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# Combining (U-Th-Sm)/He dating and geochemical budget to understand laterite formation

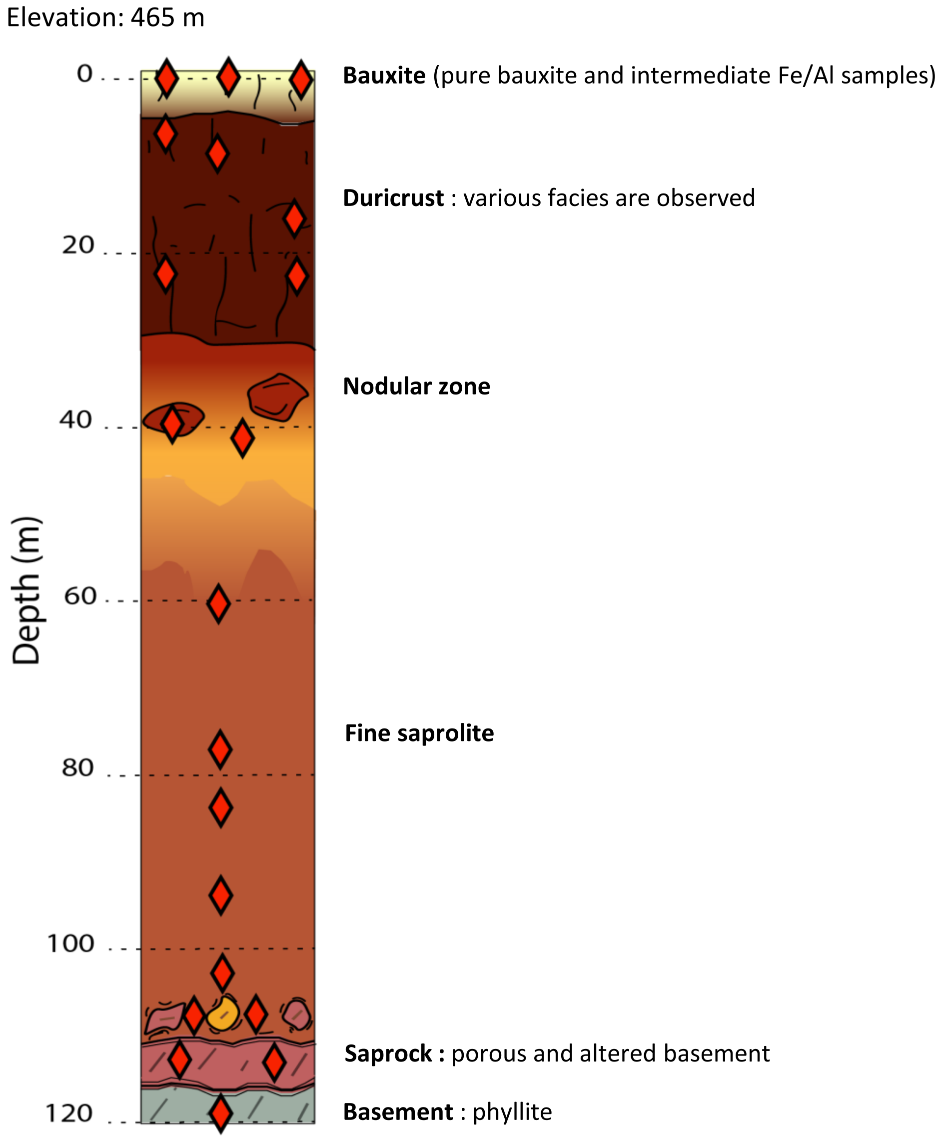
*Ansart C.[1]*, Calmels D.[1], Gautheron C.[1], Monvoisin G.[1], Agrinier P.[2], Coueffe R.[3], Roig J.Y.[3], Quantin C.[1]*

*[1]Université Paris Saclay, GEOPS, Orsay, France ; [2]Université de Paris, IPGP, France ; [3]BRGM, France*

