ART. XLIV.—*Hillocks of Angular Gravel and Disturbed Stratification;* by T. C. CHAMBERLIN.

MUCH interest has been awakened in recent years in the peculiar gravel mounds and ridges—in part embraced under the terms Kames, Eskers and Osars—which are disposed in varying frequency over a large part of the drift areas of both the eastern and western continents. Numerous writers, foreign and native, have made descriptive and theoretical contributions to the literature of the subject.* With increased attention there has

* Among these the following may be cited as having more or less immediate relevancy to the present topic: Edw. Hitchcock, Geol. of Mass., 1841, Trans. Assoc. Am. Geol. and Nat., 1840–42, Smith. Cont. ix, 1857; W. W. Mather, Geol. of N. Y., 1st Dist., 1842; J. Hall, Geol. of N. Y., 4th Dist., 1842; L. Vanuxem, Geol. of N. Y., 3d Dist., 1842; Ch. Martins, Bulletin de la Société Géologique de France, 1845–6; Robert Chambers, Tracings in the North of Europe, 1850, also, Edinburgh New Phil. Journal, 1853, liv, 229; T. F. Jamieson, On the Drift and Rolled Gravels of the North of Scotland, Quar. Journal Geol. Soc., 1860, xvi, p. 347, also, ibid, 1865, xxi, p. 161, also ibid, 1874, p. 329; C. H. Hitchcock, Agri. and Geol. of Maine, 1861, pp. 271–274, 1862, pp 388–391; Geol. of New Hampshire, iii, 1878; G. H. Kinahan, On the Eskers of the Central Plain of Ireland, Jour. Geol. Soc. Dublin, 1863, x, p. 109, also Dublin Quar. Jour. Sci., 1864, iv, p. 109, and Geol. Mag., 1875, p. 86; C. Whittlesey, Fresh Water Glacial Drift of the North Western States, Smith. Contrib's, 1866; L. Agassiz, Glacial Phenomena in Maine, Geol. Sketches, 1876, p. 101 (originally in Atlantic Monthly, xix, Feb., 1867); A. Erdmann, Exposè des formations quaternaires de la Suède, 1868; N. H. Winchell, Surface Geol. of Northwestern Ohio, Proc. Am. Assoc., 1872, xxi, p. 65, also Geol. Reports of Minn. and Ohio; D. Hummel, Om Rullstensbildningar; K. Svenska, Vet. Akad. Handlingar, 1874; James. Geikie, The Great Ice Age, 1874, pp. 201–237, Riv. Ed., 1876, Kames, pp. 210–225, Eskers, 395–6, Åsar, 407–409; J. S. Newberry, Geol. Survey of Ohio, vol. ii, 1874, p. 41, vol. iii, 1878, p. 40; N. O. Holst, Om de Glaciala rullstensaarne, Stockholm, Geol. fören. Förh, 1876–77, iii, 97; T. C. Chamberlin, Trans. Wis. Acad. Sci., iv, 1876–77, p. 201, Geol. of Wis., ii, 1877, p. 207, Comptes Rendus, Congrès International de Geologie, Paris, 1878, p. 254; Warren Upham, On the Origin of Kames or Eskers in New Hampshire, Proc. Am. Assoc., 1876, Modified Drift, Geol. of New Hampshire, vol. iii, 1878; G. F. Wright, Some Remarkable Gravel Ridges in the Merrimac Valley, Proc. Boston Soc. Nat. History, 1876–8, xix, 47, also, The Kames and Moraines of New England, Ibid., 1879–80, xx, 210; A. S. Packard, Glacial Marks on the Pacific and Atlantic coasts compared, Am. Nat., 1877, xi, 674; E. Orton, Geol. Surv. of Ohio, vol. iii, 1878, p. 646; A. C. Lindmuth, Geol. Surv. of Ohio, vol. iii, 1878, p. 503; W. J. McGee, On the Complete Series of Superficial Geol. Formations of Northeastern Iowa, Am. Assoc., 1878; G. H. Stone, Kames of Maine, Proc. Am. Assoc., 1880; M. N. Elrod, Geol. and Nat. Hist. of Indiana, 1881, p. 154; J. D. Dana, On the relations of the so-called "Kames" of the Connecticut River Valley to the Terrace formation, Am.

been progress in analytical delineation, classification and nomenclature. That there is still abundant room for amplification in these regards is broadly manifest.

