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Age constraints for pedological and hydrological processes in natural analogues of earth covers for waste disposal: case study from a sediment-soil sequence in Dessel, Northern Belgium

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Proper assessment of the long-term evolution of engineered barriers consisting of earth covers is an indispensable part of safety studies for near-surface waste disposal. Suitable soil sequences and sedimentary archives may serve as natural analogues for the study of various processes that may act upon such earth covers. We present preliminary results of various dating techniques to establish a sound chronology for processes observed in a sediment-soil sequence which we believe contains crucial information on (i) soil and landscape evolution and (ii) present and past groundwater recharge rates in the region of interest (Campine area, Northern Belgium). The integrated results include those from optically stimulated luminescence (OSL) dating, radiocarbon (C-14) dating, palynological investigations, historical archives and stable Cl and Pb profiles.

At its base, the 2-m deep profile shows a well-developed podzol soil (spodozol) in quartz-rich sands, from which the A1-horizon has been removed by subsequent soil erosion. The truncated podzol is overlain by a 1.5-m thick dune sand deposit that shows four alternating phases of landscape instability (sand drift and dune accretion or deposition) and stabilization (development of thin O-horizons).

The earliest phase of soil development (podzolisation) observed in the profile is currently bracketed between $\sim$ 11 ka and $\sim$ 1 ka BP. This time window is expected to become tighter by C-14 dating results that are currently underway.
OSL results from the overlying dune sands were obtained using the single aliquot regenerative dose (SAR) protocol (Murray and Wintle, 2003) after carefully considering issues regarding recuperation, recycling and recovery. This resulted in a stratigraphically consistent set of five OSL ages, suggesting that dune development occurred between $\sim$ 300 and $\sim$ 600 years ago.
The pollen spectra of organic-rich horizons within the dune show very high percentages of Calluna species (heather) and very small values of Pinus species (pine). This strongly suggests that dune accretion occurred before pine reforestation in the 18th-19th century (various reliable historical sources). The abundance of heather pollen is consistent with sand drifting and dune accretion in the proposed time-window. Small percentages of Fagopyrum (buckwheat) further indicate that the dune developed after $\sim$ AD 1400.
The depth profile of stable Pb is somewhat difficult to interpret, but does not contradict other records indicating that lead deposition and subsequent leaching would have occurred after AD 1843 (Shotyk et al., 1998), posterior to dune fixation.
The latest phase of profile development is attested by chloride measurements from soil water. Application of the chloride mass balance (CMB) approach (Scanlon et al., 2002) reveals a record of infiltration of 1-2 years, while an older recharge signal may have been preserved in the podzol (Beerten and Mallants, this volume).

We conclude that the obtained chronology for various processes observed in the investigated profile is reliable because of the internally consistent and converging results from various methods and techniques.

References

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