Rio Tinto

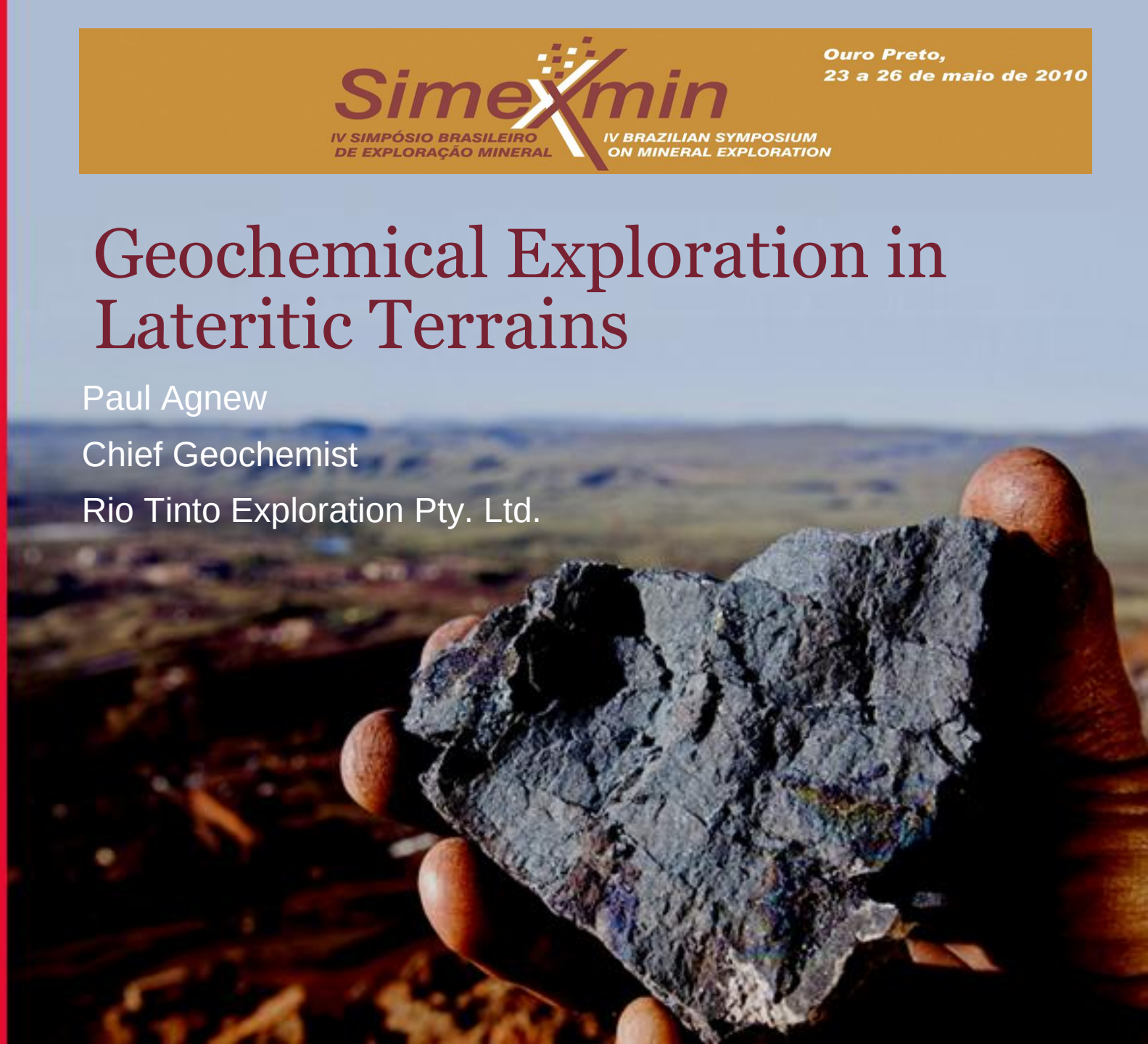
SimeXmin
IV SIMPÓSIO BRASILEIRO DE EXPLORAÇÃO MINERAL
IV BRAZILIAN SYMPOSIUM ON MINERAL EXPLORATION
Ouro Preto, 23 a 26 de maio de 2010

Geochemical Exploration in Lateritic Terrains

Paul Agnew

Chief Geochemist

Rio Tinto Exploration Pty. Ltd.

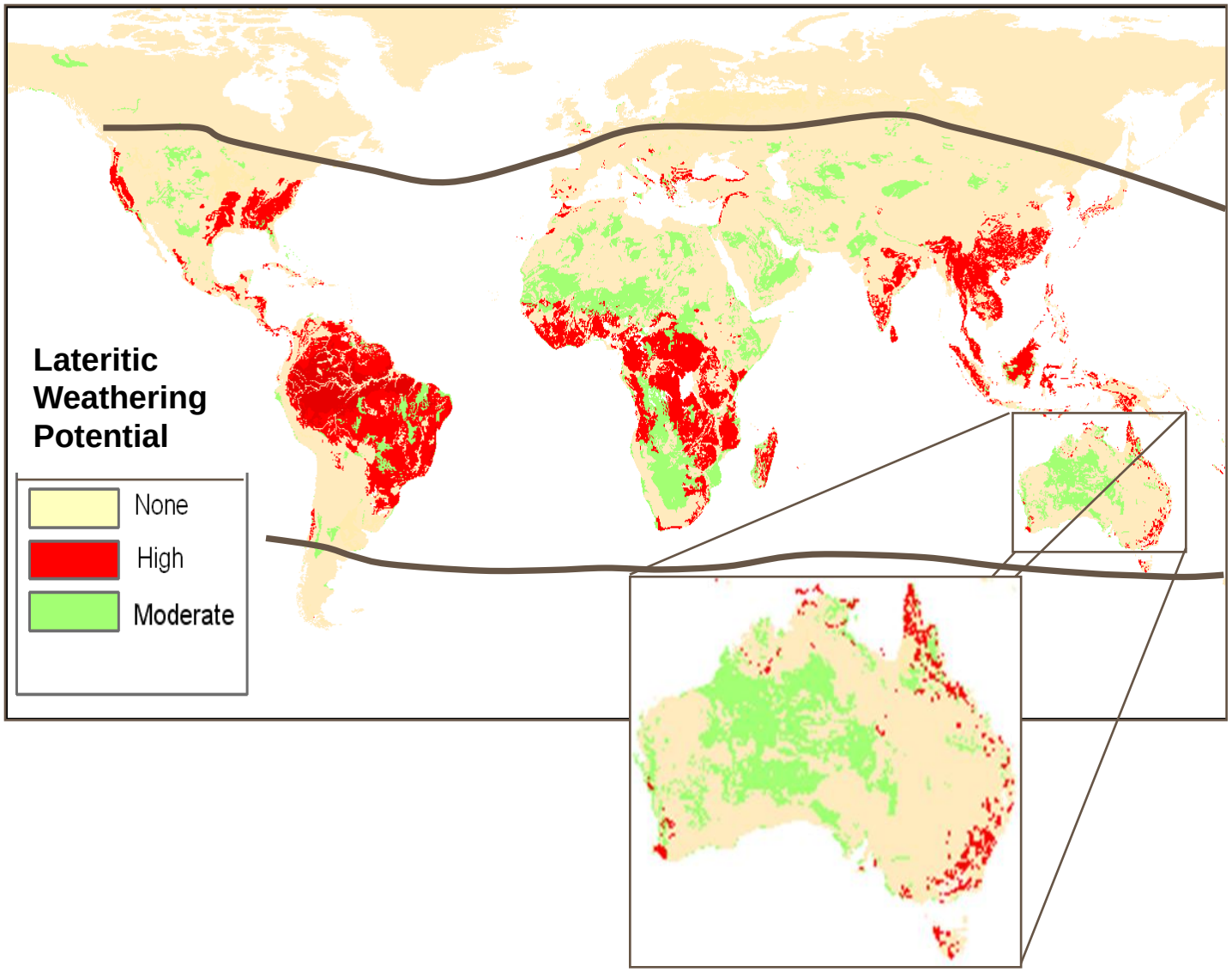


Presentation outline

- The Lateritic Weathering Profile
- Geochemical Exploration in Lateritic Environments
- Analytical Techniques
- The Microscopic Future

