

Notebook No. 280 - Leverett

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June 9, 1923 - Menomonie, Wisconsin

Aneroid 29.240 at Hotel Royal equals 860' A.T. at 7:45 A.M.

In Section 28, T.27N., R.13W., Gravel 860' on Red Cedar

We find boulders at frequent intervals down Red Cedar Valley on west side past Irvington in the low land and up on the terrace 850-860 feet A.T. and in a few places on slopes above the terrace.

Red silt loam 13 feet at place where old Beaver Valley came into Red Cedar near center of Section 28, Township 27 North, Range 13 West. The map makes surface 873 so the gravel is 860 feet. It includes stones up to five or six inches and many are three inches. They are fresh looking and so is the sandy matrix. Above Irvington the Red Cedar is in about as narrow a rock gorge as that above Downs ville with sandstone bluffs 40 feet or more high capped with the sandy gravel up to 860 feet.

Gravel on Beaver Creek

The road from Irvington south nearest the river is over deep gullies cut in sandy gravel to north edge of Section 21 and then over slate hills past the Lutheran Church to the old Beaver Valley. The new map omits a road that runs west through center of Section 29. It is a main road on which we went west to line of Sections 29 and 30. We then went one-half mile south and followed Beaver Creek west on line of Sections 30 and 31. There is glacial gravel near mouth of Beaver Creek and along Knight Creek. This may be washed in from the drift of the uplands.

Weidman made a pebble classification of gravel in Section 36, Township 27 North, Range 17 West, and another in Section 33 on Eau Claire River and as he found Barron quartzite here he inferred that the ice movement was from the "Central Wisconsin lobe" and not from the Minnesota lobe. (See notebook 279, page 59). We went up the valley to Weston and found it heavily coated with red clay so no exposures of drift pebbles were seen.

Till Near Weston

On the uplands west of Weston there are boulders and a few feet of till. It is of reddish color and contains quartzite, quartz, porphyry, jasper rock, etc. as well as greenstones and granites. There is some bog iron over sandstone on the line of Lucas and Weston Townships, Sections 30 and 4, a deposit 2-4 feet thick.

I went east from Hatchville to road running north between Sections 33 and 34, Lucas township and saw boulders and thin deposits of till all the way. ? ? ? ? Sections are present just to the town line of Lucas and Menomonie on upland. The valley filling ? ? ? ? in northeast part of Section 27 and east of Section 22, Lucas is wet and peaty and there is wet land to the west in the valley for over two miles as indicated on Weidman's map. The stream begins trenching just east of this road.

What Age for Brick Clay at Menomonie

I turned east on the highway and found a few boulders in Section 23. The shale outcrops on low swells on the valley borders and slopes higher up.

The barometer indicates 900 feet at the exposures of red clay in Section 20 examined last Sunday, June 3, that are loess-covered. This looks to me today to be an older deposit than that near Menomonie from which brick is made. It is a deeper red and has bands of dark iron-rust color in it. Its surface is also fully 50 feet higher than that of the laminated brick clays of the Excelsior and other companies. It may be Illinoian and the brick clays Wisconsin.

I made a drive in the afternoon up Wilson Creek valley to Knapp. The filling along the creek seems to hold a uniform level as far west as the northeast section (Section 1) in Lucas township and is about the same as Menomonie Junction. My barometer makes it 865-70 starting at 862 feet at Hotel Royal.

I later went by train and found it the same as Menomonie Junction. There is a rapid rise up the valley in Stanton township, the altitude at Knapp Station being about 40 feet higher than at Menomonie Junction.

Features Near Knapp Mountain

I am told by the auto driver W. H. Miller that on a farm he crossed on the ridge two miles southwest of Knapp in Section 5, there are numerous boulders and the distance to rock ranged from 10 or 15 feet up to 50 feet or more. His own well was dug about 50 feet without entering solid rock.

We drove north from east end of Knapp, a road running east in north part of Section 26. This crosses rock ridges on which we saw a few boulders and smaller erratics.

Drift Along Annie Creek

We found much more drift on east side of Annie Creek in Sections 24 and 25, and on the line of Stanton and Sherman in Sections 25 and 30. Several feet of cobbly drift is exposed on this line where the road descends southeast to Annie Creek. The valley bottoms here also are full of small erratics. We passed a few greenstone boulders in a deepened part of center of Section 30.

The next exposure of drift noted is at a tributary of Annie Creek near line of Sections 29 and 32, Sherman township. There are boulders 6-8 inches in diameter of greenstone and granite.

South from here the slope and bottom lands have a thick deposit of reddish silt loam 12-15 feet or more, so shallow, ravines fail to reach its bottom. Is it a loess deposit? This deposit covers the uplands as shown on Weidman's map ????? .

Silt Loam or Loess

Loess, western Monasenic and to the south Weidman calls it "Hartland silt loam" and "loess soil". It covers uplands and undulating slopes. I think my mapping beats out Weidman's except east and northeast of Eau Claire where I found shale very close to the surface and where the valleys are sandy. In some places there may be three feet of silt loam. In the districts where I should class the deposit as loess the thickness is from 6 to 15 feet or more except in some high divides, like those near Ketchville where it is 2 to 6 feet. I took a train at Monasenic Junction at 3 P.M. to Hudson. The loess or silt loam seems to have about the limits given by

Weidman where this railway crosses, for surface boulders become numerous a mile or so east of Wilson.

Red Illinoian Drift

This district was covered by R. T. Chamberlain and myself about 1906 and conferences with T. C. Chamberlin and S. Weidman were held as to the presence of red drift over a calcareous till from Manitoba. This drift was recognized clearly from this railway northward and tentatively to the south toward Red Wing.

Features in and Near Hudson, Wisconsin

I went up to the top of the rock hill in southeast part of Hudson. It stands but little above a plain of sandy gravel east of here but is higher than the plain of sandy gravel west of the St. Croix opposite Hudson, perhaps 50 feet. Boulders are strewn over its crest and slopes but there is rock within 10 feet of the highest points.

East of the south end of this rock hill there are gravel pits and knolls that are a little lower than this till. One of the knolls has a nucleus of soft white sandstone. Each of them has a few boulders in the pits, greenstone and gneiss. The stones on the rock hill include many red rocks and the drift has a reddish tinge. There are red quartzites, quartz porphyry, jaspilite rocks and indurated sandstones. The greenstones, gneiss, and granite are well represented. Weidman classes this area as the Early Wisconsin.

Along the railroad for several miles east of Hudson the drift is undulating but is of gravel and cobble with few rocks a foot in diameter. Most of the coarse ones are 6-8 inches or less. It does not look like a till area, yet is not flat like a gravel plain. The material seems to have been washed over by water in the course of its deposition. The highest part is classed by Weidman as Rice Lake Loam (RLL) and the lower part along Willow River as the bordering till areas "Gul".

Features in Minneapolis

June 10, 1923. I went into St. Paul on the morning train and spent the day

with Sanderson. We visited excavations in and around the University campus and found an interesting variety of drift. There are patches of clayey, gray drift of Wisconsin age under the river rubble of the glacial Mississippi. This river rubble has some wind drifted sand on it, 2-10 feet. Below the river rubble and the patches of gray drift there is gravel of red drift of Wisconsin age. This in places is deeply iron-stained so it looks as rusty and old as in the cuts in the Illinoian drift near Albertville. It is there a peaty bog drained westward Sanderson says. There are springs along the railroad grade at west end of this rusty gravel exposure. It is near the west end of the campus. Below the red drift there are patches of blue pre-Wisconsin (probably Kansan) till. But in places shale immediately underlie the gravel.

At Sanderson's home, 431 1/2 Harvard Street, the surface sand which he calls "dune sand" is 2-4 feet. Below this is river rubble of the glacial Mississippi River.

On Railway to St. Paul and New Richmond

June 11, '08. Train to New Richmond, Wisconsin, on Grand Railroad leaving St. Paul 8:25 A.M.

The gravelly deposits near Northline and Burdhardt have a few boulders embedded, the largest being 3 feet and most of them above one foot in diameter. There are many basins and chains of basins as if drainage had been blocked by a readvance of the ice, in early Wisconsin time. The rock hill in Section 7, two miles northeast of Burdhardt called Mt. Helen, is stated by Sanderson to have Trenton limestone at top. It is fully 100 feet above the surrounding gravelly district and probably not less than 1050 feet A.T.

I saw fewer boulders northeast of Burdhardt Station than between Hudson and Burdhardt. The surface is nearly plane aside from basins between Boardman and New Richmond. It has the general appearance of an outwash plain from the remains west of Willow River. It is washed Rice Lake Loan (RLL). There is a bluff at its east border at the change on map from RLL to RSL. It rises 20-30 feet above the plain. I can see a few boulders on its slope.

Limestone outcrops nearly to surface at a ravine south of New Richmond one-half mile and also on Willow River in the village.

There is a higher limestone ridge west and northwest of New Richmond in section 4, Richmond and sections 35 and 26, Star Prairie township that stands about 50 feet above the plain on which New Richmond is built. This higher area is partly on Weidman's "HLL" land and partly in "Cul". I went onto it as far as the line of sections 34 and 35, one-quarter mile west of the Poor House (County Infirmary). There is a red till west of the outcrop of limestone, the outcrop being east of the Infirmary buildings. The Soo Line Railroad cuts into this till 20 feet without rock near line of sections 34 and 35. The till has saucer-like depressions holding ponds and also swalls. It is not so sharply morainic as the St. Croix morainic till which is in view to the west in section 33 and northwest part of section 34. Boulders are numerous on it and I passed several four to six feet in diameter. On line of sections 34 and 35 and in north part of section 4 (Richmond). I went south to Highway 64 and followed it east to New Richmond.

Features Near New Richmond, Wisconsin

It crosses the limestone escarpment near center of NW $\frac{1}{4}$ Section 4, Richmond Township. There is a gravel pit on the west side of Willow River in Section 4, that is 25 feet deep. It is of the height of the plain on which New Richmond stands. It is fresh looking gravel. The till in this tract also is not deeply weathered. It is classed by Weidman as "Early Wisconsin". There is a narrow strip of this land between Willow River and the St. Croix Morainic belt in northwestern Richmond township and adjacent part of Star Prairie township. I went by auto two miles north-northeast across a pitted outwash plain with marshes and ponds. I then went west a mile and there left the plain and rose over a bouldery gravelly strip with gently undulating surface to the edge of the St. Croix moraine which crosses into the NW $\frac{1}{4}$ Section 26 and SW $\frac{1}{4}$ Section 23, Star Prairie township. It stops at the south side of a lake on line of Sections 22 and 23 and the gravel plain extends to Apple River at Johannesburg.

The high gravel plain north of New Richmond is about 1000 feet A.P. in Sections 23, 24, and 25, Star Prairie township and in east part of Section 14 and in Section 13. But in the west part of Section 14 is a plain only 950 feet A.P. This is 50 feet higher than Apple River bridge at Johannesburg in Section 21, 10-12 feet above the river.

There is a hummocky remains west of the river extending as far west as Squaw Lake in Sections 8 and 17, Star Prairie township. The auto driver says plain sets in west of Squaw Lake that extends northwest to East Wauwatosa. I was on this plain with Weidman a few years ago.

Apple River in a Glacial Fosse

There is a plain along Apple River from Johannesburg up to Star Prairie extending about 450 feet. West of the river is an ice-contact face or slope slightly houldery that separates this plain from the high one that runs down Willow River. This lower plain seems to end at Star Prairie. Apple River is in a narrow valley above there where east bluff extends up to the high outwash plain while the west bluff is strongly hummocky. The river follows a fosse at the base of the ice-contact face.

Star Prairie Outwash Plain

The high plain east and northwest from Star Prairie has deeper basins than those near New Richmond, being 30-40 feet while those near New Richmond are 15 to 25 feet lower than bordering parts of the gravel plain.

I went east into this high plain to the corner of Sections 5, 6, 7, and 8, Stanton township, reaching an altitude of 1030-1040 feet. I then go north to middle of line of Sections 31 and 32, Alden township, and reach 1050 feet. There is a yellowish brown loam in the part of this outwash tract that Weidman classes as "Cul" while sand and gravel are nearer the surface in what he classes as "Fill". Gravel sets in at 3-4 feet in the "Cul" part of the outwash plain. I found in an earlier trip with Weidman several years ago that the head of this outwash is in Sections 16 and 17, Alden township. There is an ice-contact face on east side of Apple River from

Star Prairie north to Section 17 and merging west of the river with strong expression.

St. Croix Morainic System

The St. Croix moraine, of what Weidman terms the Hennepin Lobe, lies east of this high outwash plain from Section 16, Alden township, southward to Sections 9 and 10, Stanton township. It then turns eastward and runs just north of Deer Park to Clear Lake and to Clayton, its east edge within a mile east of the C&NP and GRR from Clear Lake to Clayton and it is about two miles east of the railroad at Turtle Lake. The interlobate St. Croix moraine between the main lobe and the Hennepin sublobe extends according to Weidman's description (given when we were in the field together) past Noranda to Balsam Lake and even farther.

Thin Wisconsin Drift on Valleys and Knolls

Today I left the Hennepin part of the St. Croix moraine in Sections 9 and 10, Stanton township, at its extreme southwest part and went south past Stanton into what Weidman classes as Early Wisconsin drift. I find it is much like the district outside the Early Wisconsin border, there being only a slight veneering and obtruding of valleys cut in the Kansan drift. As I continue south there seems to be an increase in the modification of the surface for low swells dot the low areas and also the sloping of the broad valleys that had been cut in the Kansan drift. One of these knolls is a mile in the southeast corner. Section 28, Stanton, has been opened for gravel and enough obtained to cover several miles of road. It is not now in operation - this knoll is only 10-15 feet above flat land around it in one of the post-Kansan drainage depressions. A mile south in Sections 33 and 34, Stanton, and north part of Section 5, Erin Prairie township, there are marshy basins shut in by drift knolls. The drift is thickly set with boulders in this Early Wisconsin drift of Stanton township so as to be piled in large heaps in fields and many are still in the soil. The drift has a distinctly red tinge and pebbles in it include many red rocks.

Blue Kansan Till

According to Weidman, blue till of Kansan age underlies this region as

far north as the vicinity of Clear Lake. I continued south across Willow River on line of Sections 5, 6, 7, and 8, Erin Prairie township. There is more gravelly drift along and south of Willow River than I noted north in Stanton township. There is gravel in many of the knolls in Sections 7 and 8, Erin Prairie township and sections to the west and south, so the auto driver states. I passed pits in knolls in Sections 7 and 8. The high points in the northeast part of Richmond township and northwest of Erin Prairie are about 50-60 feet above New Richmond or nearly 1050 feet A.S.

Boulders are not rare in this district south of Willow River characterized by the gravelly knolls but are less conspicuous than in the more clayey drift north of the river.

Features near Clover

I took the afternoon train back to Hudson from New Richmond. I take the train to River Falls and road 850 on the gravel plain at Prescott Road. The plain has a loess-like silt capping several feet thick. There is a higher plain with boulders in the gravel in which barometer reads 890, in section 8. East from here is a knolly tract back of a rock ridge before reaching Clover about 950 feet. A very flat tract southeast of Clover in Sections 14 and 15 reads 950 feet. This seems to be a plain of aggradation.

A knoll with gravel pit in it is passed in Section 29 on southwest side of the railroad. Several medium sized boulders are thrown out of it. The railway descends from here toward River Falls and is 896 at the railroad station.

Lenses of Red Till and Gravel

June 12, 1923. River Falls, Wisconsin.

The Minnisknick River is cutting into limestone here but a soft sandstone forms the bluffs nearly to top where another limestone comes in as a cap rock and causes flat tableland. There is a thin coating of gravelly drift with a few boulders on the lowlands in and around River Falls. I went north to a road running west across Section 36, Troy township, in a gravelly plain with low consistent knolls to the south near the line of Troy and Clifton townships. There are a few boulders in

a gravelly matrix.

I went northwest in Section 35 over low swells with gravelly coating, then north through Center of Section 26 over gravelly knolls with sandstone base.

I examined the gravel pit in SE $\frac{1}{4}$ Section 23 and found a sandstone base in the knoll but there is fully 20 feet of gravel on its east slope. This is rusty and earthy to a depth of 6-8 feet, below which there is a clean gravel, looking as fresh as the ordinary Wisconsin gravel deposits.

There are lenses of red till in beds from a few inches to two feet thick in the midst of the gravel. The bedding is somewhat irregular with sharp dips that seem to be cross bedding rather than disturbed stratification. There seems to be a more rolling upland north and west from here than south and east with less of the flat tableland aspect. This may be due to the presence of thicker drift to the west and north. The hills close to River Falls have very little drift. I went on one in Section 35 on my way to the gravel pit and found it boulder strewn and carrying a thin deposit of drift probably less than 10 feet. Boulders are numerous in Sections 26 and 23, but I notice scarcely any in Sections 24 and 25. There is a sandy coating with a few pebbles in it to depth of 2-4 feet and below this cobble and gravel in the lowlands along a north tributary of Kinnikinic River. A gravel pit has been opened in this lowland a short distance southwest of center of Section 24.

On Train - River Falls to Ellsworth, Wisconsin

I returned to River Falls along Highway 45 from Section 24 and took train at 10th Avenue to Ellsworth. The lowlands are like those around River Falls for 2-3 miles southeast with gravelly material and a few boulders showing in cuts and ravines, while the bluffs are of sandstone nearly to top. In Section 17 the railway begins a steep ascent to a summit in Section 28 where the aneroid reads 1100 feet. There is bouldery drift here with very little if any loess. My map notes loess within a mile south in Section 33, River Falls township. A descent of about 150 feet is made to Trumbell River in Section 35, River Falls township and there is only a slight rise from

there to Beldenville, where the altitude is 975 feet. Southeast from Beldenville, a rise is made to about 1150 feet in west part of Section 8, Ellsworth township on a loess-covered upland. There is then a descent to 1068 feet at Ellsworth Station. The hotel and courthouse are a mile west on a ridge 1200-1225 feet.

The rock outcrops in west part of Ellsworth at a level 25-30 feet lower than the courthouse or at nearly 1200 feet A.T. It is a shale with thin limestone layers in places. Below it is sandstone forming the greater part of the hill slopes. The uplands around Ellsworth are loess covered to depth of several feet.

Features Near Ellsworth, Wisconsin

I went west on the highway leading to Prescott and found loess for a mile or more but on descending into a lower tract that covers much of Sections 21, 22, and 23, Trumbull township, sandy drift with occasional boulders is at the surface. There is limestone on the shelf-like terrace each side of Trumbull River about 75 feet above the stream in Sections 20, and 21, Trumbull township. It has very little drift on it; I notice only an occasional boulder and no till. West of Trumbull River, knolls with some gravel and with boulders on surface occur as far west as the N-S road in Section 18 on land about 1000 feet A.T.

