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NEW LIGHT ON THE DRIFT IN SOUTH DAKOTA.

BY J. E. TODD.

Hitherto, the writer's study of the drift of South Dakota has led him to consider it to belong mainly, if not entirely, to the Wisconsin epoch. The reasons briefly stated are as follows:

(a) The numerous borings made in the state for artesian wells, have nowhere revealed distinctly, well defined forest-beds or soils, such as are found in some other regions. Though limited sheets of sand have been found in till at certain points, it has not been clearly proved that they are not such as might have been formed by sub-glacial streams or a slight advance of the ice-sheet during a single period of occupation. A few exposures described herein in the eastern part of the state have thrown some doubt upon this point.

(b) The drift in northeastern Nebraska, though suggesting previous advance by an ice-sheet, is, nevertheless, from its thinness and its relation to the Altamont moraine, thought to be due, in part, to the marginal waters; with a possible sub-glacial origin for a portion of it resulting from an extreme advance of the ice-sheet, slightly antedating that moraine. Because this conclusion seemed to disagree with those derived from other regions, the writer's results of several years' work in the Missouri valley have been withheld from publication for several years.

This summer, while revising these results, the following inference presented itself. It is strange that it had not suggested itself before.

I. *Inference from the Trough of the Missouri River.*—Since 1884, it has been generally recognized that the relation of the outer moraine and its drainage channels and attendant deposits, to the Missouri river, and the narrowness of the channel of the latter above Yankton, with the reflection of pre-glacial topography in the ice movements, all indicate that the Missouri river was displaced from the James river valley, and forced to take

its present course above Yankton, by the advent of the Wisconsin ice-sheet. Now the inference mentioned is this: that if the Missouri was so displaced by the Wisconsin advance (and this hypothesis certainly furnishes the best explanation of the known facts), then the James river valley was occupied by the stream previous to that time, at least during the so-called Kansan stage. (Possibly some of its upper tributaries may have discharged to the northeast in pre-glacial times.) If so, we can hardly conceive any sub-glacial till occurring in or west of the axis of that valley or in the Missouri valley above Sioux City. That the James river valley and that of the Missouri river below Yankton, are really identical is indicated by their widths and depths and relations to the drift. If this were not true, then we must believe that both the James valley and the wide Missouri valley below Yankton are of pre-glacial origin to their present depths; that the Missouri was displaced by the Kansan advance; that it must have had another channel below Niobrara or Yankton in that epoch, and that that channel has been so filled that it is unrecognizable, while the Missouri below the latter place has been kept unfilled in some inconceivable way during the recession of the Kansan ice and particularly during the deposition of the loess. If the latter be true, it adds another complication to the problem of the origin of the loess. If the James valley was not a pathway for ice during the Kansan stage, then, if the till in Kansas is really of the Kansan stage, the ice forming it advanced from the Des Moines valley, and the first excavation or the re-excavation of the trough of the lower Missouri is post-Kansan and post-loessial. This the writer urged in his Missouri report,* where he also pointed out an adequate cause for the subsequent great erosion, in the floods of water coming from the whole western margin of the retreating ice-sheet, as well as from the eastern slope of the Rocky Mountains; but he refrains from theorizing further till we have considered other recent observations. We shall find some difficulty with this view.

II. *Old Soil in the Big Sioux Valley.*—Early in September last the writer, with Mr. Bain, of the Iowa Geological Survey, and Mr. Leverett, of the U. S. Geological Survey, visited some instructive localities, near Sioux Falls, which had attracted the attention of the writer; first, in his examination of

*Missouri Geological Report, Vol. X.