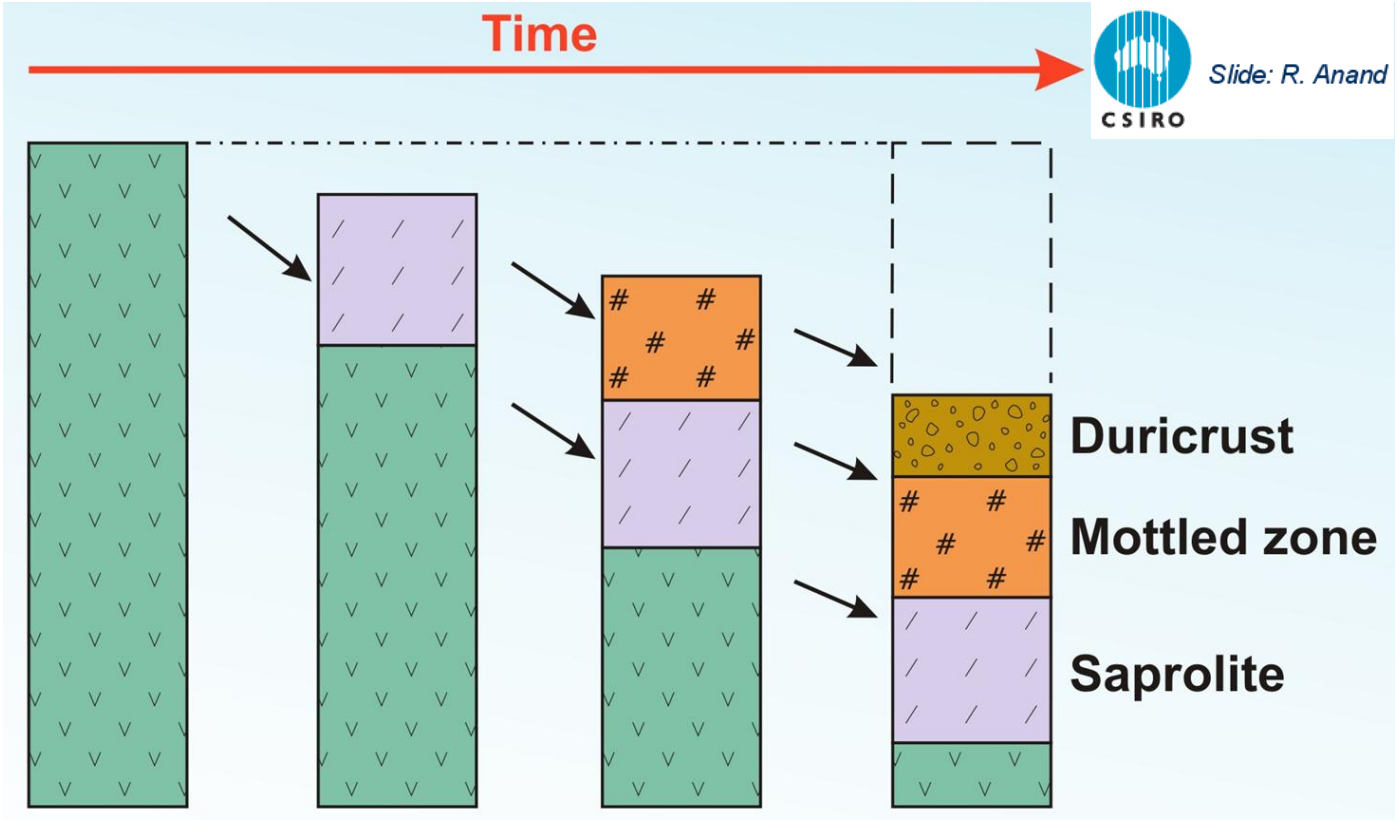
Global Lateritic Weathering

Global Distribution of "Lateritic Soils"



Deep Lateritic Weathering

- *A process of "Landscape Reduction" in tropical environments*
- *Multiple periods of extended weathering caused by fluctuating water table*
- *Leads to the development of a "weathering profile"*



Lateritic Landscapes - Australia

Australian "Dry" Lateritic Terrain - A challenge to early explorers

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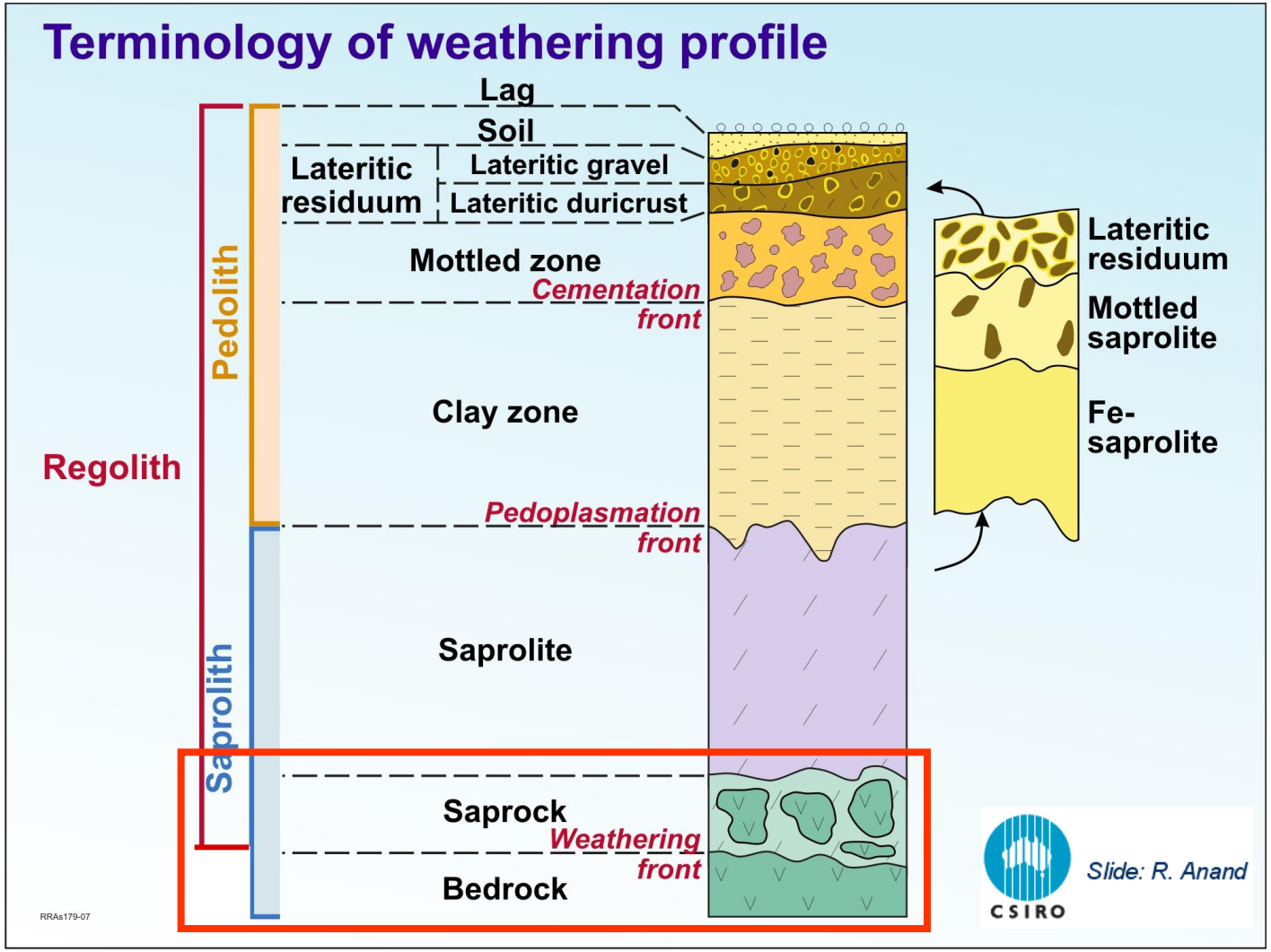
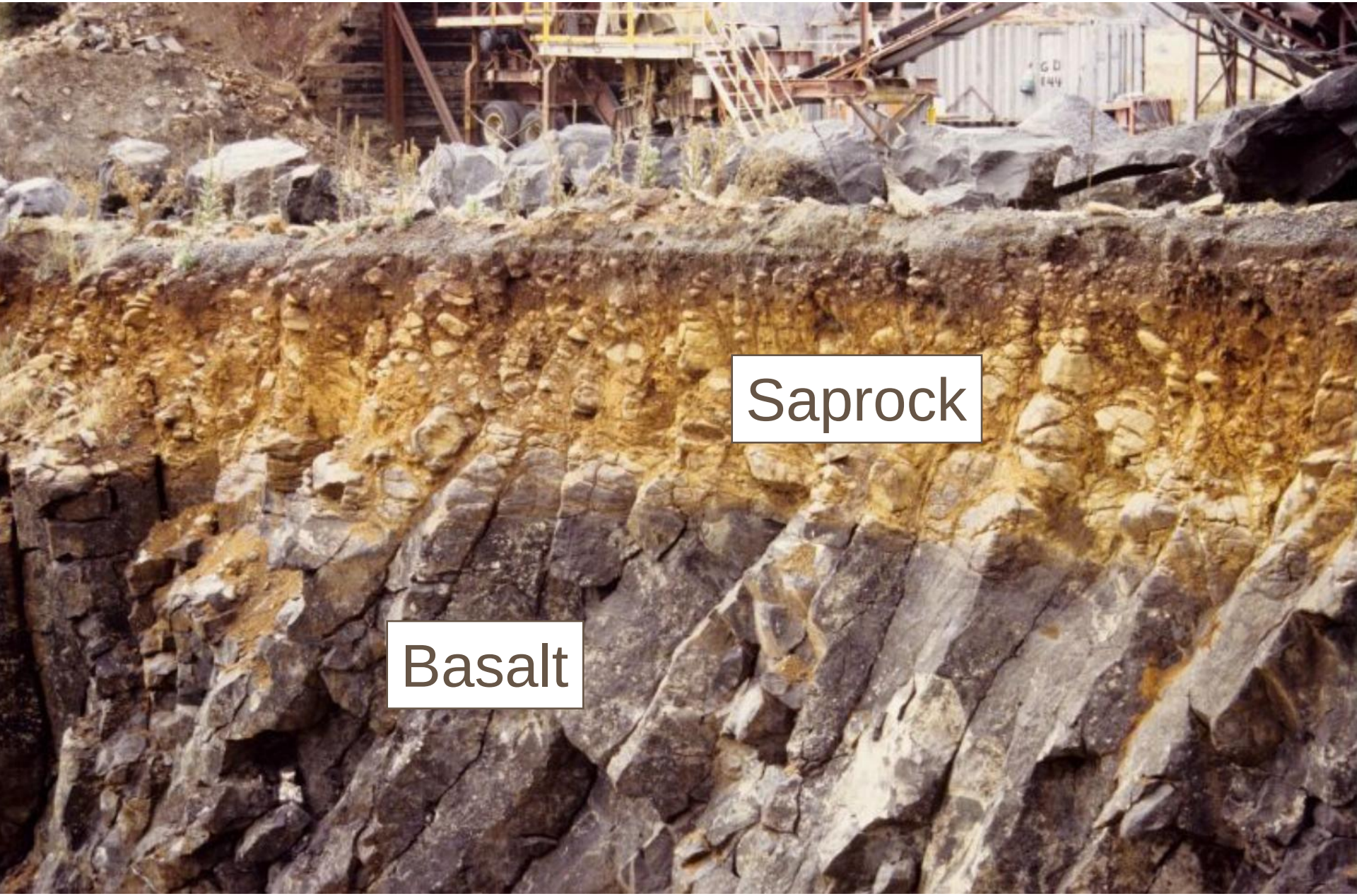
Australian "Dry" Lateritic Terrain - A challenge to early explorers

Regolith :
Everything between Fresh Rock and Fresh Air!

