XLVI. *On the SURFACE GEOLOGY of GLASGOW.* By Mr. JAMES BENNIE.

(Read December 7th, 1865.)

THE three great divisions into which the superficial deposits of the district in and around Glasgow naturally group themselves,—the period of land ice, represented by the boulder clay; the period of sea deposits, represented by the boreal shell beds; and the recent or human period, represented by the sand and gravel beds, containing canoes—certainly in part, if not wholly, of fresh water origin—are not only better exhibited in this district than anywhere else, but the amount of observation bestowed upon them has rendered this classic region the most typical among the post-tertiary deposits of Scotland.

The peculiarities of the boulder drift early attracted the attention of our local geologists, and were accurately described by them; but, when they tried to account for its origin—having no light to guide them but that of their own experience—they failed completely. The phenomena of the boulder drift was attributed to the action of water, not, of course, in its ordinary action, as they instinctively felt that such action was quite insufficient to account for them, but to some of its extraordinary exceptional effects, such as those occasioned by “earthquake waves,” and some imaginary ones,—“waves of translation,” as they have been called. Theories such as these, did little good, except to excite discussion, and keep observation alive. During the meeting of the British Association, held at Glasgow, in 1840, a good example of our boulder drift—exposed by the levelling of what was then known as “Bell’s Park,” was pointed out to Agassiz; and he, being familiar with the various forms of ice-action, from recent study of the glaciers of the Alps, immediately recognised the peculiar striations on the pebbles and boulders as the result of similar agencies, and with characteristic courage declared the boulder clay to be a true deposit of moraine matter. That opinion, as it explained the best understood phenomena of the boulder drift, was accepted by most geologists; but, being carried to extravagance in a theory which supposed the glacial conditions to be universal, instead of restricted to those localities in which the boulder clay existed, it was neglected for some years, and the action of icebergs and coast

ice called in to account for the phenomena. Of late, however, geological observers have reverted to land ice again, and as many new facts have been discovered which it alone seems capable of explaining completely, this last adoption of it will probably be final.

Shortly before the visit of Agassiz to Glasgow, light broke in unexpectedly from another quarter upon the mystery of the boulder drift, and made its glacial origin probable. The venerable President of this Society, Mr. Smith, of Jordanhill, instituted a series of researches, first on land at Dalmuir, Paisley, Ardincaple, Balnakaillie, in the Kyles of Bute, and other places, during which he extracted from these old sea beds, 190 species of shells, among which were 19 species utterly unknown to local collectors; and, afterwards, to make certain that these might not be yet lurking undiscovered in the neighbouring frith, he searched it thoroughly by a long course of systematic dredging. On comparing the lists of the dead shells from the land, with the living shells from the frith, the remarkable result was elucidated, that a large per-centage of the former were non-existent therein at the present time. These were at first supposed to be extinct species, but Mr. Smith having recognised several as identical with shells from Uddevalla, in Sweden, they were submitted to M. Deshayes, the eminent French conchologist, and recognised by him as living arctic shells; and this clue being followed out, the great fact was established by Mr. Smith, in 1839, that, during the times represented by these shell beds, the climate of Scotland was half arctic in its character, and thus the life of the period bore ample testimony to the teaching of the glacialized pebbles and blocks of the boulder drift.

Of the third or human epoch, characterised by the canoes, little is known geologically; the observers in this field being antiquaries, and not geologists, their attention was absorbed in the canoes, to the neglect of the beds cut through in excavating them. They cannot, therefore, speak with decision, as to whether the water in which the canoes floated was salt or fresh, river or sea. Marine shells indeed were found in one, but being edible species—"whelks and mussels," they might have been shipped as cargo; and their marine character is therefore of no account in settling the question mooted. Of the canoes, as works of art, an excellent description is given by Mr. John Buchanan, in his "Desultory Sketches," published in "Glasgow, Past and Present." From the details given by him, we must conclude that the period was a long one

during which man advanced from hewing trees into canoes,—little better than simple rafts that could only enable him to float upon water he could not wade through—to building boats as elaborate as herring wherries; and from using only implements of stone, to handling tools that must have been made of iron.

