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Heterogeneity of hydrogeological conceptual models in crystalline basement aquifers under equatorial climate: case study of French Guiana

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1. French Guiana geological context

French Guiana is mostly composed of **Paleoproterozoic rocks** belonging to the Guiana Shield. It was formed during protracted periods of intense suprasubduction related **magmatism, metamorphism and deformation**, culminating with the Transamazonian orogeny, bracketed between **2.3 and 1.9 Ga**. This peculiar geological history creates a large diversity of geological units from undeformed **granitic units** to **ultramylonitized shears-zone related meta-volcano-sedimentary units** and through **brittle to ductile** deformed units.

Furthermore, over almost 200 Ma, the French Guiana recorded a **deep weathering phase** leading to heterogeneous and complex altered profiles up to 80-100 m deep.

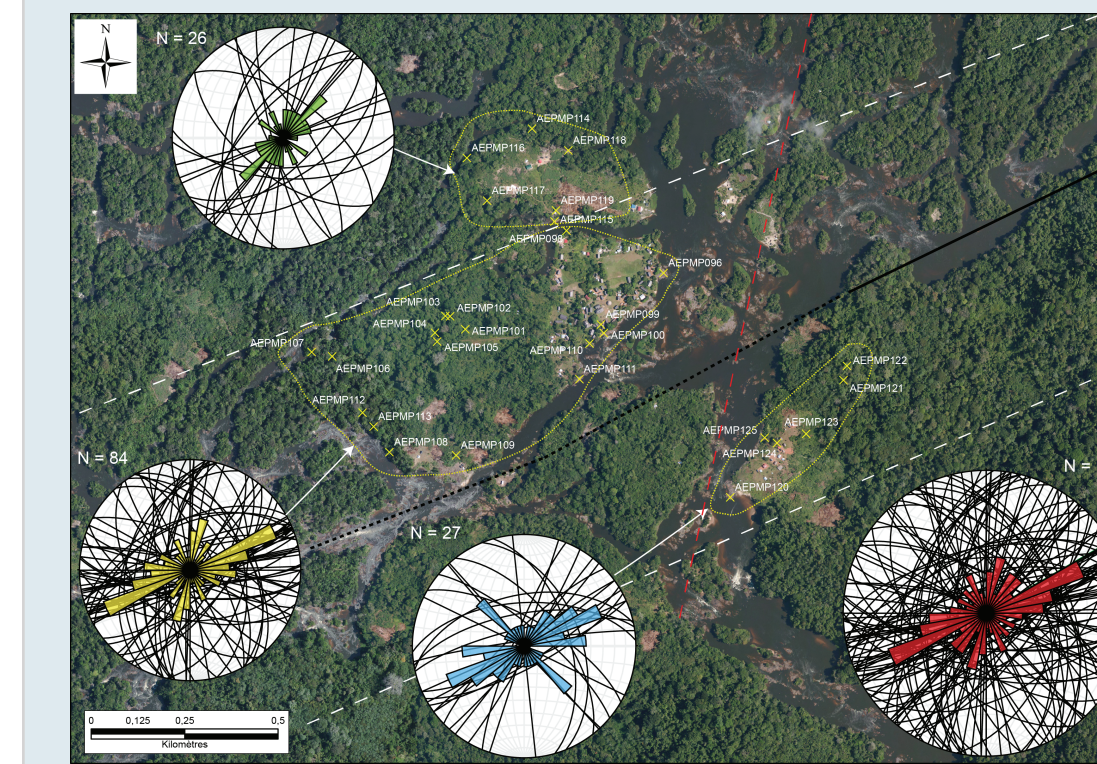
2. Basement crystalline aquifers (BCA)

BCA were usually represented with a low aquifer potential giving **low well yields**. Over the world, more than 880 millions people live on BCA. Thus, abilities to spot sufficient groundwater resource are crucial. Nevertheless, assessment of the **sustainable reservoirs** is **challenging**. The well-admitted **conceptual model** presents a stratiform-weathered profile above a fractured zone showing a decreasing fracture density with depth. The interconnection between these two compartments defines the hydraulic parameters: the weathered profile is capacitive while the fractured zone is transmissive. (A)

This model could be improved considering the high range of BCA lithology, geometry and interaction with other lithological units.