As a minor contribution to the subject it is the object of this paper to direct attention to a class of hillocks whose characteristics have some significance.

By way of approach to their taxonomic relations, we may set aside the entire classes of gravel hills and ridges that are formed by *degradational processes*—the chief agency of which is erosive sculpture—not because they are unimportant, but because they are widely distinct in real character from those to be here considered, as will appear from their description.

From the *constructive* classes we may also eliminate those which are formed by littoral and subaqueous agencies, whether these are waves, currents or floating ice, since they are distinguished by characters of their own, and may usually be satisfactorily discriminated from the class in question. We may also disregard those which are obviously caused by violent fluviatile currents in the eddies and angles of river troughs, when their relationship to the valley drift and topographical environment clearly indicate their origin. If we also set aside some less frequent classes of other possible origins and limit our attention to those gravel heapings whose position, constitution and distribution point to an origin springing from the mutual relations of glaciers and glacial waters, we must still distinguish between two somewhat broad classes. (1.) The first predominantly take the form of linear ridges which lie essentially *parallel* to the course of drift movement, notable examples of which are the osars of Sweden and Maine. (2.) The second class more commonly assume the form of mounds—either clustered or dispersed—and when disposed in chains or belts, which is their predominant habit, they lie *transverse* to the lines of glacial movement.

If we correlate these two classes somewhat more widely with glacial phenomena, the first falls into association (*a*) with the linear axi-radiant drift hills so prevalent in many regions (of which the "drums," "drumlins," "lenticular," or "elliptical hills" of New Hampshire, Massachusetts, New York and Wisconsin are special shapely examples), (*b*) with the longitudinal crevasses of the glaciers, and (*c*) with superglacial and, to a measurable extent, sub-glacial drainage.

The second class drop into comparison (*a*) with terminal and

Jour. Sci., vol. xxii, Dec., 1881; N. S. Shaler, Illustrations of the Earth's Surface, Glaciers, 1881, p. 66, On the Origin of Kames, Boston Soc. Nat. Hist., 1884, Feb. 6 (unpublished and contents unknown to the writer); A. Geikie, Text-book of Geology, p. 892; L. C. Wooster, Kames near Lansing, Mich., Science, 1884, Jan. 4; Robert Bell, Report of Progress Geol. Surv. of Canada, 1880–81–82, C. vi, p. 9.

recessional moraines, and all forms of peripheral ridging, (*b*) with transverse crevasses, and (*c*) with marginal drainage. By marginal drainage I mean either that which was intimately associated with the ice-margin, or was essentially limited in its action as a genetic agency to the periphery of the glacier. The waters may have had their ulterior origin back from the margin, either upon or beneath the ice, and, of course, they flowed away from it to the sea, but their efficiency in constructing gravel hills was essentially peripheral.

If correlated with rock topography, it may be observed as a broad and somewhat loose generalization that the first class usually conform, with measurable divergences, to the general rock slopes, while the second are disposed in much negligence of associated rock contours, and often stand in seeming independence if not antagonism to them. If, however, the study of their relationships be carried into detail, the subjacent topography will be found more or less influential in determining the special disposition of both classes, but it will lead aside from the present purpose to pursue this phase of the subject.