I have considered it necessary to give this rough outline of what has been hitherto known of the surface geology of Glasgow, as it will introduce what additions to it, recent excavations of the surface deposits in and around the city have enabled me to make. But ere I break ground to note what lies underneath, it will be necessary to attend to the form of that ground; as topography often suggests, and indeed sometimes proves, the geology of a district. The inference early drawn from the discovery of the canoes in the ground beneath Glasgow—that its site was once the bottom of a frith or lake-like river of goodly width and depth—is confirmed by the form of the area over which the canoes ranged, which is everywhere decidedly deltoidal in shape; all the low-lying parts of Glasgow being comparatively level as the bed of a lake or river would be; while all the higher parts of the city, those eminences known in local language as “hills and braes,” such as Drygate Brae, Balmanno Brae, Garnethill, and Cranstonhill, on the north, and Rutherglen Brae, Langside Hill, and Ibrox Hill, on the south, overlook the lower parts in a way which suggests the idea that they were banks which bounded in this ancient lake or frith. The delta thus indicated in the city, becomes quite apparent in the country above or below Glasgow. If we trace it upwards, we find it converging to an apex at the gorge out of which the Clyde issues beneath Blantyre Priory; and if we trace it downwards, we find it opening out fan-like to near Bowling, which may be considered the bottom of this ancient delta of the Clyde—a goodly one without question, to the formation of which the *debris* of Clydesdale has gone for many hundreds of centuries.

When we examine this old delta lithologically, we find it to be composed of sands, gravels, and clays, in no way differing from what the Clyde deposits in the delta now forming between Greenock and Helensburgh; and we may therefore conclude that the older Clyde, and the country through which it flowed, was in character identical with that of to-day. But if we examine the banks of this old delta, those mound-like hillocks that skirt it on either side, we will find them composed of strange materials—clay over-

crowded with stones, of shapes as different as their characters are diverse; but all agreeing in certain peculiarities which individualise them beyond all precedent, and make the formation they mark, that unique one known as the "boulder drift." It is very largely developed in Glasgow, all the higher parts of the city being built upon it; yet, as I have little that is new to record, I will not enlarge upon it, but merely state a fact or two which will confirm the theory of its being exclusively a deposit of land ice, or help to fix its position among the beds under consideration. About twenty years ago, Bell's Park—that hillock which Agassiz has made famous in post-tertiary geology—was built upon, and became an integral part of Glasgow, during which operation it was so thoroughly dissected and exposed to observation, that if any remains of shells, or other forms of marine life, had been in it, some trace of them must have been seen in the minute examination to which it was then subjected. None, however, were observed, so far as I could ascertain. On the contrary, a sight was revealed that would have delighted Agassiz, as it gave positive testimony to his theory. The surface of the underlying rock was exposed, and found to be completely glacialised, polished, striated, and even moulded, though somewhat minutely, in the fashion called "*roches moutonnées*." The direction of the *striæ*, and the form of the mouldings, proved that the ice had come from the west—the very direction from which the boulders had been judged to have come, from their mineral character agreeing only with rocks situated to the west of Glasgow.

In the "hills," the boulder clay overtops all the other drifts of the delta, and might, therefore, be supposed to overlie them, while in truth, it dips underneath and underlies them all. This was well shown in Tod & M'Gregor's graving dock, at Meadowside, Partick, situated in the middle of the delta. The strata cut through was, first, sand and shingle, equivalent to the river drift, succeeded by a thick bed of brick clay, corresponding to the glacial shelly clay; then a thick bed of muddy silt, which I have now no hesitation in thinking to be the fine white sand that now bulks so largely in the surface geology of the district; and, lastly, the boulder clay, identical in every respect with that of the "hills;" and into it there projected from beneath, a pinnacle, of soft carboniferous sandstone, as if for the purpose of satisfying geologists that the section was complete. Another example of the boulder

drift occurring under all the surface deposits, is shown at present in the banks of Clyde, at Westthorn, immediately above "Harvie's Dyke," and in the banks of Dalbeth burn. In both cases, the boulder clay is so well marked, as to be unmistakable; and the thick bed of brick clay above it, must be simply the outcrop of the Camlachie clay fields, exposed by denudation.

