

Supply-limited weathering regime in a tropical shields basin (Ogooué River basin, Gabon)

What is the variability of weathering/erosion rates with respect to
lithological effect and geomorphology on two tropical basins
(Ogooué and M'Bei rivers, Gabon)?

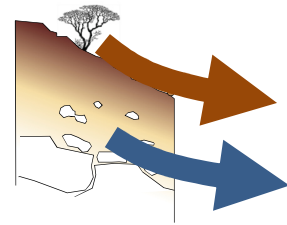
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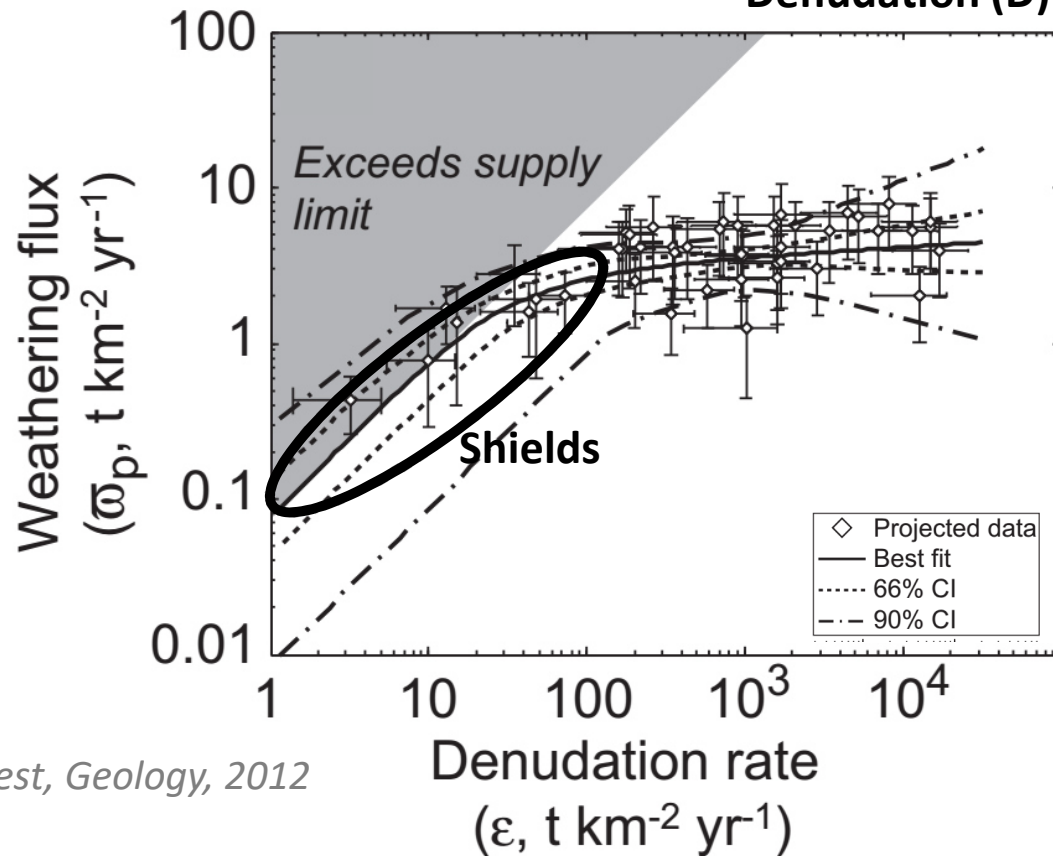
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Introduction



$$\begin{aligned} & \text{Erosion (E)} \\ & + \\ & \text{Weathering (W)} \\ & = \\ & \text{Denudation (D)} \end{aligned}$$



West, *Geology*, 2012

Lateritic shields :

