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XLI.—On the Natural Terraces on the Eildon Hills being formed by the Action of Ancient Glaciers

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The *Rotifer vulgaris* travels quite at his ease in these protuberances; he traverses the partitions, displaces the chromule and pushes it to the two extremities of the vesicle, so that this appears darker at these parts. One day I opened a protuberance gently: I waited to see the *Rotifer* spring out and enjoy the liberty so dear to all creatures, even to infusorial animals; but no—he preferred to bury himself in his prison, descending into the tubes of the plant, and to nestle himself in the middle of a mass of green matter rather than swim about freely in the neighbourhood of his dwelling.

Some of these protuberances had greenish threads appended to their free end, and others had none: I thought at first that these threads were some *mucus* from within, escaped through some opening which might have served the Rotifer as an entrance; but an attentive and lengthened observation convinced me that in this there was no solution of continuity, and that the arrival of the Rotiferi in the Vaucheriæ was not at all to be explained in this way. How are these parasitic animalcules generated within them? This is what further research has some day to show. Meanwhile, I have thought that it should be made known, that the animalcule found in the Vaucheriæ by Unger was the *Rotifer vulgaris* of zoologists.

XLI.—*On the Natural Terraces on the Eildon Hills being formed by the Action of Ancient Glaciers.* By J. E. Bowman, Esq., F.L.S. & F.G.S.

Scarcely could my communication on these terraces in the last Number of the Annals have been set in type, when I saw the first announcement, by Prof. Agassiz, of the evidences he had seen of the former existence of Glaciers in Scotland. A little reflection, aided by my own recollections of the Swiss glaciers, and of the general views so ably given by him at the late meeting at Glasgow, soon satisfied me that his theory would meet all the difficulties that had so much perplexed me, and explain the actual appearances exhibited on the hills in the neighbourhood of Galashiels. I regret that I was not aware of his discovery when I wrote my remarks; though it must be allowed that my ignorance of it has saved me from the imputation of any bias in applying it to the phænomena in question.

As the fact of the former existence of glaciers in Scotland is now exciting general attention, and will soon, I doubt not, be firmly established, I might have silently left it to others to consider them as the true cause of these terraces, had not a

recent visit from Prof. Agassiz afforded me an opportunity of giving him the details of my own observations, and of hearing from himself that the appearances I described have often been seen by him on the sides of existing glaciers. I trust, therefore, the subject may be thought of sufficient interest to warrant a second communication.

It would be difficult, as I know from experience, to make intelligible to readers who have not visited Switzerland, the real nature and appearance of a glacier. For years I had read and thought much about them, and fancied I understood them; but, until I actually saw and traversed them, I had no correct idea of their real structure and appearance, and little anticipated the powerful impression they are capable of making upon the mind, when first examined under favourable circumstances. Saussure and other Alpine travellers have given very lively descriptions of their wonderful appearance, but the laws by which many of their phænomena are produced and regulated, were never satisfactorily understood until Prof. Agassiz undertook their examination. The result of five years' arduous and patient investigation by this illustrious savant will be found in papers read before the Geological Society of France, and more at large in his 'Etudes sur les Glaciers de la Suisse,' now just published. His discovery also, since the meeting of the British Association at Glasgow, of the traces of ancient glaciers in Scotland, Ireland, and the North of England has been announced to the Geological Society of London, and is expected to appear in detail in the forthcoming Number of the 'Edinburgh New Philosophical Journal.' It would, therefore, be extremely arrogant in me to attempt to anticipate that communication; but, as I have already raised objections to the received theory from my observations on the Eildon Hills, it seems but fair, now that I am enabled, from the familiar explanations of my distinguished friend, to support as well as answer them by referring the appearances to a more rational cause, that I should be allowed to do so.

As Prof. Agassiz entertains no doubt, from a perusal of the article in Chambers's Edinb. Journal, and of my paper, that most of the terraces on the hills in the neighbourhood of the Tweed, are the *morains* of ancient glaciers, I shall confine myself to a few particulars connected with their origin and mode of formation.