I come now to the delta itself, and to the recent excavations which have revealed the true geological character of the sand, gravels, and clays, which compose it, and of the conditions under which they were laid down. The principal of these excavations is that of Windmillcroft dock; but ere describing what was shewn there, it will be necessary to epitomise the phenomena of a similar kind which have been observed in other parts of Glasgow, as these will better serve to elucidate the true character of the sections there exhibited, and shew, that, to explain them, it is not sufficient to extend the range of the present river by imagining impossible floods in it, or shiftings of its course, so as to overrun repeatedly the whole space over which the river drift is now found—from Cranstonhill to near Langside Hill—but that we must suppose a river of that width, with a corresponding flow of water down it, though probably of no great depth. These observations, carried on for many years, and extending over the whole area of Glasgow, from Hutchesontown to Whiteinch, Partick, are too numerous to be detailed here minutely in the order in which they were made, but the results of them all, summed up as follows, must suffice :—

First,—The centre of this old delta is occupied by a series of silts, sands, and gravels, so like river *debris* that I can only call them "Clyde drift," meaning thereby that they consist solely of the waste of the country which the Clyde drains, carried down by it, and deposited in its quieter depths, which happened to be then situated where the city now stands. This drift I found to contain great beds of vegetable *debris*, consisting of leaves of trees, sprigs of moss, nut shells, pieces of bark, and wood rounded into pebbles, in fact, everything that could float and be carried by water. This vegetable *debris* had evidently once been the same sort of wrack that we now see carried down by the Clyde in every autumnal spate, and deposited in every quiet nook and corner of its course, there to remain till it sinks through over-saturation, and is covered up by the next precipitation of sediment that occurs.

These beds of sands and gravels extend from five to fifteen feet in depth, varying greatly in short distances, showing that the surface of the lake or frith bottom had many hollows in it, scooped out, most probably, by the water that carried the gravel. At the foot of the gravel bed a layer of large pebbles, broken boulders, and odd-shaped pieces of stone, invariably occurred, the origin of which has cost me many a thought, but I could never hit upon a satisfactory solution, and the puzzle is a puzzle still.

Second,—Below these sands and gravels, a bed of a very peculiar sand shewed itself in several foundations for stores in Robertson Street and James Watt Street, at the General Terminus Railway, and at the excavations for Mavisbank Quay. It was, when dry, white, soft, and almost impalpable to the touch, singularly free from grit or gravel, indeed, often totally free, and rarely marked by lamination, ripple mark, or false-bedding. The contrast between it and the gravel above was striking, and never failed to suggest a very diverse origin to that of the rough ochrey gravel lying immediately above it. I instinctively styled it “sea sand,” as it seemed to me that only “in the stillness of some central sea” could such sand sink; and I explained the abrupt change from it to the rough gravel, by supposing, that an upheaval had taken place, in the interval between them, by which the sea bottom had been lifted up from a region of quiet deposition by gravitation, to a region where currents, tides, and waves prevail. Whatever may have been the cause, the change is remarkable, and arrests the eye and fascinates the mind at once.

Third,—In many places excavated for sewers,—especially in the eastern parts of the city, a thick bed of firm, compact clay was frequently exposed. It was always highly laminated, and often, nearest the surface, full of decaying roots or stems of water plants, which were evidently *in situ* and had lived and died in the clay. In neither of these three deposits did I find, at that time, any shells or other signs of life that could enable me to settle the character of the water that deposited them. I did not, however, conclude that no life had ever been there, but imagined that, during the long period since this old delta had been elevated into dry land, the rain water, penetrating freely through the loose sand and open gravels, had wasted away the shells once lodged in them, and made them only *apparently* azoic, a guess which subsequent discoveries have shown to be very near the truth.