- ~ 30% of the continents
- Significant weathering budget

BUT

W vs D relationship lowly investigated

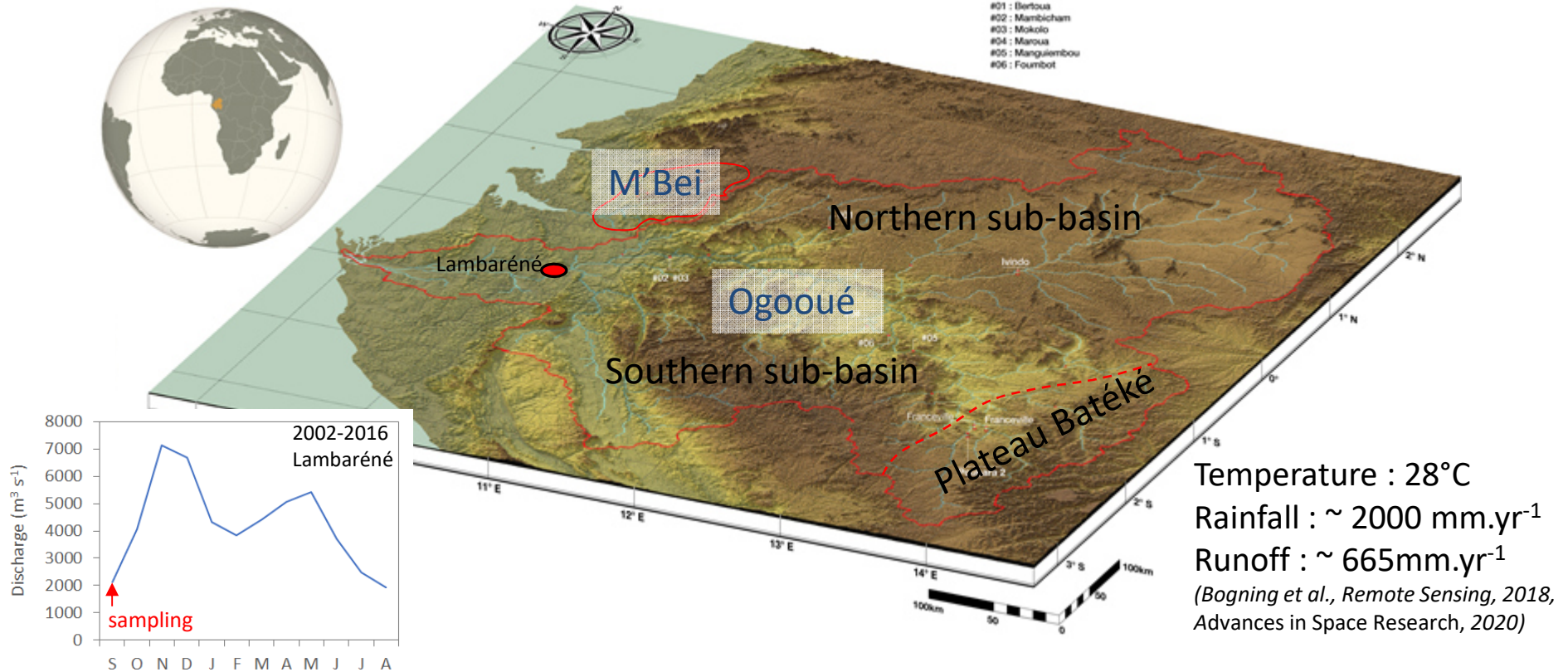
What is the variability of weathering/erosion rates with respect to lithological effect and geomorphology on two tropical basins (Ogooué and M'Bei rivers, Gabon)?

Shield weathering : the Ogooué basin case



Project RALTERAC (J.J. Braun-IRD)

Ogooué basin (Central Africa Craton)

