

Lateritic duricrusts: Crowning glory of deep weathering profiles, or early product of lateral groundwater flow?

Sacred cows make the best hamburgers!

Leigh Bettenay

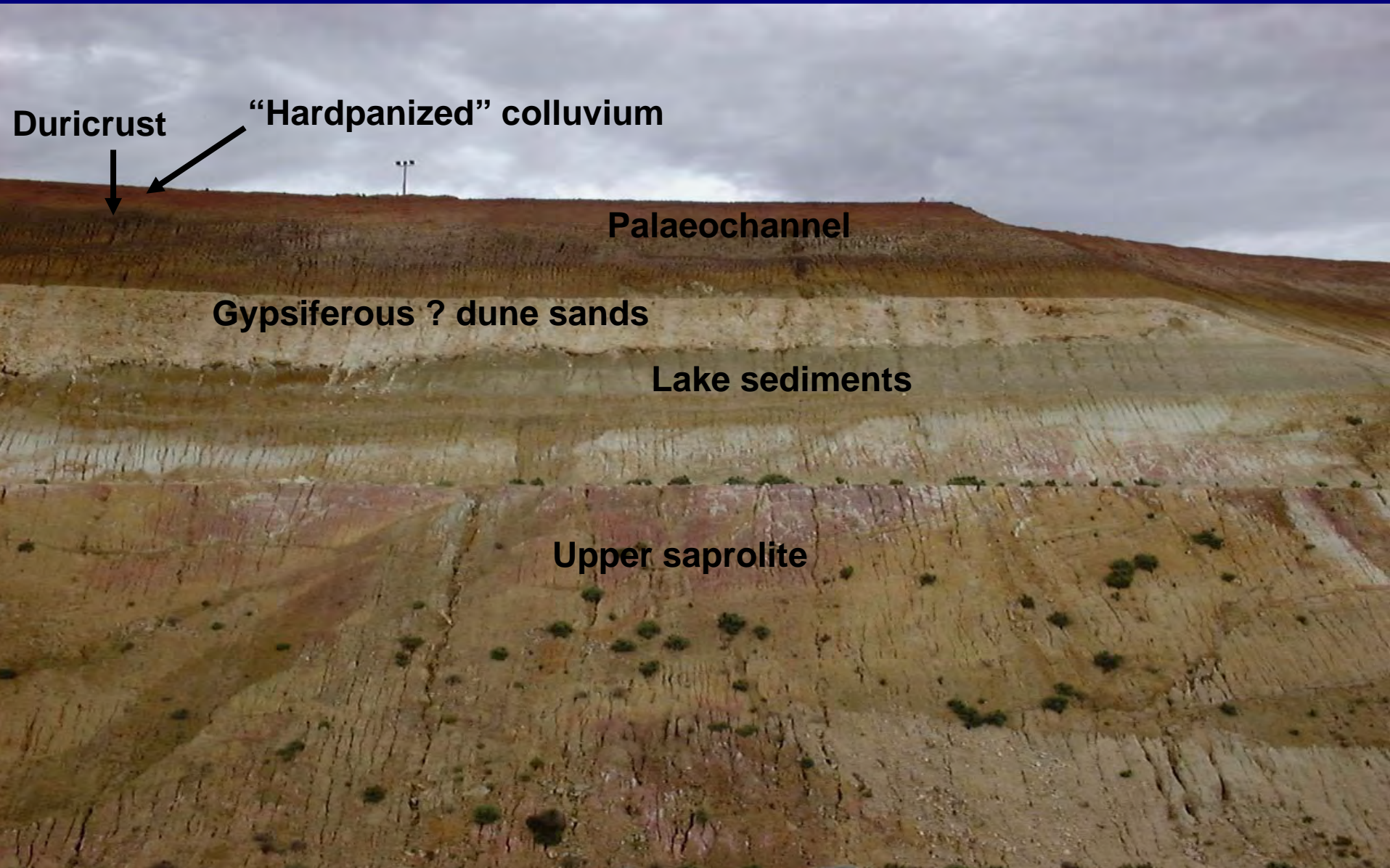


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Lateritic breakaway - a Yilgarn “mountain”



Typically complex Yilgarn profile



Heavy hitters of the LEME Laterite team



A less nimble member of the LEME team

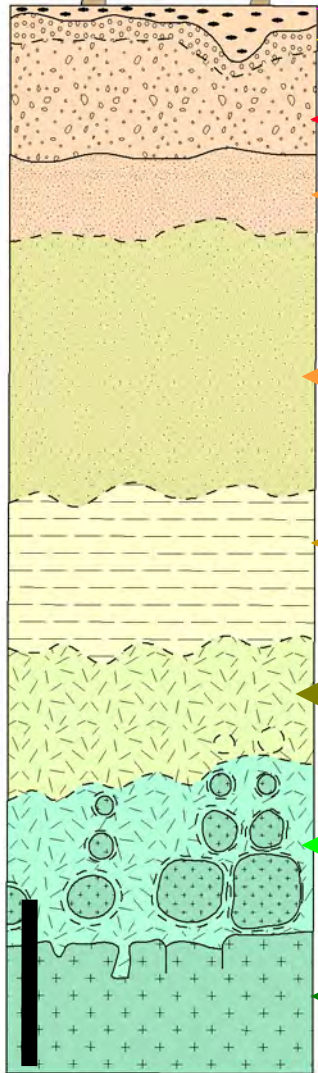
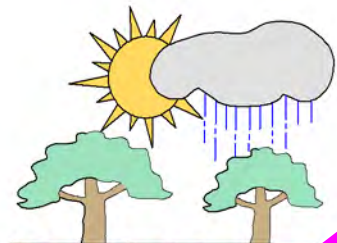


What we know about Yilgarn laterites

- They are incredibly difficult to interpret because of superimposed events
- BUT we can sample the Fe-rich zones (duricrust or pisolites) to get indications of mineralization nearby
- There seems to be better chemical and textural preservation in pisolites than in saprolite below!
- Lateritic breakaways almost always have “back-slopes”
- Palaeochannels (and ferricretes) commonly occur behind the back-slopes.



