XXXV.—*On the Formation of Mould.*

By CHARLES DARWIN, Esq., F.R.S., Sec. G.S.

[Read November 1, 1837.]

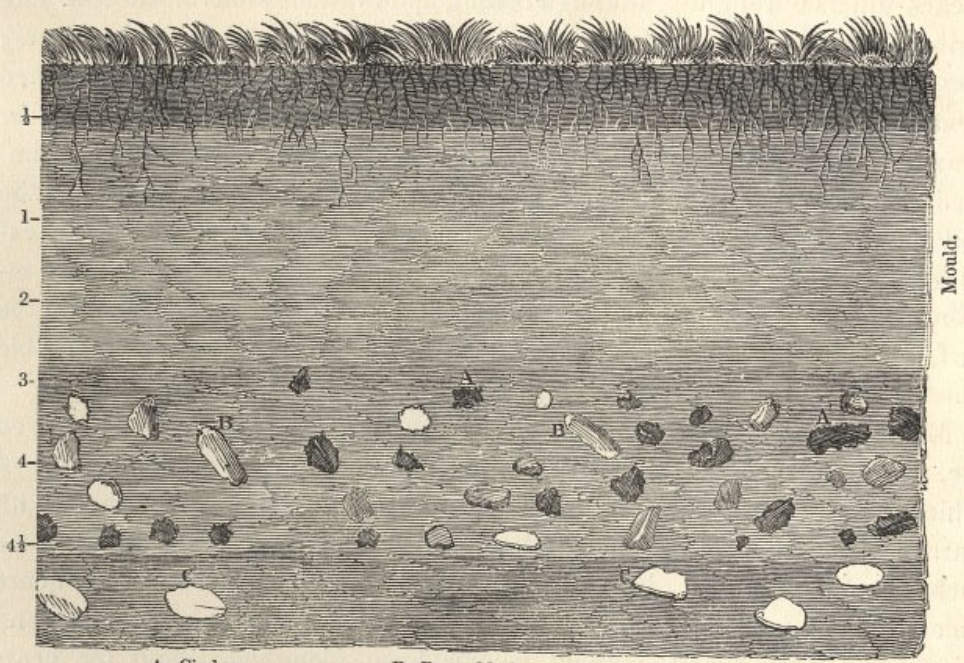
THE formation of the superficial layer of earth, commonly called vegetable mould, offers some difficulties in being fully understood, which apparently have been overlooked. In old pasture lands, the mould, to the depth of a few inches, differs but slightly, although resting upon various kinds of sub-soil. The uniform fineness of its particles is one of its chief distinguishing characters; and this may be well observed in a gravelly country, where a recently ploughed field immediately adjoins another, which has long remained undisturbed for grazing. In the latter, not a pebble will be seen, either on the surface or immediately below it; although in the ploughed field, a large proportion of the soil may be composed of small stones. From the prevailing use of the expression "vegetable mould," it would appear that its origin is generally attributed to some effect of vegetation; yet it is scarcely conceivable that the turf, in the case of the two adjoining fields, can have produced so remarkable a difference as that alluded to.

My attention was called to this subject by Mr. Wedgwood, who showed me, whilst I was staying at Maer Hall, in Staffordshire, several fields, some of which a few years previously had been covered with lime, and others with burnt marl and cinders. These substances, in every case, were buried some inches beneath the turf. In several parts of three grazing fields, I dug square holes, and obtained the following results:—1st. In some good pasture land which had been limed, without having been ploughed, about ten years before, the turf, or the layer in which the roots of the grasses are closely woven together, was about half an inch thick. At two inches and a half beneath this, or about three from the surface, a layer of lime, or a row of small aggregated lumps of it, formed a well-marked white line around the holes. The soil beneath this layer of lime was gravelly, or of a coarse sandy nature, and differed considerably from the mould nearer the surface. About three years ago cinders also had been spread on this field; but when I examined it, they were buried at the depth of one inch. They were not sufficiently numerous to form a layer, though a line of black spots could clearly be traced

parallel to and above the white one of lime. Some other cinders, which had been scattered in another part of this same field, only about half a year before, lay either on the surface or were entangled in the roots of the grass.

The second field, I mention only from the fact of the cinders being buried in such quantities, about three inches deep, as to form a stratum nearly one inch in thickness. The layer in some parts was so continuous, that the upper soil was united to the lower only by the longer roots of the grasses. The sub-soil was a red clay, and it occurred a little below the cinders.