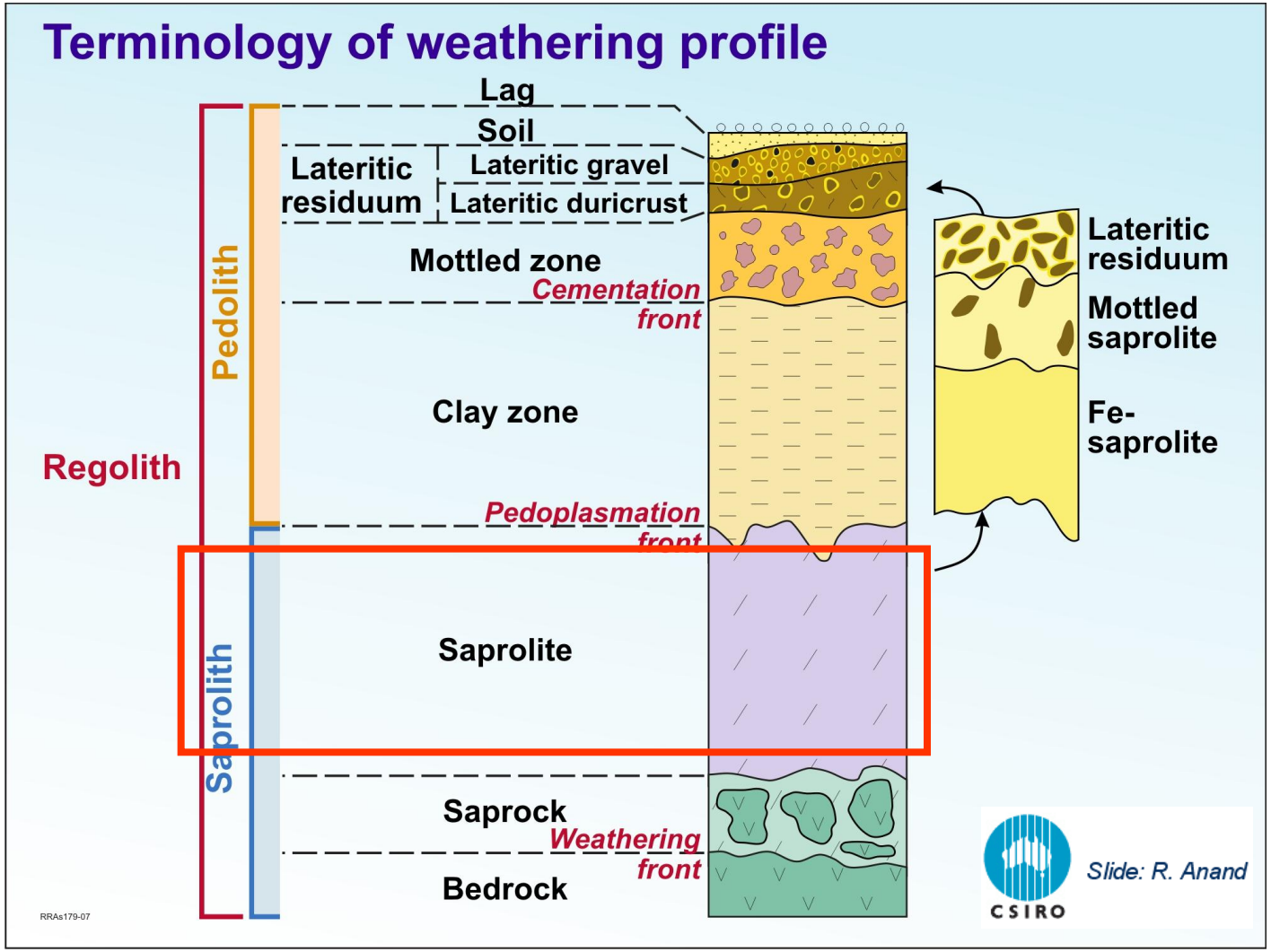
The Lateritic Profile




Saprock
Basalt

Regolith :
Everything between Fresh Rock and Fresh Air!

The Lateritic Profile

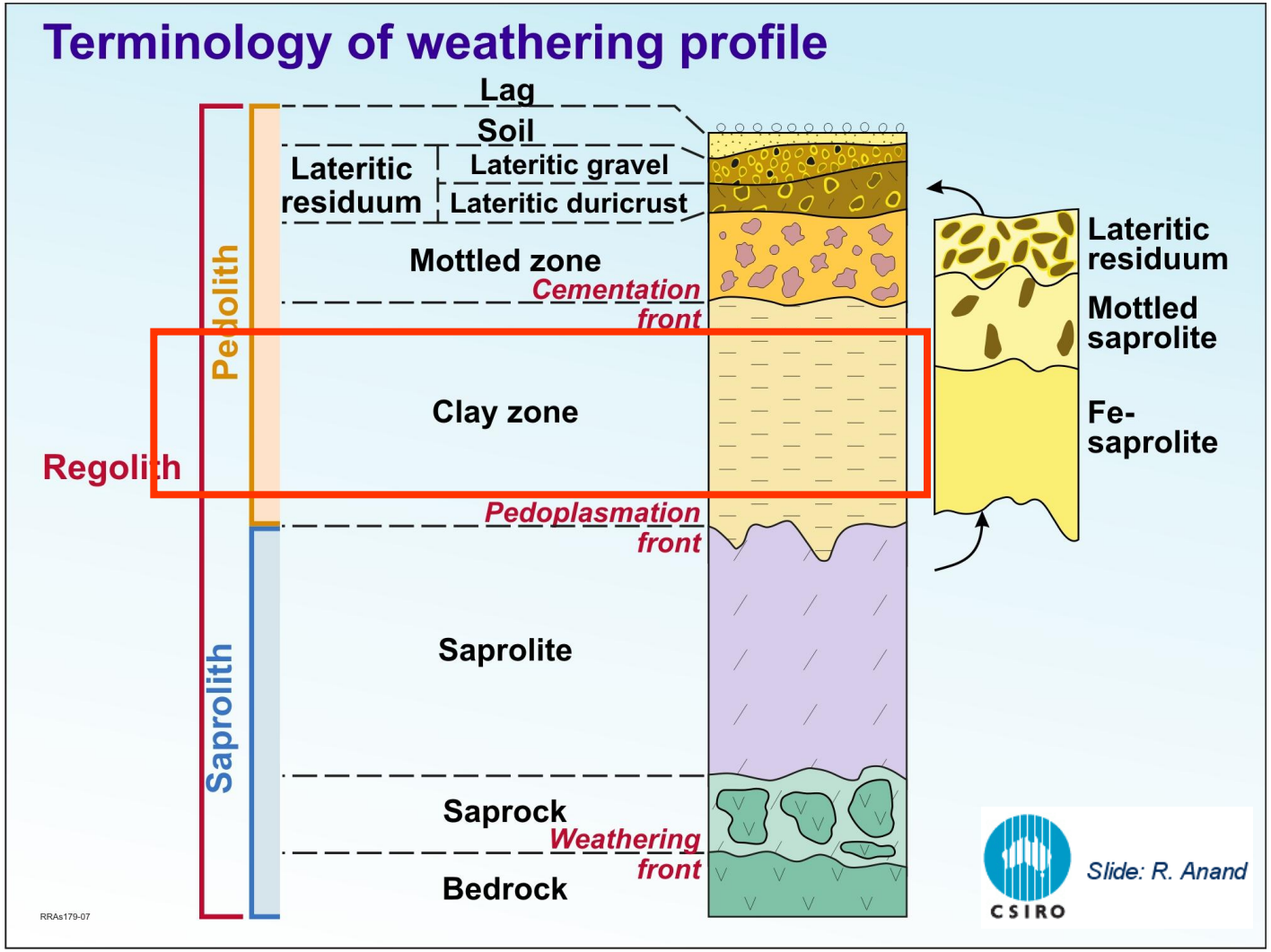



Leached
Saprolite


Ferruginous
Saprolite

Regolith :
Everything between Fresh Rock and Fresh Air!