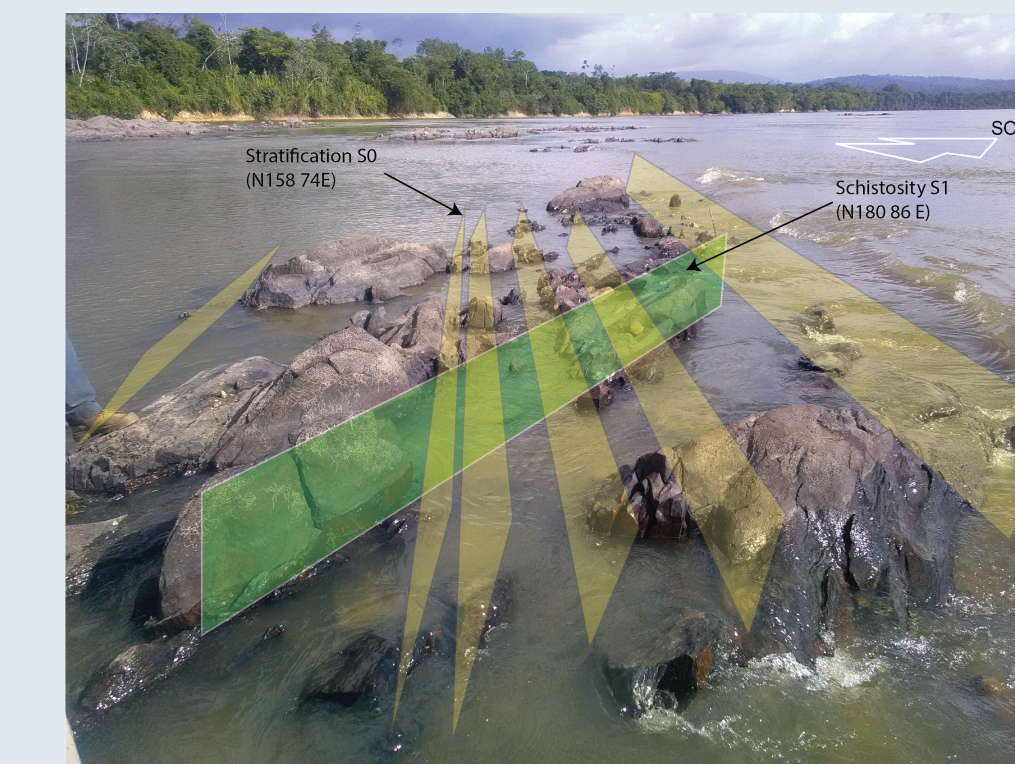
3. Groundwater prospection method (Multi-disciplinary approach)