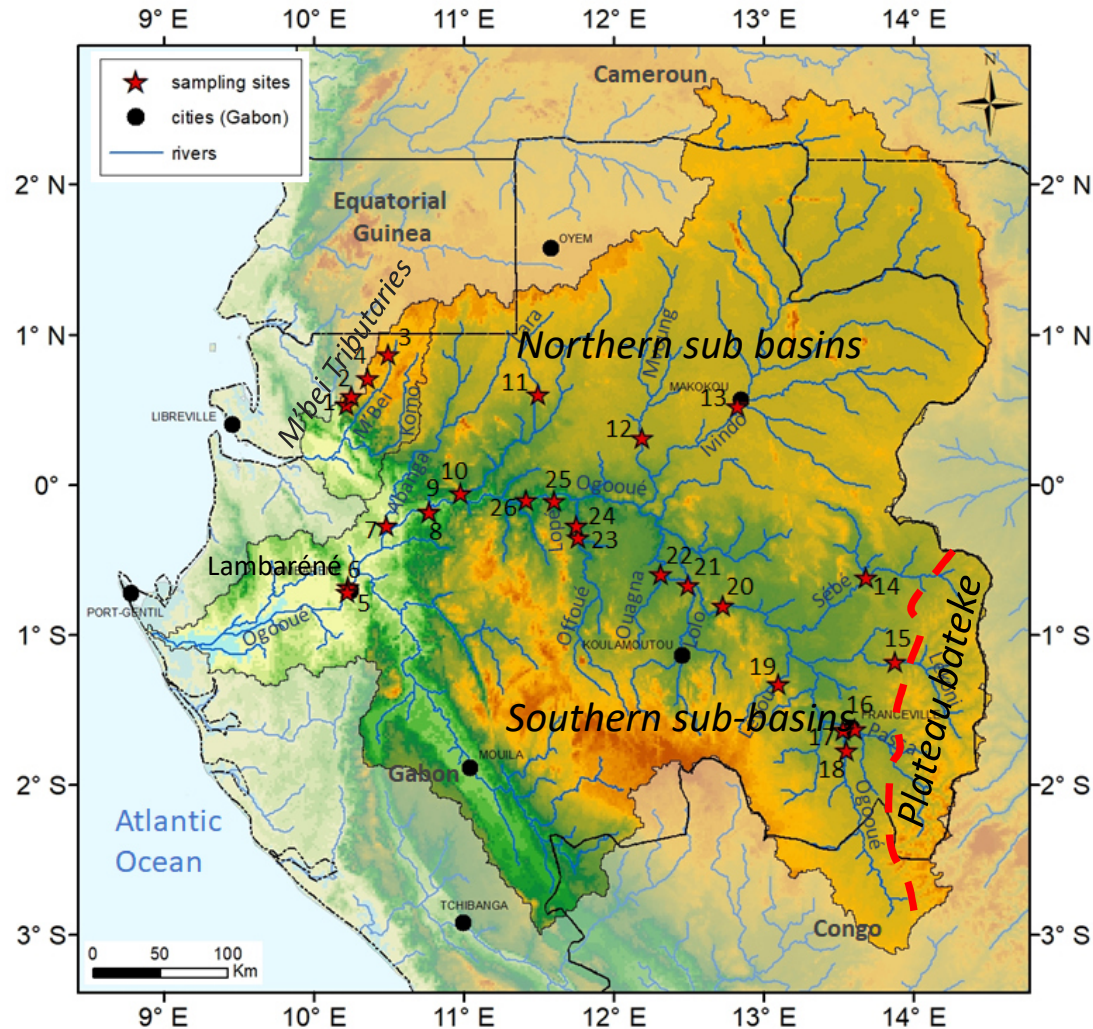


3 geological/geomorphological regions :

- Plateau Bateke : sand (pure quartz) - tectonically quiescent and low erosion rates.
- Northern sub-basins : granites - deep lateritic soils, tectonically quiescent, low erosion rates
- Southern sub-basins Mixed lithology - uplift activity - erosion

Sampling campaign

september 2017



24 sampling (including 18 tributaries):
Water, suspended sediments, river bank sand

Data available : daily discharge at
Lambaréné, rainfall (TRMM), MNT (SRTM90)

In situ measurements :

pH : 4,63-7,62

Conductivity: 5-78 μ S.cm⁻¹

Water temperature : 22-28°C

Lab analyses :

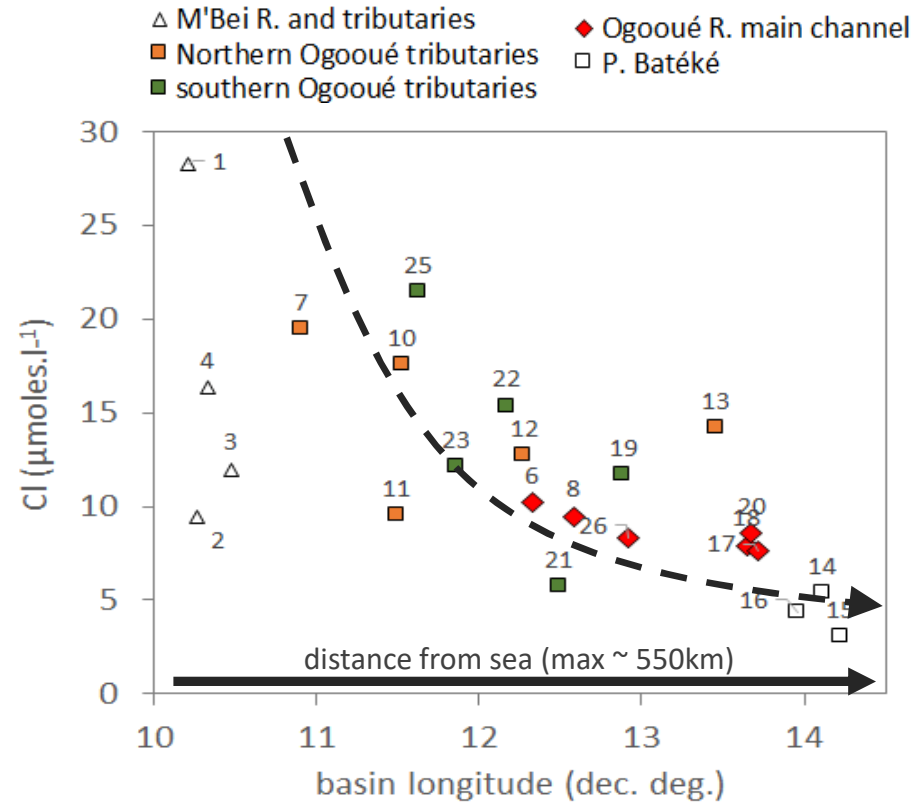
Major and trace elements

⁸⁷Sr/⁸⁶Sr + ϵ Nd (only sediments) (not
presented)