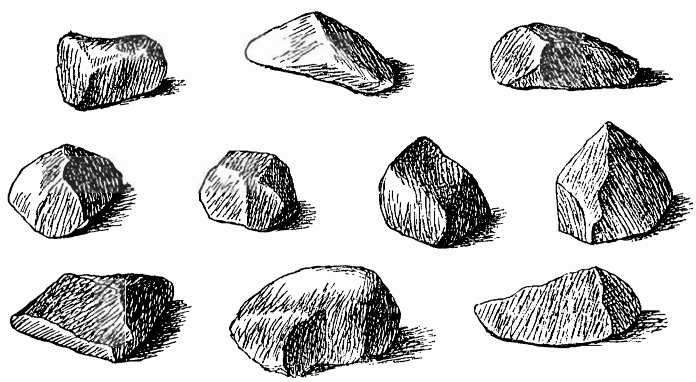
Those of the second class are the almost constant associates of the terminal moraines of this continent, and are, like them, disposed variously, but not altogether indifferently, over summits, slopes and valleys. It is several years since I called attention to the habitual association of gravelly accumulations with the Kettle moraine of Wisconsin, and its correlatives in the interior States.* These vary in form and structure through a somewhat wide amplitude, and as structural classes are not limited to association with well defined marginal moraines, though themselves indirectly peripheral glacial phenomena. It is only to a sub-class of this order that attention is here directed. They became subjects of special interest in tracing the margin of the later drift across the plain tracts between the hilly regions of Wisconsin and those of eastern Ohio, over which reliefs are relatively feeble, and therefore compel the more critical attention. Illustrative examples will be chosen from that region. They are not, however, confined or even predisposed to plain tracts, but frequent also hilly regions, perching upon slopes and summits, and nestling in valleys.

Surface aspects.—The surface contours of these hillocks are somewhat various and probably have no sharply defined limitations. Very commonly they are simple isolated mounds, not conspicuously unsymmetrical, and range from flatter forms not exceeding ten or twelve feet in height to more sharply

* Geol. of Wisc., vol. ii, pages 207 to 211—Le Kettle moraine et les mouvements des glaciers qui lui ont donnés naissance. Comptes Rendus, Congrés International de Géologie, Paris, 1878.—Extent and significance of the Wisc. Kettle Moraine, Trans. Wisc. Acad. Sci., 1876–77.

peaked examples reaching up to forty and fifty feet or occasionally beyond. These simple tumulous forms are more common in the plainer tracts. When clustered they usually assume a rapidly undulatory knob-and-basin contour. Not infrequently they are appendages of more massive ridges of till or till-covered rock in which case they constitute unsymmetrical embossments of varying forms.

1.



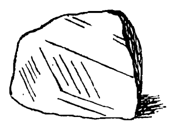
Angular gravel, natural size; from a hillock one mile north of Midway, Madison County, Ohio.

Internal Constitution.—They are built up chiefly of gravel and subordinately of sand, clay and bowlders. Special interest attaches to the form and composition of these constituents and their associations with each other. The gravel is largely formed of limestone fragments,* which, instead of having been reduced to the rounded form common to gravel, retain a high degree of angularity. Their surfaces are, however, worn to a greater or less degree, but it is of the type produced by forceful rubbing rather than rolling. There are not infrequent examples of undoubted glacial striation. The whole aspect of the attrition suggests the common form of glacial abrasion which the stony fragments of till present, modified by slight subsequent rolling. Indeed it is easy to demonstrate that the gravel is directly derived from the till and has suffered little modification in the assortment, for numbers of the hillocks show in certain portions of their diverse material true till, in other portions, till from which most of the clay has been removed; still other portions consist of the rock-fragments of the till with a meagre amount of clay in the interstices; while yet other portions consist of the subangular gravel above described, quite thoroughly separated from the clay and slightly

* The illustrative examples are here described, not the whole class.

worn; and in even yet other portions, the gravel is more notably worn but rarely well rounded. The process of assortment is thus exemplified in all its stages, within the narrow limits of a single hillock. The angularity of the fragments that constitute this gravel is illustrated by the preceding figures, *natural size*, which represent with a fair degree of truthfulness the character of the originals. The selection, it will be observed, is from the smaller grade of gravel, which presumptively suffered more transportation and rolling than the larger fragments.

2.



Striated limestone fragment, natural size, from the above locality.

These specimens were taken from a representative collection seriatim under the limits in size determined upon. Figure 2 represents a glaciated fragment, *natural size*, which happened to be drawn out of the collection with the above group. It would be difficult to find a clearer demonstration of the slight attrition which these gravels have suffered in their assortment from the parent till. It is to be remarked, however, prudentially that so slight a degree of attrition is not universal to the material of the hillocks under consideration, though the above specimens were taken from well assorted and thoroughly stratified beds and were intended to represent the average character of a very considerable number of these hills. There are usually some portions of each mound in which the material is more rounded and there are other accumulations of a similar nature in other respects and similarly situated, whose material is considerably more worn.

