Rainfall as the major driver of plant Si availability in gibbsitic Andosols

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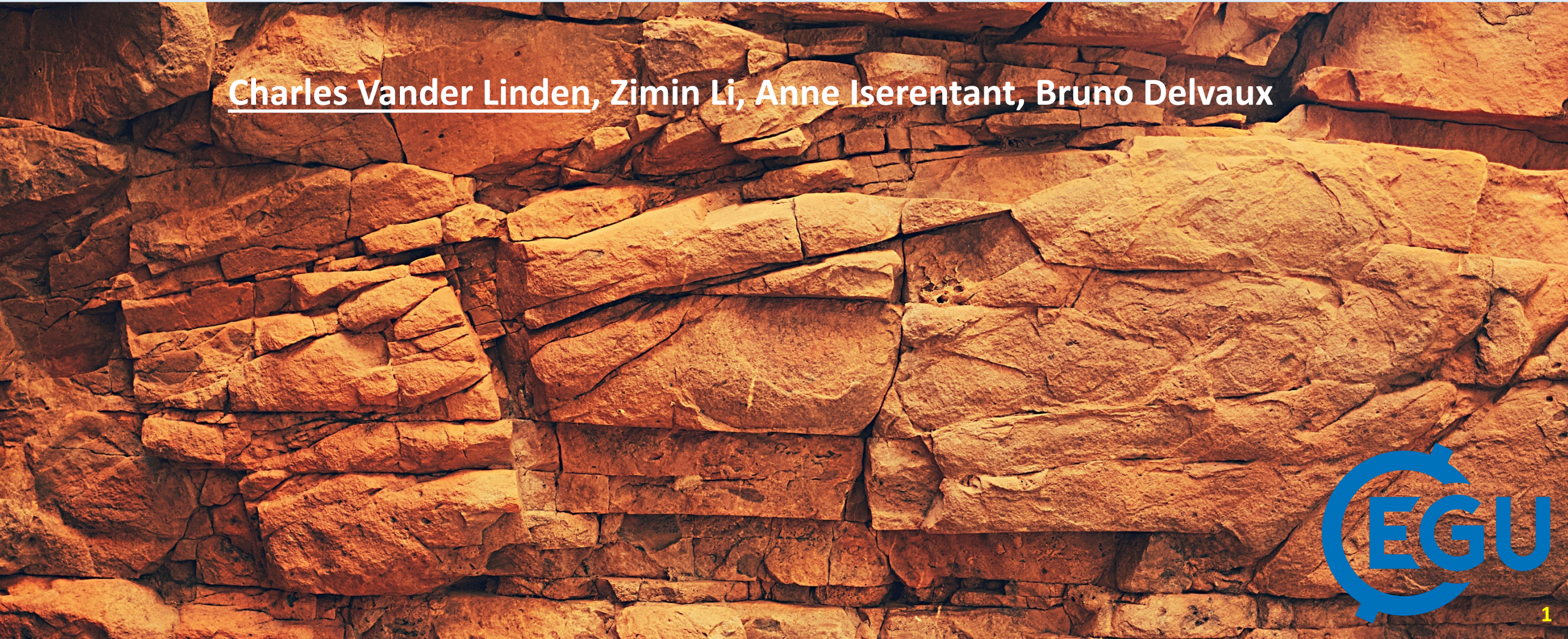
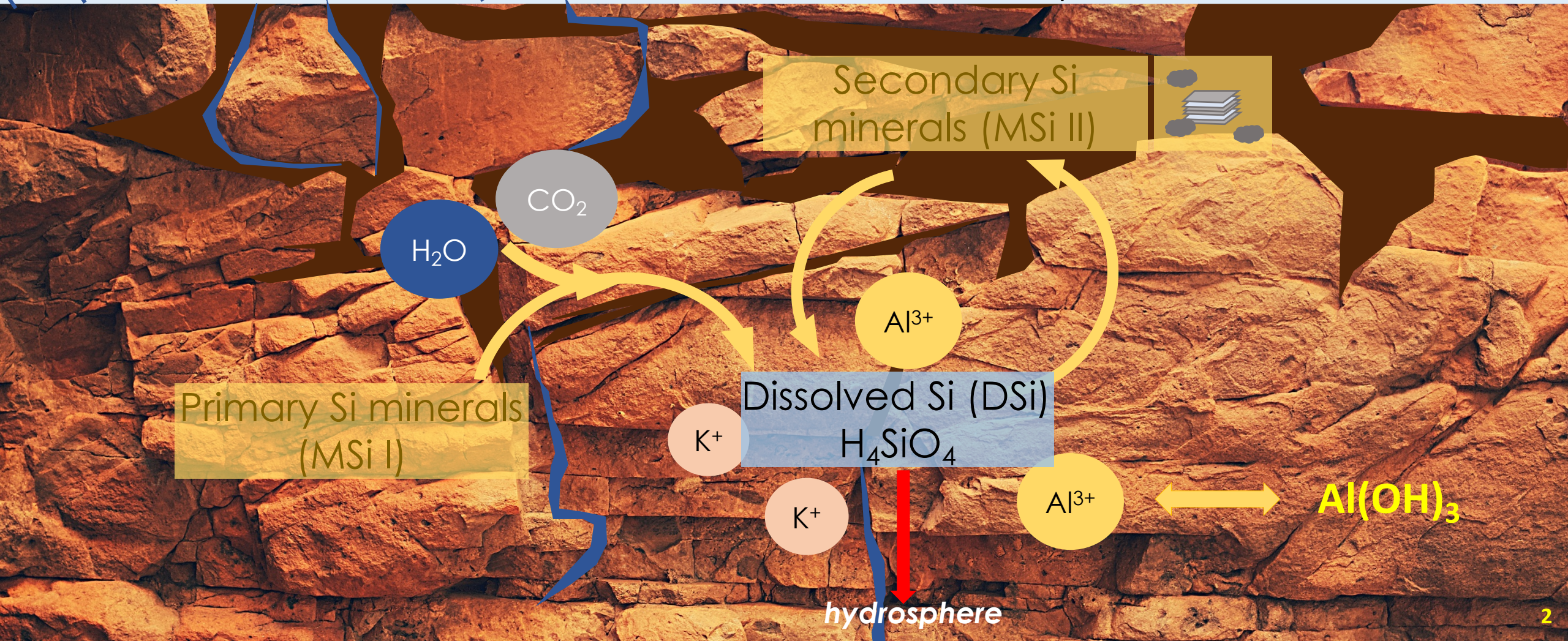