the region in 1884, and later, during the season of 1897. Allusion is made to former observations in Bulletin No. 1, of the South Dakota Geological Survey. In the grading of streets in Sioux Falls, at several points, a dark band resembling soil was noted. This is true more particularly north and west of the brewery. This band was first explained by the writer, as marking a temporary flood-plain of the Big Sioux during some stage of the occupation of the outer moraine. He was unable to find evidence of its extending very far from the stream. The soil was underlain by till, and also overlain by that which seemed to be of nearly the same age. During the recent visit, not only were these localities re-examined, but others, developed by more recent grading, were observed near the postoffice, and a more notable example was found a mile or more northeast of the postoffice, in cuts along the Illinois Central railroad. At the latter point, there were found distinct traces of a buried pond, somewhat like a basin of the present. In its deeper portions, there is a depth of several feet of dark soil, containing numerous fresh-water shells — *Valvata*, *Planorbis*, *Limnea*, and also fragments of a cervical vertebra of a large vertebrate; fragments of turtle-shell, resembling the common mud-turtle in appearance and size, and two or three small bones, apparently of an animal about the size of a rabbit. The visit was brief, and further investigation would doubtless reveal more fossils. The vertebrate remains were submitted to Prof. William B. Scott, of Princeton, who determined the largest to be a cervical vertebra of a horse. The other bones were undeterminable.

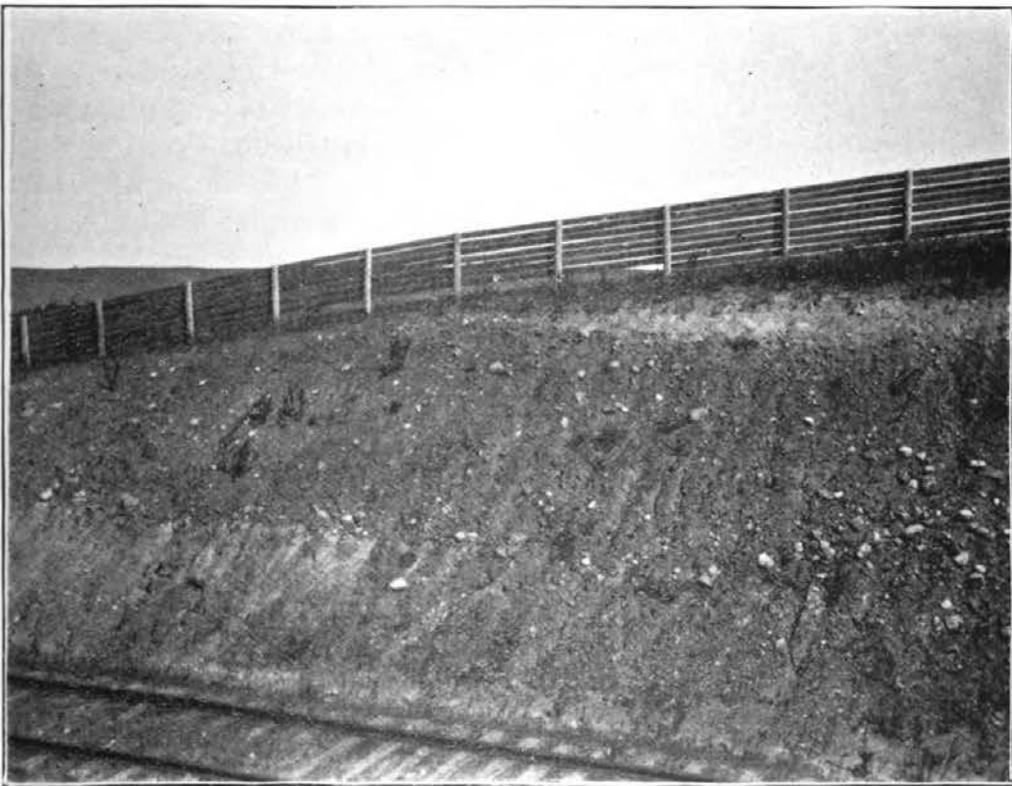
Through the thoughtfulness of Mr. Bain, a series of the shells was submitted to Professor Shimek, in time to have his determinations for this paper. His report is as follows:

“The following are from the Illinois Central railroad cut east of Sioux Falls, S. D.:

- “1. *Planorbis bicarinatus* Say.
- “2. *Planorbis parvus* Say.
- “3. *Physa heterostropha* (Say) Say.
- “4. *Limnea caperata* Say.
- “5. *Valvata tricarinata* (Say) Say.
- “6. *Sphærium sulcatum* (Lam.) Prime.
- “7. *Pisidium compressum* Prime.
- “8. *Vallonia costata* (Müll.) Ster.

