

# Proceedings of the Iowa Academy of Science

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Volume 2 | Annual Issue

Article 44

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1894

## Extension of the Illinois Lobe of the Great Ice Sheet into Iowa

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### Recommended Citation

Fultz, Francis M. (1894) "Extension of the Illinois Lobe of the Great Ice Sheet into Iowa," *Proceedings of the Iowa Academy of Science*, 2(1), 209-212.

Available at: <https://scholarworks.uni.edu/pias/vol2/iss1/44>

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except possibly that part of the great river which lies between Montrose and Keokuk, where, for ten or twelve miles, it flows over a rock bed, making rapids so shallow as to necessitate a canal for the accommodation of river traffic during low water stage.

A detailed explanation was given regarding the principal streams of the southeastern part of the state, and the conclusion reached that all except the Mississippi above Keokuk are running in old channels.

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## EXTENSION OF THE ILLINOIS LOBE OF THE GREAT ICE SHEET INTO IOWA.

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BY FRANCIS M. FULTZ.

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In the great southern flow of ice, two streams, one coming through Iowa and the other through Illinois, apparently merged their forces in the valley of the Mississippi. This union extended from somewhere near where Clinton now stands to about the present site of St. Louis. It is not at all likely that the ice streams first met at the northern point indicated; for the center of the movement on the Illinois side was well over towards the eastern part of the state, and likewise the center of the Iowa lobe was a goodly distance away from the Mississippi. From these centers the advancing fronts deployed to the right and left, thus producing movements diverging from the central axis. It was these spreading fan-like margins which first met somewhere near the present line of the Mississippi—just where it would be difficult to say—not unlikely as far south as the mouth of the Des Moines river. From this meeting point the ice would rapidly fill up the valley in both directions. To the southward the two streams would immediately merge and flow as one current. To the northward the ice would pile up until the general level of the two ice fields was attained, when the motion would practically stop, until, through the increasing volume of ice, the width of the direct forward motion in each stream had increased to such a degree

that the angle at the point of meeting was very much reduced. When the angle had thus become small enough, the union of currents would practically be perfect from the junction point, and thence onward the movement would be nearly directly southward. The retreat would of course be in the reverse order of the advance. This might account for the varying direction of striæ; for where we find several sets of markings on the same surface, the oldest trend more nearly north and south and latest more nearly east and west.

There are other factors entering into this problem. This theory supposes that the two ice sheets were contemporaneous, and simultaneously moved up to the Mississippi, near which they met. Now it is by no means certain that they met at the channel of the river. It may have been in Illinois, it may have been in Iowa, or it may never have happened at all; for, as already intimated, the movements may not have been contemporaneous. But whatever doubts there may be concerning that phase of the question, it is reasonably sure that the Illinois glacier once invaded Iowa.

The witness most frequently summoned to testify to ice movements radiating from the region north of Lake Huron, is again called upon. It is the well-known jasper conglomerate. Erratics from this Canadian ledge had been found ranging from eastern Ohio to western Illinois. One from Kentucky is figured in Wright's "Great Ice Age." They are scattered over southern Illinois, even as far south as Louisville, in Clay county, where Mr. Frank Leverett, of the U. S. Geological Survey, recently found one. One has also been found at Alton, Ill., twenty-five miles above St. Louis, and another at Hamilton, Ill., opposite Keokuk. So it was pretty definitely settled that this Canadian ice stream had invaded the country to the present channel of the Mississippi. That it had crossed the river and moved into Iowa soil was thought scarcely possible; yet such is now shown to have been the case. During the present year two of the jasper boulders have been found in southeastern Iowa; one in Des Moines county, about six miles from the river, and one near Denmark, in Lee county, about twelve miles back from the river. The latter was discovered by Mr. Frank Leverett and the other was located by myself. Both were fully 200 feet above low water in the Mississippi.

The presence of these Huron erratics at so great an altitude and so far back from the river, shows conclusively that the ice

sheet must have crossed from the Illinois side and invaded Iowa. It may have been that the two streams met somewhere near the Mississippi, and the Illinois current being the stronger, crowded back its weaker opponent; and then, when the retreat began, the Iowa ice field, released from its pressure, may have followed up for some time the withdrawal of its adversary. Of course the reverse of this might be true. Besides there remains the possibility that the culmination on the one side antedated that of the other. But in any theorizing the invasion of Iowa by the Illinois glacier must be now considered an established fact.

Whatever may have been the earlier sequence of those movements, the Iowa ice stream was last to hold possession of the western bluff of the Mississippi. For this reason few of these Huron boulders will ever be found west of the river. The reasons are based on two different kinds of evidence, glacial scorings and terminal deposits. In Des Moines county glacial scorings have been discovered at no less than half a dozen places.<sup>1</sup> In nearly all instances the markings are deep, amounting to grooves, and, for the most part, remarkably well preserved; so there is no ambiguity as to their evidence. The direction varies from 15 degrees east of south to nearly 80 degrees east of south. This shows either a southeastward or a northwestward movement. Now it can be conceived how the ice from the Illinois glacier might flow westward, even due westward; but the imagination is not elastic enough to account for it moving northwestward at the angle indicated by most of these scratches. Besides, at least three of the scorings themselves give evidence as to the direction of the ice flow. One where the striation of the lateral surface occurs, another where the whole face of the bluff is glaciated, and the third where the intersecting striæ on the level limestone floor tell their story. These striæ, scratches and grooves give no evidence whatever of any other movement than towards the southeast.

Now as to terminal deposits. It is generally supposed that outside of the region occupied by the second ice invasion, marginal deposits are scarcely to be found. Yet there is no finer example of a terminal moraine than may be seen near Sandusky, in Lee county, about six miles north of Keokuk. This ridge is about a quarter of a mile from the Mississippi and parallel to it. It is about a mile and a quarter long and at its greatest depth

<sup>1</sup> White; Geol. of Iowa, Vol. I, p. 93. 1870.  
Keyes; Iowa Geol. Sur., Vol. III, p. 155. 1893.  
Fultz; *Ibid.*, p. 158. 1893.

the deposit measures forty feet or more. The base is not more than thirty-five or forty feet above low water. The ridge is made up almost entirely of erratics. Some of them are quite large; one, which was particularly noticed, had one surface exposed which was fully six by ten feet. There are a few limestone boulders of local origin, but they are generally small and form a very little part of the whole. The ridge occupies the front of a broad depression in the high bluff, which, with this exception, borders the Mississippi from Montrose to Keokuk. It is apparently undisturbed, excepting at the south end, where Lamlee creek has cut its channel through and down into the limestone beneath. Surely no subsequent ice sheet ever moved over it. This boulder ridge marks the termination of a small lobe of the attenuated margin of the great Iowa ice sheet, just before its final retreat. The position of the ice lobe was locally determined by the depression already mentioned.

There is also a boulder bed in the southern part of the city of Keokuk. It is on the very margin of the bluff and lies on the very-much-disturbed surface of the St. Louis limestone. From its position it is not easy to tell from which direction its material came—possibly from both east and west. This Keokuk boulder bed is not brought up as evidence in the present discussion, but simply as a fact of concurrent interest.

The Sandusky boulder ridge and the glacial scratches are probably the dying records of the great ice sheet, when its attenuated margin would be much cut up, and the movements greatly influenced by the local topography. And to me the evidence at present seems clear that these last movements were from the west and northwest. Future developments may change these views. When some one has taken up the subject of erratics and made it a minute study, so as to positively identify them and locate their origin, then the question of ice flows in this locality will be a comparatively easy one.