TYPICAL SOIL STRUCTURES AS THE RESULT OF THE ACTIVITIES OF MUDWORMS

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In the central part of the Netherlands clay soils are deposited by the rivers Maas and Rhine, including IJssel and Waal. In the subsoil of these soils, in many places typical structures of a spongy appearance are present (Fig. 1). The most characteristic features of this structure are the presence of small, nearly round brown-red patches with a diameter of up to 5 mm, irregular holes with a brown-red lining and fine pores with a diameter of less than 1 mm. If the river later on cuts through its old deposits, the clay is eroded and gets a very peculiar coral-like appearance (Fig. 2).

The explanation of the origin of these structures offered so far, did not seem very satisfactory, which made us decide to go a little deeper into this problem, which in fact did prove not to be very intricate.

On top of the structure described, there is a clay soil which evidently was deposited at a time that the soil was already covered by vegetation, most likely grasses. This made it evident, that the formation of the soil which had our interest, had taken place at a time at which this part of the land had been covered permanently or nearly so by the water of the river.

We therefore studied recent deposits of the Rhine at exceptionally low water and found enormous numbers of Tubificidae hiding in the partly solidified mud. They were present as dense globular clusters of up to 1 cm in diameter. The walls of their holes were covered with very fine clay, obviously rich in organic matter and blueish black by reduction.

To prove our supposition that these worms are responsible for the soil structure described, we took a great number of them to the laboratory where we kept them in vertical pipes of perspex (diam. 10 cm) in a layer of mud from the river which had been washed through a fine sieve (50 μm) to destroy all structures that might have been present.

Tap water was constantly flowing into the pipe some cm over the mud and carried off at the top of the pipe, in order to provide the Tubificidae (spp. not specified) with oxygen.

Every few days a quantity of sieved mud was allowed to settle on top of the mud present. During this process the flow of tap water was stopped temporary. The worms at once burrowed through the new deposits to regain their normal positions with their tail-part freely moving in the water, their front part burried and burrowing in the mud (Fig. 3). The burrows are used by many worms often forming strings of parallel lying and-moving animals.

After the mud layer had become thick enough, the water was drained off and the mud allowed to dry slowly. The worms collected in clusters like we had found in the field. At the end of the drying process, the block of clay obtained in this way, showed exactly the same structure of the clay samples collected in the field which had raised our curiosity. We therefore believe that we may say that this structure is due to the activities of Tubificidae and that its formation took place under a permanent or nearly permanent cover of fresh water. This knowledge might enable us to decide upon the origin of certain clay deposits. It remains to be studied which is the salt tolerance of the different species of the family Tubificidae.

As the subsoil of many clay-soils in the north of the country which are deposited by the sea are very permeable and also have a spongy appearance (Fig. 4), we collected a number of a *Nereis* sp. in the mud plains in tidal waters and kept them in perspex pipes as described. Instead of by a flow of tap water, as in the *Tubifex* experiment, the sea water was aerated by a constant airstream which kept the water in slow movement. The worms were originally kept either in fine sand or silt in which they made their characteristic, more or less U shaped burrows with two exits in which they keep the water streaming. This results in a very good aeration of the burrows and their surroundings. The mud, both in the field and in the perspex pipes is dark blue by reduction, but around the burrows of *Nereis*, 5 mm of the soil is brown by oxidation.

Every few days a quantity of sieved silt was allowed to settle on top of the sand or silt. The worms at once reopened the clogged entrances of their burrows. After some months of sedimentation, the sea water was replaced by fresh water which was regularly renewed, to carry off all salt present in the soil. The worms left their burrows and died, but the burrows remained intact, even those in the sandy soils, if only some silt had been deposited on top of it. The burrows had been lined with some silt which gave them a stability comparable to that in the silty soils. The structure of these artificial soils can be easily recognised in naturel soils (fig. 4). Characteristic is the oval cross-section of the holes with sometimes a faint pattern of cross-stripes which distinguishes these burrows from those of earthworms.

Fig. 1. Natural soil structure in the field, presumably produced by *Tubifex* spp.

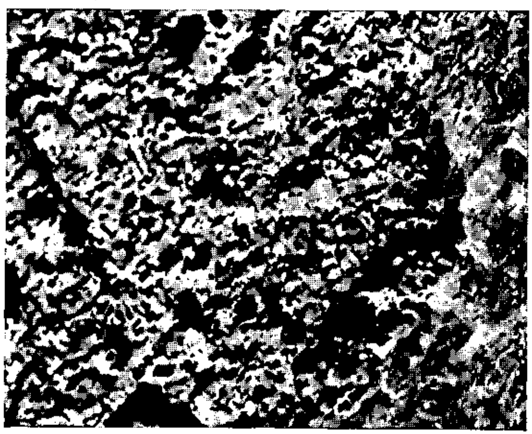

Fig. 2. Soil as in fig. 1, corroded by the river.

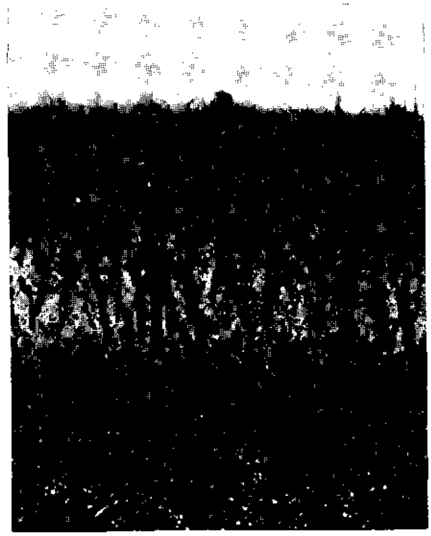

Fig. 3. *Tubifex* spp. in the mud.

Fig. 4. Soil structure produced by *Nereis* sp.