The Lateritic Profile

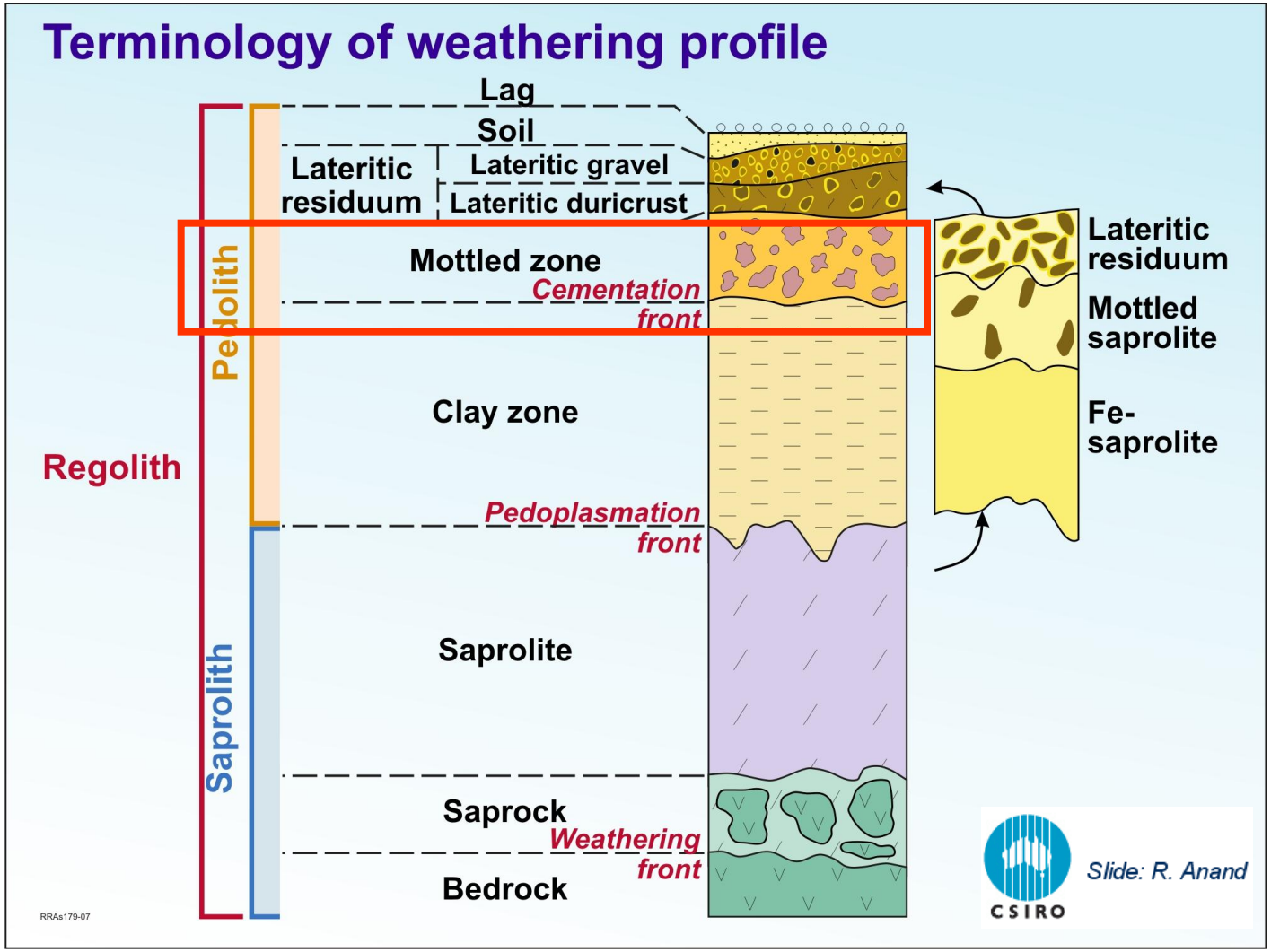


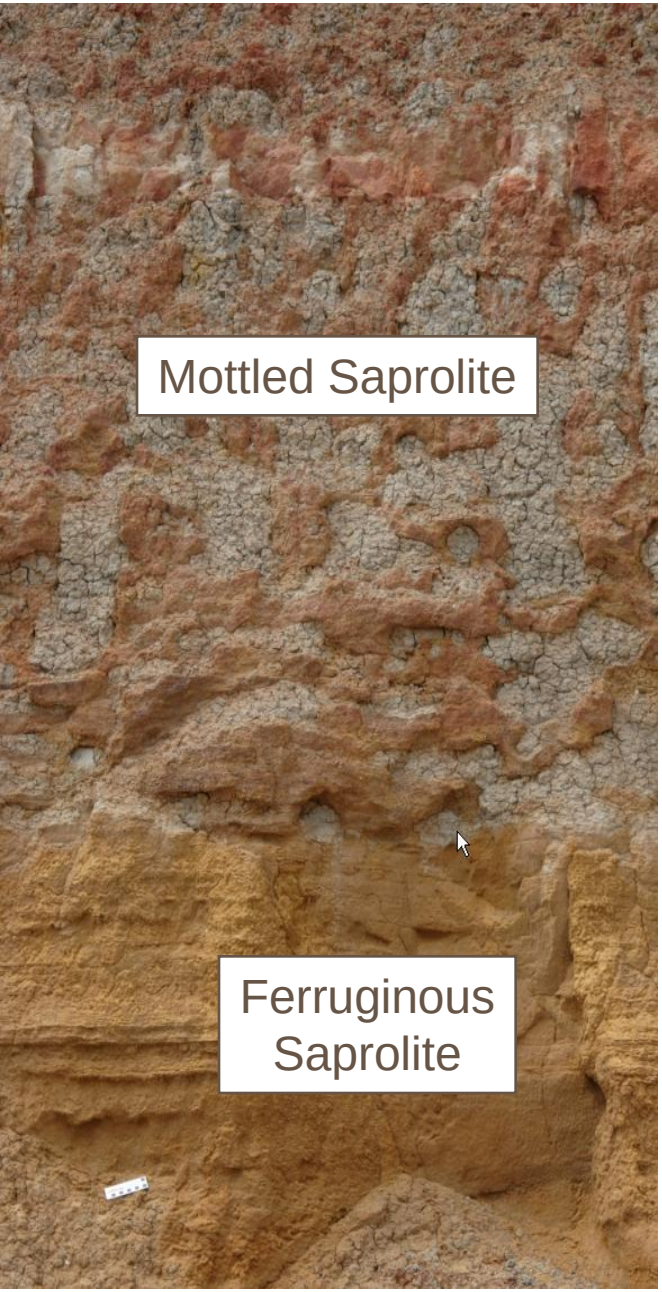

Clay Zone Leached Saprolite


Ferruginous Saprolite
Clay Zone Leached Saprolite

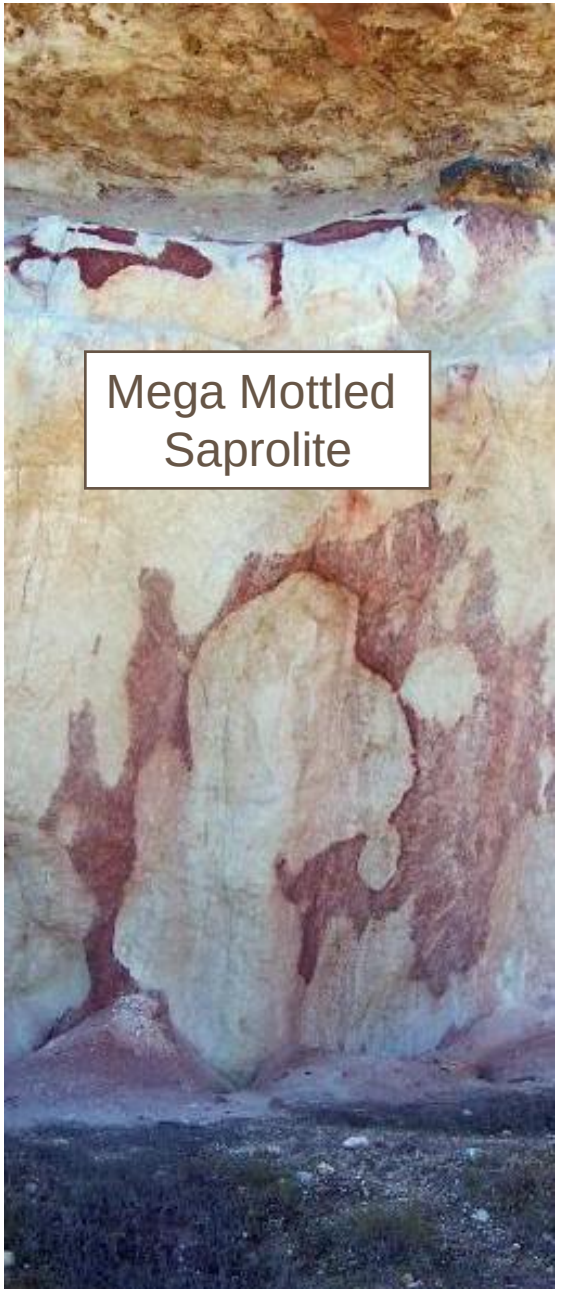
Regolith :
Everything between Fresh Rock and Fresh Air!

