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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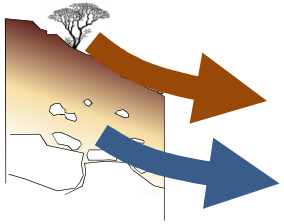
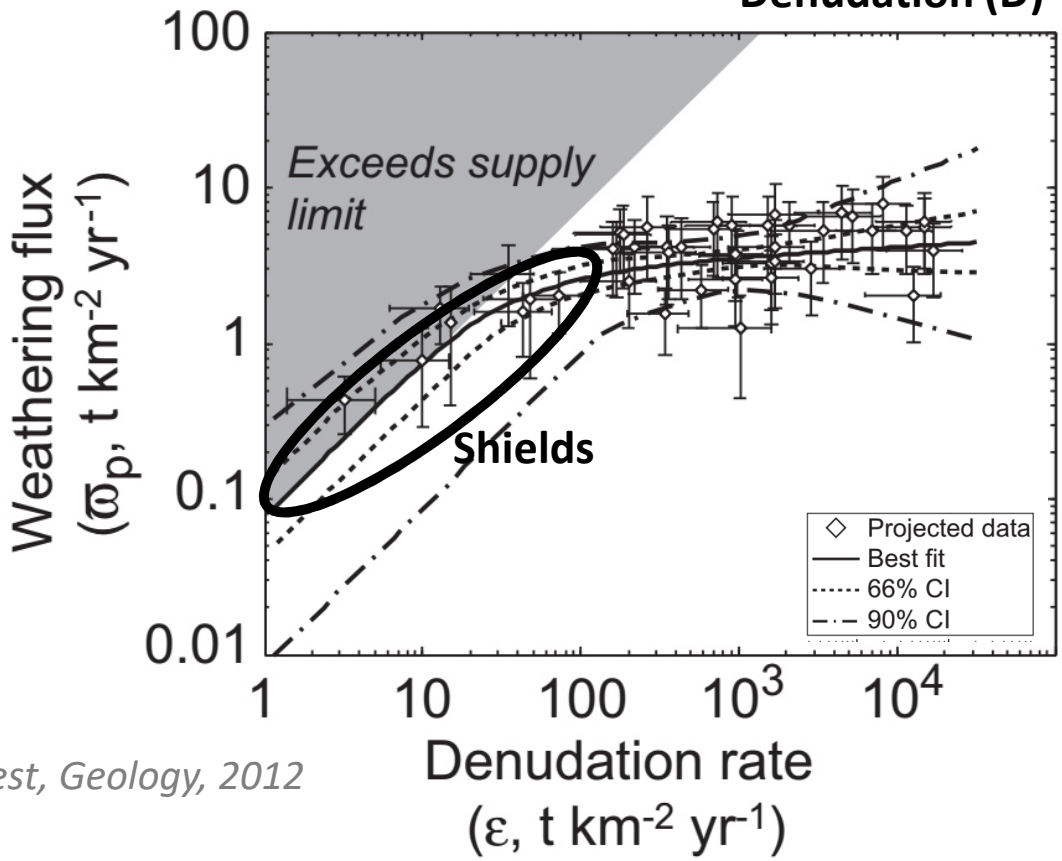
Ogooué River- Gabon

Introduction



Erosion (E)
+
Weathering (W)
=
Denudation (D)



West, Geology, 2012

Lateritic shields :

