and it is in the moraine except for 2 or 3 miles at its northern end, where it is in the inner border till plain.

MASON ESKER.

Investigation.—The Mason esker (see Pl. VIII), which passes through the city of Mason, the county seat of Ingham County, and the Williamston-Dansville esker (see Pl. IX), which lies a few miles farther east, were each described briefly by C. C. Douglas¹ in 1839, being among the first of this class of ridges to be described in North America. The Mason esker was also briefly described by L. C. Wooster² in 1884. The Mason and Charlotte eskers were studied by the writer in the fall of 1887, and the description here given of the Mason esker was prepared by him in the following winter but was never submitted for publication.

Extent.—The Mason esker is the longest yet observed in Michigan, its length being not less than 20 miles. Cemetery Hill, a prominent gravel knoll 2 miles southeast from the state-house at Lansing, near the mouth of Sycamore Creek, may be regarded as its northern terminus. This hill rises about 60 feet above the bed of the creek on the west and 30 feet above the valley on the east; a few gravelly knolls to the east and northeast form an indefinite northward extension. Its southern terminus is in the Charlotte morainic system southeast of Mason. For its entire length it lies in a well-marked trough.

Esker trough.—For about 3 miles south from Cemetery Hill the esker follows a depression, one-fourth to one-half mile wide, in which Sycamore Creek flows. About $1\frac{1}{2}$ miles north of Holt, however, the creek bends abruptly, and the esker trough leaves the creek valley and remains distinct from it for 7 or 8 miles. The esker trough in places has a width of half a mile and a depth of 25 to 30 feet, but within the space of a mile it may contract to 100 to 150 yards or may become so shallow that it is difficult to trace. For about 5 miles it maintains

¹ Second Ann. Rept. First Michigan Geol. Survey, 1839, p. 67.

² Kames near Lansing, Mich.: Science, vol. 3, 1884, p. 4.

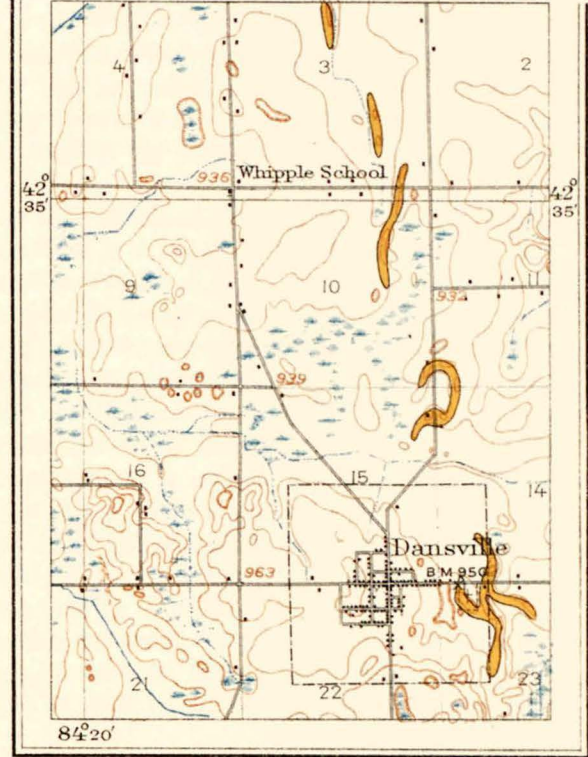
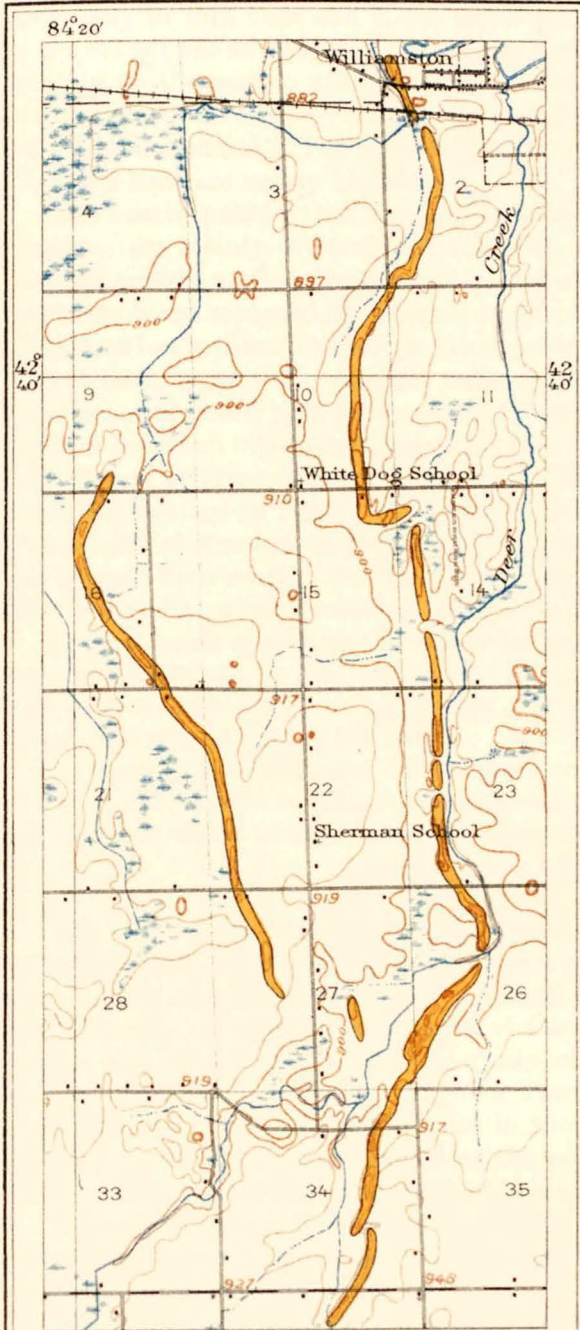
a uniform course approximately S. 20° E., then changes abruptly to about S. 70° E., and so continues for 2 miles or more, when it reunites with the valley of Sycamore Creek. For 3 miles the united valley takes a course fluctuating between S. 20° E. and S. 30° E.; then it changes and runs S. 50°-70° E. to the Mud Creek valley at the inner border of the Charlotte system where it swings abruptly south and follows the creek to its source in the northeast part of Leslie Township (T. 1 N., R. 1 W.). Its form changes with its trend, being deepest where it runs S. 20° E. and shallowest where it passes eastward to join the Sycamore Creek valley; it deepens again when combined with the Sycamore Creek valley but shallows in crossing over to Mud Creek.