I now come to the excavation of Windmillcroft dock, the strata exposed therein, and the discovery of shells in it, which have at length told us in the unmistakable language of Palæontology the true character of these sands, gravels, and clays, and reduced them to such orderly sequence that we can now read their history with ease. The excavation was divided into two periods—the first, undertaken by the Clyde Trustees themselves, some seven or eight years ago, during which the western half of the dock was only half dug out, when it was stopped by a temporary fit of economy on the part of the Trustees elected under their new constitution; the second excavation was commenced by the contractor for the dock last year, and is now almost completed. During both periods, delighted with such a favourable opportunity of studying systematically the strata I had so long explored at random, I attended almost daily upon the progress of the diggers, and watched everything turned out. The sections exposed during the first excavation were not deep, only ten or twelve feet deep at most, but they revealed the two strata of river drift and sea sand, as shewn in excavations in other parts of the town. The beds of vegetable *debris*, also, were identical in appearance, but more determined in character than in other places, many large oak trees occurring amongst them. The dimensions of one may be noted. It was sixteen or eighteen feet in length by three and a-half feet in diameter, and had been stripped of its bark by water action; it was rotten on the outside, but quite sound at the heart, and had evidently been long knocking about as a “drift log” in the old estuary ere it had sank in its waters. As a whole fleet of canoes had been found in excavating for Springfield Quay, adjoining Windmillcroft, I expected that, during the excavation of it, some might be found there also, and the ambition of my heart satisfied by assisting at the discovery of a canoe. None, however, were discovered—all my wishing, waiting, and watching, failing to bring one to light. However, it was not all in vain, as I had the happiness to find several articles which must have belonged to the old canoemen, and been used by them in the daily economy of their life. I looked anxiously for shells, bones, or any evidence which might characterise the water as salt or fresh, but saw none sufficient to determine that point. Once, however, I saw the shadow of a shell, the epidermis and cast of it in the sand, but supposing it to be that of the common edible mussel, which some

old canoeman might have chucked overboard, after baiting his line, I failed, then, to realise the fact which I had in my very grasp.

Ere I describe any of the sections in Windmillcroft, I may note the dimensions of the space at present excavated, and the solid contents taken out, in order that those who have not visited the dock may form some idea of its extent, and realise for themselves how good a sample of the old delta of the Clyde, and of the bottom of the sea that preceded it, I had the good fortune to examine and draw my conclusions from. Length of excavation, eleven hundred and fifty feet; breadth, two hundred and seventy feet; depth from the original surface, twenty-two feet, which gives upwards of six and a half millions of cubic feet of soil removed. There is still fourteen feet in depth to be excavated, but as that is to be done by dredging machines, the same facilities for observation will not recur; but it matters less, now that we know the probable character of the beds the dredge will traverse.

As the sections varied much, I must describe two at least, taking first, that beginning at the foot of West Street and running westward, as it holds the key to all the rest, by containing the clay with boreal shells in it, and therefore the most typical of them all. In this section there occurs, under the surface, rubbish and vegetable mould, say two feet, succeeded by a soft red sand three feet thick; next, a bed of open gravel, having but little sand intermixed with it, four feet thick; then a bed of clay, similar in every respect to our common brick clay. This was cut through to a thickness of eleven or twelve feet, but it goes several feet farther down. Beneath this clay the white sand must lie, because at a little distance from the face of this section the clay thins considerably, and the white sand crops out from under it. At the distance of forty or fifty yards from the foot of West Street, the bed of clay ends abruptly, being cut off by denudation, after thinning out to only four or five feet in thickness. The upper bed of gravel lay in the hollow, and took the place once occupied by the clay, so that in the section, after that, there was seen soil, two feet; soft red sand, three feet; gravel, with much sand now mixed with it, seven or eight feet; white sand, five or six feet. But these thicknesses are not persistent for any great distance, the white sand sometimes disappearing out of the section altogether, and the river drift, in the form of rough sand or grit or vegetable *debris*, extending to

the bottom of the excavation, a depth of twenty-two feet. This, however, is exceptional, it being evident that a hollow had been scooped out by denudation in the clay and white sand, into which hollow the river sand and gravel had been drifted—a fact worth recording, as absolute depth is on that account no safe guide, and cannot be depended on in such circumstances. The significance of this caution will be seen hereafter, when we try to fix the age of the causes.

