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STUDIES IN THE DRIFTLESS REGION OF WISCONSIN

by

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By G. H. Squier. March 23 1905

Although the unglaciated region of Wisconsin and adjoining states has been an object of interest to geologists since its peculiarity became known, and the reason for its non glaciation was for a time a subject of discussion the region has not been a fruitful field for geological work, and the deposits of Quaternary age have been either ignored or noticed only as to their more obvious and superficial features.

Partial exceptions to this statement are found in the Loess, and in the glacial gravels of the Mississippi Valley.

It is the belief of the writer that the recent deposits of the region are worthy of and will well repay a much more careful study. Geological records were being made throughout a good share of the Glacial period, and what gives to them an added value is the fact that the records are in no small degree the complements of those in the glaciated regions, being of the sort usually mutilated or destroyed by the glaciers.

The writer has utilized his infrequent intervals of leisure for a number of years in the study of such parts of the region as he was able to visit, and these studies have shown that the deposits are much more varied in character than a casual inspection would lead one to suppose, and the purpose of this paper is to give a general idea of the character of the deposits, and something of the scope of the evidence derivable therefrom.

Deposits of the main valley.

The general features of the gravel deposits along the course of the Mississippi are so well known that a description of them here would be superfluous, but details of structure are difficult to obtain and have corresponding value, and Trempealeau owing to a peculiar topographical feature gives opportunity for the study of an unusual number of details.

The divide separating the river from one of its small tributaries on the west side had become so attenuated that the agrading of the river bed caused it to be soon overflowed, and the river took possession of the small valley which thence forward seems to have become its permanent course. It is worthy of note that the deposits with which the forsaken valley became filled, show little indication of a glacial origin, so far as they can be seen on the surface, or in wells, (Note) but are very like those shown in the lateral valleys under the Loess. This perhaps means that the conditions were not favorable for the transportation of coarse material save in the deep main channel.

In its newly adopted course the Mississippi began active erosion on either shore.

The amount removed from the bases of the bluffs was considerable, amounting in some cases to several hundred feet.

The indications are that this new channel was never filled to any great extent with depositional matter, and that during its stage of greatest development the river flowed through in a volume eighty to one hundred feet deep, and nearly a mile wide. It would not seem, however, that the current was rapid, for the cones built up at the mouths of the circs appear to have withstood it without material detriment to their integrity. Below these narrows the river expanded and deposition of gravels was active. The full extent of the gravels is unknown as they extend downward below water level and are somewhat concealed on the surface so that their range of occurrence can only be determined from wells.

In the gravel pit of the C.B. & Q.R.R. they are shown to comprise two series. The lowest occupying about two thirds of the height from the river level, and showing scarcely any variation is of a dark color, contains but little material as fine as sand, nor on the other hand, does it contain any very coarse gravel. The upper series is of a red-

dish color contains a great preponderance of pine material, while at the same time the range in size of the gravel is far greater bowlders up to several cubic feet volume occurring. Between these two gravel series there is shown at one end of the pit a clay having a maximum thickness of little over a foot. Although this has but a small outcrop in the pit, it is probable that it has a rather wide development for a number of permanent pondholes scattered about the prairie and certain wells which obtain an unfailing supply of water at this level indicate an impervious stratum of considerable extent.

This clay contains gravel in some places, but in appearance and texture it is indistinguishable from the Loess, and I am strongly inclined to the opinion that it does in fact represent a part of that formation, and that it marks an important break in the sequence of the deposits.

The Lateral Valleys, opening into that of the Mississippi necessarily agraded their beds as a consequence of the filling of the main valley, but it is probable that they did not quite keep even step in this process, but that in periods of very rapid deposition the main valley filled the faster giving rise to shallow lakes in the lower parts of the laterals. These alluvial fillings consist mainly of sand somewhat streaked with clay in some places especially in the more distinctly locustrine portions. Within the vertical range of such sections as I have seen no important break in the deposits is shown, but a number of wells have been reported to me from different localities, which at depths of twenty to thirty feet encountered forest or swamp growths. In some reports there was a hint of clay beneath the deposit of vegetable matter, but usually this feature was not reported on. The level of this bed is near enough to that of the clay parting in the gravel so that the two might very well belong to the same horizon.

The Valley Head Deposits.