Topography.—In the first 3 miles of its course the esker consists of short ridges interrupted by longer gaps, one of which, 2 miles south of Cemetery Hill, gives passage to Sycamore Creek. Farther south, beyond the point where the esker trough reunites with the Sycamore Valley, the esker makes several abrupt turns but keeps within the limits of the valley. (See Pl. VIII.) Its interruptions are slight, apparently aggregating scarcely one-sixth of the combined length of the constituent ridges. The height of the ridges varies considerably and in places changes abruptly, dropping off in a few yards from 40 feet to less than 10 feet and even terminating abruptly to reappear within a few rods as a low ridge. On account of these abrupt breaks it has been used as a wagon road for but a short distance. Its width is only 50 to 100 yards even when highest, and its slopes are very steep, reaching 30° in places. The ridge is especially prominent where it makes the eastward deflection to come back to Sycamore Creek near Mason, its height being 20 to 30 feet above the bordering till plains. The esker passes directly through the city of Mason, where, for a short distance, it lies well up on the east slope of the valley, and rises above the bordering upland. For about 2 miles south of Mason it is 30 to 40 feet in height and practically continuous. After leaving Sycamore Creek in secs. 21 and 22, T. 2 N., R. 1 W., it is low and interrupted by gaps for a mile or more, but on the swampy divide between Sycamore and Mud creeks it is broken by only narrow gaps. In the vicinity of the Charlotte morainic system it expands into a series of kames or plexus of ridges which inclose swampy depressions. Around the southern end of this kame plexus the moraine itself is exceptionally gravelly over an area of about 10 square miles, a feature which is perhaps due in part to the same subglacial drainage that produced the esker.

The course of the subglacial stream which formed the esker, as is shown by the bedding of the gravel, was from north to south, or the reverse of the present drainage, and the elevation of the esker trough increases in passing from the head southward, being about 830 feet near Lansing, 900 feet at Mason, 11 miles up Sycamore Creek, and about 915 feet at the southern terminus 7 or 8 miles farther south. It therefore ascends about 85 feet in less than 20 miles. If the gravelly portion of the moraine adjacent to the southern end of the esker trough be included the rise is 50 to 75 feet more, to the summits of the most prominent knolls. This rise is made abruptly, in places in less than one-half mile. It is doubtful if the stream which formed the esker and esker trough really made such an ascent. The esker trough seems likely to be a result of depletion of the basal portion of the ice by streams within the ice rather than beneath it. If so, the streams may have made little or no ascent.