The character of the sand and clay comports perfectly with the derivation above indicated. The sand, instead of the familiar well worn grains of quartz, consists, in large part, of particles of limestone with which are mingled minute fragments of shale and some rounded grains of quartz. Numerous acid tests of these sands made in the field invariably elicited prompt and active effervescence, which indicates unleached limestone particles. Under the lens, the grains present, in the main, clean fresh surfaces of characteristic texture.

As an approach to a more accurate determination of their character, 130 grains, selected indiscriminately from the smallest particles that could be conveniently handled (mainly less than 1^{mm} in diameter) were dropped in succession into dilute hydrochloric acid slightly warmed. These were taken from a quantity gathered from the face of an excavation (one mile north of Midway, Madison Co., Ohio) in such a way as to represent fairly the average of six feet vertical depth and twenty feet face, lying between six and twelve feet from the surface. Of the grains so treated, 95 gave notable effervescence, and mainly dissolved; 18 light-colored grains gave no action and were manifestly quartzose; 17 dark-colored grains gave no perceptible response. After digesting twelve hours, 16 dark grains remained and 18 light colored ones. There were in addition a few minute quartz particles, probably nuclear points. or particles that adhered unobserved to larger ones when dropped in the acid.

From the same sample 107 grains, selected indiscriminately, except that a larger grade was chosen (1 to 4^{mm} in size) were treated in a similar way. Of these 94 gave notable effervescence, 9 dark colored grains gave slow or feeble action, and four light colored particles gave no response. This confirmed what a general inspection seemed to indicate, that with increasing size of the grains there was increased proportion of limestone particles, and inspection of the finer gravel stones fully bears out this law. A magnet drawn through the sand brought forth a few bristles of magnetite. Examined under a polarizing microscope the associated dust is seen to be largely quartz, and the finer grains to be mainly quartz and fragments of granular limestone and dolomite, to which are added a few splinters of clean crystalline calcite, an occasional grain of magnetite, and not infrequent dark or black, nearly or quite opaque grains, whose character was not determined.

An analysis of the leading ingredients by Professor E. G. Smith gave:

Insoluble in HCl.		Soluble in HCl.	
SiO_2 =	21·157	$CaCO_3$ =	44·294
Al_2O_3	1·057	$MgCO_3$	26·070
Fe_2O_3	·839		
CaO	trace, undetermined		70·364
MgO	" "		
	23·053		

P_2O_5	undetermined	6·583 subject to correction for loss or gain.
H_2O	"	
Fe_2O_3	"	
Al_2O_3	"	
		100·00

A second sample of finer grain gave:

Insoluble in HCl.

SiO_2	=	21·507
Al_2O_3		2·480
Fe_2O_3		·409
MgO		undetermined
CaO		"
		24·396

Soluble in HCl.

$CaCO_3$	undetermined	75·604 estimated by loss; subject to correction for loss or gain.
$MgCO_3$	"	
Fe_2O_3	"	
Al_2O_3	"	
P_2O_5	"	
H_2O	"	
		100·00

These, in the light of the preliminary inspection, may be interpreted roundly to signify about 70 per cent of magnesian limestone particles, less than 20 per cent of quartzose sand and less than 5 per cent of shale particles. In another aspect they seem to disclose that 70 per cent certainly, and probably 90 per cent, were derived by mechanical action, while probably not more than 10 per cent arose from decomposition.

A similar analysis of a much more worn sand taken from a hill about 6 miles southwest of Bellefontaine, Logan County, Ohio, gave the following results:

Insoluble in HCl.

SiO_2	=	29·341
Al_2O_3		14·516
Fe_2O_3		1·964
CaO		trace, undetermined
MgO		" "
		45·821

Soluble in HCl.

$CaCO_3$	=	31·079
$MgCO_3$		7·885
		38·964

Fe_2O_3	undetermined	15·215 subject to correction for loss or gain.
P_2O_5	"	
H_2O	"	
Al_2O_3	"	
		100·00

This shows a much less, but still large proportion of limestone derivatives and a much greater ingredient of a clayey or shaley character.