The torrential upper portions of the valleys - their heads - would normally under agrading conditions receive deposits of coarse material. The presence therefore, of such beds in these localities was not calculated to attract especial attention, and it was not until certain peculiarities came to my notice that I was led to study them more particularly. These peculiar features seemed very difficult to account for in normally developed torrential deposits, but strongly suggested a glacial origin. In a series of articles published in the Journal of Geology I have stated the case in considerable detail and will not repeat the matter here, but as a result of the heavy rains of the past two or three years, supplemented by considerable work with the spade I have obtained a much more accurate knowledge of the forms of the stone beds than I possessed when those articles were written.

I have thus ascertained that in at least four cases the stone beds have the forms of ridges transverse to the directions of the valleys, with reverse slopes i.e. sloping up as well as down the valleys. I levelled from the crest of one of these ridges and found that the vertical height above the top of the stone bed a little way above was about ten feet. The full height in the other cases is not see, but I judge that it is at least as great as in the one measured. One of them has where cut through by the gully a width at base of about a hundred feet and is over four hundred feet long. In the valley giving the most complete section, stone beds of four successive stages are to be seen, and the largest will probably have to be divided as excavations where I have made them show a Loess parting. As a rule these clay partings are thicker than the included stone beds. Typically the Loess is wholly free from coarse material to the very line of contact both above and below the stone beds, while the stone beds themselves show but a very small percentage of mater-

ial as fine as sand. One exception to these statements should, however, be noted. On the down stream side of the ridges, the Loess frequently contains more or less coarse material which shows by its position that it is outwash material from the ridges above. The earliest of the stone beds exposed if not antedating the earliest of the Loess, is at least at its base, while the latest is well toward its top.

The Loess. As forming part of a very wide spread deposit and one which has given rise to considerable controversy as to the transporting agent, this formation has received much attention from geologists. I think, however, that my own studies have brought to my notice features which had not been previously observed, especially in the valley heads.

In its geographical distribution the Loess shows its heaviest deposits in those parts of the lateral valleys adjacent to the main valley of the Mississippi. It gradually becomes thinner as we ascend the valleys, and may be entirely wanting near their heads as in portions of the upper La Crosse Valley. It is noteworthy that in this valley its presence or absence on the headwaters seems to depend on the presence or absence of limestone on the bluff tops, the more southerly branches having limestone on the hill tops, and showing Loess, the more northerly ones having no limestone and showing no Loess. In Lewises Valley (next north of La Crosse) the southern divide is heavily capped with limestone, the northern shows little or none and here the south side of the valley shows much heavier deposits of Loess than the north side. These and other examples which I might mention show that the formation is composite in origin, both local and extra local sources having contributed to it, and it is apparent that assuming a certain amount of submergence between these two sources of supply the distribution is very well accounted for, but as an aeolian deposit it is very different from what we should expect.

Its vertical range seems to have included the entire height of

the Trempealeau bluffs, for although it is not abundant above the tops of the highest foothills which reach to between three and four hundred feet above the river, yet in favorable situations it may be found at all elevations to the top, as a rule it has quite disappeared from the steep upper slopes of the bluffs and from the sharp ridges. Where it occurs its freedom from residual cherts, or other coarse material and its well marked contact plane at base seem to mark its identity quite plainly. Having probably been removed in large part from the higher bluffs it is difficult to say how far back from the river such high level deposits extended apparently for only a short distance.

It is difficult to state the average thickness of the Loess for it shows a strong tendency to collect in the hollows among the foothills to a great depth. In the small valley among the Trempealeau bluffs where so good a section of the stone beds is obtained, the Loess shows in one place a thickness of fifty, or perhaps sixty feet. In these bluffs the thickness is much greater on the downstream than on the upstream side as though it had been influenced by a current setting down the valley. It is probable that in hollows among the foothills a thickness of thirty or forty feet is not uncommon and that twenty feet is the rule rather than the exception. On the tops of the foothills from five to ten feet would be the general run. These figures would be for the lower portions of the lateral valleys. In the valley bottoms especially on the level portions constituting the terraces the thickness seems to be about six or eight feet, considerably less than the average thickness in the foothills which leads one to suspect that a portion of the Loess was deposited before the completion of the alluvial fillings and is covered by them. Possibly it may be found beneath the forest bed.