The Lateritic Profile



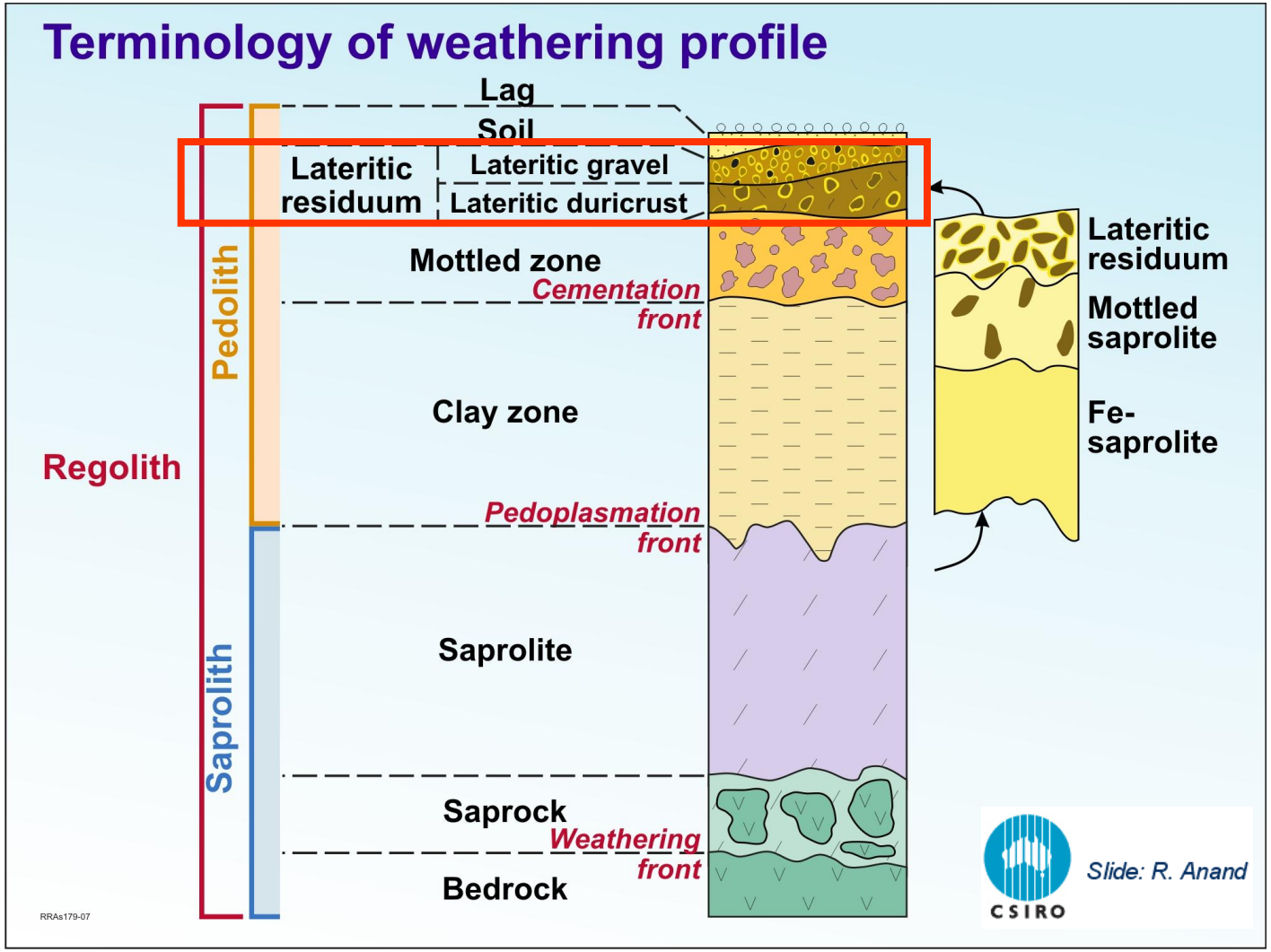

Mottled Saprolite
Ferruginous Saprolite


Mottled Saprolite

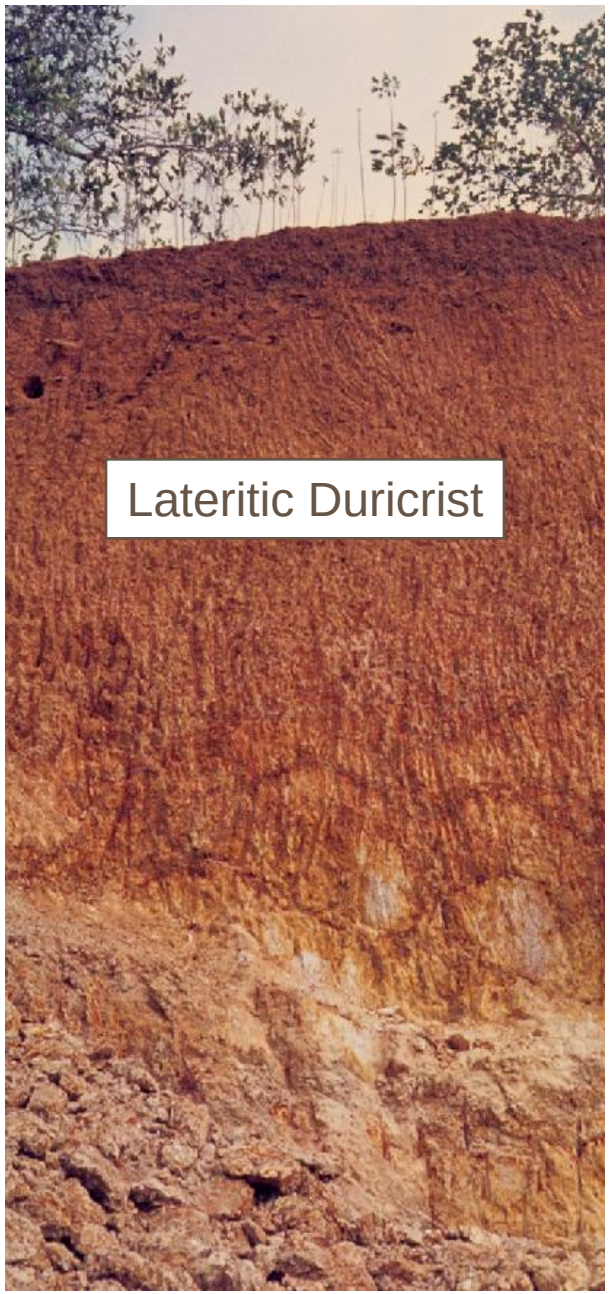

Mega Mottled Saprolite

Regolith :
Everything between Fresh Rock and Fresh Air!