Dissolving primary silicates release solutes (Si, Al, Fe…) that recombine to form secondary clay minerals and/or (Al, Fe) oxides. In perhumid conditions, most of H_4SiO_4 can be leached out whereas gibbsite ($Al(OH)_3$) forms.

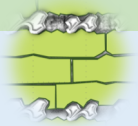
Gibbsite is thus a pertinent indicator of desilication intensity and Si bioavailability



How does rainfall affect the leaching of DSi (H_4SiO_4), the respective formations of allophane and gibbsite?

What is the impact of rainfall on the soil-plant Si cycle?

Phytoliths (PhSi)
$SiO_2.nH_20$



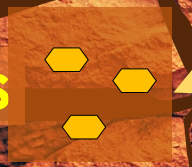
Biological Si feedback loop

Silicate minerals (MSi I and MSi II)

Dissolved Si (DSi) H_4SiO_4

Biogenic Si (BSi)

(Fe,Al) oxides



hydrosphere

Basse Terre island, Guadeloupe

La Soufrière volcano
asl 1467 m

MAP = 7000 mm

4400 mm

2500 mm

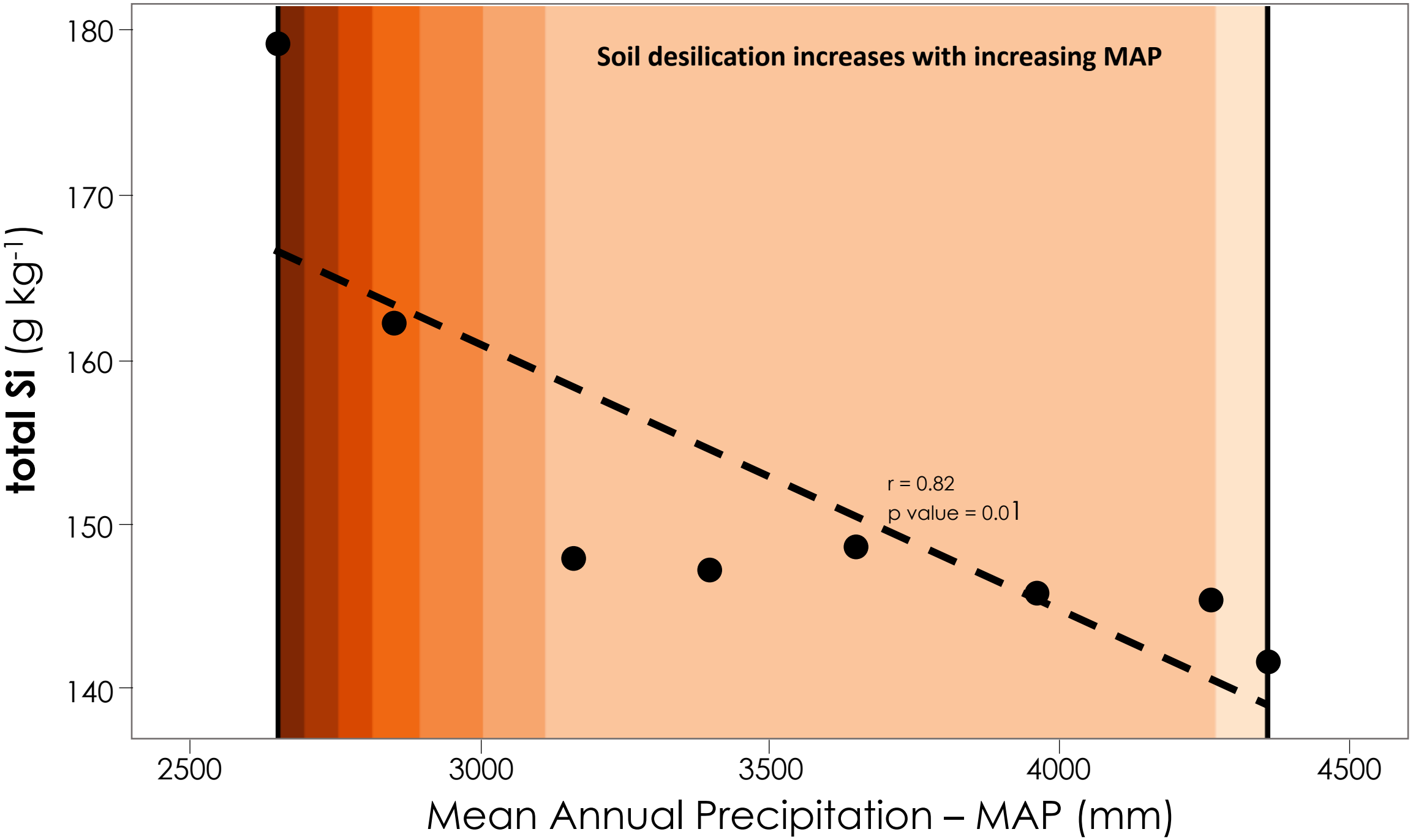
400 m
350 m
300 m
250 m
200 m
150 m
100 m
50 m