I wish to point out in closing these notices of the Does that the alternation of stone beds with it in the valley heads offers very important evidence as to the existance of water well up the sides of the bluffs

for it is evident that a stoneless deposit could only be formed in such situations, under conditions which served to shut out material which would normally come down from the upper slopes. As the highest stone so far noted is about two hundred feet above the river it is evident that the water must have extended much above that level. There is other confirmatory evidence of the presence of water even at the tops of the bluffs, so that it is not necessary to rely solely on the evidence of the Loess in predicating a deep submergence for the region.

The Valley of the Wisconsin. After crossing the divide from the headwaters of the La Crosse River we enter the western border of that broad stretch of level country which including eastern Monroe, Juneau and Adams counties constitutes the great sand plain of the Wisconsin above the Dalles. This plain which forms the most conspicuous feature of the topography and is one of the finest examples of its class owes its character to the combined effects of the relatively rapid progress of base leveling in the soft sandstones, and to an agrading of the valley bottom which has buried a good share of such surface reliefs as remained. On the upper Lemonweir River for which I have some data the filling amounts to upwards of a hundred feet, probably considerably more than that in the deeper portions. I have never visited the eastern side of the plain, but from some things mentioned in the report of D. Irving I am led to suspect that the filling may be less on that side. At least a study of the elevations (railroad stations and barometrical readings Reports of Wisconsin Geological Survey 1873-1877 Elevations refer to Lake Michigan as datum plane) shows a peculiar feature suggesting a tilting of the eastern side of the plane.

If we select for comparison the Lemonweir River on the west and the Little and Big Roche a cris Creeks on the east, we find, taking only such parts of their courses as fall well within the limits of the plain that while the former in a course of 34 miles falls 90 feet or

at the rate of 2-2/3 feet to the mile, the latter in courses of about 20 miles fall about 200 feet at the rate of 10 feet to the mile. If we make the comparison along a section transverse to the plain the contrast is still more striking.. The nearest approximation to such a section extends from Valley Junction on the west by way of Petenwell Peak on the Wisconsin, through Friendship Mound to Pilot Knob on the east. Valley Junction is about 20 miles west of Petenwell Peak, and has an elevation of 350 feet. The plain at the foot of the latter has an elevation of 340 feet giving a fall of 10 feet, ½ foot to the mile. Ten miles east of Petenwell Peak the plain at the foot of Friendship Mound has an elevation of 440 feet, and twenty miles east at the foot of Pilot Knob of 540 feet giving in both cases a ratio of 10 feet to the mile, and showing a very regular and rapid rise on that side. Any surface having such a slope, which is so little eroded as to be called a plain is certainly of no great age geologically speaking.

Locustrine Conditions. During at least some part of the glacial period the plain of the Wisconsin was doubtless occupied by a lake. This lake must at different times have shown three different phases. The most contracted of these was the one whose height was determined by/level of the country through which the Dalles are cut. This narrow channel is evidently a past glacial cutting made necessary by the closing of the old channel of the Wisconsin. (This old channel must have been to the eastward, but I am not aware that it has been located, or even sought for.) During this phase the lake level would have gradually fallen as the cutting was deepened. For a time, however, the lake level would have been determined by another and higher point of outflow, for at the time that the glacier invaded the Baraboo quartzite range the lowest point of outflow southward would have been west of that range at an elevation of 500 feet, but as the elevation of the divide toward Black River was not much over 400 feet that would have

been the natural direction of outflow.

The third phase was that during which the lake became merged with the supposed Lake Nenepin which with its maximum level approaching 700 feet would have submerged almost the entire driftless region, most of the land surface being confined to the elevated region the angle between the Wisconsin and the Mississippi.

The explanation of so deep a submergence lies rather outside of this field, and I can only say that the cumulative evidence derived from several different sources points to a very fluctuating upper level, and this in turn suggests a glacial dam. Of late, however, the existance of such a dam appears to be questioned. For the lake which as an independent body of water occupied this portion of the Wisconsin Valley, I propose the name Lake Wisconsin.

It would be difficult to fix on the upper limit of the locustrine deposits along the western border of this lake, but the most extensive conform well with the level of the Black River outlet. They have been somewhat eroded, giving rise to low terraces. The time during which the Dalles were being cut having been a period of quite regular subsidence, a gentle slope of the surface has been the result.

Gravel Deposits. Three of the principal headwater branches of the Lemonweir rise in the high divide eight or ten miles south of Tomah. They are in order from east to west, Bear Creek, Council Creek, and South Fork. In connection with these valleys occur certain extensive gravel deposits whose forms and distribution show very interesting features. They have formed the subject of a separate, but unpublished article of mine. In this article I must confine myself to the more salient features which are the deposits at the lower end of the valleys and in the plain over against their mouths.