As the highway rises west from the cross-roads on line of Sections 18 and 19, it passes through a till cut exposing 8-10 feet of brown till in which I see bands or partings of red that look like the red drift. Otherwise it does not have the characteristic red tinge of the post Kansan drift of this region. South from here, along the N-S quarter line road in Sections 19, 30, and 31, Trumbull township, the loess is so thick I see no exposures of till, and doubt if there is more than a trace of drift here. I went to corner of Oak Grove, Trumbull, and Diamond Bluffs townships and then north on the line between Trumbull and Oak Grove and passed an exposure of a few drift pebbles near middle of line of 31 and 36. A mile farther north in west part of Section 30, is a gravel pit on a point of land between two northwest draining ravines. It is on a limestone ledge and is 18-20 feet deep at farthest point into this ridge. The surface has a crust of calcareous material 3-4 inches thick that

looks like a limestone layer from a few rods' distance. It is found on the crest of the ridge. On the slopes, there is a red clay loam several feet thick, probably allied to loess, for all the surrounding high land is loess-covered. This gravel becomes remarkably fresh looking at about 8 feet. Above that it is rusty and earthy. It seems to have fewer red rocks than the ordinary red drift of the region, and so may prove to be Kansan from the Kewatin center. I found a limestone pebble that looks like the well rounded and polished pebbles that come from Manitoba, and which abound in the Kansan drift. I do not find other gravel deposits around this one, within 1½-2 miles north or west. The gravelly deposits from Section 13, Oak Grove township westward in nearly every hill and northward from Sections 8, 9 and 16. There is a large pit near center of Section 9 that has much lime concentration in upper part, but loose gravel below. It has a sandstone base with about 20 feet of gravel over it. The gravel has a predominant sharp eastward dip like a delta. There is very little loess west of Big River valley except on the immediate border of the Mississippi bluffs for scarcely a mile back.

The surface is bollowy like a moraine, but part of this is referable to rock knolls, that have a veneer of drift. The drift is not so bouldery here as in Sections 13, 14, 10, and 11.

I crossed Big River near line of Sections 22 and 27, Oak Grove and got reading 840 feet A.P. The uplands are 1050-1125 feet plus or minus in this vicinity. There is very little loess on the east side of the river or the road in Section 27 and boulders are rather numerous about to the line of 27 and 26. East from there I rise into a loess-covered upland that ends in southeast part of Section 14 and south part of Section 13, Oak Grove, where the gravelly bouldery knolls above noted set in. The knolly and bouldery material seems likely to be a continuation of what Sanderson and I have classed as Illinoian or as old red drift, and which embraces the Hampton moraine.

Loess Near Ellsworth

On our return we went from Frumbell to Heldenville along or near Frumbell

River and its tributary Goose Creek, and we find scarcely any loess on the slopes or in the valleys. Boulders are not conspicuous though a few were seen. On turning south from Beltsville into the upland a rise of 200 feet is made to a loess covered tract that continues loess covered past Ellsworth. It is, however, on a typical red till fall of red rocks, good exposures of which are to be seen on the highway running north from Ellsworth past the west side of the fairgrounds and race track. There is about four feet of loess over the till. There is not a deep ferrite or weathered surface upon this till under the loess, but instead the normal color such as it presents in its lower part.

Shale and shaly limestone outcrop at the fairground entrance at a level 25 feet lower than the top of the till near the north limits of the village on a prominent ridge. The aneroid reads 1195 at the shale surface and 1220 at top of the till one-quarter mile north of the fairground entrance.

Boundary of Drift (West Hansen)

ridges trace the border of the post-Kansas drift from Red Wing northeast as far as to pass about five miles south and east of Ellsworth. It seems to me more likely to run toward Walker, Minnesota than Red Wing from near Ellsworth.

Red Post-Kansas Till South of Ellsworth

June 13, 1927. Ellsworth, Wisconsin.

I find that ravines in southeast part of the village expose shale at about 25 feet below the level of the crests of ridges such as that on which the courthouse stands. As there is 4-5 feet of loess, the glacial deposits are not likely to exceed 20 feet on these ridges unless they fill depressions or gullies previously cut in the rock.

I go south by auto and find the red drift (till) well displayed near center of Section 30, $1\frac{1}{2}$ miles south of Ellsworth and also in south part of Section 19 nearer the village. There is a thin deposit of loess 3-4 feet or less, over it. South from here is a larger tract with no loess. There are a few boulders and smaller stones and the land is somewhat sandy but not a light soil. The altitude is 1050-1075 on this

lower tract.

Gravel Ridge with deep weathering

I went west on line of Sections 1 and 12 and then south to gravel ridges that I visited with Chamberlain in 1906 on line of Sections 13 and 14. The aneroid reads 1100 here. The gravel is very much iron stained and rotten for 6-8 feet from the top but under this there is relatively fresh looking gravel with scarcely any iron stain. It contains much local limestone. There is another gravelly ridge about 70 rods south of similar height but not so well exposed. It, however, has fresh looking or unstained and loose gravel in its core. The north ridge is opened to 15 feet depth. There is some loess loams on each slope and the country from here south to the river bluffs has a heavy coating of loess.

Gravel Ridges in Hartland Township

I go west into Hartland township and find gravel knolls extend eastward across the northern half of the township into the northwest part of Salem township to Sections 6, 7, 8, and 18. There is a pit in a sharp knoll cut by the road near south end of line of Section 17 and 18, Hartland about 15 feet deep but this is rather sandy for highway use. It is like that on line of Sections 13 and 14, Trenton township above noted, with considerable iron stain near top but loose unstained gravel below.

There is a sharp esker-like gravel ridge 35-40 feet high and about as narrow as the ordinary esker in southeast part of Section 7 and edge of Section 8. A pit in it in Section 8 at southeast end is 20 feet deep and shows the gravel to be banked against a sandstone cliff at south side of the pit. There is 6-8 feet of iron stained gravel over the sandstone. The gravel north of this cliff is dug already 8-10 feet below the top of the sandstone without reaching the rock. This pit shows loose unstained gravel full of local limestone extending up to the crest of the ridge but the slopes have deeply stained gravel and coarse stones. There are granite boulders close by the pit 3-4 feet in diameter that may have come out of it. This ridge is about one-quarter mile long and runs west-northwest and east-southeast.

In the east part of Section 8 there is an irregular chain of gravel knolls

one of which is opened for gravel 10 feet plus or minus and shows loose unstained gravel. Another pit is being opened now 40 rods west of it in NW $\frac{1}{4}$ Section 8. These gravelly knolls look a little like an ecker chain less than one-half mile long. There is another gravel knoll with small pit in it in north part of Section 10. There is a group of low gravel knolls each side the road one-half mile west of Herbert in Sections 12 and 13, and a thin deposit caps a hill one-quarter mile south of Herbert.

There is a very prominent group of Kames in the northeast part of Section 12 about 75 feet high. The north slope is literally covered with large granite boulders in several places. One boulder is 3 feet in diameter. The gravel is loose and but little stained. My aneroid reads 1180 on the highest point in this group of knolls. It covers about 40 acres in north half of NW $\frac{1}{4}$ Section 12.

Gravel Knolls in Salem Township

West from here on line of Sections 6 and 7, Salem township, there is gravel with many red rocks such as characterize the red drift. There was a gravel pit on Mr. Binchert's farm in southeast part of Section 7 some years ago and a small one is now opened in a knoll in west part of Section 8, Salem township. I can learn of no gravel farther east and south and there is a general coating of loess of considerable depth, so road cuts eight feet deep do not reach the bottom.

Gravel Knolls in Ellsworth Township

I went back to Ellsworth on the diagonal road from southeast corner Section 1, Hartland to line of Sections 16 and 21, Ellsworth township. This leads over a chain of prominent gravel knolls and ridges in northwest part of Section 35, Ellsworth township, which are 1150-1175 feet on highest points and 25-50 feet above border land. At the line of Sections 26 and 35, near west end, just north of a cemetery, the road cuts into a red till that underlies 15-20 feet of gravel. I took a specimen of the till.

Border of Post-Illinoian Drift

There are gravel knolls interspersed with sandstone knolls in Sections 26

and 27 as far west as this highway. Weidman's map carries a pencil line through this gravelly strip as the border of the "Iowan or Later Illinoian drift". I am inclined to put this red drift border out far enough to include the gravelly knolls of northern Hartland and northwestern Salem townships. There is considerable red rock material in these knolls and they seem to belong to the same system as those in Sections 26, 27, 34, and 35, Ellsworth township, that Weidman recognized as post-Kansan.

In the afternoon I drove east from Ellsworth across the township and found a boulder strewn area with a few gravelly knolls among sandstone hills as far as Lost Creek valley. The drift is very scanty in places with limestone under the flat land at 2-4 foot depth.

There is a heavy coating of loess east of Lost Creek where road ascends in Sections 19 and 20, Ellsworth Township.

Loess

But, in crossing over onto the slope toward Rush River, boulders appear at the surface. I turned south in a bouldery area into Section 20, El Paso township and soon came into thick loess. There seems to be very little drift here.

I returned to the highway at line of Sections 17 and 20 and continued east across Rush River to Waverly. Drift is very scanty all the way. About one-third mile west of Waverly the road cuts through a gravelly concentrate 5-6 feet thick which rests on rock.

Red Drift Over Kansan Gumbo

I turned north of Waverly on line of El Paso and Rock Elm townships and on in a loess covered area with little exposure of under-lying formations for over a mile. I then make a descent and pass exposures of red drift over a gumbo of grayish color that forms the surface of the Kansan drift. I collected samples of: (1) the red till, (2) the gray gumbo, (3) the brown till under the gumbo. The till below is deep brown color with dark staining in the joints and seems to be typical Kansan till. The red till is plastered on the slope both above and below where the gumbo soil outcrops so it evidently is younger, as is suggested by the presence of the gumbo soil.

Red (Post-Kansan) Till

I turned west in Section 1, El Paso township and noted several exposures of the red till in road cuts in Sections 1 and 2. From there westward to corner of El Paso, Ellsworth, Gilman, and Martell townships, the road is crossing valleys and I saw no good drift exposures.

There is but little loess along the line of Ellsworth and Martell townships east of Lawton so boulders are seen, though not numerous. Directly south of Lawton the road on line of Sections 2 and 3, Ellsworth township, cuts through red till about six feet thick into Kansan till of deep brown color with much eroded surface. There is a similar exposure one three-quarter miles south of Lawton near south end of line of Sections 10 and 11, Ellsworth township. There is very little loess here, on the highway south from Lawton, or westward to Ellsworth Station.

I took evening train from Ellsworth to Hudson. The aneroid read 980 at Glover siding at the border of the Early Wisconsin drift as interpreted by Weidman. The billowy basin tract for a mile northwest of Glover has only small boulders exposed in cuts seldom a foot in diameter. Much of it is about 950 feet. On the high outwash plain of the St. Croix valley at Prescott Road, the aneroid read 875 or fully 200 feet above St. Croix River. There is about 15 feet of sand here over the coarse cobble and gravel. There are a few boulders in the gravel, up to 2 or 3 feet in diameter. Most of the gravel is fresh with but little iron stain. About a mile south of Hudson, I noted some iron staining in its lower part.

Features Near Hudson, Wisconsin

June 14, 1923. Hudson, Wisconsin.

I set aneroid at 730 feet at Chapin Hotel and read 840 feet at level of the plain and 870 at Prescott Road.

Limestone hill east of Prescott Road in Section 7, Troy township, is 940 feet or 70 feet above the gravel plain west of it. There are a few boulders on this plain on line of Sections 30 and 31, and in south part of Section 31, Hudson township. There are slight swells and shallow basins where the boulders occur.

The moraine of Wisconsin drift that runs from near Roberts past Glover to the St. Croix valley in northwest corner of Pierce County, has knolls and basins and a moderate number of boulders. The boulders are usually small but occasional large ones were seen. It is strikingly in contrast to the plain outside in southern Troy township and southeast of Glover station. The width is a mile or more. The swells fill mouths of ravines that head up in higher land to the southeast and are found in some places well up in the bluffs and there may be a few on the uplands.

Wisconsin Drift Border

There is a rock ridge on east side of St. Croix River in Section 23 and 24, of Western Troy township. The Wisconsin drift knolls lie east of it in Sections 19 and 30. There is very little flat gravel plain east of the river on the inner side of this moraine in southwest Troy township.

I found that evidence is not clear that the Wisconsin drift borders run eastward from Twin Lakes past Roberts. It seems more likely to find continuation northward through western Warren township in the area marked "Cul" on Weidman's map. This has a choppy topography like that near Glover, while the district east of it has wide open valleys with smooth slopes. There are a few sandstone swells. There are also occasional kames. I examined a cluster of kame knolls in northeast part of Section 3, Kinnikinic township. These may have a sandstone base for I noted sandstone knolls to the north in Sections 34 and 35, Warren township. Sandstone knolls are numerous in the morainic area in northwest Warren township, but there are also drift knolls. Basins are a conspicuous feature here and small ponds. The knolly land is traceable to the small stream that comes into Boardman from the east. North of this stream is a high gravel plain, with deep basins, but with few, if any, boulders, that occupies the west part of Section 22 and adjacent parts of Sections 15, 16, and 21, Richmond township. It is about 30 feet higher than the plain marked "BLR" on Weidman's map.

I crossed Willow River at Boardman and went to south end of Bass Lake passing around the north end of a high rock hill in north part of Section 25, St. Joseph

township

St. Croix Moraine

I am surprised at the weak expression of the St. Croix moraine east of Bass Lake. It has very few boulders and is more of a basin tract than knolly. There are, however, morainic features that distinguish it from a gravelly plain between it and Willow River in Section 35, St. Joseph, and Sections 2 and 3 of the township north. In this gravelly plain basins are conspicuous but the land between or among them has flat surfaces where best aggraded.

Basins Near Burkhardt

South of Burkhardt, the gravel plain has numerous basins, and but little of it comes up to the full height of the plain. In fact there is so little flat surface, and small boulders are so numerous as to lead me to question whether it might not be classed as a sandy ground moraine. What is true here may find application over much of the gravelly area between the outer Wisconsin moraine and the St. Croix moraine that I had classed as outwash. The numerous small boulders and occasional large ones have distribution all over this area and within the deposits.

Is There Early Wisconsin Drift?

It now seems to me hardly probable that the moraine which forms the border of the Wisconsin drift is enough older than the St. Croix to be classed as Early Wisconsin. Instead it seems to be the immediate forerunner of the St. Croix and should perhaps be put in the same morainic system. This as well as the St. Croix may prove to pass west of New Richmond. I shall need to study each side of Weidman's Early Wisconsin boundary in the district east from Roberts to determine the basis of his mapping and its significance.

Post-Kansan Drift East of Roberts

I took evening train from Hudson to Woodville and Spring Valley. The impression I got from the appearance of gravel and boulders in cuts west from Roberts with those east is that the drift east is pre-Wisconsin, while that west

is fresh enough to be Wisconsin. There are several deep cuts east of Chapman that do not expose rock but on a bouldery cobbly semi-assorted drift of rather fresh aspect from top to bottom, in some cases 25-30 feet. The cuts in gravelly material from Roberts eastward show a deeply weathered material. The erosion features also are of the wide open type and not the ill-defined sort found west of Roberts. I noted the yellow and blue tills under red drift in the cut west of Woodville and also in one near Brookville that was visited with Chamberlin in 1906. The cut near the county line which we visited is ~~crossed~~ crossed over now.

Granite Rocks in Post-Kansan Till near Spring Valley

Spring Valley, Wisconsin. June 15, 1923.

I follow Highway 79, northeast across Section 5, rising through rock ledges to altitude 1075. Above this the gullies show red drift with a cover of loess loam several feet thick. I found one biscuit shaped bench pebble (?) of Lake Superior sandstone. The red rocks are very conspicuous and the till is of red color.

I read 1175 where the highway comes to the county line one one-half miles northeast of Spring Valley at corner of Sections 4 and 5, 32 and 33 on general level of uplands.

East from here at altitude 1150, rock outcrops in this road near middle of line Sections 4 and 33. There is a little red drift over it.

About one-quarter mile farther, I cross a ridge 1195 feet with red till covering it. The loess here is very scanty.

I go south on line of Sections 3 and 4, crossing a ridge near one-quarter post, altitude 1175. Red till is well exposed on crest and slopes of this ridge.

Rock outcrops at 1125 feet both north and west of corner of Sections 3, 4, 9, and 10, Spring Lake township.

I took road west down a ravine to Eau Claire River. It has rock ledges

bordering it all the way. In the bed of the ravine I notice greenstones are more numerous than other rocks. On the uplands in the red drift, granite seems to be the chief boulder. Does this signify that the red drift is characterized by granite, while the older drift is characterized by greenstone? Or is it a mere accident of local distribution?

Post-Kansan Red Till to Olivet and Waverly

I went by auto to Olivet and Waverly and found red till is present clear to Waverly. It is a much thicker deposit from Olivet northward than between there and Waverly but I find 3-4 feet of it in a cut one-quarter mile north and in one one-quarter mile east of Waverly. Between there and Rock Elm, rock is close to the surface in all the ridges. The slight deposits of pebbly material on it include red drift material. A mile east of Rock Elm village I turned south on road that runs through center of Section 15, Rock Elm township and find red drift in thin deposit clear to south side of Section 15 in several cuts in ridges and slopes. It is only 3-4 feet thick but has the characteristic red color and is full of red rocks. It is probable that this drift is the one I found on uplands southeast of Elmwood a few days ago. I recall seeing numerous granite rocks among the boulders, and there are red rock pebbles present.

Is Old Drift Here Nebraskan?

I went north into Eau Claire valley on line of Sections 10 and 11 and across Section 2, Rock Elm township. The upland where I begin descent is about 1100 feet. The highest points I crossed north of Waverly are over 1200 feet. See altitudes recorded on the map. On the highest land, considerable drift is preserved. This is likely to be the calcareous Kansan (or perhaps Nebraskan) drift. The presence of the blue-black till allies it to Nebraskan rather than Kansan drift and the reduction to strips and patches seems more consistent with Nebraskan than Kansan age.

Loess

Aneroid 28825 ± 922 feet at Spring Valley Wisconsin at 1:40 P.M. I

drive four miles down Eau Claire Valley and then go east into uplands. The highest land is about 1150 feet in Sections 22 and 23 and 26, Spring Lake township. There is a heavy coating of reddish loess here so the drift is seldom seen. I find a little on the hill north of Elmwood in Section 25, both on descent in west part of the section and in ascent in the northeast part. It has the red tinge and includes many red rocks.

The aneroid reads 1170 on the hill northeast of Elmwood near county line. North from here the drift is scanty as far as Hatchville, but is of the red drift type with red tinge and numerous red rocks.

I went a mile north of Hatchville and crossed a gravelly hill with very rusty gravel, opened 6-8 feet. The drift is much thicker here and to the north than farther south. There is very little loess, and boulders abound, mainly granite.

Features South of Wilson

I went west two miles on line of Sections 25 and 36, 26 and 35, Cady township, then north to Wilson over a very much eroded tract. I passed through a cut in a gravel ridge near south end of line of Sections 26 and 27, fully 15 feet deep, that has deeply iron-stained gravel from top to bottom with no loose fresh-looking gravel. It seems to be the red drift material.

Pre-Wisconsin East of Roberts

I took train from Wilson to Hudson. The drift exposures have a similar advanced state of weathering all the way from Wilson to Hersey. But from a mile west of Hersey westward, the drift is less weathered and the topography less toned down. I am impressed with the likelihood that Weidman's Early Wisconsin is a misinterpretation from Roberts eastward. The moraine west of Roberts seems also to be Middle Wisconsin, as noted yesterday, with about same age as the St. Croix morainic belt.

Features East of St. Paul, Minnesota

I take motor bus to St. Paul. Fresh terrain in Lakeland 770.

High gravel plains west of Lakeland 860 feet. Fresh gravel. First cross roads on plain 870 feet. Cobbly, bouldery newly plain tract 920-25. Basins at edge of moraine - some red till.