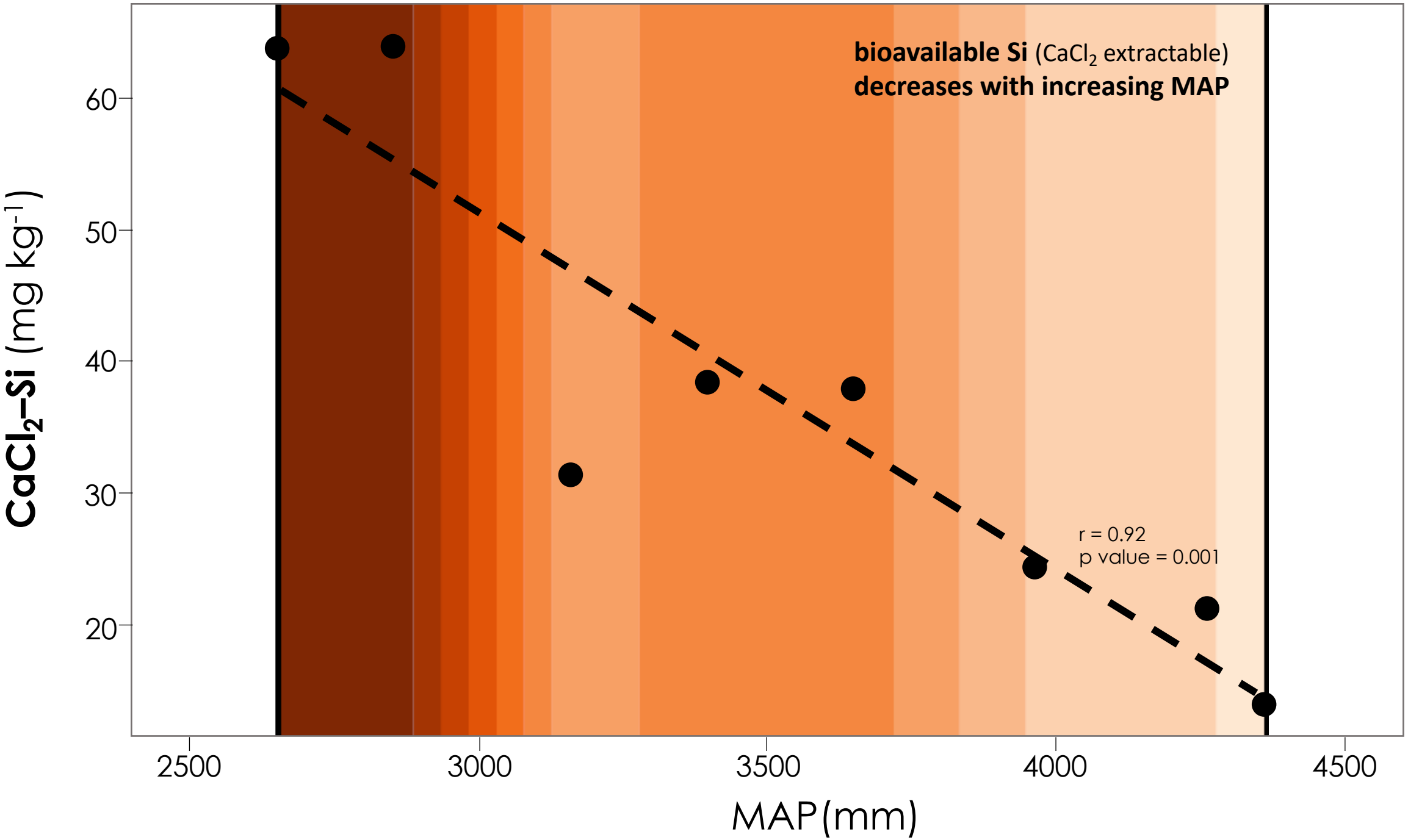
5 km

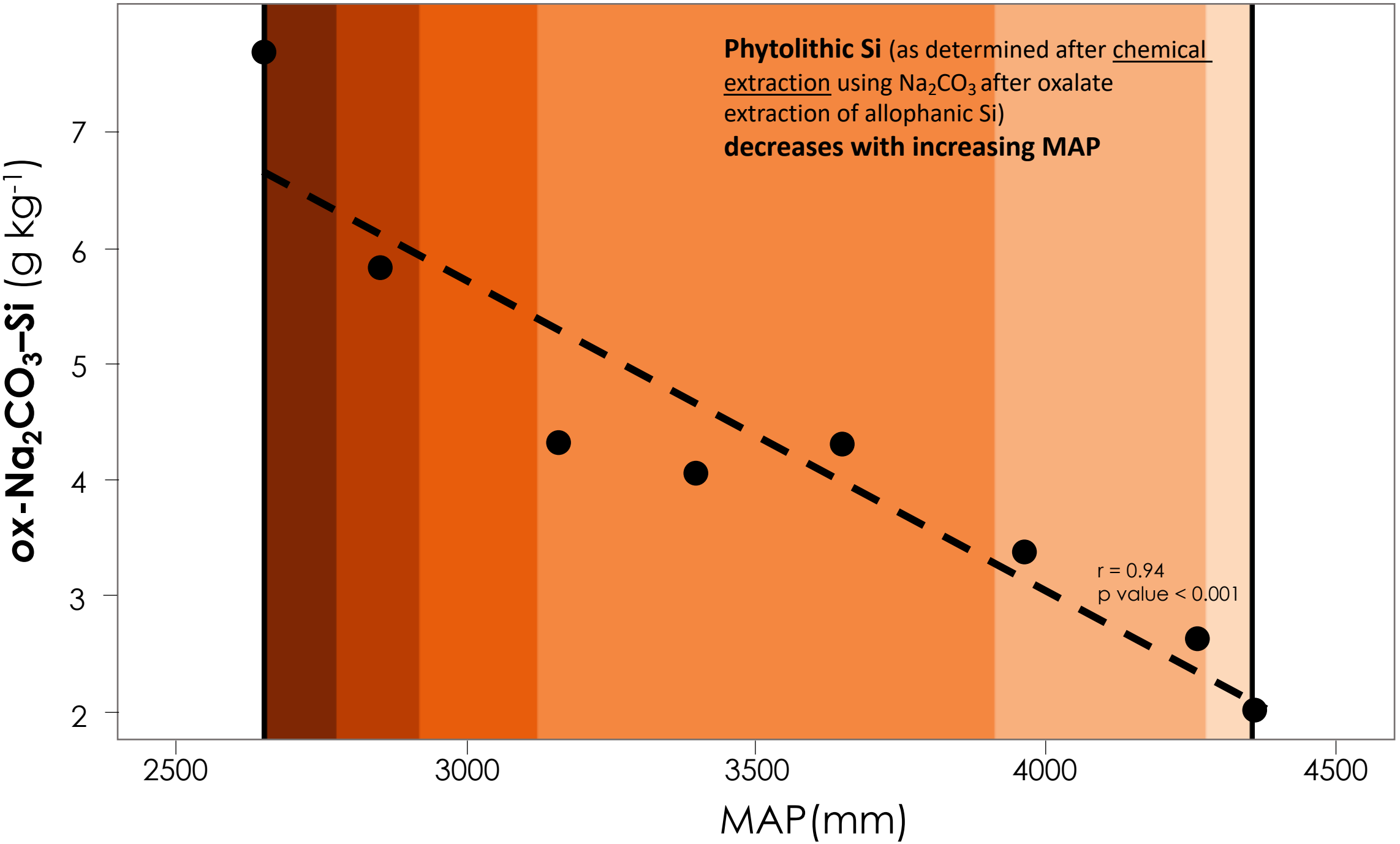
The Andosols have reached an advanced stage of weathering:
- dominant secondary minerals are gibbsite, ferrihydrite and aluminous allophane,
- gibbsite content increases with altitude and MAP,
- SOM content increases with altitude and MAP,
- at 400 m asl, perhydrated Andosols are gibbsitic non-allophanic, and humus-rich.