Remote sensing + literature



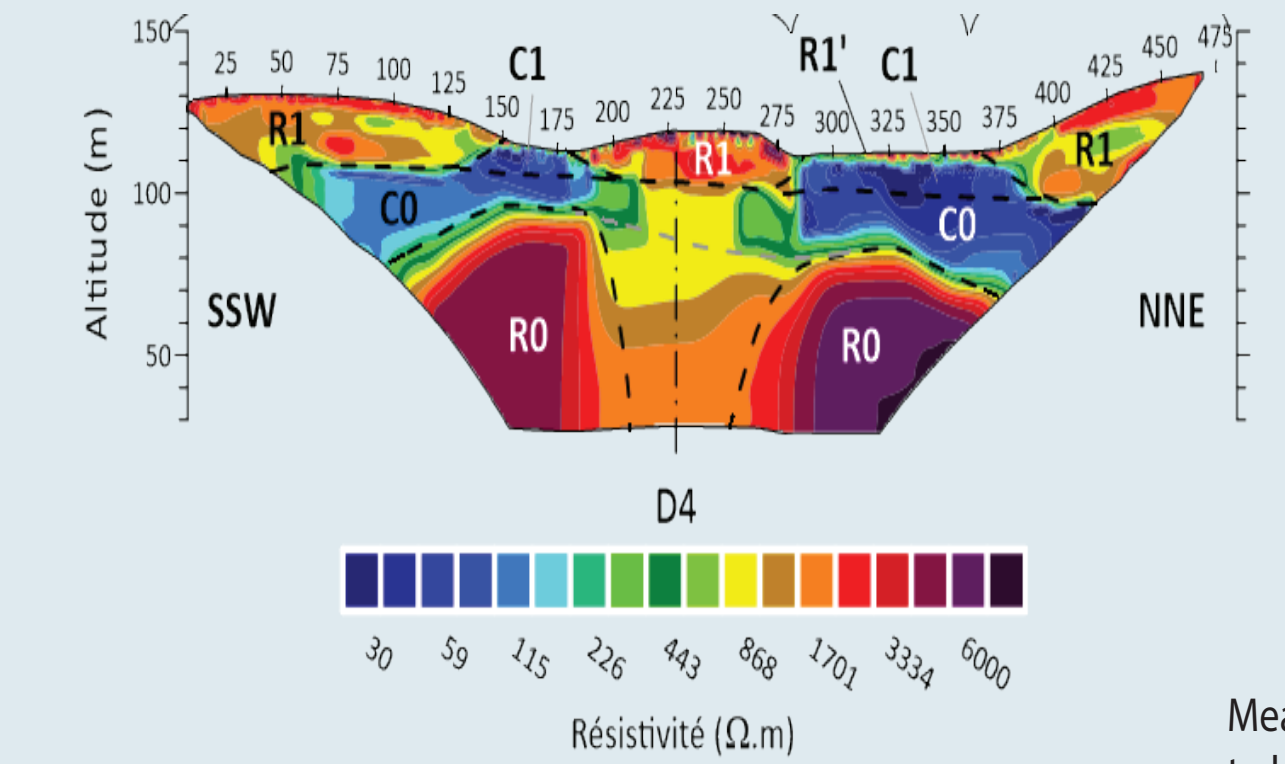
Spotting structural anomalies

Field observations



Lithological and structural measurements

ERT profiles (geophysical)



Resistivity tomography to identify the units geometry

Radon emanometry



Measurement of radon 222 content in soil, to locate the zones affected by advective gas transfers that usually coincide vertically in hydraulically active fracture zones (B)

