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

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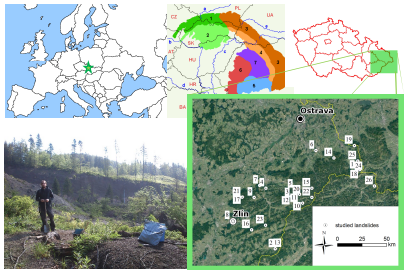
1 Background

- The size of the long-term capacity of soils to store carbon still remains unclear.
- Soil C dynamics are closely linked to the cycles of nitrogen (N) and phosphorus (P) since these elements represent the most common nutrients limiting terrestrial primary productivity.
- 73% of land surface is covered by sedimentary rocks (Wilkinson et al., 2009).
- Most of previous studies addressing long-term SOM dynamics have been carried out in rather extreme climatic and/or parent rock environments and extrapolating findings of such studies to European natural soils is questionable.
- Certain type of landsliding events create new land surfaces where soil development is completely restarted. Newly exposed rock surfaces are colonized by plants in the process of primary succession.

2 Study area



- **26 landslides ranging in age from 4 to 12 800 (+ 22 control sites) along the border of Czech Republic and Slovakia**
- The Flysch Belt of the Outer Western Carpathians
  - alternating layers of Cretaceous and Paleogene sandstones, claystones and shales with different water permeability
  - fold-and-thrust structure (Paleogene/Neogene)

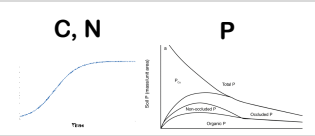
  ⇒ **susceptible to landsliding**
- Age of landslides (>100 years) - ^{14}C dating of organic material buried in the landslide or in an associated peat bog or a landslide-damned lake (Pánek et al., 2013).
- Soils – shallow <30 cm, high rock content
- Vegetation – woody spontaneous regrowth/ 1 pine plantation (<80 years), spruce and/or beech forest (older landslides and control sites)
- MAT: 3–4 °C
- MAP: 900–1500 mm
- Area of each landslide: 3–250 ha

3 Objective

To describe long-term dynamics of C, N and P in soils on a chronosequence of landslides.

*Ages of landslides on the pictures from left to right (years): 4, 44, 900, 1330, 1650, 3780, 11 280

4 Hypotheses

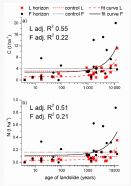


Walker and Syers (1976)

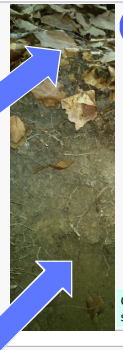
5 Results*

*Only fit curves of significant relationships (p<0.05) are shown

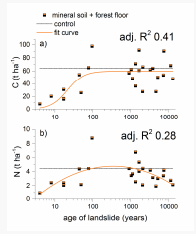
A Forest floor



Carbon (a) and nitrogen (b) stocks in the litter (L) and fermentation (F) layer of the forest floor. Control denotes adjacent undisturbed sites.

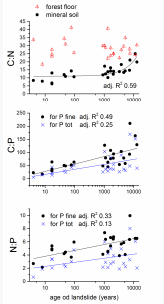


C Total stock



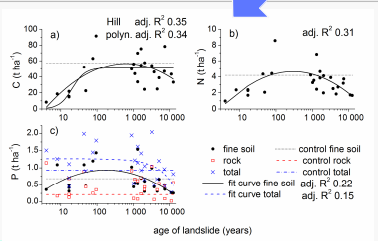
Carbon (a) and nitrogen (b) total soil stocks including forest floor.

D Stoichiometry

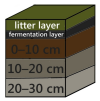


C:N ratio of forest floor and mineral soil, C:P and N:P ratios of mineral soil, calculated using P in <2mm soil (P fine) or including rock P (P tot)

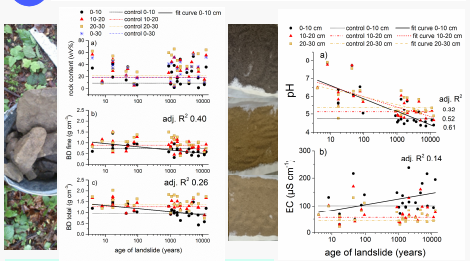
B Mineral soil



Carbon (a), nitrogen (b) and phosphorus (c) stocks. Phosphorus stocks are presented separately for fine soil (<2mm), rock and gravel (>2mm) and as their sum (total P stock).



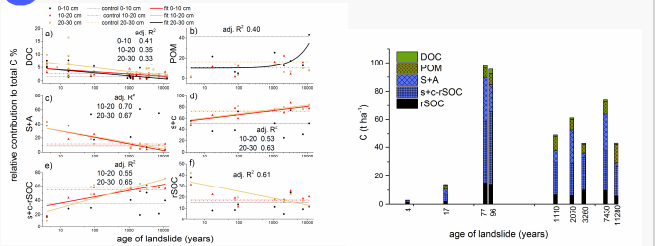
F Rock content, bulk density, pH, EC



Volumetric rock content (a), bulk density of fine soil (b),and total bulk density (c) in the 0-10, 10-20, and 20-30-cm layers.

pH (a) and electrical conductivity (b) of soil.

E Carbon fractions



Relative contribution of carbon fractions to total organic carbon expressed as wt.% in 0-10, 10-20, and 20-30-cm layers.

Contribution of carbon fractions (t ha^{-1}) to total organic carbon stock.

Zimmerman et al. 2007:
- DOC dissolved organic carbon
- POM particulate organic matter
- S+A carbon associated with sand and aggregates
- s+c carbon associated with silt and clay
- s+c-rSOC non-resistant carbon associated with silt and clay
- rSOC resistant soil organic carbon

6 Conclusions

Most intensive soil organic matter accumulation occurs in the first 100 years of landslide soil development ⇒ rather high C sequestration rate of ~0.5 t.ha^{-1}.yr^{-1}

Mineral soil C stock levels out at ~52 t.ha^{-1} (although with high variability). Stability of this stored C is intermediate.

Nitrogen stock first increases rapidly, peaks after ~ 300 years and then slowly decreases.

Total phosphorus (including rocks) decreases over time in accordance with Walker and Syers model (1976). P content in <2 mm soil first increases due to redistribution of P from greater depths, followed by a decrease in the sites older than 100 years caused by leaching and loss of P from soil.