Many plains are "17 miles from St. Paul" (900'). No boulders in view for a mile, then gentle undulations and gradual change to moraine with red till, not much gravel. Boulders not rare on surface, and many in the till. Moraine has faint expression for two miles further. It then is strong for 10-12 miles, or clear into St. Paul. There are many small deep basins and sharp knolls on the newer or western half of this morainic belt.

An Electric Railway Minneapolis to Northfield, Minnesota

June 16, 1923. Minneapolis to Northfield on the Minneapolis, Northfield and Southern, or "Dan Patch" Line.

This is through gray drift moraine and outwash from Minneapolis south to Minnesota River. It is then close to the border of the young gray drift to Orchard Lake (See Dakota County Map). From Orchard Lake to Lakeville Lake and on south side of that lake there is Wisconsin red drift. This railway cuts across points of pre-Wisconsin from here to Eureka Center. The valley that comes in from the southwest has gray drift outwash but the one just south of Lakeville Lake has red outwash.

There is young gray drift along or near the railway from here to Northfield, and it scarcely extends a mile east of the railway anywhere, unless it is just north of Waterford, where it extends nearly a mile east of that village. It covers the city of Northfield, the border being on east side of a creek in the east part of the city. Yet there is some loess in east part of the city under 2-5 feet of the till.

Chubb Creek has a broad flat low plain a mile plus or minus wide where this railway crosses, that extends up the creek to the west as far as I can see

(a mile or more). It probably heads in a well defined moraine.

On Wisconsin Red Drift St. Paul, Minnesota, to New Richmond,
Wisconsin by Soo Line Railroad

June 18, 1923. St. Paul to New Richmond, Wisconsin on Soo Line Railroad.

This is in red drift moraine nearly all the way, there being very little plain surface. The moraine borders St. Croix River closely on each side. Weidman reported lenses of gray calcareous till in the red drift in cuts in this railroad near Somerset but I do not catch sight of any such drift from the train. It is probably pre-Wisconsin drift that has been shoved up into the morainic knolls of red Wisconsin drift.

The cut one one-half miles west of New Richmond that I looked at a week ago has a relatively fresh red till at top, below which is a rusty sandy gravel that may be pre-Wisconsin (Illinoian?). The fresh till is 5-15 feet thick.

The hummocky morainic topography sets in one-half mile west of this cut where the Soo Line Railway crosses the line of Richmond and Star Prairie townships. There is a relatively smooth undulating till east of here in east part of Section 5 and northwest part of Section 4, Richmond township. The gravel plain comes west into southeast part of Section 7 and covers the east half of Section 18 and southeast part of Section 8, Richmond township. The gently undulating till east of the sharply outlined moraine is thus a narrow strip scarcely a mile wide at best, extending from Section 18, Richmond township, northward to south part of Section 23, Star Prairie. This seems to be veneered with Wisconsin drift its entire length and it has a different topography from that outside the Wisconsin, the slopes being wavy with slight basin like depressions and corresponding elevations or swells.

Basins in Gravel Plain near Boardman

I find basins numerous and deep in the plain on which Boardman stands as well as on a higher gravel area east of it. This plain extends south from Boardman about two miles, to the township line covering the west part of Sections 29 and 32.

Richmond township. The higher plain east of it extends into Sections 27 and 34. It is deeply indented by basins. There are only a few boulders in view in it and these usually are small.

There is some irregularity of slopes with basins and swells in the northeast part of Richmond township and gravel knolls occur in the northwest part of Evin Prairie township as far south as Sections 17 and 18. I am not certain that these are within the Wisconsin drift area, but think that there may be Wisconsin drift as far east as Sections 1, 12, and 13, Richmond township.

Old River Course

There is an old river course westward from Willow River across south part of Sections 1 and 2 and north part of Sections 11 and 12, Richmond township with a gravel plain standing about 25-30 feet above the stream. There is a narrow stream channel through it and the river ran through this a few years ago when an ice jam blocked it just above New Richmond.

There is a strip of moraine north of this old valley in Sections 1 and 2, Richmond township that the river passes through in a narrow valley winding among the morainic knolls in northwest part of Section 1, Richmond township. This seems to be a moraine of Wisconsin drift.

Outer Wisconsin Moraine

I find it continues northeastward to Deer Park along the east side of the gravel plain as far as Sections 15 and 16, Stanton township, and then eastward to Black Brook. There are saucer like basins in it and a wavy surface on slopes of the eroded country. East of the great Star Prairie gravel plain, from Stanton Station southwest to New Richmond the width is scarcely a mile. To the east of this is a district with wide open gentle slopes like that in southeastern St. Croix County in the pre-Wisconsin drift area.

Esker

In Sections 12 and 13, Stanton township there is a sharp esker ridge crossed by the road on the section line. It is 25 feet high for a length of one-

quarter mile (plus or minus) and composed of gravel and cobble with some coarser stones well revealed near the top of the exposure.

It is possible the Wisconsin drift protrudes south to Black Brook valley in the east part of Stanton and west part of Cylon townships for the surface is largely plane and lower than the eroded uplands to the east and west. There is also flat land between Black Brook and Willow River in Section 31, Cylon, and Section 36, Stanton, standing about 40 feet above the streams. It is higher than a plain between these streams in Section 30, Cylon, and 25, Stanton, which is only 20-25 feet or less above the streams and about 10 feet above a swamp that occupies part of Section 30. The flat land in Sections 31 and 36 is clayey but I see no boulders on it. There may be gravel or sand under the clay. There is sandy land east from here toward Cylon in Sections 32 and 33, Cylon township. I am inclined to think the Wisconsin ice did not extend south of Section 19, Cylon, and Section 24, Stanton. It seems to have only touched the northwest of Section 22 and may not have reached Section 23, Stanton township.

Limits of Wisconsin Drift Northeast of New Richmond

There is flat land around a lake three miles east of New Richmond on the township line and this extends south to Willow River. It seems to be high enough to correlate with the abandoned valley noted above in Sections 1, 2, 11, 12, Richmond. I do not see how the Wisconsin ice could have reached to this lake basin from the west for it is nearly 2 miles from the moraine above noted, but perhaps the extreme limit of the Wisconsin ice is outside the definite moraine and marked by basins of this sort in a plain. This and the features in northwest part of Erin Prairie and in Sections 11, 12, 13, 14, 22, and 23, Richmond, suggest influence of the Wisconsin ice sheet.

Pre-Wisconsin Drift North of Hammond

I went south from Cylon to Pine Lake over a district with wide open smooth slopes all the way. Pine Lake is in a valley 25-30 feet lower than the immediate border lowlands. There are smooth slopes down to this level and not a

moraine topography. The depressions in which this lake and others, like Bushnell and Casey Lakes lie are the only irregularities except some small gravelly knolls, one in southwest part of Section 10, Hammond, and another near north end of line of Sections 3 and 4, being the only ones noted. The road cuts through this one and shows some sand at base and some inclusions of yellow till in red till above this sand. It is an old looking red drift like that in southern St. Croix and Pierce County. I am not inclined therefore to refer these scattered knolls, nor the basins in which these lakes lie, to the Wisconsin ice invasion. There are such knolls and also some basins in lowlands far to the south where no one has suggested Wisconsin ice. It happens that Weidman included these features near Pine and Bushnell Lakes in the Wisconsin drift.

Question Weidman's "Early Wisconsin"

June 19, 1922. New Richmond to Boyceville on Soo line.

There is a billowy surface with basins and low swells in the valley of Willow River all the way to Jewett Mills that has the appearance of Wisconsin ice rather than Pre-Wisconsin. It is in contrast with the more open valley with smooth slopes and bottoms farther east.

Northwest of Emerald, one one-half miles there are some knolls at this place where Weidman runs the border of the Early Wisconsin drift. The sharpest one is south of the track in southeast part of Section 11, Emerald township and is about 15 feet higher and looks to be gravelly. Between Cylon and here the valley is a wide open one with smooth gentle slopes. There is also a flat valley bottom to the southeast in Section 13.

Drift Knolls in Pre-Wisconsin Drift

A high divide 1200-1250 feet is crossed in Section 20, Glenwood township, the railway summit being 1210 by aneroid and bordering land 30-40 feet higher. This is a region of thick drift, Kansan, Nebraskan or both, with a veneer of red post-Kansan drift. Two miles north in Section 8 a well 215 feet did not reach rock. On this lowland between Glenwood and Downing in Section 36, Glenwood, there

are gravelly drift knolls with as sharp expression as those northwest of Emerald. I passed two that lie south of the railroad and one north of it. They are about 20 feet high and cover a few acres each, perhaps 10 acres.

Rock ledges become a conspicuous feature. Near Glenwood on Tiffany Creek and its tributaries, I noticed boulders on a knoll one one-half miles east of Downing in northeast part of Section 32, Tiffany township. There is several feet of drift exposed here in the railroad cut. Farther east, rock is exposed wherever any cuts are made by railroad or stream.

The barometer is very low today, 28.600 at Boyceville at altitude 948 feet. There have been heavy showers during the night and this forenoon before I left New Richmond.

I went west one-half mile to a knoll in northwest part of Section 35, Tiffany township and find that it is shale clear to top. I see no drift on it but there are a few boulders in a farm yard just north of it.

Features Between Boyceville and Monomonic, Wisconsin

From Boyceville I took the Monomonic road south and came to a gravel pit near center of Section 1, Stanton township, opened 15 feet deep. The gravel contains many quartzites, jasper rocks, and red quartz porphyry. There are several greenstone boulders 12-15 inches in diameter in the pit. They are old and rotten in appearance with heavy weathered rind. Small boulders of quartzite, granite and greenstone less than a foot in diameter are scattered along the farms by the highway in Section 1.

Boulders become conspicuous in northwest part of Section 7 and drift deposits a few feet thick cover the west part of southwest quarter Section 8. The road surcut cuts into typical red till 5-6 feet in southwest part of Section 8. The knolls on north side of the road are boulder strewn as far at least as the center of Section 8. There is a high limestone ridge in Section 8 on which the farmers say they have not seen boulders but boulders occur both north and south of it on sandstone.

I went down a valley to southwest part of Section 16 and found loess is heavy on its south bluff but there are boulders in the bottom land. I saw a lot of them in southwest part of Section 16 and the farmers say they are present a mile farther east to the head of the swamp which Lamb Creek enters in Section 15.

I crossed over a rock ridge on south-north road in north part of Section 16. On descending from it in Section 9, I came into boulders and cobble near its base.

The road running east in Section 9 is in a sandy lowland on which cobble and a few small boulders occur. Boulders are more numerous and larger and there is some till in Section 4 and southeast part of Section 5 and north part of Section 8 in sandstone hills. The road on line of Sections 5 and 8 cuts through a gravelly till about 5-6 feet thick resting on the crest of the sandstone ridge which is crossed near middle of section line. This strip of till and boulders is along Weidman's line that marks the limits of the red drift as determined by him. It seems probable however that the boulders and sandy cobbly deposits I have noted in Sections 9 and 16, are in this drift. I find very little drift on road across Section 6, Sherman. The gravelly deposits in central part of Section 1, Stanton, noted on the way out, are the chief glacial material there. There are low knolls on the divide in a lowland that runs across from a small stream in Section 1 to one near line of Sections 1 and 6, that runs north across Section 31, Hay River township.

Features East of Boyceville

June 20, 1923. Boyceville, Wisconsin.

I go by auto livery east to center of Section 29, Hay River township, in the sandy lowland bordering the south fork of Hay River. There are places where there is enough pebbly material with the sand to make road material, but usually it is too sandy.

I went south to center of Section 32 over low hills of sandy shale and saw scarcely any glacial material. I went east across Section 33 without seeing many boulders, there being an occasional small one.

I passed a few boulders on rock hills near center of Section 34, greenstone seems to predominate. From Wheeler I went north on Highway 25. There are only a few boulders on the hills in Sections 13, 14, 23, and 24.

There is a broad sandy lowland between Hay River and Otter Creek north of these hills. At its northeast border on line of Sections 1 and 12, Hay River, there is a cluster of drift knolls 25-35 feet higher than this plain in which a gravel pit has been opened. There are boulders in the gravel up to 4 feet in diameter. They include greenstone and granite and quartz, porphyry and quartzite of several colors; white, red and purplish color. There are a good many red rocks in the pebbles; some being a red or purplish sandstone that breaks into layers one-half inch or less in thickness. I noticed some biscuit shaped sandstones that seem to be beach pebbles. ~~They are water worn and same shape as ordinary beach pebbles and~~ seem likely to have been brought from the Lake Superior basin. This cluster of knolls seems to be red drift material.

Features in Northern Dunn County, Wisconsin

I made a circuit through southwest part of Wilson township going as far northeast as the corner of Sections 22, 23, 26, 27, and find scattered boulders, chiefly greenstone, this far east on land 1175 to 1200 feet A. S. The farmers say they are present in small numbers on nearly every farm in this vicinity.

I went southwest to Highway 64 in central part of Section 34. I find a few small boulders and pebbles, chiefly greenstone, on a low sandstone knoll crossed by the highway in southwest part of Section 34. I saw no more west from here to Highway 64 to southeast part of Section 36, Sheridan township. I went south on line of Sections 1 and 2, 11 and 12, Hay River township across a sandy plain. I there turned west and crossed some sandstone points but saw no boulders or other drift material. Then I went south across other rock points but saw no boulders. From near north end of line of Sections 22 and 23, Hay River, I was on a sandy plain to Wheeler.

Chippewa Gravel Plain

I took the train at Wheeler to Chippewa Falls. There is little drift until I get near the east line of Colfax township, but from there eastward it is abundant. (See notes on deep drift in vicinity of Albertville made about June 2 in drive with Mr. Bean.) I went to the high Wisconsin terrace on south side of Chippewa River and found it about 90 feet above the level of the river above the dam and falls and about 70 feet above the Soo Line and Omaha depots on south side the river. If they are 861 and 859 the terrace is 930 feet. It is gravelly at top in this part east of the depots and includes a few boulders up to 2 feet or more in diameter in the upper 10 feet. I see no loess here such as Weidman states is present on the highest terrace and which for that reason, together with other reasons, he classed it as pre-Wisconsin. The amount of weathering is not so great as in exposures that I found today as the weathering and rusty condition found in the Illinoian.

Wisconsin Gravel Filling and 930' at Chippewa Falls

I went east to the area in Section 8 just east of the south part of the city marked "A1" on Weidman's map and find it is a gravelly area standing 980-990 feet with numerous boulderets and a few large granite boulders on the top and slopes. Red or pink quartzite and some purplish quartzite or indurated sandstone are common. This area shows markedly greater erosion than the highest Wisconsin terrace. Very little of it is up to the original level to which it seems to have been built. Some slight exposures in the slope in places where small gravel pits have been opened show a rusty gravel that looks to be Illinoian.

I returned to the north side of the Chippewa River and ascending to the highest Wisconsin terrace I find it also 930 feet. It has suffered very little dissection by the small tributaries of the river.

Wisconsin Border at Jim Falls

June 21, 1923. Chippewa Falls, Wisconsin.

I drove by auto northeast across the high terrace of Chippewa River.

There are large boulders scattered over it in Sections 27 and 28 but the terrace is of gravel and cobble with some sandy coating. The sandy places stand a few feet above the general level. Quartzites and red quartz porphyry are conspicuous in the cobble. The boulders are largely greenstone.

After crossing Chippewa River I went east to the hills marked "A1" on Weidman's map and find sandstone and shale with only a thin deposit of glacial material. There are quartzite boulders as well as cobble in abundance.

The area in Sections 5, 6, 7, and 8, Anson township, Marked "Ch1" has only a thin veneer of drift and includes red quartzite and other red rocks. I doubt if it is within the Wisconsin drift limits. There may be no Wisconsin drift outside the moraine which crosses Chippewa River at Jim Falls.

The moraine comes down to the level of a terrace at about the altitude of Jim Falls Station, 960 feet. This terrace is thickly strewn with boulders in east part of Section 36 and west part of Section 31 on west side of Chippewa River just below Jim Falls.

Features North of Chippewa Falls

There is a higher plain west of this in Sections 2 and 35 that has few feet of cobble over sand where the road rises to it in Section 2. It stands about 1000 feet A.T. The deposit does not look much more weathered than the Wisconsin gravel. It is what Weidman calls the highest Chippewa Terrace. It is not clear to me what relation it bears to the moraine, whether a dependency of it, or an older deposit. It seems to be developed only very locally, for there are no signs of it outside these sections.

There is nothing corresponding to it in O'Neill Creek. The broad terrace on which Eagle Point stands, 973 feet A.T., is the highest and correlates with the one at 960 near Jim Falls on the Chippewa River. O'Neill Creek seems to have been aggraded to this height when the strong moraine that crosses at Jim Falls was formed for the plain runs up to that moraine about three miles north of Eagle Point. I crossed O'Neill Creek a mile northwest of Eagle Point and went south over hilly

uplands west of the creek. This carries deposits of drift that seem to be Illinoian. The road cuts in Sections 1 and 12, Tilden, show it nicely. There is some red till and some assorted material. The red rocks abound both in the boulders and cobble. There is a similar deposit just north of Chippewa Falls in the sandstone hills in Sections 29, 30, 31, and 32, mainly cobbly and boulders with numerous red rocks.

Direction of Ice Movements

In the moraine near Jim Falls quartzites are relatively few compared with the number in the older drift, but they are not rare. The Illinoian Drift was probably brought in southward movement and the Wisconsin by a southwestward, so the latter did not override the quartzite area northeast of Cameron on its way to this district near Jim Falls, while the former may have done so.

Features Near Albertville

In the afternoon I drove west from Chippewa Falls over a district with very scanty drift for 7 or 8 miles, or through the area marked "BSE" on Weidman's map. There seems, however, to be very little loess here. The road is in a sandy valley for two miles east of Albertville opposite the heavy deposits of gravelly drift that the railroad cuts through, both east and west of Albertville station. The road I am on runs to old Albertville in Section 4. Whether there is much gravelly drift southeast of old Albertville, I did not determine, but went southwest into such an area in Sections 5 and 8 and am in it westward past the county line. Gravel knolls and bouldery gravelly material is abundant for about a mile into Elk Mound township, on its east side its entire length. The amount of gravel is somewhat greater than in the township south of Elk Mound. I find, however, that it is less than to the east in south-half of the southwest township of Chippewa County. There, hills 50-75 feet high seem to be entirely of drift. This heavy drift extends east to Chippewa River over the area marked "A1". I am told by farmers that the northeast quarter of the southwest township of Chippewa County has the shale hills such as I crossed in going west from Chippewa Falls.

Gravelly drift is found south of the Omaha Railroad in Sections 4 and 9

and north of the railroad in Section 1, Township 27 North, Range 10 West. The amount of glacial material here is in striking contrast to the scanty drift west of Chippewa Falls. It is old enough, so far as weathering and staining with iron is concerned, to indicate an age as great as the Illinoian.

Illinoian Deposits in Chippewa Valley

I see no difference in the degree of weathering of these thick deposits and the scattered and thin deposits to the southwest, south of Elk Mound, so the thin deposits may be illinoian. I noted thick deposits of gravelly drift on the rolling land in Sections 16 and 17, Township 28 North, Range 9 West. There is rusty gravel under the Chippewa terrace in the central part of this township as well as in the bend in Section 29 that Mr. Jean and I examined about June 1st. ~~The Chippewa Valley may thus have been filled to near the height of the Wisconsin~~ aggradation over a large area in Illinoian time.

Wisconsin Limits Near Cameron

June 22, 1923. Chippewa Falls to Cameron, Wisconsin.