The Lateritic Profile




Lateritic Duricrist


Lateritic Duricrist

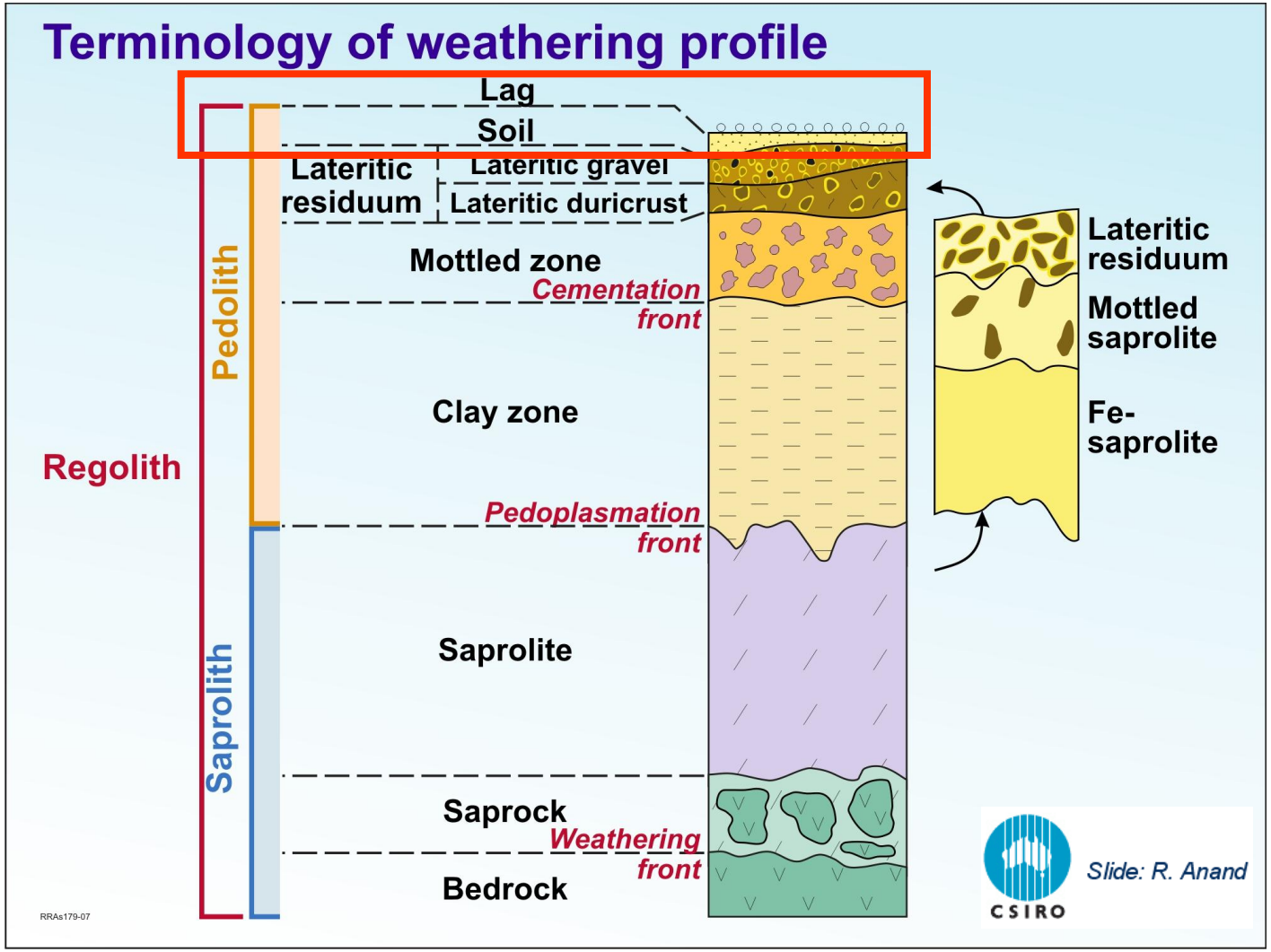

Lateritic Duricrist

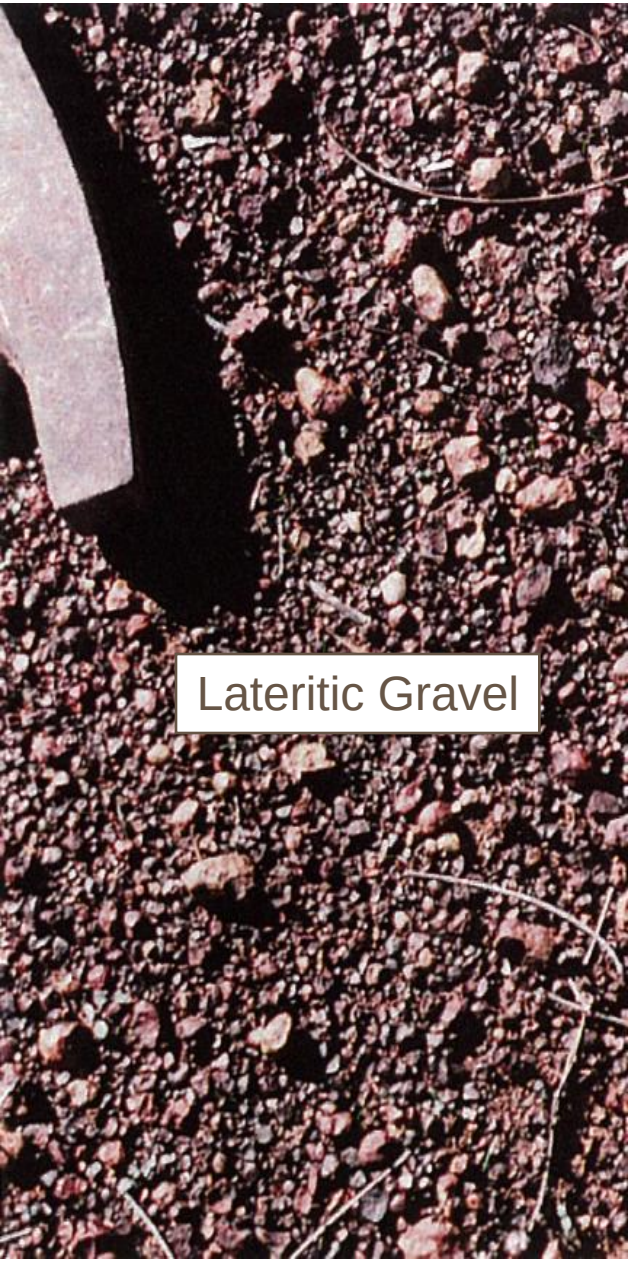

Ferruginous Duricrist
1cm

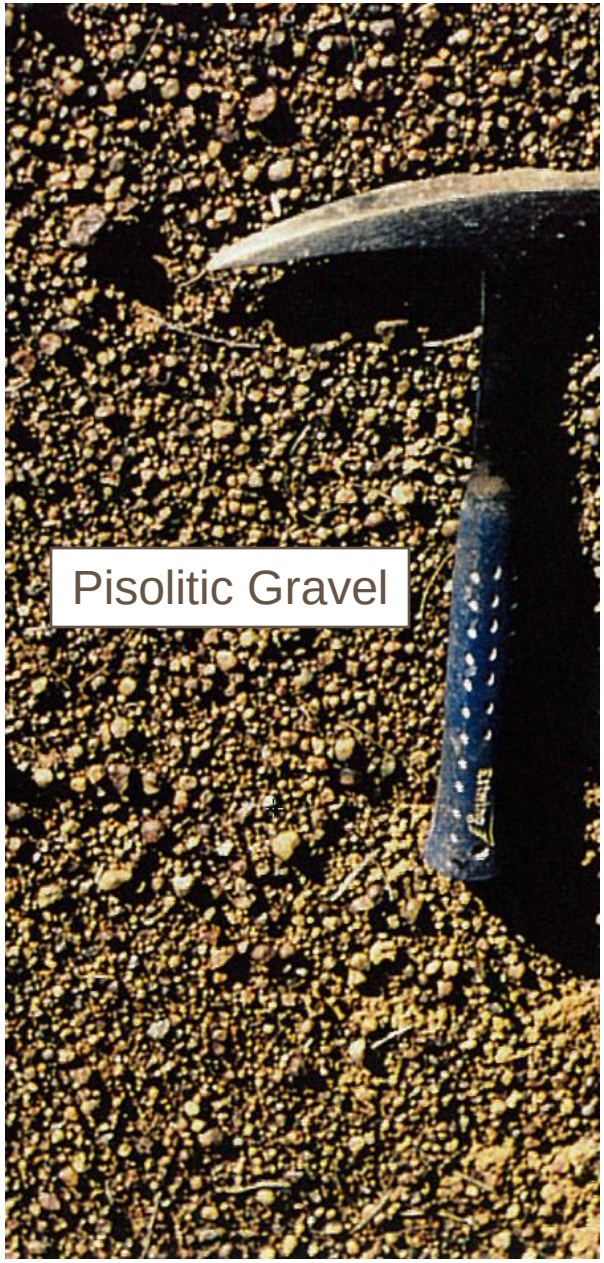

Bauxitic Duricrist

Regolith :
Everything between Fresh Rock and Fresh Air!