The clays, associated with some portions of the gravelly mass of these hills, have not been analyzed, but acid tests in the field indicate the abundant presence of the carbonates. Two conditions of the clay may be recognized, linked by intermediate gradations. The one, in which it constitutes a matrix embracing the stony fragments after the manner of bowlder clay—indeed the mass is indistinguishable from pebbly till—the other, in which it is only a coating of the angular gravel, or a partial filling of its interstices, giving the impression that it is a secondary inter-deposition. These two varieties are connected by intermediate gradations, giving rise to an interesting series of clayey gravels and gravelly clays.

3.

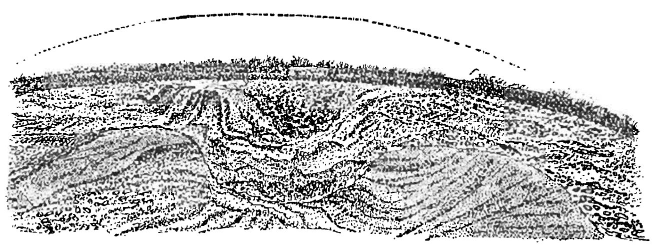
Section of a portion of a gravel hill, showing highly inclined and contorted stratification. East line of Sec. 28, T. XXI, R. 5 W., Jackson, Tippecanoe Co., Indiana.

Stratification.—The gravel in certain portions of these hills is completely assorted and stratified in horizontal layers. A larger proportion assumes various inclined attitudes, and examples of curved and discordant stratification appear in the greatest abundance and variety. But it is to be observed that the slope of the inclined beds is not limited to the moderate inclinations to which such material is confined when deposited under running water, but stands at all inclinations, even up to verticality. Moreover the beds are often twisted and contorted, or crushed into confusion, and occasionally, though rather rarely, broken and disjointed. The partially assorted portions partake most of these anomalous attitudes, being pushed into various irregular shapes and curiously inwrought among the better assorted portions. It is in association with these disturbed beds that the till-like portions are found. Vertical and inclined *veins*, more or less irregular, and filled with a very fine silt, occasionally present themselves. The accompanying figures very imperfectly represent the general aspect of the interior structure of these hillocks. To fully appreciate their real complexity, it is necessary that the study of the actual section should be carried into detail.

It thus appears that these hills present gradations (1) of material from mixed stony clays to finely assorted sand and gravel; (2) of attrition, from that of the glaciated till fragments to moderately worn sand and gravel, and (3) of stratification, from contorted and disturbed beds to almost complete horizontality. The interesting fact is that this occurs within the limited compass of a single hill, it may be a mere hillock, scarcely exceeding in size an artificial tumulus.

Inferences.—The following inferences are drawn, if not altogether from the brief statements above made, at least from the wider range of facts observed.

4.



Section of a portion of a gravel hill near Midway, Madison County, Ohio, showing discordant and contorted stratification.

I. *The angular gravel is an immediate derivative from the adjacent till.* This is manifest from its passage into till through a complete series of gradations, and from the identity of its stony constituents with those of the till.

II. *The material is of extremely local derivation*—considered as a secondary formation—(1) because it is so little worn in its extraction, (2) because it is so imperfectly and so variously assorted, and (3) because of the intimate stratigraphical associations above indicated. Considered as to its ultimate genesis through its parent till, it is at least not of remote origin, in the main; for, aside from the lithological and paleontological evidence that is applicable to the coarser material, and by inference, and to some extent by microscopic inspection, to the sands and clays, it is manifest that material containing from 40 to 70 per cent of limestone was not derived from the crystalline rocks of the Canadian highlands, nor from these combined, in the ratio of surface exposure, with the Lake-basin series of sandstones, limestones and shales, nor even from these combined ratably with the formations adjacent to the deposits. If a uniform shaving were cut from the face of the successive strata from the Canadian heights to the locality of the deposits, it would not give the higher percentage of calcareous and magnesian material, even if no account were taken of surface-leached material, which must inevitably have become mixed with the drift. The character of the material indubitably indicates that, while a minor portion was brought from distant sources, the great mass was gathered from the adjacent limestones.

III. *These hills were formed in the presence of an intermittent disturbing agency.* It seems quite impossible to explain the curious relations of the disturbed and undisturbed portions of the mounds by postulating a single thrust, or even a succession of disconnected sudden impulses. It seems necessary to assume the continued presence but intermittent action of the disturbing agency. This is strengthened by the following consideration.

