

Open File Report XLI
FIELD NOTES OF FRANK LEVERETT

Notebook No. 215 - Leverett

COUNTY

Muskegon

Newaygo

Oakland County elevations

Oceana

Ottawa

OTHER STATES

Illinois

Minnesota

Wisconsin

Other States

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TO
NOTEBOOK NO. 215**

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- Nov. 13, 1906. Ames to Des Moines, Albion and New London. Drive New London to Denmark.
- Nov. 14, 1906. Studied exposures of blue-black till near Denmark.
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- pp. 53-72. Pebble classifications etc., by R. T. Chamberlin and C. W. Hall and notes from Wisconsin and Minnesota reports.
- pp. 73-90. Conference with Chamberlin and Calvin in northeastern Iowa on Iowan drift, July 24-27, 1907.

- pp. 91-104. Notes on beaches east of Lake Michigan with F. B. Taylor and J. W. Goldthwaite, July 28-August 4.
- Aug. 16, 1907: Oelwein, Iowa, Alta Vista, etc., pp. 105-114.
- pp. 115, etc. In southern Minnesota. (See sheet with abstract of notes inclosed)

Abstract of notes in notebook

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- 58-59. Near middle of book. Notes on peat, wood, etc., in northeast Iowa and southeast Minnesota between tills from Winchell's paper on Proc. AAAS, Vol. 24, 1875, Pt. 2, pp. 43-56.
- 60-66. Notes by C. W. Hall on:
1. Limestone pebbles in blue-black till at Lime Springs, Iowa. Not dolomitic, possibly in upper Ordovician or post Ordovician, and not lower Ordovician or Cambrian.
 2. On sand in pale clay under gumbo at Cresco, Iowa. "Rough, unworn quartz sand, not from such formations as St. Peter or Jordan sandstone.
 3. Pebbles over the upper pale clay at Cresco, Iowa. A mixed lot, no significance noted.
 4. Yellow till under gummy clay at Cresco, Iowa. Grains show little wear. Not from underlying Paleozoic formations of southeast Minnesota.
 5. Pebbles from top of black gumbo at Cresco, Iowa, mostly angular and from granitic quartz. A quartz diorite and a curiously cracked pebble--what cracked it?
 6. Grains in another sample from in the black gumbo at Cresco. Small properties of quartz grains wash out. They appear to be from granitic rocks.
 7. Pale clay above black gumbo--grains 50% or more unworn; about 20% impure quartz or silicates with other source than underlying rock formations.
- 70-71. Analyses of peat from railroad cut southeast of Faribault, Minnesota.
73. Iowan filling east of Atkinson, Iowa, with T. C. Chamberlin and Calvin. Veneered erosion.

76. Loess-free bouldery tract in southwest part of Decorah. Fresh sandy terrace on Upper Iowa River at Freeport below Decorah, altitude 920 feet. Older looking gravel east of Freeport at only 25-35 feet above stream.
78. Loess-free area east of Clermont relieved by paha ridges.
- 79-82. Loess free strip on Turkey River. How produced?
- 82-84. Remarks on lowan area in southeast Minnesota and need for further study.
84. Terraces of lowan (?) age on Turkey River near Elgin and Clermont, 60 feet above stream.
- 86-90. Chamberlin's interpretation of tongues of loess-free land in northeast Iowa due to wind drafts.
105. Trip, Oelwein, Iowa, north to Alta Vista and cuts south of Alta Vista with leached till and unleached.
111. Cut a mile south of Elma shows lowan (?) drift over gray gumbo. Gumbo is 6-8 feet and above it is a sandy clay with an occasional boulder. Is the upper clay Kansan? Altitude of rock at Elma, 1,188 feet ±, or about same as depot.
115. Drift at Taopi, 140 feet, making rock surface 1,200 feet A.T. Drift at Bailey, Iowa, 40 feet.
118. Two wells at Taopi strike a black muck under sandy and gravelly drift at 35-40 feet. It seems to be at top of the blue-black till.
- 120-121. Samples collected in cut 1½ miles northwest of Taopi, altitude 1,370 feet. Till leached 6 feet.
122. Stained gravel at pit 1/2 mile east of Taopi. Sample for pebble classes (Notebook 216). Samples from old gravel 2½ miles west of Leroy (see (Notebook 216).
123. Bark found at 19 feet in dug well in Section 12 near Leroy. Altitude 1,335 feet.
124. Cut in railroad summit, northeast part Section 12, Leroy, altitude 1,350 feet, shows calcareous till at 4 feet. Fresh till brought up by crawfish in a slough in northeast part Section 14, Leroy.
125. Rusty, sandy gravel in pit in south part Section 1, Leroy.
126. Cut 3½ feet deep on summit in Section 31, Bloomfield Township, reaches calcareous till altitude 25 feet above Ostrander.
127. Polished quartz pebbles in gravel around Ostrander.
129. Cuts southwest of Spring Valley have a rusty, brown clay 3-4 feet thick over a gray gumbo, as noted in 1906.
130. Wells around Wyckoff enter rock just below the loess at 20 feet ±. Drift over 75 feet in well in Section 5, Bloomfield Township. Altitude 1,335 feet. Water in gravel.
131. "Lignite" found in wells in Bennington Township, Mower County, at various depths up to 60 feet.
132. Rock usually at less than 50 feet and, in places, at 15 feet in northern Bennington Township, each side of South Root River.
133. Drift over 90 feet in south part Section 27, Clayton Township, Mower County, largely blue till. Sand under mill foundation at Taopi settled so much the mill was abandoned.

*Page numbers are those of notebook, not of transcription.

NOTEBOOK NO. 215

November 7, 1906.

Elkader, Iowa, 3:00 p.m. I take road south, crossing valley of a creek in southwest part Section 23, Boardman, in which the sand is rather red and is overlaid by loess. It looks to be older or more deeply stained than the sand on the upland east of Elkader in south part of sections 23 and 24 and north part of sections 25 and 26, Boardman Township.

Continuing south across Section 26 to forks of road, I find reddish, gravelly till well exposed to depth of 12-15 feet in northwest part of Section 35. The rock is exposed under it. From here southeast toward Communia there is only scanty drift to Section 12, Cox Creek Township. I there pass red drift several feet thick and there is a similar deposit north of Communia in Section 7, where road rises toward the Turkey bluff. From the valley at Communia I go up to a ridge eastward that overlooks the Turkey River Valley and follow it to the mouth of Volga River. There is thick loess on it but only scanty drift deposits. The loess is present on both bluffs of Turkey River. I am told sand and gravel is confined to low tracts along the river 50 feet ± above the river. The sand is, in places, reddish and covered with silt. There is gravel, in places, with stones 2 inches in diameter.

November 8, 1906.

Elkport, Iowa. I go southeast into Section 36, Volga, and find a remarkable accumulation of boulders in south half of Section 36 on high ground 750-800 feet. There are hundreds of large ones 3-6 feet in diameter. There is a sandy strip along the bluff north of the bouldery strip and somewhat higher. The boulders extend east to the east part of SE $\frac{1}{4}$ Section 36 to Ed Jennings' place and there are sandy knolls from there east to the river bluffs (Turkey River).

I take road east onto the high ridge south of river. There are some bare ledges up here but generally loess is present and it is a heavy deposit on the lower tracts to the west in Section 1, Elk, and Section 6, Mallory Township. I turn south in Section 5, Mallory, and follow the high ridge to Section 20. It has chert under the loess and very little drift, I pass exposures of red drift in southeast part of Section 20--a gravelly till, and there are other exposures between here and Colesburg. The drift becomes thick south of Golesburg and there is a large amount of blue till. Mr. Dittmer, in SE $\frac{1}{4}$ Section 19, Colony, has a well 206 feet that terminates in sand under a heavy deposit of blue till and other wells in that vicinity are more than 100 feet without striking rocks.

The smooth tract in Colony Township seems to owe its smoothness to the great deposit of drift and to its location at heads of streams (Bear Creek, Elk Creek, and Little Turkey River). It is loess covered but the loess is very thin on some slopes so that boulders may be seen. There is scarcely a farm but has a few boulders on its slopes. The upper part of the till, next to the loess, is brown rather than red and thus looks different from the red till seen north of Golesburg.

I go west into Elk Township through south part of sections 24 and 23 and come to rock ledges in Section 23. There is red till here above the rock, usually quite gravelly. Rock is apparently near the surface from here west to Greeley. There is bare rock on east edge of the lowan tract in east part of Greeley near line of sections 28 and 29, Elk Township.

In Greeley, the distance to rock ranges from a few feet up to 75 feet or more. H. C. Hiltenbeck, driller at Greeley. A well 80 rods east of Wood Village on H. Q. Ashline farm, was 92 feet to rock. 1. Yellow clay, loess and till, 25 feet \pm ; 2. Blue till with a streak of sand at 80 feet. Well is 213 feet. There is 16 feet of water.

There is blue till at George Ash well, about a mile north of Wood, on east side of road. Yellow till 25 feet \pm ; blue till to rock at 48 feet. It is in NW $\frac{1}{4}$ Section 28.

The deepest to rock, Mr. Hiltenbeck has found, is about 4 $\frac{1}{2}$ miles southeast of Strawberry Point and is 230 feet to rock. Yellow clay 15 feet \pm ; remainder blue till with streaks of sand. It is on Milo Fitzpatrick's farm.