Entering the rather narrow valley of Bear Creek by the wagon road from the west a mile or so above its mouth we find gravel on both sides,

that on the east being most abundant, and rising up the valley side nearly to the top. It continues to hug the side of the valley in this way until the valley itself opens out to the eastward when the gravel gradually draws away from the hillside and continues outward toward the plain as an independent ridge. Before becoming finally separated from the hillside the ridge crosses the mouth of a small lateral valley so damming it that the drainage from the valley has been forced to cut a narrow notch through the ridge to pass out, and there is still a level piece of swamp several acres in extent just above the ridge.

For more than a mile after leaving the side of the valley, the ridge averaging perhaps a quarter of a mile in width, has a very irregular contour, which cannot be better described than by saying that it shows the same billowy forms as those with which we are familiar in glaciated regions. As it begins toget well into the plain this irregular configuration gives way to a tabular form which it retains for the remainder of its length, about two miles, and then gradually drops down to the level of the plain. It is cut through by the C.M. & St. P.R.R. at Oakdale, the cutting being more than a quarter of a mile long and about as deep as the height of the telegraph poles, but not showing the base.

Council Creek and South Fork unite just north of Tomah, and their valleys coalesce a couple of miles south of that place. This interval from the junction of the valleys to that of the streams is heavily gravel covered for a width of perhaps half a mile. The town site of Tomah consists of low gravel covered sandstone hills, but south of the town there is a wide deep gravel filled depression which the topographical features seem to point out as the old course of the stream. The most extensive series of apparently connected gravel ridges that I have seen is that extending in an irregular semicircle for a distance of several miles on the west, northwest, north around to northeast of Tomah. I began to trace it on a group of isolated hills a couple of

miles west of the town. They are all heavily covered with gravel save the southwestern one which shows not a trace. The gravel border can be located to within a few rods, but not exactly being covered by Loess which on these hills is practically conterminous with the gravel. Extending westward from these hills is a rather wide swampy valley. On the north side of this and more than a mile west of the hills just described is a gravel ridge which parallels the bluffs at a distance of from an eighth to a quarter of a mile in a NE.SW direction for a mile or more. This ridge has a rather gentle southeasterly slope, but its northwest slope, facing the bluffs is about as steep as it will stand. Save for what appears to be outwash material the gravel seems to end abruptly at the foot of this slope. This ridge is broken down at its eastern end, but heavy gravel deposits continue in a northeast direction and for a couple of miles skirt a broad rather high outlying hill. It covers the southern slope of this hill and extends some little distance onto the top. Reaching the eastern end of this hill a more open country is presented and the gravel makes an outward bend. The broad loop thus formed is traceable for three or four miles, the outer margin being shown within narrow limits. Reaching the plain it ceases to be traceable for some distance, but following its general direction to a point some miles northeast of Tomah we encounter another extensive deposit. At the east end of this ridge is a sandstone hill heavily covered with gravel on the south side and top, but bare of it on the north side. In the series thus described there are only two important breaks located where the old valley bottom drops off to a considerable depth. But I know from wells that in some localities at least the gravel passes beneath the alluvial deposits. It is probable, therefore, that the breaks are only apparent.

We have thus a depositional ridge or series of ridges surmounting hills within certain limits and crossing the valleys in a way that at

once stamps it as moraine like. At the same its course is influenced by the topography inthe same manner, forming projecting or reentering loops according as obstructions are encountered or a broad open course is presented.

There are a number of other occurrences of gravel which I will not here describe, but there is one of a very different character and of great interest which remains to be mentioned.

North of the series of gravel ridges just described is a generally level region of locustrine deposits. The surface over an unknown extent, but certainly several square miles,is covered by a layer of gravel a foot or two in thickness. Within the region affected not a break is shown save where it is cut through by streams. The sections given in such places show it to be sharply distinguished from the underlying locustrine deposits, both by its well defined junction plane and by the character of the material, the locustrine containing scarcely anything coarser than sand, while the gravel contains many fragments the size of a mans head or larger and from that downward. That such course material should be distributed in so uniform a layer, over so wide an extent of level country as an ordinary locustrine or alluvial deposit is manifestly impossible. But considered as having been dropped by ice floating away from a glacier, it presents no difficulties but is rather what would have been predicted.