The third case which I shall describe, is that of a field which, Mr. Wedgwood informed me, was waste land fifteen years ago. It was at that time drained, ploughed, harrowed, and well covered with burnt marl and cinders. It has not been disturbed since, and now supports a tolerably good but rather



A. Cinders. B. Burnt Marl. C. Quartz Pebbles.

coarse pasture. The section in this field, as represented in the wood-cut, was, turf half an inch; vegetable mould two inches and a half; a layer, one and a half inch thick, of fragments of burnt marl, (conspicuous from their bright red colour), of cinders, and a few quartz pebbles, mingled with earth. One of the angular fragments of burnt marl lying near the bottom, measured one inch in length by half an inch in breadth, and a quarter in thickness. Lastly, about four inches and a half below the surface, was the original black peaty soil. We thus find, beneath a layer, nearly four inches thick, composed of

fine particles of earth mixed with decayed vegetable matter, those substances which had been spread on the *surface* fifteen years before.

The appearance in all the above cases was, as if (in the language of the farmers, who are acquainted with these facts) the fragments had worked themselves down. It is, however, scarcely possible that cinders or pebbles, and still less powdered quick-lime, could sink through compact earth and a layer of matted roots of vegetables, to a depth of some inches; nor is it at all probable that the decay of the grass, although adding to the surface some of the constituent parts of the mould, should separate in so short a time the fine from the coarse earth, and accumulate the former on those objects, which so lately had been on the surface. I may add, that I have repeatedly observed fragments of pottery and bones buried beneath the turf, in fields near towns, (on which such substances are often thrown with manure); and as these fields did not appear to have been ploughed, the circumstance often surprised me. On the contrary, I have noticed in gardens lately dug, that the rain, by washing away the finer particles, leaves stones and other hard bodies accumulated on the surface.

The explanation of these facts, which occurred to Mr. Wedgwood, although it may appear trivial at first, I have not the least doubt is the correct one, namely, that the whole operation is due to the digestive process of the common earth-worm. On carefully examining between the blades of grass in the fields above described, I found scarcely a space of two inches square without a little heap of the cylindrical castings of worms. It is well known, that worms, in their excavations, swallow earthy matter, and that, having separated the portion which serves for their nutriment, they eject at the mouth of their burrows the remainder in little, intestine-shaped heaps. These partly retain their form until the rain and thaws of winter, as I have observed, spread the matter uniformly over the surface. The worm is unable to swallow coarse particles, and as it would naturally avoid pure or caustic lime, the finer earth lying beneath the cinders, burnt marl, or lime, would be removed, by a slow process, to the surface. This supposition is not imaginary; for in the field in which cinders had been spread out only half a year before, I actually saw the castings of the worms heaped on the smaller fragments. Nor, I repeat, is the agency so trivial as at first it might be thought: the great number of earth-worms, as every one must be aware who has ever dug in a grass field, making up for the insignificant quantity of the work which each performs. On the idea of the superficial mould having been thus prepared, the advantage of old pasture land, which it is well known farmers in England are particularly averse to break up, is explained; for the length of time required

to form a thick stratum must be considerable. In the peaty field, in the course of fifteen years, about three inches and a half had been well prepared; but it is probable that the process is continued, though at a very slow rate, to a much greater depth. Every time a worm is driven, by dry weather or any other cause, to descend deep, it must bring to the surface, when it empties the contents of its body, a few particles of fresh earth*. Thus, the manures added by man, as well as the original constituent parts of the soil, become thoroughly mingled, and a nearly homogeneous character is given to the whole.

Although the conclusion may appear at first startling, it will be difficult to deny the probability, that every particle of earth forming the bed from which the turf in old pasture land springs, has passed through the intestines of worms; and hence the term "animal mould" would in some respects be more appropriate than that of "vegetable mould."

I may conclude by remarking, that the agriculturist in ploughing the ground follows a method strictly natural; he only imitates in a rude manner, without being able either to bury the pebbles or to sift the fine from the coarse earth, the work which nature is daily performing by the agency of the earth-worm.