- **~ 30% of the continents**
- **Significant weathering budget**

BUT

W vs D relationship lowly investigated

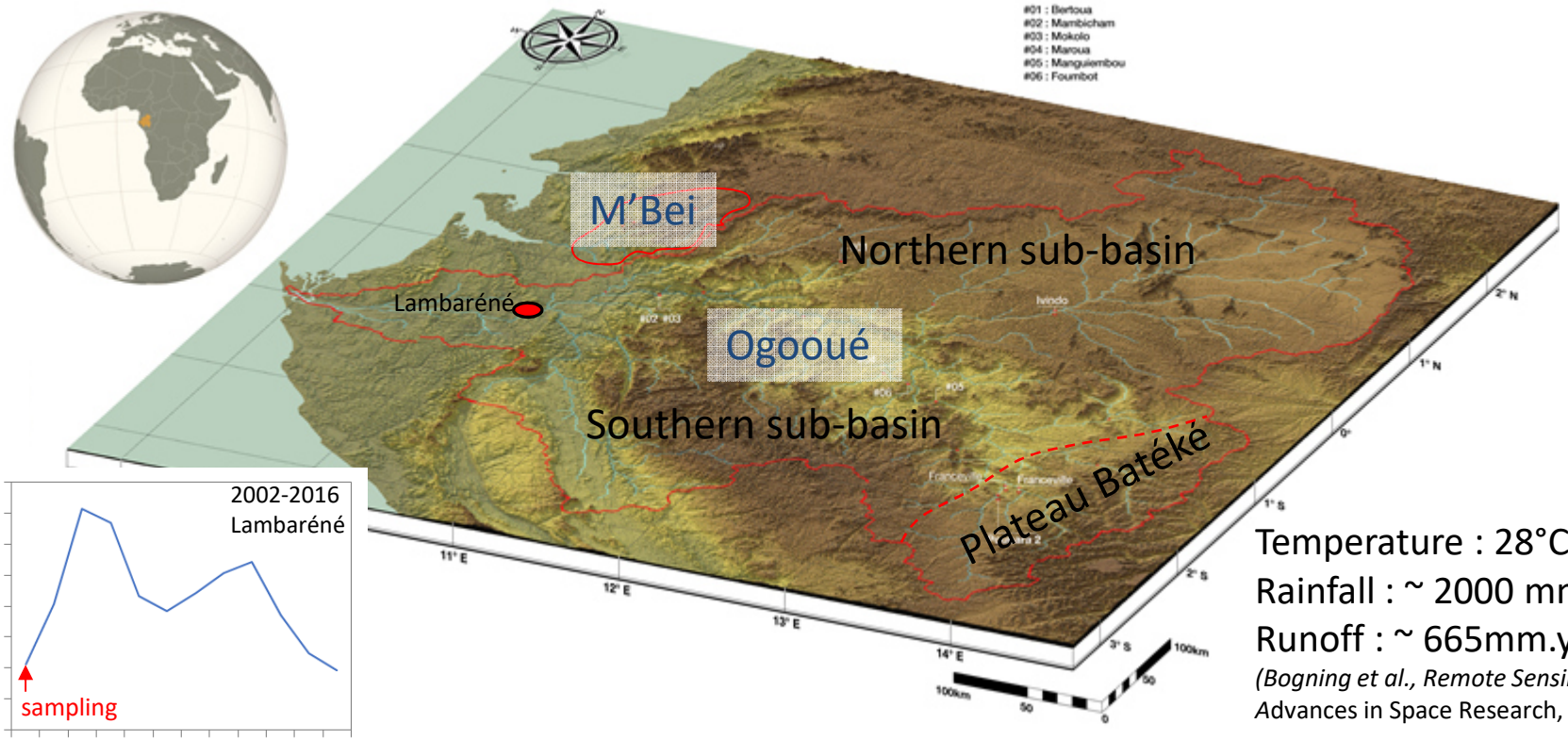
What is the variability of weathering/erosion rates with respect to lithological effect and geomorphology on two tropical basins (Ogooué and M'Bei rivers, Gabon)?

Shield weathering : the Ogooué basin case

Ecosphère Continentale et Côtière

Project RALTERAC (J.J. Braun-IRD)

Ogooué basin (Central Africa Craton)



Temperature : 28°C

Rainfall : ~ 2000 mm.yr^{-1}

Runoff : ~ 665mm.yr^{-1}

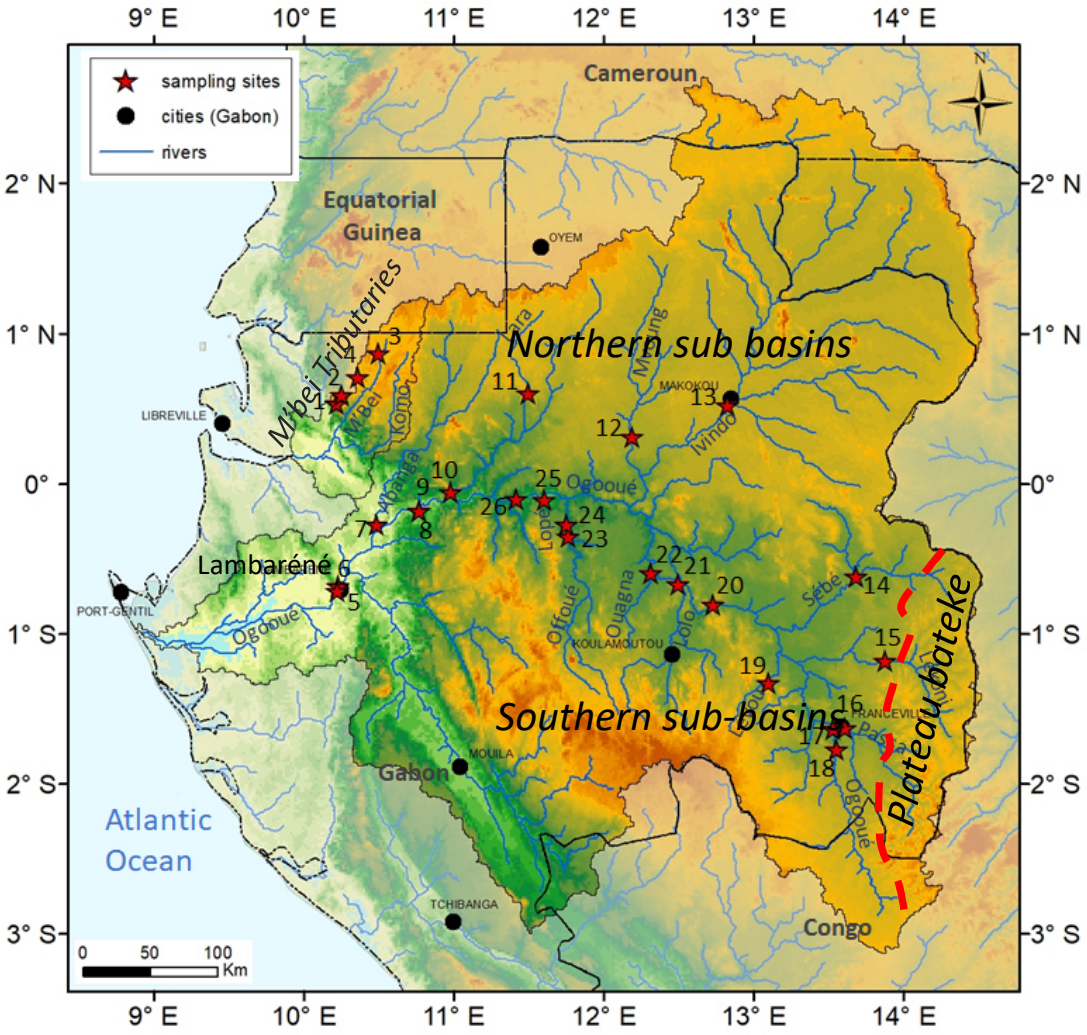
(Bogning et al., Remote Sensing, 2018, Advances in Space Research, 2020)