The gravel which forms all these deposits has for its most important constituent the residual chert derived from the Lower Magnesian limestone, which in the divides south of Tomah is exceedingly rich in that constituent, more so than in any other locality with which I am acquainted. The fragments range in size from about a cubic foot in volume downward.- <u>The proportion of this gravel in the various localities</u>. - It is usually greater in the inner deposits where it sometimes makes up

almost the entire body, but in the outer deposits it is much less abundant scarcely 1/00 in some of them, the balance of the material being sand together with residual fragments from the sandstone such as ferruginous nodules and the like. Large rock masses are rare, but not altogether wanting.

Whether glacial erosion exists in the valleys I am not yet prepared to say, not having had time to give the matter much attention.

Loess. Deposits of clay having the characteristics of this formation occur in this region in irregular areas. Such an erratic distribution would be inexplicable regarded as an aeolian deposit. It is scarcely less so if regarded as an aqueous deposit derived from the glaciers bounding the driftless region. But assuming that it was derived from the residual clays of the high southern divide - that the larger valleys were occupied by glaciers - and that Lake Wisconsin reached an elevation of something like five hundred feet, it becomes apparent that the distribution is along natural and predicable lines, moving outward into the lake with the outward setting currents from the various drainage channels. Perhaps the largest area is a broad belt extending northward from the combined South Fork and Council Creek valleys, following the western side of Lake Wisconsin toward the presumed outlet into Black River.

Bear Creek furnishes a very fine example illustrating the peculiarities of its distribution. The road from Tomah to Oakdale enters the valley of Bear Creek some distance from its lower end by crossing a ridge from a smaller valley on the west. This ridge forms a portion of a dissected base plane six or eight miles wide, from the escarpments toward the lake to the limestone covered divide.

The hills being wholly of sandstone, the soil both in the valleys and on the tops is poor and sandy save where they have received material from extraneous sources. As we follow the road from Tomah winding in and out along the bases of the hills, we have for miles a soil of the

poorest quality until we reach the middle of the valley next west of Bear Creek when we suddenly encounter clay covering all the east side of the valley and extending up the hillside to the top. At the top of the hill we see stretching away to the southward a series of fine forms showing the presence of the enriching clay. The obvious interpretation of the phenomonon seems to be that the valley of Bear Creek being occupied by a glacier, the outflowing waters carrying their load of fine material spread over the surface of the plateau until reaching another valley they flowed down its sides.

It is probable that a very considerable share of the clay came from the surface of the limestone divide directly, without having been included in the glaciers. Generally speaking indeed, the observed phenomena seem best explained by the assumption that the glaciers had not a very extended period of activity, but that the conditions were such as to hold them long in a balanced condition, neither permitting much movement, nor yet allowing them to disappear from the valleys.

Resume. In the effort to keep this paper within reasonable limits I have omitted a great share of the details already collected, nevertheless of all the features mentioned there is not one concerning which the work of investigation can be said to have reached a stage approaching completeness. As to most, it is no more than well begun. For example, gravel deposits similar to those about Tomah occur on Silver Creek, a tributary of the LaCrosse River, also on the headwaters of the Kickapoo, possibly also on those of the Baraboo, but I have been unable to visit those regions for the purpose of studying them. Quite a few questions both of fact and of interpretation arise which require the study of a much more extensive region than I have been able to cover. It is moreover, reasonable to suppose that a study of the driftless region as a whole would reveal other features of interest not yet noted.

It is to be observed, moreover, that the synchronism of the various

observed features and their correlation with the various phases of the drift must await a more complete marshalling of all attainable facts. I would recall in this connection the clay parting in the Mississippi gravels, the forest beds of the lateral valleys, and place with them a feature told me by a well digger, namely, that at Valley Junction in digging a well he found near the bottom a log in a good state of preservation, and below that a bed of waterworn gravel from archaean sources. In reaching it, he passed through the thin widespread layer of flint gravel on the surface, then a great thickness of locustrine deposits. This archaean gravel may have been derived from areas of archaean rocks on the old valley bottom, but it may also be outwash from an earlier invasion of the northern glacier. Should this prove to be the correct explanation it is evident that an important piece of evidence would be furnished in regard to recurring glacial and interglacial periods. It would seem also that approaching the drift border from outside as a student of extra drift deposits should, by presenting features in a different light, add much to our understanding of the whole series.

Note.