**claire.ansart@universite-paris-saclay.fr*

www.reca.universite-paris-saclay.fr

# Objectives and methods

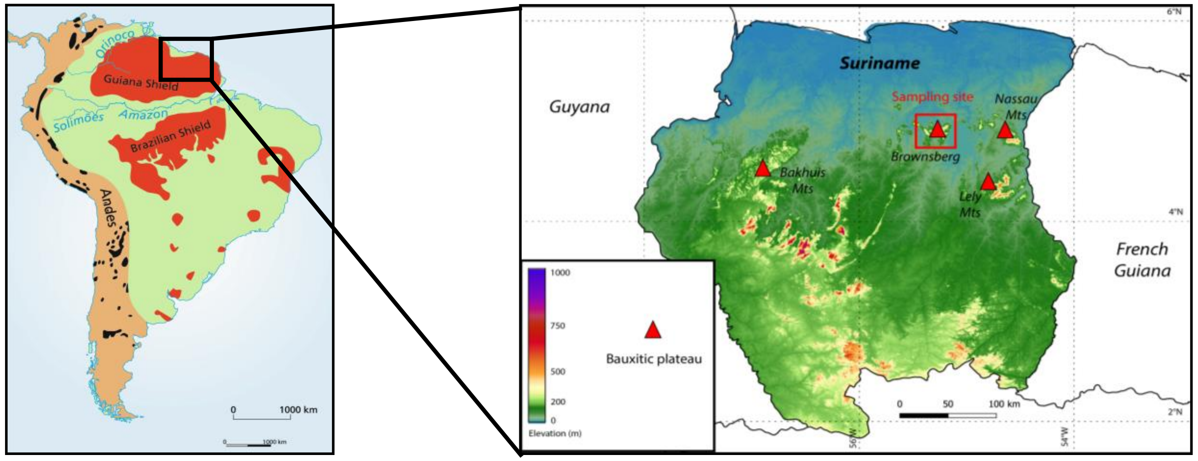



*Schematic representation of the studied profile, its compartments and sampling sites*

→ **Identify** and **quantify** weathering processes of laterites, i.e., thick regolith

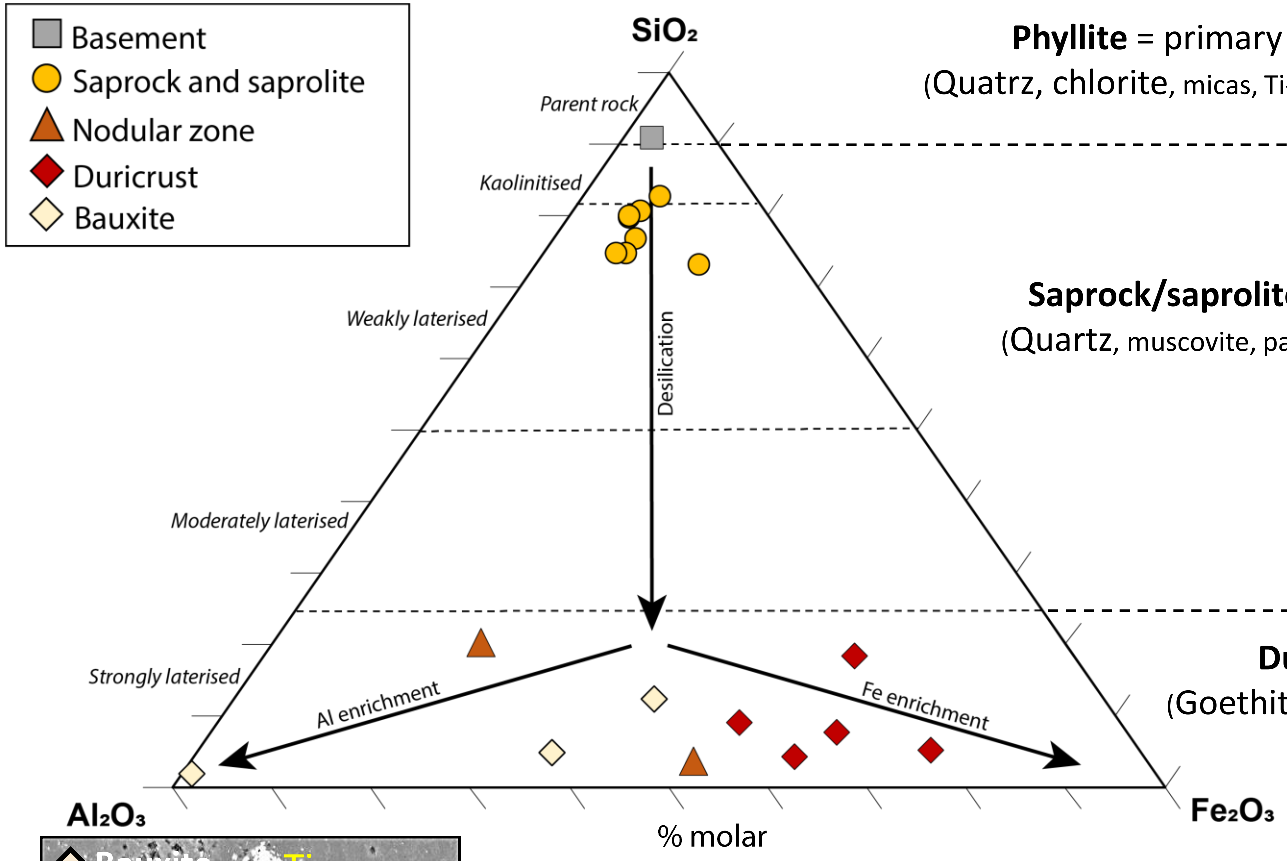
→ **Date duricrust** and weathering processes leading to duricrust formation