Composition.—The esker, wherever opened, is composed of stratified and more or less perfectly assorted material. It gives evidence of the action of a stream which varied greatly in the rapidity of flow in different places along a given horizon, both longitudinally and from side to side, as well as at different horizons. The phenomena displayed are not unlike those found in the beds of existing streams flowing subaerially. The esker is evidently a stream-bed deposit, though probably deposited within ice walls.

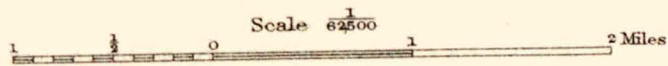
The most extensive excavation is a railway gravel pit about a mile south of Mason. The esker here has a height of 35 to 40 feet and a breadth of only 50 to 75 yards at the base. The excavation is about one-fourth mile in length and passes obliquely through the esker, its southern end showing the structure of the east side and its northern of the west side, the main part of the exposure being in the elevated central portion. The eastern slope is underlain by fine sand but the main body of the ridge is of gravel. It has a capping of brown clayey gravel, varying



Base from U. S. G. S. Mason atlas sheet.



MAP SHOWING THE WILLIAMSTON-DANSVILLE ESKER
INGHAM COUNTY, MICHIGAN



Contour interval 20 feet.

Datum is mean sea level.

1914



INDIAN COUNTY, KENTUCKY
 SHOWING THE WILLIAMS-TOLSON-DAVIS-LEWIS

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in depth from a few inches on the crest to several feet on the less abrupt portions of the slope. The longitudinal vertical section shows that the beds both of the sand and the gravel have a nearly horizontal stratification, though they arch and sag slightly at intervals. Cross-bedding occurs only in thin beds and is not extensive. A transverse section near the southern end of the gravel pit shows evidence of gouging and subsequent refilling; the gravel beds break off suddenly on the east to a depth of 15 feet or more and are replaced by sand. In places the gravel has been taken away completely by the railway company and only a nearly perpendicular wall of sand remains. The sand beds dip rapidly toward the eastern edge of the ridge, but the gravel beds are nearly horizontal.

The coarse pebbles, cobbles, and bowlderets in this esker, as well as in others studied in Michigan, are mainly of local rock material, which here is a sandstone of Carboniferous age. The finer pebbles are less conspicuously local and embrace rocks of various classes. Increase in angularity is accompanied by decrease in size, large pebbles being well rounded and pebbles one-half inch or less in diameter more or less angular. Of 91 pebbles whose diameter averages less than one-half inch, 32 were of crystalline rocks, largely granites, and the remaining 59 were sandstone, limestone, and chert, principally of local derivation. Of 374 pebbles classified whose diameter averages less than one-fourth inch, 134 were of crystalline rocks and the remaining 240 of the same classes as those of the other group. Much significance is attached to the fact that the coarse pebbles are so largely of local derivation; for if, as some suppose, eskers were formed by superglacial streams, they would have contained less local material (this being for the most part beyond their reach), and the coarse rocks would be largely of granites and other distantly derived material which had been brought to the surface by ablation.

Several small gravel pits revealed features similar to those in the large pit. In some of them—for example, in the pit on the line of secs. 9 and 16, Vevay Township—the gravel beds showed a marked southward dip. In the pit at Holt station the beds dip perceptibly toward the eastern edge of the ridge.

In the plexus of ridges at the southern end of the esker more or less clay is mixed with the sand and gravel, and in places the material exposed appears to be partly assorted till. The flow of water seems to have been less vigorous than in the linear portion of the esker.

WILLIAMSTON-DANSVILLE ESKER SYSTEM.

The Williamston-Dansville esker system (see Pl. IX) consists of a main chain of ridges leading from near Williamston, Ingham County, southward past Dansville, a distance of about 10 miles, and of two tributary chains of ridges, one leading southeastward from sec. 16, Wheatfield Township, to join the main chain at the Deer Creek valley in sec. 27, a distance of about 3 miles, and the other following the valley of Doan Creek in a course west of south from sec. 19, Leroy Township, to sec. 23, Ingham Township, a distance of 8 miles. This last chain is interrupted by a gap of fully 2 miles in the northeast part of Ingham Township. A plexus of sharp gravel knolls is developed at the southern end of the esker system, which is at the northern edge of the Charlotte morainic system.