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

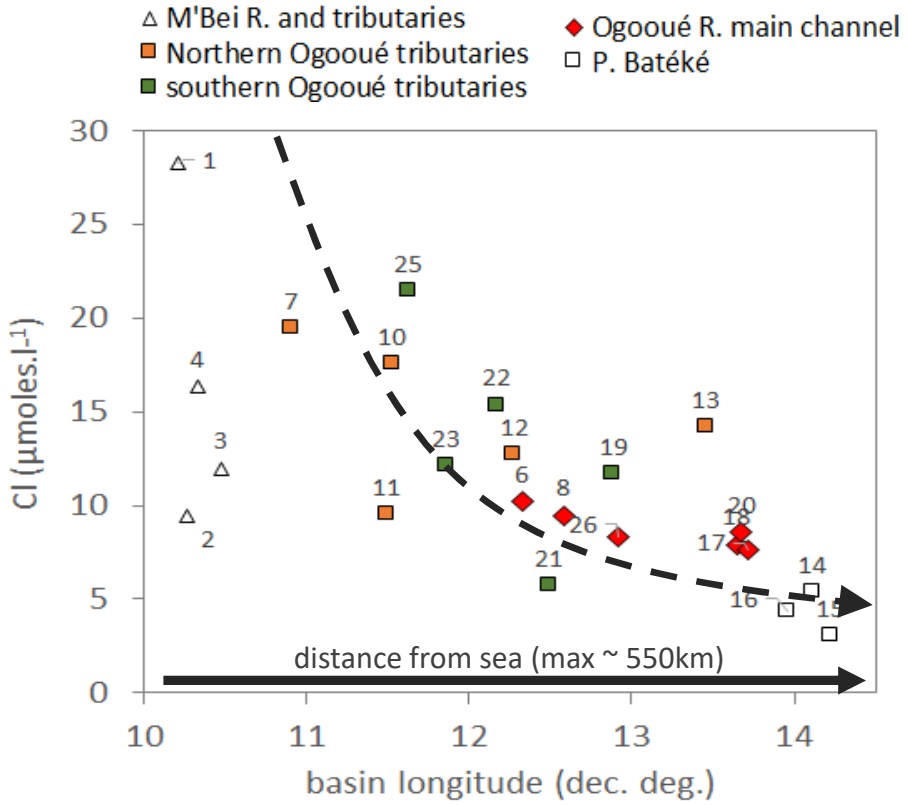
Data available : daily discharge at Lambaréné, rainfall (TRMM), MNT (SRTM90)

In situ measurements :
pH : 4,63-7,62
Conductivity: 5-78µS.cm^{-1}
Water temperature : 22-28°C

Lab analyses :
Major and trace elements
$^{87}Sr/^{86}Sr$ + εNd (only sediments) (not presented)
^{10}Be on sand