“Typical lateritic iron crust profile” (Nahon & Tardy, 1992 p43)



Pebbly ferruginous layer

Pisolitic iron crust

Indurated conglomeratic iron crust

Soft nodular iron crust

Mottled zone

Fine saprolite - massive facies

Fine saprolite - porous facies

Coarse grained saprolite

Parent rock

5 m

EVOLUTION OF LATERITE PROFILES

- the classical view

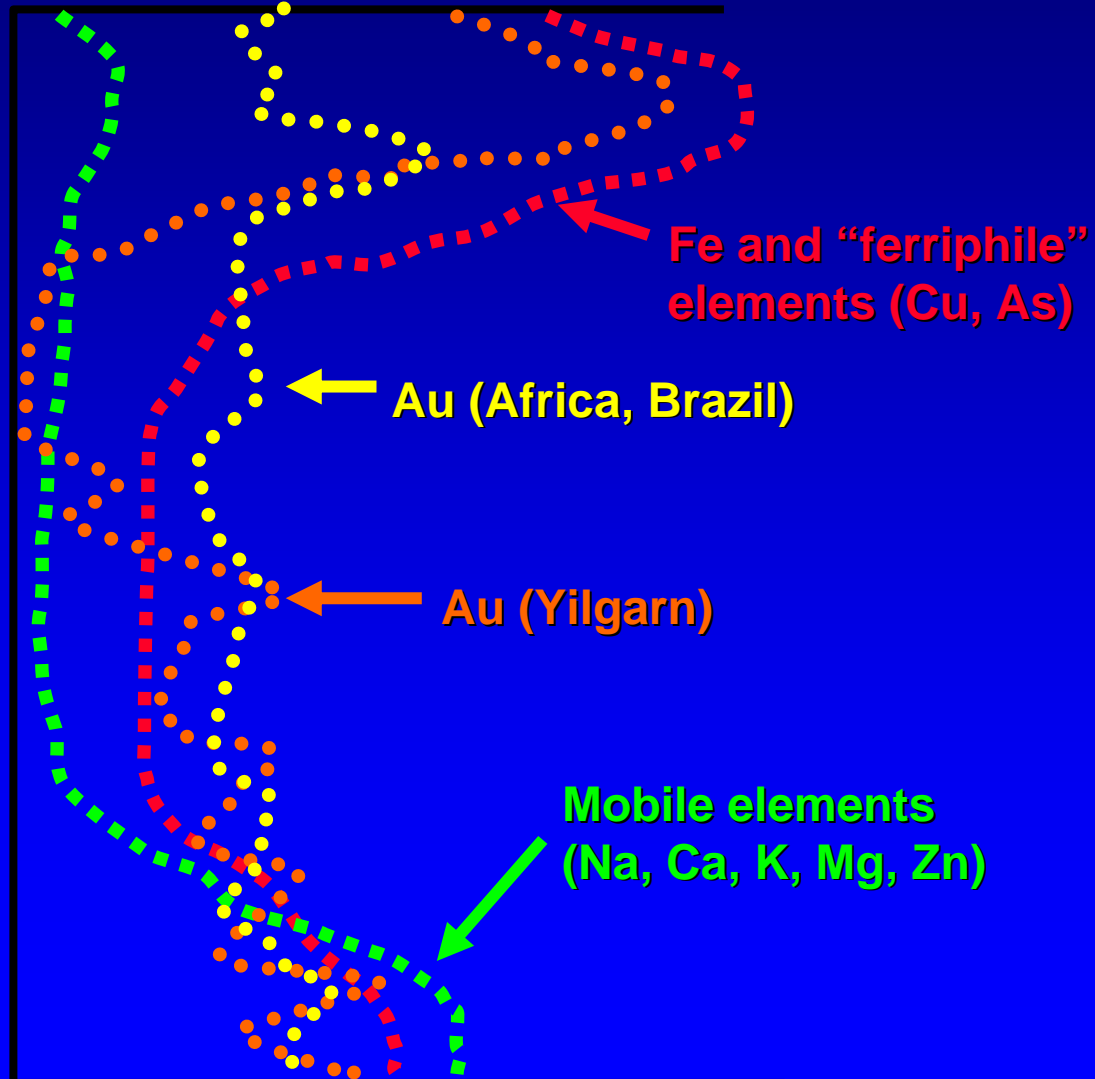
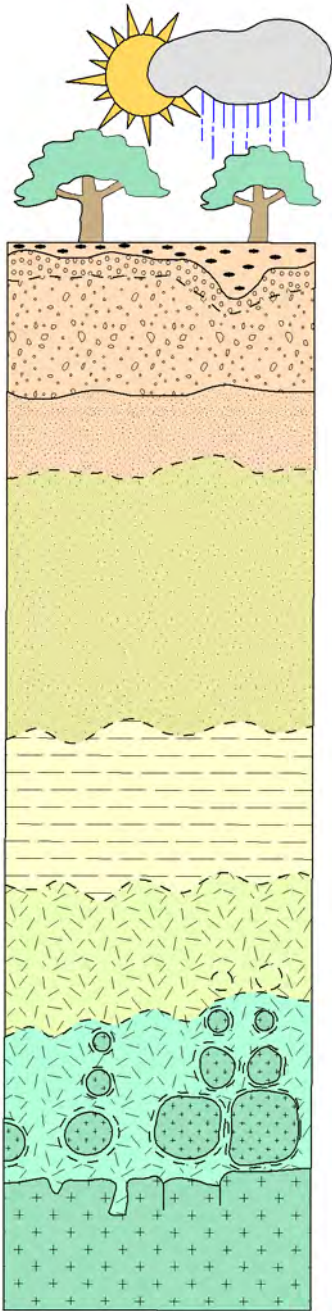
- a progressive sequence of vertical transformations

- “These horizons are superposed vertically and correspond to a pedogenic sequence whose organizations derive from each other during lowering of the surficial mantle in the landscape; namely each horizon develops at the expense of the underlying one, but at the same time also feeds the underlying horizon at various levels with the products it liberates”

OMIGOD!! IT IS SO NOT LIKE THAT !!!!!