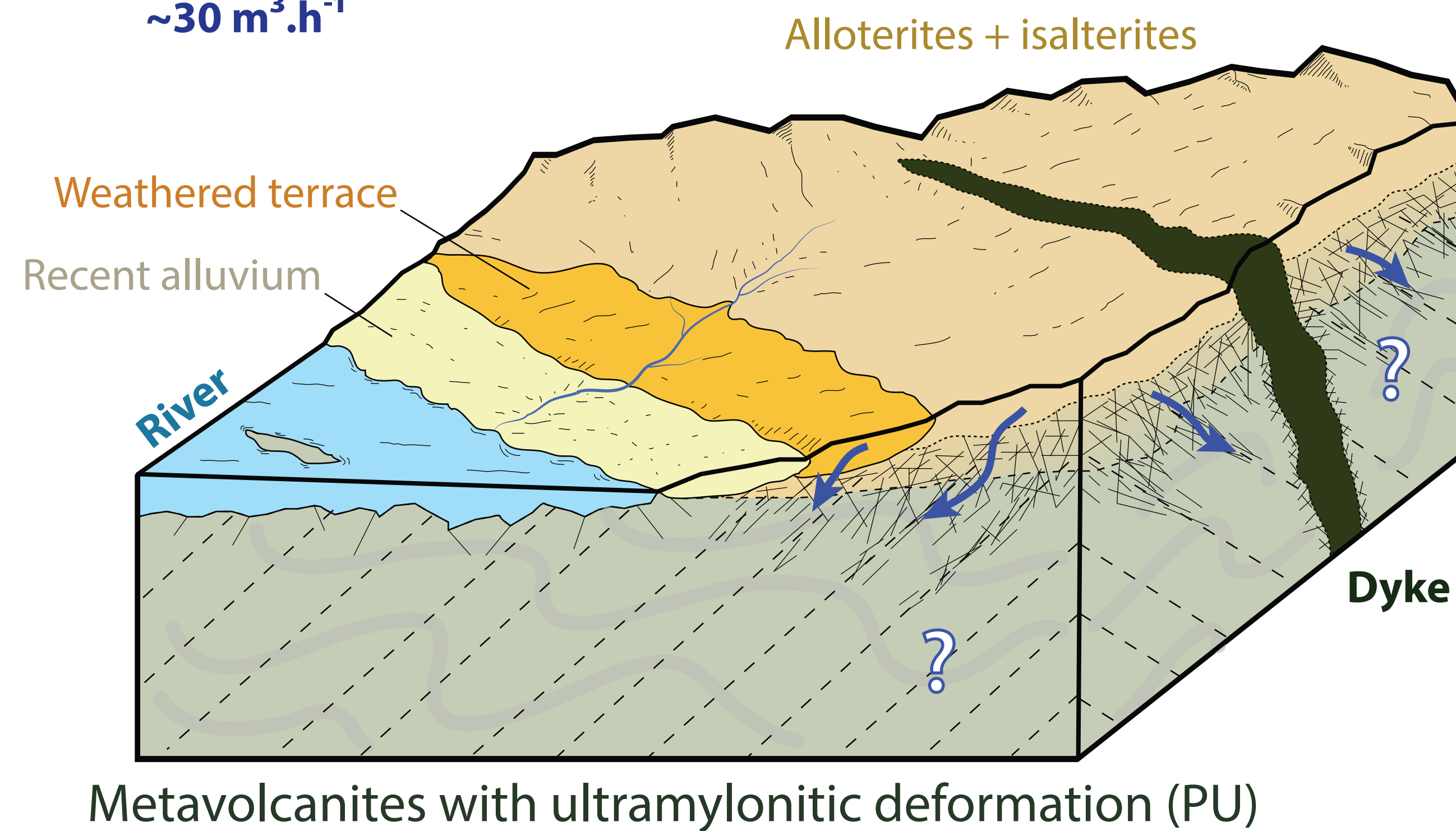
4. Conceptual models

After 15 years of hydrogeological surveys, the BRGM has studied plural units. A large heterogeneity of hydrogeological conceptual models for each context is proposed and would require further investigations.

The MM is a classical isotropic units displaying a deep weathered profile. The highest yields in French Guiana for crystalline basement rocks are found in confined aquifer in PU context. The RBU is a contrasting unit as it does not show developed weathered profile and seems recharging deep fractured aquifers.

Ultramylonitized unit (Paramaca Unit (PU))