The sands, pebbles, and broken boulders, but, above all, the large slabs of splint coal, testify as to the rocks from which they had been derived—the upper coal measures, which the river traverses before it reaches Glasgow; but, from many circumstances, I have come to the conclusion, that very little of this drift had been derived directly from these rocks, it being essentially a re-deposit from the boulder clay and other glacial drifts in the upper wards of Clydesdale. Many facts proved this: not a few of the pebbles had the hunchback form common to glacial pebbles, and some were still partially marked with striæ—a good sized boulder of boulder clay once turned up, and at another time a patch of it, so large, that it looked like an outlier of that formation still *in situ*. From both, pebbles were obtained, as intensely glacialized as any from the “hills” of old boulder clay round Glasgow. Pebbles of the brick clay, that lay beneath or rather just beyond the land, occurred in it not unfrequently. Rounded bits of peat moss, and fragments of those pipe-like incrustations that are formed round roots and stems of plants, showed that the river had not spared its own banks in former times. Everything about this drift testified that it had been swept down by a great river like the Clyde, draining a country such as Clydesdale is now. Like all others, this portion of the river drift had its beds of vegetable *debris* in all the various forms—leaf beds, drift peat, water-worn twigs, and nut shells. Space will not permit a description of these beds in detail, even if I were botanist enough for the task, but I think a good service might be rendered to science if some botanist zealous enough were to make a special study of these old leaf beds of the Clyde—representing, as they do, the old flora of Clydesdale—and give us a good monograph on the subject; not only would he earn fame for himself, but he would make the present flora of Clydesdale better understood than it has yet been. In proof of this, I may state, that no beech nuts or leaves have been found in these old

leaf beds; and, as the nuts and leaves of the beech form the most abundant constituent of the Clyde wrack of the present time, a great change in the flora must have occurred.

I will now describe the discovery of shells in this old drift, which proved it a river drift indeed. This section faces the south, and being exposed directly to the full force of the sun and the wind, suffers the utmost amount of denudation they can conjointly effect. As the sand falls or is blown away, the pebbles are brought into strong relief, and can be inspected with ease. I examined them frequently in the hope of finding a cinder or "ghaist" among them, to prove that the canoemen knew so much of the fragments of splint or common coal they saw among the gravel, as to make fires of them. While thus engaged, one windy day, I noticed something fluttering among the pebbles, and soon realised the nature of it, as a shred of the epidermis of the common fresh water mussel (*Unio margaritifera*, Linn.), so frequently found in the Clyde at the present day. Knowing the geological significance of the fact, I commenced a strict search for more, and soon ascertained that they occurred abundantly in the gravel. After a very windy day, I have found next morning as many as five, and for some time, I did not fail to find one daily. Altogether, I have found sixty-seven of those shell skins—a number sufficient to characterise the water that deposited this drift as fresh water, as much so, indeed, as that of the Clyde anywhere above Glasgow. A few of them had belonged to single valves, and in one or two instances, the epidermis of both valves was flattened together; but the greater number were lying in their natural position, with the umbonal portion undermost, proving that they had lived and died in the gravel, and had not been drifted down by a spate. Not a vestige of the shell remained, in any instance, attached to the epidermis, the shelly matter having been dissolved by the action of rain water percolating through the soil. Indeed, in all of them, only the thicker parts round the lip of the shell were preserved. I may remark, finally, that if strong shells like these *Unios* suffered so much, more fragile fresh water shells have little chance of escaping destruction; and it is vain to hope for them.