On the uplands crossed by the C 51-PM and ORR there is Illinoian drift in a sheet of some feet depth wherever I see cuts. About midway between New Auburn and Chetek there are knolls of gravelly drift probably in Sections 15, 16, 21, and 22, Dover township, Township 32 North, Range 10 West.

From Cameron I got auto livery and drove west a mile then north three one-half miles across a gravelly plain. I then entered a till tract with wide open smooth valley slopes and with relatively few boulders. The till is the dark red color characteristic of Illinoian drift. There seems to be no Wisconsin drift over it in southwestern Rice Lake township and southern Stanford township, Barron County, but Wisconsin drift is present directly west of Rice Lake with small knolls and numerous boulders, especially small stones 6-8 inches in diameter. This comes south into the edge of Sections 29 and 30, Rice Lake, and Sections 19 and 24 in Stanford township. The south part of Sections 21, 22, and 23 is outside the Wisconsin drift or at least the topography is of the wide open valley type with smooth slopes

but in the north part of these sections drift hummocks and boulders are present on the slopes of the old erosion topography.

Esker

In Section 20, there is an esker which has a sinuous course for about one-half mile with general north-south direction. It is 6-20 feet high and only a few rods wide. It has a gravel pit in the highest part south of the east-west highway near the center of the section.

Junction of Ice Lobes

In the southwest part of Section 19, there is a rock ridge of sandstone which runs west about two miles. North of it is a gravel plain with a clay cover 5-6 feet or less in thickness. It lies between the outer moraine of the St. Croix system and this moraine in Stanford township that Weidman calls the "Stanford Moraine". It embraces several square miles. Yellow River cuts into it about 30 feet. There are small lakes in it whose surface is 20 plus or minus below the level of the plain.

I traversed this plain along the line of Township 35, Ranges 12 and 13 West, clear to the north end. It is there encircled by the moraines of the two ice lobes.

Gap in Moraine South of Rice Lake

Chippewa and Namakegon

I went east on line of Sections 30 and 31, 29 and 32, 28 and 33, 27 and 34, Bear Lake township, Barron County, and there came to the inner border of the moraine of the Chippewa Lobe. There is a much lower country lying to the north and east. From here I went south four miles across moraine and then east four miles to Rice Lake on moraine. The moraine has a gap about three miles across south of Rice Lake but is conspicuous in the area marked "Ch1" in central Stanley township in Sections 8, 9, 10, 15, 16, 21, and 22. It has some red till, but most of the exposures are in cobbly bouldery material. The Barron quartzite is abundant in the drift here and around Rice Lake.

I drive east from Cameron and find that much of the area marked "Col" on Weidman's soil map is flat sandy gravel plain called Pokegama Prairie. There are some boulder strewn hills in Section 36, Stanley township, and north edge of Section 1, and northeast of Section 2, Chetek township. These are probably Wisconsin drift. So also is a strip of drift knolls on east side of Mud Lake and Pokegama Lake. There is considerable sandstone in this trip, however, so the thickness of drift ranges from a few feet up to the full height of knolls. Much of the "Col" area on Weidman's map is knolly drift and fresh enough to be classed as Wisconsin drift. The pre-Wisconsin drift lies west of Lake Chetek and Prairie Lake.

There are quartzite ledges near Sumner in the southeast part of Section 30, Sumner township, of which I obtained samples. The quartzite is present southeast of Sumner in Section 32. There are quartzite hills on west side of Pokegama Creek in Sections 1, 2, 11, and 12, Stanley township. There is a large area east of Pokegama Creek in Silver Creek and Rock Creek Drainage areas.

Weidman's Interlobate Moraine

I went across the channel between Mud Lake and Pokegama and traversed the sandstone hill area in Sections 15 and 16. It has drift knolls in north part of these sections but chiefly rock hills in south part and in line of Sections 21 and 22.

I crossed the channel between Pokegama and Chetek Lakes and went south through Chetek and down the outlet of Chetek Lake to the line of Chetek and Doore townships then west over sandstone hills to Red Cedar River and then down the valley to Section 21, Dallas township. I there turned west to see Weidman's interlobate Illinoian moraine. I find there is only a scanty deposit of drift here. There are small "cradle knolls" of rock in Section 20 and 21. These look like the hummocks of a moraine but there is not enough drift here to be classified as a moraine. I went northward along the line that Weidman considered an interlobate moraine but saw only a few places where the drift has enough depth to form a knoll. It is usually a veneer of stony material. I noticed a lot of Jasper pebbles and

quartz but only a few of Barron quartzite in Sections 20 and 21, Dallas township. The quartzite becomes more abundant in the drift as I work northward. There is a great outwash plain south and southwest of Cameron as far as Yellow River. I returned on the evening train to Chippewa Falls.

Studies Northwest of Chippewa Falls

June 23, 1923. Chippewa Falls, Wisconsin.

I drove north on the range line to quarter post of Sections 25 and 30, Township 29, Ranges 8 and 9 West, over hills with shaley rock at surface. I then went west into loess covered upland in Sections 26 and 27, and found loess prevalent to the southwest corner of Township 29, Range 9 West. There is very little glacial material here or in Sections 25 and 36, Township 29, Range 10 West. But in Sections 26 and 35 it becomes conspicuous. It is very heavy near Albertville and westward from there to the county line. I went north one-half mile from Albertville over gravelly drift knolls and ridges. I then went east one-half mile to line of Sections 27 and 28 in such drift; I went north to corner of Sections 15, 16, 21, and 22, and found it becoming scanty. It is very scanty farther north in Sections 10 and 15. But on turning west into Section 9, I found it gets thicker and is conspicuous westward to about the county line.

I turned north in Section 12, Colfax township. There is gravel a short distance east of this road, there being a pit in a knoll in northeast part of Section 1, Colfax. I see none along the highway until I reach the southwest part of Section 19, Township 30, Range 10 West. It there sets in abruptly at a sandstone knoll crossed by the highway and I find traces of it northward along the county line to Trout Creek valley. It is not heavy like it is near Albertville, but cobbles and boulders are present nearly everywhere, scattered over rock hills. I went eastward to Bloomer and found a similar thin coating quite prevalent. There is a thick deposit with gravel pit in it two one-half miles west of Bloomer in northwest part of Section 12. A knoll covering 40 acres or more may be entirely gravel. The pit is fully 25 feet deep at south end of this knoll. There is a scanty deposit of

drift east from here past Bloomer. The hills at Bloomer and those three miles east have sandstone near the surface. There seems to be less drift on them than on the hills in the bend of O'Neill Creek in Sections 13, 14, 15, 22, 23, 24, and 25. The cobbly bouldery drift with some red till is present there. These deposits show well from the Omaha Railroad trains and I crossed the north end of the group of drift hills in line of Sections 12 and 13.

East of O'Neill Creek in Sections 7 and 18, boulders are numerous on the surface of the outwash plain. Weidman puts the Wisconsin drift border in Sections 5 and 8, 17 and 16, but there seems to be no relief above this plain. The ice may have covered the swampy area to the east in sections 4 and 9 and had an ice contact face along the edge of the outwash plain.

I passed boulders two miles south of Eagle Point on southwest bluff of O'Neill Creek. Several of Barron quartzite were noted. The Barron quartzite has been very abundant in the entire circuit. I traversed this forenoon from Chippewa Falls to Albertville and along Dunn County line and east to Bloomer and back to Chippewa Falls.

Studies South of Chippewa Falls

In the afternoon I drove south from Chippewa Falls on the range line road to quarter post of Sections 25 and 30; all the way in the Chippewa Valley. I then went east over low sandstone hills in Section 30 on which there is only a scanty showing of glacial material.

I went south on line of Sections 29 and 30, 31 and 32 and crossed a swampy plain that can be drained either to the Eau Claire or Chippewa. It is marked "RL" on Weidman's map. The hills each side have very scanty drift deposits. There seems to be less drift on those south than on those north of this swale.

I went as far south as center of Section 7, Seymour township, Eau Claire County. I then turned east on the north edge of Eau Claire Valley and skirted the bluffs to the corner of Sections 2, 3, 10, and 11. I there went north into a tributary valley and crossed it on the county line. It has shale in the soil and I see

scarcely any glacial material. The higher land to the east also has very scanty glacial material, merely a few boulders and small drift pebbles, with little or no till.

I turned north on the line of Sections 31 and 32, Lafayette township. Boulders are so numerous in the northeast part of Section 31 and in Sections 29 and 30 as to be piled in the fields and along the roads, but rock is generally found at only a foot or two from the surface. Quartzites are conspicuous. I went west one-half mile on line of Sections 18 and 19. On turning north in Section 18, I soon came into heavier deposits of old drift partly till and partly stony material. I find the south edge of this thicker drift runs west across the north part of Section 23 into Section 22. A swamp lies in its path in Sections 15, 21, and 22. Northwest of this swamp is the Illinoian drift area that I noted June 20, in Sections 8, 9, 10, 15, 16, and 17, directly southeast of the city of Chippewa Falls.

Features Between Chippewa Falls and Eau Claire, Wisconsin

June 24, 1923. Chippewa Falls, Wisconsin.

I went by electric car to Section 26 about half way to Eau Claire. There is a strip of dune sand here that runs southwest across northwest part of Section 35. The plain southeast of it has gravel near surface which has been used on roads.

I went south across this plain in Sections 26 and 35 and came to low sandstone hills in south part of Section 35.

I crossed over a range of hills on line of Sections 1 and 2 that has very little drift on crest or slopes. The south slope has a heavy coating of loess. The lower land in south part of Sections 1 and 2, does not have a loess capping. I passed a pile of large boulders, chiefly greenstone in southeast corner of Section 2 and others in the north part of Section 11. There are a few small quartzites (Barron) among these boulders, and scattered over the surface of the low hills on north side of Eau Claire Valley. There is however, very little drift from here into Eau Claire.

I went in electric car to north end of line in northwest part of Eau Claire and then went northwest along the Omaha Railroad to corner of Sections 1, 2, 11 and 12. This takes me into heavy deposits of Illinoian drift. The surface is billowy like a moraine. There are only small stones here less than a foot in diameter but larger ones come in a short distance north so the farmers say. The cobble and boulders seem to extend down only a few feet. Below this wells are in sand to considerable depth. There is gravel nearly to the south side of Section 12, that is suitable for highway use. A pit is opened in it in southeast part of southwest quarter of southwest quarter of Section 12. It is a deeply stained gravel and is at an elevation of about 20 feet above a plain south of there. This plain has shallow basins 8-10 feet lower than its general level occupying a few acres each. ~~The plain is sandy with only fine pebbles in the sand. It may be an outwash~~ from the Illinoian ice sheet. There is a valley a mile wide leading southeast from here to Chippewa River with prominent rock hills on each side. The hills in north are in east part of Section 13 and west of Section 18. There is a narrow gap where the Omaha Railroad runs northwest with rock hills north of it in Section 7 and southwest of it in Section 12. This gap is filled with thick deposits of Illinoian drift.

Illinoian Gravel Filling Higher than Wisconsin

Chippewa River cuts off a rock point just above the crossing of the Omaha Railroad. A single small rock hill stands on the east side near corner Sections 7, 8, 17, and 18. The space between rock bluffs here is about one-quarter mile. The rock ridge on west side of the river runs north into southeast part of Section 6. The rest of the section outside the Chippewa Valley terrace is Illinoian drift as noted in the trip June 21.

The plain or valley above noted that runs southeast to the Chippewa in Sections 14, 13, and 24, Union township is 25-30 feet higher in south part of Section 13 than the highest Wisconsin terrace east of there. This seems to show that Illinoian aggradation here was higher than Wisconsin. It is at the edge of an

Illinoian moraine, whereas the Wisconsin terrace here is some 20 miles from the moraine with which it correlates.

I returned on electric car from Eau Claire to Chippewa Falls. There is a strip of dunes along the railway from near the county line northwest three miles to near the corner of Sections 23, 24, 25, and 26. The highest is only about 15 feet and the general height about 10 feet above the bordering gravel plain.

The rock hills in northeast part of Eau Claire have ledges exposed clear to the top. The heavy Illinoian drift seems, therefore, to have failed to reach to these hills. So this border travels north of east from the Chippewa River.

Features near Cadott, Wisconsin

June 25. 29.550 Aneroid at Soo Line depot Chippewa Falls = 860 feet A.T. (very rainy morning.)

I take the train to Cadott, Wisconsin, and pass through sandstone cuts before reaching the level of the outwash plain. There is 10-20 feet or more of gravel over the rock in a lower terrace 905-910 feet A.T. Water above the big dam is about 900 feet A.T. I read 935 on plain east of the flooded area at range line and 950 two miles east and 960 at line of Sections 3 and 4. The knolls in Sections 4 and 9 are cobbly and low and look to be Illinoian drift.

Aneroid 28.410 at Cadott equals 977 feet A.T.

There are knolls of till here that have about the sharpness of Wisconsin drift knolls. The till is rather more weathered in appearance than most of the Wisconsin drift.

I drove north by auto and found wide open valleys with smooth slopes for two miles. I then came to what seems without question to be Wisconsin drift. In Section 19, two one-half miles north of Cadott there is an esker ridge on the east side of the section by Mr. Hills residence that is about one-quarter mile long and 6-10 feet high. On the west side of the section is another irregular winding and disjointed gravelly ridge or esker with some points 20 feet high. It is opened for gravel and sand, there being sand suitable for Mason's use under a few feet of

gravel and cobble. There is a large amount of cobble and boulders in parts of the ridge. The Barron quartzite is relatively scarce, forming perhaps not over five per cent of the coarse stones. Granite is very abundant, but this is the local rock with outcrops as far south as Cadott on Yellow River. This set of ridges is between one-quarter and one-half mile long with general north-south course but quite winding. The surface is nearly plane around each of the gravel ridges as far north as Seth Creek. There are scattered knolls in northeast part of Section 18 and northwest of Section 17, Township 29, Range 6 West. A mile farther north drift hummocks become as numerous as ordinarily found in moraines. The knolls range in size from 20 feet downward. This morainic topography runs northwest into the bend of Big Dogwood Creek in Section 1, Township 29, Range 7 West, and continues in that direction passing within a mile southwest of Drywood with scattered knolls a mile or more farther southwest, or to the edge of the swampy land shown on Weidman's map in Sections 2, 3, 4, 5, 10, and 11. I think this moraine is closely connected with the one Weidman recognized, that runs from Jim Falls to Drywood.

I went into Drywood and took road northeast to center of Section 30, Township 30, Range 6 West and then east to line of Sections 29 and 30 to a north-south State Highway. The surface expression is not strikingly different in the moraine here from what I found for two one-half miles south of Drywood.

I went south on this highway noting the esker in east part of Section 19, Township 29, Range 6 West. This seems to be near the southern limit of the Wisconsin drift, for at the corner of Sections 19, 20, 29, and 30, there is the characteristic wide-open erosion type of surface with smooth gentle slopes. There is a chain of drift knolls running east southeast across southwest quarter Section 20. The north part of Section 21 has the knolly surface and irregular slopes of the Wisconsin drift. This covers all of Section 22 except the southwest corner and of Section 23 except the southeast corner, for it protrudes down Yellow River into the edge of Sections 26 and 27. I traced the border no farther west than to the east bluff of Yellow River this afternoon.

I turned south at corner of Sections 23, 24, 25, and 26, Township 29, Range 6 West and traversed a district with wide open erosion and smooth slopes for two miles to the east-west highway on the line of Townships 28 and 29 and can see the same type for a mile or more farther south.

I went west to Cadott and found mainly smooth slopes but there are some irregularities on the borders of Yellow River Valley with gentle swells that are gravelly. These are noticeable along and near the line of Sections 4 and 33 and also in Cadott village. These seem likely to be pre-Wisconsin drift features. I note that Weidman has "Early Wisconsin Drift" extending south one to one one-half miles beyond Cadott over this region with smooth wide open erosion topography. He also has the Marshfield moraine border at Cadott in his published map, its limits being the same as the southwest limit of the soil type "Col".

I went a mile west from Cadott and then south five miles through a district in which there is a coating of red till and stony material 10-20 feet plus or minus in thickness. The Barron quartzite is conspicuous in this drift. The red color is a deeper red than that of the Wisconsin Drift as I find by comparing samples of it with samples collected at Drywood. This fairly continuous sheet of drift is present to the north edge of prominent hills near the corner of Townships 27 and 28 North, Ranges 6 and 7 West or over all of the soil marked "A1" on Weidman's map. The "H51" area to the south is loess covered, in part, and a district with scanty drift.

The sheet of Illinoian drift covers the "A1" area of Weidman's map in Sections 21, 22, 27, 26, 25, 36, and 35, but Sections 28, 33 and 34 seem to be of the rock hill type with but little drift.

There seems to be a heavy drift in the low undulating areas south of the Soo line in Sections 4 and 9 and in Sections 1 and 2, Township 28, Range 7 West. Sandstone comes to the surface in a few places south and southwest of Cadott. I crossed such outcrop on line of Sections 12 and 7.

Boulders are very numerous in places in this district, one place noted being in the southwest corner of Section 7, Township 28, Range 6 West, where they

form a literal pavement over several acres.

The knoll southeast of the depot in Cadott has a core of rock with only 6 or 7 feet of drift on its highest part. It stands about 10 feet above bordering swales. I went out to the southeast part of the village past the water tank and found the ridge, on which the business part of the village stands, and across which the railroad cuts, just east of the main north-south street, rises to the southeast for nearly one-half mile to the general level of the upland. It is merely a sloping point between ravines that come into Yellow River on each side of it. There is not a knolly slope but a smooth one, such as is the general thing in this area outside the Wisconsin drift border.

June 26, 1923. Cadott, Wisconsin.

I went north to the river bridge at the falls over granite ledges. Just south of the bridge is a knoll about 6 feet above the bordering flood plain, that is probably due to circumdenudation and not a constructional feature. Its north slope next to the river is coated with sand but the knoll is mainly red till.

Wisconsin Drift Border near Stanley

I take train at 6:54 A.M. from Cadott to Stanley, Wisconsin. I pass rock outcrops in south part of Section 24 and north part of Section 3 about three miles west of Cadott.

There is shale in bluffs of Yellow River north from here where I crossed yesterday, up to 50 or 60 feet above the stream. The drift may not be thick on the highland but the rock is generally concealed. There is the wide open erosion topography to within a mile of Stanley. There, on the borders of Wolf River, scattered knolls of fresh contour set in. These are found along the west side of the valley as far down as the town line, a mile south of Stanley depot. Below there the valley has smooth slopes and bottom land. There is a gravel knoll with pit in it just south of center of Section 26 which was about 20 feet high before excavation. There is very flat land northeast of this knoll with a coating of brown silt loam 5-6 feet thick which is used in a brick plant in east part of Section 26. There are small knolls of Wisconsin drift each side of Wolf River and close to it near corner

of Sections 23, 24, 25, and 26. There are little hummocks of gravelly material rising 3-5 feet above clay covered flat land. There is a wavy surface along each side of the river in the residence section in west part of Section 25 that seems to be a constructional, not erosion, topography.

I traced the border of the Wisconsin drift westward from Section 23 across Sections 22, 21, 20, and 19, Township 29, Range 5 West, and Section 24, Range 6 West, thus connecting with the tracing made in the drive from Cadott yesterday. There are numerous hummocks 10-20 feet high and many small basins with bogs in them. Boulders are also more conspicuous than in the land outside.

