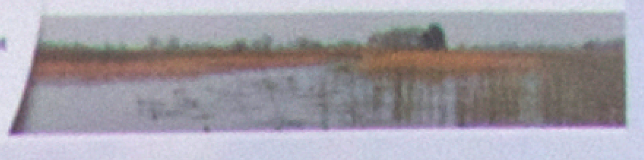
Pedogenic Silica in two croplands of the Belgian Loam Belt



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BACKGROUND AND MOTIVATION

The majority of cultivated crops worldwide are Si accumulators, with significant benefits associated with Si uptake (Guntzer et *al.* 2011). Crops take up dissolved Si (DSi) which is mainly deposited in the cell walls as phytoliths (BSi). Normally when leafs are mixed in the top soil, BSi dissolves (faster than minerals due to its higher solubility) and replenishes the pore water in DSi (Alexandre et *al.* 1997, Conley 2002). Efficient harvesting in European croplands prevent this from happening, depleting the soils in BSi (Keller et *al.* 2012). Recently, it has been acknowledged that other Si pools formed in the soil with no biogenic origin can represent a significant amount of the total biogeochemical available Si (Sommer et *al.* 2006). However, the formation and significance of this pedogenic pool (PSi) in croplands remains unclear as well as its role for the immediate availability of DSi in the pore water in systems with intense cultivation.

Biogenic Si (BSi) — Non-Biogenic Si (non-BSi)