Glaciers occupy the gullies and lateral indentations of high mountain chains; and consist of immense accumulations of spongy porous ice, or half-melted snow again solidified by frost. Their texture near the apex or upper extremity, ap-

proaches the nearest to snow, and the opposite or lower end, to ice, the change being gradual and the consequence of the alternate melting and freezing of the surface. Above the height of about 7000 feet, the temperature of the air is seldom high enough to melt the snow; and as all ice has previously been water, it is clear there can be but little of it in a solid state at still greater elevations. The blocks and fragments of rock that are detached from the surrounding precipices, accordingly sink through the mass to the bottom of the snow. At less elevations, where during summer the melting process is more active on the surface of the glacier, the water percolates between the particles of the porous mass, till it reaches the rocks on which it rests. Here, the temperature being lower, it is reconverted into ice, which cements together the stones and gravel, and by its expansive property in passing into the solid state, has a tendency to detach them from the bottom. Thus a new layer or skin of ice is continually accumulating between the lower surface of the glacier and the face of its rocky bed, which, as it thickens, acts a wedge and imperceptibly keeps forcing up the whole superincumbent mass, and with it the stones and gravel which it had entangled at the bottom. But the cooperation of another agent is necessary to bring them to the surface. This is the heat of the sun, which during summer, especially in the day time, melts the upper layers of the ice, and consequently diminishes its thickness; till at length, by this double action, the stones which lay upon the bottom are lifted up till they lie exposed upon the surface of the glacier. So that here, a kind of circulation or interchange of particles takes place, as in a lake, modified by circumstances; their ascent being retarded while in a state of congelation, and their descent accelerated by the perpendicular cracks and fissures which everywhere intersect the mass.

This expansion from below is going on at the same time in the direction of both the longitudinal and transverse axes of the glacier; and as the whole mass lies in a hollow or inclined trough, the power of gravity prevents it from moving in any other direction than downwards. But the motion is not uniform; the sides advance with greater rapidity than the middle; so that if a row of stones were placed at equal distances in a straight line across the glacier, they would soon arrange themselves into a curve or arch; those at each side being carried down more rapidly, would form the base; while those in the middle having comparatively little motion, would be left behind and form the highest part of the arch. This is owing to the following cause: a slight elevation of temperature in

the air near the lateral edges of the glacier, caused by radiation from the neighbouring rocks, occasions a more copious melting of the ice and snow in those parts, and consequently a greater quantity of water is introduced into what remains unmelted. This water being refrozen at night, produces a greater expansion near the edges than in the central portions of the glacier; and this excess accelerates the motion of the sides downwards. It must be recollected that a glacier is not one solid piece of ice, but is broken up and intersected by many chasms or fissures of greater or less width and depth, which allow an independent motion of its different parts. This greater expansion has a tendency also to divert the descending stones from a rectilinear course, and to carry them toward the point of least resistance, in other words, nearer to the sides; so that a large portion of them, instead of reaching the foot of the glacier, are deposited in longitudinal or irregularly curved lines on the inclined slopes of the contiguous rocks, their peculiar form being modified by local circumstances. It is also evident that the greatest accumulations of these lateral shelves, or *morains,* will be found near and upon the most prominent slopes of rock, especially on the side next to the head of the glacier; because these projections not only arrest the stones in their downward course, but by their agency in causing more radiation, melting and freezing, attract, if I may so say, a greater quantity of surface wreck. Again, as the opposite sides of a glacier at any given point have a general coincidence of level, these *morains* will often be found to correspond in horizontal position; though, for obvious reasons, not so precisely as the opposite shores of a bay or lake. They must also be formed solely of fragments from the higher surrounding rocks, not rounded into pebbles, but more or less angular, or mixed with clay or earth, in proportion to the nature and hardness of the material. Neither sea nor freshwater shells will be found among them. Other *morains* are formed at the foot of the glacier, and often present very different appearances; but as it is to the lateral ones that most of the terraces on the Galashiels hills are to be referred, I shall not pursue the explanation further.

I think a careful perusal of the details given in my former paper will show that a large portion of these terraces, or rather shelves, correspond with the *morains* whose origin I have just been tracing. Their broken and interrupted character on the Eastern Eildon and on Williamlaw; their irregular width and rude horizontality of surface, combined with a general coincidence of level; their angular stones and the total absence of gravel, sand or shells, are precisely such as

the causes now explained would produce, and are at this day producing in Switzerland. Their occurrence also on the spur of Williamlaw, which projects into the valley of the Gala, and on the Eildons facing the great valley of the Tweed, which I attempted to show was incompatible with the laws of tidal action, are thus satisfactorily explained; and I feel persuaded that the theory of their formation by water must be abandoned, and that they must be considered to be the true *morains* of ancient glaciers.

