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Soil development in OSL dated sandy dune substrates under Quercus robur Forest (Netherlands)

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Coastal dune landscapes are very dynamic. The present distribution of vegetation and soil is the result of over 2000 years of natural processes and human management. The initial soil development was controlled by an increase of the organic matter content, which consisted mainly of decomposed roots of grasses (rhizomull), and a decrease of the soil pH to 3-4 by decalcification. This stage was followed by the development of a deciduous forest, which was dominated by Quercus robur. Since 1600 AD, a large part of the deciduous forest that dominated the east side of the coastal dune landscape transferred in expensive residential areas and urbanizations. Nevertheless some parts of the oak forest belt remained. The present forest soils are acid and the controlling soil processes are leaching of sesquioxides and storage of organic matter in mormoder humus forms.

The sustainability of ecosystems is closely related to the quality of the humus form, controlling nutrient cycling and water supply. Therefore, improve of knowledge of humus form development and properties is important. We applied soil micromorphology and pyrolysis-gas chromatography/mass spectrometry (GC/MS) to investigate more details of humus form development at two locations (Duivendrift and Hoek van Klaas) in the coastal dune area of the Amsterdamse Waterleidingduinen (near Haarlem, the Netherlands). However, to understand forest soil development, including the organic matter composition in the humus form, the age of the substrate and the forest is required. Therefore, we used tradition techniques as pollen analysis and radiocarbon dating but also the recently introduced optical stimulated luminescence (OSL) dating technique. OSL dating works excellent for aeolian sandy deposits with a high percentage of quartz grains. The OSL age is defined as the time after the last bleaching by solar radiation of mineral grains. Or in other words, the start of a stable period without sand drifting.

In the Ah horizons we observed palynological traces of a former dune landscape with grasses and typical dune land shrubs. The F and H horizons were dominated by Quercus pollen. In thin sections we found that in the upper part of the F horizons the soil skeleton was formed by leaf litter fragments that were fragmented and decomposed by fungi and micro arthropods. The soil skeleton of the lower part of the F horizons consisted of a mixture of leaf litter fragments and (dead) root fragments. In this part of the profile, fungi and micro arthropods were also responsible for the physical and chemical organic matter decomposition. The soil skeleton of the Ah horizons was formed by mineral grains in which small sized organic aggregates occurred. These aggregates may have four possible sources: (1) sinsedimentary aggregates, involved in sand drifting, (2) fecal relicts from decomposed (older) roots of a former dune land vegetation, (2) fecal relicts from decomposed (younger) roots of the forest and its understory, and (3) infiltrated parts of fecal pallets from the overlying F horizons.

The calibrated radiocarbon dates of organic matter from the upper 5 cm of the Ah horizons go back to around 1960 AD. This points to a 45 year period for the development of the ectorganic horizons, assuming that fresh organic matter did not 'contaminate' the radiocarbon dating. The OSL the ages of quartz grains from the upper 5 cm of the Ah horizons indicate landscape stabilization around 1800AD implying that two centuries were available for vegetation and soil development.

There seems to be a significant difference between the OSL and 14C ages of the top of the Ah horizon. The OSL dates are very reliable. They indicate the correct time of the transformation of drift sand into stable, vegetated landscape. The pollen spectra of the Ah horizon show traces of dune grass and shrub landscape, but probably these pollen grains originate from sinsedimentary organic aggregates. And during the juvenile phase of a quercus forest, the quercus pollen production is very low and other wind pollinated grains from dune grasses and shrubs can dominate the pollen spectra. Based upon OSL dates, a period of 200 year forest soil development is more

reliable than the 14C based 45 year. We must reject the 14C ages, due to complexity of sources of soil organic matter in the Ah horizon

The organic matter as investigated by analytical pyrolysis and thermally assisted hydrolysis and methylation and subsequent analysis by GC/MS revealed a major oak-derived picture. The L+F1 horizons reflected relatively undecomposed organic matter mainly derived from leaves. By contrast, in both F2+H and the Ah horizons leaf material was accompanied by root-derived components, particularly suberin. The latter may originate from barks as well, but in the Ah horizons the contribution of roots was most probably much greater. Apart from a common transformation pattern (decrease of polysaccharides, degradation of lignin and accumulation of lipids), a very small contribution of C26 alkanol indicated a chemical fingerprint of the previous grass vegetation.

In conclusion: chemical analysis confirmed the soil micromorphological data, and the application of OSL dating improves our knowledge about geochronology of the system.