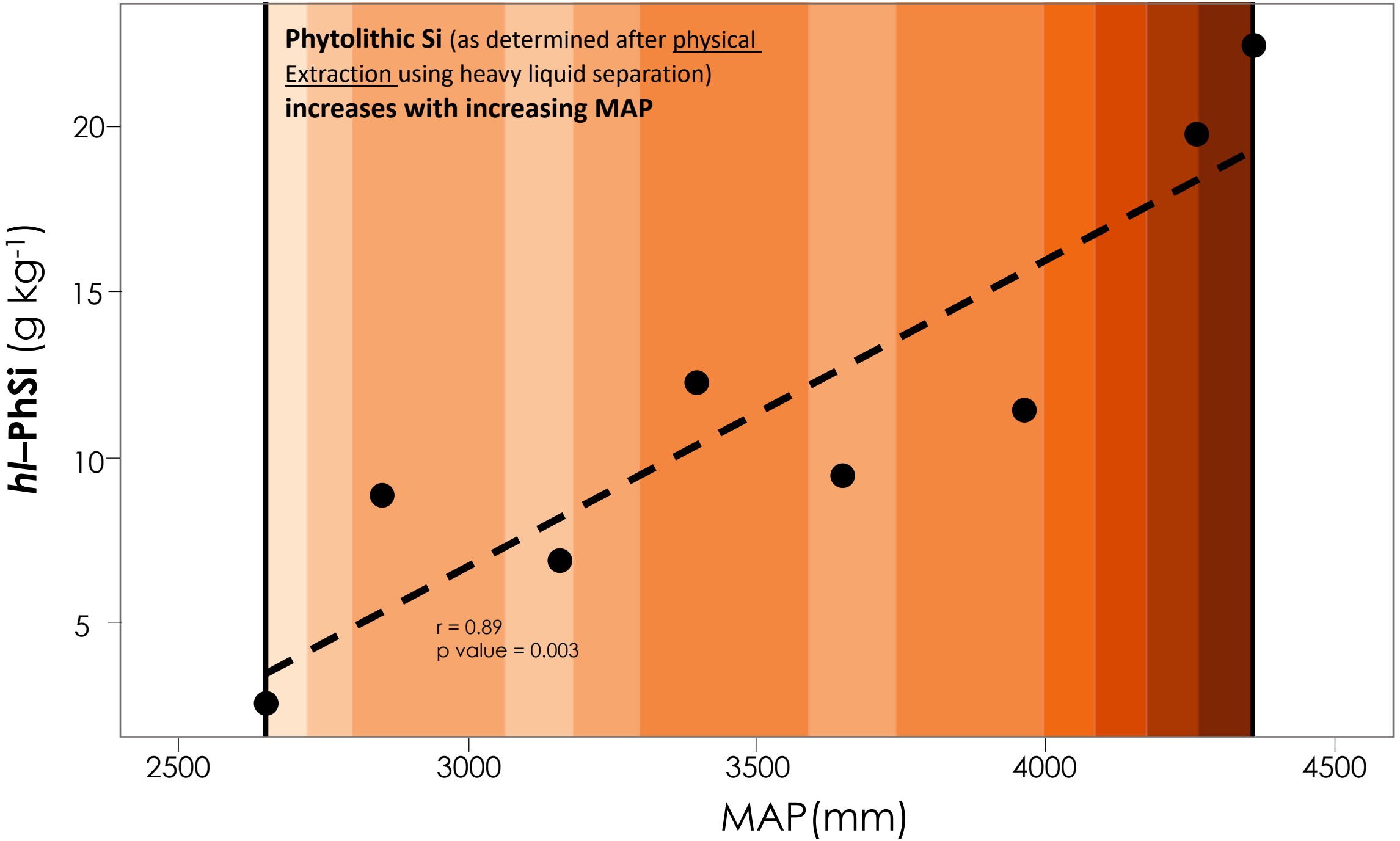
8 sites were selected for soil/plant sampling in a soil topoclimosequence of ash derived Andosols.

In topsoils, we determined:
- total Si
- $CaCl_2$-extractable Si ($CaCl_2$-Si)
- Na_2CO_3 Si after oxalate: ox-Na_2CO_3-Si
- phytolithic Si by heavy liquid separation: *hl*-PhSi


Soil desilication increases with increasing MAP
r = 0.82
p value = 0.01
total Si (g kg-1)
180
170
160
150
140
2500
3000
3500
4000
4500
Mean Annual Precipitation – MAP (mm)