- Daniel Nahon, 1990, p 209

Idealized element profiles

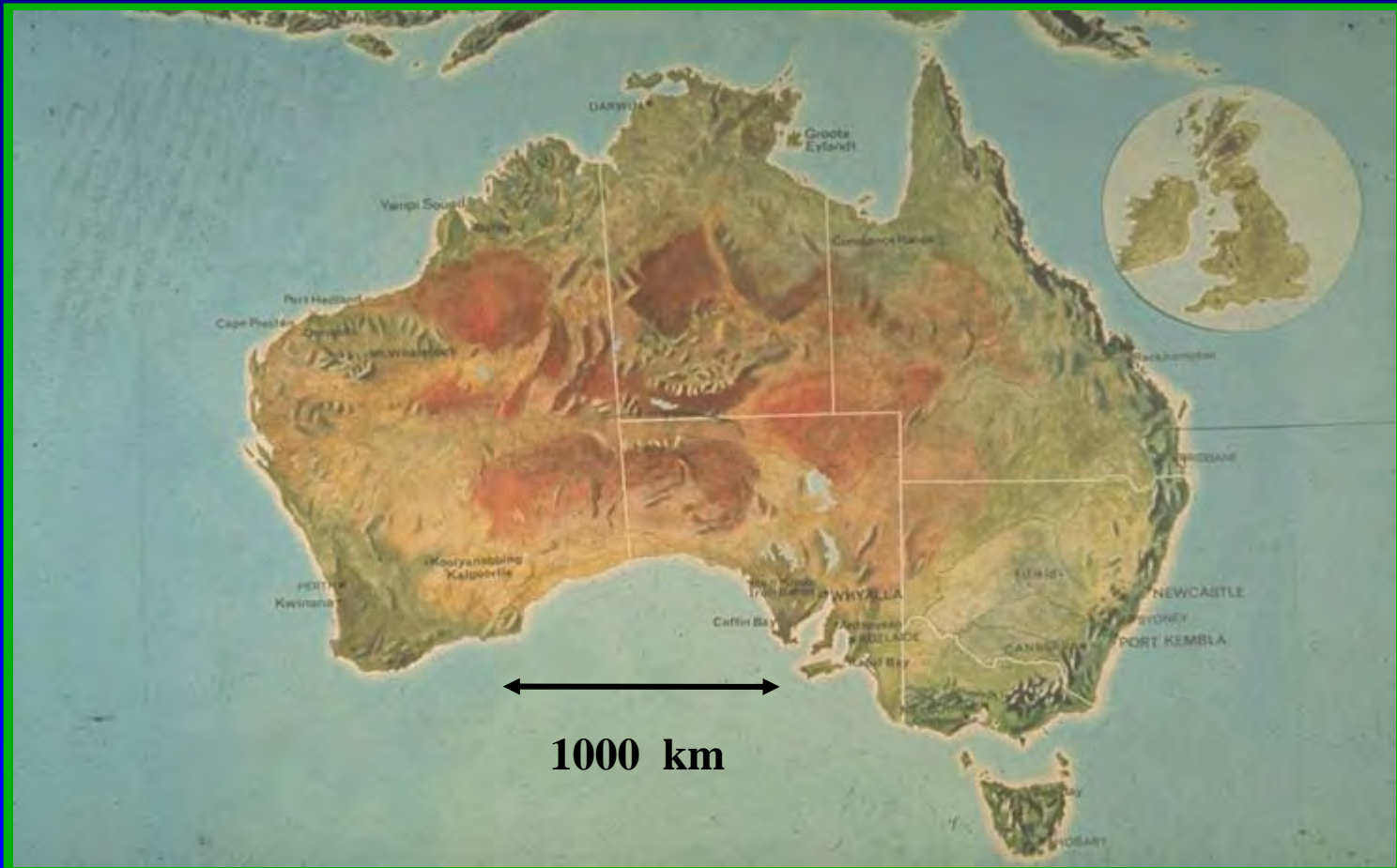


Laterite Profiles- Starting assumptions

- The loss of soluble elements from laterite profiles tells us that there has been major groundwater flux (= groundwater flow – through)
- Major groundwater flux is likely a pre-requisite for deep weathering
- Groundwater flowing through a profile can (and probably does) bring in components while taking other components out

Australia- you're standing in it.

If the Yilgarn is so difficult, where can we go to study laterite formation?



North Queensland savannah hilltops

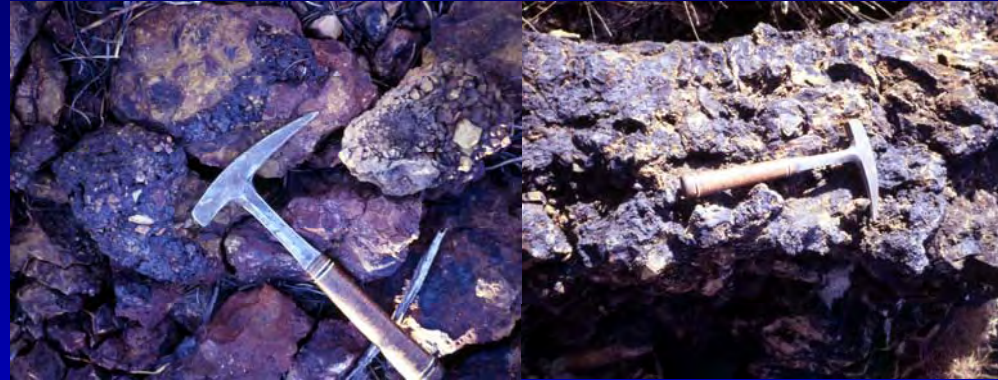


Thin skeletal soils overlying friable “saprock” (exposed by recent scouring related to over - clearing downstream)



North Queensland savannah drainages

“Creek rocks”,
ferricretes, coffee
rocks galore!!



Evidence for
active ferrolysis
at down-slope
positions into
current drainages

Often directly on
(and into) fresh
bedrock



Brazil (Carajas) laterite profiles

Thick and complex profiles

Possibly show even more events than in Yilgarn!

So NOT where we should go to understand profile evolution!