The Lateritic Profile




Lateritic Gravel

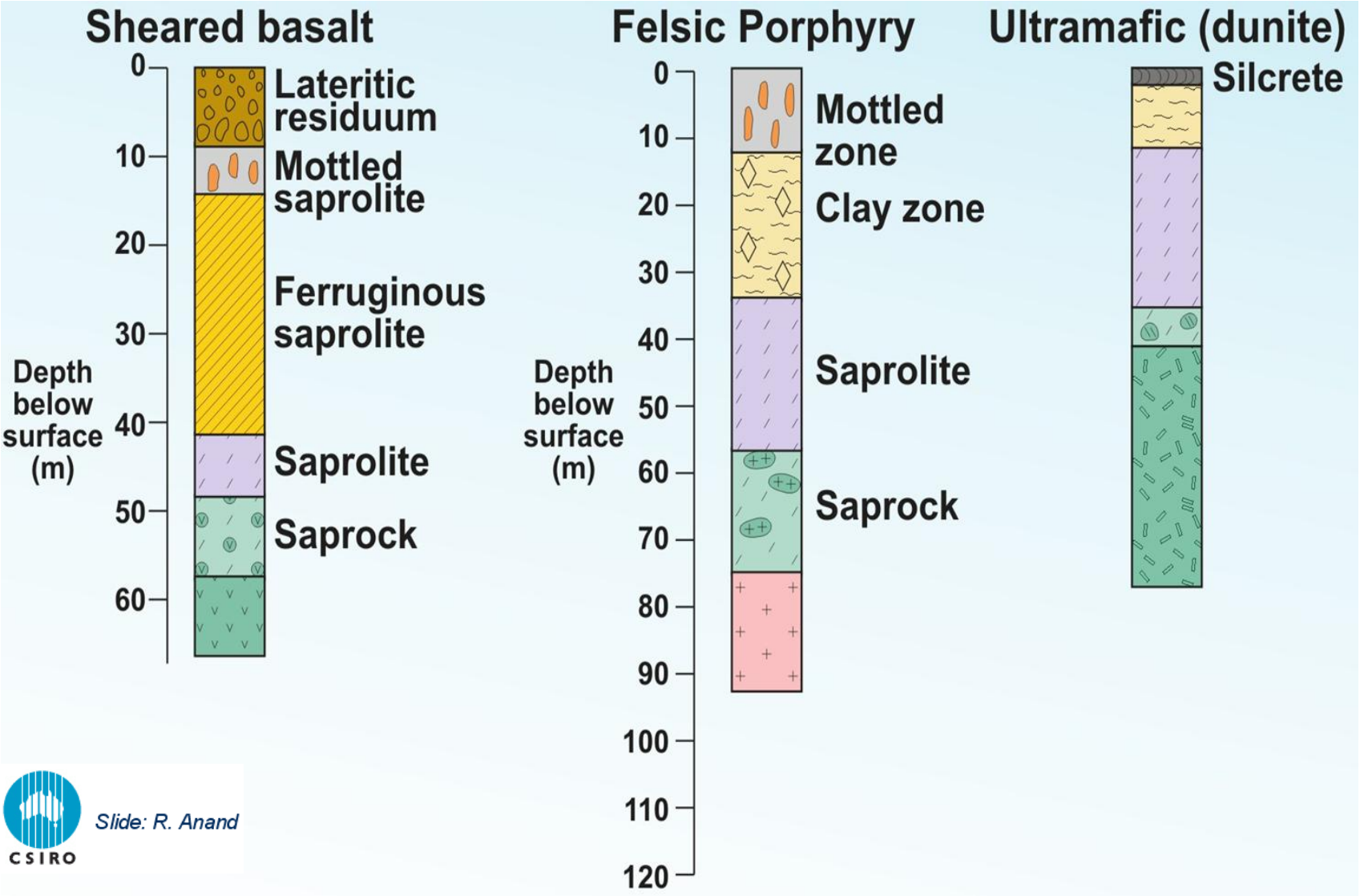

Pisolitic Gravel


Mottle Fragments
ASAHI
PENTAX

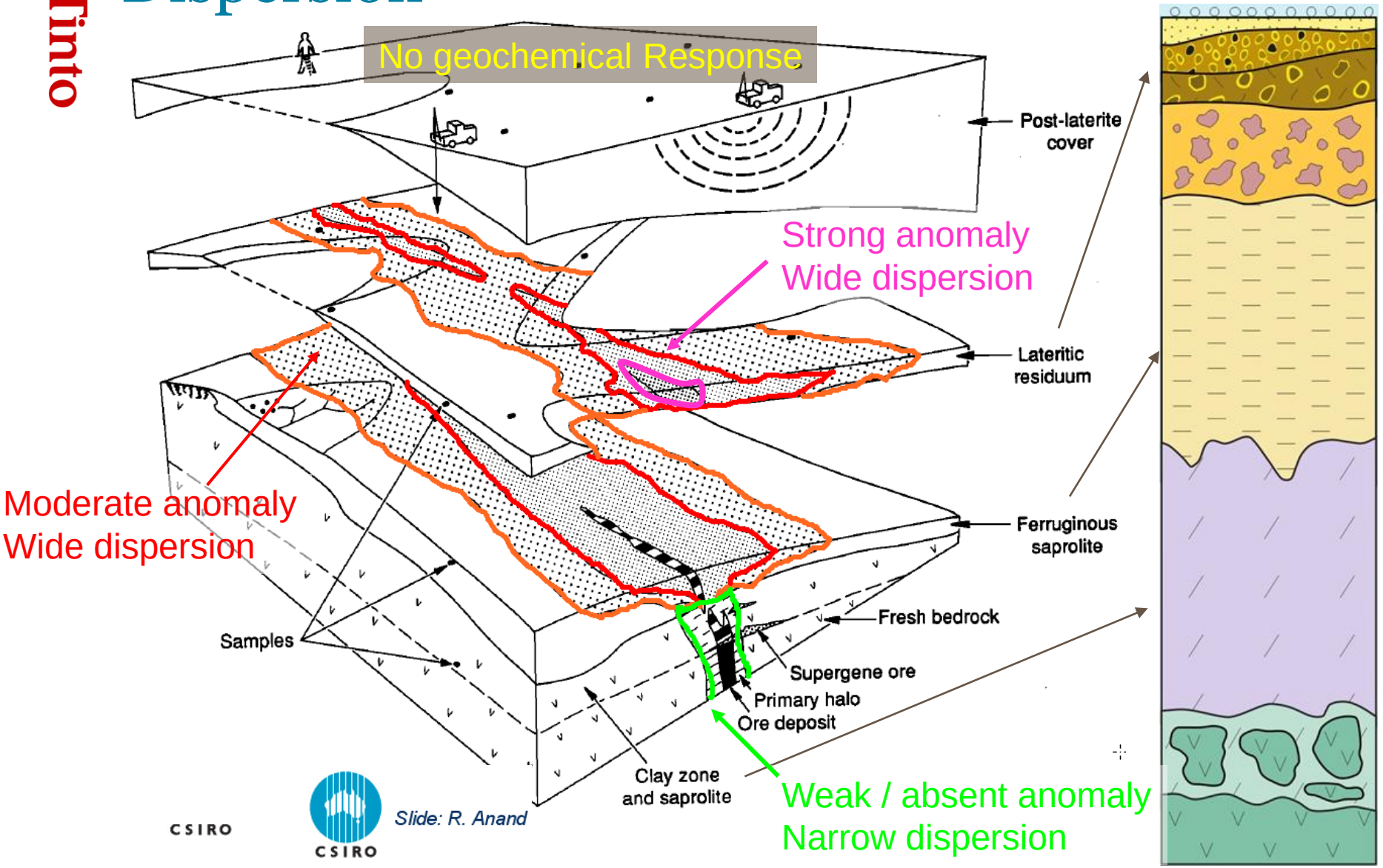

Pisolitic Lag


Lateritic Soil

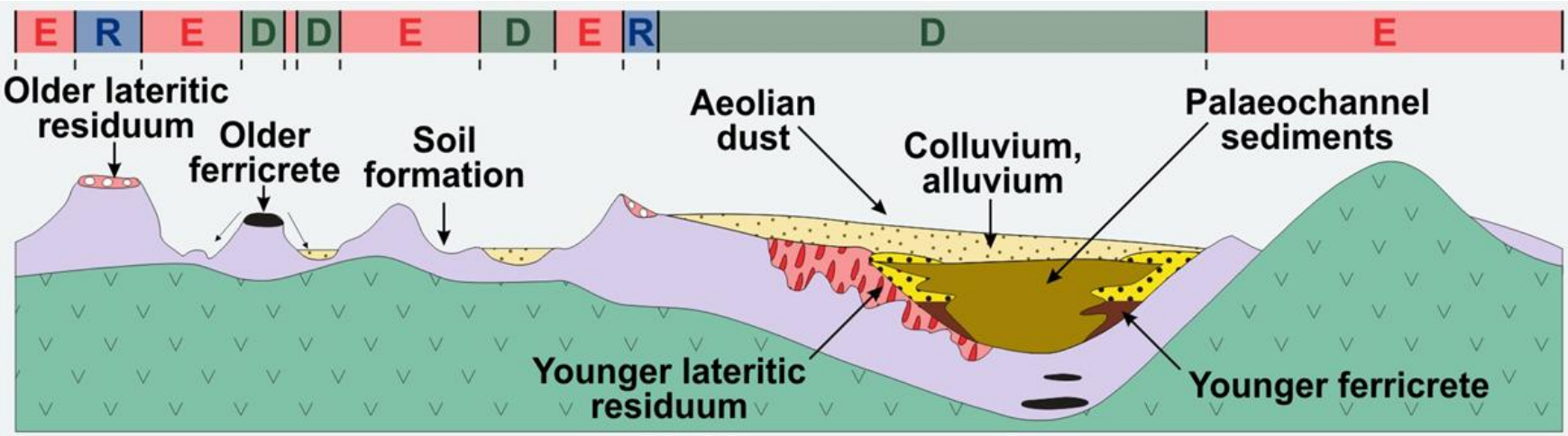
Protolith controls on the regolith profile…



Regolith Controls on Geochemical Dispersion



Residual – Erosional – Depositional



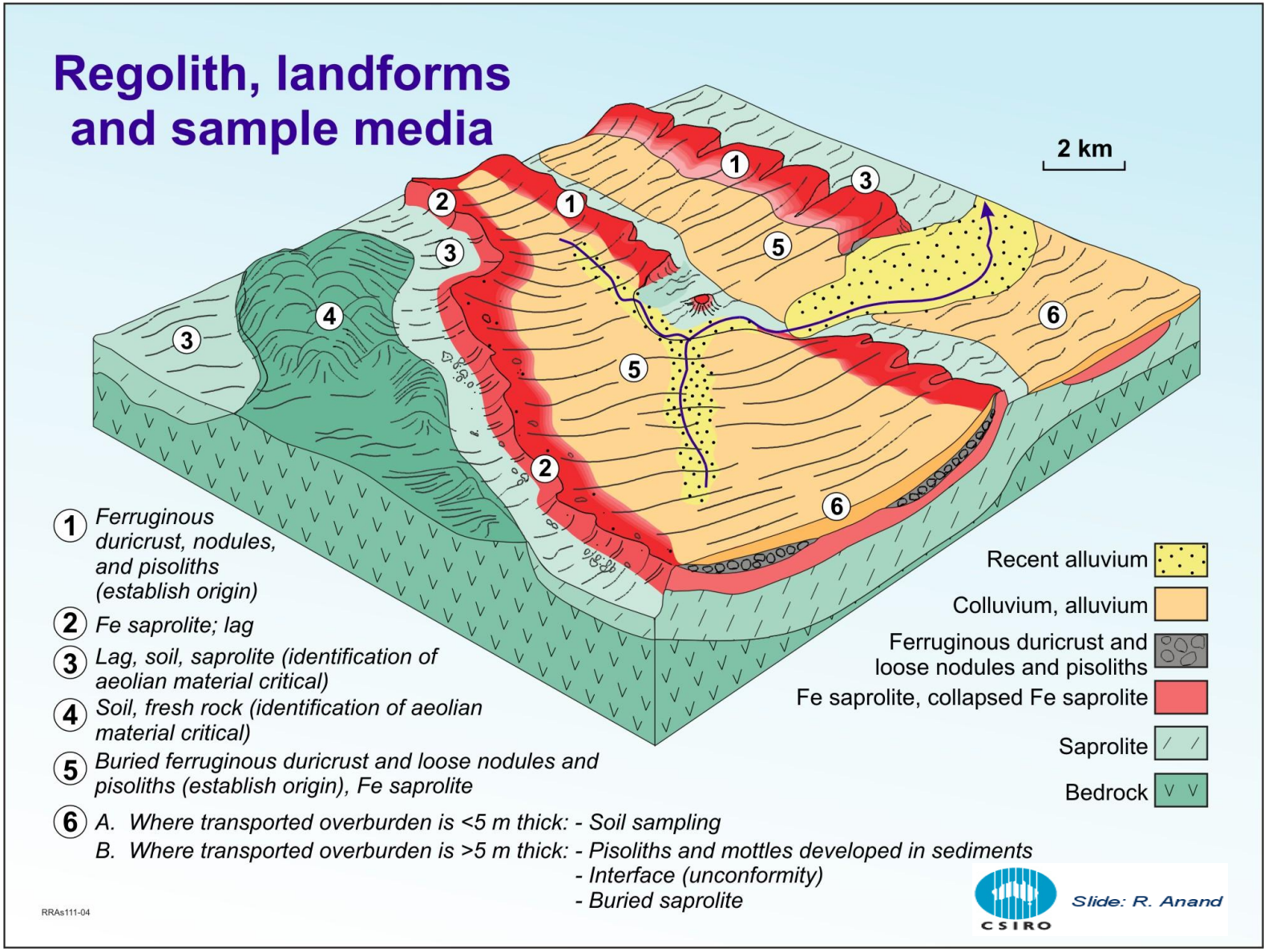
Relict regime (R)
- Lateritic residuum

Erosional regime (E)
- Residual soil and ferruginous lag
- Ferruginous saprolite
- Saprolite

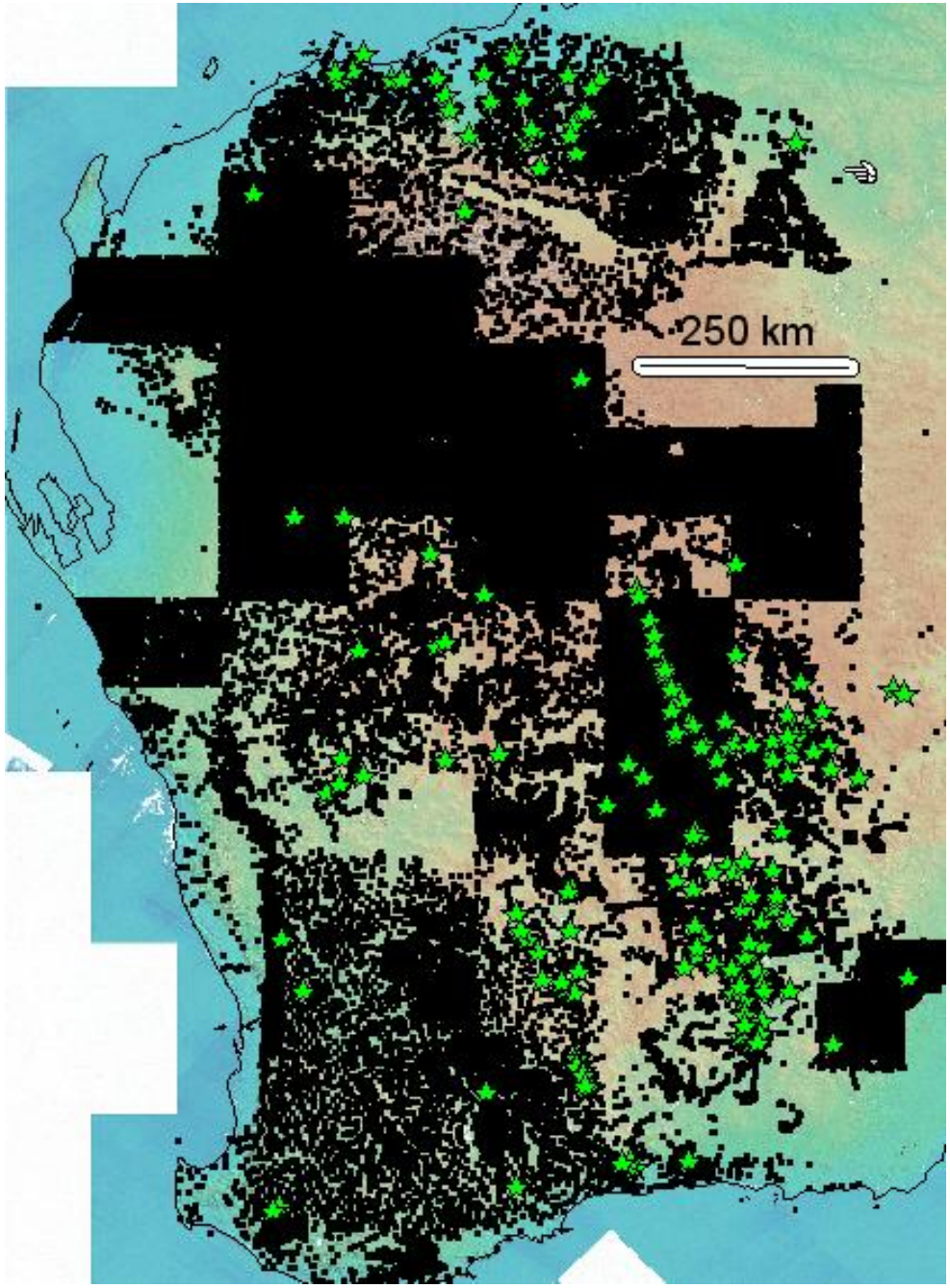
Depositional regime (D)
- Exposed and buried ferricrete (Fe-cemented sediments)
- Colluvium and alluvium