I take road west from Greeley into Section 19 and find loess present but only a thin deposit. Upon turning north I soon leave the loess and have sand and boulders to

south edge of Section 7. Drift is there with frequent outcrops of rock. The loess border seems to be in Section 17 and runs northwest through central part of Section 7. It then turns northeast across south part of Section 6. I did not find its course down States Branch to where it crosses. It covers north edge of Section 6 nearly to west line and then bears west-northwest, as indicated on Clayton County map.

I follow a ridge road past Woods store toward Elkport. The drift is not thick, as a rule. Usually rock is struck at 40-50 feet and of this, probably half is loess. The drab phase of loess is developed here.

November 9, 1906.

7:00 a.m. Elkport, Iowa. I walk down the railroad track 1 $\frac{1}{2}$ miles and there cross over a point of land on north side Turkey River. It has a sandy soil up to 800 feet in east part of Section 31, Jefferson Township, but I see no boulders. North and east from here there is loess. I follow a wagon road northeast along north side of river in Section 32 and upon descending into this low bottom I pass a gravel terrace standing 50-60 feet above the low bottom. It has a capping of loess-like loam 8-10 feet thick. The gravel is of medium coarseness, 2 inches or less. Just before descending to this terrace I passed a small granite boulder 15 inches in diameter on slope at about 740 feet A.T. or 100 feet above the low bottom land.

I should have noted that there is loess at East Elkport just west of the depot under the sandy gravel. Loess comes down the slope in Section 32, Jefferson Township, below the level at which I saw the sand on the point in Section 31, and possibly this loam on the gravel terrace in Section 32 is loess. The gravel looks fresh as lowan.

I ascend the bluff at a farm road in southeast part of Section 33 and find bare ledges to 770 feet A.T. Here loess sets in and at the base of the loess in a gully that cuts through it I find a quartzite boulder if feet in diameter and several small pebbles.

For a mile below here there is a terrace of sandy gravel 675-680 feet A.T. It has a loamy clay capping about 4 feet thick but not loess. There are little pebbles scattered through it. The top of the gravel, to a depth of 2-3 feet, is reddish brown in places, but below this is a fresh color unstained by iron. It seems likely to be no older than lowan.

In a recess north of Osterdock Station there is sand on the terrace up to 50 feet above station. About 1/2 mile east of Osterdock a terrace remnant on north side of track has red gravel near base and fresher above.

In east part Section 36 I go up a ravine 1/2 mile and find one greenstone boulder 10 inches and several drift pebbles 3 to 6 inches in diameter, so there seems to have been glaciation at least to here. This is only 2 $\frac{1}{2}$ miles by direct line from the Mississippi bluff.

About 1/4 mile east of the mouth of this ravine I find a greenstone boulder 2½ feet in diameter in a field north of track where a gully has brought down coarse material from the bluff above it. The boulder lies 25 feet above the level of the track. It has one glaciated face. It is old looking, with weathered surface.

In a gully in north part of Section 4, Millville Township, east of a valley that comes in from the northwest, I find a small granite rock 8 inches in diameter. It is back of G. H. Freudlein's buildings. This is only a mile by direct line from the bluff of the Mississippi River. I also find some small jasper pebbles in same ravine but see no greenstones. The drift seems to be very scanty. The Mississippi backs up Turkey River at high stages into this valley.

At Millville Station is a sandy terrace about 25 feet above level of station or 665 feet, the station being 639 feet. The upper part, to a depth of 15 feet, is largely clay of red and brown colors with small pebbles in it, but below this is sand of fresh color. Probably the clay is a slack water deposit connected with the high stages of the Mississippi, but the sand may be Pleistocene (Iowan?). There is a tract of 50-60 acres or more at the fall line east of Millville. The sand contains numerous small well-rounded fresh looking granite and greenstone pebbles up to 1½ inches in diameter. There are cherty and local rocks in the clay rather than drift pebbles.

In a recess a mile east of Millville the upper part of the sandy gravel is reddened to a depth of 3 feet ±. Above this is clay 15 feet, as in the recess near Millville, and the top of terrace is 665 feet.

I continue on foot down to Buena Vista and ascend several of the gulches. In one I found a small jasper pebble 2 inches in diameter. It is about a mile above Buena Vista. In another I ascended to altitude 750 feet and found a filling with earthy material and blocks of local rock. I found one small piece of black flint here at over 700 feet A.T.

I am told by a section boss on railroad track that he has not noticed boulders in these gulches that open directly into the Mississippi, but thinks he has seen them within a few miles back from the river. He is an old resident and has been over all the hills and gulches near Buena Vista hunting.

I take train to Dubuque from Buena Vista. The only bottoms of note on the Iowan side are at mouth of Little Maquoketa and called "Perce bottoms". The altitude is 60 feet above river, or above 640-foot contour. I continue to Sabula on same train. High bluffs border the river closely below Dubuque to a creek about 3 miles below Gordons Ferry. Sand here sets in and continues past mouth of Spruce Creek, as noted a few weeks ago. There is a very gradual ascent back from the railroad for about a mile in this interval of 3 miles or more.

November 10, 1906.

Lyons, Iowa. (See Notebook 130, notes made October 11, 1894, for well data). Walter Scofield, in southwest part of Section 2, Hampshire, has well 162 feet that is just to rock. It has a large amount of blue till. There is 90 feet of water.

Mr. Everhart's well, across road, is 137 feet in depth and struck a hard blue till at 70 feet.

G. F. Cook, in northeast part Section 12, has well 84 feet that went through blue clay and struck gravel and water at 80-84 feet. A water well near it is 90 feet to rock and is 157 feet deep. One across road, on George Au farm, is 160 feet, about 60 feet to rock. This is in northwest part Section 7—largely red clay.

A well on Shattuck farm, in Mississippi bottoms in west part of Section 31, Elk River Township (T 83 N, R 7 E), is 100 feet and terminates in sand under blue clay. The clay is described to be free from grit. The well is perhaps 60 feet above river level. (It is about 640 feet A.T.)

In the trip today I drive north from Lyons to a cemetery near middle of line sections 19 and 20, Spring Valley, and find thin drift. Rock on ridges at 30 feet ± and mainly loess above rock. I go west to range line and pass exposures of red drift, rather gravelly, a few feet thick resting on the rock. I go north 1/2 mile and then west on line of sections 13 and 24, T 82 N, R 6 E. It leads through a tract with thin drift and red color, somewhat gravelly. I come to the angling road on line of sections 14 and 23 and follow it north, rising into the belt of thick drift, with ascent of 80 feet ± from line of sections 14 and 23 north to center of Section 11, the crest of the ridge of blue till being above 840 feet. The wells in southwest corner of Section 2 are just below 840 feet.

I continued north to line of sections 26 and 35, T 83 N, R 6 E. I turned east here and passed a cut with sand under the loess and under this a gray gumbo soil with pebbles. There is a clayey loess east from here to the Mississippi bottoms near the range line of sections 6 and 7, with red till under it.

I turned south, passing the Shattuck well, and then rising to the high tract that runs out to the river in north part of Section 7, T 82 N, R 7 E, directly opposite the line of Whiteside and Carroll counties, Illinois. On the rise I passed exposures of brown till and of red, gravelly till. On the ridge loess conceals the till both here and where I drove north.

I leave the thick drift near middle of line of Section 7, Spring Valley and Section 12, Hampshire Township. From there to Lyons the rock is frequently exposed and drift is generally reddish color.

The blue clay struck in a well in northeast part of Section 12 may prove to be something else than blue-black till, for the owner says he did not notice it in his other well or in the Au well, and he was around the well when drilled. It was largely yellow clay with little or no sand.

The Clinton Brewery well penetrated sand and gravel 200 feet and then entered blue shale and stopped at 285 feet ±. Altitude 25-30 feet above river.

A well at Eagle Point park, northeast of cemetery, is 464 feet. It has 200 feet of shale from 166-360 feet and below this a white rock in which but little water was found.

A well 1 mile east and 1 south of Bryant is 409 feet. Drift 142 feet. It has considerable blue till--on J. Sullivan farm. This was carried through the blue shale, he thinks.

A well about 2½-3 miles south of Charlotte is 212 feet and does not reach rock. It was largely blue clay. At Andover, rock is at 40-60 feet. Drift largely sandy. Many wells are driven 25-40 feet.

I take electric car from Clinton to Davenport. It is on bottom lands to south side of Wapsipinicon River. Then, just north of Princeton, it makes cuts 30 feet ± deep, showing loess 20-25 feet resting on the rock. I see no drift. About midway between Princeton and Le Claire there is a plain where boulders are strewn over the slope up to 50 feet or more above the river. This is rather surprising, since loess generally occurs down to the base of the steep bluffs, 30-40 feet above river level.

November 11, 1906.

Davenport, Iowa. I take train on Rock Island to Iowa City. Dark blue till at base of cuts in west part of Davenport. On uplands just west of Davenport till and boulders are very near surface for a mile or so. Surface is remarkably flat west from Davenport.

Northwest of Durant 1½ miles ± is an oval hill like a paha--30 feet ± high a I saw a faint suggestion of paha like ridges several miles farther east on north side of track. But as a rule, the surface is remarkably flat clear to the sandy belt on Cedar River at Moscow.

At Iowa City I meet Professor Calvin who reports he has found scattered boulders nearly to Waukon in western Allamakee County and patches of till and occasional boulders over the part of Winneshiek County north of the Upper Iowa River. He noted a ferruginous conglomerate at the iron mine 4 miles northeast of Waukon and scattered pebbles over much of Allamakee County.