Brazil (lowlands) laterite profiles

**Extensive
Duricrusts in
wide valleys with
highlands of
leached saprolite**



West African Laterite profiles

**Duricrusts
underlain by
bleached and
?leached
saprolite**



West African Laterite profiles



West African duricrusts have “detrital” textures and often contain fragments of older duricrust

Their textures closely resemble the “oxisols” forming now in stable landscapes around them

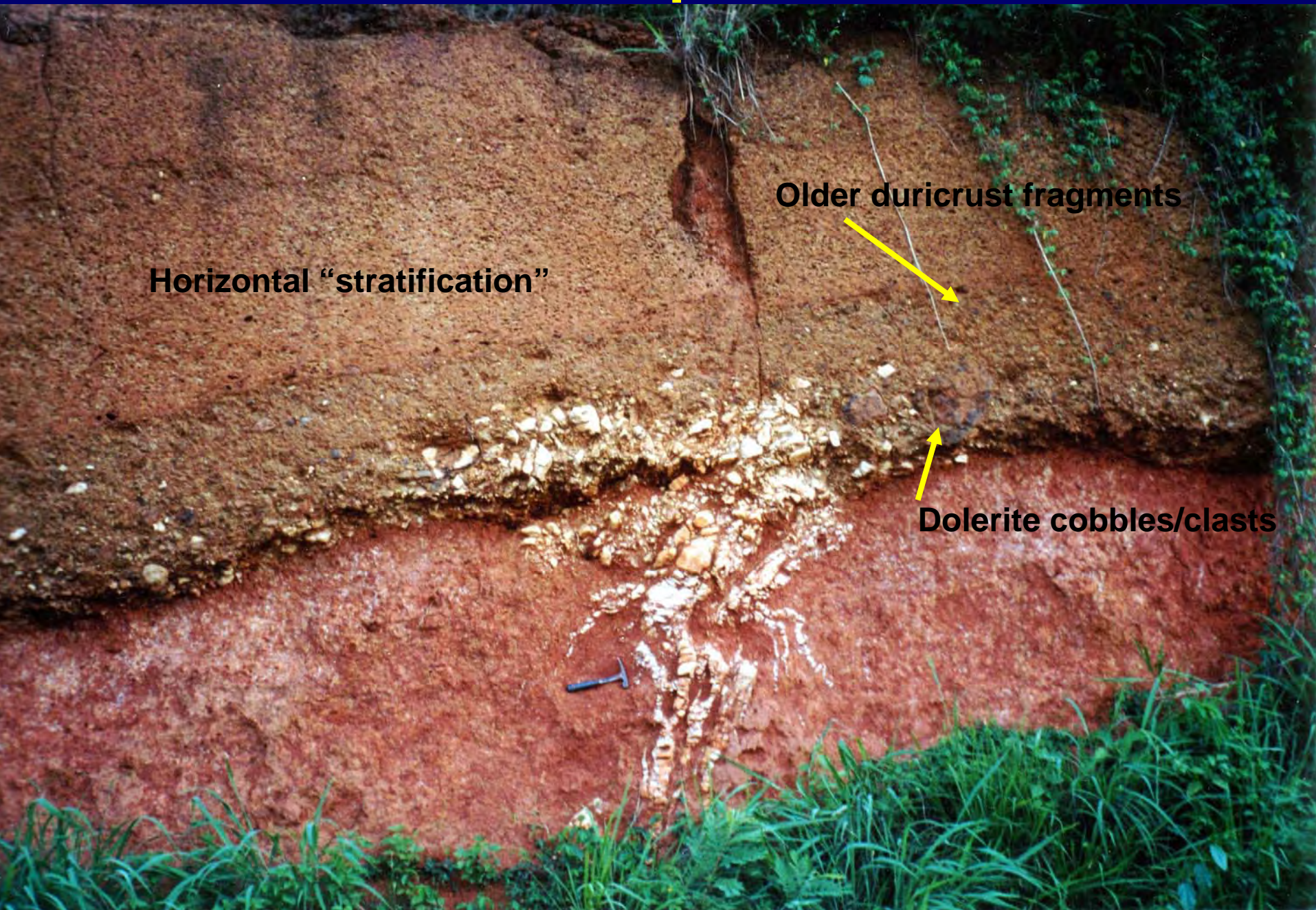


West African Laterite profiles

**Ferricrete or
lateritic duricrust
blankets with
sharp contacts
against saprolite**



West African Laterite profiles – stone lines



Horizontal “stratification”

Older duricrust fragments

Dolerite cobbles/clasts

West African Laterite profiles

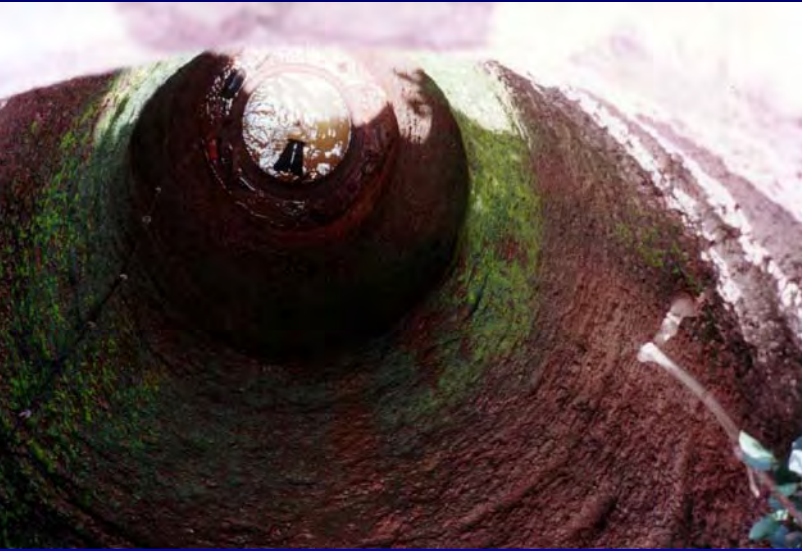


Artisinal workings in/through
“duricrusts”

Question: were they hard when
dug, or did the digging cause
hardening?



West African Laterite profiles

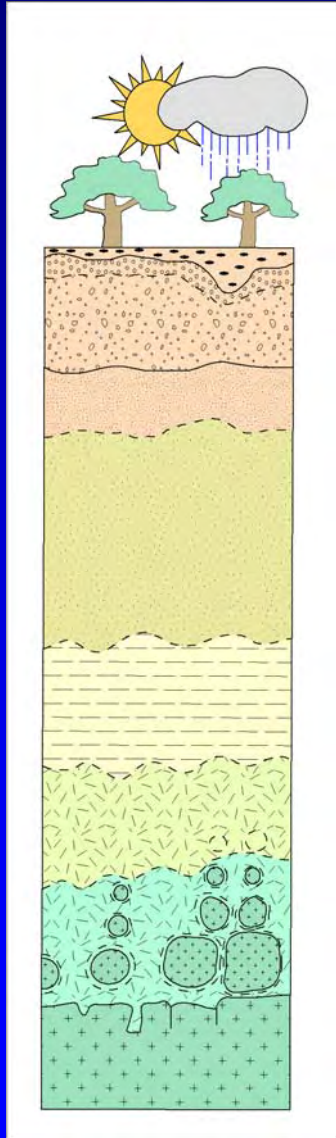


Wells and road-cuttings demonstrate profile hardening occurs rapidly when the groundwater table is interrupted



Note: road-cut profiles harden within 5 years!