Borewell yield range
 $\sim 30 \text{ m}^3 \cdot \text{h}^{-1}$

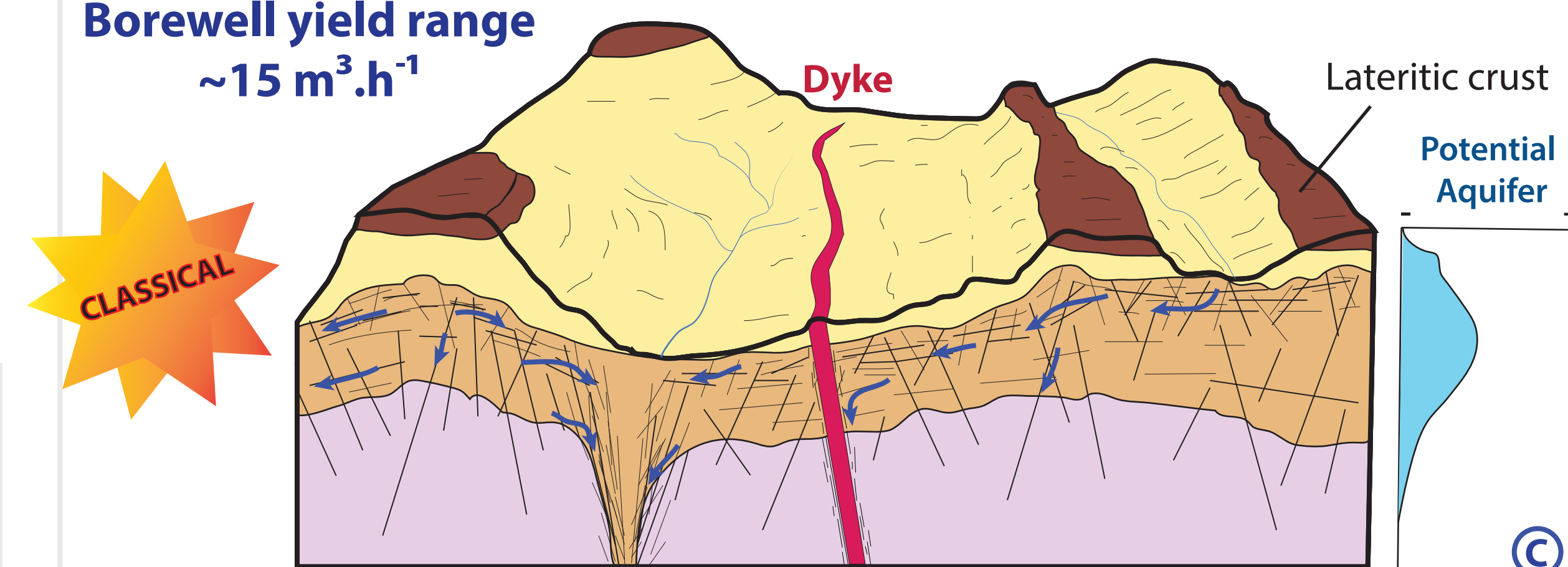


Metavolcanites with ultramylonitic deformation (PU)

Stratiform unit (Mahury Massif (MM))

