Quantification of the phytoliths pool in a tropical Andosol, A new method

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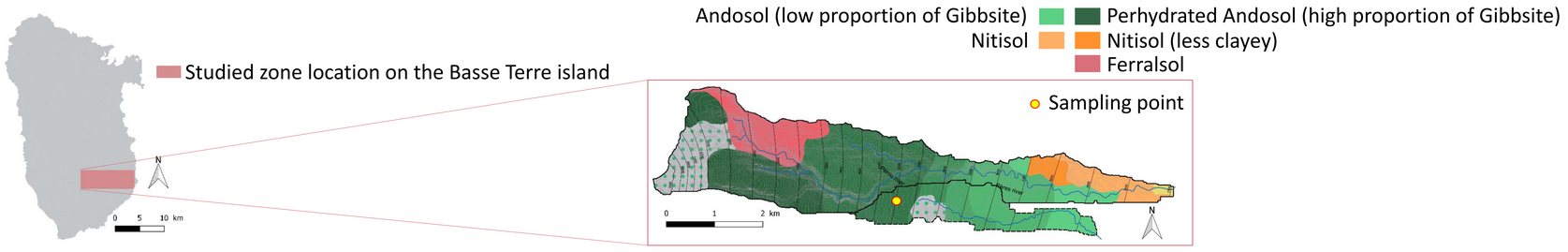
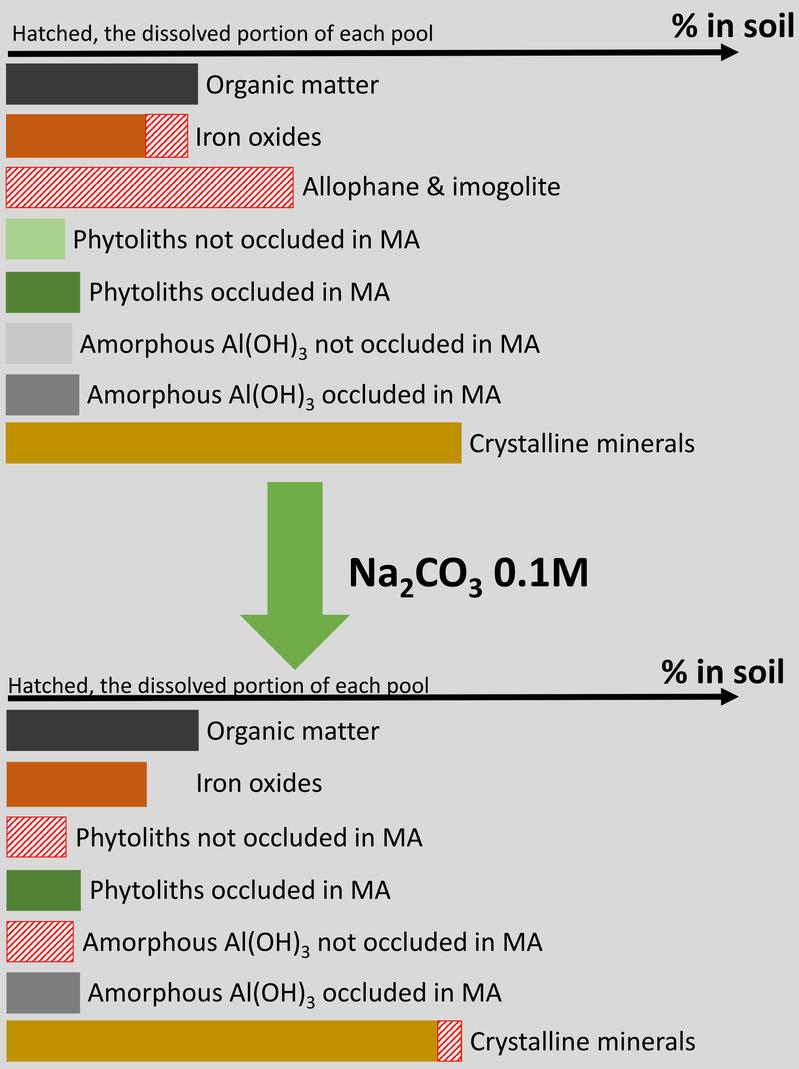
Silicon (Si) is the second most abundant element of the earth crust. The Si cycle strongly depends on the bio-cycling of Si by plants. Plants roots absorb the dissolved silicon (DSi) present in the soil solution and accumulate it into amorphous silica bodies called **phytoliths (PhSi)**. Once plant debris return to soil, **PhSi may constitute an important silica pool in soil**. PhSi **strongly contributes to the DSi pool**; especially in desilicated weathered soils. To understand the soil-plant Si cycle it is thus primordial to quantify the PhSi pool in the soil.
However, **quantification methods are still not very well defined** especially in soils in which pedogenic amorphous silica pools are abundant.