By "driftless" in his reports he simply means that drift is not sufficient to greatly modify the preglacial topography. It would seem better to say "thin or patchy drift" for the word "driftless" misleads the readers of his reports. He says there is loess along west bluff of the Turkey from Fort Atkinson up to Spillville.

He does not think the boulders on Waukon road east of Decorah are lowan type. They are chiefly quartzites of pre-lowan. The tracts free from loess, such as I noted east of Decorah, and those in southeastern Jackson County he thinks may simply represent places where there was no vegetation to collect the loess and not a sure indication of the persistence of lowan ice. He

follows Shimek in thinking the loess was deposited during a warm climate between glacial epochs. The drab loess with ferruginous tubes and flakes is thought by him to be decidedly older than the overlying brown loess, yet he says he has not noted unconformities or other evidence of a break between the two. The drab simply seems to be older because it contains the iron in concentrated form. Shimek has found the drab loess oxidized at top where exposed near Iowa City below the later loess.

Professor Udden still holds the view that there may have been a tundra around the edge of the lowan ice sheet. Faulting in the loess seems best explained by giving way of frozen ground. He thinks the fauna of tundra regions should be examined to see how it compares with the loess fauna. Udden has recently found the blue-black till on west side of Illinois River valley near Peoria. It carries pebbles of the Winnipeg limestone, also compressed cedar or other conifer wood, and has just the aspect of the blue-black till at Muscatine.

Udden thinks pebbles of very resistant rock such as are found north of the Wisconsin River in the driftless area may easily have persisted from long before the glacial epoch and have been brought in by streams, for streams, in the course of ages, have a great deal of shifting of valleys back and forth. He has noted in Texas, where there has been no glaciation, pebbles up to a foot in diameter scattered over interfluvial tracts, as these greenstones, quartz, jasper, and quartzite pebbles are scattered over the part of the driftless area north of Wisconsin River. He thinks nothing but ancient rivers could have transported those in Texas, some of the stones being from Colorado, but they are now on interfluvial tracts.

I take electric car to Cedar Rapids from Iowa City in evening, after dark, so could make no notes. Calvin reports fresh lowan sand along river level.

November 12, 1906.

Cedar Rapids, Iowa. I take train to Ames on C. & N.W. Railroad. I see no surface boulders between Cedar Rapids and Belleplaine and there seems to be loess over much of the surface. In a cut a mile east of Belleplaine, loess in vertical walls is present to top, 8-10 feet. Below this is yellow till, and under this, blue till. The top of blue till is 20 feet ± from top of cut. The cut is 35 feet deep (estimated).

It is at Belleplaine that a great artesian well from drift was obtained some 20 years ago. The town is on Iowa River. The valley here is about 2 miles wide. There is a range of loess-capped hills on north side of the river which, in places, have low peaks like those around Council Bluffs. They rise about 200 feet above the river in vicinity of Chelsea. The valley exceeds 2 miles in width west of Chelsea and continues very wide past Long Point and Tama. The cuts west of Tama are so obscured by talus and grass that I get no good view of

the interesting section reported by Savage in Proceedings, Iowa Academy of Science, Volume VIII. The Iowa valley maintains its great width up to Marshalltown.

The railway soon leaves the Iowa valley and runs up a tributary that has loess-covered bluffs past Lamoille. A cut a mile east of Lamoille shows 8 feet of loess. There are, occasionally, places where boulders lie on the slope both east and west of Lamoille, but they are probably exposed by erosion of the loess. Cuts east of State Center show loess 10 feet or more. About 1½-2 miles west of State Center a moraine of the Wisconsin drift is reached. It has low swells 10-25 feet high and among them wet tracts of irregular shape. There are also a few surface boulders. For 2 or 3 miles there is a wavy surface but it becomes less pronounced near Colo. There are drainage lines around Colo village to give it unevenness. The surface is wavy to the west of Colo and boulders somewhat more numerous than to the east. It is flatter west of a creek for 2-3 miles east of Nevada, though not free from occasional swells. None of the surface from the Wisconsin border near State Center westward to Ames is sharply morainic. The last expression is within 2-3 miles of the border.

There seems to be a little strip of knolls east of Skunk River valley, but possibly erosion features in part. Similar features on west side, at Ames. Dr. S. W. Beyer says there is not a definite undulatory tract along the east side Skunk River valley.

The loess under till west of the Agricultural College is largely of the drab color with iron concretions and tubes. It is fossiliferous. Dr. Beyer has noted it at Kelley in an excavation. The till over the loess at the brickyard west of Agricultural College has brown seams in the joints of darker color than the yellowish brown till. Possibly it is Kansan till but there seems to be no fresher till over it here.

November 13, 1906.

Ames, Iowa. I take train to Des Moines on C. & N.W. Railroad but see no cuts of interest. From Des Moines I go to Albia and then east to New London. Between Ottumwa and Agency are a large number of interesting cuts. Those nearest Agency show loess 8-9 feet; gray gumbo (3-6 feet ±), or red ferretto zone 3-6 feet ±; 3, brown till with calcareous nodules 5-25 feet. No. 3 differs in amount of exposure--the greatest being 25 feet ±. The general aspect of the brown or Kansan till is more like that seen at overhead bridge east of Delmar, Iowa, than I had expected so that may be Kansan above the blue-black till.

East of Agency a couple of miles gray gumbo under loess is exposed below level of track where excavations have been made for filling and also in gullies along ravines. There are no more till I am within 2 miles of Batavia where a cut extends into gray gumbo 2-4 feet. In cut ¾-1 mile east of there is a good exposure of

gumbo. It is under about 6-7 feet of loess. The upper is gray and lower part brown and it has only a few tiny pebbles. It is exposed 8 feet ±. A similar one occurs 1/2 mile farther east where overhead wagon bridge crosses. The next cut, ¼ mile east of overhead bridge, has the ferretto zone 4-5 feet thick at top of till. It is quite red. The till below is brown. This ferretto, just as well as that below, is stony.

I then pass a ravine. The cut east of it shows only loess 6-8 feet, but the next one east, about 1/3 mile west of Bernhart has a good showing of ferretto. At or just west of Bernhart is a cut with gray gumbo. It is 12 feet deep with 4-5 feet of gumbo. One just east of the station shows some brown gumbo as well as gray.

Excavations a little farther west, on north side of track, show what looks like a thin bed of stony clay with deep ferretto stone 3-4 feet and below this gray gumbo. Cuts and excavations for a mile farther east show similar features except that the ferretto stone is in a gumbo of brown color above the gray gumbo. There are several of these cuts. In some 15-20 feet deep no clay with coarse stone is reached, there being gumbo 6-8 feet at base. The deep brown color of upper part of gumbo contrasts strikingly with the pale gray color below it.

A cut 25 feet deep and an excavation below track 20 feet ± are then passed in which till is within 10 feet of top. These are 1½ miles west of Fairfield. There is a shallow cut in loess just west of the station. In excavation on south side of track in east part of Fairfield shows gumbo nicely and so does the cut ¼ mile farther east and deeper ones a mile east. The brown phase of gumbo predominates over the gray. One deep excavation about a mile east of Fairfield shows a pale clay 5-6 feet thick between brownish-yellow till, but I could not see it well enough to determine if it is gumbo. No fresh cuts east of Beckwith past Glendale. Ferretto is conspicuous east of Glendale past Lockridge. No good exposures between there and New London.

I get a sample of gray gumbo under yellow till a mile southwest of New London. The top of the gumbo is about 50 feet below level of uplands and it is 8 feet ± with a pale clay exposed under it at base of bluff. The overlying till seems to be Kansan with perhaps 3 or 4 feet of Illinoian at top. At least there is a trashy sort of surface to the till that may be Illinoian and in places a little gumbo between it and the typical till below.

I drive southeast from here to a point 2 miles west of Danville Center and pass a number of exposures of gray gumbo at base of loess. I then go south and cross Skunk River at Iron bridge and continue to Denmark.

November 14, 1906.

Denmark, Iowa. I collected pebbles from blue-black till in exposure at north end of Whitmarsh farm near northeast corner of Denmark Village. It rises to a height of 25 feet or more above the creek bed and the pebbles were taken from about 15 feet above creek bed. Above

this is a brown till that I supposed to be Kansan but I find a small shark tooth in it. I collect pebbles from this brown till to compare with those from the blue-black till. I also take specimens of all boulders at base of this bluff that exceed 1 foot in diameter. There is a large granite boulder a few rods north of base of bluff lying in the creek bed. It is 9 feet in largest diameter and 6 or 7 feet in shortest. I take a piece of this also.

I go to exposures on Lost Creek southwest of Denmark between the West Point and west Fort Madison road and collect pebbles from the blue-black till there. It rises to about 30 feet above the creek. Above it is 10-12 feet of yellow sand and above this is a gummy brown clay 12-15 feet thick with but few pebbles. In the creek bed I find a large glaciated limestone boulder 5 feet in diameter that may be Winnipeg limestone. I take a sample from it, I also collect pebbles from gray gumbo on the West Point road about 1/2 mile west from where the Fort Madison road leads south. They largely are quartz, chert, jasper, etc. I find a chunk of hematite iron of which I take a small piece.

November 15, 1906.