Textures and chemistry of Yilgarn pisolites and duricrusts



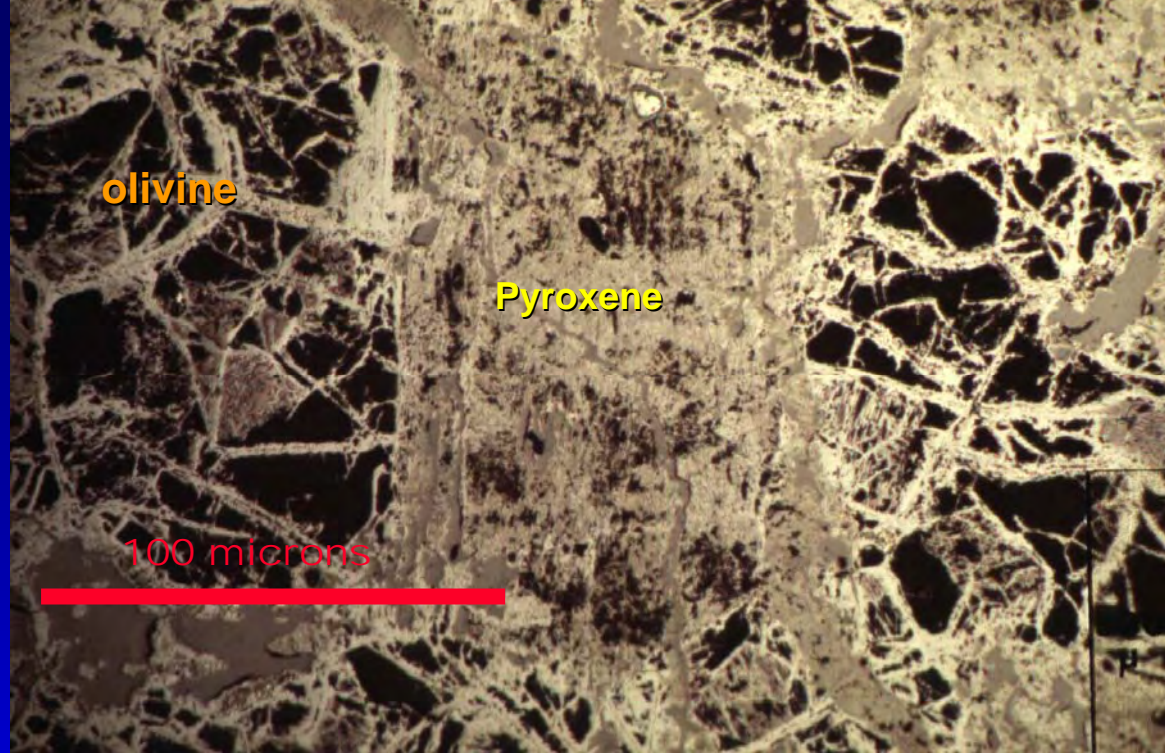
Key Question:

have these
been through
this



**Olivine and pyroxene
pseudomorphs in pisolite from
Ora Banda (slide courtesy Ian
Robertson CRCLEME)**

**Original textures
preserved in Yilgarn
pisolites and
duricrusts**



**Quartz phenocryst and
microlitic “flow” texture in
pisolite from Golden Grove
(slide courtesy Ray Smith
CSIRO)**

**Slide showing excellent micro-textural
preservation**

**[Not available for publication –refer R.E.
Smith 2004 and 2005 in prep]**

Slide showing excellent micro-textural and geochemical preservation of strong pathfinder elements in gossan fragment within pisolite

[Not available for publication –refer R.E. Smith 2005 in prep]

KEY QUESTION: How do we preserve these original textural and chemical signatures in pisolites and duricrusts, if they have been through all the underlying weathering stages?

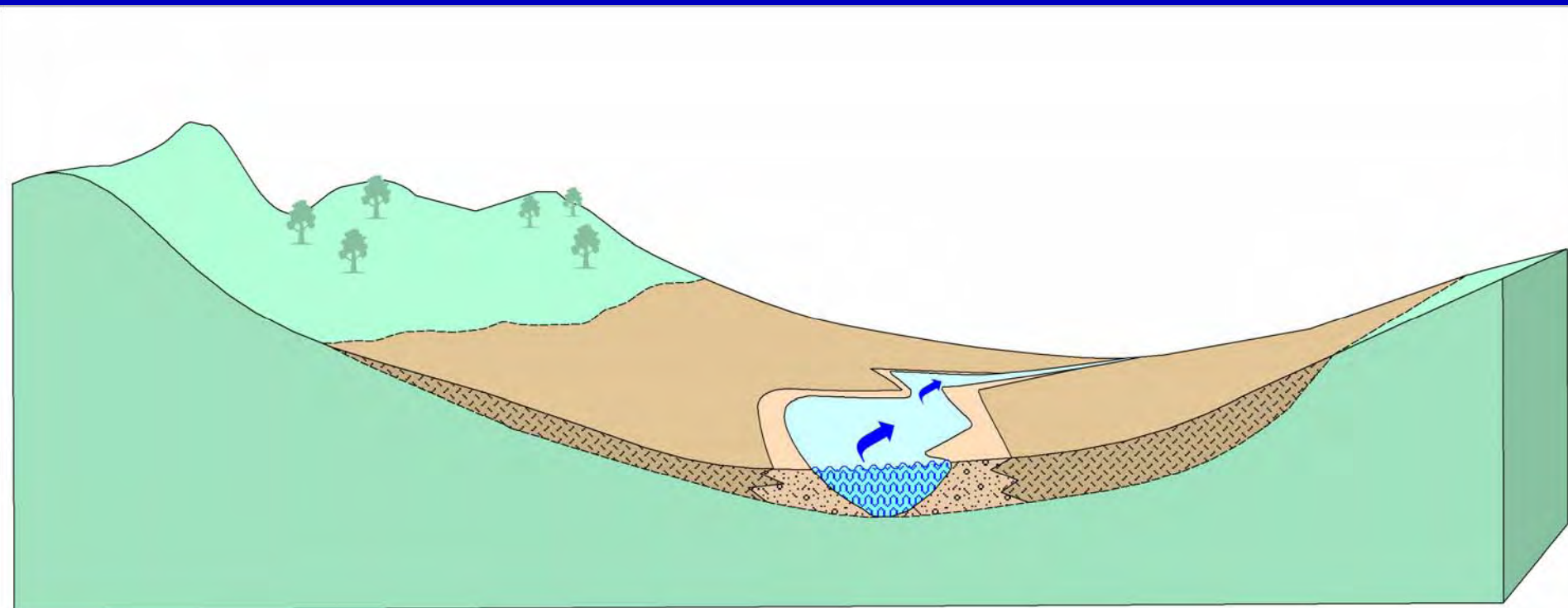
Model for Duricrust Formation - Stage 1

Broad valley fills with immature “colluvium”