The next division of the section is the great bed of clay. It must be sixteen or eighteen feet thick, and, for most of that thickness, very pure—little sand being mixed with it. Very few stones are in it, and none of them large; in form, they resembled

glacial pebbles. One, a piece of a broken boulder, was distinctly striated; so there can be little doubt that this was a true glacial clay washed out of the old boulder clay and re-deposited, while the glacial condition still existed in Scotland. This was confirmed by the shells that occurred in it. They were not numerous either in species or individuals; indeed, I have gathered more at Paisley, in a single day, than I have got in a whole year from Windmillcroft. It will be seen from the list of these shells, and the accompanying note appended to this paper—for which I am indebted to the Rev. H. W. Crosskey—that he has recognised several distinctive glacial species among them, such as *Tellina calcarea* (proxima), *Leda pernula*, and *Leda pygmaea*. The sea, therefore, in which this clay was deposited, must have possessed (in a modified degree, of course), the same glacial character as that which formed the great boreal shell bed at Paisley, and elsewhere throughout the lower parts of the basin of the Clyde—a very important fact, as it introduces order among the great masses of clay and sand forming the old delta of the Clyde, and reveals to us better than hitherto, under what diverse conditions it was formed.

The next member of the series—the white sand, seems to me the greatest of them all in thickness and extent. From the irregular manner denudation has acted upon it, it is difficult at first sight to realise its total depth; and it is only after some consideration that one is prepared to admit it to be so great as it is. In some parts, it approaches within five or six feet of the surface; while in dredging between the piles at the entrance of the dock, they have gone down nineteen feet without exhausting it. This gives it a depth of more than thirty feet; the present depth of the dock being twenty-two feet. I have been told that in the boring for the Union Railway bridge across the Clyde, a depth of eighty feet was reached without passing through it; and I have seen it lately in the lands of Barrowfield, forming a thick bed twelve feet and more, below a bed of well-marked river drift, twenty feet in depth. From these, and many other facts of a like import, I have little doubt that it extends over the whole area of Glasgow. Now, when we consider the peculiarities of this sand, so soft, so fine, so free from grit or pebble, and consider the process of its formation, we must prepare our minds to conceive of the period of its deposition as one of great duration; and the work of reducing ordinary sandstone, not to speak of crystalline

quartz, as almost infinitely great, and only to be equalled by the great time or agencies occupied in forming a like thickness of glacial clay. I have sometimes thought, while considering its place here, its colour and general appearance, so like the sand that remains after washing the glacial clay for shells, that it is a re-deposit, and is but the sand of the boulder clay washed out of it and reformed again; as the brick clay is undoubtedly the clay of the boulder drift so sifted and assorted. But whether this is a fact or not, I have no doubt that it is a member of the glacial series, and must be reckoned among them when they are summed up as a whole. This was proved not only by its underlying the clay with the glacial shells, but also by what was lately found in itself, namely, about a score of boulders of the regular form and character; one large limestone block being as emphatically polished and striated as any in the old boulder clay of Bell's Park or Cranstonhill.

So far as shells can testify of life, it is a perfect blank; not a vestige of any having appeared in all my many years' acquaintance with it; neither have I seen any signs of vegetable life. Indeed, it seems perfectly *azoic*; and I am only prevented from finally concluding it to be totally void of life, by the thought, that in some almost miraculous manner, remains of life may yet be found here preserved in it; my experience of the Clyde drift and the glacial clay teaching me never to despair of finding life in any likely place whatever.

Perhaps it may help to make the sections just described more intelligible, if I note the relations which I conceive to exist between the various beds of which they consist. The white sand and the clay which evidently lay in a hollow in it, must be considered as one geological formation; or, perhaps, it will express better the circumstances of the case to say, that the deposition of the clay was but an episode in the formation of the great bed of white sand which lies below and above it. The clay, where thickest, is very pure, and free from admixture with sand; but as it thins out towards its edges, it becomes frequently interstratified with the sand—many alternations of the one with the other occurring in very short distances. I have seen reason to believe that these thin beds of clay and sand were of later date, though lying in the same plane as the great bed of clay. They are very level, indeed apparently quite horizontal; while the thick bed of clay shews

signs of disturbance so palpably, that even the workmen noticed it, and spoke openly of it as troubled or distempered. The laminations dip always at a very high angle, and dykes of fine sand run through the clay from top to bottom, somewhat after the manner of trap dykes in carboniferous sandstone and shale. Further, I have lately detected roots of plants in these thin beds of clay and sand, which indicate brackish, if not fresh water conditions, as the plants, I am told, are not sea weeds, but probably *Equisetaceæ*. These roots extend sometimes two or three feet, with no appearance of beginning or end, and little change of diameter. I suppose them to belong to the period of these thin beds, and not to that of the river gravel that lies immediately above, because, among other reasons, they seem always to stop short of it; and, besides, the gravel indicates running water, and plants having such habits as the *Equisetaceæ* could not live in it.