Phytoliths

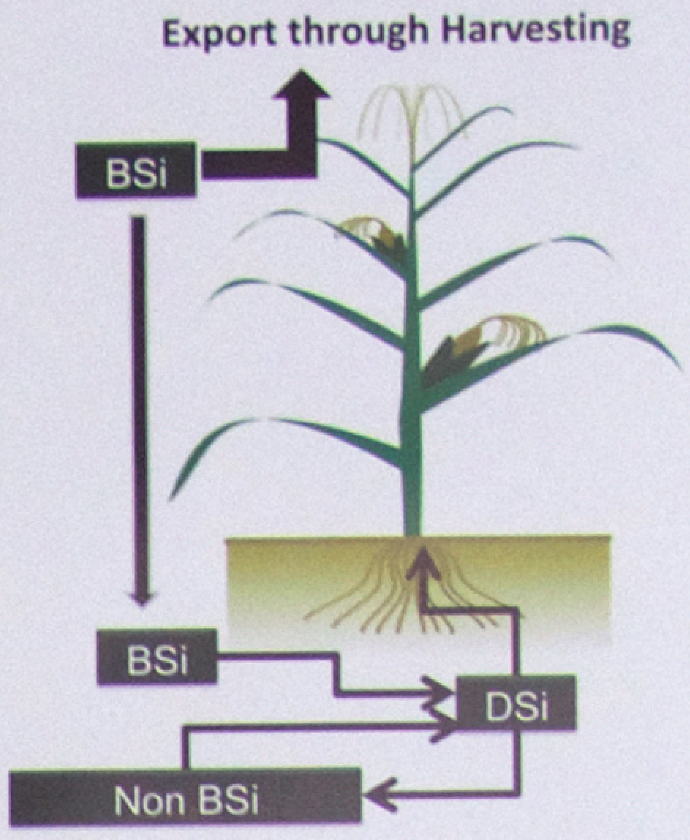
Short-order range minerals

Reactive Clay Minerals

Si adsorbed in Al and Fe oxi/hydroxides

Benefits of Si for crops

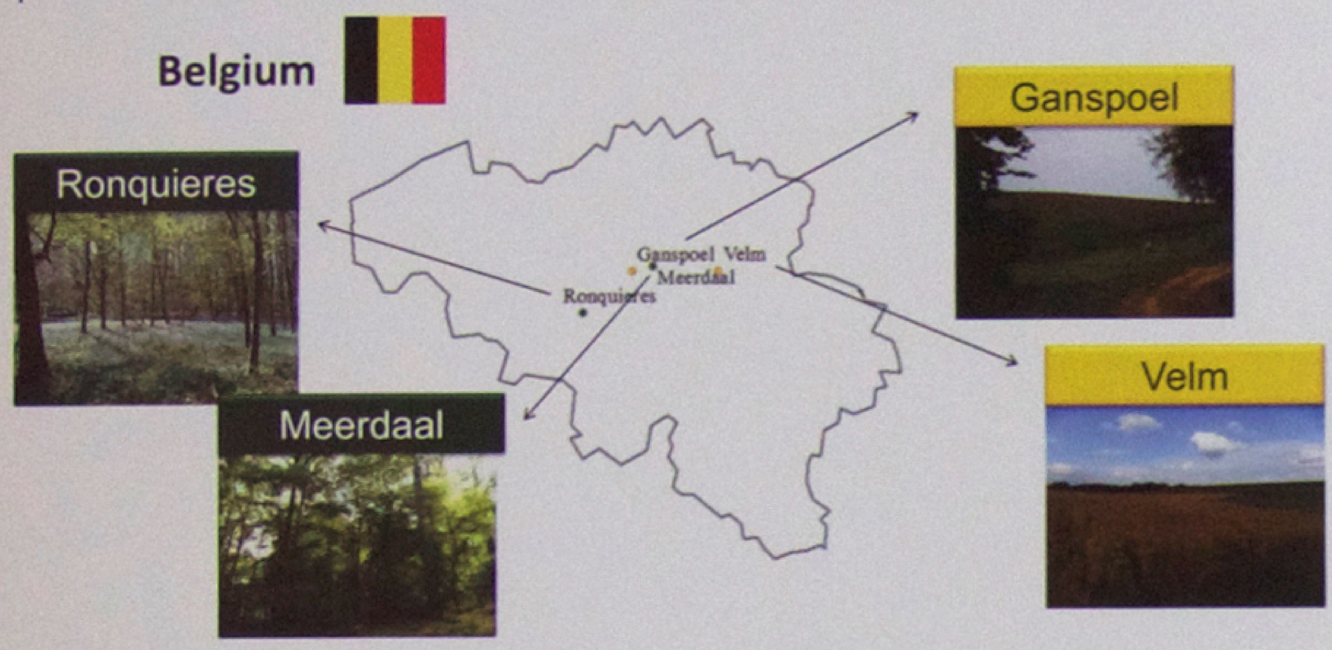
- Increase resistance to insects
- Increase resistance to strong rain and wind
- Alleviation of drought
- Alleviation of salt stress
- Improvement of K and Ca uptake
- Alleviation P deficiency
- Alleviation Fe, Al, Cd, Mn and Zn toxicity



Objective : Evaluate the origin, significance and influence of the non biogenic Si pool in intense cultivated soils from the Belgian Loam Belt for the Si cycle and Si availability

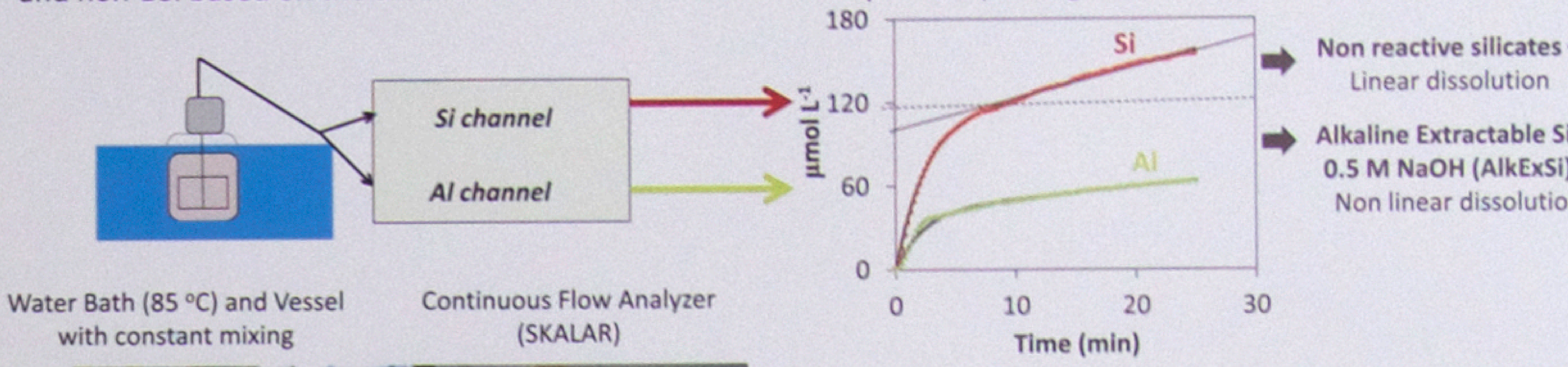
METHODOLOGY

1) Two soil profiles (~150-200 cm total) from two croplands located in the Belgian Loam Belt (Luvisol with eolian loess as parent material) were collected. As a reference situation, two soil profiles from two deciduous forests from the same location were also collected.