Pre-requisites:

Tectonic stability, no major drop in base level of erosion, high (seasonal) rainfall

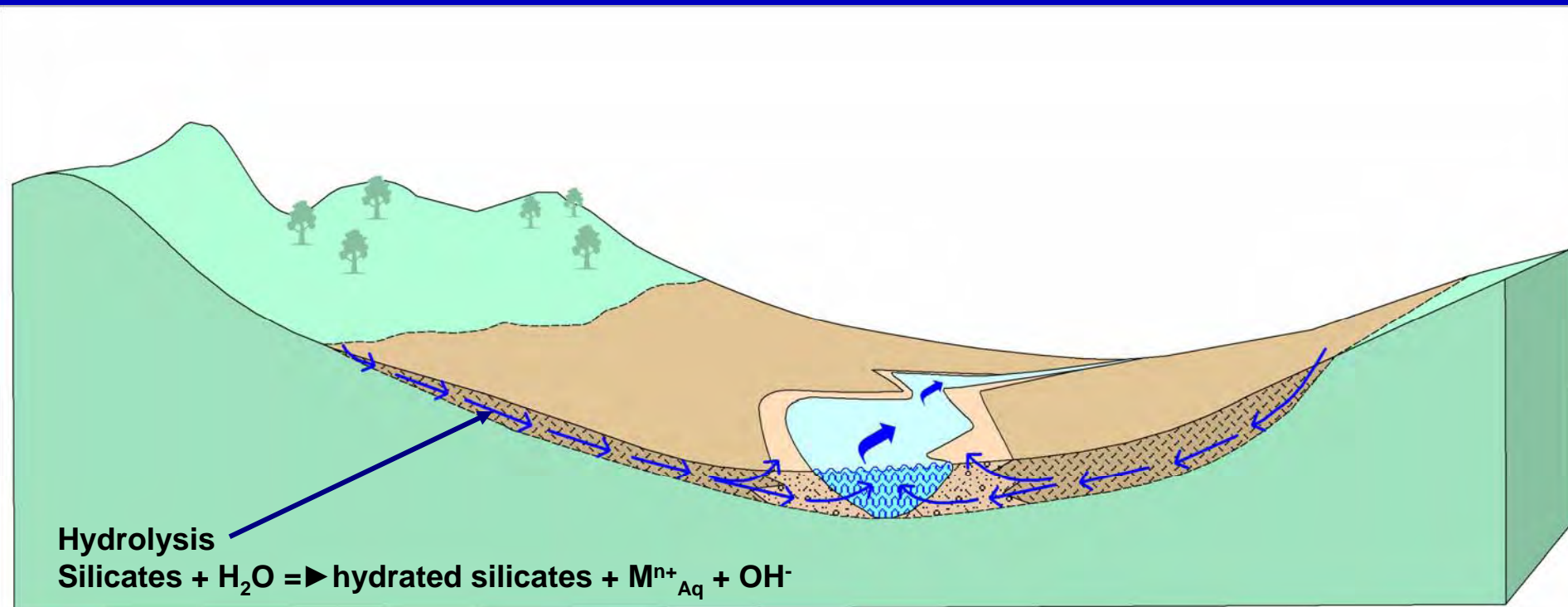
NB: highland areas might include saprolite +/- older duricrusts



Model for Duricrust Formation - Stage 2

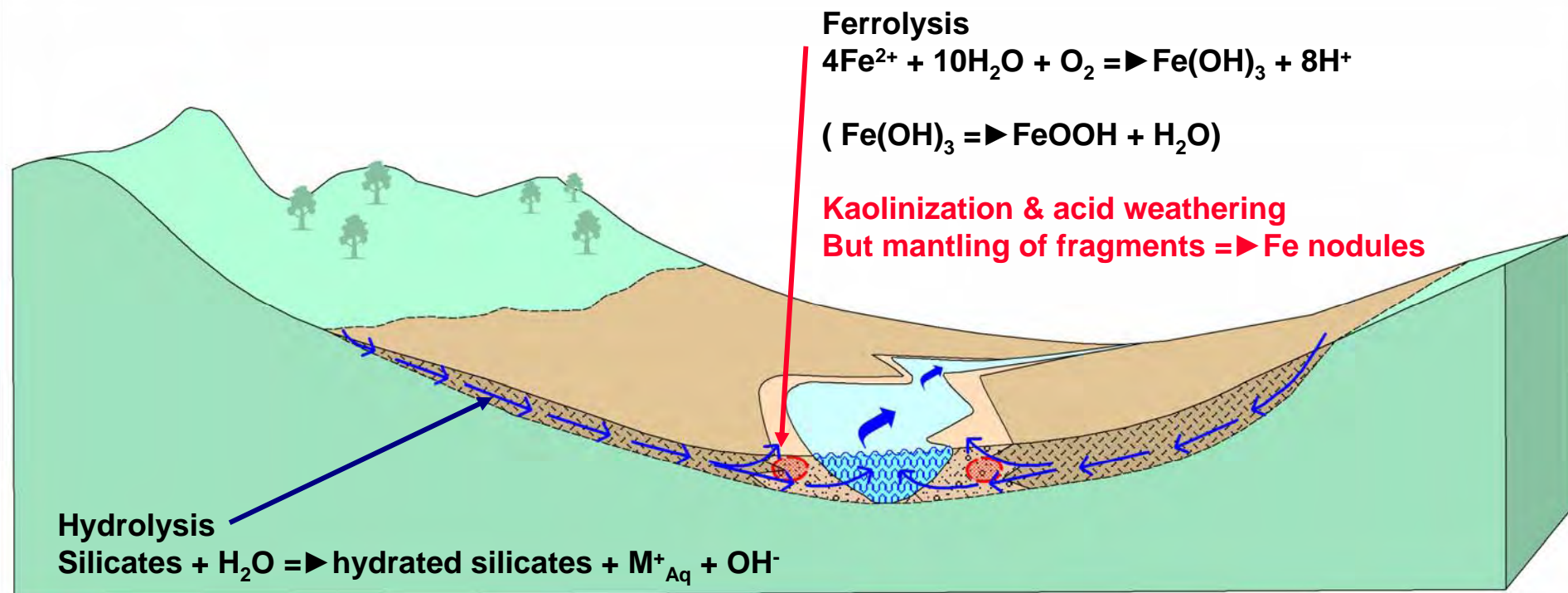
Groundwater flow at colluvium-bedrock interface