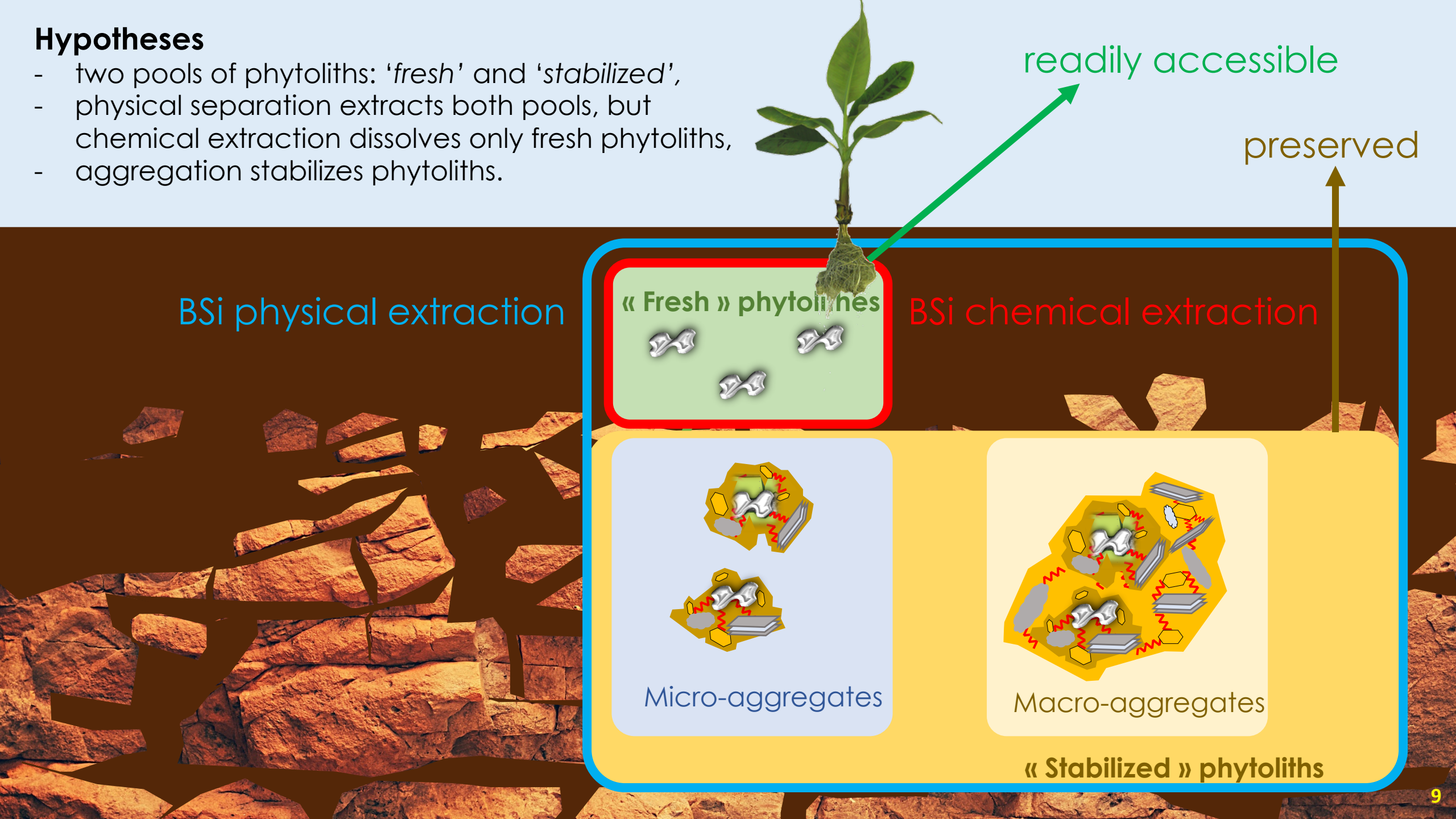

bioavailable Si ($CaCl_2$ extractable)
decreases with increasing MAP
r = 0.92
p value = 0.001
$CaCl_2$–Si (mg kg^{-1})
60
50
40
30
20
2500
3000
3500
4000
4500
MAP(mm)