¹⁰Be on sand

Chemical weathering deduced from the water chemistry

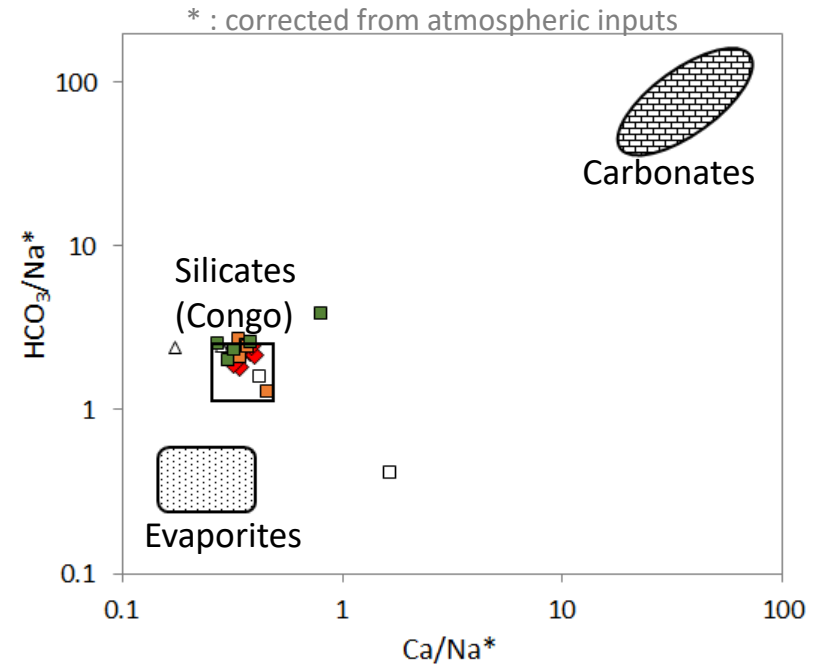
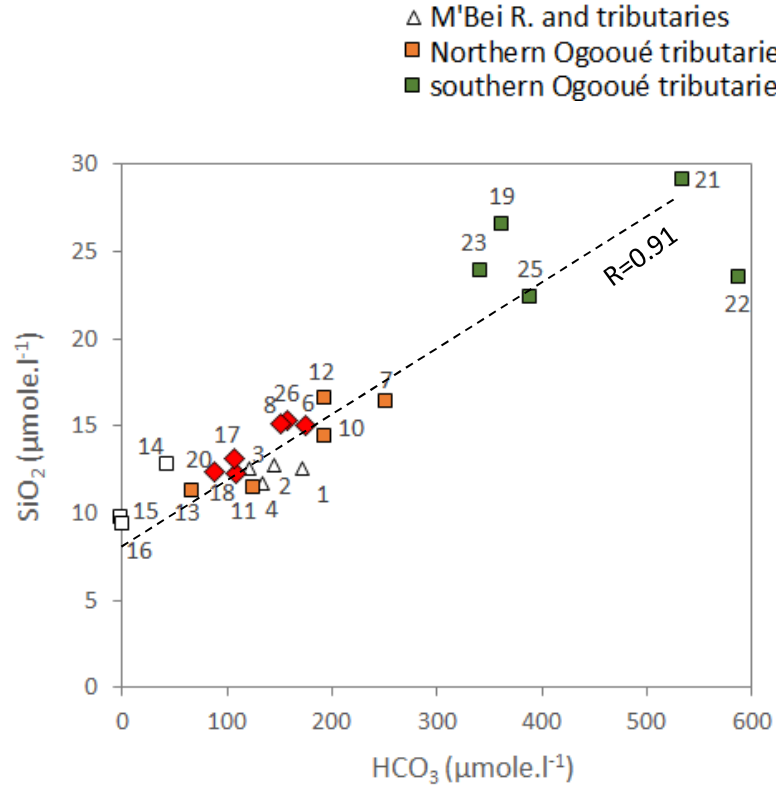
Atmospheric inputs



- Classical Cl concentration decrease from the Ocean (*ex : Congo : Negrel et al., GCA, 1993*)
- **No evaporites inputs** → Cl is used for atmospheric correction

Chemical weathering deduced from the water chemistry

Lithological sources



Endmembers from Gaillardet
et al., Chem. Geol., 1999

→ Excellent correlation between Si and HCO₃⁻

→ Homogenous silicate source for almost all samples

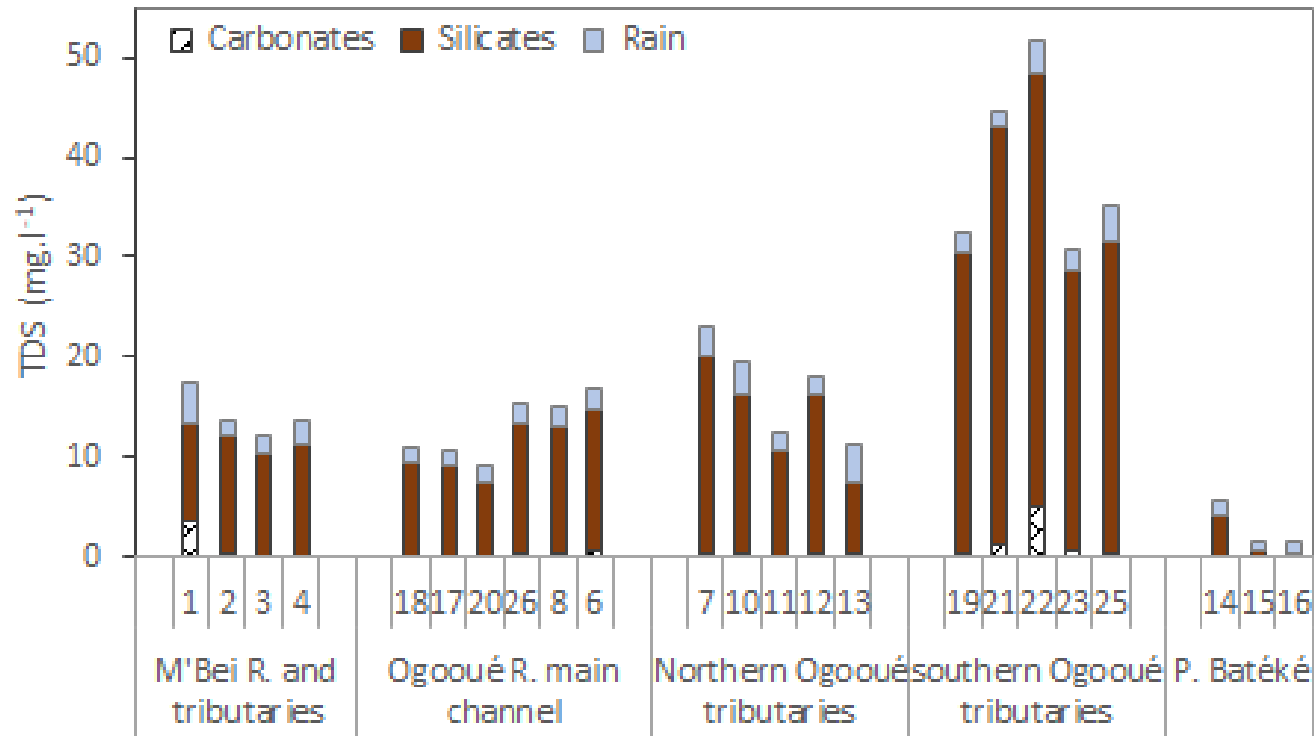
→ silicate weathering dominate the solutes and CO₂ consumption