Chemical weathering deduced from the water chemistry

Atmospheric inputs

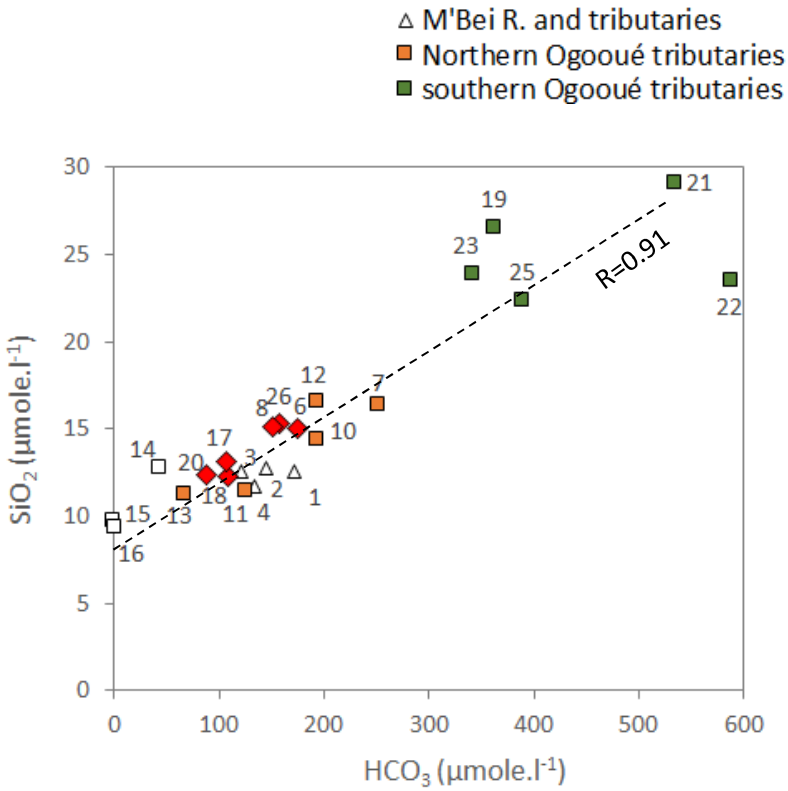


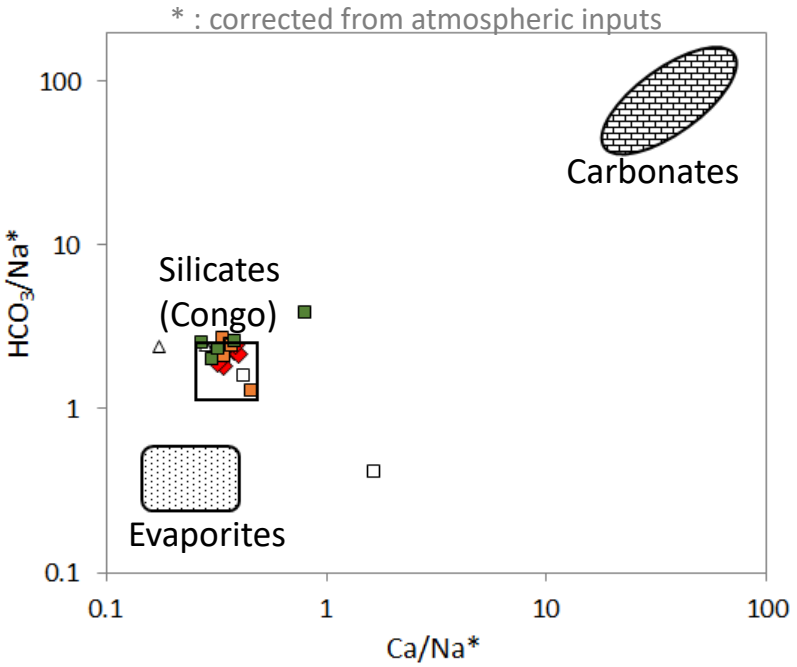
→ Classical Cl concentration decrease from the Ocean *(ex : Congo : Negrel et al., GCA, 1993)*