IV. *Their formation required a special localizing agency.* This is most apparent in the cases of isolated mounds on broad plain tracts of till, or of embossments on the slopes or crests of ridges. No existing agency, by any extension of its magnitude, is at all competent to account for their localization. The formative agency, or combination of agencies, must have produced, at once, local assortment and local heaping of the assorted material, or, in other words, the assorting waters must have been confined and concentrated in their derivative action, and likewise constrained so as to heap their material into tumuli, whose location was determined by the constraining agency more than by any feature of the local topography or other present condition.

V. I infer, therefore, that these hills could not have been produced by any form of beach action, whether assisted by ice or not, because, in addition to what has been previously implied, their external forms, their irregular dispersion, their varying altitudes, defying reduction to horizontality, as well as their otherwise irreconcilable topographic situations, are incompatible with such an origin.

VI. Their inherent characteristics, taken in connection with their association with morainic belts, supports the opinion that they were formed along the edge of the great ice sheet by numerous marginal streams. The disturbance of bedding and the intrusion of the till masses are attributable to the oscillatory action of the ice, while the partial assortment, feeble attrition of the gravel and the multiform phases of stratification, were accomplished by the issuing streams. The localization of these streams was of course determined by the special conditions of glacial drainage then existent, but now largely past determination. The heaping of the gravels is thought to have been aided by the ice which restrained both the stream and the dispersion of its products. The special phases of accumulative action were probably somewhat variable, being sometimes purely marginal, the heaping being at the *debouchure* of the streamlets, sometimes within the walls of subglacial tunnels* or small marginal ice cañons,† and sometimes, perhaps,

* Hummel, loc. cit. † Upham, loc. cit.

at the base of moulins, so near the edge of the glacier that their products did not suffer obliteration by subsequent mechanical action of the ice. I have been unable to satisfactorily picture the precise process of formation of all forms of the accumulations under the conditions of any one of these methods alone, but as all were presumptive attendants of glacial action, the various forms seem explicable by their several, or their joint, agencies.

The hypothesis of formation in this manner is in complete harmony with the local character, the angular forms and the chemical constitution of the sands and gravels.

If they had been formed by superglacial streams, it seems necessary to suppose: (1) that a much larger proportion of distant material would have been present, even if it is maintained that subglacial material rises promptly to the surface of the ice, a view which I do not entertain; (2) there must have been a more complete assortment of the material, since superglacial streams are necessarily rapid and have great selective power; (3) there would probably have been more notable attrition and (4) a greater rarity of small glaciated stones, since these are very rare, if not altogether wanting, in superficial debris.

Significance of Calcareous Character.—The highly calcareous composition of this material is worthy of special note and, independently of other considerations, is very significant of the mechanical origin of the drift. The residuary material which covers non-glaciated areas within and about the drift-bearing territory is essentially non-calcareous even when derived from limestone, as I have satisfied myself by numerous field tests over a wide area and as is being demonstrated more thoroughly by special investigations in the hands of my assistant, Mr. R. D. Salisbury, undertaken with a view to develop more precisely the important truths that lie along this line of approach to the problems of the drift. Calcareous sands of the nature above described, are, so far as I can learn, wholly unknown in non-glaciated regions and are a product quite irreconcilable with the pre-glacial conditions that prevailed in the region where they are now found.