Chemical weathering deduced from the water chemistry

sources discrimination

Direct discrimination method

(Garrel and Mack, *Marine Chemistry*, 1972)



TDS (Total dissolved solids) = $\text{Na}^+ + \text{Ca}^{2+} + \text{Mg}^{2+} + \text{K}^+ + \text{HCO}_3^- + \text{SO}_4^{2-} + \text{Cl}^- + \text{SiO}_2$

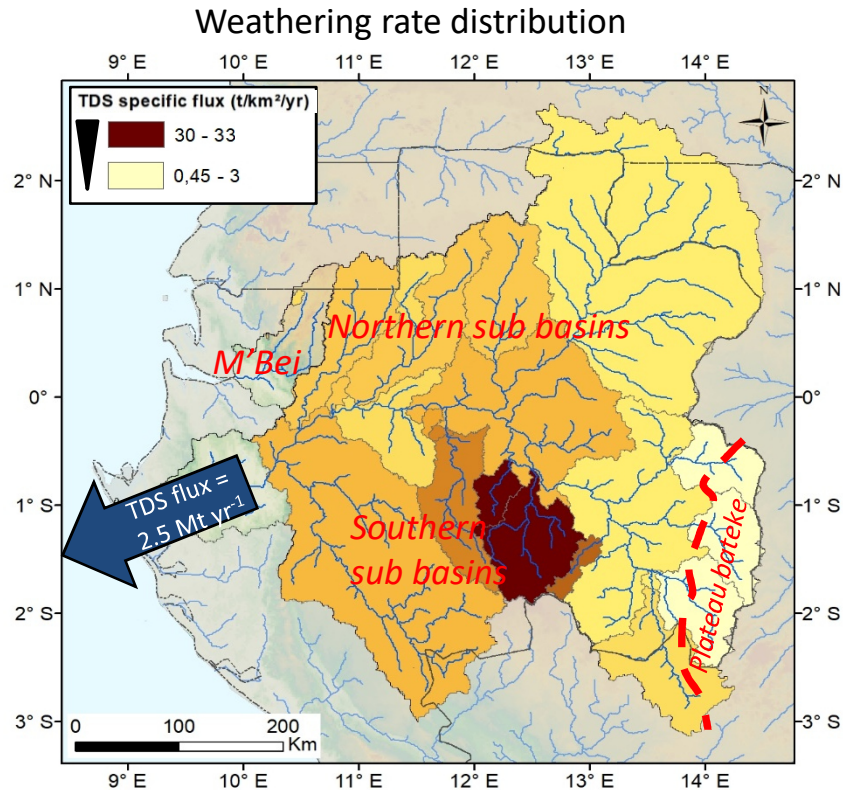
→ Silicate weathering ~ 80% of the Ogooué and Mbei solutes

→ High contrasts in solutes concentration

→ Climate effect (dilution) or geomorphological effect?

Chemical weathering deduced from the water chemistry

Weathering control : geomorphological setting?