- ▶ Incipient weathering of bedrock and basal colluvium



Model for Duricrust Formation - Stage 3

Hydrolysis up slope & ferrollysis at base of slope
▶ ferricretes and “oxisols”

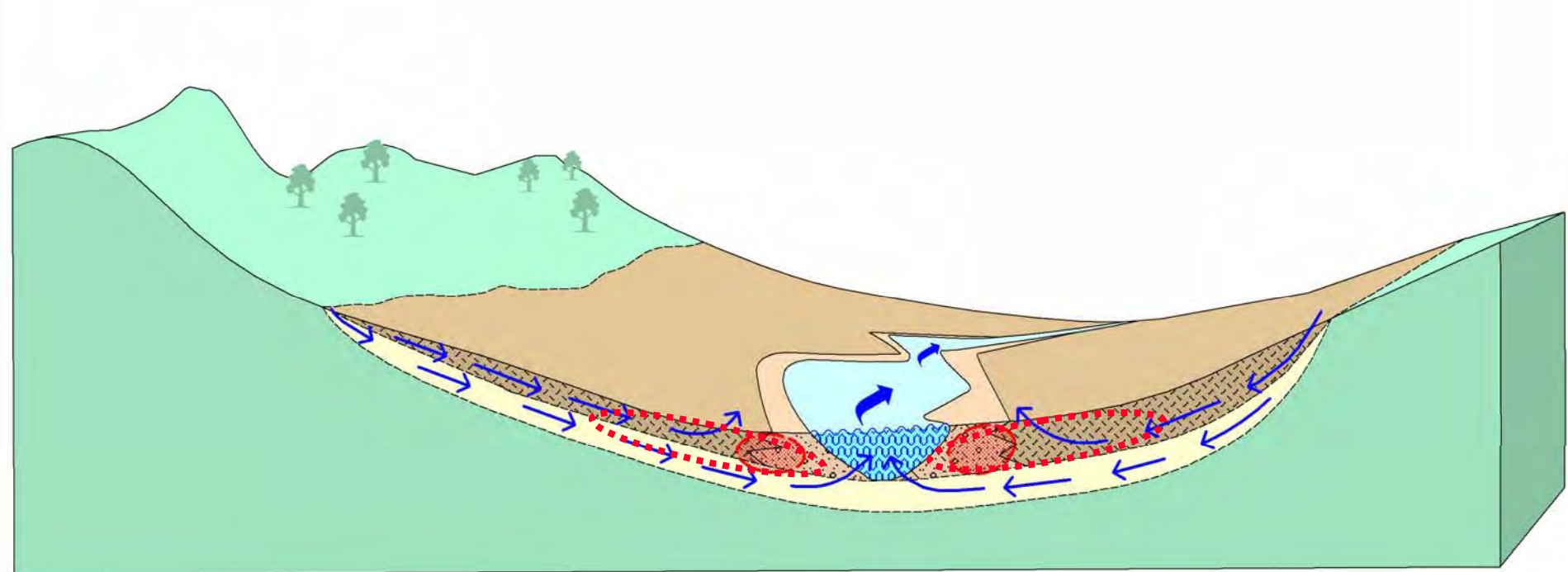


Model for Duricrust Formation - Stage 4

Clay & ferroysis ► permeability barrier

Groundwater forced to surface higher up slope
and/or into bedrock below

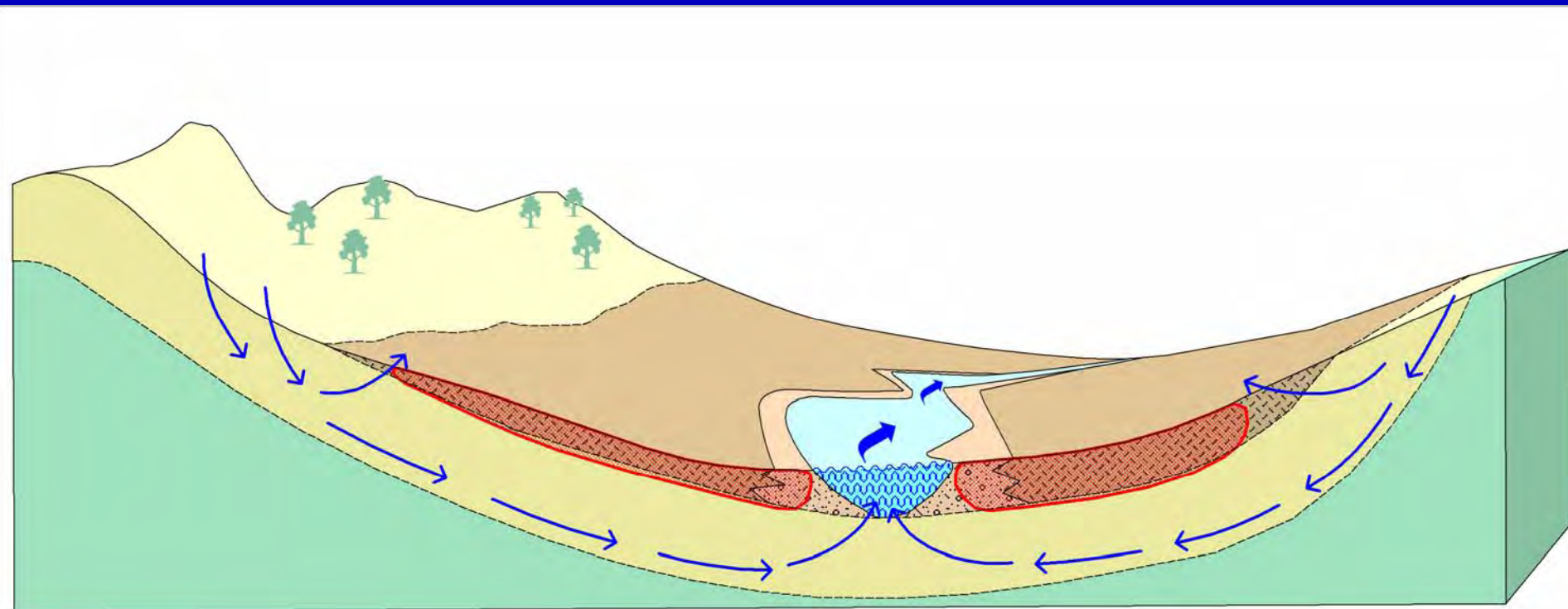
► oxisols migrate up slope and underlying
bedrock progressively weathered (i.e profile
thickens as weathering front lowered)