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PLATE V.



Buchanan Gravels East of Sioux Falls.

"Of these, one to four are *Pulmonates*, five is a gill-bearer (*Prosobranch*), six and seven are bivalves, and eight is terrestrial. The set one to seven can be duplicated in most of our northwestern ponds with muddy bottoms. Eight is terrestrial, but grows sometimes near the edges of ponds and is common along streams. There is one specimen of this.

"The other lot from Sioux Falls, S. D., 'near the brewery,' contains two species:

"*Limnea caperata* Say, and *Planorbis albus* Müll., probably. The specimens are poor. Both of these are common in northwestern ponds to-day."

West of this pond hole the rest of the underlying till had apparently had its soil, if ever formed, removed by the erosion attending the deposition of the overlying till. Between the two tills is a considerable deposit of gravel. The lower till was comparatively free from pebbles of any considerable size and has been referred to by the writer in his correspondence as a pebbleless clay, but more careful examination during the recent visit, brought out the fact that it contains small pebbles of crystalline rocks evidently of northern origin. In places it is distinctly weathered and resembles loess in color. In such cases, it failed to show effervescence when tested with acid. In the overlying gravel were numerous rotten pebbles and boulders. The overlying till revealed few, if any, rotted boulders. This break between the lower till and the upper till which is so distinctly marked at some points in the vicinity of Sioux Falls seems quite even and horizontal. In the city, tests with acid did not distinctly show difference in age between the upper and lower tills. In general, effervescence was prompt.

East of Canton, there was a similar difference noted between the upper till, which was quite stony, and the lower comparatively pebbleless till, which presented similar characteristics to those noted northeast of Sioux Falls. Between these tills was a deposit of fine sand and interstratified silt. Traces of this same horizon were traced east of Beloit, Iowa, and west of Fairview, S. D. In the latter locality, the lower till was not distinctly traced. It may be remembered that Mr. Bain, in his report on Woodbury county, Iowa, calls attention to the fine sand underneath the till at a high level northwest of Sioux City. At that point, no till had been found underneath the sand. It is known at one or two places to rest immediately upon Cretaceous beds. In that sand, which is excavated extensively for

use in Sioux City, there were found teeth, which were determined by Professor Cope to be *Equus major*. They would correspond in size, so far as can be judged, to the vertebra found near Sioux Falls, and it suggests in a striking way, that we may have here traces of the "Equus" or "Sheridan beds" that have been observed extensively in western Nebraska and Kansas. It perhaps should be added that quite thick deposits of till with gravel occur at a lower level near the Missouri at Riverside park, and seem to be of recent date.

III. *Observations Near Garretson.*—The same party also visited Garretson, northeast of Sioux Falls, not far from Palisades, S. D. That locality is especially interesting because of a small semi driftless area adjacent. Along the railroad the cuts from Palisade to about two miles north of Garretson, failed to show anything like till, and loess was exposed several feet in depth resting upon the surface of red quartzite. This red quartzite is cut into ravines at least forty feet deep in places, but there is no trace of any mass of till, nor of striæ on the surface of the quartzite. More careful examination showed that a few scattered pebbles and bowlders of northern origin were to be found in the crevices of the quartzite, but nothing that would demonstrate that the region had ever been mantled with a deposit of till such as occurs elsewhere. East of town within a few rods, the till appears and in gravel beds found in that direction numerous rotten granite pebbles were found indicating greater age than is common within the moraine. About a mile east, and further to the southeast and south, are conspicuous knolls, largely composed of drift gravel and sand, resembling osars. About a mile south of the town, one of these has been cut into and building sand has been taken from it for several years. It shows several feet of gravel and pebbles resting upon a mass of irregularly stratified sand. In a railroad cut to the east of it, there is found the unusual appearance of a stratum of gravel and bowlders overlain with loess several feet in depth, and resting upon a loess-like silt which is also shown several feet in thickness in some places, while elsewhere it is replaced by loose sand. It could not be distinctly shown that the lower silt was of markedly older age than the upper.