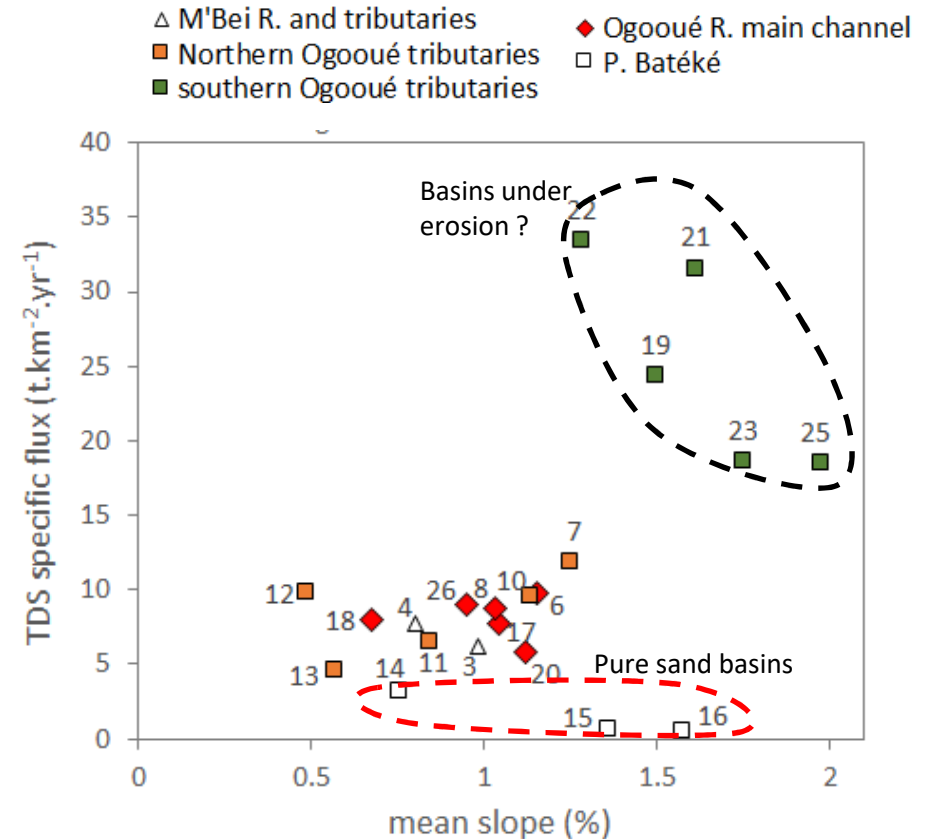
→ 2.5% of the western Africa coast TDS flux
(Milliman and Farnsworth, 2011)

→ Contrasted weathering fluxes : $0,45$ to $33t.km^{-2}.yr^{-1}$

→ Lowest : Pure sand sub-basins (Plateau Batéké)

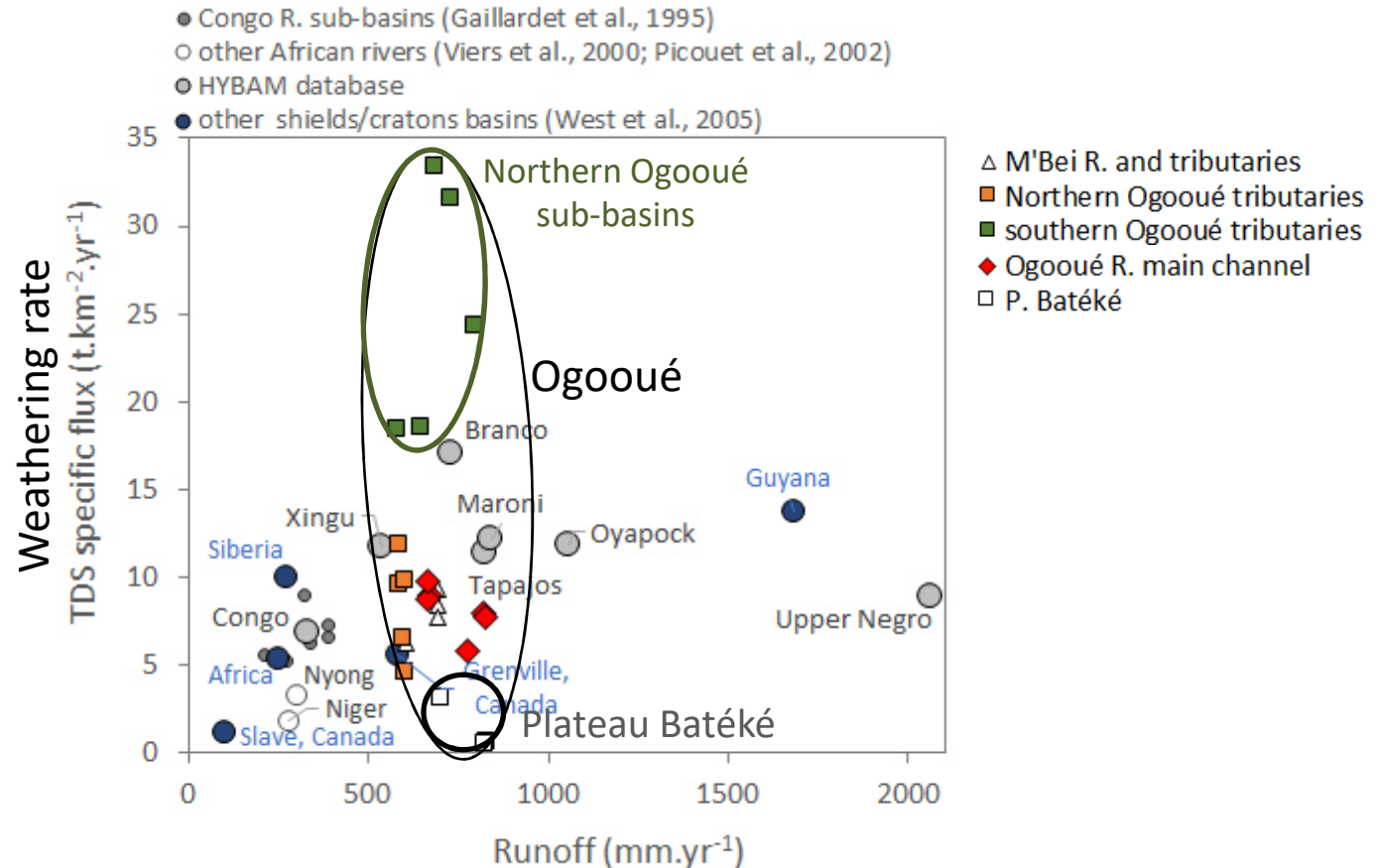
→ Highest : Southern sub-basin → higher relief / higher slope

