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Anthropogenic soil formation; Neolithic to modern times; Lower Rhine Region.

The soils of the Central European regions that have been settled since the Early Neolithic, such as the Lower Rhine Region (NW-Germany), have been influenced by agrarian societies for more than 7000 years. This long history of clearing, digging, hoeing, ploughing or fertilizing has had a deep impact on soil formation—beyond the well-known phenomena of soil erosion and colluviation. We will present examples for soil types which were formed as a result of human activities, and which are more archaeological rather than natural features: 1.) Luvic Phaeozems, which can be a product of Late Neolithic burning practices, 2.) Podzols and hydromorphic soils, which were initialized by forest clearances mainly during the Iron Ages, 3.) Cambisols, which are cryptic Plaggen soils built up since the Middle Ages and 4.) A ground surface which has been widely destroyed by concealed "micro surface mining" in the Early Modern Period.

Luvic Phaeozems (Relics of Chernozemic Soils) as a Product of Neolithic Slash and Burn Techniques

Buried humic and clay-rich dark soil remains (Bht horizons) in the Lower Rhine Basin (NW Germany) were formerly described as a typical component of Luvic Phaeozems. These Luvic Phaezomes had been considered as being evidence for the existence of Chernozems at the beginning of the Neolithic period in 5500 cal BC. Field observations, geochemical results and ages contradict this interpretation:[1] the Bht horizons in the Lower Rhine Basin occur in a patchy distribution independent of relief position and climatic condition, and they are mostly connected with artefact-free but man-made pits (off-site features) consisting of the same Bht material (Bht-pits) (Fig. 1). The presence of charred organic matter (pyrogenic carbon or Black Carbon) and its radiocarbon ages suggest that these Bht horizons are not relics of naturally formed soils but rather archaeological features caused by prehistoric burning practices. Pyrogenic carbon, mainly produced during the Young to End Neolithic period (4400–2200 BC), led to the characteristic dark coloring of the soil material. During this time span, slash and burn techniques were widely used in Central Europe.[2]

Although the field observations and the geochemical characteristics of the Bht features reflect a strong human impact, the parent material of the formation of Bht horizons was expected to be Pleistocene loess. New IRSL and OSL dating of the parent material (around 6.4–4.3 ka) indicate that the Bht horizons in the Lower Rhine Basin formed in early colluvial sediments, which also date to the Young to End Neolithic period (Fig. 1).

1 Gerlach et al. 2011.
2 Schier 2009.

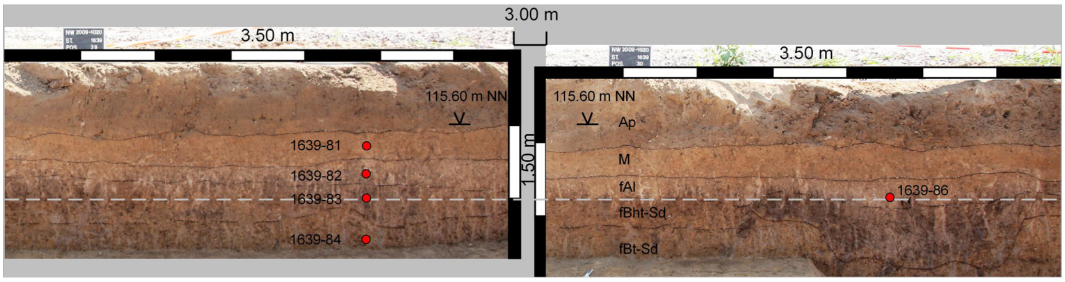

Fig. 1 | Excavation Düren-Arnoldsweiler: profile section with OSL samples. The dark humic and clay-rich illuviation horizon (Bht) is connected to Bht pits. Both Bht features are covered by younger colluvia (M), which preserved the brighter eluviations horizon (Al). OSL ages (ka): 1639-81 (M-horizon) = 2.12 ± 0.24, 1639-82 (Al-horizon) = 4.30 ±0.43, 1639-83 (Bht-horizon) = 6.23 ± 0.73, 1639-84 (Bt-horizon) = 18.9 ± 2.0, 1639-86 (Bht-pit) = 5.90 ± 0.60. Gerlach et al. 2011.