Nomenclature.—It would be quite within the sanction of prevalent practice to dub these hillocks *kames*, and there make an end of it. But at the outset of this article the manifest need of a stricter classification was alluded to. This must necessarily carry with it, or at least eventuate in, a more precise use of terms. These terms should be either simply structural or simply genetic, or else indicative of a given structure having a given origin. At present the term, *kames*, is applied broadly to embrace, on the one hand, mounds, hummocks and peaked hills, and, on the other, extensive branching gravel ridges, the two classes standing to other glacial phenomena in the contrasted relations I have previously pointed out; to say nothing of the probable inclusion under the term of fluviatile and littoral accumulations or degradational relics having no direct relationship to land ice. It is doubtless much too early to determine a final classification and nomenclature, but I think it will be a wholesome advance in that direction to restrict the term *kames* to mound-like and short-ridged accumulations whose distribution is obviously or apparently peripheral to the formative ice, and to distinguish from them under the name *osars* the extended linear and branching ridges that lie parallel to the lines of glacial movement and that belong to the longitudinal class of glacial features.* We may need to carry our distinctions much beyond this It is to be hoped that it will be possible to draw discriminations close enough ultimately to distinguish between the accumulations of (1) peripheral, (2) subglacial, (3) superglacial, and (4) ice-cañon streams, and (5) moulin cataracts, and also between the products formed in connection with (1) glacial advances, (2) glacial halts, and (3) glacial retreats. It is not improbable also that it may become important to distinguish between the drainage products (1) of active, and (2) of stagnant glaciers or glacial remnants. It is, for me at least, very difficult to form a clear and satisfactory conception of the formation of osars, one or two hundred miles in length and forty to one hundred and eighty feet or more in height, with lateral branches and meandering courses, like those of Sweden and Maine, in connection with active moving glaciers. The time requisite for the accumulation of so considerable an amount of worn and assorted material was by no means trivial when reckoned in terms of ordinary glacial motion. This motion of the ice seems incompatible with the meandering courses, and the branching forms, if not with the structure and definition of the ridges. Nor is complete satisfaction afforded by the view that they were formed progres-

* By reference to the discussions of thirty and forty years since, it will be found that the term *osars*, in its Anglicized form, was in common use as the accepted name of this class of deposits, and on this account has claims to retention. See, among other possible references, Am. Jour. Sci., xlv, 1843, p. 322, where Dr. Jackson identifies the gravel ridges of Maine as *osars;* also, Hitchcock's Elementary Geology, where *osars* are specifically defined and the term repeatedly used as one of common acceptance; also, Geol. of Lake Superior Land Dist., p. 236, where Desor likens certain gravels to "those curious ridges in Sweden, familiar to European geologists under the name osars." Also, Murchison's Geol. of Russia, vol. i, pp. 542-556, where the use of the term implies its adoption even among English writers.

But a more important reason for the retention of this term lies in the fact that the Swedish *osars* are a thoroughly typical and distinctive class, while the Scottish *kames* are comprehensive and need differentiation. The descriptions of Dr. James Geikie, which have done so much to foster interest in them, give precedence to the mound type, and justify us in restricting the term to that dominant class.

sively in channels cut back into the retreating edge of the ice by superglacial streams.*

Not to enlarge upon the subject here, suffice it to say that there are many features of the great branching osars that strongly invite the belief that they are the products of the drainage system of practically stagnant glaciers.† If this view be sustained—and that will depend, of course, not so much upon its aptness as an explanatory hypothesis, as upon collateral and independent evidence that the dissolving ice sheet, in its closing stages, became stationary in the areas involved—there will be room for a wide dynamic distinction between these by-products of ice under minimum motion, and the kames associated with terminal moraines, which are the offspring of glaciers at a stage of nearly maximum activity.

To what an extent it may be found serviceable to use distinctive genetic terms for these several classes, can only be adjudged when their respective prevalence, and the success with which they can be trustworthily discriminated, shall have been determined. Meanwhile the general structural distinction between elongated osars and hummocky kames is needed to avoid in some measure confusion of types, and to secure convenience of expression. This restriction and special application of the terms, kames and osars, is in accordance with the predominant, but not by any means uniform, foreign use of the terms, which is indeed not discriminative. Beyond question difficulties arise in the strict application of the terms, since the elongated ridges occasionally break up into clustered hillocks, and the transverse belts are attended by linear ridges, so that, structurally considered, the two types merge into close association. So also, genetically, they are related in the fact that they spring alike from the mutual relations of glaciers and glacial waters, but it seems more important to recognize the wide general distinction, than to employ a terminology so broad as to embrace phenomena that are diverse in such an important sense.

Under this restriction of terms the hillocks under discussion would be classed as kames, and would constitute one of their most distinctive, though perhaps not most common, types.

* Upham, Origin of Kames or Eskers in New Hampshire. Proc. Am. Assoc., 1876, xxv, 216.

† Prof. Stone, who has studied these special forms more extensively than any one else in this country, expresses the conviction that the flow of the ice as a whole had ceased at the time of their deposition. (Kames of Maine, p. 469.)