→ **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 HCO_3^-

→ Homogenous silicate source for almost all samples

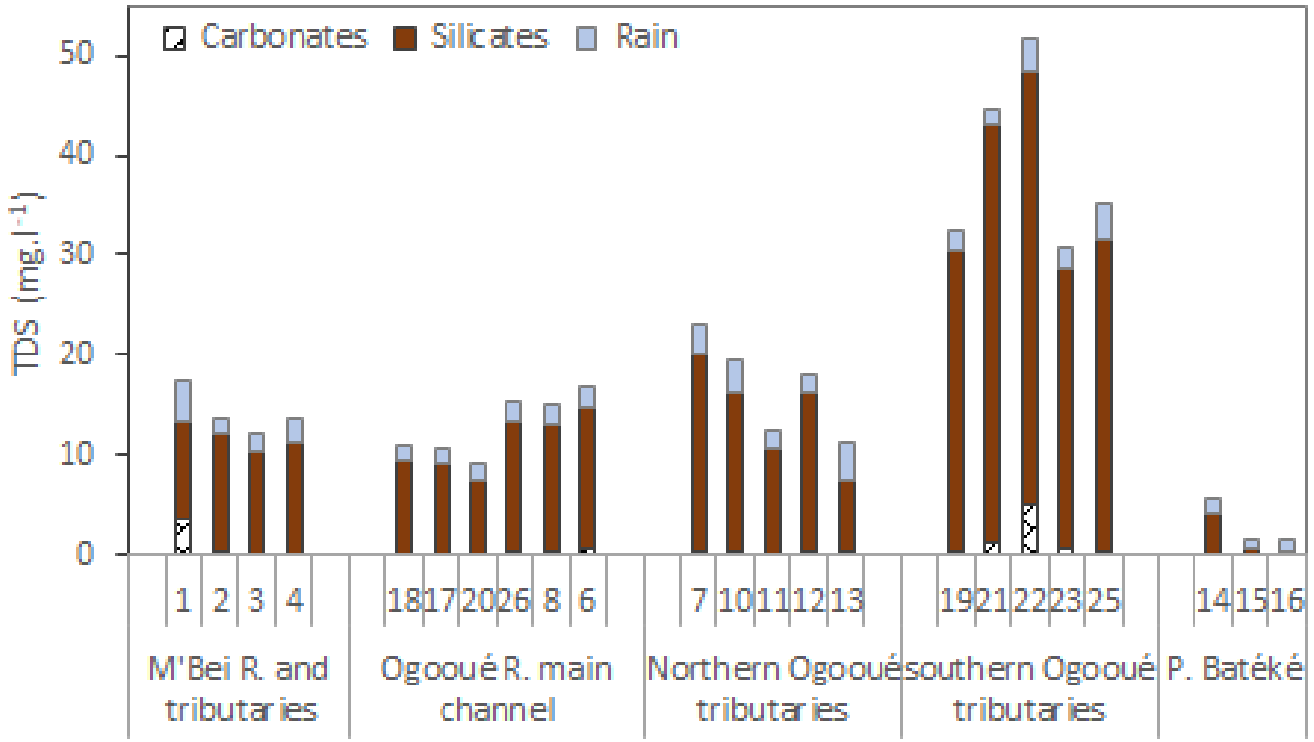
→ silicate weathering dominate the solutes and CO_2 consumption

Chemical weathering deduced from the water chemistry

sources discrimination

Direct discrimination method

(Garrel and Mack, Marine Chemistry, 1972)



TDS (Total dissolved solids) $=Na^+ + Ca^{2+} + Mg^{2+}+K^+ + HCO_3^- + SO_4^{2-} + Cl^- + SiO_2$

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

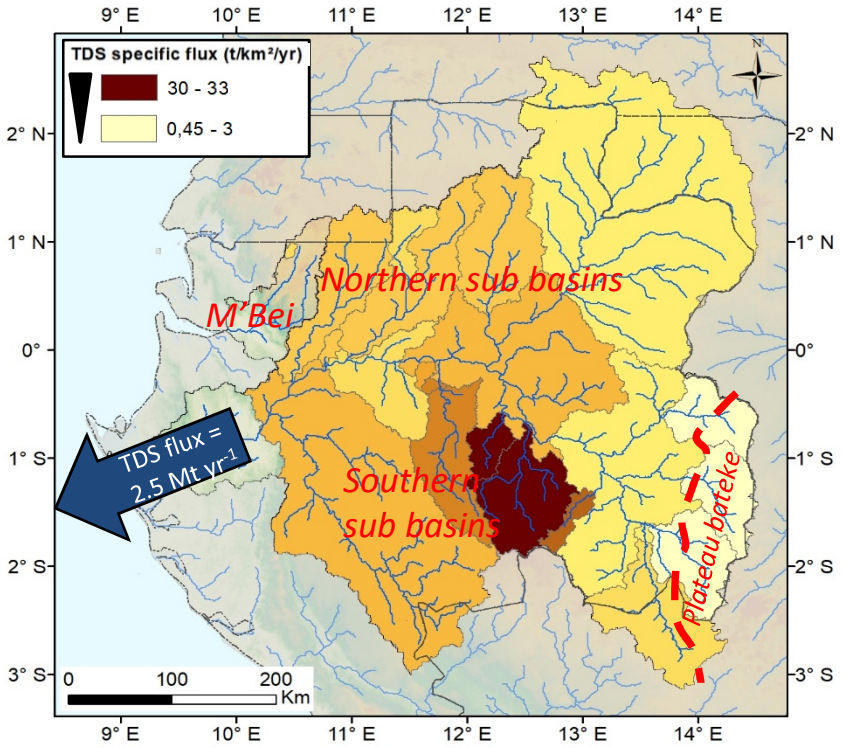
→ High contrasts in solutes concentration

→ Climate effect (dilution) or geomorphological effect?