Thus, the history of human induced soil erosion in the Lower Rhine area started more than 1000 years earlier than assumed, and was most likely connected to Neolithic burning practices which subsequently triggered soil erosion, and then influenced the formation of dark soils by eluviation and illuviation of the partly charred dark humic material, forming a Bht horizon which can be misunderstood as a diagnostic horizon of a natural Luvic Phaeozems. These Anthrosols are an example of strong human impact on soil-forming processes since the onset of agriculture.

Pedogenesis of Podzols and Hydromorphic Soils after Forest Clearances

Uprooting and farming change the soil-forming processes of sandy parent material to the point of intensive leaching of nutrients which can at last lead to a transformation from Cambisols to hardly-usable acid Podzols. Removal of crops and grazing animals enforce the depletion and may induce human mobility after abandoning arable fields. Although Podzols can be a result of climatic conditions, the Podzolization during the Holocene in Central Europe must be seen mainly as an anthropogenic process.[3]

Theo Spek[4] analyzed the interaction between soil properties and distribution of settlements in detail for the Drenthe (NL). This landscape in N-Netherlands is dominated by glacial deposits with a wide range of sandy to clayey sediments. While the first local Neolithic occupation (around 3400 BC) started by using sandy soils, probably with Cambisols, adjacent Podzolization enforced the later prehistoric farmers to shift more and more to loamy soils with better nutrient supply. Especially the plough enabled utilization of clayey soils since the Middle Ages, while the sandy podzolized areas were covered by heathland.

Also hydromorphic soils, Gleysols as well as Histosols can be a result of deforestation and anthropogenic land use. They are controlled by groundwater conditions, which can change dramatically after opening a landscape. Especially the Iron Age period (800–50 BC) is characterized by a human-induced rising of the groundwater level as a result of extensive clearings. Archaeobotanical and geoarchaeological results show that new creeks, hydromorphic soils and swamp areas were created in the Lower Rhine Area during this period.[5]

3 Goudie 2006.
4 Spek 1996.
5 Meurers-Balke 1999, Becker 2005.

Humic Cambisols as Cryptic Plaggen Soils

For centuries, arable land and sandy soils have been fertilized with Plaggen, a mixture of manure, sods, litter and sand. While in the Netherlands, Plaggen soils are widespread, they are more or less missing in the same sandy parent material beyond the Dutch-German border. Regional soil maps only display a humic Cambisol,[6] which is defined as a natural soil type.

During archaeological excavations in the northern part of the lower Rhine Region, we found that most of the so-called humic Cambisols tend to be Plaggen soils. Some distinct properties such as the sods of typical Plaggen soils are missing and led to them being interpreted as natural formed soils. Generally it is not easy to distinguish between an umbric horizon and a plaggic horizon by using hand augers. Clear evidence of anthropogenic features is required to differ between the two.[7]

The discussion about the age of Plaggen soils is still ongoing because it is difficult to date the relocated soil material by incorporated archaeological finds or charcoal. Both could be also relocated and yield only maximum ages while the sedimentation of the Plaggen material can be significantly younger.[8] Dating the last sedimentation process is only possible using the Optical Stimulated Luminescence technique (OSL). A first reliable OSL dating of a humic sandy horizon at the Lower Rhine Region, which can be now reinterpreted as a plaggic horizon, yields an age of 1.1 ± 0.1 ka.[9] This is one of the oldest ages (early High Middle Ages) of a plaggic horizon in the Dutch-German Region.

