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Soil organic matter dynamics on a long chronosequence of landslides in the Outer Western Carpathians

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Much research over the past years has been focused on possibilities to sequester carbon in soils and thus mitigate the on-going increase of CO_2 in the atmosphere (Lal 2004). However, the size of the long-term capacity of soils to store carbon still remains unclear mainly because it is difficult to determine the age of older natural soils (Hassink 1997). The studies addressing long-term soil organic matter dynamics have been carried out in rather extreme climatic and/or parent rock environments such as montane rainforests, volcanic islands, or retreating glaciers (Crews et al., 1995; Crocker and Major, 1955; Walker et al., 2013). Extrapolating findings of such studies to European natural soils is questionable. Moreover, studies addressing soil development on millenial time-scales were restricted to volcanic islands (Crews et al. 1995).

Landslides are fast movements of rock or soil along slip surfaces. They are important hazardous phenomena but also offer a unique opportunity to study soil development using the chronosequence approach. Newly exposed rock surfaces are colonized by plants in the process of primary succession.

In this study we describe long-term soil carbon, nitrogen and phosphorus dynamics using a chronosequence of 26 landslides ranging in age from 4 to 12 000 years located near the border of Czech Republic and Slovakia.

Soil samples were collected at 26 landslides including 4 reactivations and at 22 adjacent undisturbed sites. Total soil organic carbon (C), nitrogen (N), and phosphorus content, pH and electrical conductivity was measured in soil samples. Carbon fractions were measured using the fractionation procedure of Zimmermann et al. (2007). The age of landslides was previously determined by radiocarbon dating (Pánek et al., 2013).

Both carbon and nitrogen stocks were found to increase with age especially in the first 100 years both in the mineral soil and in the forest floor. C stock in mineral soil can be described by logarithmic (adj. R2 0.19) or by the Hill equation (adj. R2 0.33). The mean stock for undisturbed soils is 58 t ha-1 which is quite close to the capacity parameter 52 t ha-1 found by fitting the Hill function.

The relative contribution of labile C (dissolved organic carbon) to C stock decreases significantly with the age of landslide. In the older landslides, most C is associated with the silt and clay fraction and this contribution increases significantly in the 10-20 cm layer.

Total phosphorus showed a significant linear increase (p=0.033) in the first 100 years which may be due to redistribution of P from greater depths, followed by a linear decrease (p=0.037) in the sites older than 100 years probably caused by leaching and loss of P from soil.

We conclude that the most intensive soil organic matter accumulation occurs in the first 100 years of soil development. This represents a rather high carbon sequestration rate of about 0.5 t.ha-1.yr-1 during the first 100 years. Soil carbon stock on landslides levels out at around 52 t.ha-1 (although with high variability) and stability of this stored C is intermediate.