A portion of this esker system, as already noted, was studied by C. C. Douglas¹ about 1839. The present writer studied the southern part in 1887 but did not trace out the esker system completely until the summer of 1900.

The main esker heads a mile west of Williamston near the south bluff of Cedar River in a prominent ridge 30 to 35 feet high. This follows the west side of the Deer Creek valley southward through sec. 2, Wheatfield Township, but takes a more direct course west of it in secs. 10 and 15. In the last two sections its general height is 15 to 25 feet, but in sec. 15 it consists only of a string of knolls broader than the ridge. For the next 2 miles it follows the Deer Creek valley along the line of secs. 22 and 23, 26 and 27, reaching a height of 50 feet in places in the second half of the distance. In sec. 34 it continues prominent, ascending about 30 feet from the creek valley to a till plain on the east, above which it rises 25 to 30 feet. In the south part of sec. 34 it descends into a swampy sag or esker trough and follows it past Dansville to

¹ Op. cit., p. 67.

the edge of the Charlotte morainic system. The border tracts are more undulating and bowldery from about a mile north of Dansville southward than they are farther north. As a rule, this main esker consists of a single string of ridges, but about a mile north of Dansville, where the main ridge curves to the east, describing nearly a half circle, small ridges run across the arc in line with the general course of the esker. Its height is from 15 to 30 feet in the vicinity of Dansville. In the plexus of knolls at the southern end of the esker points reach 50 to 75 feet above neighboring swamps. The knolls here contain some till as well as gravel, but the esker seems to be composed entirely of gravel and sand.

The branch in Wheatfield Township lies in a till plain and is not accompanied by a trough or sag. It is exceptionally regular and smooth and has a height of 15 to 20 feet and rather steep sides. It has no delta at its southeast end, but terminates on the bluff of Deer Creek, one-half mile or more from the main esker. So far as exposed by gravel pits it shows a fine material, some parts being sandy, but most being coarse enough for road ballast.

The branch along Doan Creek has a few ridges strung along in secs. 19 and 30, Leroy, and secs. 25 and 36, Wheatfield townships, with only short interruptions. Then it is broken by a gap of over 2 miles, though the swampy esker trough persists. Near the center of sec. 13, Ingham Township, a ridge sets in and runs southwestward, with but slight breaks, for about 2 miles to the intersection of the main esker. In the last mile it is bulky and irregular, but elsewhere it is a low and narrow ridge and is of typical esker form. The best exposure is in a gravel pit in sec. 36, Wheatfield Township, where a ridge 30 feet high is opened from top to bottom and exposes gravel suitable for road ballast for its entire depth.