→ **Erosion rate probably control weathering rate in this shield environment**



Chemical weathering deduced from the water chemistry

Comparison with global shields basins



Ogooué basin : No relationship between weathering rate and runoff

→ Rainfall is almost **homogenous** and the basin is **geomorphologically contrasted**

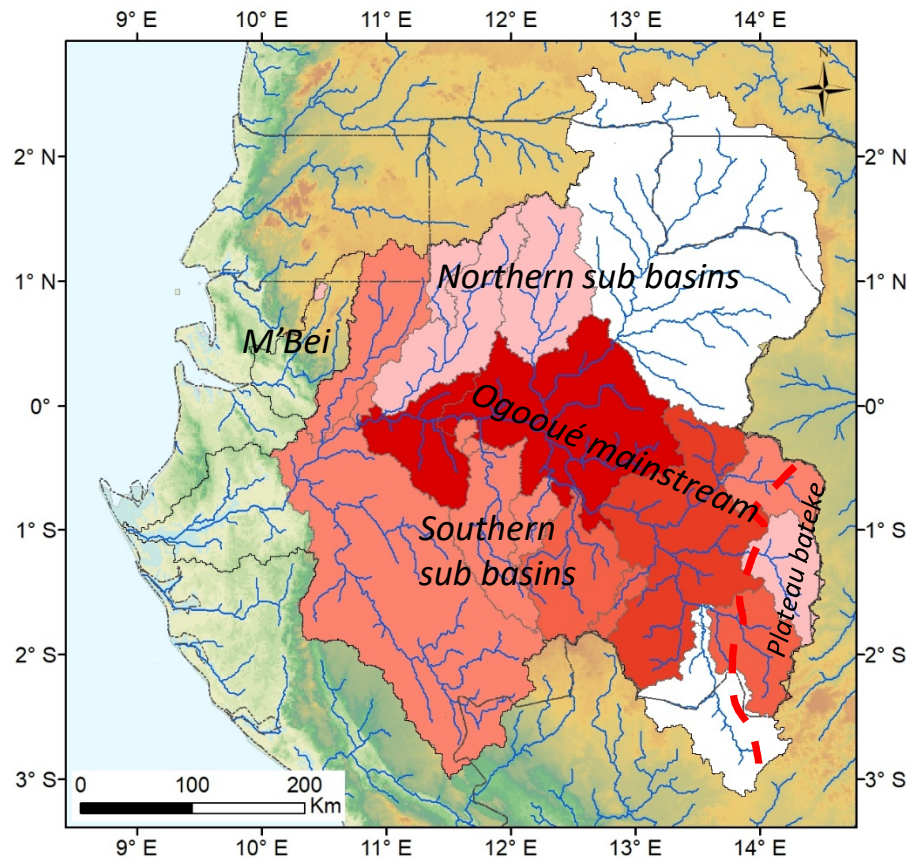
Shield basin compilation :

→ Runoff is not the first order control of shields weathering

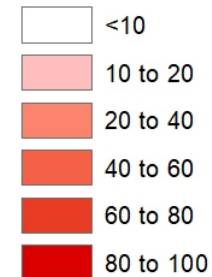
→ Ogooué sub-basins : highest and the lowest weathering rates

→ **Shields can exhibit very contrasted weathering regime!**

Denudation rate based on sand ^{10}Be



^{10}Be denudation ($\text{t km}^{-2} \text{yr}^{-1}$)