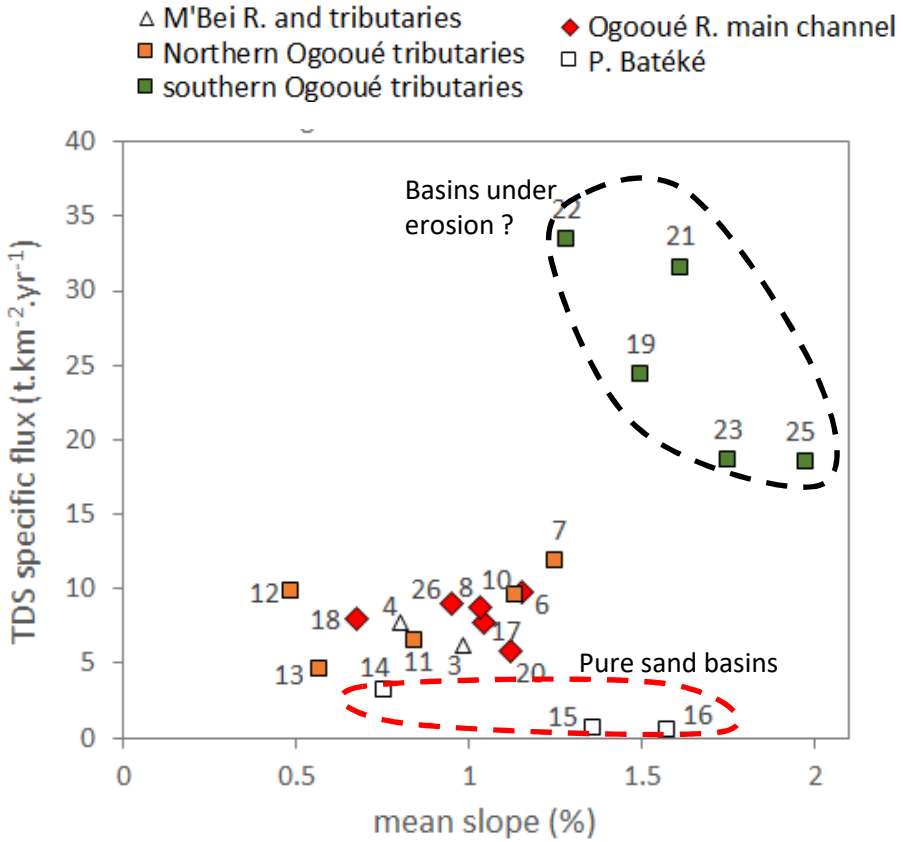
Chemical weathering deduced from the water chemistry

Weathering control : geomorphological setting?

Weathering rate distribution



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



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

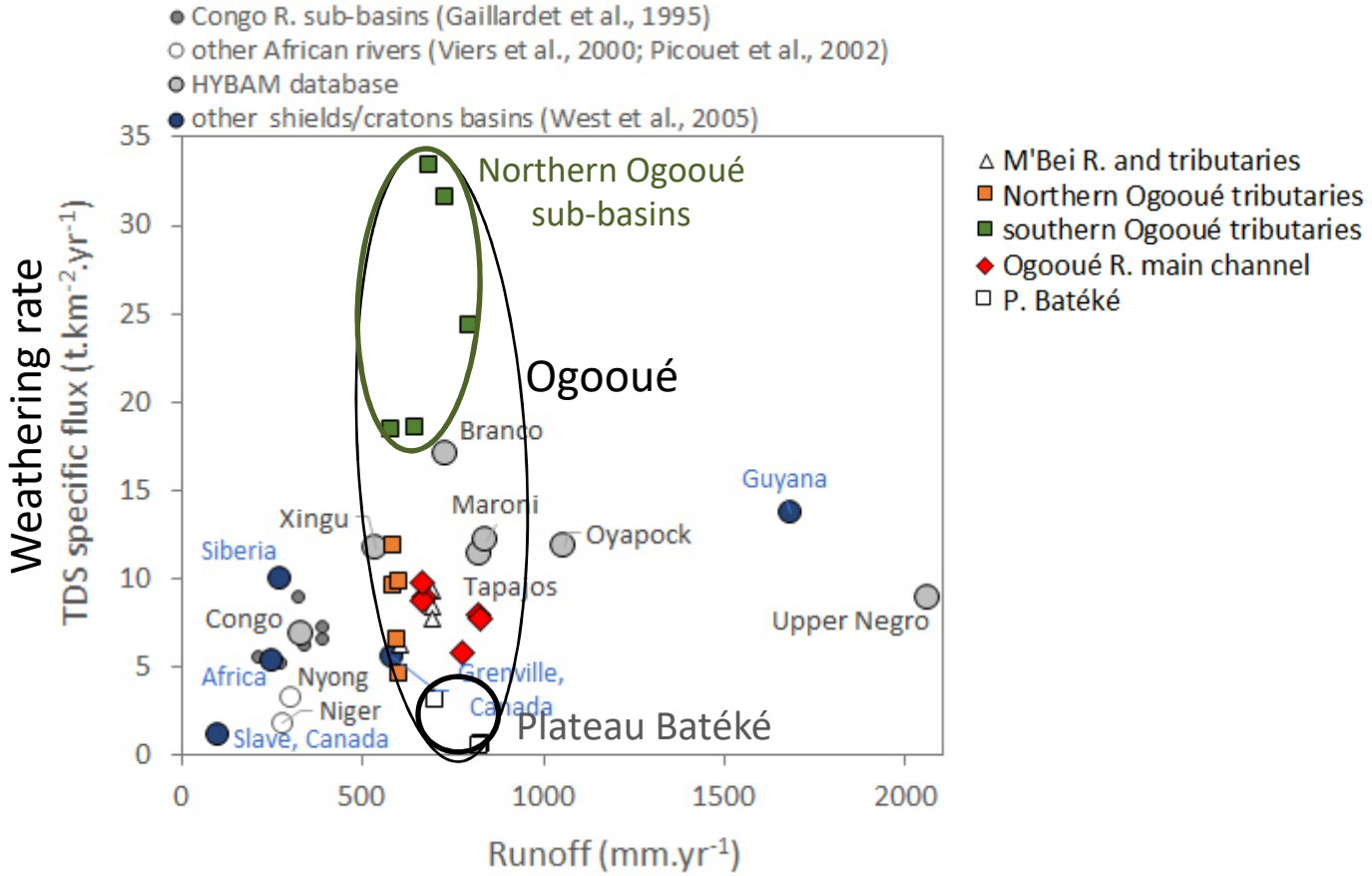
→ Lowest : Pure sand sub-basins (Plateau Batéké)