Mapping of Wisconsin Border

In the afternoon I traced the Wisconsin drift border eastward to Eau Claire River to where I mapped it some years ago from Eau Claire River eastward across northwest part of Withee township, Township 29, Range 3 West. The border in Township 29, Range 4 West runs across the north part of Sections 19 and 20, and northwest corner of Section 21 with chains of low hummocks 10-15 plus or minus high. The definitely morainic land has its margin in central and northeast part of Section 16, southeast part of Section 9, central and southeast part of Section 10, and near the line of Sections 14 and 15 to Eau Claire River in Section 14. There is a single drift hummock in west part of Section 15 less than 10 feet high but the surface is flat for one-half mile or more north and east to the belt of hummocks above noted. On the east side of Eau Claire River the strong moraine is found about to south side of Section 12 and covers such of Sections 5, 6, and 7, Township 29, Range 3 West as determined several years ago. This border needs to be traced eastward.

Illinoian Drift South of Boyd

I made a drive southward from Boyd this morning to the border of the definite sheet of Illinoian drift with red till and other features noted in Clark County. I came to the limits of the undulating drift in the south part of Section 31, Edson township. Farther south there is a flat surface. There is a thin surface clay with boulders (?) and an occasional boulder beneath which is sand of considerable

depth. I went two miles south on this flat land to line of Sections 7 and 12, Township 27, Range 5 West. I then went east two one-half miles across wet land on which I noted a few boulders. When I turned north on line of Sections 9 and 10, I came into the definite sheet of Illinoian drift with undulating surface and much red till, within one-quarter mile from the section corners 9, 10, 15, and 16. There is heavier drift here in southern Edison township than in the central and northeastern parts. I reached an altitude of 1200 feet on the line of Sections 15 and 16. Rock is exposed on ground nearly as high to the south.

Moraine of pre-Wisconsin Drift in Northwest Clark County

I made another drive south from Edswold in northwestern Clark County and found a moraine of pre-Wisconsin drift in the southwest part of Worden township, Township 28, Range 4 West in Sections 27, 28, 29, 30, 31, 32, 33, and 34. It extends into the township south about to corner of Sections 5, 6, 7, and 8. The soil is productive and much of it cleared for farming as far south as the Worden and Butler township line west of Eau Claire River. But farther south, part of it is in pine stump land with loose-textured drift. It is stony and contains some gravel. There is a prominent gravel cluster in northwest part of Section 27, Worden, 65-75 feet high which seems likely to be a good source for road material. It is on the farm of Mr. Berge. He has test pitted it and found good quality of gravel. Mr. Berge's well at his residence, on ground 75 feet lower than the top of the gravel hill on a lower part of the same group, is 86 feet deep, and does not reach rock. Altitude 1130 feet. Altitude of gravel knoll 1165 feet. I passed small gravel pits in south part of Section 28 and at other places in the southwest part of the township.

This morainic area is present on west side of Wolf River about to the county line in Sections 35 and 36 and, as noted above, as far as south part of Sections 9 and 10 in Township 27, Range 5 West in Eau Claire County. Much of Sections 1, 2, 11, and 12 of this township is a sandy plain filling the space between Wolf and Eau Claire Rivers.

Marshfield Moraine (Illinoian?)

On the road leading from the county line north to Stanley, there is a heavier coating of drift and a more knolly surface in the southeast part of Edison township than in the northwest part. It seems likely that this heavier drift is the "Marshfield Moraine" of Weidman, but he did not extend it so far south as it should be.

Red Rocks

I found red quartzite abundant in the drift as far east as I went today, to border of Eau Claire River Valley. There is also considerable red jasper and other rocks that seem referable to the iron formation. Quartz porphyry is abundant, both red and purplish color, but this may, like the granite, be of local derivation in part. Granite is struck in low areas near Stanley at 20-40 feet and at about the same depth in the high tract around Tharp.

Lam on Wisconsin Deposits

There is a remarkable amount of surface lam on the glacial deposits immediately north of Stanley within the Wisconsin drift limits in Sections 13, 23, and 24 at altitudes 30-40 feet above the streams as well as in the valley bottoms as at the Stanley brickyards above noted (page 45). In the southeast part of Stanley and farther south, gravel is found in a terrace about 20 feet above the level of Wolf River which seems to be outwash from the end of the lobe of ice that protruded down the valley to Stanley.

Illinoian Ground Moraine South of Tharp

June 27, 1923. Stanley, Wisconsin, 7:20 A.M. Aneroid 28.375 = 1077 feet.

I took the train to Tharp, Wisconsin. There is flat land east of Eau Claire River for a mile or more that may represent aggradation in Wisconsin glacial stage. It is not boulder stream. This is two miles below where the moraine border comes to the valley as noted yesterday. The surface is very gently undulating for a mile farther. Then the wide open smooth slope erosion topography sets in. Tharp is on high land slightly above 1200 feet. I got an auto livery at Tharp and drove

south to determine the course of the "Marshfield Moraine". Aneroid 28,230 at Thorp at 8:00 A.M.

I drove south four miles on the range line through a tract with smooth slopes and enough red till to make a nearly continuous coating. There is shale on some of the hill side slopes to within 10-20 feet of top. There are only a few boulders, so it looks to be ground moraine in structure and topography.

Border of Red Till Area

I went west on line of Sections 13 and 24, Worden township to a creamery on a prominent ridge 1165 feet (Barometric). I here turn south and descent 115 feet in a mile to Stirling Creek. On the high land south from here there is a red till sheet with smooth slopes about to the township line, corner Sections 35 and 36, Worden, and Sections 1 and 2, Butler township. Here knolls and a looser textured drift with numerous boulders sets in. The amount of drift is scarcely as much as to the north, rock being near the top of some ridges. This kind of land runs south into Sections 25, 26, and 27, Butler township. It has hardwood forest with scattered pine. I went west on line of Sections 11 and 14, then south to middle of line of Sections 26 and 27 to the edge of the bouldery drift. South from here to south Han Claire River is a sandy plain.

Extent of Till in Butler Township

I interviewed Mr. J. M. Kile, the assessor of Butler township (who lives in northwest part of Section 23), as to the extent of the hardwood land with numerous boulders. He says the north fork of Han Claire River cuts through a hardwood ridge where it turns west in Section 17, Butler township. This does not extend north much beyond the corner of Sections 7, 8, 17, and 18. It bears southeast across Section 17 and northeast part of Section 20 into west part of Section 21. He thinks it is 50 feet above the river. There is a swamp north of it in Sections 7 and 8. There is also a swamp in much of Section 21 which separates this hardwood ridge from the main belt to the east. The southwest quarter of Butler township is a sandy plain except a part of Sections 20 and 21. It is not agricultural land and has no settlers nor wagon roads.

Border of Wisconsin Drift

We return to Thorp and drive north to the Wisconsin moraine which sets in near corner of Sections 12 and 13, 7 and 18. It covers the north and west part of Section 7, but the southeast part is outside. The north half of Section 8 is in it and a little of north part of northwest quarter Section 9. The border then bears northward across Section 4, the east side of the section being swampy. There is undulating land along line of Sections 9 and 10 that bears south-southwest across Section 16. Each side of it is a flatter more swampy tract, much of Section 15 and northwest part of Section 22 being flat and wet. The west part of 9 and east part of 8 is also wet and there is a flat surface in west part of Section 16 and in Section 17. But Sections 20 and 21 are undulating and higher land.

I hardly know why so much land is flat and wet. It is clay land so does not look like outwash from the Wisconsin ice border. It may, however, be the effect of ponded waters.

Wisconsin Moraine near Maplehurst

I came to sharp drift knolls near north end of line of Sections 3 and 4, Withee township. There is wet land south of this nearly to corners of Sections 3, 4, 9, and 10. No road runs east on the county line because of swamps on part of the line of Sections 3 and 34. The Wisconsin moraine border, however, seems to run near the county line as far east as the corner of Sections 1 and 2, Withee township and Sections 35 and 36 of the township north. It crosses the Soo line Railroad about one-half mile north of the county line. There is flat land south, however, as far as Clark Spur on line of Sections 5 and 6 Hixon township, Clark County. The driver says the knolly moraine border runs north about as shown on Weidman's map through the west part of Maplehurst township. It is slightly undulating at Maplehurst around corners of Sections 20, 21, 28, and 29, but is nearly level, rather poorly drained land, for three miles north of these corners. There the hummocks set in and he thinks they run east about to Black River on the north line of Maplehurst township on Highway

I went south from Clark Station on west side of Black River and am in the pre-Wisconsin Drift with wide open drainage features as in the district outside elsewhere.

Esker

I crossed Black River on line of Sections 8 and 17, Hixon township and came into a lower and flatter area than that west of the river. This has a chain of esker ridges in it that extends from the west part of Section 4, south-southeast about two miles to the line of Sections 15 and 16 about 60 rods south of corner of Sections 9, 10, 15, and 16. It is not continuous and in places there are two ridges side by side. There is some clay over the gravel where road cuts the ridges on line of Sections 4 and 9. There is a higher short gravel ridge west of the Soo Line Railroad about one-third mile long in south part of Section 9 and north part of Section 16. It is 20 feet or more in highest part while the other ridge is from 6-12 feet high and very narrow. This large ridge is irregular like a kame but elongated like an esker. It has some clay and boulders on its crest and slopes. The clay is mixed with sand and not so stony as ordinary till but is somewhat pebbly, whereas the clay in the small ridge is not pebbly.

Limits of Wisconsin Ice Sheet in Maplehurst Township

The flat land in which the esker system lies covers the west part of Section 10 and all of Section 3 except the southeast quarter and covers all of Sections 4 and 9 and extends south into Sections 15 and 16. It also extends north into Taylor county across Section 34 and west part of Section 35, Maplehurst township to Black River in Section 27. This may all be within the Wisconsin drift limit but the district east in Sections 25, 35, and 36, Maplehurst, has the wide open erosion topography with more undulation than this flat area. There may thus have been a protrusion of ice down the east side of Black River into Sections 15 and 16, Hixon township in a tongue (?) about two miles wide.

I noted a few red quartzites in the gravel in this esker but the rocks are mainly granite, derived perhaps from the local formation which is the top rock over

the greater part of the area just north.

The gravel does not seem so old and iron stained as the pre-Wisconsin gravel. It now seems probable that the Wisconsin ice sheet reached to Black River in Maplehurst township and covered the wet land outside, east of the sharp hummocky moraine.

I made a trip this afternoon through this moraine going north on line of Sections 32, 33, 28, and 29, Township 30, Range 3 West, then east two three-quarter miles to the Soo Line Railroad then along the railroad across northeast part of Section 26 and south to corner of Sections 25, 26, 35, and 36, then east to the range line at corner of Sections 25, 36, 30, and 31. Then south to border of the sharp moraine near middle of line of Sections 31 and 36. It runs southwest from there to the county line in southwest part of Section 36. The knolls in the area thus traversed are sharp and range in height from 10 or 15 feet up to 40 feet or more. Among them are peaty basins and much poorly drained land. After I had studied the district around the esker chain, I went to Redville and then east to the range line of Ranges 1 and 2 into the wide open erosion topography. I then went south on line of Sections 31 and 36, entering Clark County at line of Board and Nixon townships and followed this line south to Owen through a district with the wide open erosion type of topography.

Wisconsin Drift Border in and near Medford

June 28, 1923. Owen Wisconsin, 8:00 A.M.

I take the train to Abbotsford across a district with the wide open erosion type of topography. It has rather shallow valleys but broad. From Abbotsford I go by stage to Medford through a similar topography all the way. The highest points crossed are about 1475 feet and there is little or no land in view each side of this line that runs above 1500 feet A.T.

I find that the Wisconsin drift comes to the north edge of the city of Medford and it extends a little beyond Highway 64 in the creek valley east of Medford

in Section 26, Medford township, perhaps 60 rods. There is a gravel pit in just north of this highway in Section 26. The slopes of the creek valley have little knolls on them. There are a few low swales just north of Highway 64 in east part of Medford scarcely 5 feet high. About three-quarters mile north in west part of Section 23, and in Section 22, there are numerous hummocks thickly strewn with boulders. They are small, 10-15 feet or less in height. North from these in south part of Sections 14 and 15, the surface is nearly plane but the north part of these sections have strong moraine with knolls up to 30 or 40 feet high. This strong moraine extends into the north part of Section 13 also. It touches the northwest corner of Section 18, Township 31, Range 2 East, and is strong in Section 7 except the southeast corner. I went no farther northeast than quarter post of Sections 12 and 18 (four miles northeast of Medford). From there I could see the moraine as far northeast as the west part of Section 8, Township 31, Range 2 East.

I am here just at the border of the Wisconsin drift. The range line south from here is over the wide open erosion topography. The limits of the Wisconsin drift is marked by low bouldery swells or hummocks; runs southwest from here across the northwest part of Section 24 to center of Section 23, and then south a little past the center of Section 26 along the east side of the small creek noted above. It then runs westward near Highway 64 into Medford.

Studies near Border of Wisconsin Drift

I go by auto west a mile on Highway 64 in Wisconsin drift and then turn south to section corner, Sections 28, 29, 32, and 33, and find the Wisconsin drift has good expression in hummocks nearly to south side of Sections 28 and 29, and there are scattered knolls in Sections 32 and 33. The moraine border turns abruptly northward in Section 30 and runs through Sections 19 and 18 to a swamp in Section 7. North of this there is a prominent moraine with border as shown on Weidman's map in Sections 7 and 8 and in Sections 12, 11, 10, and 9 in Hamzel township.

The Wisconsin ice sheet may have covered much of the swamp land in Hamzel

township west of a creek that runs southwest through Sections 13 and 23, for there are hummocks of drift in Section 14 and north part of Section 23. East of this creek in Sections 13 and 24, Hammel township, and in such of Sections 18, 19, and 30 and 31, Medford township, there is the wide open erosion topography. There is swampy undeveloped country across Hammel township west from here for about two miles north from Black River. South of the river, wet land extends south across Section 26 into 35, Hammel township, but the southeast part of Section 26 is pre-Wisconsin drift, and a considerable part of Section 27. Swampy or poorly drained land with occasional knolls is found south of the river in Sections 28, 29, 30, 31, 32, and 33, Hammel township, and north part of Section 4, Holway township. The west part of Section 5, all of Section 6, and north part of Section 7, Holway, are wet land with a few low swells and probably were covered by the Wisconsin ice sheet. Sections 1 and 12, Maplehurst township, east of Black River, are also of this class of land, but Sections 13, 24, 25, 26, 35, and 36 are largely of the wide open erosion type of land. West of Black River there is strong moraine in Sections 2, 6, 7, 10, 15, 18, 19, 20, 29, and 30, Maplehurst township, except where swamps make bowls. One large swamp covers part of Sections 8, 9, and 16, but moraine features are said to be strong around corners of Sections 9, 10, 15, and 16.

The moraine is very strong along Highway 64 from east part of Section 2, Maplehurst, and Section 35, Township 31, Range 2 West, westward for several miles, and it has very sharp knolls on line of Sections 4 and 5, but not farther south on road to Maplehurst. On the return I went south from Highway 64 on line of Sections 4, 5, 8, 9, 16, and 17, Holway township, through a tract with the wide open erosion topography with smooth slopes. I went west in that same sort of land on line of Sections 17, 20, 18, and 19, Holway. I then came back and crossed Holway township on the center line east-west road. I was in the good farm land with gentle slopes and well drained surface about to Sections 15 and 22. East from there are gravelly ridges and swamps, and a hummocky surface in places that make it look like a Wisconsin drift area. This is especially so in Sections 13 and 24, Holway, and

Sections 17, 18, 19, and 20, Little Black township. Farther east is good farm land with the wide open erosion topography. It extends to Black River in Sections 8 and 9, and 3, Little Black township. The morainic features north of the river near Medford are found only as far south as north part of Sections 32 and 33 and north-west corner of Section 34, Medford. There are smooth slopes and bottom lands south from here.

I went back by auto bus to Colby.

The roads in vicinity of Dorchester are gravelled with arkose from a pit three miles east that is opened to depth of six feet. I am told by the driver of the bus. Below this the granite is too hard to excavate easily. This makes an excellent cover for the highway.

Illinoian Drift Near Colby

June 29, 1923. 6:00 A.M., Colby, Wisconsin. Altitude 1353 feet.

I go east from north side of the village in line of Sections 7 and 18, 8 and 17, Hull township, Marathon County, past where Weidman puts the border of the Marshfield moraine and find the drift heavy enough to be a part of the moraine. A farmer in south part of Section 8 says wells in the vicinity are dug 40 feet in hard red clay and that this is true for about three miles farther east to the Eau Claire River. There rock is exposed but not farther west. He thinks it is about 80 feet to rock on high points near Colby standing 1400 feet, plus or minus, A.T. There is very little sand in the drift and some wells are weak. Some wells in Colby are strong so they cannot be pumped dry. The city well at Colby is 125 feet. Private wells, and the Nichoff Hotel, will strike granite here at about 35 feet to 45 feet. This is in a valley 40 feet, plus or minus, below neighboring high points. There is quicksand at surface and below this red till, with some sand or gravel next to the rock. Charles Brummer, who drives the auto stage north from Colby, has a farm east of Abbotsford in northeast part of Section 34, Helton, that struck granite at 25 feet. It is nearer the surface east from Eau Claire River but from his farm west to Abbotsford it is covered 40 feet or more by glacial deposits.

Arkose

The pit where arkose is obtained for roads (east of Dorchester) is in north part of Section 16 on low ground so water comes in at about six feet. The river has a gravelly bed east of Abbotsford in Sections 34 and 35, Holton township.

Illinoian Drift near Marshfield and Stratford

I take train from Colby to Marshfield. There is considerable rather flat land between Unity and Spencer, and a large tamarac bog west of Spencer in Section 6, Spencer township. Weidman's map, published in 1907, does not have the short cut of Soo Line Railroad from Owen to Spencer. It crosses the north edge of the bog. The surface is very flat for a mile southeast from Spencer along the railroad.

There are cuts in the Marshfield moraine for one one-half miles or more northwest from center of Marshfield that expose the deep red Illinoian till 20 feet, plus or minus. I went by auto with a commercial traveler from Marshfield to Wausau. The road leads across McMillan township. There is a heavy deposit of till as far as southwest part of Section 23 and northwest of Section 26, McMillan township. From there to Little Eau Claire the granite is near surface and ledges protrude slightly in places.

I came to till east of the stream in northwest part of Section 24 that is several feet thick and of characteristic deep red color and thickly set with erratics.

From Section 13 northward to Stratford there is arkose near surface and very little drift. On going north from Stratford on Highway 97, I came into till deposits near corner of Sections 12 and 13, Eau Claire, and Sections 7 and 18, Cleveland township, and it becomes conspicuous near corner of Sections 1, 6, 7, and 12, and continues so northward past Highway 16 at corner of Sections 13 and 24, Frankfort, and Sections 18 and 19, Wein. I go east on this highway through continuous till to east part of line of Sections 17 and 20, Cassel township. Then after crossing a small stream I find arkose, etc., all the way to Wausau. There is, however, fresh looking gravel in Rib River Valley in a terrace 40-50 feet higher than Marathon strata (?) with pits in it north of the city.

Studies Northwest of Wausau

I get an auto livery and drive northwest from Wausau across Sections 22 and 16, Township 29, Range 7 East, and find thin deposits of red till in northwest part of Section 22 and westward from there. I went north on line of Sections 8 and 9, in a district with thin deposits of till over arkose. I find arkose exposed in high land near corners of Sections 5, 6, 7, and 8. I here turn west and run four one-half miles across a district with nearly complete blanket of red till several feet thick. Farmers say granite is usually entered on high land at about 25 feet and in places at 15 feet. As there may be some arkose above the granite the drift is likely to be somewhat less, perhaps 10-15 feet.