Note.—Since my communication on the "formation of mould," read on the 1st of November, I have received from Staffordshire an account which corroborates the statements then made, on the apparent sinking of objects placed on the surface of turf land. The first case I mention only because the substance is different from those previously described. In the spring of 1835 a boggy field, which had long remained as grass land, was so thickly covered with sand that the whole surface appeared of a red colour. At the present time, namely about two years and a half afterwards, the sand forms

* Mr. W. Lindsay Carnagie of Kimblethment, writing from Scotland to Mr. Lyell on the subject of this paper, as it is given in the Proceedings, states, that in clearing away a stiff clayey soil above a stone quarry, he has seen worms in small chambered passages between seven and eight feet below the surface. The black mould on the clay was there two feet thick. Mr. Carnagie observes, also, in his letter, that the Scotch farmers, from a belief that the lime itself has some tendency to sink, are afraid of putting it on ploughed land until just before it is laid down for pasture. He then adds, "Some years since, in autumn, I laid lime on an oat-stubble and ploughed it down; thus bringing it into immediate contact with the dead vegetable matter, and securing its thorough mixture through the means of all subsequent operations of fallow; I was considered, in consequence of the above prejudice, to have committed a great fault, but the result was eminently successful, and the practice *partially* followed. By means of Mr. Darwin's observations, I think the prejudice will be entirely removed."—June 1838.

a layer three-fourths of an inch below the surface, that thickness consisting of peaty soil.

The second case is more interesting. It has been ascertained that a field, which has since been ploughed, was covered about eighty years ago with marl; an imperfect layer of it, but sufficiently distinct to be traced, is now found at a depth, very carefully measured from the surface, of twelve inches in some parts and fourteen in others: the difference corresponding to the top and hollow of the ridges produced by ploughing. It is certain, the marl must have sunk or been buried before the field was ploughed, for otherwise the fragments would have been scattered in the soil: this conclusion, moreover, explains the circumstance of the layer being horizontal, whilst the surface is undulating. At the present time no plough could possibly touch the marl, as the land in this country is never turned up to a greater depth than eight inches. In the preceding communication, I have shown, that in a field lately reclaimed from being waste land, three inches of mould had been prepared by the worms in the course of fifteen years. We now find, that within a period of less than eighty years, (but how much less cannot be told, unless the date when the field was first ploughed were known) the earth-worms have covered the marl, which was originally strewed on the surface, with a bed of earth of an average thickness of no less than twelve or thirteen inches.

November 14, 1837.

PLATES AND MAPS

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1840.

this specimen is the *Apus corniformis*, of the rivers of central and southern Europe.

The remains represented in figures 1 to 7 are considered by Dr. Milne Edwards of great interest, as they exhibit characters intermediate between the living *Limulus* and the extinct Trilobite.

Fig. 10 and 11. Bones of the head of a *Megalichthys*. (See *antè*, p. 443.)

Fig. 12, a tooth, and fig. 13, a spine, are assigned provisionally to the genus *Hybodus*; the characters of the allied coal-measure genus *Diplodus* not being yet published by M. Agassiz.

Fig. 14. A tooth of a *Cochliodus*.

Fig. 15. A spine, assigned with doubts to the genus *Pleuracanthus*, the state of preservation of the specimen not being good. The spine is round but compressed, and is armed with two opposite rows of teeth. There are no traces in the specimen of the groove mentioned by M. Agassiz as one of the distinguishing characters of the genus.

WOOD-CUTS.

Fig. 1 to 4. Diagrams of the effects of faults in the coal-measures: p. 453.

Fig. 5. Diagram of the effects of lateral pressure produced by faults, from the Holywell pits, Malinslee: p. 454.

Fig. 6. Section of changes of level produced by dislocation in the "best coal" Meadow pits, Madeley: p. 454.

Fig. 7. Diagram of a step-like dislocation at Priorslee, due apparently to unequal hardness in the strata: p. 454.

Fig. 8 to 10. Diagrams of complicated dislocations: p. 454.

Fig. 11. Plan of minor faults and fractures inclosed between two principal faults, the Boundary and Ketley: p. 455.

Diagram of the minor faults which flank the Ketley fault near Donnington Wood furnaces: p. 456.

WOOD-CUTS

To illustrate the notice of Capt. Cautley and Dr. Falconer on the remains of a Fossil Monkey from the Sevâlik Hills: pp. 499–501.

Fig. 1 and 3. The Fossil Astragalus, natural size.

Fig. 2 and 4. Astragalus of the *Semnopithecus Entellus*, natural size.

WOOD-CUT

Explanatory of Mr. Darwin's paper on the Formation of Mould: pp. 505, 506.