- Geochemical characterization of lateritic profile and dating data interpretations
- Clear **differentiation** of regolith → weathering processes
- **Intense weathering** (bauxite/duricrust)




→ Lateritic profile in Brownsberg, **Suriname** on the tectonically stable **Guiana Shield** → close to the equator for 100 Myr (Tardy et al., 1991)

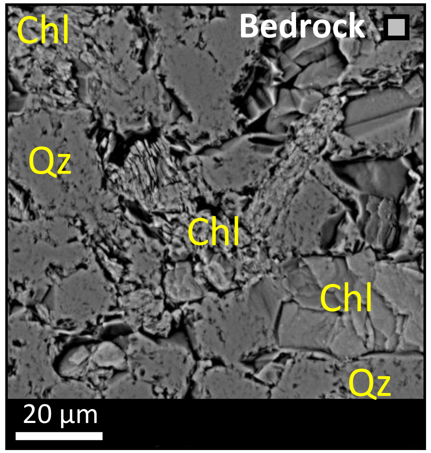
# Mineralogical and geochemical evolution : progressive weathering

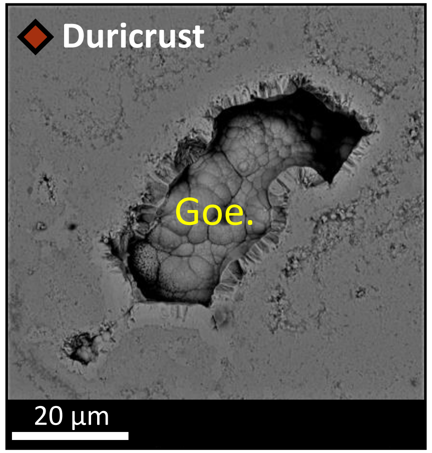


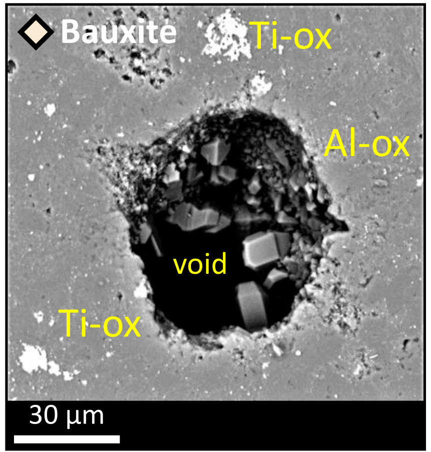

**Phyllite** = primary
(Quatrz, chlorite, micas, Ti-oxides)

