CUSPS ON THE BEACH OF LAKE MICHIGAN AT EVANSTON, ILLINOIS

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The cusps on the Evanston beach, in common with those described from the sea shore, are irregular heaps of sand, gravel, and boulders, occurring rather uniformly spaced, trending at right angles to the water's margin, and tapering to a point near the water's edge. They should not be confused with the much larger and more permanent cuspate forms found on the prograded shore near Kenosha, Wisconsin. They bear no particular relation to the latter, except that both are formed by wave action.

MATERIALS OF THE SHORE AT EVANSTON

With the exception of a few small areas near Milwaukee and Racine, Wisconsin, no bed rock exposures occur along the lake shore in the vicinity of Evanston. The lake is everywhere bordered by bluffs composed entirely of glacial till and lake deposits. The till is commonly bouldery and is easily eroded by the waves. The clay particles are carried some distance off shore and deposited, but the sand and gravel make up an abundance of beach material which is easily transported and reworked by the waves.

FORM

The cusps on the Evanston beach, when best formed, have the shape of a rude isosceles triangle with the base parallel to the shore line and the apex pointing toward the water. However, they are often imperfectly formed, and some are merely rude piles of gravel or sand with no characteristic form whatsoever. Some are sharply pointed, while others are very blunt at the apex. Some have their greatest dimension from apex to base, while others are longest parallel to the base. It appears that as a general rule the smaller cusps are more slender and more nearly ideal in shape than the larger ones.

SIZE

Much variation in size is found in the cusps, but in any particular set the variation between individual cusps is slight. The largest cusps observed were found to have a length of about 12 feet from apex to base, a width of about 20 feet across the base, and a height of about 18 inches above the general level of the beach. The smallest cusps measured about 18 or 20 inches in length and width and one or two inches in height. Smaller cusps are, no doubt, frequently formed, but because of their slight relief and ease of destruction they escape detection.

In some cases the cusps form a part of the beach ridge thrown up by storm waves, in which case the base of one cusp merges into the base of its neighbor. When the beach ridge is lacking, as it often is, the intercusp areas are likely to run entirely through the line of cusps as a shallow trough.

MATERIAL

In building the cusps, the waves make use of any material available. Since the size of the cusp depends on the size of the waves, and since the larger waves move coarser material than the smaller ones, it follows that as a general rule the larger cusps are made of pebbles from one-half inch to three inches in diameter, and the smaller cusps are made of sand and gravel ranging in size from wheat grains to corn grain. This is largely brought about, no doubt, by the fact that much coarse material is nearly always available for the strong waves to move, and it does not follow that large cusps could not be made of fine sand. But if a difference in the size of material does exist, it is always true that the cusps will be made of coarser material than the intercusp areas.

SPACING

The distances between the apices in a set of cusps are remarkably uniform. In the largest set measured this was found to have an average value of 22 feet; in the smallest set, about 6 feet. While the distances in every set depart from the average (in the largest cusps as much as 5 or 6 feet), the uniformity is remarkably striking. The spacing of one set of eleven cusps will illustrate the point. The distances in feet are as follows: 24, 20, 24, 20, 21, 25, 27, 25, 20, 22.

PERMANENCY

The life of these cusps is ordinarily very short. They are formed only under a peculiar set of conditions, and if these conditions are changed the cusps are destroyed. The larger cusps are, of course, more stable than the smaller ones, because the main mass of them is farther back on the beach and can be reached only by the larger waves. The smaller ones seldom last more than one or two days at most, unless the lake is remarkably quiet. On more than one occasion the writer has found that cusps which were formed in the morning disappeared before noon because of changing conditions on the lake during the forenoon.

RELATION TO DIRECTION OF WAVE

It has been mentioned that cusps are formed only under peculiar conditions. Chief among these, as pointed out by Johnson[1], is that the waves must strike the shore essentially parallel to it. Nothing has been observed by the writer along the Evanston beach to refute this argument. In fact, all observations support it very strongly. The destruction of cusps previously mentioned has been traced, in the majority of cases, to conditions which caused the waves to change their direction so that they came into the shore at an angle rather than parallel to it. Only in very rare cases has the writer observed cusps formed by oblique waves, and here the angle with the shore was very small. The ideal wave for cusp formation along the Evanston beach is a low, gentle swell which everywhere breaks along the beach at practically the same instant.