I examined exposures near Ed Johnson's farm in southeast part of Denmark Township and found quartz pebbles very numerous. I collected pebbles from an exposure in east part of Section 35 that is of the Kansan type.

November 16 and 17, 1906.

These two days were spent in looking over old collections of specimens stored at Denmark and preparing them for shipment to Chamberlin and to Ann Arbor*

November 19, 1906.

Monday. I took train at Danville, Iowa, for Aurora, Illinois. On morning of November 20 I went into Chicago to consult with Professor Chamberlin and in afternoon took train to Ann Arbor.

A LETTER from Professor Ellwood Schmidt of Northfield, Minnesota, written December 3, 1906, reports the occurrence of a boulder 7 miles east of Northfield which, by pacing, is 22 by 18 feet and resembled an old haystack as it was a dead gray color due to the lichens that covered it.

Press Bulletin, U.S.G.S., No. 258, for December 10 gives altitudes in the Pontiac quadrangle as follows:

	<u>Feet A.T.</u>
Bald Mountain	1,192
Orchard Lake	932
Sylvan Lake	930
Walled Lake	932
Pine Lake	932
Cass Lake	931
Upper Straits Lake	932

Bench marks:	
Franklin on Bingham's store	787.136
Southwest corner Section 9, T 2 N, R 10 E	937.002
Southwest corner Saginaw and Huron Streets, Pontiac (on Oakland County courthouse)	943.908
On Waterford schoolhouse, center of Section 26, T 2 N, R 9 E	944.174
Schoolhouse southeast corner Section 32, T 3 N, R 9 E	954.808
Commerce (1 1/4 miles north of center of Section 3, T 2 N, R 8 E)	947.761
Walled Lake on Rose's store	943.696
Schoolhouse northeast corner Section 6, T 1 N, R 9 E	895.392
Middle of north side Section 27, T 3 N, R 8 E, on Stockwell's house	997.768
Northeast corner Section 3, T 3 N, R 8 E on barn	1,024.724
Clarkston, on Methodist Church	1,014.801
"Sashabaw Plains" Presbyterian Church, northwest corner Section 35, T 4 N, R 9 E	990.524

The above are all in Oakland County, Michigan.

Pebbles in brown till above blue-black till at Whitmarsh bluff northeast of Denmark, Iowa, classified by Rollin T. Chamberlin, December 8, 1906.

Shale	2'
Limestone of all sorts	34
Sandstone (2 red)	6
Quartz pebbles	18
Chert	8
Black chert	3
Quartzite (light yellow)	1
Fine-grained greenstones	14
Greenstone schists	4
Gabbro-diorite	4
Decayed igneous	1
Fine-grained reddish rock	1
Granite	3
Syenite	1
	<u>100</u>

A shark tooth in this brown till is thought to be cretaceous but one found by Mr. G. K. Gilbert in the underlying blue-black till is thought by F. A. Lucas to be of Tertiary age, though they may perhaps be older.

Boulders at base of bluff in the Whitmarsh bank at Denmark, Iowa, classified by Rollin T. Chamberlin.

Granite of very varied types	8'
Crystalline limestone with prominent facets of dolomite	3
Gabbro diorite	2
Aphanitic greenstone	1

This set has the makeup of Keewatin drift.

Pebbles from the blue-black (pre-Kansan) till at bank on Whitmarsh land northeast of Denmark, Iowa, classified by Rollin T. Chamberlin.

Shale	31
Limestone of all sorts	38
Sandstone (2 red)	10
Quartz pebbles	10
Chert	4
Quartzose	4
Quartzite (1 white, 1 yellow)	2
Clay ironstone	1
Fine-grained greenstone	12
Greenstone schists	4
Decayed igneous	4
Granite	13
Feldspar crystals from granite	3
	<u>108</u>

From blue-black till on Lost Creek, 1 mile southwest of Denmark, Iowa, classified by R. T. Chamberlin.

Shale (3 very black)	5
Clay ironstone	2
Limestone	43
Chalk (probably from Niobrara)	1
Sandstone (1 red)	6
Chert	1
Quartz pebbles	5
Hematite	4
Fine-grained greenstones	14
Greenstone schists	3
Decayed igneous	2
Granite	11
	<u>97</u>

The hematite, it is thought, may be from such a local formation as that near Waukon, Iowa (See Geology of Allamakee County, in Iowa Geological Survey). A limestone boulder 5 feet in diameter found at base of this bluff does not reveal its geological horizon when examined by Weller.

December 12, 1906.

Mr. Harry Reid sent the following record of a boring at Brown's Station, Clinton County, Iowa, which was in progress in October when I visited it (Mr. Kingsley is the driller).

Old well	121
Soft blue clay	18
Blue till and sand	52
Coarse gravel and sand	28
Blue till (sample sent)	22
Light blue or drab silt (sample)	30
Blue clay with gravel partings and some water	31
Chocolate colored clay	6
	<u>199</u>

Maquoketa shale at 199 feet.

The well drilling is suspended now (December 12, 1906) in order to learn from Railroad Company whether to go any deeper.

Pebbles collected from what seems to be Kansan till in bluff near the old Dan Brown place (now occupied by E. Murphy), 3 miles east of Denmark, Iowa, classified by R. T. Chamberlin, December 20, 1906.

Limestone (of all sorts)	591
Quartz (well-rounded pebbles)	16
Chert	6
Quartzite	2
Shale	2
Sandstone (1 red, 3 brown)	4
Coal	1
Granite	3
Syenite	1
Fine-grained greenstones	6
	<u>100</u>

Pebbles from the gray gumbo (Sangamon) under the loess on road toward West Point about 1/2 mile from west edge of Denmark, Iowa, classified by R. T. Chamberlin, December 20, 1906.

Zaphrentis coral	1
Limestone, much weathered	11
Chert (many hard yellow flints)	36
Quartz, well-rounded pebbles	33
Sandstone (3 red, 4 pink, 1 white)	8
Jasper	2
Granite, much weathered	2
Fine-grained greenstones	3
Decomposed igneous	2
Red aphanitic	1
Quartz diorite	1
	<u>100</u>

The quartz pebbles are well-rounded but the chert are angular and subangular showing little evidence of water action. The material all gives the appearance of much age.

The gravel from bottom of J. Sykes well noted in Monograph 38 was examined by R. T. Chamberlin for glacial material, but none was found.

The conglomerate from near Rockford, Illinois, was found to have heavy iron stain on the sand grains but ferric oxide is often concentrated in recent or postglacial deposits to a degree comparable with this.

McGee appears to have noted the lowan drift tract northwest of Wadena, Minnesota (See Plate XLIV and page 386 of Eleventh Annual Report, U.S.G.S.).

He also notes sandy and pebbly loam above loess on the Turkey River above Elkader, Iowa which he considers alluvium (see page 440 and figure 40).

On page 443 McGee notes presence of loess on the newer (lowan) drift sheet.

In Geology of Wisconsin, Volume IV, page 92, drift is noted in Buffalo County, Wisconsin as follows: Section 14, T 19 N, R 11 W at 380 feet above Mississippi River; Section 3, T 19 N, R 11 W at 480 feet above Mississippi River. From these points northwest to Chippewa River patches of drift gravel at numerous points, but boulders are rare.

Beyond (west of) the Chippewa, boulders and more considerable deposits of drift occur but glacial deposits nowhere appear in great force in the district reported upon.

Gravel in Mississippi Valley at DeSoto, 50 feet above river. Whitney, in report for 1862, mentions glacial deposits near Dubuque and in Catfish Valley consisting of clay mixed with gravelly materials.

Winchell, in Proceedings A.A.A.S., Volume 24, 1875, part 2, pages 43-56:

1. C. A. White's Davenport locality.
2. Peat 2 miles south of Iowa City in Iowa River valley at 30 feet below surface struck in well.
3. In Adair County in valley of Middle Nodaway River, peat 2-3 feet under a blue clay.

Two miles east of Lime Springs, Iowa, peat was found on T. Irving farm at 44 feet from surface under nearly 20 feet of sand and it is 4 feet thick. One mile south of Lime Springs, on C. H. Wood farm, wood at 40 feet. Similar occurrence of wood 7 miles southwest of Lime Springs. At Albert Lea, Minnesota, muck under gravel at 38-40 feet contains vegetal material and wood. Peat in Section 13, Pleasant Valley; also in Bennington and Terry Townships at considerable depth. In Fillmore County, Minnesota, in the southwest and northwest townships: NW¼ Section 6, Beaver Township, on Andrew Oleson land, peat 2-3 feet thick at depth of 30 feet, below a blue clay and over black clay. Section 2, Sumner Township, on William Bailey land, wood at 35 feet. Sections 29 and 30, Jordan Township, wood in wells of M. Robins and George Hare.

Notes by Professor C. W. Hall on limestone pebbles from blue-black till at Lime Springs, Iowa: "These pebbles effervesce too readily to be considered Oneota or Shakopee dolomite. I should, therefore, regard them as of a limestone formation rather than of a dolomite, i.e., from Upper Ordovician or post Ordovician rather than a lower Ordovician or Cambrian.

Notes by Professor C. W. Hall on the sand contained in a pale clay below a black soil (?) (at depth of 2 feet) at a brickyard at Cresco, Iowa: "This clay has a fairly high percentage of quartz sand intermingled. The grains are, to a large percent, rough and unworn. This indicates that they did not come from such sandstone formations as the St. Peter and Jordan but from the Siliceous rocks of central and northern Minnesota, possibly Wisconsin and possibly from the geodic and other concretionary masses in the Shakopee and Oneota dolomites. At all events, most of the sand grains show surprisingly small amount of wear. The CaCO₃ test shows a very small proportion present--practically none."