**Saprock/saprolite** = primary + secondary minerals
(Quartz, muscovite, paragonite, Ti-oxides, kaolinite, goehtite)

**Duricrust/Bauxite** = secondary minerals
(Goethite, gibbsite, hematite, remaining quartz and Ti-oxides)

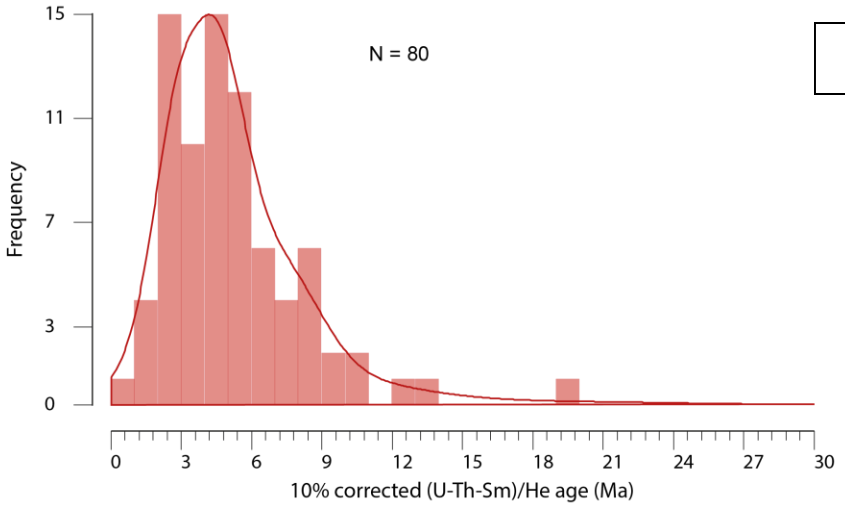


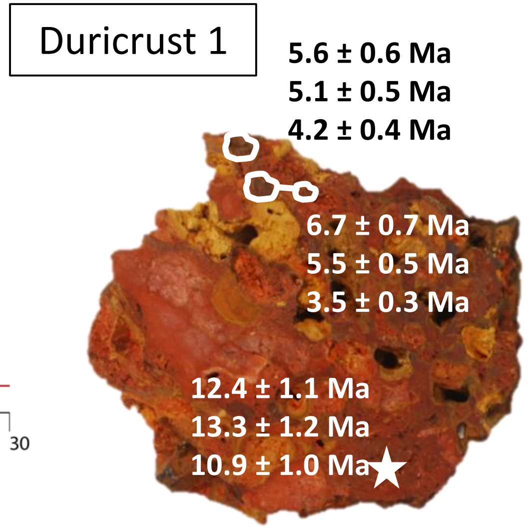



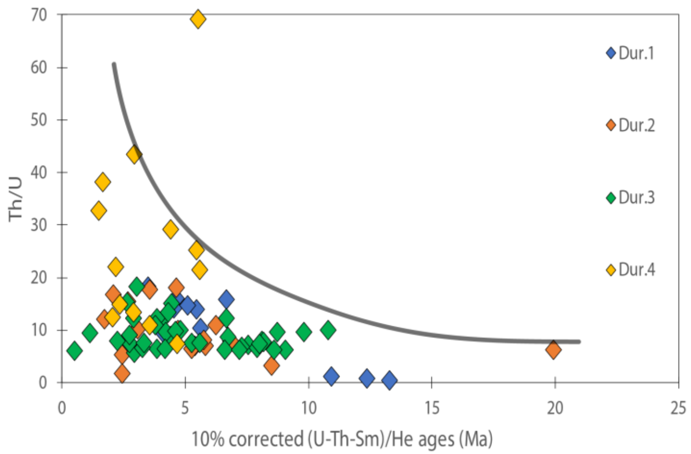



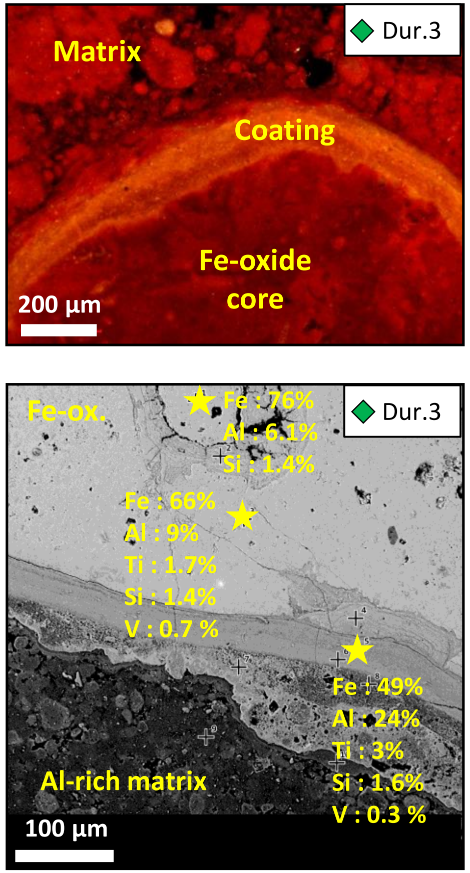

- A **bauxite particularly rich in Al** compared to other bauxite in the Suriname (Monsels et Bergen 2017)
- **Goethitic/gibbsitic** content express weathering processes linked with **very humid** and warm climatic context (Tardy et al. 1991; Schellmann 1994)