The studied soil is located on the Basse-Terre island in Guadeloupe. The soil is a perhydrated Andosol with high organic matter content and secondary minerals typical of Andosols such as allophane, imogolite, amorphous $Al(OH)_3$ and gibbsite.

Method 1 : Quantification of the free PhSi pool

Dark oxalate extraction



Na_2CO_3 0.1M

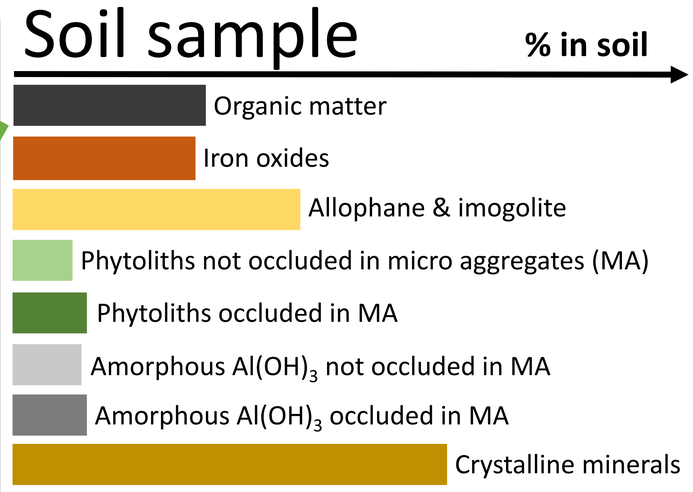
Alkaline reagents (e.g. Na_2CO_3) quickly dissolve phytoliths, and part of allophane and imogolite pools. They also dissolve crystalline minerals slowly and continuously. The time course extraction method developed by DeMaster (1981)[1] allows to differentiate amorphous from crystalline Si pools by extrapolating the linear part of the extraction (after 2h) to time zero.
However this method does not allow to distinguish between the pedogenic and biogenic amorphous Si pools, and therefore often overestimates the biogenic Si pool. To avoid this problem, we first use dark oxalate extraction to remove allophane and imogolite.

The remaining amorphous pools are the PhSi and amorphous $Al(OH)_3$ and the time course extraction allows thus to quantify these pools (Figure 1). PhSi that are dissolved here are considered as free PhSi, i.e. not occluded in micro aggregates.

Al from the dissolution of all the amorphous $Al(OH)_3$ pool that is not protected in micro aggregates
Si from the dissolution of all the PhSi pool that is not protected in micro aggregates