Pebbles found on surface of the upper pale clay at Cresco, Iowa: "A miscellaneous lot of material, quartz pebbles, coarsely crystalline and finely crystalline, decomposed "greenstone" pebbles, conglomerate and conglomerate fragments; and other material of an uncertain character, making a diverse aggregation. Apparently every kind of rock seems to have its mass in place in northern and northeastern Minnesota and no doubt in adjacent regions."

Yellow till under the gummy clay at Cresco, Iowa, brickyard: "Washed residue examined. A comparatively small proportion of the grains in this washed residue are worn to a rounded habit. The clay also contains many pebbles of varying size and composition. The angular condition of the grains and their diverse mineral

composition are quite positive proof that only a small part of the material could come from the underlying Paleozoic sandstones of southeastern Minnesota." "A goodly proportion of these grains and pebbles seem undoubtedly to come from the tufts felsites and graywackes of northeastern Minnesota."

Pebbles from top of black soil at Cresco, Iowa. This is 3 feet below natural surface. See notes September 21, 1906: "A miscellaneous collection of pebbles, chiefly angular and subangular in form. Most of them are of granitic quartz. One or two seem to be of a different type--a sort of quartz diorite, as Kloos called it some years ago in Neues Jahrbuch für Mineralogie, 1877, page 228." "One curiously cracked pebble was found and the question arises "What cracked it?"

"Query, Is the large proportion of granitic quartz due to its being of lowan derivation? If so, are the pebbles of the underlying pale clay "pre-lowan"?"

Black gumbo soil below pale clay (at 3 feet) in Cresco, Iowa, brickyards Marked II: "A much smaller proportion of quartz grains wash out from this clay than from I (the pale clay at 7 feet depth) and the grains seem to be quite as irregular in shape and size as those in the package marked I (from below the black gumbo). The grains here seem to come from granitic rocks through their degradation, the formation of kaolin, chlorite, etc, being other results of the degradation processes."

Pale clay above black soil (at 2 feet) in brickyard at Cresco, Iowa. Washed specimens: "At least 1/2 the grains in this washed sample are unworn and 1/5 of them are impure quartz or grains of silicates--conditions which point to other sources of supply than the ~~peat~~ great underlying sandstone beds of southeastern Minnesota."

Notes on old drift in Rock River Valley near Rockford, Illinois, from a paper by G. D. Swezey, Science, April 21, 1893, page 216: It is a pudding-stone thoroughly indurated, so as to make an excellent rock for cellar walls and the like; in some cases it is cemented together by a calcareous matrix, in other cases there is a large percentage of iron hydroxide in the cementing material. The striking contrast in appearance between the loose gravels and the conglomerate tends to impress one with the idea that the latter is relatively very old. So striking is this appearance that at one exposure which I visited I found the owner of the field laboriously digging up an outcropping mass of this conglomerate somewhat harder and redder than usual, under the supposition that it was a meteorite."

Water used by elevators in Ann Arbor, Michigan: Mack & Company, 588,664 cubic feet, or 4,414,970 gallons per year. Martin Haller, 23,200 cubic feet, or 176,000 gallons per year. The Ann Arbor Savings Bank Block has elevator that is charged a flat rate of \$1.00 a day, as stated by city engineer Gowers. Mack & Company pay 8 cents per 1,000 gallons, or about \$350.00 per year.

April 23, 1907: Dr. Lane reports a well in southern Newaygo County, Michigan Section 36, T 11 N, R 14 W, that is 305 feet to rock. It penetrated quicksand and marl 150 feet and clay 155 feet.

Interglacial Peat Analyses: Dr. C. W. Hall reports the following results of analyses of two samples of peat collected in C.R.I. & P. Railroad cut 1½ miles southeast of Faribault, Minnesota, last season and of a sample collected by N. H. Winchell in Mower County, Minnesota.

1. Light colored	2. Dark colored	3. Winchell's #2374 from Mower Co., Minnesota; Inter- glacial peat.	
Per cent	Per cent	Per cent	
1.05	1.58	4.20	Moisture
8.10	15.32	40.25	Volatile matter
0.00	0.00	11.75	Fixed carbon
90.85	83.10	43.80	Ash

All were thoroughly air-dried. The absence of any figure for fixed carbon is probably due to oxidation of ferrous iron when the carbon burnt out. This, however, would not amount to much more than 0.50%. Rock analyses of Nos. 1 and 2 are as follows:

	(1)	(2)
SiO ₂	65.10%	55.10%
Al ₂ O ₃	10.42	10.60
TiO ₂	.82	.60
FeO	4.74	4.47
MgO	2.06	2.06
CaO	4.52	7.26
H ₂ O	1.05	1.58
Loss Ign.	8.10	15.32

Alkalies present but not determined. Total iron is reported as FeO on account of abundant organic matter.

Moraine northwest of New Hartford, Butler County, Iowa, mentioned by Calvin. Jamison, on Osceola Branch of C.R.I. & P. is in a loess-free tract (Calvin).

July 24, 1907.

At Calmer, Iowa, with Professors Chamberlin and Calvin. We drive to Conover and find thick loess from north edge of Calmer. The tract free from loess at Calmer is narrow and runs about with the railroad east from the depot 1/2-3/4 mile. There is thick loess each side and the loess sets in 1/2 mile east of Calmer. This strip has boulders and wet sloughs, and seems to be lowan.

We go west from Conover through a tract of thin drift with rock ledges practically at surface. The main valleys are deep but have not a good, system of laterals like the loess-covered tracts. In the loess tracts laterals are far deeper and better developed than in the lowan drift plain.

South of Spillville loess is present on west side of Turkey River only in very small areas that stand above the general level. The most conspicuous are immediately northwest of Fort Atkinson within two miles, setting in near the old fort and running west to the bend of the river.

We go east from Fort Atkinson on road toward Festina to the schoolhouse on a loess ridge that separates the two

bouldery areas that I noted last fall. The tract north of this loess ridge has black soil and sloughs in which boulders are present much as they are west of Calmer.

Professor Calvin is hardly ready to admit that this is an lowan area though it has several of the lowan characteristics such as the filled up condition of the old erosion channels in the drift, the surface boulders, the absence of loess except in paha like ridges, etc. In fact, I fail to see any that it lacks.

In the strip that extends east a little beyond Calmer, Professor Calvin is not ready to admit lowan age. He stops the lowan near the school building.

July 25, 1907.

We go from Calmer to Decorah and drive up on the hills in southwest part of Decorah. The boulders and exclusion of loess are all that I would cite here as suggestive of lowan, for the till looks older. If it is not lowan, how did the loess free strip originate? Why has the loess so definite a border?

We find the sandy terrace near Freeport fresh looking and with a definite upper limit at about 920 feet. This seems to all of us a probably lowan terrace. It is well displayed both south and southwest of Freeport, the latter place being where a sand pit is opened and not far from bench mark 848 feet on topographic sheet.

There is older looking gravel east of Freeport along road south of river at a level only 25-35 feet above the stream. We went north from Decorah to see the exposure of two loess deposits shown in Calvin's Winneshiek County report as occurring in Section 3, Decorah but do not find a good exposure now.

In afternoon we go to Postville and drive to the loess-free strip east of Clermont. It is very disappointing to both Chamberlin and Calvin. The exclusion of loess does not, to them, seem to mean much, while the gray sand, they think, may easily be derived from the Kansan till as it is largely quartz. The boulders seem to be ordinary Kansan boulders; at best, nothing distinctively lowan was noted. The paha like ridges of loess inside this loess-free tract seem of no significance so far as proving this to be lowan is concerned. The topography is not such as one finds on lowan drift plains. They, therefore, find no feature that points distinctly to lowan ice presence and the features of the whole surrounding country seem that of the loess--Kansan. I doubt myself the ability of the ice to run out in these narrow tongues 40 or 50 miles. If it cannot be proved to have covered the intervening tracts where loess is now heavy, it would seem necessary to abandon the lowan ice idea completely. The remarkably direct course of these loess-free tracts across projections of all heights along the border of Turkey River valley and the very definite edge of the loess on each side as definite as the loess at the edge of the lowan drift plain are features that seem to me more than mere haphazard incidents due to vegetation or other chance attendant features. It would

seem very strange, also, if wind currents should leave so definite a track. Suppose a cyclone or hurricane were to have followed this course at a time when the loess had already been deposited and had denuded these tracts of the loess, would the features that we have here have been produced? Is there likely to have been, outside of the lowan ice, a strong wind current radiating out from its edge that would have given this effect and the effect of same kind along Volga valley below Fayette?

These two loess free strips extend east from lowan areas, but are strikingly parallel to the lowan drift border south of here their whole length. The Decorah strip is not. The Rochester, Minnesota, strip is not. There is no more evidence that lowan ice covered the Rochester loess free strip than those on the borders of the Iowa, the Turkey, and the Volga.

The Zumbrota strip seems to have some fresh drift and so does the Oronoko, but I do not feel positive that there is clear evidence of lowan invasion. They each need to be revisited and so does the cut near Lena that seems to have lowan drift under loess.