IV. *Preglacial Deposits in Turkey Ridge.*—In the examination of Turkey ridge, there was found, at a point about four miles south of Irene, Clay county, S. D., a stratum of loess-like loam

underlying the drift, and resting, judging from an exposure of that several rods away, upon chalk deposits. A more careful examination may possibly reveal the characteristics of older till in these deposits, but no pebbles were noted where it was studied. Reports from wells in the region seem to corroborate the idea of a preglacial silt in that locality. Turkey ridge is a high divide between the Vermillion and James rivers, which became an interlobular portion of the Altamont moraine.

V. *Recent Fossils from Near Bradley, Clark County, S. D.* — In 1895 Miss Helen M. Buzzell, a teacher in the common schools, became interested in some curious things found in digging wells a few miles north of Bradley. I have not been able to visit the locality and can only quote from her description: “The land here is very rough, showing hills, little level places and big sloughs, or old lake beds. The well is about fifty rods from the foot of a hill, which, I should think, is nearly 300 feet high, at the head of a slough. The latter is hardly a ravine—rather a hollow—and here are the figures as given by the man who dug the well, describing the different soils as they came:

	FEET.
1. Black loam.....	3
2. Crumbly yellow clay.....	14
3. White material.....	3
4. Tree	9
5. Blue clay.....	6

“This is on Mr. J. D. Foley’s place, section thirty-five, Spring Valley township, six miles from Bradley; there are others similar.”

The white material is evidently a white marl. It contains *Valvata tricarinata*, *Planorbis bicarinatus*, *P. parvus* and *Limnea humilis*. Miss Buzzell sent numerous pieces of wood, most of which I judged to be coniferous. They show the characteristic tracheids and resemble tamarack. Specimens of muck, No. 4, contain fresh water shells similar to those in No. 3, and also *Anadonta* and *Spærium bulcatum*. The data are not sufficient as it would seem for asserting that this deposit is interglacial. It may result from the filling of a recent lake basin. If such is the case, it resembles the locality north of Grand View, in Douglas county, which was described in Bulletin No. 1, of the South Dakota Survey, page, 126. Both localities are inside the Altamont moraine.

Conclusions and Suggestions.—From the data given, we seem justified in concluding that there had been considerable deposition of till over the region of the Big Sioux valley, previous to the occupation of the Altamont moraine of the Wisconsin epoch. The readiest explanation, no doubt, is that the ice sheet spread, at least, over the region mentioned, although it seems not impossible that the comparatively pebbleless till which has been observed at Sioux Falls and east of Canton, may have been deposited by marginal waters, and while occasional boulders are found they are by no means as numerous nor as large as in the Wisconsin till. From the comparatively driftless region about Garretson and the direction of the striæ west of Palisades, we can scarcely doubt that the valley of the Big Sioux was occupied by a lobe of ice but that there were patches east which were comparatively stationary,

We have not given the subject sufficient study to speak with confidence and yet it seems permissible, at least, to offer a few suggestions which are little more than speculations.