I passed for about two miles through bottom lands of Little Rib River. This valley has gravel terraces 30 feet, plus or minus, above the stream preserved less completely than those on the Big Rib River from Marathon down to Wausau. The gravel does not seem so fresh as that in Big Rib River and has a loamy coating several feet thick. This coating is present to some extent in Big Rib River. I am wondering if this is referable to the Illinoian glaciation.

I turned north in Section 4 and went across the west branch of Little Rib River and came up to a county highway at north side of Section 33, Berlin township. I then went one one-half miles west and took a road north to the county line of Marathon and Lincoln. The drift coating seems to be about the same here as farther east and seldom exceeds 25 feet, as stated by farmers. Wells are dug to the hard granite and then blasted a few feet in it.

I go east on the county line for five miles, then north one-half mile, and east across Section 34 to the highway running from Merrill to Wausau. I am in a district where Weidman represents "third drift" over "first drift" on his 1907 map, but find conditions similar to where he represents only third drift to be present.

On turning south I find several good exposures of typical Illinoian red drift. It is so thick the underlying rock is concealed most of the way across Township 33, Range 7 East.

I find thin deposits from there eastward practically to the bluff of Wisconsin River on a east-west road across Section 10, Township 29, Range 7 East. It is thin or patchy but has the typical aspect of till with rounded stones of all sizes in a red clayey matrix. This is as much, or more, outside the limits given by Weidman on his 1907 map.

Large boulders are scattered over the surface in Section 10 and the subsoil has rounded stones of all sizes up to boulders imbedded in it at 2-4 feet from the surface. In places arkose comes up into the soil and there is no drift over it, so the drift is somewhat patchy as well as thin in this section and in Sections 15 and 22.

A prominent rock hill in west part of Section 22 and east of Section 21 is not within the drift border by Weidman. It is 100 feet or more above the surrounding land (Refer to the Wausau-Marathon contour map for its height and extent).

I took the evening train on the C.W. & St.P. from Wausau to Merrill, Wisconsin, but it is nearly dark so do not get a good view of the features along this part of the Wisconsin valley.

Studies near Merrill and Cleason, Wisconsin

June 30, 1923. Merrill, Wisconsin.

There is a moraine of Wisconsin drift on the south side of the river at Merrill. It has sharp hummocks with peaty bogs among them. There is some gravel in the hummocks and they are on the whole more stony than the pre-Wisconsin drift underneath and outside.

At the bridge, south end, about opposite the courthouse, there is a gravel pit with Wisconsin drift over the gravel. This is being stripped to get at the gravel. There is 10-20 feet of it. It includes large boulders and some clayey or loamy material. The gravel is fresh looking and may be Wisconsin outwash overridden at the farthest extent of the ice.

I find the moraine bears west-southwest for several miles from Section 19, Township 31, Range 7 East to the northeast part of Section 30, Township 31, Range 6

East. It is one-half mile or more in usual width.

The ice seems to have protruded a mile or more up Devil Creek Valley for it does not appear to have covered high land in the northwest part of Section 20 and southwest of Section 17, and only covered a little of the northeast part of Section 18, at least hummocky topography is lacking outside this line and the surface looks like the pre-Wisconsin drift surface. There is not so sharply developed moraine from Devils Creek northwest, as this south of the creek - and the border is in places difficult to locate. I seem to be outside of the Wisconsin drift in the southwest part of Section 7 and southeast of Section 12. But around the corners of Sections 11, 12, 13, and 14, there are low swells and irregularities in the slopes that suggest the presence of Wisconsin drift. The ice border may have protruded southward past the section corner while it fell short of the section corners a mile east and a mile west. It is doubtful if the Wisconsin ice sheet covered all of Section 11, the part west of a south tributary of Copper River being smooth sloped. It may have protruded a little into Copper River Valley and may have covered the large swamp that borders the stream from Section 3 westward four or five miles.

Weidman represents the strong moraine to run eastward from the northeast part of this swamp to Wisconsin River at the Dallas.

I returned to Merrill and noted wide bottoms on south side of the river extending back nearly a mile in Sections 15 and 16.

In the afternoon I went by auto livery northeast from Merrill and found the moraine less compact and less well defined than south and southwest of the city. It extends into Sections 8 and 5, and northwest corner of Section 4, Township 31, Range 7 East. It runs through Sections 33, 34, 27, 26, 23, and 13 of this township.

There are scattered knolls in Section 18 and north part of Section 19, Township 31, Range 8 East and the ice probably covered the swamp in Section 17, for a string of drift hummocks runs from the swamp northeast in Sections 9, 4, and 3, on east side of Hay Meadow Creek. This creek seems to be along or near the Wisconsin drift border its entire length. There is considerable flat land between it and

Prairie River and the streams have nearly parallel courses for ten miles, only one one-half to two miles apart.

There are weak knolly strips 10 feet, plus or minus, in height and less than one-quarter mile wide, running parallel with these streams, that are probably ice border features. I went no farther than Gleason. I went south on line of Sections 33 and 34, Township 33, Range 8 East and found the Wisconsin drift border in Sections 3 and 4, Township 32, Range 8 East. It crosses into Section 9, near the middle of line of Sections 4 and 9. I went south to corner of Sections 21, 22, 27, and 28, Township 32, Range 8 East over pre-Wisconsin drift. I turned west and at the range line of Ranges 7 and 8 East, went north a mile and found features indicating Wisconsin drift in north part of Section 19 and in Section 18, Township 32 North, Range 8 East, but there is a pre-Wisconsin drift surface north past the corner of Sections 18, 19, 13, and 24. Only the northwest part of Section 24 is knolly.

I came west to the highway that leads from Gleason to Merrill and followed it to near corner of Sections 26, 27, 34, and 35, Township 31, Range 7 East. I then went east a mile in pre-Wisconsin area and south three miles to trunk line 64, then west into Merrill.

I passed some gravelly knolls in the Illinoian drift near corner of Sections 10, 11, 14, and 15, Township 31, Range 7 East. A pit is opened in one to depth of 20 feet. The driver says he has seen similar knolls farther east near the junction of the forks of Pine River, probably in Sections 5 and 8, Township 31, Range 8 East.

He says there is a gently undulating country from ten miles east of Merrill to Antigo, much clay land, so roads are slippery when wet.

On returning to Merrill I took train south on C. M. & St. P. to Chicago, having completed the study in Wisconsin.

On Train South from Merrill

There is a gravel filling up to 50 feet above the river below where the Wisconsin moraine crosses. A pit exposes its full height just north of the mouth of

Pine River. The material is fine gravel in the lower part but the upper 10-15 feet has boulders scattered through it or distributed at certain levels. The gravel seems to be fresh enough to refer to the Wisconsin glaciation. The gravel filling, however, is preserved at full height at only a few places. The valley seems to be about one one-half miles in average width, from the place where the moraine crosses a mile east of Merrill, down to Wausau. At Granite Heights granite bluffs in the west rise precipitously 100 feet. (plus or minus) above the river. This is where Weidman puts the north end of the driftless area on his 1907 map.

Shore at about 700 feet - Grassmere?

July 16, 1922. Emory Junction, Michigan.

I came up here to get the limits of Lake Warren in Iosco County and the course of the West Huron moraine system in Iosco and Ogemaw Counties. There is a thin coating of sand over a nearly pebbleless red clay around Emory Junction, usually less than four feet and in places a foot or less. It has scarcely any pebbles.

I go west on road to Whittimore and come into a pebbly sand about five-eighths mile east of Au Gres River at an altitude 695-700 feet. It looks like a delta of Au Gres River in a lake that stood about 700 feet A.T. here.

West of Au Gres River there is shale capped by a few feet of thin bedded limestone up to about 700 feet and there is a now worked plain to this height. The rock is, in places, bare.

There is a bouldery drift west from here setting in near the one-quarter post of Sections 1 and 12, Burleigh township, Township 21, Range 5 East. It has a coating of pebbly sand with boulders and cobble in it, that seems to be largely the product of lake waters. As I got up nearly to Whittimore I find a shore line that has practically the same level as the station. It crosses the railroad about 2 blocks east (600-700 feet) of the depot and passes a block south, the Whittimore Inn being in it. It crosses the line of Sections 2 and 11, Burleigh township, about 80 rods from west end and has more gravel there than in the vicinity of the depot. Outside (westward of) this bench the till is at surface and lacks the pebbly,

bouldery and cobbly sand that is found below it.

Limits of Lake Warren near Whittemore and Taft, Michigan. Plus or Minus 780

As this beach is on the irregular slope of a moraine it has not changed it to a plain, but the glacial features are only slightly toned down in the submerged part, especially at 20-40 feet below the level of Lake Warren.

Probably some of the sandy deposit below the Warren beach is due to Lake Wayne, but its beach does not seem to be clearly defined or preserved.

The 700 foot lake level is likely to be Greenere or perhaps Elkton.

I go north from Whittemore and find the Warren shore crosses into Section 3, Burleigh township, south of the quarter post. A creek on line of Sections 2, and 3, 80 rods, plus or minus, from north end is 720 on bridge 15 feet, plus or minus, above the water (barometric). The north bluff at township line is 770 barometric.

Lake Warren does not have a well defined shore in Section 34, Reno township, but probably crossed only the east part. The aneroid read 695 at Augres River on line of Sections 26 and 27. The north bluff near one-quarter post of Sections 26 and 27 is 780 barometric and the Lake Warren shore seems to cross into Section 26 here and bears northeast across the northwest part of the section and then east across southeast part of Section 23 and southwest quarter Section 24 and across southeast part of northeast quarter Section 24 into Grant township. It crosses the northwest corner of Section 19 and curves around to the north and northwest in Section 18 crossing back into Reno township across northeast part of Section 13.

Lake Warren covered swamps east of Taft to within one-quarter mile of the station and extended north over the east part of Section 1, Reno township, in a swamp. There is higher land east of it in Section 6, Grant township, but much of that section is a sandy plain and so is Section 7, Grant township. My old map has knolly land in Sections 29, 31, and 32, Township 23, Range 6 East, but this auto driver thinks the hills are sandy rather than till. He is Mr. Barhart and has hunted all over that region for game. The shore of Lake Warren may be east of these hills in Section 29 and 31. This can be examined into by a drive east from Hale, or a mile

south of Hale. We returned from Taft to Whittamore. Taft is 810 feet barometric. The land is slightly higher along the railroad and east of it in Section 13. Reno, than in the west part, being about 800-810 feet while the west is about 790 feet (Barometric). The altitude is 820 feet a mile west of Taft and also at corner Sections 10, 11, 14, and 15, but the surface is very gently undulating compared with its expression around Prescott and northwest of Prescott.

Shore of Lake Warren Southwest from Whittamore

We drive west from the south part of Whittamore and find that Lake Warren did not cover the northwest half of Section 10 and touched only the south edge of Section 9. It extended a little into the northeast and the southeast parts of Section 17 and perhaps into the southwest part but most of Section 17 is undulating till more undulating than the till tracts around Taft and Whittamore. The west part of Sections 18, 19 and 30, Burleigh township, are undulating till also. There may have been extensions of Lake Warren up valleys into Sections 24 and 25, Richland township, Ogemaw County and it is likely to have covered the southeast part of Section 36 where there is a sandy plain as noted in 1922.

At Soil Survey Camp in Section 7, Richland Township

I went into Prescott from the county line at corner of Sections 19, 30, 24, and 25. There is some flat land in south part of Section 24 and north part of Section 25 bordering a stream that seems low enough to have been covered by Lake Warren, the barometer being about 760 on it.

From Prescott I went with Professor Young to the camp in Section 7, Richland township, and found a hummocky till tract all the way out there from Prescott, altitude 835 feet at camp 5 feet above lake. We then drove south along or near line of Mills and Richland townships to the south end of the hummocky till at a creek south of the quarter post of Sections 25 and 30. There is a little of the northwest end of the southeast quarter of section 25 and all of the northeast quarter on the hummocky till, but the rest is a pebbly sand plain. The altitude is 800 feet (barometric) at the level of the sandy plain. It grows lower south and west, being

790 feet at line of Sections 25 and 26, and 795 feet just south of corner of Sections 30, 31, 25, and 36 (barometric).

The till border runs through the north and east parts of Section 31, Richland township, but most of that section is on the sandy plain.

I find the aneroid reads 835 on returning to the camp in Section 7, Richland, as it did when I started out, so the readings in the district south of here, in Sections 25 and 36 and 31, seem reliable.

Well Data

Mr. Stickley's well in south part of Section 7 on east side of Clear Lake is 75 feet deep and has 3 feet of sand at bottom, the rest is mainly till. The head is at the same level as Clear Lake, about 15 feet below the surface of the well mouth.

Features near Clear Lake

Mr. Stickley says Clear Lake is 45 feet deep in one place. It has a southwest outlet to the Rifle River drainage. The divide between the Rifle and Augres drainage is in Sections 5, 8, 17, 20, 29, and 28, Richland township.

The till here is of chocolate red color full of pebbles, many of which are limestone. It is calcareous nearly to the top. In places there is a loamy, sandy coating from 1-5 feet deep or even deeper if on dunes. This is probably largely post glacial wind and wash material. It does not have lime and has acid reaction.

Port Huron Moraine in Mills Township, Ogemaw County

July 17, 1923. In Camp, Section 7, Richland Township, Ogemaw County.

I go west passing the moraine crest near the middle of line of Sections 12 and 13, Mills township, at 860 feet. The plain west of here, just west of corner of Sections 11, 12, 13 and 14, is 810-815 feet at east edge. The sand has been blown up on the slope of the moraine for 40 rods, plus or minus, in a nearly continuous coating from a few inches to several feet in depth along the west side of Section 13 and east edge of Section 14. The moraine extends 50 rods or more west of the corner of Sections 13, 24, 14, and 23, and there is but little sand along the line of Sections 23 and 24, clayey till being near the surface. The altitude is 835 (barometric)

just north of middle of line of Sections 23 and 24. It is the same on crest of moraine 80 rods from west end of line of Sections 13 and 24. There are sandy hummocks (wind drifted) on the crest near this section line.

The moraine border is near corner of Sections 23, 24, 25, and 26.

In the afternoon I went to Prescott and took road west. The surface is morainic all the way from Clear Lake to Prescott in Sections 18, 17, 16, 21, 28, and 27, but the strongly hummocky surface covers only the east edge of Sections 20 and 29 and the northeast of 33. There is a sandy gravel outwash in southwest of 33 and all but north edge of Section 32 and nearly all of Section 31. Much of Sections 19, 20, 29, and 30, is nearly plane and part of it is coated with pebbly sand but till is generally at the surface and there are a few till swells 10-15 feet high in west part of Section 29. ~~The strong moraine east of here runs from Maple Ridge northwest across Sections 11, 12, 1 and 2, Mason township, Arenac County, and Sections 33, 34, 27, 28, etc. in Richland township to northwest corner of this township.~~

Port Huron Moraine in Arenac County

I find that the outer part of the Port Huron morainic system in Arenac County runs north in east part of Sections 8 and 5 almost to the county line leaving only a narrow strip of sandy land between it and Mansfield Creek in Sections 5, 8, 9, and 10. There is some sandy and pebbly land in west part of Section 9 inside of this projecting spur that stands 20-25 feet above the plain outside. It was probably filled in as the ice border receded eastward in Section 9.

With State Geologist, R. A. Smith, In Iosco, Arenac, and Ogemaw Counties

July 18, 1923. At Clear Lake Camp, Section 7, Richland Township, Ogemaw County, Mich.

I went by auto with the State Geologist, R. A. Smith, on a tour of south-east Ogemaw, southwest Iosco, and northern Arenac Counties, covering a distance of nearly 100 miles. We drove east to corner of Sections 9, 10, 15, and 16, Richland, in morainic tract. We then went north and had a nearly plain tract from near corner of Sections 3, 4, 9, and 10, northward to a tributary of AuGres River near corner of Sections 21, 22, 27, and 28, Logan township, Township 22 North, Range 4 East. This

plain does not extend far to the west; much of Sections 29 and 32, being morainic as well as sections to the west. We turned east and came to AuGres River in southwest part of Section 23. Its level here seems to be about 750-760 feet while the border plain is 800 feet. We came into sandy gravel on the bluffs near the county line at an altitude 780-790 feet, or low enough to correlate with Lake Warren. In fact, a bay may have extended up about to the county line. The sandy land lies west of a moraine that crosses AuGres River near corner of Sections 21, 22, 27, and 28, Reno township. The valley is bordered more closely by high land in Section 27 where it cuts through this moraine than in sections above or below this place.

There is only a gentle undulation in the highest part but the slopes of the moraine are humpy in Sections 21, 22, 27, and 28. This moraine has more expression southwest from AuGres River Valley toward Mills than northeast toward Taft. The surface is plain to very gently undulating from this stream northwest past Taft and Hale. It makes a fine farming district. There are only a few surface boulders and the till is seldom covered to more than a foot or two by loamy or sandy material.

We continued east in Iosco County and came into a belt of ridged and knolly sandy gravel where we crossed the D & M Railroad in line of Sections 19 and 30 (near west end of line) in Township 22, Range 6 East. This may be partly the work of Lake Warren. We cross several of these ridges in the first mile east of the railroad and the barometer indicates very little difference in altitude of their crests, it being between 750 and 760 feet A.T.

On crossing the east branch of AuGres River we came into till with very gently undulating surface. Its altitude near west end of line of Sections 21 and 28 is about 750 feet (barometric) and it is about 740 feet two miles east to where the road turns north (to Sand Lake) or on the plain 40 rods east or north. The road intersection being in a depression about 725 feet.

We drive north and leave the till near corner of Sections 14, 15, 22, and 23, Grant township. For two miles north to Sand Lake there is a jack-pine and scrub

oak sandy plain. It rises northward so as to be 775-780 feet on south side of Sand Lake and 785-790 feet on north side. This is about the altitude of Lake Warren here. The shore, as mapped some 21 years ago, runs past the south side of Indian Lake to the east end of Sand Lake. It is shown on my old map to bear north of west from Sand Lake to the East Branch of Augres River near the place where Hale and Smith Creek unite.

There is a nearly plane till tract in southeast part of Section 29, Township 23, Range 6 East that is 15-20 feet above the old lake level. My aneroid reads 810 on it and 790 on the sandy plain to the north and west of it in Section 29. There may be about a square mile of good land east of Smith's Creek mainly in Section 29, but extending a little into Sections 28, 32, and 33. Sandy gravel with ~~norway pine lies east of Smith Creek in Sections 19, 20, and 29, Township 23, Range 6 East, and northeast of Section 24 and southeast of Section 13, Township 23, Range 5 East as far west as a small lake and its outlet in Section 13.~~ Clayey till there sets in and there is clayey till west of Smith Creek down to its junction with Hale Creek to form East Branch of Augres River. This till tract west of Smith Creek seems to be 825-840 feet in vicinity of Hale Station. This is fine farm land from Loon Lake southward to Whittemore. We drove to Whittemore for dinner.

We went east one one-half miles to get specimens of the limestone and shale from the outcrop on west bluff of Augres River noted June 16. The altitude here is 700 feet. At Whittemore rock is struck at about 60 feet or at about 715 feet A.T.