RELATION TO HEIGHT OF WAVE

The part played by the height of the wave is very pronounced in determining the distance between the apices of the cusps. For conditions along the Evanston beach the following conclusions regarding this relation appear to be approximately correct:

Height of wave *Inches*	Average distance between apices *Feet*
5– 6	6
7– 8	10
12–14	15
18–20	22

[1] Johnson, D. W., Beach Cusps, Geol. Soc. Amer. Bull. XXI, p. 614, 1910.

It will be recalled that for the individuals of the smallest and largest set of cusps observed the average apical distances were 6 feet and 22 feet, respectively. It appears, then, from the figures given above, that the apical distance is directly proportional to the height of the wave. This same conclusion was reached by Johnson[2] some years ago, but the figures given here are based upon observations by the writer.

Waves higher than 18 or 20 inches are frequently found on Lake Michigan, but the writer has not observed cusps formed by them.

From the above it will be seen that the cusps are also often destroyed by the waves merely changing their height as well as their direction. This is especially true if the waves grow larger instead of smaller.

RELATION TO DIRECTION OF WIND

The direction of the wind is a factor in cusp formation in that the wind generates the type of wave that either brings about the formation of cusps, destroys them, or prevents their formation entirely. Inasmuch as cusps are seldom formed unless the waves come in parallel to the shore, it follows that winds giving rise to oblique waves are the ones bringing about the destruction of cusps or preventing their formation. It is easily seen, then, that for the west shore of Lake Michigan winds other than almost due east or west would not likely generate the proper kind of waves for cusp formation. Winds directly from the east are rare in Evanston, but west and southwest winds are common. It has been found that the best time to find cusps on the Evanston beach is a few hours after a pronounced low-pressure area has passed, that is, during the comparative calm immediately preceding a "high" of ordinary intensity, or a short time after the "high" has passed. In the first case the wind will be from the west, with the result that the waves will run counter to the wind as low swells and break parallel to the shore; in the second case the wind will likely shift to almost due east, especially if the next approaching "low" has its center far to the south of Evanston.

[2] Johnson, D. W., op. cit. p. 610.

RELATION TO TIME OF YEAR

Cusps along the Evanston beach are of very frequent formation at all times of the year except in the dead of winter. From the latter part of December until early March, cusps are only occasionally formed. This is because of the fact that during the winter months the water in the sand and gravel along the shore is commonly frozen. Also, mush ice, thrown up by waves, and drifting snow accumulate as a solid wall against which the waves break instead of against the shore. Again, large ice floes often drift against the shore and stop all wave action as long as they remain there. For these reasons cusp formation is reduced to a minimum during the winter.

It is believed that cusps are formed more abundantly in late summer and early autumn than during the spring because of greater freedom of the lake from strong north and northeast winds.

ORIGIN OF CUSPS

Numerous hypotheses by Branner[3], Jefferson[4], Johnson[5], and others have been set forth to explain the origin of cusps, but that of Johnson seems best in accord with the available evidence. The writier will go no further than quote briefly Johnson's theory. It is as follows: "Selective erosion by the swash develops from initial irregular depressions in the beach shallow troughs of approximately uniform breadth, whose ultimate size is proportional to the size of the waves and determines the relatively uniform spacing of the cusps which develop on the inter-trough elevations."

CONCLUSIONS

1. Cusps are formed abundantly on the Evanston beach at all times of the year except in the dead of winter.

2. They are very seldom formed except when the waves strike parallel to the shore.

3. Waves parallel to the shore are most frequently generated when the wind is from the east or west. This takes place when a "low" is approaching, or just after its center has passed.

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[3] Branner, J. C. Origin of Beach Cusps, Jour. Geol., Vol. VIII, pp. 481-484, 1900.
[4] Jefferson, M. S. W., Jour. Geol., Vol. VII, pp. 237-246, 1899.
[5] Johnson, D. W., op. cit., p. 620.

4. The distances between the apices of the cusps in a particular set is approximately in direct proportion to the height of the waves.

5. The cusps are composed of any kind of material available, but it is the general rule that the larger ones are composed of coarser material than the smaller ones, and the cusps are of coarser material than the intercusp areas.

6. Cusps last for only a few days at most. The smaller ones are generally destroyed in a few hours by the waves changing their direction or height.

7. Cusps are developed by the selective erosion of the swash from initial depressions on the beach. The scalloped shore line thus represents a delicate balance between wave erosion and deposition.