Further questioning has developed the fact that on the north side of the valley the wells as a rule strike gravel at their extreme bottoms ninety to one hundred feet below the surface. As it is the water bearing stratum they do not penetrate it to any considerable depth. Conversely, some of the wells on the gravel terrace adjoining the river bottoms are said to reach below the gravel into sand and a well on the bottoms sunk upwards of one hundred feet was through river silts for the upper fifty or sixty feet, the rest of the way being through sand showing little or no gravel. I give a diagramatic section across the valley the better to convey through the eye the relationships indicated.

An excellent natural section is shown on the Black River a couple of miles above where its valley joins that of the Mississippi which should be compared with the one given above. A recent burst has cut a deep gully in a terrace, exposing its whole thickness down to the level of the flood plain.

At the top is the Loess having a thickness of about fourteen feet. Below that are about eight feet of glacial sands and gravel. Underlying these, extending to the bottom of the gully some eighteen or twenty feet, and having an unknown thickness additional is a stratified deposit consisting of a somewhat sandy loam containing quite an abundance of small stones from the neighboring hills but no gravel nor indeed any material which could not be derived from its own drainage basin.

No unconformity is shown in this section, but a small one rather further out from the valley walls shows a greater thickness of the sand and gravel deposit resting on an eroded surface of the stratified beds. In mid-valley it was probably eroded very extensively.

Whether there is an older gravel under the stratified beds on the Black River, I do not know, but the one shown synchronizes I think with the upper one of the Mississippi section and the stratified beds with the upper sand on the north side in that section.

