Clay:organic-carbon and organic-carbon as determinants of the soil physical properties

Reassessment of the Complexed Organic Carbon concept

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SOC controls most soil functions

SOC: Soil Organic Carbon

- Direct impact on soil quality
- A “hot” topic at all scales ➔ goals for cropped land?

Global (worldwide) scale

Local (plot) scale

Global Warming
Carbon sequestration

Eco-functions
Filtration, Water storage, Soil stability

Biodiversity
Habitat and gene reservoir

Fertility
Crops yields

Source: http://natureiswonderful.com/terre-notre-planete
SOC and Physical properties

- Porosity
- Water retention
- Plant Available Water
- Air content
- Infiltration
- Mechanical properties
- Stability
- Biological activity
- Nutrient reserve
- Depuration
- Etc.

Is the relation always linear?
More is better?
Goals for soil management?
Reasonable targets?
Does clay content matter?

«increasingly higher quantities of C were required to achieve the same level of aggregate stability in soils of increasing clay content (16-49% clay)».

_Feller and Beare 1997_
Clay:SOC ratio and determination of the physical properties: “complexed” OC: **COC**

“Complexed organic matter controls soil physical properties”

*Dexter et al. 2008*

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Permanent pasture

Dexter et al. 2008

COC + NCOC, g/(100g) vs clay content, g/(100g)

NCOC

COC
Many questions with the empirical COC approach

- Different databases along the study
- Different soil types (bed rock, pedogenesis)
- Decreasing $n \rightarrow$ less samples and more sandy soils along the graph
- Methods for volume measurement? Field water content?
- Structural state of the samples?
- Optimum for $r$, but for the properties?
- Etc.
Methods

- Large scale sampling, unique soil order and bed rock (Cambi-luvisol)
- Shrinkage analysis
- VESS scoring of the samples analysed
- Discuss SOC effect on physical properties

- Similar mineralogy, large texture and SOC ranges
- Volume at controlled matric potential
- + other physical parameters
- Classes of structural quality

Adapted from Ball et al. (2007) by Johannes et al. (in prep).
Sampling site: Swiss plateau

- 120 km across the Swiss plateau
- 157 undisturbed samples randomly collected
- From spring to autumn (2012 – 2014). Topsoil (5-10 cm)
- 3 different managements: No-till; Conventional tillage; Permanent pasture

Cambi-Luvisol on morain - molasse
Soils with good VESS score

*Volume at -10 hPa and air-dry*

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**Graph Description**

- **Correlation, r between COC and V (cm$^3$ g$^{-1}$)**
- **Average COC : SOC tot. ratio (%)**

- **Lines and Markers**:
  - Green squares: 1/BD -10 hPa
  - Yellow squares: 1/BD dry
  - Red diamonds: Dexter et al. (2008) "optimum" considered SOC tot. fraction

- **Axes**:
  - X-axis: n = Clay : SOC ratio (-)
  - Y-axis: Correlation, r

- **Inset**:
  - Graph showing correlation, r vs. n for all POLHYDRO soils.
Modified formula (sample exclusion)

Correlation, $r$ between COC and $V$ (cm$^3$ g$^{-1}$)

- $1/BD -10$ hPa
- $1/BD$ dry

Average Total Sand Content of all discarded samples

$R^2 = 0.86$

$n = Clay : SOC$ ratio (-)

Total Sand Content (%)
Partial conclusions

- There is no optimum of the correlation between clay:soc ratio and the physical properties
  - Also true for other parameters than bulk volume, e.g. Structural porosity

- The maximum correlation is obtained when all the SOC is taken into account $n \approx 7$

- The correlations are much larger than in Dexter et al., 2008

- What about the physical effect of SOC and clay:SOC ratios?
Relation with physical properties

Good VESS score (< 3)

The relation between SOC or clay:SOC and physical properties is linear. R² always higher with SOC than with clay:SOC.

R² is not improved.
Does clay:SOC matter for soil quality?  

**Optimum ratio**

![Graph showing the relationship between SOC and Clay percentages across different samples.](image)

Legend:
- PP
- SD
- CL

- **n = 10**
- **n = 7**
Does clay:SOC matter for soil quality?

Minimum ratio

Bad VESS scores (> 3)

- Ssq = 3.5
- Ssq = 4
- Ssq >4

n = 13

Linéaire (Ssq >4)
Three different limits

n=10 : reasonable goal  -- n=7 : top value --  n = 13: unacceptable ratio
Average VESS > 4
n=10 and VESS Score=3 (limit of acceptable)
Thank you for your attention

- SOC: for physical properties, the more is the best
- There is no clay:SOC optimum ratio
- However, n= 10 is a “reasonable goal” – good agreement with VESS =3
- This soil shows a “Maximum possible SOC” at n=7
- n=13 is average value of the VESS scores > 4 : unacceptable ratio

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