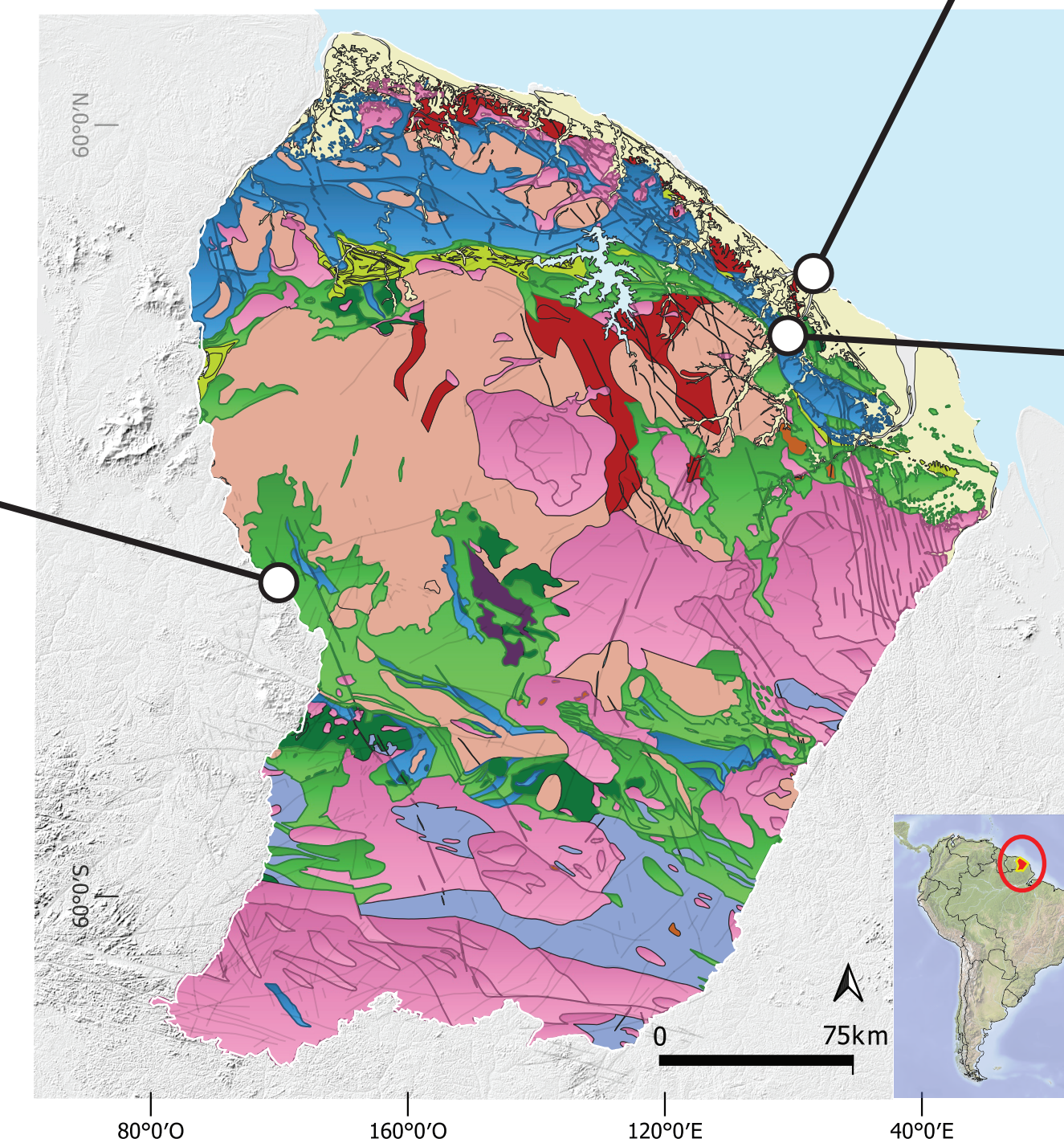
Granitoid with weathered profile (alloterite -fissured - rock)

Borewell yield range
 $\sim 15 \text{ m}^3 \cdot \text{h}^{-1}$



CLASSICAL

(C)