# (U-Th-Sm)/He dating on goethite



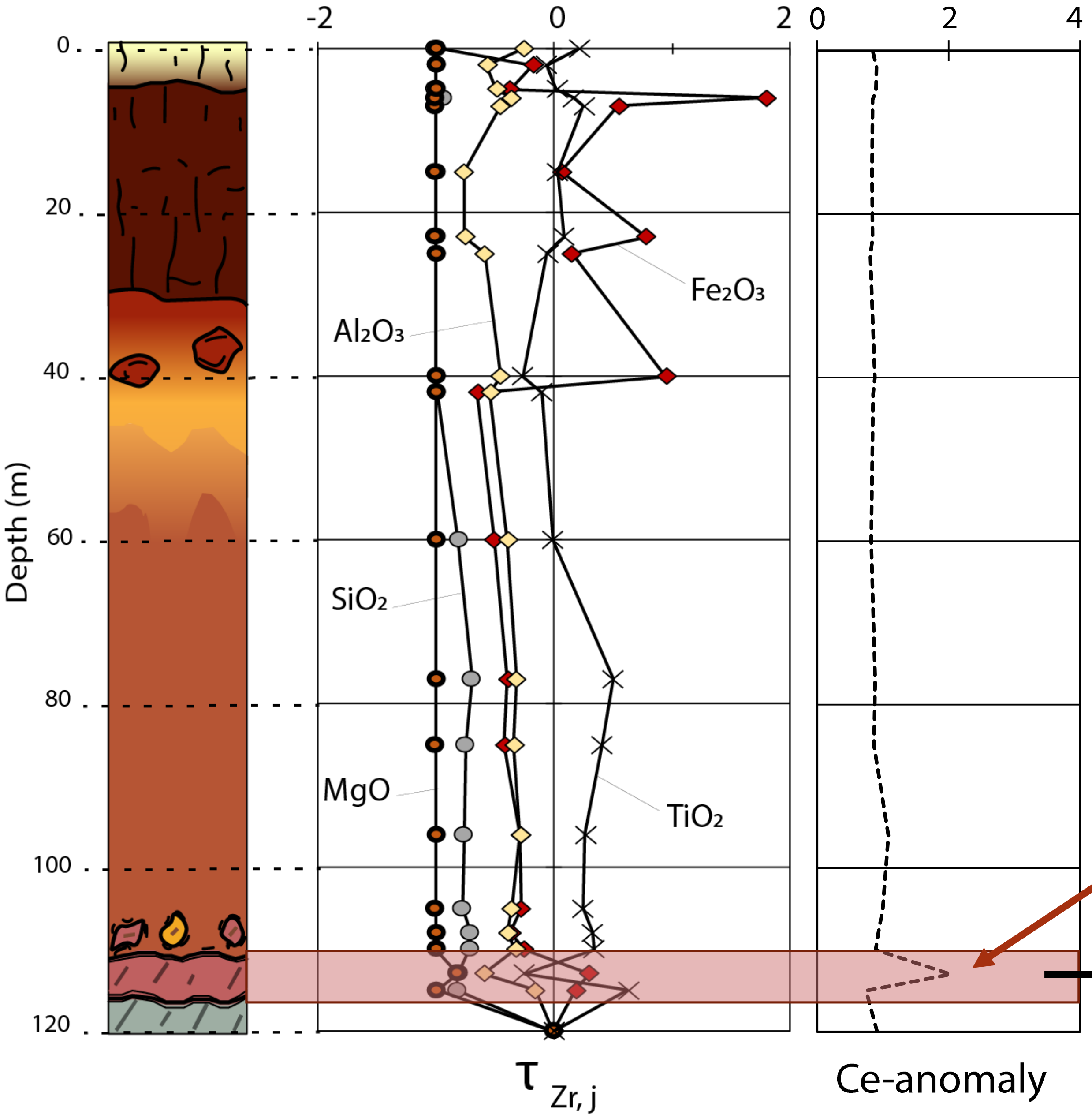



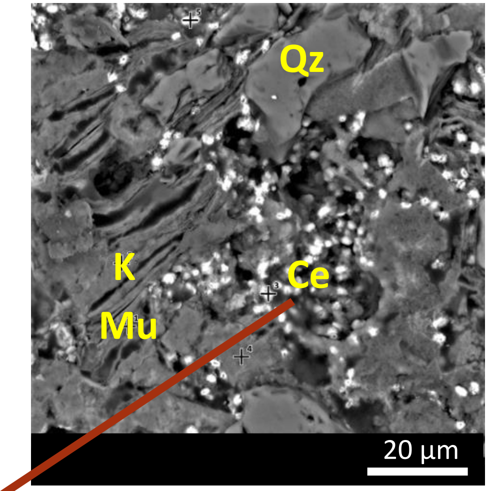




*Optical microphotograph and SEM observation of an heterogenuous Fe-oxide*

- Ages ranging between 0.5 and 20 Ma.
- Paleomagnetism studies (Théveniaut et Freyssinet, 1999, 2002) suggest a period of formation in the Guiana Shield Paleocene – Eocene (66 to 34 Ma) for such paleosurfaces. (U-Th-Sm)/He ages show a peak of formation around 3 or 5 Ma, but still, with older ages.