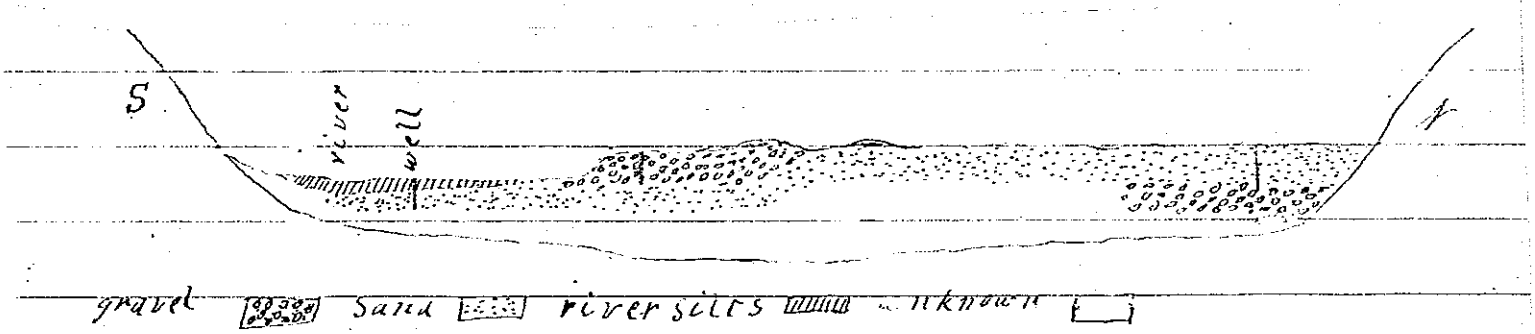


Figure for Note

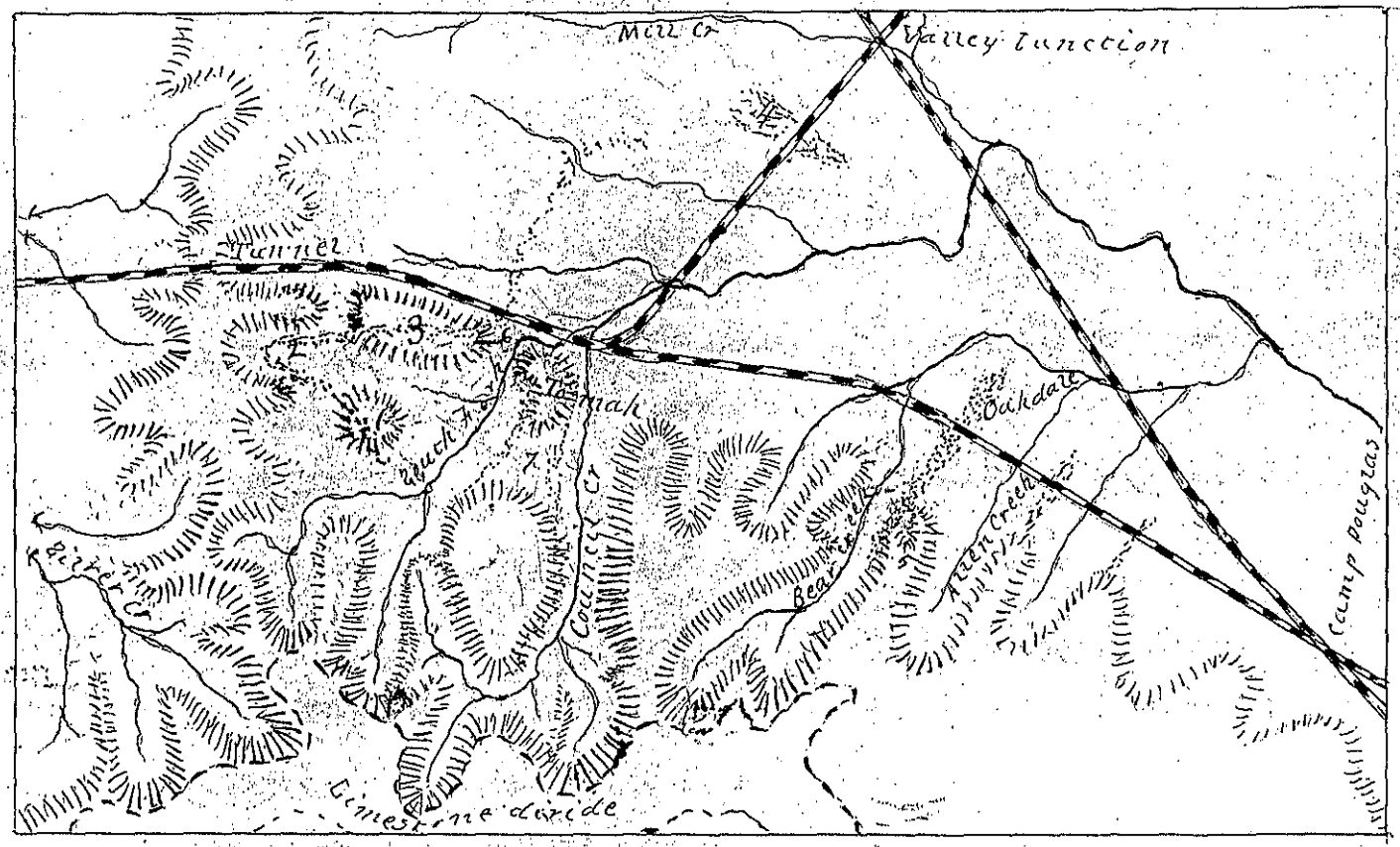
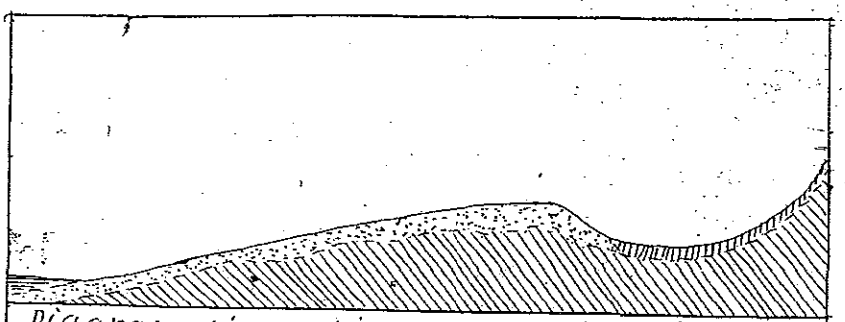
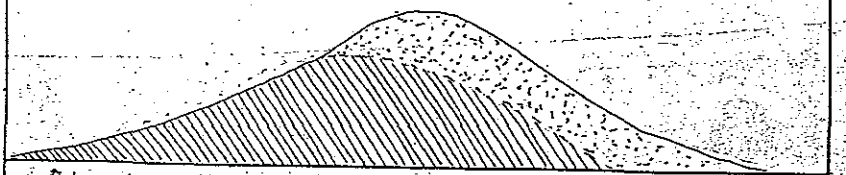


Fig 8 Sketch-map, Tomah and vicinity.
Scale about three miles to an inch.



Diagramatic section at locality No 2



Diagramatic section at east end of ridge
locality No 4. gravel sandstone
loess swamp

Fig 9