Digging and Filling: Alteration of the Soil Surface

The technique of fertilizing by direct deposition of more or less enriched (organic or anorganic) soil material (e.g. Plaggen or marl), especially from the Early Modern Period onwards, formed not only banked-up soils but also created excavated areas that changed the micro-relief and perforated the ground surface.

Since the 19th century, industrialization required a huge amount of building material such as brickearth, sand and gravel. Most of these historic pits are more or less completely refilled with soil material and are nearly invisible at the surface and in the auger. However, the disturbance of the original surface as well as the filled-in soil material—often with relocated artefacts—limits the possibility of reconstructing archaeological sites. It has been shown that more than 10 percent of a rural landscape can be affected by such soil disturbances, and this is only the part which can be identified based on our sources (e.g. hollows in Digital Elevation Models (DEM's)), the true amount is definitely larger (Fig. 2). This means that rural landscapes are more deeply affected by direct anthropogenic soil and relief modifications than was assumed before.[10]

Conclusion

From a pedological point of view it is necessary to consider that since the onset of the Neolithic period, human activities have had a much greater impact on soil forming processes than reflected in the major soil classification systems.

6 Umbrisol after FAO 1998.
7 FAO 1998.
8 Spek 2006.
9 Burow 2010.
10 Gerlach, Herzog, and Koblinski 2008.

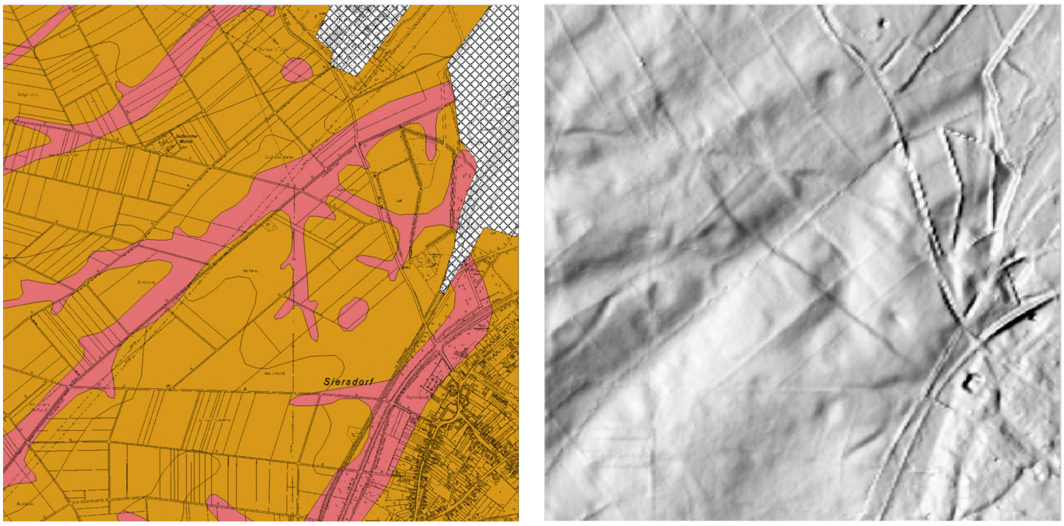

Fig. 2 | Rural landscape (2km^2) in the Loess Region near Aachen (Baesweiler). Left: The digital soil map (Geological Survey of Northrhine-Westfalia) mainly recorded Luvisols (brown) Colluvia (red) and some industrial soil destructions (NE corner). Right: The shaded relief of the DEM revealed that the landscape is strewn with artificial hollows = historic marl and brickearth pits.

From an archaeological point of view, it may become necessary to revise conventional wisdom of a uniform, natural soil development for many Central European soils and to discover soil material as an archaeological feature. Prehistoric soil material, which has been preserved as pit fillings or buried and banked-up soils, contains valuable information about the use and alteration of the ground. Geochemical data from such ancient soil material can therefore be used as proxies for cultural activities, e.g. to reconstruct farming systems such as slash and burn practices.

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