- Various Th/U ratio evidence the presence of different generation of iron oxides in a system still active today.
- High Th/U → U leaching over Th (oxidizing conditions) → multiple processes of **dissolution – reprecipitation** of goethite

# Elemental fluxes : mass balance transport of major elements and weahtering processes




*Cerium oxides in the saprock*

**Duricrust/Bauxite**

Fe enrichment

Moderate loss of $Al_2O_3$

$TiO_2$ mobile

**Saprolite**

Total loss of alkali/earth-alkali +

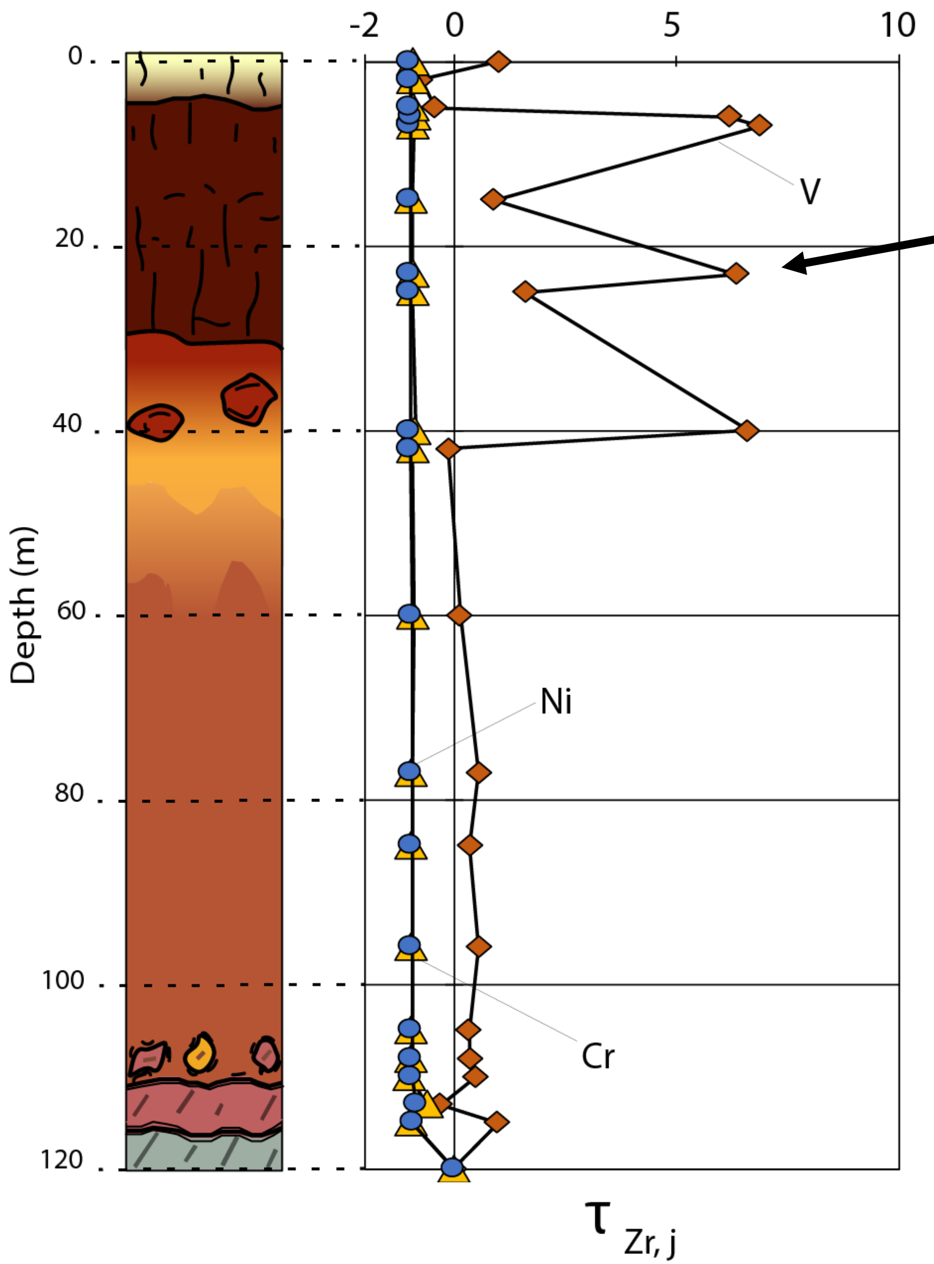
moderate loss of $SiO_2$ + $Fe_2O_3$ + $Al_2O_3$

