The surface elemental composition of soil microaggregates of different size fractions – Possible implications for functioning

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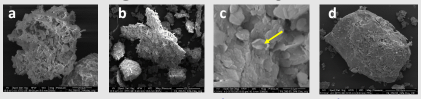
What is known?

Soil microaggregate (20-250 µm; SMA) formation depends on the surface properties (e.g. exposed functional groups, surface charge, wettability) of the aggregate building units (<20µm; BU). However, soil particles generally exhibit a surface layer different in chemical composition from that of the bulk material (e.g. [1], [2]).

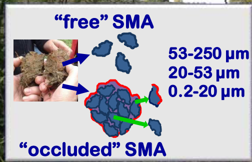
Motivation

Specific analysis of the surface elemental composition (as assessed by XPS) of SMA for better understanding of aggregate formation, functioning, and stability.



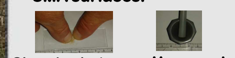
SEM analysis of 53-250 µm-SMA (33% clay content) reveals SMA build up from fine particles (a) and with OM-rich core (b), microbial residues (c; s. arrow), and primary particles (d).

SMA tested



- Water-stable SMA isolated by wet sieving (free SMA) and combined sonication and wet sieving (occluded SMA)
- SMA from loess-derived luvisol toposequence with clay gradient (Experimental site Scheyern, Germany)

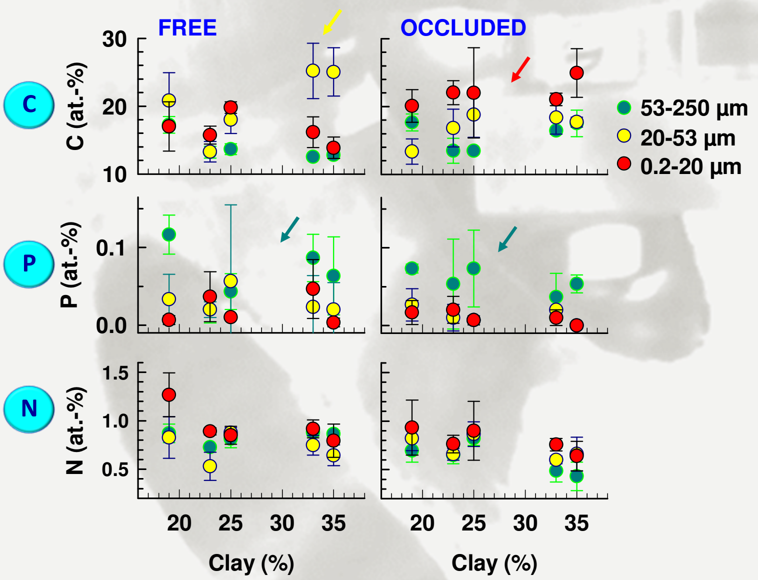
Exposure of more inner SMA surfaces:



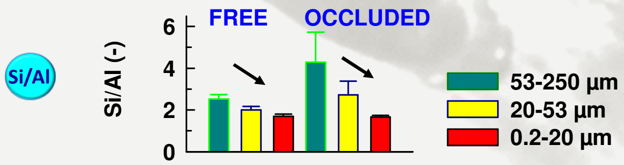
Shearing between two glass plates | Homogenization (mortar)

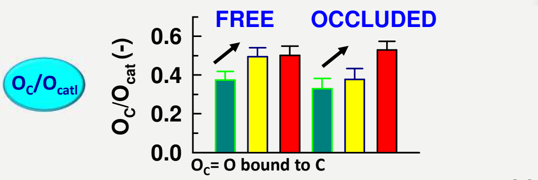
MAJOR FINDINGS

1 Impact of clay content and SMA size fraction



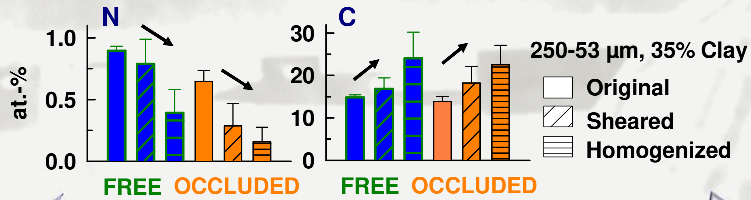
2 Impact of SMA size fraction





O_C= O bound to C
O_{cat}= O bound to mineral-derived cations [3]

3 Specific location of elements within SMA



SMA size fraction:

- Occluded SMA had greatest C content in smallest SMA
  - ► Indication for a greater protection function for C in small SMA and/or a higher share of primary particles in large occluded SMA (1)
- P mainly in 53-250 µm fraction
  - ► Indication for conducive conditions for microorganisms (MO) at the outer surfaces of large SMA (1)
- Si/Al ratio smallest for 0.2-20 µm SMA
  - ► Indication for less quartz and highest clay mineral content in smallest fraction and thus greater stability (2)
- C_C/O_{cat} ratio greater with smaller SMA size (esp. occl. SMA)
  - ► Indication for greater amounts of OM in small SMA (2)

Clay content of bulk material:

- At high clay content of bulk material free 20-53 µm-SMA show C maximum
  - ► Indication for C adsorption to clay minerals (1)

External *vs.* more internal surfaces

- Application of slight shear forces and homogenization of SMA reveals decreasing N and increasing C content
  - ► Indication for preferred localization of MO at outer SMA surfaces and C se-questration within SMA interior (3)

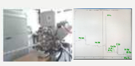
N, C/N ratio

- N and the C/N ratio show no clear trend with SMA type (i.e. free or occluded), SMA size fraction, or clay content of bulk material ► these findings need further research! (1)

Surface O/C ratio

- Surface O/C ratio generally was >2, indicating wettable surfaces [2] and thus no restrictions for microbial life due to water limitation

Surface elemental analysis



- *Analytical tool:* X-Ray Photoelectron Spectroscopy (**XPS**; max. analysis depth 10 nm; Axis Ultra DLD, Kratos Analytical, Manchester, UK)
- *Measurement parameters*: **Survey spectra,** Al*K*α (1486.6 eV), 20 mA, 12 kV, pass energy 160 eV, 3 spectra per sample (n=3), measured area 300x700 µm
- *Evaluation*: **Quantification** (Vision 2, Kratos Analytical, Manchester, UK)

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