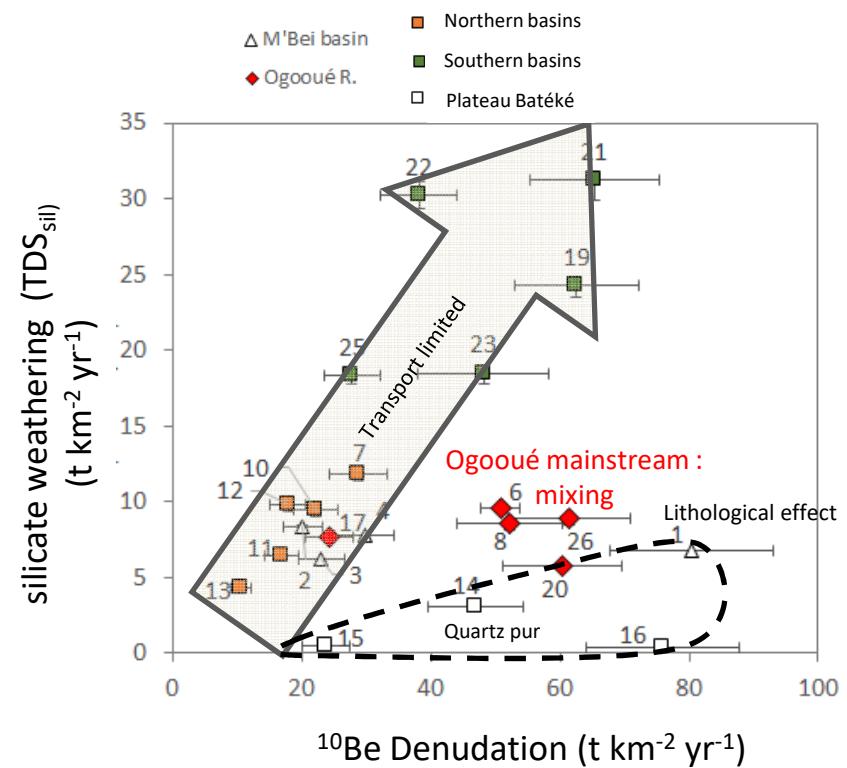
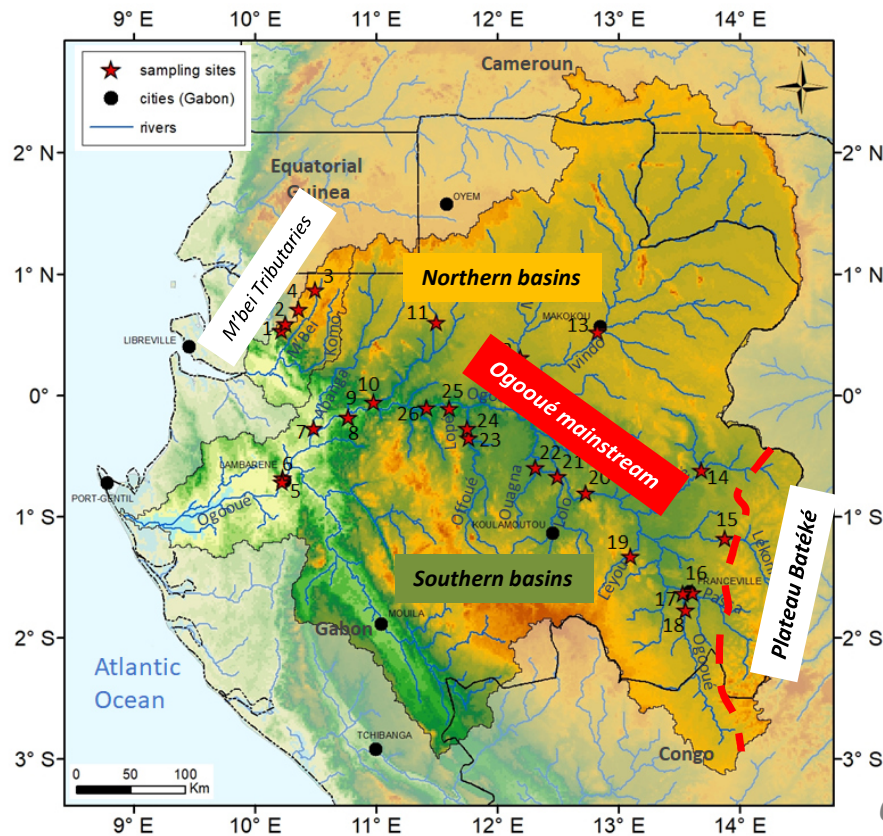
Preliminary results

The error associated to the main Ogooué channel can be > 50% due to error propagation at confluences budget

- ➔ **Oggoué mainstream : main erosion area** from plateau Batéké to plain
- ➔ Very low erosion rate in the eastern part of the northern and southern basins ($< 10 \text{ t km}^{-2} \text{ yr}^{-1}$)
- ➔ Low erosion rate in the rest of the basin but

$$E_{\text{southern basins}} (20-50 \text{ t km}^{-2} \text{ yr}^{-1}) > E_{\text{northern basin}} (12-20 \text{ t km}^{-2} \text{ yr}^{-1})$$

Weathering vs denudation relationship



Ogooué mainstream : Not subtracted from upstream inputs

→ Two contrasted regimes :

→ **Transport limited regime** for Mbei, Northern and southern tributaries

→ **Lithological effect** (sandstone erosion –depleted in mobile element) for Plateau Batéké basins

→ Ogooué mainstream : **mixing behavior**

Conclusion

Weathering rate (water chemistry):

- **Shields** exhibit a significant weathering budget
- Contrasted weathering fluxes
 - Mainly controlled by geomorphological characteristics
 - Runoff is not the first order control

sand ^{10}Be denudation :

- Main area under erosion : Ogooué mainstream (river bank sedimentary material?)
- E northern basin < E southern basin
 - Denudation deduced from sand mainly reflect mainstream behavior

W vs D regime :

Two regimes can be distinguished :

- Transport limited regime in Mbei, Northern and southern sub-basins
- Supply limited due to lithological effect in plateau Batéké and mainstream.
 - Cratonic basins do not follows a unique weathering regime