**Saprock**

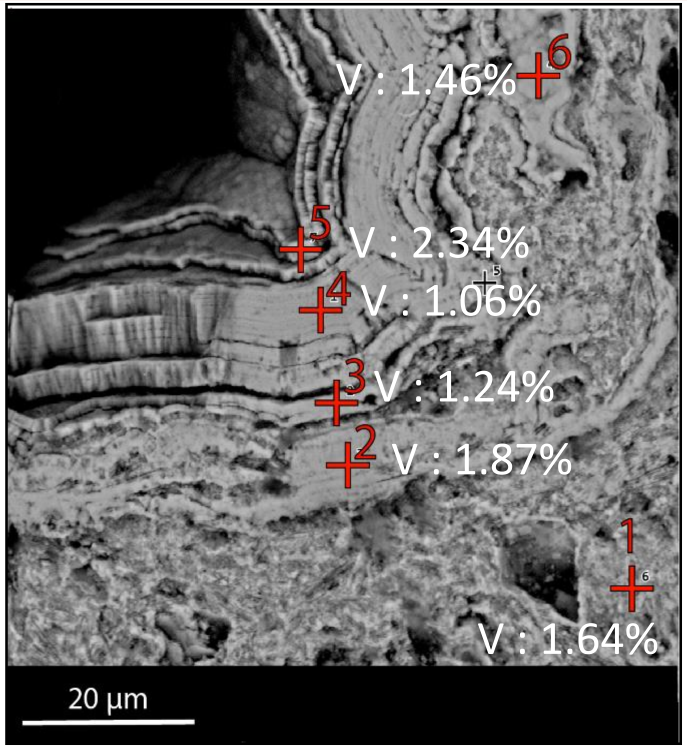
Fe enrichment + loss of other elements

**Basement**

# Elemental fluxes : mass balance transport of some trace elements



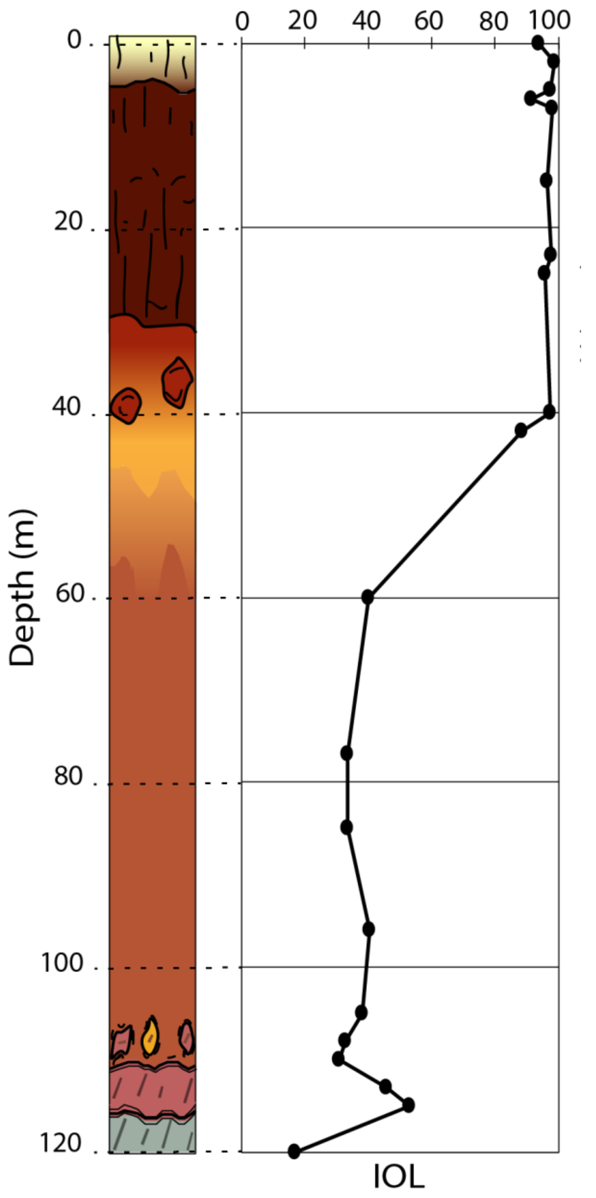


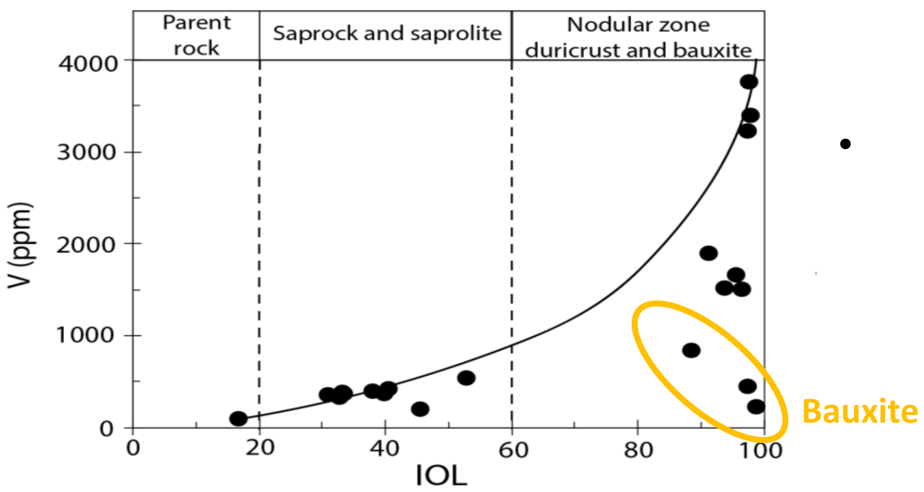



*SEM images of Fe-oxides in a duricrust and its V content compared to Fe, Al, Si and Ti*

- Most trace elements are depleted
- A significant V enrichment: 83 ppm in the basement → 3800 ppm in duricrust
- What is the origin of this strong enrichment, notably in the duricrust? What processes?

# Vanadium enrichment




- **Weathering Index Of Laterization IOL** (Babechuck et al., 2014) → intense weathering from 40 m to the surface

- V concentration is linked with the weathering intensity
- Correlation between V and $Fe_2O_3$, $Al_2O_3$, $TiO_2$
- V can substitute element in secondary phases or can be adsorbed onto secondary minerals produced during weathering (e.g. kaolinite in the saprolite or goethite in duricrusts ; Peacock and Sherman, 2004; Schwertmann and Pfab, 1994 ; Wisawapipat et Kretzschmar, 2017)

# Take home message

## Mineralogical and geochemical zonation:

- **Progressive desilication** and **Fe-enrichment** : chlorite → kaolinite→ gibbsite/Fe-hydroxides.
- **Goethite** is predominant : weathering in very humid and warm context (Tardy et Roquin, 1998; Nahon, 2003).
- **V enrichment** in the weathering profile, accentuate in the duricrust → secondary minerals.

## Continuous reorganization of the profile:

- **(U-Th-Sm)/He ages → (20 Ma)** while model of duricrust formation on the Guiana Shield by paleomagnetism (Théveniaut and Freyssinnet, 1999, 2002 )→ ≈ 40 Ma.
- **Dissolution/reprecipitation** processes of Fe-oxides lead to a constant **re-opening** of weathering profile + **enrichment of V** in secondary phases

## Future works:

- Link between secondary minerals ages and climate (d18O – dD measurments) → climate and associated weathering processes.

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