The region near Cannon Falls is in need of further study. I can easily draw a line from Rice County southward past the places where these loess-free tracts branch off that will correspond to what Calvin maps as the lowan border, so the study is as far advanced in the Minnesota area now as in Iowa. It is an easy matter to draw a line that will be safely within bounds of the lowan--much easier than to find its full limits«

From Rice County eastward across Goodhue County to the Mississippi the presence of lowan drift is still somewhat open to question. It would seem well to study that area further.

July 26, 1907.

We take train to Independence from Postville on Rock Island Railroad. Near Clermont and southward to Elgin the terraces on Turkey River impress Chamberlin as they did me as of probable lowan age. The height is not far from 60 feet above the river and they are pretty well preserved at numerous points all along the valley from Winneshiek County to the mouth. The lowan plain is finely displayed all the way from West Union to Independence.

We go east on Illinois Central to Farley through an lowan drift plain at least to Dyersville and probably to Farley. There are paha around Earlville. Boulders are very scarce east of Dyersville but the surface is smooth and there is but little loess on the smooth tract mapped by McGee and later by Calvin as the Farley lobe.

We drive from Farley across the Worthington lobe on a road just east of the divide between John Creek and Maquoketa River. We find it free from loess but the topography is of the Kansan rather than lowan and none of us feel certain that lowan ice reached this far east.

Chamberlin here suggested a new interpretation, via., that the winds from the lowan ice came down through the loess-free strips east of it and chilled the lowlands so that no vegetation could get a foothold and thus no loess was caught and these strips remain loess-free. The wind was probably stronger through them than over the border tracts on which vegetation occurred. We find sand blasted pebbles and boulders to corroborate this view. We abandon the view that the long strips were occupied by lowan ice.

July 27, 1907, Cascade, Iowa.

We drive east along the road toward Garry Owen and come to conclusion that sand polish is very marked on the siliceous boulders and cobbles exposed here. Professor Calvin takes a photograph of one in southeast part of Section 32, Whitewater Township, Dubuque County. We follow county line road east to where the road bears east-northeast and are in a loess-free tract to this point. We find a continuous loess strip however, between this loess-free strip and the loess-free strip that runs to Bernard.

The Bernard strip, like the Worthington, seems to have Kansan topography and very few places are flat enough to even suggest lowan, much less to prove it, Chamberlin's hypothesis seems to completely do away with the need for lowan ice in these tracts that extend out like fingers from the lowan area.

We find that gray sand extends across the divide between the two branches of Johns Creek 1½-3 miles north of Fillmore and the main connection between the Worthington and Bernard loess-free tracts seems to be here rather than along the west fork of Johns Creek past Fillmore.

We drive from Fillmore to Epworth and then follow a loess-free strip to Farley. The part between Farley and Epworth is apparently to be classed with the Bernard and Garry Owen strips as windswept rather than lowan covered. The surface is very rough and nothing but the gray sand and absence of loess suggests lowan. Boulders are not numerous. West from Farley there is a smooth-surfaced tract whose topography suggests lowan, but it remains to determine whether lowan drift is present there.

The whole border needs to be investigated in the light of the new interpretation. We cannot be certain of lowan ice far beyond the limits of well defined lowan drift. The paha ridges with loess capping that stand out in the loess-free strips may be at places where vegetation got a foothold and defied the blasting effects of the wind that came down from the lowan ice.

Calvin returned to Iowa City on westbound train on Illinois Central, while Professor Chamberlin and I take the east-bound train to Chicago.

July 28, 1907.

Chicago to Grand Rapids on train, reaching Grand Rapids at 7:00 a.m. I there meet F. B. Taylor, J. W. Goldthwait, and Mr. Pontra and we go to Dennison on electric car. There is some evidence of lake occupancy on west side of Coopersville Ridge, east and north of Dennison, up to a level 20 feet above Dennison Station. At Taylor's gravel pit, a mile north of Dennison, is a good gravel beach but at most places at this level (20 feet above Dennison) there are only patches of sandy gravel. Till is at surface on some knolls and in many sags. This seems to indicate a local lake, rather than Lake Chicago.

We go into Muskegon at noon and examine the cut bank at high school whose base is 35 feet and top about 47 feet above Lake Michigan. There is a sort of step in the bank at about 43 feet that seems to mark ordinary lake level. Storms may have reached to the top of the bank at 47 feet. This seems to be the Calumet beach of Lake Chicago and its level is approximately 625 feet A.T.

July 29, 1907.

We go to Dennison and Goldthwait runs levels north to Taylor's gravel pit and also from Grand River at Eastmanville to Dennison. These bring out some surprising results. The altitude of the beach at schoolhouse in Eastmanville is 51 feet above Grand River at Eastmanville and is apparently the Glenwood beach. It seems to indicate that no rise has occurred in that beach above its level near Chicago, for the datum here is 582.2 feet (by U. S. Engineer, Grand Rapids), making the beach 633 feet A.T. But upon running to what I took to be a continuation of this beach in southeast part Section 29, Polkton Township, at east side of a swamp, a level 20 feet higher is found, or 653 feet A.T.

The sandy gravel is here in low ridges with north-south trend and they are present at the same altitude over a width of 1/2 mile to the east of the edge of this swamp, or to where a road runs north across Section 28, Polkton. There is sandy and gravelly stuff in irregular shaped knolls southeast from this point to levels 10 or 15 feet higher, or to about 665 feet. There is also a sandy gravel on the crest of the Coopersville till ridge in vicinity of the cross roads two miles north of Eastmanville at 96 feet above Grand River, or 678 feet A.T. Goldthwait makes Dennison Station about 70 feet above Grand River at Eastmanville or fully 652 feet instead of 638 feet given by Gannett. So the Taylor gravel pit north of Dennison is about 672 feet and may correlate with the sandy gravel on crest of moraine two miles north of Eastmanville,

July 30, 1907:

Goldthwait and Taylor worked around Springport in forenoon and got Tolleston beach at about 22 feet. In afternoon they worked at Holland and found Tolleston 22 feet, Calumet about 35 feet, and Glenwood about 35 feet above the lake.

McLouth and I took train to Sweet Station, which is 92 feet above Lake Michigan, or about 674 feet A.T. We find a very flat sandy plain at this height from Sweet east to the Dalton town hall, 673 feet. On its north edge are dunes 10 to 30 feet higher which extend to a line running west from Twin Lake Station. A recess in the plain extends up the railroad from the Dalton town hall northeastward 2 miles to Twin Lake and reaches 693 feet at edge of Twin Lake village. Twin Lake is 681 feet. From the town hall southwest for a mile the profile shows a nearly steady altitude of about 670 feet A.T.

On this plain there is a fine sand, apparently pebbleless, and it is deep enough so that wells do not go beyond its depth to get water. They are only 8-14 feet deep, however.

I am told by workmen on the railroad that the pebbly or gravelly material sets in beyond a small sag or creek about a mile northeast of Twin Lake, but they have seen none this side. We find a very few pebbles near a road, crossing near center of Section 28, Dalton, but they are very scarce from Twin Lakes nearly to Berry. At Berry there is a pebbly sand exposed in the shallow cut by the station. The top of this cut is about 2 feet above the station, or 644 feet A.T., (See Twin Lakes topographic map), Berry Station being 642 feet A.T. Possibly this pebbly sand marks the upper limit of Lake Chicago while the higher tract between Berry and Twin Lake was covered by a local glacial lake nearly 680 feet. If it should be found that the ice border passed southward from Brewery Hill at Muskegon to the till ridge at Crisp in Ottawa County. This might hold a local glacial lake up to a level as high as the sag east of the ridge near Crisp. Possibly the ice border ran from the south end of the till ridge near Holland southward to connect with May Hill till ridge and prevent southward drainage from Holland so that the outlet would have been past Jamestown or possibly past Ross to the south from Grand Rapids. Correlation of moraines is necessarily somewhat uncertain when gaps are so wide.

The large amount of pebbleless clay near Nunica and Fruitport seems best explained by the presence of the ice close by on the west, perhaps at a line running from Brewery Hill to Crisp. It seems to be a lacustrine silt. It is of two kinds--a waxy tenacious clay at top with tinge of purple and a more granular paler clay below, in places looking a little like loess. There is scarcely a pebble to be seen in either clay where exposed on the bluffs of Crockery Creek east of Nunica.

A letter from F. B. Taylor, August 4, states that Grand River at Eastmanville by U. S. Engineer office report from Grand Rapids was 582.2 feet on July 29 and Lake Michigan 581.6 feet July 29.