Model for Duricrust Formation - Stage 5

Over time ► widespread oxisols and deepened underlying weathering profile

✦ If water table drops or groundwater flow decreases then duricrusts develop by dehydration (“irreversible hardening”)

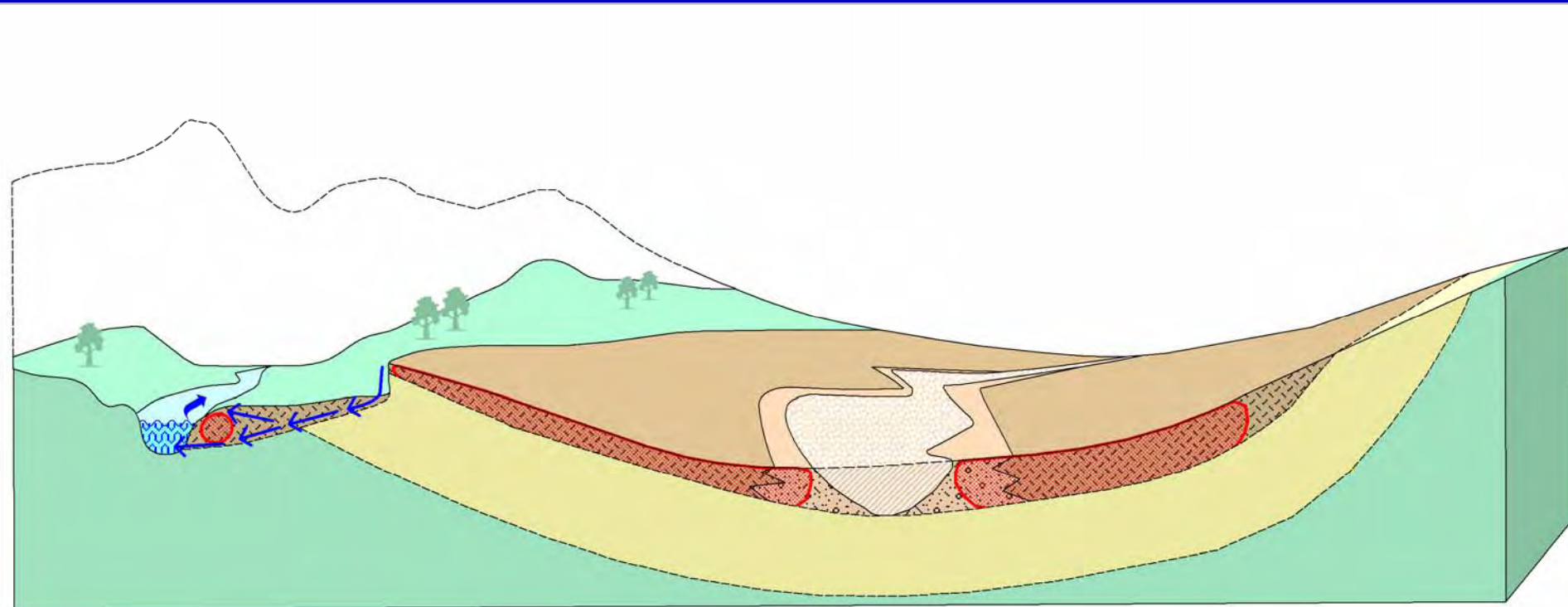


Model for Duricrust Formation - Stage 6

- ▶ Erosion of unmantled saprock
- ▶ Relief inversion and scarp retreat

New drainage system develops with new colluvium/alluvium profiles

Process then repeats by ferrolysis in downslope position of new drainage



CONCLUSIONS

- Iron impregnation in lower slope positions produces ferricretes and “oxisols” by ferrolysis
- Profile deepening and weathering of saprolite happens after this, beneath this and perhaps partly in response to this
- Chemical/textural signatures of parent rocks and mineralization are locked into ferruginous nodules and duricrusts before they “see” most of the deep weathering event.
- Duricrusts form when oxisols lose contact with groundwater and harden by drying out

CONCLUSIONS (cont'd)

- Once formed, duricrusts strongly resist erosion - so relief inversion is the rule, not the exception in laterite terrains
- Palaochannels and ferricretes are an integral early part of lateritization, so their presence within laterite terrains is to be expected
- Periods of lateritization likely involve repeated/ micro-events of ferrolysis, hardening, landscape armouring, relief inversion and re-sedimentation in newly created “colluvium”
- BUT deep weathering might take place quicker than we think.

CONCLUSIONS (cont'd)

- Laterite profiles do settle in the landscape, but not by vertical migration of zones onto and over those below; rather, it is by removal of underlying clay-rich zones through dissolution and bioturbation, and by physical removal through repeated scarp retreat and re – cementation in newly created colluvium
- Multiple overlapping and inter-connected laterite “surfaces” may be the norm.

CONCLUSIONS (cont'd)

- A geochemical anomaly in duricrust or pisolites is thus a function of:
 - Pre-lateritic colluvial dispersion +
 - Chemical infiltration and attack during ferrolysis +
 - Subsequent chemical modification and physical re-location
- But, most importantly, geochemical signatures in duricrusts are “locked in” early in the weathering event.

Acknowledgements

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**The last word -
from North Queensland road signs
(seek not the answers, but the questions)**