We then drove south from Whittemore over till for nearly two miles descending to 700 feet A.T. There a sandy plain is entered that may correlate with the Elkton shore as noted east of Whittemore on Augres Delta. Here there is a smaller stream (Johnston's Creek). The stream is about 655 feet on line of Sections 22 and 23 (barometric). There is a sandy gravel plain at 700 feet at corner of Sections 22, 23, 26, and 27. From here the plain descends slightly southward and more rapidly eastward. It is about 690 feet at corner of Sections 26, 27, 34, and 35, Burleigh township. There is a heavy marl deposit west of these corners cut into

five feet by roadside ditches. Its surface is 700-705 feet rising slightly westward toward the edge of the till of the innermost member of the Port Huron morainic system. This has its crest in Sections 28 and 33, and stands 10-20 feet or more above the level of Lake Warren. There is a strip of moraine one-half to three-quarter mile wide in Sections 28, 33, 2, and 11, that stood above Lake Warren and a strip about as wide on its inner or eastern slope that was covered by Lake Warren. West of it is a plain of sandy gravel that was about at Lake Warren level and was probably laid down as outwash.

There is moraine west from this outwash in Section 31 and northwest part of Section 32, Burling township. It is knolly in northeast part of Section 31 but very gently undulating in south and west parts like a till plain. This more level part is a clayey till while the knolly part is loose textured. The nearly plane clayey tract extends into Arenac County about a mile and descends gradually to level of Lake Warren. The swampy sandy tract on road east of Maple Ridge that I noted last year does not extend a half mile north of the road and that is the limit of Lake Warren in that direction. On Johnson Creek, Lake Warren extended into Ogemaw County, in Sections 24 and 25, Richland, and in a south tributary into Sections 25 and 36, and covered the north edge of Section 31, Burling township and much of Section 30. There is an island like knolly tract in southwest of Section 30 and southeast of Section 25 with lower flat land around it that was probably submerged as far as the flat land extends.

With H.A. Smith in Ogemaw County

We found a knolly or strongly undulating strip of land running along and east of the D & W Railroad from Prescott to Mills; the Prescott Sons' farm in Sections 12 and 13, Richland township, being on it. There is a another tract northwest of it in Sections 11 and 10 and in Sections 1 and 2, Richland, but Section 14 and south part of Section 11 are morainic, and south from those sections into Prescott Village. There is some sandy land north of Mills between Whitney Creek and the Aubree as well as along the Aubree (as noted this morning). Perhaps some of this was covered by Lake Warren. It is probably Lake Warren extended up Whitney Creek into Ogemaw County.

but it was a very narrow passage in Section 7, Burleigh township, less than one-quarter mile wide.

As some of this sand may be outwash, it is not clear how far Lake Warren extended in this district between Whitney Creek and Augres River north of Mills Station. This station is about at Lake Warren level (being 779 feet) and there seems to be some land north of there that is slightly lower, but we did not go through that district to test it. We went only to center of Section 8, Burleigh, and then went back to the camp in Section 7, Richland township.

With R. A. Smith at West Branch and Edwards Lake

July 19, 1923.

Mr. R. A. Smith and I made a trip past West Branch into Edwards Lake and back, going on M-55 west between Sections 21 and 28, 20 and 27, 19 and 30, Logan.

We are in till plain nearly to the county line but the west part of Sections 19 and 30 is morainic with points up to 875 feet or more. There is moraine around Hardwood Lake but much of Section 31, Logan, is flat. There is a strip of weak moraine running north-northwest across Sections 32 and 29.

There is a swamp in Section 18 for some distance outside the lake that is in southwest quarter and it extends across the town line into Section 13, but the northwest part of Section 18 and most of Section 13 are morainic. There is swamp in much of Section 7, Logan, but I can see ridges east of it in Section 8.

We go west across Sections 12, 11, and 10, Churchhill township, to Selkirk on Rifle River across moraine all the way.

West of Rifle River there is a gravelly plain for fully a mile but we pass a bouldery knoll in it with swamp around it and the top of the knoll is lower than the general level of the gravel plain.

We enter moraine west of a small stream in Section 8, hummocky and bouldery, that is a part of the moraine I had previously seen at Campbell's Corners.

There is a gravel pit in the moraine just west of Campbell's Corners on a high point about 1080 feet A.T.

There is a drop of 80 feet from it to a stream one-quarter mile west.

The moraine topography extends south past the angling road that runs from Campbell's Corners to West Branch to north end of Peach Lake. From there the border between Moraine and till plain runs westward near this highway. A road running east on line of Sections 20, 29, 21, 28, 22, and 27 is in till plain and the till plain continues on that road nearly to Rifle River, there being only a narrow strip of gravelly land one-quarter to one-third mile wide on west side of the river. Parts of Sections 20 and 21, Churchill, are rolling till. There is a narrow strip of sharp moraine east of Rifle River in Sections 21 and 28 with gravel plain one-half mile wide east of it. There is also gravel plain in south part of Section 22, Churchill township.

Esker-Like Ridge near Edwards Lake

We went to Edwards Lake to see the peculiar ridge on west side that R. A. Smith had thought to be a "push moraine". It is narrow as an esker but most of it has till at surface. Part of it is sandy gravel and looks just like an esker. This part is about 15 feet high and about 15 rods wide. The till part in places reaches 35-40 feet in height. In places it becomes double with a basin enclosed. At the south end it passes into ordinary hummocky moraine. The trend is about what I should expect the ice border to have had but there were ins and outs of the border that might be locally at a right angle to the general trend. I am inclined to think the part that looks like an esker had an origin like an esker while the rest is to be classed as moraine. The esker part is only about 60 rods long (that is, the part wholly of sand and gravel).

There is a till plain east of Edwards Lake in Section 22 and northwest of Section 23. There is also a till plain in Section 27 and southeast of Section 28 and in Section 33 and southeast of Section 32. To the northwest of these sections there is moraine; to the southeast, a plain of sandy gravel with a few boulders and large cobblestones.

The outlet of Edwards Lake is in a narrow trench in clayey till in its east

flowing part in Sections 26 and 27, but where it turns south in Section 26 and has gravel on its east bluff it is wider, about one-half mile at line of Sections 27 and 34. Perhaps Lake Saginaw covered this wide part but this is not certain for in sandy gravel the stream may have cut a much wider valley than in the clay. The definite or clearly determined shore of Lake Saginaw seems to be south of the till ridge in Sections 5 and 6, Burret township, and Sections 1, 12, and 11, Clement township, Gladwin County.

Lake Saginaw Beach

The limits of Lake Saginaw in Horton and Mills townships, Ogemaw County, are at a level a little above 800 feet. But in the absence of levels and in the brushy (?), poorly developed condition of the country along the shore it is not feasible to map it clearly now.

Ponding near West Branch

There was ponding clear up to West Branch to a height of 350 feet or more but only a local border feature during the recession of the ice. The swamp that runs across from the Rifle to the Tittabawassee River, near Greenwood is 815 feet as shown by the M. C. profile, i. e. the lowest part of the track in this swamp is 815 feet. The natural surface of the swamp may be 5 feet lower. We went to the place in southwest part of Section 32, West Branch township, where I located gravel for the highway two years ago and find a steam shovel and screening apparatus here. It is planned to get gravel for the nine miles from West Branch to the county line southeast from this place. The other deposits in Sections 5 and 8, Horton township will not be drawn upon unless this gives out.

With R. A. Smith in Eastern Ogemaw County

July 20, 1923.

Mr. R. A. Smith and I examined the drift in the east part of the county in northern Logan, Hill, and Gooder townships.

We found moraine in Sections 5 and 8, Logan, and sections east beyond Stiles Lake to Sages Lake. There is a plain with sandy gravel coating in west part

of Section 11 and east part of Section 10 but farther east and also north in Section 2 and east part of Section 3 is a till plain standing 50-60 feet above the lakes. The lakes are 820-825 feet. The plain on line of Sections 2 and 3 is about 875 feet. Much of the moraine to the west is lower.

The southeast part of Hill township, in Sections 13, 14, 23, 24, 25, 26, 35, and 36, is nearly plane till with a thin coating of sand over most of its surface. It seems to be so thin as to permit roots to penetrate it to the till in much of the area. There is a hummocky moraine in the northeast part of the township in Sections 1, 2, 11, and 12, and the west half appears to be mainly morainic (the Port Huron morainic system).

This morainic system has its border on the south edge of Goodar township on south side of the old river channel that runs across to Rifle River from the AnSable.

There is a pitted gravelly outwash in the southeast part of Goodar township in Sections 23, 24, 25, 26, 35 and 36. The glacial drainage from it appears to have run westward through this swampy channel a mile wide or more, in Sections 27, 34, 26, 33, 32, and 31, Goodar township, and 36, Rose township. Below this, Rifle River has cut deep enough to have dry land bordering it. So the road on line of Sections 35 and 36, Rose township, does not cross a swamp. My aneroid gives the swamp an altitude about 900 feet. It is about 20 feet lower than Moltby Station.

Rifle Lake and George Lake are at about the same altitude as the swamp, but do not drain into it as shown on the highway map, but Rifle runs into George Lake and this drains westward. The road crosses the swamp on line of Sections 32 and 33 in 85/100 miles as registered by the auto register. Its north edge is close to the corner of Sections 28, 29, 32, and 33. The land is low for a short distance opposite the north end of Rifle lake on line of Sections 32 and 5; in places only 5-10 feet above the swamp, but I can see no water course from the lake into the swamp.

There is prominent moraine west of Rifle Lake in Section 6, Hill township.

reaching about 1000 feet. There is a little outwash in northwest quarter section 7 on southwest edge of this high tract but it does not reach to the quarter post on west side of Section 7. South of the outlet of Rifle and George Lakes in south part of Section 7 and in north part of Section 18, there is a sandy plain. In places the sand is thin with till in subsoil but usually it has a thickness of several feet.

There are dune ridges in vicinity of the corner of Sections 25, 26, 35, and 36, Cumming township, 10-15 feet high on the outer slopes of the moraine at about 900-910 feet.

Mr. Schoeneman, who is in charge of the soil work in Ogemaw County, has noted many places where my boundaries between moraines and outwash, or between till plain and outwash, have errors of one-half mile to a mile. I did not take time to correct all these errors but made a few corrections in Churchhill township in Sections 15, 16, 21, 22, 27, 28, and 34. The outwash and flat land is more extensive in these sections than my map indicated.

I went from the camp with E. A. Smith as far as Pinconning in auto in the evening and to Bay City Saturday morning. I there took a train to Northville and electric car from Northville to Wayne and then to Ann Arbor.

On Ann Arbor Railroad to Cadillac, Michigan

August 7, 1923.

I took Ann Arbor train north to Cadillac. I read barometer as follows:

Beach of L. Saginaw east edge of Ithaca	29,005 = 755 ±
Ithaca Station	28,995 = 765 ±
Border of plain west of moraine	29,005 = 755
Lowest part of plain	29,020 = 740-45, say 743'
Crest of Alma moraine south of Alma	28,995 about 765'
Alma Station	29,030 = 734
Shore in west part of Alma	29,005 = 755 ±
On plain south of Shepherd	28,975 = 770
Shepherd Station	28,965 = 776.2
Beach of sandy gravel with two pits in it less than a mile north of Shepherd on east side of track	Aneroid - 28,965 = 775 ±
Extensive plains at about this level passed through by railway farther northwest.	
In swale with gravelly bed south of Mt. Pleasant	
Pleasant	28,955
Where railway turns north into Mt. Pleasant	28,950 = 800 ±
Mt. Pleasant Station	28,935 = 761
Celan Station	28,915 = 838 ±

There is sandy land for two one-half miles west, or about to corner of Sections 29, 30, 31, and 32, Grant township. From here nearly to Farwell, there is bouldery choppy land with a steep westward rise to the gravelly sandy plain on which Farwell stands. There are prominent knobs southwest of Farwell a mile but northwest there is not so sharp moraine for some three or four miles out.

Lake George station seems to be near north end of the lake in southwest part Section 8, Lincoln township. There is sandy land instead of a till plain from Clarence to the Muskegon River at Temple. Clarence, Temple, and Pennock are all abandoned and very little land is cultivated in their vicinity. Clare County seems to have run down instead of making advance as a whole these past 20 years.

I pass through a strip of clayey moraine with small hummocks one to two miles southeast of Marion.

Studies in Western Antrim County, Michigan

August 8, 1933. Mancelona, Michigan. Aneroid 28,840 = 1,112 feet.

I drive north with Mr. Schoeneman on line of Sections 16, 17, 8 and 9, 4 and 5, Township 29, Range 6 West, rising over the gravel outwash plain to 45 feet above Mancelona at edge of the moraine or 1157 feet. The moraine has points about 20 feet higher, say 1175 feet. In the moraine limestone blocks as well as pebbles abound. Granite is the most conspicuous crystalline rock. Red Lake Superior sandstone is present. The limestone pebbles are found in the soil in cuts on line of Section 33, Chestonia and Section 4, Mancelona. There is a narrow plain of sandy gravel on north side of the moraine on line of Sections 32 and 33, at altitude 25 feet lower than Mancelona. The stream on line of Sections 32 and 33 is 190 feet below Mancelona, or 922 feet. North of this is a lowland 40-50 feet above the stream that is boulder strewn.

On borders of Sections 28 and 29, there is a small tableland standing 50 feet lower than Mancelona (1062), that has a few boulders. It is mainly in Section 28 and has low land around it nearly 100 feet lower.

The corner of Sections 20, 21, 28 and 29, is about 200 feet lower than

Mancelona, or 912 feet, and the stream east of the railroad on line of Sections 21 and 28 is 250 feet lower (=862 feet). There is a rise of 150 feet from it to the crest in road just east of line of Sections 21 and 22 (=1012 feet). Near east end of line of Sections 22 and 27 a stream is crossed, east of which is a sandy gravel outwash while west of it is bouldery land. The outwash is at two levels, one 50 feet lower than Alba Station (=1116 feet) and the other 90 feet lower (=1076 feet). The lower one is narrow, scarcely one-eighth mile. The higher one covers much of Section 23 and parts of Sections 13, 14, 24, 25, and 26, touching only the northwest corner of Section 25.

The moraine directly west of Alba is 30 feet above the station of G.R. & I.P.R., or 1196 feet. My reading at Alba is 60 feet higher than Mancelona - it is 1166 feet A.T.

Four hours later - The moraine crosses into Star township in Alba and its inner edge crosses the line about 60 rods south of corner of Sections 18, 19, 13 and 24. A sandy gravel plain extends into west part of Section 18, Star township.

We go west two miles from Alba and take road north down a valley in Sections 22 and 15, Chestonia. There is bouldery sandy drift along this road on west side of the stream. On the east a steep rise is made to the gravel plain over a bouldery slope. This border is near the line of Sections 22 and 23. The gravel plain seems to extend into south edge of Section 14 and covers southeast half of Section 13.

We reach a level 360 feet lower than Alba, or about 800 feet A.T., at line of Sections 10 and 15, Chestonia, and 60 feet lower still at Jordan River in northwest part of Section 10 (=733 feet by Wisler survey). We went up to a sort of terrace north of Jordan River in south part of Section 3, which is about 100 feet higher than the stream where we crossed or not far from 830 feet. It is boulder strewn like a ground moraine rather than a fluvial feature. North of it is strong moraine in the north half of Section 3 and northeast part of Section 4. It is over 1000 feet A.T.

We returned to the river in northwest part of Section 10 and took road west on south side on the low plain bordering the river. There is a steep rise to bouldery land a short distance south of this road.

We turned north and kept near the railroad in Sections 8 and 5, Chestonia. There is high land of morainic type west of the railroad to southeast part of Section 6. The north part of Section 6 is swampy and is about 700 feet A.T.

Near the line of Chestonia and Jordan townships a plain of sandy gravel is entered that is probably a delta of Jordan River in an area of Lake Algonquin. The plain is by barometer 675 (should be 636 feet) at Jordan River Station on line of Sections 20 and 29, and the river 650 feet (should be 621 feet). (I got levels from Wisler for the stream at points where he surveyed in 1922 - see map.)

We find no lake clay on the lowland along Jordan River above this place.

We drove east and rose to 1075 feet at a crest near middle of line of Sections 23 and 26, Jordan township.

Near middle of line of Sections 24 and 25, we turned southward and followed a valley down to Jordan River in southwest part of Section 30. Much of Section 30 is rather low compared with bordering land on the east, north, and west. The river is 925 by barometer at line of Sections 30 and 31, and 859 near center of northwest quarter Section 6, Star township. (Wisler made it 786 feet at township line north side of Section 6.) From here we rise rapidly over a bouldery sandy slope to a plain near line of Sections 6 and 7 that stands 1115 feet A.T. This is the same plain that lies west of Alba. There is a slightly higher elevation of plain in west part of Section 18 than in west part of Section 7, the barometer reading on it being about 1140 feet. It seems to be of similar material to the rest of the plain. There is some cobbly land with gentle undulation along the road each side of the line of Sections 7 and 18 and a few boulders - but the moraine proper lies east of the road until we pass the corner of Sections 18, 19, 13, and 24.

From what we have seen today, it appears likely that the south part of Sections 8, 9, and 10 and much of Sections 15, 16, 17, 21, and 22, Chestonia are morainic.

There is not much outwash or terraced land in Sections 27 and 28, 32 and 33, along the northwest side of the moraine that runs through Alba but it is finely developed west and northwest of Alba in Sections 23 and 24 and adjacent parts of Sections 13, 14, and 26.

We came back to Mancelona along the highway near G.R. & I.R.R. from Alba. Distance covered today by auto about 50 miles.

Studies in Northeast Antrim County

August 9, 1923 - 7 A.M. Aneroid 28,810 at Mancelona depot. I set barometer at 1112 feet.

We drove to Alba, then east two miles to border of moraine. Altitude 1180 at base of moraine or east edge of plain at corner Sections 20, 21, 28, and 29. The moraine covers most of Section 21 and extends a little into Section 29.

We drove north through pitted gravel plain with moraine on east in Sections 21, 16, and 9. The border passes near center of Section 9 and then runs northeast near corner Sections 3, 4, 9, and 10, Star township, and across central part of Section 3 and southeast part of Section 35 to a lake in Section 36, Warren township.

The plain reads 1190 at Simons, 1192 feet and 1195 at line of Star and Warren townships in southeast corner Section 33, Warren, 1210 at northeast corner Section 34, and 1235 at corner of Sections 22, 23, 26, and 27. The plain extends one-quarter mile west of this corner. Its border is on east edge of Section 22. The altitude at northwest corner Section 23 is 1240. A hill in the moraine one-half mile north north-west in Section 15 is over 1300 feet.

We drive west in Section 15 and cross the moraine in about one-half mile. Its crest is 1260 feet here. We came into a gravel plain on line of Sections 15 and 22, standing 1190 feet. It runs southwest to the head of Jordan River in Section 21 but does not extend far north into Section 15. The ice border runs west on south side of the east-west road (Schoeneman reports a small gravel plain around corners of Sections 10, 11, 14, and 15, Varner township).

We continued down a valley across Section 16 and northeast corner of

Section 17, Warner and south part of Section 8. Then west to range line and north to county line at northwest corner of Warner township. All through strong moraine.

We then went east across Section 6 and were 890 at stream. The east part of Section 5 drains northward but from northeast corner of Section 8, there is a valley leading south across northwest part of Section 9 and then west into Section 8.

We went back to southwest corner of Section 14 and ran east on line of Sections 14 and 23, through a boulder strewn plain just outside the moraine. Boulders extend but little into Section 23 and northwest corner of Section 24.

28,675 at Elmira at 12:00 noon	= 1232 feet
28,610 at Elmira at 1:15 P.M.	= 1228 feet
28,415 on plain near north end of line of Sections 31 and 32, Elmira township, Otsego County	= 1400 feet \pm

There is a plain about 75 feet lower in east part of Section 30 north of the highway that crosses the south part of the section.