3) An extraction with $CaCl_2$ on the same samples was performed to evaluate the amount of readily soluble silica (Si_{CaCl2}) as a proxy for the available Si in the pore water (Sauer et al. 2006).

2) A continuous analysis in 0.5 M NaOH of Si and Al was performed in samples from different horizons to separate BSi and non-BSi based on the Si:Al ratios of the different fractions present (Koning et al. 2002, Barão et *al.* 2014).



Equations used to fit the continuous data from Si and Al extraction in 0.5 M NaOH:

$$Si = \sum_{i=1}^{3} AlkExSi_i \times (1 - e^{-k_i \times t}) + b \times t$$

$$Al = \sum_{i=1}^{3} \frac{AlkExSi_i}{Si/Al_i} \times (1 - e^{-k_i \times t}) + \frac{b \times t}{Si/Al_{min}}$$

Each AlkExSi fraction is characterized also by a reactivity parameter (k) reflecting the dissolution curve "shape" and its ability to dissolve in NaOH. An average reactivity is calculated for each sample:

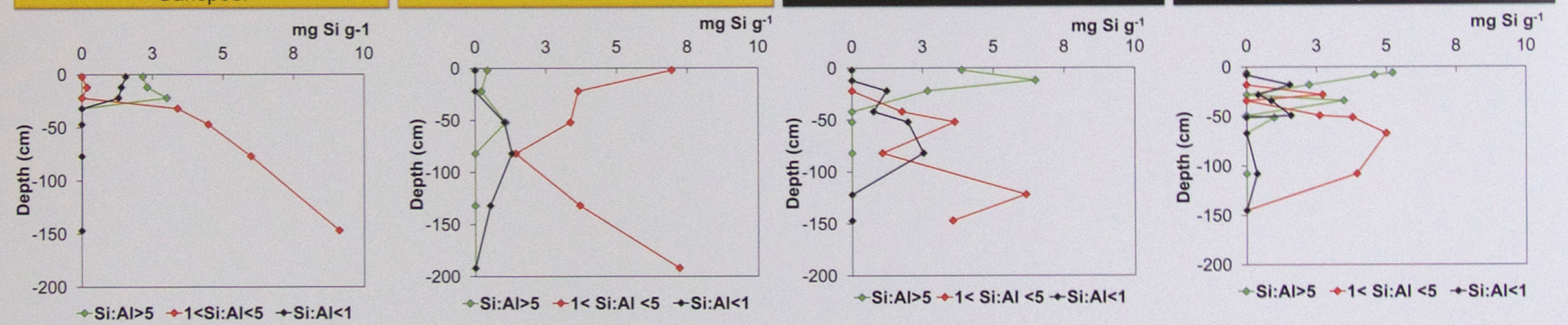
$$k_{AlkExSi} = \sum_{i=1}^{n} \frac{AlkExSi_i}{AlkExSi} \times k_i$$

AlkExSi fractions are classified according to their Si:Al ratios:

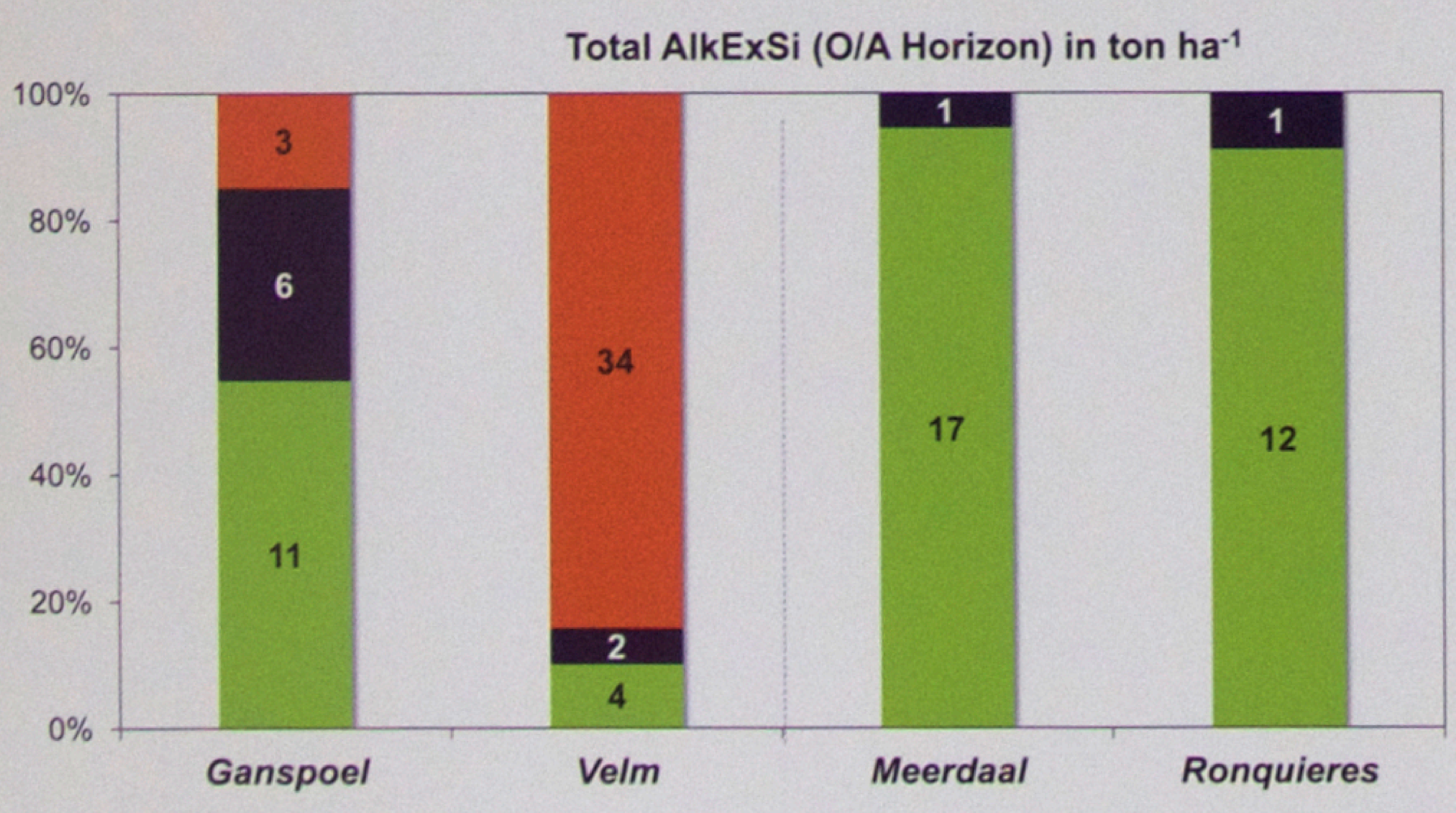
a) **Si:Al >5** (phytoliths)
b) **Si:Al <5 and >1** (reactive clay minerals)
c) **Si:Al <1** (HAS, Si adsorbed, short-order minerals)