The change from the marine beds—the white sand, the clay, and the thin beds—to the undoubted river sands and gravels, is always abrupt and sharply defined, proving that they are unconformable to each other, and indicating the occurrence of some secular change, such as an upheaval having taken place in the interval. That change must have been accompanied by much denudation, as vestiges of beds which must have lain upon the clay, occurred here and there; and the surface of the white sand was always irregular, large hollows being frequent in it. It is difficult to estimate time by a denudation, the amount of which is uncertain; but, assuredly, it warrants the conclusion that the break in the succession represents a space of time during which many changes must have taken place—the peopling of Clydesdale by man being, perhaps, the chief.

Having exhausted the sections at Windmillcroft, I may now inquire what lies beneath. To this the answer must be, that, judging from what I remember seeing in Meadowside Dock, Partick, and of what I have been told occurred in building the quay at the General Terminus Railway, viz., that they came upon the boulder clay there, and laid the foundation of the quay wall, some eighteen feet deep, in it, it is probable that the white sand, after extending downwards for several feet farther than the dredge reached, finally gives place to the boulder drift, and that again to the rocks of the Carboniferous system—and thereby ends in Windmillcroft the surface geology of Glasgow. This, of course, is a

guess, but it is probable enough to be the truth, and we will take it as such, as it closes fitly our history. All the glacial proclivities of the beds we have passed through, culminating naturally in the most glacial of them all—the old boulder clay, which all who have studied it most judge to be, without question, veritable moraine matter—the memorial and the monument of the last great ice age of the world.

Let us run rapidly through the changes which have taken place in and around Glasgow since that time. First, then, we have lowermost the boulder clay, which overtops in our Glasgow “hills” all this series of beds, yet in our docks underlies them all. It speaks of a land of ice, whose mountains were of aged snow so deep that the everlasting snow of the Alps can never equal it, and whose rivers were glaciers hundreds, if not thousands, of feet deep, the drift wrack of which is this boulder clay itself. Then we have the white sand, representing a time of quiet marine deposition, when a sea of a somewhat glacial character overspread all the lowlands round Glasgow, into which this almost impalpable sand flowed and settled quietly down, burying up nothing but a few boulders that the “ships of ice” dropped as they sailed over the surface far above. Then we have the sea of the glacial clay, when a few shellfish found here at Glasgow but scanty nourishment from its muddy waters. Then we have a great change. We have no more sea here in Clydesdale, but, instead, a great river, shallow, it may be, but broad, with the shells, whose skeletonised skins are before us, living, then, abundantly in its waters,—and we have the old canoeman of the Clyde slowly paddling his clumsy boat till he reaches his favourite fishing station here at Windmillcroft, where he anchors his canoe with a stone—this very one, it may be—and then drops his net or his line with, perhaps, one of these perforated stones as a sinker, and tries—not in vain, let us hope—to find his daily bread in the waters of the great river we now see but in its sands. All these pass away, and we have the little Clyde we know, with its Broomielaw and its Windmillcroft Dock, and beyond them the great City of Glasgow, that reckons its ships by thousands, traversing all seas, and making Clyde-built ships famous all over the world. A great change this from the log canoe—to which a voyage across the Clyde, of its time, was, perhaps, a day’s sail—to the Cunard steamer, like the Clyde-built “China,” that can cross the Atlantic

in a week. Yet let us be just to the old Glasgow canoeman. He and men like him taught the world the elements of navigation—that wood could swim and paddles propel, and without the Clyde canoe the Clyde steam-ship might not have been.