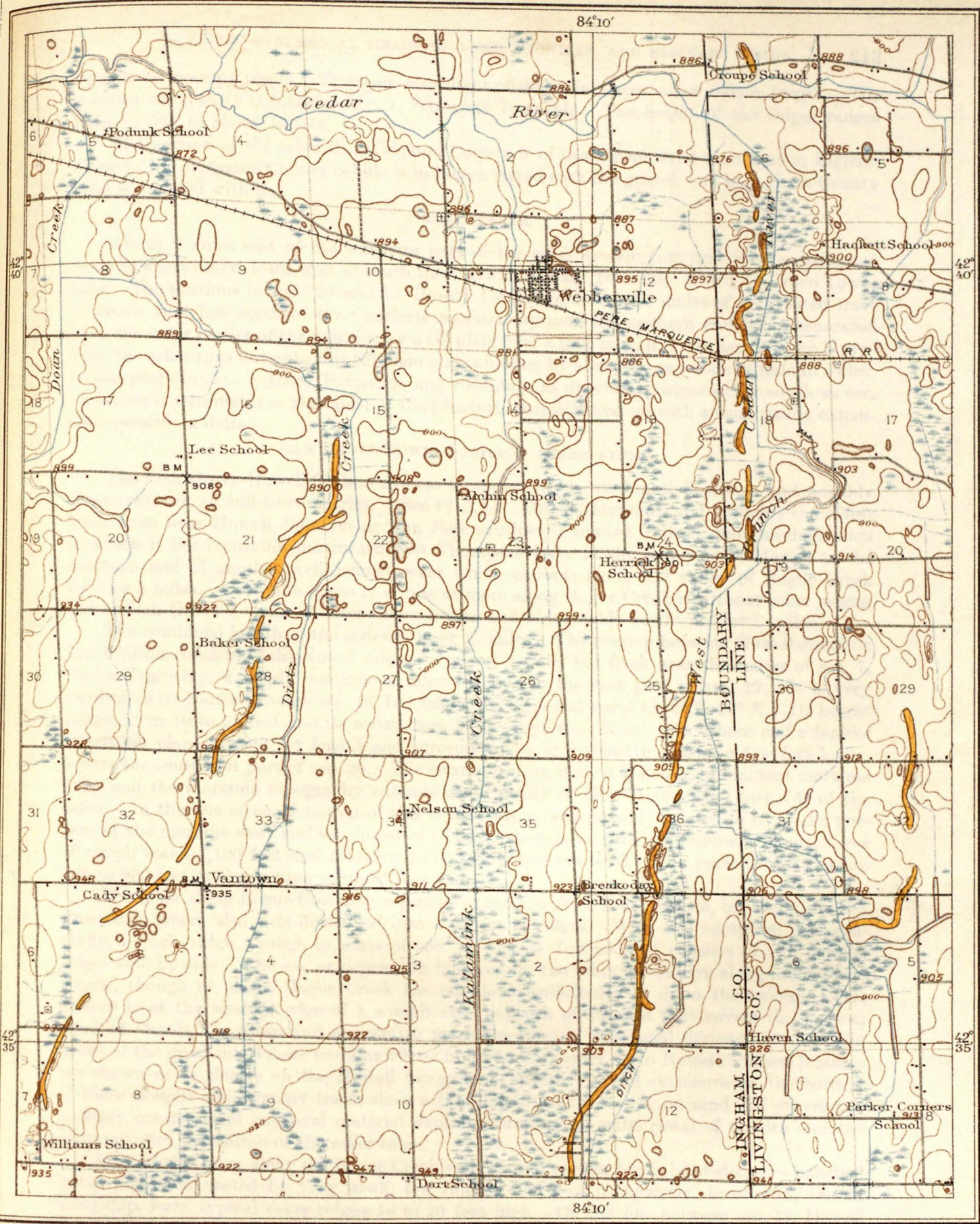
LEROY TOWNSHIP ESKER.

In Leroy Township, in eastern Ingham County, an esker about 5 miles long lies 2 to 2½ miles east of the east branch of the Dansville esker and trends nearly parallel with it from north-northeast to south-southwest. It heads in the southwest part of sec. 15 and follows a small tributary of Doan Creek through secs. 21, 28, and 33, much of the way in a swampy sag. It has a general height of 12 to 15 feet and the steep slopes characteristic of the normal esker. Its continuation on the till plain in sec. 32, Leroy Township, and the north part of sec. 5, Whiteoak Township, is rather faint, but it reappears in strength in the southwest part of sec. 5 and runs across the corner of sec. 6 into sec. 7 to the border of the main moraine of the Charlotte system. In constitution this esker is more sandy than the Mason and Williamston-Dansville esker systems.

ESKER SYSTEM OF WESTERN LIVINGSTON AND EASTERN INGHAM COUNTIES.

An esker system begins in the Cedar River valley in the southwest corner of Conway Township, Livingston County, and runs southward about 3 miles along the valley of the west branch of the Cedar one-fourth to one-half mile east of the Ingham-Livingston county line. (See Pl. X.) Its trough then bears west of south into the edge of Ingham County, but is devoid of esker ridges for about 1½ miles. In sec. 25, Leroy Township, however, ridges set in which are nearly continuous for 3 miles, in secs. 25 and 36, Leroy, and secs. 1 and 11, Whiteoak townships, Ingham County, ending in the middle of the east edge of a large tamarack swamp. The swamp is about 7 miles long and three-fourths to 1 mile wide, extending from sec. 26, Leroy Township, southward across sec. 26, Whiteoak Township. It extends back into the main moraine of the Charlotte system a couple of miles, but seems to have no esker ridges in it, the main esker terminating a mile or more north of the moraine.