But all the terraces on the hills round Galashiels cannot be exclusively attributed to the cause already assigned. Some of them, it will be recollected, are stated by Mr. Kemp to be as much as 300 feet wide. On requesting from Prof. Agassiz an explanation of these broad terraces, he stated that, as far as he could judge from my description, they probably were not true *morains,* but had been formed by the combined action of a glacier and a lake dammed up by ice, such as once formed the barrier of Glen Roy, and in our own day blocked up the stream at the foot of the glacier of Getroz, which finally burst and devastated the valley. I confess that the height at which these broad terraces occur on the Eildons, appears to me incompatible with such a view, and that if Agassiz himself were to visit the locality, he would find it necessary to modify this explanation. I also pointed out to him Mr. Kemp's description of the indentations on the inclined projecting slopes of Williamlaw; and he replied that he had seen something similar in the cliffs in Glen Roy, which he attributed to the friction of floating ice and blocks of stone.

In conclusion, Prof. Agassiz informed me that in his late travels he had traced repeated instances of the various descriptions of *morains* in different parts of Scotland; in Murrayshire he counted a series of nine terraces similar to those in Selkirkshire. He had also seen them in Ireland, and between Shap and Kendal, in Westmoreland; and he does not doubt they will be recognized, now that attention is directed to the subject, in North Wales, in the Pyrenees, the Apennines, and other high mountain chains. Indeed he believes, from strong evidences scattered over different countries, that at a recent geological period, and not long before the creation of the human race, the whole of Europe, and those parts of Asia and America which lie north of the parallel of the Mediterranean and Caspian seas, were enveloped in snow and ice; in short, consisted of a series of immense glaciers, above which only the highest hills appeared as islands; presenting a character of scenery only to be found in our day in Greenland or Ice-

land. This view, bold as it is, is strikingly supported by the fact ascertained by Mr. Kemp, that the terraces encircle the highest hills in the neighbourhood of Galashiels, almost to their summits. But as my object in this paper was merely to explain the difficulties suggested by my former one, I shall not anticipate the more able communications about to appear on this important and absorbing subject, or the pleasure to be derived from the "Etudes sur les Glaciers de la Suisse" of Prof. Agassiz himself. J. E. Bowman.

Manchester, Nov. 16th, 1840.

XLII.—Carabideous *Insects collected by* Charles Darwin, Esq., *during the Voyage of Her Majesty's Ship Beagle.* By G. R. Waterhouse, Esq.

[Continued from p. 257.]

All the species noticed in this communication are from Maldonado, La Plata.

Genus Brachinus.

Sp. 1. *Brachinus maculipes.*

B. niger; capite, thorace, pedibus, pectoreque ferrugineis; genubus nigris; antennis fuscescentibus; articulis primo et secundo ferrugineis, tertio quartoque nigris: elytris subcostatis.

B. crepitanti ferè similis, at duplò major.

Long $6\frac{1}{2}$ lin.; lat. $2\frac{3}{4}$ lin.

In form and appearance this species greatly resembles the *Brachinus crepitans*, but its size is much larger; the eyes are rather more prominent, the elytra are black, and in the specimen before me, destitute of the blue or green tint usually observable in that species, and the striæ are a trifle more distinct; it moreover differs in having the apical portion of all the femora black. Like *B. crepitans*, the third and fourth joints of the antennæ are black, but the following joints are pitchy-black, and thus differ from the corresponding joints in that species: the abdomen is black beneath, but the chest is pitchy-red.

But one specimen of this species was brought home by Mr. Darwin: it is readily distinguished from *Brachinus Platensis* by its larger size, the black third and fourth joints of the antennæ, the black tip to the femora, and the darker colour of the elytra.

Sp. 2. *Brachinus Platensis.*

B. ferrugineus; elytris fuscescenti-nigris, subcostatis; abdomine ad apicem nigricante.

B. crepitanti simillimus, sed paulò major.

Long $4\frac{1}{2}$—5 lin.; lat. 2—$2\frac{1}{4}$ lin.