List of perforated and grooved stones found in the river drift at Windmillcroft, and supposed to have been used by the canoemen as sinkers for their fishing lines, or nets, or other purposes of their craft:—

No. 1.—Circlet of splint coal—diameter, $3\frac{1}{2}$ inches; thickness, $1\frac{1}{2}$ inch; width of perforation, $1\frac{1}{2}$ inch; weight, $6\frac{1}{2}$ oz.; neatly made. As much labour must have been bestowed in making it almost perfectly circular, it is doubtful whether it was used as a sinker.

No. 2.—Circlet of bituminous shale—diameter, $5\frac{1}{2}$ inches; thickness, $1\frac{1}{2}$ inch; width of perforation, $1\frac{1}{2}$ inch—the sides of the perforation are much bevelled; weight, $16\frac{1}{2}$ oz.; rudely made. As it is much worn, it had probably been long used ere lost.

No. 3.—Oblong square of bituminous shale—longest diameter, 7 inches; shortest, $4\frac{1}{2}$ inches; thickness, 1 inch; width of perforation, 2 inches—sides of perforation slightly bevelled; weight, 14 oz.; rudely made.

No. 4.—Oblong pebble of grey-wacke. As the edges are well rounded, it must have undergone much water wear ere pressed into the service of man. Longest diameter, $5\frac{1}{2}$ inches; shortest, $3\frac{1}{2}$ inches; width of perforation, $\frac{1}{2}$ inch. Sides of perforation slightly bevelled, but they are very irregular, as the stone is very tough in texture, and must have been difficult to cut through. The workman, after having cut it about half through, must have turned the stone and commenced on the other side, and continued till he had completed the perforation. Weight, $14\frac{1}{2}$ oz.

No. 5.—Circlet of iron—diameter, $1\frac{3}{4}$ inch; thickness, $\frac{3}{4}$ inch; width of perforation, $\frac{1}{4}$ inch; neatly made. The workman who made this sinker must have been an adept in handling metals. Weight, 8 oz.

No. 6.—An old glacial pebble of greenstone of the regular hunchback form—longest diameter, $2\frac{3}{4}$ inches; shortest, $2\frac{1}{4}$ inches; thickness, $1\frac{1}{2}$ inch; grooved all round in the direction of its longest diameter—depth and width of groove, $\frac{1}{8}$ inch; weight, 8 oz.

No. 7.—Oblong square block of sandstone—probably an old glacial boulder—length, 14 inches; breadth, 10 inches; thickness, 7 inches; grooved all round, deeply at the corners, but slightly on the sides; greatest width of groove, $2\frac{3}{4}$ inches; greatest depth, 2 inches; weight, 58 lbs. This stone, I suppose, might have been used as an anchor to one of the smaller canoes.

Note.—All these articles were obtained from the gravel bed, so emphatically proved by the epidermis of the *Unios* to be river drift, and the depth at which they occurred did not exceed 15 feet. Along with the circlet of iron (No. 5 of the list), I found an implement made of wood, bent somewhat in the form of the letter *S*. The upper part had been used as a handle, as it was hollowed out to fit the hand so as to give it a better grasp; the lower part was more sharply bent, and had been used to hook things by, and the impression of a string was distinctly visible at the acutest corner of the angle. I also found several pieces of wood not unlike, in shape, a boy's bat. The handles were always very short, just enough to grasp by. These, I supposed, might have been rude paddles, but they must have been very ineffective, as the person using them must have bent over the side of the boat ere he could touch the water with them. I found also a well rounded and otherwise water-worn pebble of burnt shale, which had evidently been a "ghaist" or cinder once in an artificial fire.

XLVII. *Note on the FOSSILS collected by Mr. JAMES BENNIE at WINDMILLCROFT.* By the Rev. H. W. CROSSKEY, Vice-President.

THE fossils of the glacial bed of the Clyde are generally so abundant, that the occurrence of a clay through which they are very sparingly scattered, in itself becomes significant. During the glacial epoch, it would appear that the fauna of the sea was distributed according to the usual laws, and not by any exceptional catastrophes. Each kind of sea bottom had its own specialities; the finer and coarser muds, and the sandy, in their various admixtures, had severally their own characteristically abundant species, exactly as the naturalist finds to be the case in the frith, at the present day. The action of different currents and inflowings