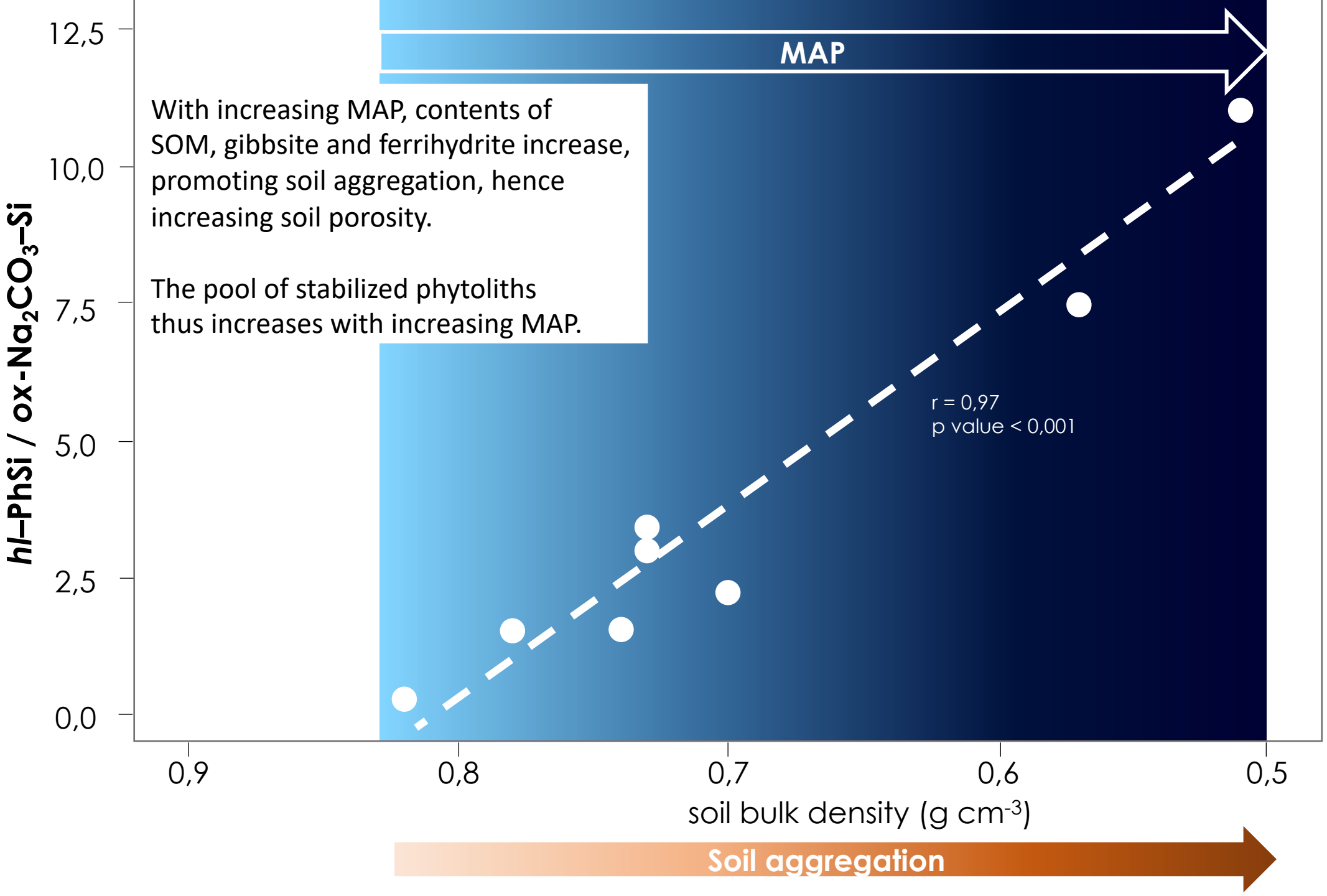

Phytolithic Si (as determined after chemical extraction using Na_2CO_3 after oxalate extraction of allophanic Si)
decreases with increasing MAP
r = 0.94
p value < 0.001
ox-Na_2CO_3–Si (g kg^{-1})
MAP(mm)
2
3
4
5
6
7
2500
3000
3500
4000
4500


Phytolithic Si (as determined after physical Extraction using heavy liquid separation) **increases with increasing MAP**
r = 0.89
p value = 0.003
hl–PhSi (g kg^{-1})
20
15
10
5
2500
3000
3500
4000
4500
MAP(mm)

Hypotheses

- two pools of phytoliths: '*fresh*' and '*stabilized*',
- physical separation extracts both pools, but chemical extraction dissolves only fresh phytoliths,
- aggregation stabilizes phytoliths.




MAP
With increasing MAP, contents of SOM, gibbsite and ferrihydrite increase, promoting soil aggregation, hence increasing soil porosity.
The pool of stabilized phytoliths thus increases with increasing MAP.
r = 0,97
p value < 0,001
hl–PhSi / ox-Na2CO3–Si
12,5
10,0
7,5
5,0
2,5
0,0
0,9
0,8
0,7
0,6
0,5
soil bulk density (g cm-3)
Soil aggregation

Conclusions

- MAP is the driver of bioavailable Si content in the studied gibbsitic Andosols.
  The increase in MAP:
  - increases soil desilication,
  - promotes the formation of gibbsite,
  - decreases the content of bioavailable Si in soil.

- The physical (heavy liquid separation) and chemical (Na_2CO_3) extractions show very contrasting yields.
  The Si contents extracted by these two methods are in fact strongly and negatively correlated with each other.

- We suggest that two pools of phytoliths occur in the studied perhydrated gibbsitic Andosols: fresh phytoliths that readily dissolve in Na_2CO_3 and aged or stabilized phytoliths.
  Both types are likely extracted by the heavy liquid separation.


Thank You