The high plain has small boulders and cobblestones on it, so numerous as to furnish large piles in fields. My map shows them to extend out nearly two miles beyond the moraine, the limit being in the east part of Sections 21 and 22 and the central part of Section 33, Elmira township, Otsego County. The border of the bouldery land there is shown to run southwest across northwest part of Section 5, Township 30, Range 4 West, and south part of Section 6 into Star township, Antrim County. There are, however, some farms with scarcely a boulder on them.

There is some gently undulating very sandy land with a few small boulders, and rarely a large one, east of the moraine for two miles in Star township in Sections 13, 14, 23, and 24. The north and west parts of Section 22 are morainic with numerous large boulders. There is a brown clayey till at southwest corner of Section 22 in a road cut 15-20 rods north of corner. This is the first clayey till I have seen in this township. The till generally is sandy with only a moderate supply of coarse stones. There are few places where gravel is coarse enough or free enough from sand to be used on highways without screening the sand. Farms are badly worn

out in eastern Star township where the drift is so sandy, the crops this year being below the general average in this part of the county.

Wells in northeastern Star township on land 1375 feet A.S., are slightly above 200 feet depth. There seems to be no good supply at less depth. They are nearly as deep on the lower plain near Simons, 1200 feet A.S.

I went to the camp of the Land and Economic Survey at Simons for supper and then to Mancelona by auto in the evening. The moraine border on west side of the G.R. & I.R.R. is about a mile west at Simons but the space narrows gradually southwestward to nothing at Alba. It is about one-third mile northwest from the track at line of Chestonia and Mancelona townships but diverges widely from there southwestward. The general width of the plain between this moraine and the one east of the railroad is two to two one-quarter miles from Elmira to Wetzel but is three miles or more in Mancelona and Custer townships. It seems to slope southwest about 8 feet per mile in its course across Antrim County.

Features near Mancelona

August 10, 1923. Mancelona, Michigan

I went by auto along the border of the moraine east of the G.R. & I.R.R. to a lake near corner of Sections 1, 2, 11, and 12, Mancelona township, then north into Alba and east four one-half miles to where the outwash plain is clearly defined. There is good morainic topography in Section 22 and in all of Section 27 except south-east third. A few boulders occur on the plain as far out as middle of line of Sections 23 and 26, Star township.

The moraine is about 1320 on crest on line of Sections 22 and 27. There is a prominent hill in Section 33 that may reach 1400 feet. It is about a mile northwest of Lead Lake (Lake Harold). The moraine is prominent west of the lake a mile farther south into Section 4, Township 29, Range 5 West. A very prominent hill over 1400 feet lies out in this plain near line of Sections 10 and 11, Township 29, Range 5 West. It is a landmark for miles around. It is nearly one-half mile north-south, but not so wide. H. J. Barney, of the Antrim Iron Company, locates it as

mainly in northwest quarter Section 11, Township 29, Range 5 West. There are sandy plains west of it for about a mile to a small lake in northeast part of Section 9. North and west of this lake is rolling land in Section 4 and north part of Section 9.

Moraines and Gravel Plains in Antrim County

The plain east of it near the railroad is about 1300 feet. Manistee River heads in Sections 1 and 2, Township 29, Range 5 West on a plain about 1300 feet. We drove along the Detroit and Charlevoix Railroad to line of Sections 13 and 24 where the highway that runs to Mancelona crosses it. The aneroid reads about 1230 at the railroad but is 1280 on general level of the plain one-quarter mile west and holds this level for a mile west. I read 1300 at corner of Sections 14, 15, 22, and 23 on the plain. ~~There is gently undulating land in south part of Section 23~~ and it widens out and becomes more decidedly morainic in Sections 26, 34, 35, and 36. I am told by Mr. Berney that Section 36 is hilly, especially in west part. There is gently undulating land in Sections 32 and 33 and near Sand Lake on corner of Sections 28 and 29.

There is a knob of bouldery land close to the east-west highway in north part of Section 20 that is fully 1400 feet. It is about 80 feet (estimated) above the plain at northwest corner of Section 20 and that by barometer is 1340 feet. The plain is 1325 on west side of Hawk Lake and about 1315 on east side, while the lake is about 1250 feet. It has abrupt borders on rim about 50 feet and gentle rise above this to the plain.

We drove north on line of Sections 17 and 18, 7 and 8, Township 29, Range 5 West across a plain. There is gentle undulation and a few boulders in Sections 7 and 8 near this road, and good morainic topography in west part of Section 7. The moraine occupies much of Sections 4, 5, and 6. It is 1370 feet at a new logging camp in southeast part of Section 5. This is 20-25 feet above the bordering plain in south part of southwest quarter Section 5.

The moraine border runs southwest across Sections 13 and 23, Mancelona

and then south through east part of Sections 27 and 34. The plain is about as high as the moraine, the readings on it being 1350 feet and on high points in the moraine 1365-1380 feet. It is 1365 feet at a tower just erected by the Forest Service in the southwest part of northwest quarter, Section 22, or 250 feet above Mancelona Station.

There is a hill on the plain east of the moraine, around corner of Sections 19, 20, 29 and 30, Township 29 North, Range 5 West, that reaches 1400 feet. Its highest part is in the northeast part of Section 30.

In the afternoon I went south and found a higher outwash preserved along the east side of the plain than that through which the G.R. & I.R.R. runs. It is 1150 feet at line of Sections 20 and 29 and near middle of line of Sections 28 and 29. This is 40 feet above the lower plain in Mancelona and vicinity.

There is an isolated strip of moraine surrounded by this higher outwash plain. It runs from the southwest corner of Section 29 southward through 32 into Kalkaska County, and dies out in the northeast part of Section 7, Township 28 North, Range 6 West. Its highest points are over 1200 feet. The plain east of it is a mile wide in Sections 28, 29, 32, and 33, Mancelona, and Sections 4, 5, 8, and 7, Township 28 North, Range 6 West. The high plain extends nearly to the G.R. & I.R.R. in Sections 1 and 12, and 13, Township 28 North, Range 7 West, and the northwest part of Section 6, Township 28 North, Range 6 West. The border runs to the northeast corner of Section 31, Mancelona township, and a little west of center of Section 29. It is 1135 feet at the town line east of Westwood, while the lower plain is a little below 1100 feet A.T. I read 1095 at the base of bluff cut in the higher plain, and only 1080 on the west side of G.R. & I.R.R. track near south end of line of Sections 31 and 36. This is below a low bank on which the railroad runs. I read 1100 at line of Sections 30 and 31 at level of the railroad track, and 1110 at Antrim Furnace, and 1115 at Mancelona at 3 p.m. where it read the same at 1 p.m.

The higher plain in the southwest part of Mancelona township and the northwest part of Township 28 North, Range 6 West in Kalkaska County, slopes south-

west at about the same rate as the main plain on which the G.R. & I.R.R. runs, or 25 feet in three or four miles, if barometric determinations are reliable. It seems to be younger than the isolated strip of moraine, or at least it surrounds that strip in such way as to make it an island rising out of the higher plain. There are basins in it along line of Sections 4 and 5, Township 28 North, Range 6 West, and in Sections 7 and 8. But basins also occur in the plain traversed by the G.R. & I.R.R.

I went west from Marcelona across the outwash plain to the edge of the moraine which passes a few rods west of corner of Sections 13, 14, 23, and 24, Custer township. It has a definite chain of knolls here, standing 20-30 feet above the plain. The plain is about 1130 at edge of moraine.

The border crosses the northwest corner of Section 13, and runs northeast across Section 12 to its northeast corner. There are basins in the outwash in Sections 13 and 24, near the moraine border.

I went northwest into the moraine, descending about 200 feet to center of Section 11. The moraine extends nearly to the north side of Section 11, and covers the southeast quarter of Section 10. The remainder of Section 10 is largely swamp about 800 feet A.T.

There is very prominent moraine on its northwest border in Sections 3 and 4 and 9. The moraine ends abruptly in the northeast part of Section 8. A sandy plain around the center of Section 8 is about 800 feet. There is an abrupt drop on its west edge of over 100 feet to a lower plain bordering Grass Lake. This plain is underlaid by clay to large extent, and was covered by areas of Lake Algonquin that occupied Torch Lake, Intermediate Lake, and Grass Lake and their connecting lowlands.

There is a prominent moraine on the east edge of Sections 30 and 31, Kearney township, immediately outside of Bellaire, and its west border runs near the line of Sections 5 and 6, Custer Township.

Mr. R. Leavitt, an attorney at Bellaire, says a very strong flowing well was obtained some years ago in the north part of northeast quarter, Section 29, Kearney township. It is on the low plain that runs east from Bellaire to Jordan

River.

There is a small water power development at Bellaire on Intermediate River, the outlet of Intermediate Lake. The strong moraine east of Alden in Helena township seems to be a continuation of that southeast of Bellaire, but from Section 8, Custer township to Section 24, Helena, a distance of three miles, there is no moraine, but simply a bluff with outwash plain at top and lake plain at base. The bluff is nearly 150 feet high. I return to Mancelona after dark on some road I came to Bellaire on.

August 11, 1923. Mancelona, Michigan.

I went by auto to Antrim and then west across the outwash plain to the edge of the moraine near middle of line of Sections 23 and 26, Custer township (Township 29 North, Range 7 West). I there overlook much lower country to the west that is morainic for a width of about two miles, though there are local, nearly plane tracts of 40-80 acres or more among the knolls.

I went south on line of Sections 25 and 26, and then west to edge of moraine near south quarter east of Section 27. I continued west through the moraine a distance of over two one-half miles, but flat areas are found among the knolls that are like outwash aprons, but they do not seem to line up in definite strips. The moraine extends into southeast corner of Section 30 and east part of Section 31, Custer township. It is separated by only a narrow strip of lowland one-third to one-half mile wide, from the moraine to the west. This lowland seems to be about 850 feet at line of Sections 30 and 31. It is swampy in the southwest quarter of Section 31.

I went east on county line from middle of line of Section 31, Custer township, and Section 6, Township 28 North, Range 7 West, in Kalkaska County, rising about 200 feet, or to 1050 feet at corner of Sections 32, 33, 4 and 5. I go south and come to edge of moraine about one-third mile south of the county line on line of Sections 4 and 5. The outwash plain here is about 1100 feet. It covers nearly all of Section 4, except about 80 acres in northwest part. It covers about 120

acres in southeast part of Section 5 and the east half of Section 8, Township 28 North, Range 7 West. My old map shows the moraine border to extend east in the south part of Section 17 to the southeast corner of the section.

In Sections 3 and 4 there is a good forest with some White and Norway Pine with Poplar and Maple starting up without help from man. I came to a lower plain one one-half miles west of Westwood Club House, near line of Sections 2 and 3, Township 28 North, Range 7 West. Its width is about one one-half miles here, but it narrows to a mile or less near the line of Kalkaska and Antrim Counties. It runs southward along and west of the G.R. & I.R.R. past Leetsville, with a width of one one-half miles or more, and then bears southwest away from the railroad, for that runs to a higher plain within a mile south of Leetsville. This seems to be a shallow erosion feature.

ON Train, Mancelona to Grand Rapids

I took train on G.R. & I.R.R. from Mancelona to Grand Rapids at 10:30 a.m. From the car window I could see the banks on each side of the shallow erosion channel from a mile north of Westwood to Leetsville. It is 30-40 feet high on east and about 20 feet on west side. This valley probably finds continuation down Boardman River from the bend of Rapid River in Section 32, Township 28 North, Range 7 West, but I have not traced its course from one drainage to the other. My old map shows a "swale" in Sections 7, 8, and 18, Kalkaska township, and Sections 13, 14, 22, and 27, Wilson Township, but it is only one-eighth mile wide, whereas this valley is one one-half miles.

The outwash plain extends south of Boardman River along the G.R. & I.R.R. to line of Sections 30 and 31, Kalkaska township. There is a swamp at its south edge in Sections 28, 29, 30, and 31, Kalkaska, and Sections 25 and 36, Wilson township. For a mile northeast of Crofton, there is a gently undulating sandy drift with a few boulders. This continues for a mile or more southwest from Crofton. I there can see a ridged belt apparently in Section 10, Boardman, that runs 20-30 feet or more above the plain. There is a sandy plain south of it along the rail-

road nearly to South Boardman. I there enter strong moraine which continues nearly to Fife Lake. There is outwash from Fife Lake past Walton to the Manistee River in northeastern Washtenaw County.

There seems to be need for some revision of my mapping of moraine north of Manton, and near Gilbert. I make some changes such as can be seen from the car window. I change moraine to till plain in Sections 20 and 29, Township 24 North, Range 9 West, Liberty township.

I add moraine features in Sections 21 and 22, Township 23 North, Range 9 West, and southeast corner of Section 20 where the old map shows gravel plain.

The summit on the railroad is in Section 32, Township 23 North, Range 9 West, and the barometer indicates 1440 feet here instead of 1540. The highest points on the moraine in this vicinity scarcely rise to 1500 feet. The moraine is very sandy and there are only a few small boulders in any of the cuts, and some have no boulders.

There was nothing of note to add to what I already have noted on this line from here to Grand Rapids. I continued on M.E.R. from Grand Rapids to Jackson and Ann Arbor. This takes through weak moraine and such ground moraine in southeast Kent County, but is in a valley from near Middleville eastward past Vermontville. This broad valley land is due to glacial drainage.

The upland crossed west of Charlotte is not moraine, but an undulating till tract with gentle smooth slopes such like that north of Leslie. The mapping should be revised here when I work in the northwest part of the Marshall quadrangle. The channel from Charlotte to Eaton Rapids is peaty and may be built up several feet over its old bed. That may stand below 900 feet all the way across from Grand River to Battle Creek. I saw no other features needing revision between here and Ann Arbor.

Southeast Tip of Campus Outwash Plain on South University Avenue

August 1923. Ann Arbor Campus Outwash.

Excavations for a tunnel on south University Avenue show beds in the out-

wash with a dip east and south instead of west and south, as far west as the Alumni Memorial Building, and the ground has a slight rise from the southeast corner of the campus as far west as the President's residence. It is 3-4 feet higher there than at the intersection of South University with East University Avenue. There seems to have been a strong flow of water with heavy burden of material across the southwest part of the campus with a spread towards the southeast that caused beds to dip in that direction.

Excavations at the new Physics Building in the middle of east side of the campus and at the Chemical Engineering Building farther southeast show beds dipping east and south. The beds in the center of the campus at the Library site show southwest dip. It thus appears that the strong current with the normal southwest flow passed through the center of the campus from the northeast corner and that it spread eastward over a lower one and filled it with beds dipping southeast.

Lumps of Coal in Outwash

A pocket of waterworn coal was found by Mr. Mussey and myself on the north edge of the excavation for the Law Club south of South University, about 20 rods east of State Street at depth of 3 feet. Lumps of well rounded coal up to 2 inches in diameter occur. Mr. Mussey will turn them over to Professor Bartlett of the Botany Department for study. Similar pockets were found by Professor Bartlett during the excavation for the new Main Building in fall of 1922, which he has made a subject of careful study. This coal is in outwash from the Erie Griblobe, and its source is thus a more difficult matter to determine than if it were in outwash from the Saginaw lobe. Perhaps there are outlines of coal in the area covered by the Erie lobe. If not, it may be found that the coal was carried southward at the Kansan or Nebraskan stage and then redeposited by the waters from the Erie lobe in the Wisconsin stage. The heavy drift in southeastern Michigan may easily cover any outlines of coal so that no natural exposures will be found. Possibly borings will reveal such outlines.

It seems singular that the coal should be segregated in pockets instead

of being scattered through the gravel. Its specific gravity is different from that of the limestones and other pebbles that make up the gravel, probably a little lighter. I have seen scattered pieces of coal in the till in some excavations in Ann Arbor, one being at Professor Hobbs' residence at corner of Oxford Road and Hill Street. It occurred there in a silty clay that contained very few pebbles. A similar silty clay with few pebbles is found in northwest part of the school grounds south of South University Avenue. It is yellowish brown at surface and blue at depth of a few feet. It differs from the ordinary till of this part of the city which is thickly set with small stones and a sticky clay. This silt is loess-like in appearance, with mellow soil, and is not muddy or sticky when wet.

Data on Ann Arbor Waterworks

August 28, 1923.

Rate of pumping at waterworks is such as to give about 2,600,000 in 17 hours, pump capacity 3,750,000 gallons. Examinations made with Howard Hollands and Louis Agrie, August 28, 1923, in Steere Farm area, Lawrenceville, north of east-west road and west of A.A.R.R. in Section 9, 45.5 inches from top of pipe. Top of pipe is 20-21 inches above level of ground. Measured August 28 by Agrie and witnessed by Leverett. On June 10 it was 28.5 inches.

Steere's north well on south side road, 27.5 inches below top of pipe in ditch several inches below natural surface in part east of here. On June 10 it was 9.5 inches.

Large well at 2:20 p.m. is 13 feet two one-half inches below surface. The ground is about 4 feet below top of well where measurement was taken, so water is about 9 feet below natural surface. In the morning when pumping starts, it is about two one-half feet, 26 feet 7 inches from top of curb. This is about the level of ditches near it.

Gauge well south of pumping station is down 9 feet one three-quarter inches at 2:30 p.m. The ground water here is 4 feet 11 inches below top of pipe but only a few inches below level of surface of ground.

Old well at bottling works of Steere's, west of road, 43 inches. Pipe is very nearly same level as ground.

Lavender well, 23 1/2 inches below top of large pipe. This is in an excavation about 2 feet below peat surface. Depth of well 100 feet. This flowed while city was not pumping from May 27 to June 10. (City stopped pumping May 21 to June 4). Poor potatoes on Lavender's peat land.

East's south well, 30 inches. Pipe is near level of peaty ground (for depth see notes, 1922). Excellent corn on this land, poor potatoes.

East's north well - 45.875". Pipe is near level of peat. This is 40 rods north northeast of south well.

Davison's well by windmill on Davison's, 9 feet 9 3/8 inches. Top of pipe 2 feet above surface of ground.

Davison flowing well near line of city property, 54.5 feet from top of pipe that is near level of ground. We detached a 28 inch pipe above it.

Ground water in city well near Davison well is 64 inches below top of well. This is 2 feet above general level of ground around, so the ground water is about 3 feet below the surface. This shows the Davison well has artesian head below the ground water of over a foot.

On Sutherland property southeast of L.S.R.R. in Section 29, the water is still coming out enough to make a wet area 20 by 10 feet, water bubbling up in a ditch.

At southeast hole in Loker's 40 acres, ground water is 48 inches. There is three one-half feet of peaty material here over the gravel. The water is in the gravel. This is 30-40 rods south of Eberbach well and on opposite side of road (west side).

The north hole on Loker's 40 acres is about 50 rods farther north on west side of road, or but little north of the Eberbach well and the ground water is down 7 feet, 8 1/2 inches. There is about 2 feet of suck here.

At the Eberbach well, also called Hutzel well, the water is down 9 feet 5 inches from top of a pipe 2 feet above ground, making water in pipe 7.5 feet below

surface of ground.

Loker's hole in the "Nine Acres" has water table 8 feet below surface. There is about 1 foot of muck over a sandy gray gravel. Excellent corn all around this hole.

Pontney well near south limits of Ann Arbor, east of State Street, has head $8 \frac{3}{4}$ inches from top of pipe, or about even with ground surface. This was flowing in 1922.