→ 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**

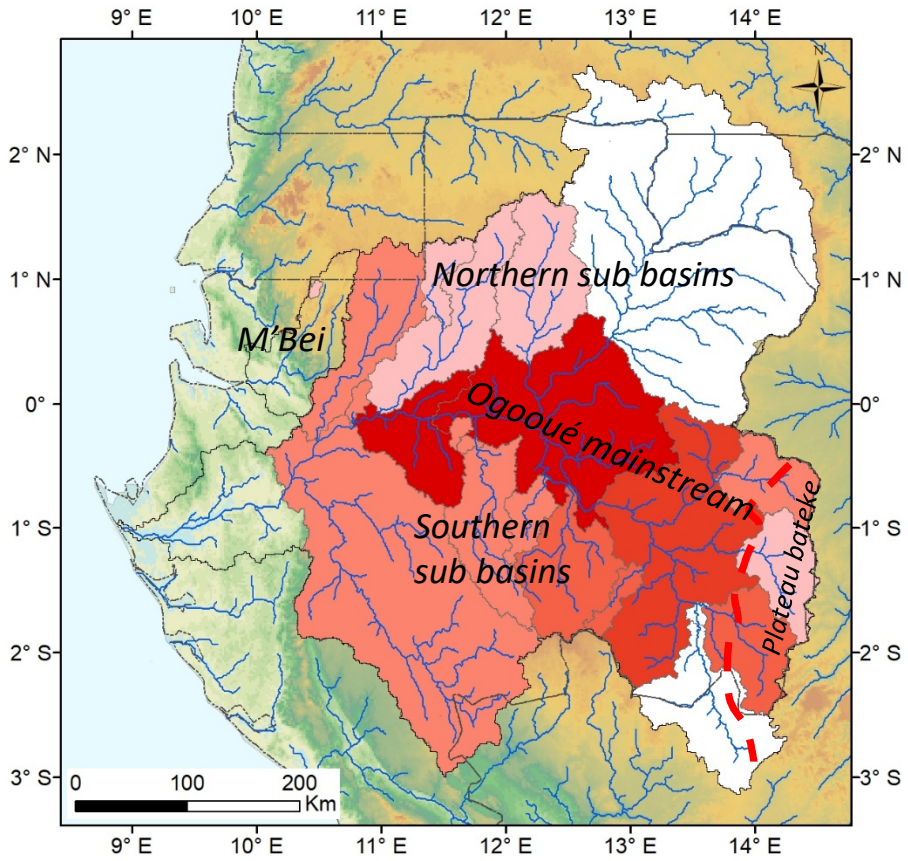
Shield basin compilation :

→ 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 (t km^{-2} yr^{-1})