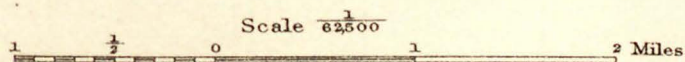
A single segment of the esker about 15 feet high and nearly one-half mile long lies north of Cedar River in a marshy tract just south of a moraine in sec. 31, Conway Township. A space of nearly a mile separates it from the next segment to the south in sec. 6, Handy Township. From sec. 6 to sec. 19, Handy Township, it is nearly continuous and has a height ranging from 5 to 40 feet. It is double for a short distance near the Pere Marquette Railroad and incloses a small basin. It does not follow the sag or esker trough, but lies between the trough and Cedar River on a till plain that stands about 20 feet above the river. The portion in Ingham County is in places double or even treble, ridges being nearly parallel to one another and separated



Base from U. S. G. S. Fowlerville atlas sheet

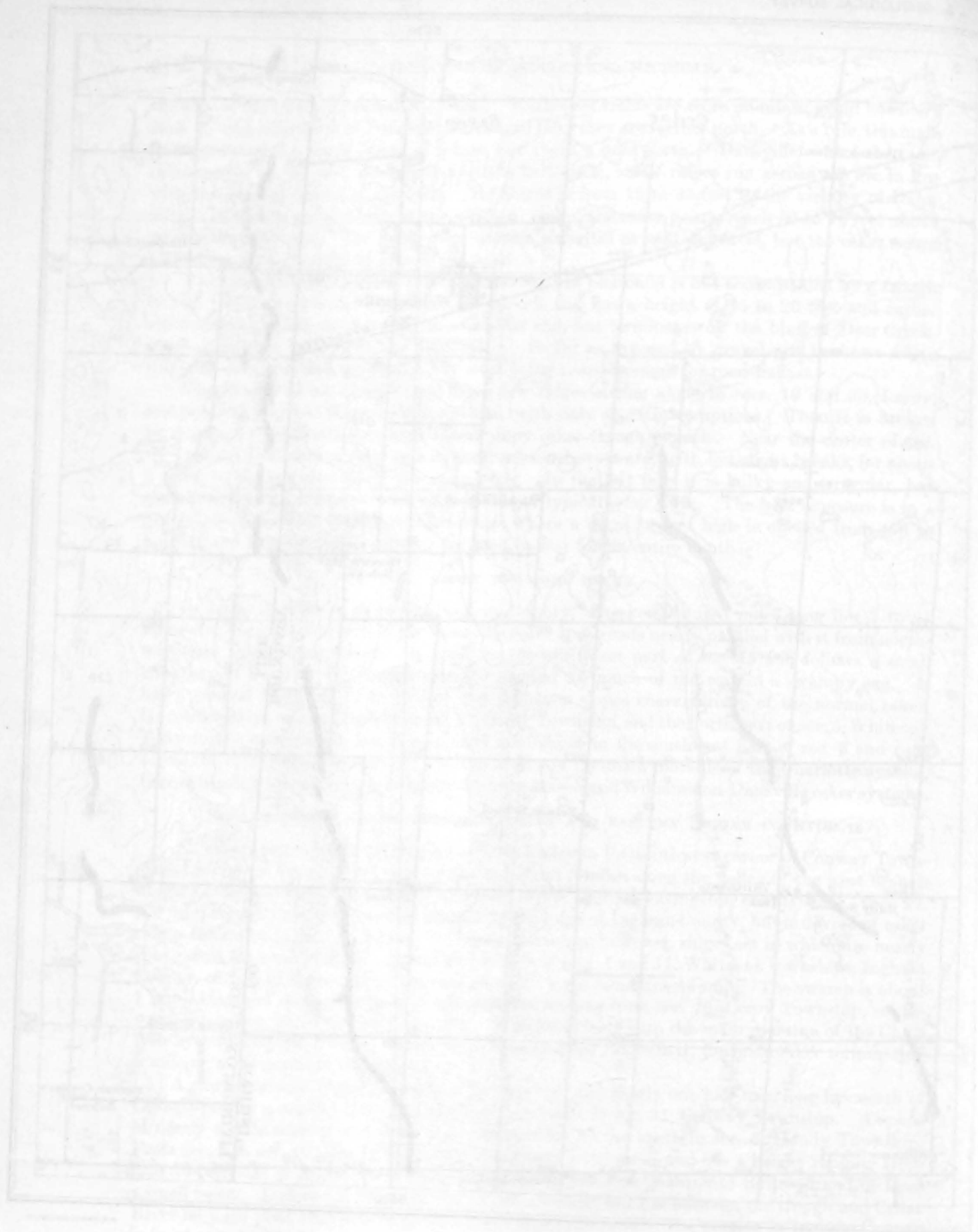
A. HOEN & CO. BALTIMORE.