August 4, 1907:

Levels at Muskegon by Goldthwait:

Obscure gravelly ridge near Knitting Mill	9.63
Broad gravelly ridge followed by Western Avenue	34.45
Another followed by Mercer (?) and Houston Avenues	33.92
Ridge on Grand Avenue	34.10
Cut beach near Hughert and Southern	36.18
Highest ridge suspected to be a beach near Hughert & Forest	46.23
Same ridge on open lot 2 blocks northeast	46.42
Base of bluff southwest of Brewery Hill (probably Nipissing, bluff is 30 feet high)	14.44
Flat sandy ridge near school on Davis Street	51.56
East slope of Brewery Hill doubtful beach ridge on Hudson Avenue east of car lane	13.52
Hudson Avenue near Washington—good gravelly beach (Tolleston?)	22.85
Beach or gravelly ridge crossing Grand and Hudson Avenues	28.00
Another near last	31.72
Gravelly terrace east of Brewery Hill (outwash?)	40.62
Top of yellow gravel layer at Lake Michigan Park (dune sand 30 feet above it)	25.00

Montague:

In south part of village, west of bridge:

Base of steep bluff	13.54
Flat sandy ridge at brow of steep bluff	52.73
Another close by	51.89
Another a block east	62.05
Broad ridge running east-west a few blocks northwest of preceding	74.47
Same a block farther west	76.63
Gravel ridge at Dowling Street	75.49
Broad strong ridge 100 rods south of last, moderately steep front slope down to a 55-foot terrace of sand and gravel	76.90
Flattish ridges of sandy gravel in that vicinity	51.00 and 52.57

Pentwater:

Cut terrace (gravel above it to 40 feet)	14.27
Sandy gravel ridge at school (doubtful beach)	28.34
Bass Lake and vicinity:	
Bass Lake	0.50
Bluff southeast edge of lake (at base)	15.66
(at top)	21.00
Long gradual rise from 21 to	46.00
Strong gravelly ridge (passes under Carl Jensens) concluding there was no lake level at points between 21 and 40 feet.	46.72
Other gravelly ridges at	57.17 and 60.09
Beach on west side of a north-south road east of north part of Bass Lake	48.38
Faint ridge 100 yards west (lost in dunes to north & south)	38.62
Gravel ridge at S. Reinhart's crossing north-south road in north-northwest – south-southeast direction	60.48
Double crested ridge at corner where road runs west past north end of Bass Lake	67.83 and 68.10
Broad ridge 1/4 mile north of last. Part of it looks like a beach.	69.10

August 16, 1907:

Oelwein, Iowa. 8:30 a.m. I take train to Alta Vista on C. & G.W. Railroad to study the cuts near Alta Vista and Elma. Red gravel near Sumner in a knoll. Fresher gravel at pit on north edge of Fredericksburg. Shallow cuts 8-10 feet between Fredericksburg and Boyd. Drift looks rather weathered, as if Kansan. Cut south of New Hampton, 15 feet, has old-looking drift. There is also a gravel pit with old reddened drift in it between this cut and New Hampton on east side of track. Aneroid 28.725 = 1,159 feet at New Hampton at 9:45 a.m.; 28.730 at Alta Vista at 10:00 a.m.

I go south on railroad to cuts in south part Section 29 and north part Section 32, T 97 N, R 13 W. The altitude is 40-50 feet higher at top of cut than Alta Vista station. It exposes the following:

1. Leached brown till, 4-6 feet.
2. Local development of pale clay a little more gummy than till above and below it (grayish-brown color; no response with acid) scarcely a foot thick, 1 foot.
3. Calcareous till of brown color, 6-8 feet.
4. Dark blue-black till, very calcareous, exposed, 6 feet.

This till has the slanting laminae noted in the blue-black till at Muscatine and at other places in southeast Iowa, and may be pre-Kansan.

Near the middle of this cut on east side of railroad in south part Section 29 is a well at residence of A. L. Piehn, 127 feet deep that is 10 feet into rock. Mr. Piehn did not live here when it was drilled but was told that it was nearly all a hard dark-colored pebbly clay from 12 feet down to rock. There was a little sand midway of the deposit. This dark till was exceedingly hard in lower part and is reported to reach clear to the rock.

In a cut 1/2 mile south of Alta Vista Station the blue-black till is only 6-7 feet from the surface.

The country here is considerably eroded so the ridges are 30-50 feet above the valleys, and do not seem to be up to the plain of original deposition. The slopes are gradual but sloughs are not so conspicuous as in most of the lowan area. I do not find any drift in these cuts that can be referred to the lowan with certainty. It all looks older.

The well at Union Hotel in Alta Vista is 69 feet and does not reach rock. There is 20 feet or more of sandy clay of brown color and then considerable drab, blue-black clay. The lower part is sand or sandy gravel. The head is -6 feet.

West from Alta Vista is a timbered tract extending to Osage, but east of here is prairie to Crane Creek valley. There is said to be sandy land along the valleys west of Alta Vista in northwest part of county but the upland is clay land.

Elk Creek at Alta Vista has a flat nearly 1/4 mile wide underlaid by a sandy gravel. The pebbles are scattering and rather small, seldom 2 inches. There is coarser material in a black clay or alluvium 2 feet thick that overlies it. I collect a sample of the sand, putting in with it about 50 pebbles an inch or less in diameter for classification.

I also collect a sample of washed sand from the creek bed west of village. This has a gray color and fresh aspect but probably is simply the yellow sand washed free from its iron stain.

I also collect a sample of washed sand brought from Wapsipinicon River 2 miles west of Alta Vista to use in plastering. In this sample I include about 100 pebbles an inch or less in diameter.

I go up into the timber west of Alta Vista and find that boulders occur in the sags but the higher ground has a silty clay a few inches thick with but few pebbles.

I follow the railroad toward Elma. The cut a mile south of Elma has a large amount of gray gumbo near top, 4-6 feet from top. It is, in places, 6-8 feet thick. Above it is a rather sandy clay with an occasional boulder and smaller stone. This cut is on a high summit at east end of a strip of timber. The soil is the yellow sandy clay.

There is limestone at depth of about 50 feet at a farmhouse on east side of track opposite deepest part of the cut but the owner of place is away. The well is about 100 feet.

I think the rusty till above the gumbo south of Elma is more likely to be Kansan than lowan. Rock is quarried each side of the railroad in north part of Elma in the low bluff of a stream that comes in from the northeast. The rock reaches 15-20 feet above stream level, or about to the level of Elma Station, 1,188 feet.

I take train to Taopi at 6:00 p.m. The railway runs on the flat bottom of a south flowing stream for several miles and makes no cuts. The uplands are 30 feet \pm above this bottom land. The railway cuts into a sloping point just south of Lowther and another at Riceville but nowhere else from Elma to Riceville. These cuts show nothing but talus.

The Wapsipinicon at Riceville has a trench 15-20 feet lower than the broad sag in which it runs. This trench is inconspicuous at McIntire. Shallow cuts just south of McIntire talus and grass covered. The sag in which the Wapsipinicon flows is nearly a mile wide just north of McIntire. There are gravel pits along the eastern edge south of Bailey 10 feet \pm above the marshy flat.

The district north of Bailey does not have so well defined a broad valley with bluffs as that to the south, but instead the valley heads in several sloughs with low interfluvial tracts 10 feet \pm above the sloughs. It approaches a plain nearer than any divides seen this side of Oelwein.

Aneroid 28.500 on high plain near state line of Iowa and Minnesota, south of Taopi; 28.515 at Taopi, Minnesota, at 6:45 = 1,341 feet.

The proprietor of Taopi Hotel has a well 112 feet that gets water in sand or gravel and does not reach rock. The head is -42 feet. The Chicago and Great Western has a well 509 feet deep just north of railway crossing that has a head about -40 feet. It is about 140 feet to rock. The distance to rock in this vicinity ranges from 120 to 150 feet.

There are flowing wells in northeastern Mitchell County near Johnsburg and New Haven. One 1½ miles northeast of New Haven throws a 6-inch stream. They are all within the Cedar watershed. One southwest of Germania a mile is on the bank of Little Cedar and discharges into the stream. It is on the Minnesota side of the line. Germania is now called Johnsburg.

Near Bailey, Iowa, rock is struck at about 40 feet. There is some hard blue till in the drift around Bailey. Ordinarily, wells around Taopi are through blue-black till with only thin streaks of gravel and sand. A well 3/4 mile northwest of Taopi in a pasture on Mitchell farm penetrated 60 feet of white sand that set in at about 30 feet.

Taopi is near the head of the upper Iowa. The Wapsipinicon heads south of here near the state line and the Cedar watershed sets in a short distance west of

here. Sloughs in this vicinity are 10-15 feet below the plain.

The Chicago and Great Western made a dug well a few years ago just north of the railroad crossing at Taopi that struck a muck bed with wood in it at 35-40 feet. It was brownish-black peaty material. Dug about 18 years ago (Thomas Cahill).

A well west of crossing on Mitchell farm made recently:

Sand and gravel, reddish brown	35 feet
Black muck	3
Blue till, dark color	60
Sand, gray color, and water	2
	<hr/>
	100 feet

August 17, 1907.

I drive west from Taopi and collect sample of the sand from a pit 40 rods west of railroad crossing at depth of 3-4 feet. The sand is not so dark brown as that in the Mitchell well 30 rods north of it on higher ground.

There is a more rapid descent west from the dividing ridge than east--a fall of 60-70 feet to Cedar Creek where it crosses line of Lodi and Adams a mile north of the railroad. The pit 1½ miles east of Adams is on a slope and exposes about 20 feet of mainly rusty gravel. There are local inclusions of brown till. There is a washed gravel above one of these at 3-6 feet from top of pit from which I collect about 50 pebbles. I see no limestone in it nor in the rusty gravel below the till. The rusty gravel has numerous quartz pebbles. I hardly think this fresher gravel above the till is lowan. It is covered by rusty looking loamy material.

At the Chicago and Great Western cut 1½ miles northwest of Taopi I find calcareous till at 6 feet from top, but above this there is leached till with no limestone pebbles so far as I can discover. Small white limestone pebbles are in the calcareous till. The altitude here is about 30 feet above Taopi or 1,370 feet ± A.T. I collect about 50 pebbles from 2 feet below surface and till from same level; also calcareous till at 6 feet.