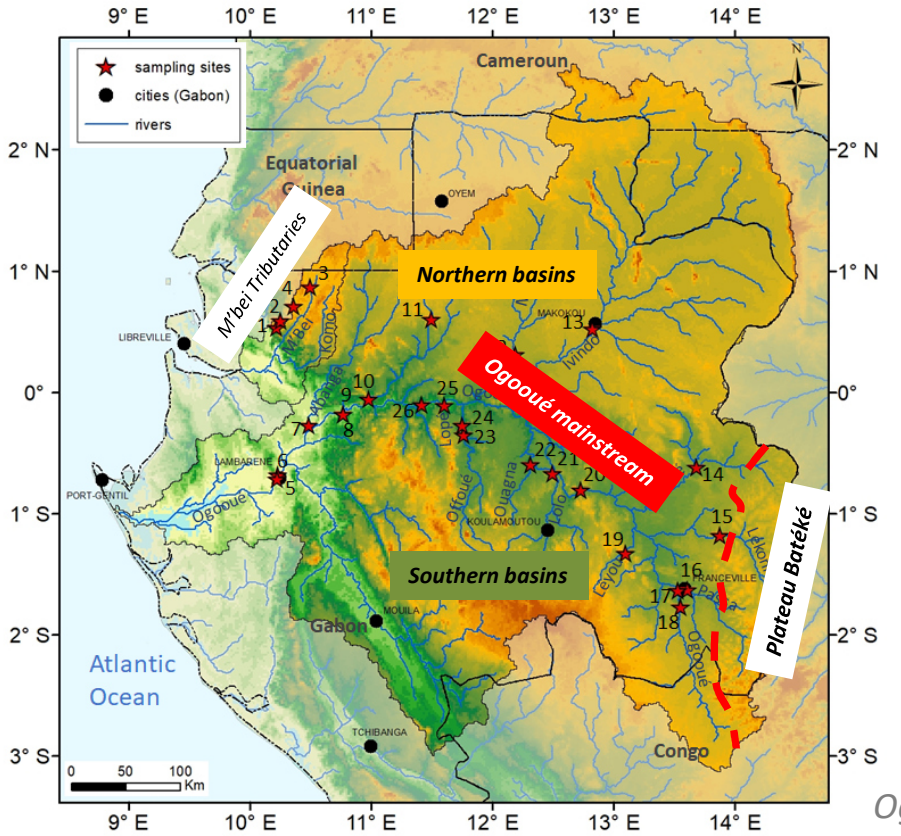
- <10
- 10 to 20
- 20 to 40
- 40 to 60
- 60 to 80
- 80 to 100

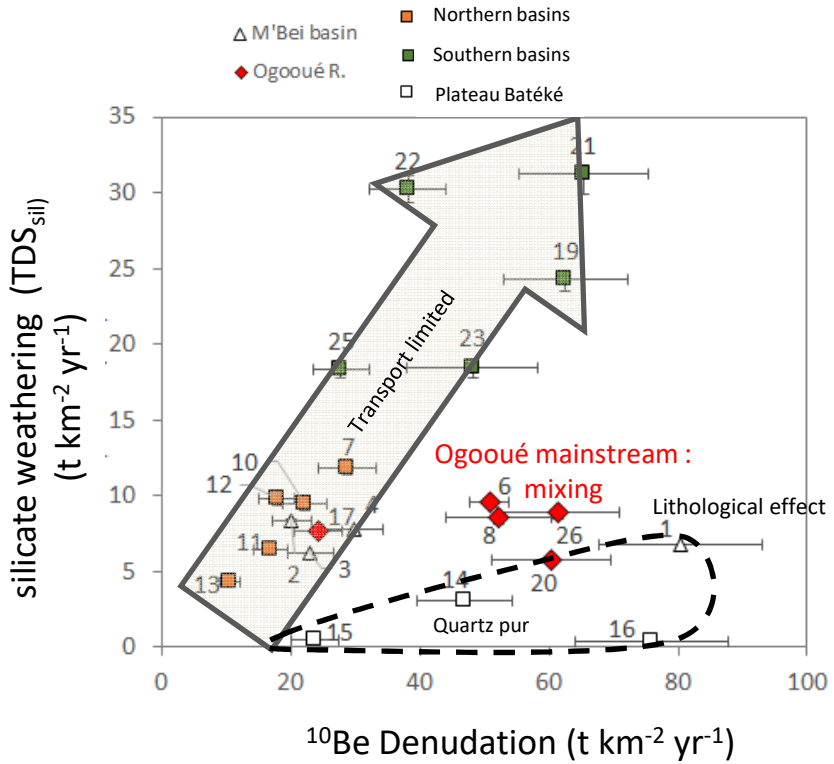
Preliminary results
The error associated to the main Ogooué channel can be > 50% due to error propagation at confluences budget

➔ **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 t km^{-2} yr^{-1})
➔ Low erosion rate in the rest of the basin but

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

Weathering vs denudation relationship





Ogooué mainstream : Not subtsracted 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