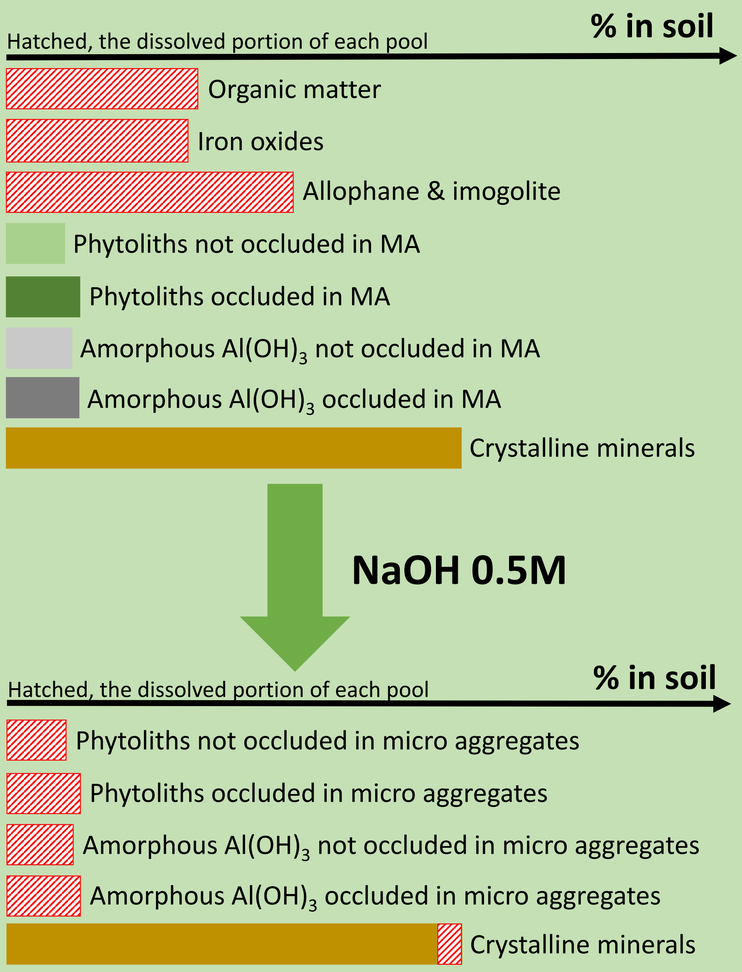
Figure 1

Soil sample



Method 2 : Quantification of the total PhSi pool (including free and occluded)

Successive H_2O_2, DCB and dark oxalate extractions



NaOH 0.5M

The classical physical extraction method (adapted from Kelly 1990[2]) extracted much more PhSi than method 1 did. Thus, organic matter and Fe-oxides micro aggregates might protect phytoliths from alkaline dissolution. Therefore, we quantified the PhSi pool by using an alkaline reagent after removal of organic matter, Fe oxide, and allophane and imogolite. Figure 2 shows that, indeed, the quantity of PhSi measured with method 2 is much larger than the one measured by method 1 for the same sample. We conclude that with method 2, the entire PhSi pool is quantified (including the one clustered in micro aggregates).

Al from the dissolution of all the amorphous $Al(OH)_3$ pool
Si from the dissolution of all the PhSi pool

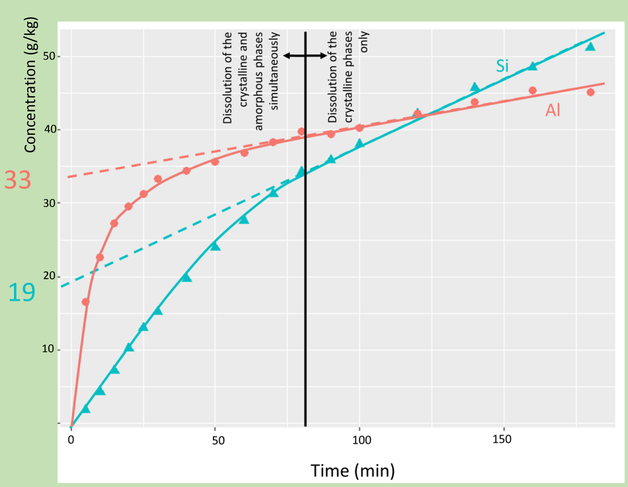


Figure 2

Concluding remarks

In Andosol, allophane, imogolite and micro aggregates make the quantification of the PhSi pool difficult and pre-treatment of soil samples is necessary. We propose here two new methods to quantify the free PhSi pool that is readily active in the soil-plant Si cycle and the total PhSi pool. Occluded PhSi in micro aggregates may further explain the resilience of phytoliths in soils.

A warm thank you to…
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[1]DeMaster, D. J. (1981) *Geochimica et Cosmochimica acta*, *45*(10), 1715-1732., [2]Kelly E.F. (1990) *Workshop on biotic indicators of global change (Seattle-Washington)*