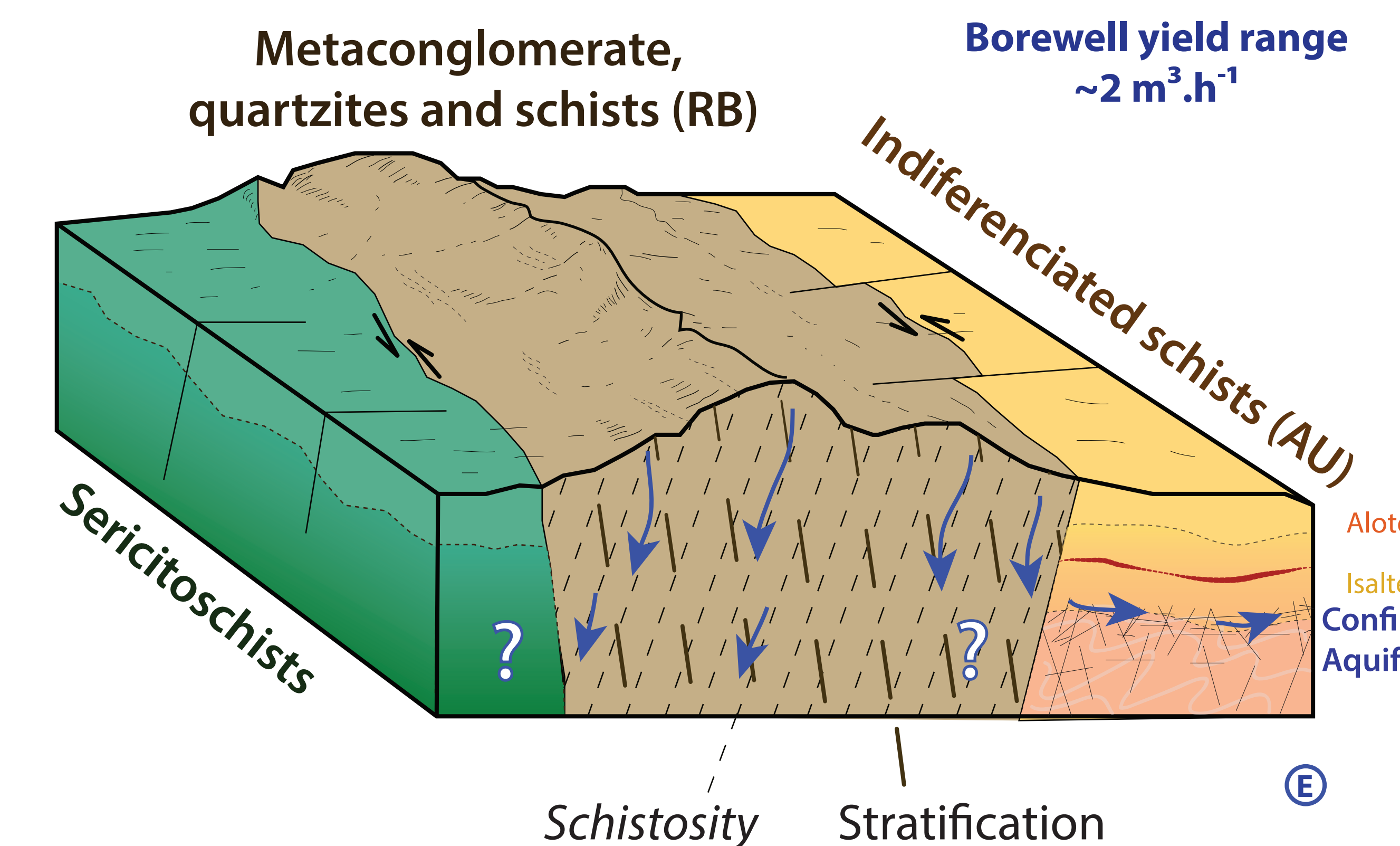
Updated structure

Simplified stratigraphy

- Veins and Dykes
- Quaternary sedimentary formation
- Rhyacian sup (plutonic) Saut Anatase and St Joseph massifs (gabbros)
- Rhyacian sup (plutonic) St Georges of Oyapock massifs (granites)
- Rhyacian inf (metamorphic) Cayenne island complex
- Rhyacian sup (plutonic) Rosebel-Bonidoro units (Sandstone/quartzites)
- Rhyacian mid (plutonic) Central complex TTG (gneiss/granites)
- Metamorphic units of Green Rocks belt (metavolcanites) Armina unit
- Rhyacian mid (plutonic) Laussat et Tamouri complex
- Metamorphic units of Green Rocks belt (metavolcanites) Paramaca Unit
- Rhyacian mid (plutonic) basics and ultrabasics complexes
- Volcanic units

Ductile to brittle deformed units (Rosebel-Bonidoro unit and Armina Unit (RB - AU))

Deformed metamorphic units separated by strike-slip fault. The schistosity has a strong influence on groundwater circulation and could allow the recharge of deeper confined aquifers below the alterites in surrounding units. The residence time and recharge rate are probably low and could explain the low yields. This hydro-system required further investigations.



Borewell yield range
 $\sim 2 \text{ m}^3 \cdot \text{h}^{-1}$

(E)

5. Conclusion

This work highlights the high potential of ductile to ultramylonitic shear zones for groundwater resource. Taking together, these conceptual models highlight that, in French Guiana and probably in entire Guiana Shield, Transamazonian tectonometamorphic structures as well as early Jurassic extensive faults correspond to sustainable useable groundwater resources.

6. References

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