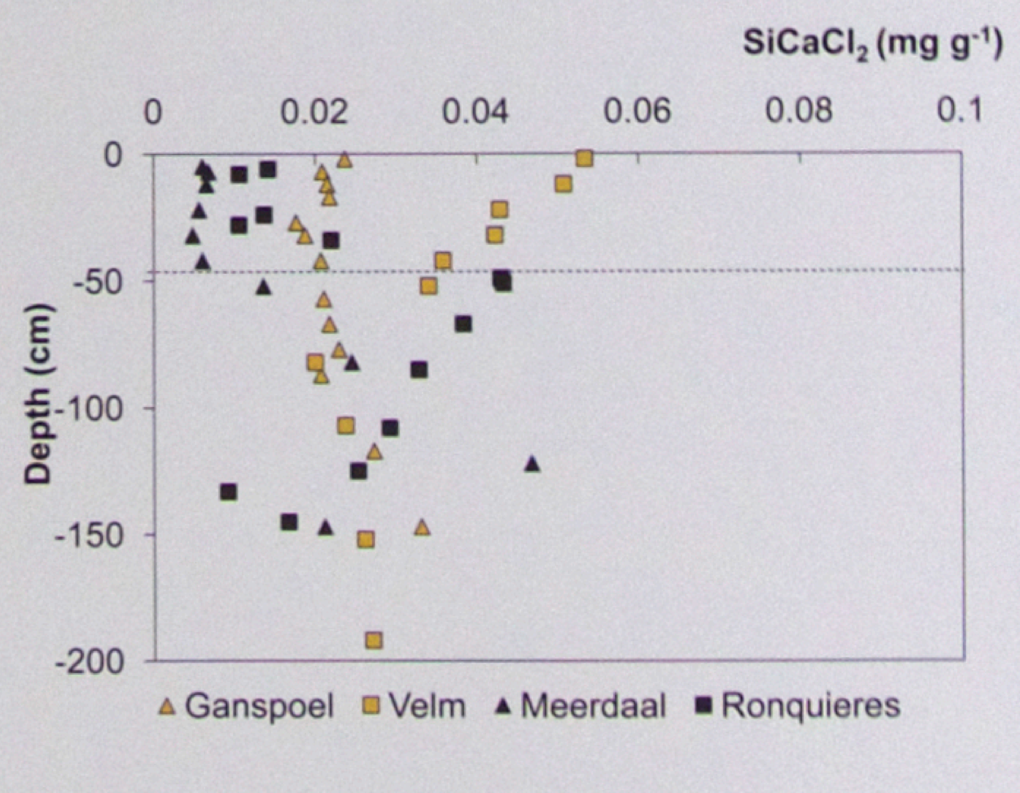
RESULTS AND CONCLUSIONS

1) **Distribution of AlkExSi fractions in the soil profile** - Fractions with Si:Al ratios >5 which correspond to phytoliths are focused in the first centimetres of the top soil and disappear below 50 cm. While both forests show a concentration of this BSi pool around 5 mg g^{-1} in the O horizon, both croplands present signs of depletion (0-3 mg g^{-1}). The non-BSi fractions with Si:Al between 1 and 5, corresponding to clay minerals with higher reactivity in alkaline environments are very representative in all sites (0-8 mg g^{-1}) but especially in the croplands. The AlkExSi fractions with Si:Al<1 resulting from longer weathering and pedogenic processes are less significant in all sites (0-3 mg g^{-1}).

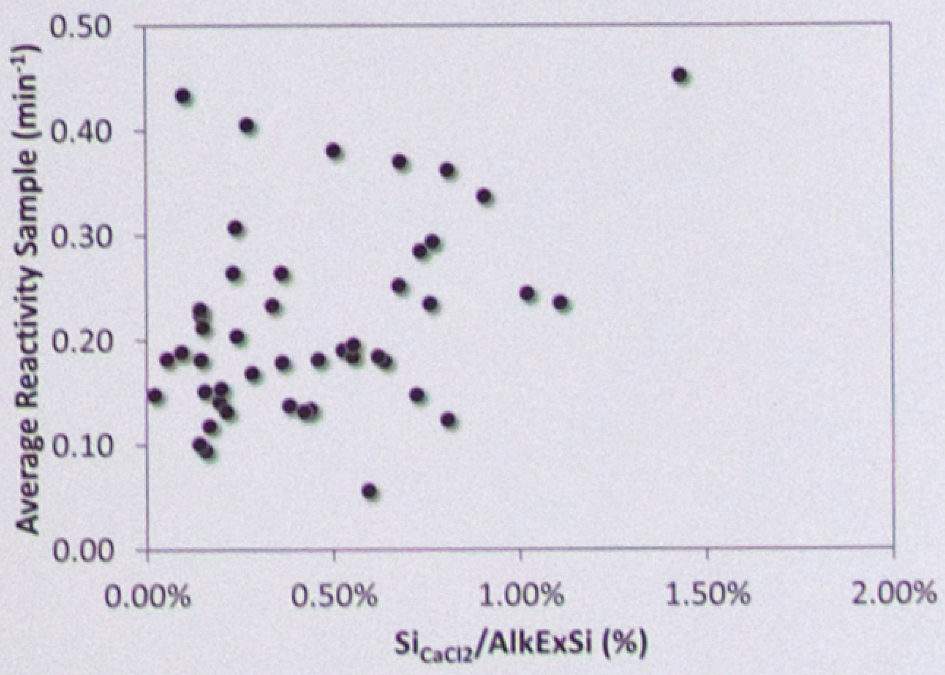


2) **Total AlkExSi pools (ton ha⁻¹) in the O/A horizon** – Croplands are depleted in BSi compared to the forests. Both croplands also show a significant accumulation of reactive clay minerals that are absent from the organic horizons in the forests





3) **Si_{CaCl2} distribution in the soil profile** – In the first 50 cm the Si_{CaCl2} concentration is higher in both croplands (especially Velm) compared to the forests that only reach the same concentrations in the mineral horizons (below 50 cm).



4) The average reactivity calculated for each sample is correlated with the Si readily available (r=0.367). These results indicate that reactive clay minerals are also biogeochemically active in the normal pH ranges found in soils, as compared to the phytoliths.

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