If we examine the map of the region, we shall find that the valley of the James river in South Dakota is separated by a high table land rising over considerable of its surface, to a height of 2,000 feet above the sea. Immediately north of the South Dakota line, the James river makes its nearest approach to the Red River of the North, the distance being about seventy miles. At that point the divide between the streams is very low and close to the former stream. A cut of twenty to twenty-five feet would probably turn the James river into the Wild Rice and Red rivers. From that point northward, although the divide is about 150 feet above the James, there is no well defined ridge, as further south. This brings us to a serious objection to the view that the course of the Missouri was down the James river valley, especially while the mass of ice was moving up the Red river valley. Moreover, some have thought that the ancient drainage was once northeast through the valley of the Wild Rice. If such were the case, the difficulties of keeping the James river valley open for passage of the water while the Red river valley was occupied by ice, would be still more difficult to explain, if not inconceivable. It seems, therefore, more probable that the dividing ridge, which is now so well defined in South Dakota, previous to the Wisconsin epoch, extended further north, possibly as far north as Devil's Lake; though it was narrower and probably lower there than

farther south; and that this ridge played an important part in hindering the advance of the ice until it had accumulated sufficiently to break through into the James river valley, as it did during the Wisconsin epoch. This would be the more easily explained if the ice sheet from the north, *i. e.*, from the Keewatin center was not so vigorous in the early stages, *i. e.*, in the Kansan and pre-Kansan stages.

From a general consideration of the extent of the so-called Kansan till as compared with the Wisconsin, we may infer that the natural center during the former stage was further east; probably northeast of Lake Superior. In fact, we may conceive that some of the higher points north of Lake Huron were the first to receive a permanent ice cap. As the region became more chilled, the zone of accumulation would extend naturally along the more elevated surface of the ice and then the greatest accumulation would lie naturally near the edge of the zone and advance slowly outward. In this way, we may perhaps account for the greater vigor of the streams passing down Lake Michigan and Lake Superior during the Kansan stage or, as some would say, the latter during the Kansan stage and the former during the Illinoian stage. If we believe the ice to have here pushed forward southwest in the axis of Lake Superior basin, it is not difficult to conceive that its course would lie diagonally across the state of Minnesota, being confined in a broad shallow channel between the highlands about Itasca and the region of central Wisconsin, that it was directed to the Minnesota valley and across it against the high transverse ridge of the "East Coteau" the high divide separating the Minnesota from the James, which now has an elevation of 1,700 to 2,000 feet. From the shape of the land and the course of the stream, it seems not unlikely that the highest elevations were along the axis of this stream. As the Des Moines valley to the south offered an easier slope, we may conceive the ice sheet to have expanded more rapidly in that direction and to have spread out during the Kansan stage, from that valley westward and south into northwestern Missouri. We may account for its failure to press westward over into the James valley by the elevation of the Coteau region and by the diverting influence of the Big Sioux valley, which we may suppose had greater effect upon the thinner edge of the ice which there lay in the zone of ablation.

The failure of the ice to press equally northward may be

accounted for, not only by the ridge, as we have before stated, but by the depth of the Red river valley together with the delaying influence of a north slope. For we conceive it reasonable to suppose that the ice would be more plastic in the region of greater warmth and that there would be more rapid accumulation along the southern side of the zone of accumulation. Both relations would favor such a conclusion.* If such a state of affairs is conceivable, we may not only account for the Kansan till, so far as it is sub-glacial, but we may have found a partial explanation of the more difficult phenomena of the course of the ice during the Iowan stage. One of the strange things connected with that stage is the persistent course of the ice toward the southeast. Now, if the summit of the ice lobe, during the Kansan stage, rose to the altitude of the zone of accumulation in western Minnesota, we may conceive that it might for a time act as a secondary center of glacial motion. The persistent easterly tendency of the ice might be partially accounted for in this way, but we may find another factor in the possible subsistence of the driftless area. The very existence of that area has suggested its former greater elevation, and we have learned to expect subsidence as one of the effects of ice occupation. The Kansan load, acting for a time on the west, and subsequently, if not in part contemporaneously, the Illinoian on the east and south may have at last brought it down to a considerable lower level. The movement of the Iowan ice lobes, both in Iowa and Illinois, would harmonize with such a view. See Leverett's map, "Interglacial Deposits in Iowa," page 8.

*Moreover, Mr. Upham's study of Lake Agassiz would lead us to think there was then greater northward elevation.