MAP SHOWING ESKERS NEAR WEBBERVILLE, MICHIGAN



Contour interval 20 feet.

Datum is mean sea level.



MAP SHOWING ESKEES NEAR WARBRELLITE, MICHIGAN

Scale 1:50,000

Copyright 1910 by the State of Michigan

by narrow swampy tracts. There are also slight offshoots in places, a few rods in length. The greatest complexity is found in sec. 1, Whiteoak Township. The height of the ridges ranges from 15 feet to about 40 feet.

The portion of the esker in Livingston County is of coarser material than that in Ingham County; in Livingston County cobble is in places mixed with the gravel, and in Ingham County sand is mingled with it.

IOSCO ESKER.

About 2 miles east of the southern part of the esker system just described a disjointed chain of short eskers leads west of south from sec. 29, Handy Township, to sec. 19, Iosco Township. The portions in secs. 29 and 32, Handy Township, are in the midst of an isolated tract of knolls that lies north of the Charlotte morainic system, its southern end being separated from the inner border of the moraine by a till plain over a mile in width. In sec. 5, Iosco Township, the esker runs out onto this till plain and is broken by a marshy gap about a mile in width. It reappears in sec. 7, Iosco Township, and continues as disjointed ridges as far south as sec. 19, where it terminates in the midst of the Charlotte morainic system with a small sandy expansion, possibly a delta.

OAK GROVE-HOWELL-CHILSON ESKER SYSTEM.

The Oak Grove-Howell-Chilson system is apparently a combination of two and possibly three eskers in an end-to-end series. (See Pl. XI.) The southernmost and probably the oldest leads from near Howell Junction or Ann Pere southward toward Chilson, but the depression in which it lies continues northward past Thompson Lake in the east part of Howell to the southern end of another well-defined esker which extends along the valley of Bogue Creek for 4 or 5 miles. Beyond a space of a mile or more along Bogue Creek is without esker ridges, but at Oak Grove a chain of esker ridges begins and is traceable northward for 2 miles.

The combined length of the series is 14 or 15 miles. The portion between Howell Junction and Chilson consists of disjointed ridges for about a mile, but from near the center of sec. 7, Genoa Township, a nearly continuous ridge extends to the east part of sec. 19. It is very winding in its course through sec. 18, but maintains a general trend about S. 20° E. Its height ranges from 10 to 20 feet and its width from 50 to 75 yards. Near its southern end a fanlike expansion plane, except for basins and surrounded by an extensive swamp a few feet lower, covers the southwest part of sec. 20. The swamp in turn is surrounded by prominent morainic hills, and the morainic topography extends north nearly to Howell along the east side of the esker. In the line of continuation of this esker system, and possibly related to it, in the portion of the moraine west and southwest of Chilson, there is a chain of prominent kames, three of which reach 1,100 feet and a fourth 1,060 feet above sea level. The esker trough reaches 920 to 950 feet in the portion south of Ann Pere.

The esker along Bogue Creek has a fanlike expansion at its southern end, in sec. 25, Howell Township, where also it is developed into a plexus of ridges. With this exception it is generally a single ridge, though in parts of sec. 19, Oceola Township, it consists of two parallel ridges side by side. The sag or depression followed by the esker is swampy along much of its length, though in places Bogue Creek has cut down sufficiently to drain the swamp. This swamp is at the western edge of a complicated network of swamps that covers the western third of Oceola Township and appears to mark the lines of subglacial drainage in the plain north of the great interlobate moraine whose inner border comes up to Howell. These features are shown quite clearly on the Howell topographic sheet. Several exposures on the borders of these sloughs and swampy tracts show a thin deposit of till resting on sand and gravel and possibly consisting of englacial material deposited during the withdrawal of the ice and the contemporary deposition of the esker ridge.

Most of this esker along the Bogue Creek valley is not regular but is bead-shaped—bunched up in places connected by very weak, low ridges. Parts of it, however, in sec. 18, Oceola Township, form typical esker ridges 10 to 20 feet high. On the line between sec. 12, Howell Township, and sec. 7, Oceola Township, the ridge is 30 to 40 feet high and in places nearly one-