There are ponds in a slough that drains to the upper Iowa a mile north of Taopi. The slough heads 2 miles north of Taopi. There is a boulder 15 feet in diameter a mile north of Taopi on east side of railway track in a slough. There is a fresh looking pink granite with striated surface on the railway cut 1½ miles north of Taopi--largest diameter 6 feet.

The gravel pit 1/2 mile east of Taopi has very red color and is in a low knoll. I take a sample of it. Exposures east of here at lower levels show a less rusty gravel, but it has perhaps been rewashed by upper Iowa River as it is in a terrace of the river. There are a few places where I see boulders on this terrace. I am not certain that they are on gravel, for till may underlie parts of the terrace.

I follow the C.M. & St.P. Railroad to Le Roy. The only notable exposure is one of reddened gravel 2½ miles west of Le Roy in northwest part Section 29, Le Roy Township. It is exposed 15 feet deep by ditch on south side of railway and is very red with ferretto and rusty from top to bottom. I collect about 50 pebbles from it at 6-8 feet from top. The pebbles in this and also in the pit east of Adams are largely quartz, possibly from Cretaceous beds.

Rock outcrops each side the upper Iowa at Le Roy and is found on farms north from there across Section 23 at slight depth so there are sinkholes. At Mr. Schatz farm in east part Section 22, altitude 1,325 feet, rock at 14 feet.

J. Johnson, in southwest part Section 12, altitude 1,335 feet, well 80 feet--no rock, sandy stuff 10 feet, blue till to sand at bottom--till is hard. Some bark found in dug well near it at 19 feet.

Calcareous clay in slough in Section 14, northeast part, on east side railroad track brought up by crawfish (sample). At the railway summit in north part of Section 12, Le Roy, altitude 1,350 feet ±, there is a cut 4 feet deep and it is into a calcareous till. The till contains many limestone pebbles within 2 feet of top. I collect a set of pebbles at 2-3 feet. This may be lowan. If so it ought to be dug into and a fresh exposure made to see the amount of weathering. It certainly looks fresh and so does the till in the slough a mile southwest noted above.

About 1/2 mile northeast from this summit, in the south part of Section 1, Le Roy, is a sand pit of rusty brownish color. The sand is crossbedded. It has only a few small pebbles and is dug into 6 or 7 feet. Above it is gravel 3-4 feet that is very rusty and old looking. I find ~~red~~ no limestone pebbles in it or in the sand below it. This pit is in a small knoll on a slope facing north. Its highest point is 15 feet lower than the summit southwest of here in Section 12. I pass another low knoll of this sort of sand and gravel in southwest part Section 31, Bloomfield Township, Fillmore County. The summit in northeast part of Section 31 has a cut 3½ feet deep that reaches the calcareous till and has limestone pebbles in lower part. It is about 25 feet higher than Ostrander Station. Aneroid reads 1,340 at Ostrander at 6:00 p.m. and 1,350 at 7:00 p.m.

There few large boulders in this region. I saw none over 5 feet in diameter east of Taopi or between Le Roy and Ostrander. The one 15 feet in diameter a mile north of Taopi is the only very large one noted.

East of Ostrander 1/2 mile is a gravel pit in a low knoll. It is rather fresh looking with very little iron stain. The pebbles are largely quartz and chert. I see no limestone. It can scarcely be called a good case of fresh gravel. A ditch at south side of road 1/4 mile farther east cuts into quartz gravel with many polished white pebbles.

I return to Ostrander and take road north. This passes sink holes and the drift is very thin clear to Root River. There is rock in bluffs of Root River 15-20 feet above

stream. The stream here is a set of pools with short rapids between. The pools are said to be 10 feet or more deep in places.

Wells at Ostrander are often 75-80 feet deep. It is usually less than 30 feet to the rock in this village (See driller at Spring Valley) and, in places, rock is close to the surface.

August 18, 1907.

Spring Valley. I find the cuts on Chicago and Great Western Railroad southwest of Spring Valley show no calcareous clay. There is rusty brown clay and gravelly stuff 3-5 feet deep below which is gray gumbo, as noted last year. The rock reaches a level about as high as the station, or 1,316 feet A.T., just south of the railroad crossing.

On the ridge 2 miles south-southwest of the station at altitude about 1,350 feet rock is struck at a farmhouse just west of C. & G.W. track in north part of Section 8, Bloomfield, at 30 feet. There was blue clay above it. The well is 60 feet deep. A man from Wyckoff is at this farmhouse and he reports the wells in that village reach rock at about 30 feet and pass through some blue clay--gumbo? or blue-black till? A farm well in southwest part of Section 5, Bloomfield, on ground 1,335 feet ±, is 75 feet deep and gets water in gravel without striking rock.

Well at C. & G.W. depot in Spring Valley is 212 feet: yellow limestone 40 feet; bluish rock, fine grit 170 feet ±; yellow rock near bottom. There is a strip of bluish clay running northwest-southeast from north of C. & G.W. depot to center of village. Wells along it are 40-70 feet to rock (data by C. E. Huntley).

Mr. Huntley found lignite coal in a well on John R. Campfield's farm, 3/4 mile east of Racine at about 60 feet just above rock. Lead ore was found in Spring Valley in grading for streets and railways some years ago. Lignite has been found in several wells in Bennington Township, Mower County, at depths of 20 to 50 feet. Rock is struck in northern Bennington along each side of South Root River at 15 to 50 feet.

There is considerable quartz gravel next to the rock in central and southern Bennington Township, under quite a deposit of drift. East of Ostrander there is a large area with the quartz pebbles near surface. Boulders are very numerous 2 miles north of Chester, Iowa, on edge of Beaver Township, Fillmore County. There is one large boulder north of Taopi 5 rods around it by pacing. Large boulders are numerous along line of Bennington and Clayton near south end of line. They can be seen at distance of 2-3 miles. There are also large ones in Pleasant Valley Township and north nearly to Stewartville.

On J. Mihen farm, in south part Section 10, Bennington, a well 40 feet deep has head -6 feet. There was a crust of rock or perhaps cemented drift above the water.

In south part Section 279 Clayton Township, on a high place on Kennedy farm, a well 90 feet did not reach rock. It was mainly blue till of dark color. Water in gravel.

There was a mill at Taopi which settled so much that the mill machinery was thrown out of good running shape so mill was abandoned. It was underlaid by sand.

Notes from back of Notebook 215:

Levels above Lake Muskegon:

Occidental Hotel, corner 3rd and Western Avenue	24.7 feet
Brewery Hill	55.3
Pere Marquette at city limits	51.1
Pere Marquette railroad at head of Irwin Street	50.2
Clinton and Grand	47.6
Clinton and Irwin	43.9
At top of first rise	47.6
	43.9
	35'±

Flat below the lower cut is 35 feet.

Grand Trunk at City Limits	46.8
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Aneroid 29.260 at Clinton and Grand Streets in Muskegon = 630 feet ±. It is 47.6 feet above Muskegon Lake.

Pere Marquette profile, Muskegon to Twin Lakes:

Datum 35.4 feet below mean level of Lake Michigan or	546 feet
Pere Marquette Station in Muskegon, 47 =	593
Berry, 101.4 =	647
Twin Lakes, 146.6 =	692
There is a flat for a mile at 3-4 miles from Berry at 131-132 =	678
Sweet Station is 133-134 =	680

Aneroid 29.395 at Muskegon at 9:10 a.m. = 593 feet. Dalton reads 650 aneroid = 125 above datum, or 671 feet A.T. Sweet is 29.320 = 680 feet ±. Town hall of Dalton is on a line of dunes leading northwest-southeast that stands about 105 feet above Lake Michigan. The flat south is 96 feet ±. There is a gradual rise to 108 feet toward the northeast in the two miles to edge of ridges at Twin Lakes. The old lake plain may reach 108 feet or about 690 feet A.T. or it may only come to the line of dunes at town hall near southeast corner Section 15, Dalton, which is on a plain 96 feet above Lake Michigan, or 677 feet.

Pebbly sand 2 miles northeast of Berry at 85 feet above Lake Michigan, 666 feet. It is just east of a north-south road near center of Section 28. At Berry there is pebbly sand up to a level $2\frac{1}{2}$ feet \pm above level of station, or 104 feet above the railway datum, $104 - 35.4 = 68.6$ above Lake Michigan = 650 feet.

Hughert and Forest + 2 = beach. Hughert and Southern, manhole cover + $4\frac{1}{2}$ = beach. Hydrant at northwest corner of intersection + 1 = beach (Hughert and Southern).

There is said to be no pebbles in the sand between the Dalton town hall and Twin Lake station. North and east of the lake is a pebbly drift, both till and gravel. The south edge of the gravelly pitted plain lies 1-2 miles back from the edge of the flat tract, the interval being filled by sandy ridges. The flat surface is about 100 feet above Lake Michigan. Near Twin Lakes it is 108 feet, or about 690 feet A.T.

Possibly Lake Chicago reached this high level:

- 120 at Fillmore
 - 108 at Twin Lakes
 - 90 at various points
 - 70 at various points
 - 55 Glenwood (Holland)
 - 39-40 Calumet cut (Holland)
 - 22 Tolleston
 - 14 cut = 16 ridge?
 - 11 ridge, Algoma
- o-o-o-o-o-o-o-o-