CSIRO *Slide: R. Anand*

Geochemical Exploration in Lateritic Terrains



Rio Tinto

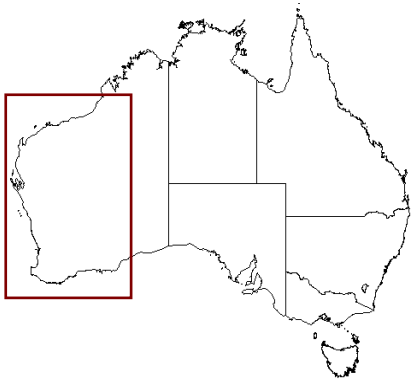


Public Domain Geochemical Sampling

Western Australia: n= >194,000

★ Ni Deposits and Occurrences

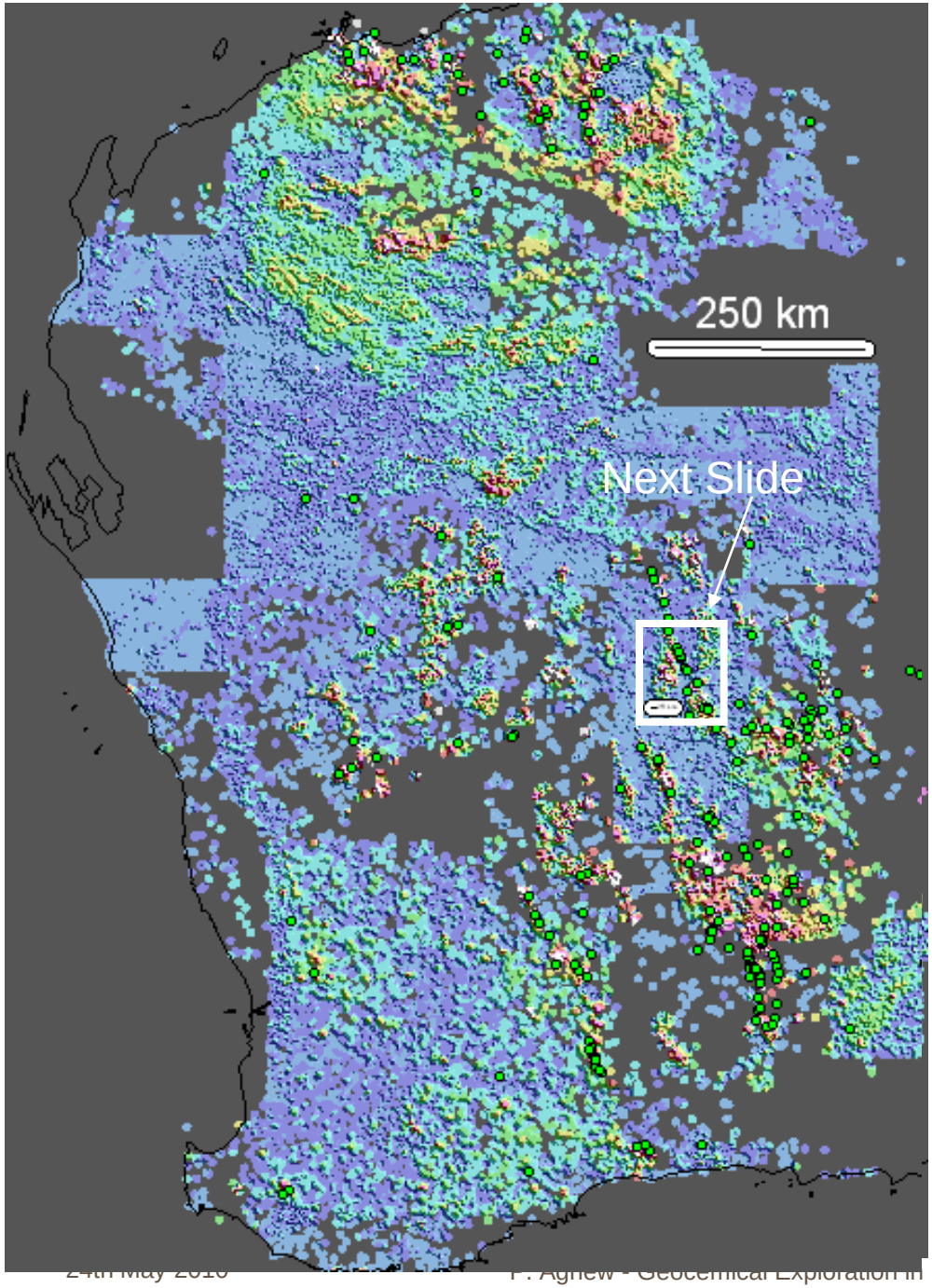
- Geochemical Sample Location (soil, pisolitic lag, laterite, ferruginous saprolite, sediment, rock)



Public Domain Geochemical Sampling

Western Australia: n= >194,000

Percentile Sliced **Ni** (All Media – Raw)

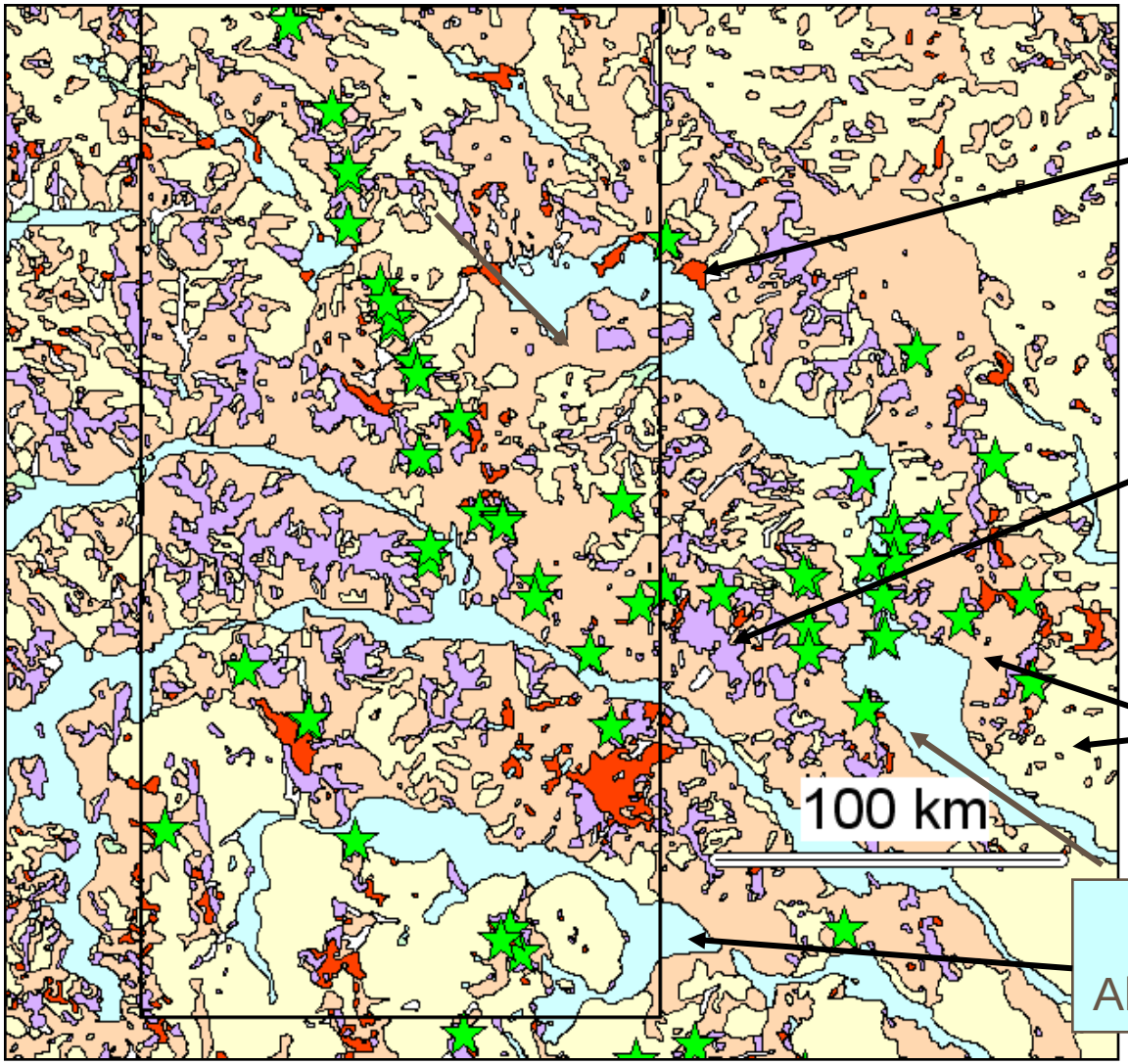


Ni Deposits and Occurrences

Percentile Slice Legend

- > 99th %
- 98th - 99th %
- 95th - 98th %
- 90th - 95th %
- 80th - 90th %
- 60th - 80th %
- 30th - 60th %
- < 30th %

SW Western Australia Regolith Map 1:500,000



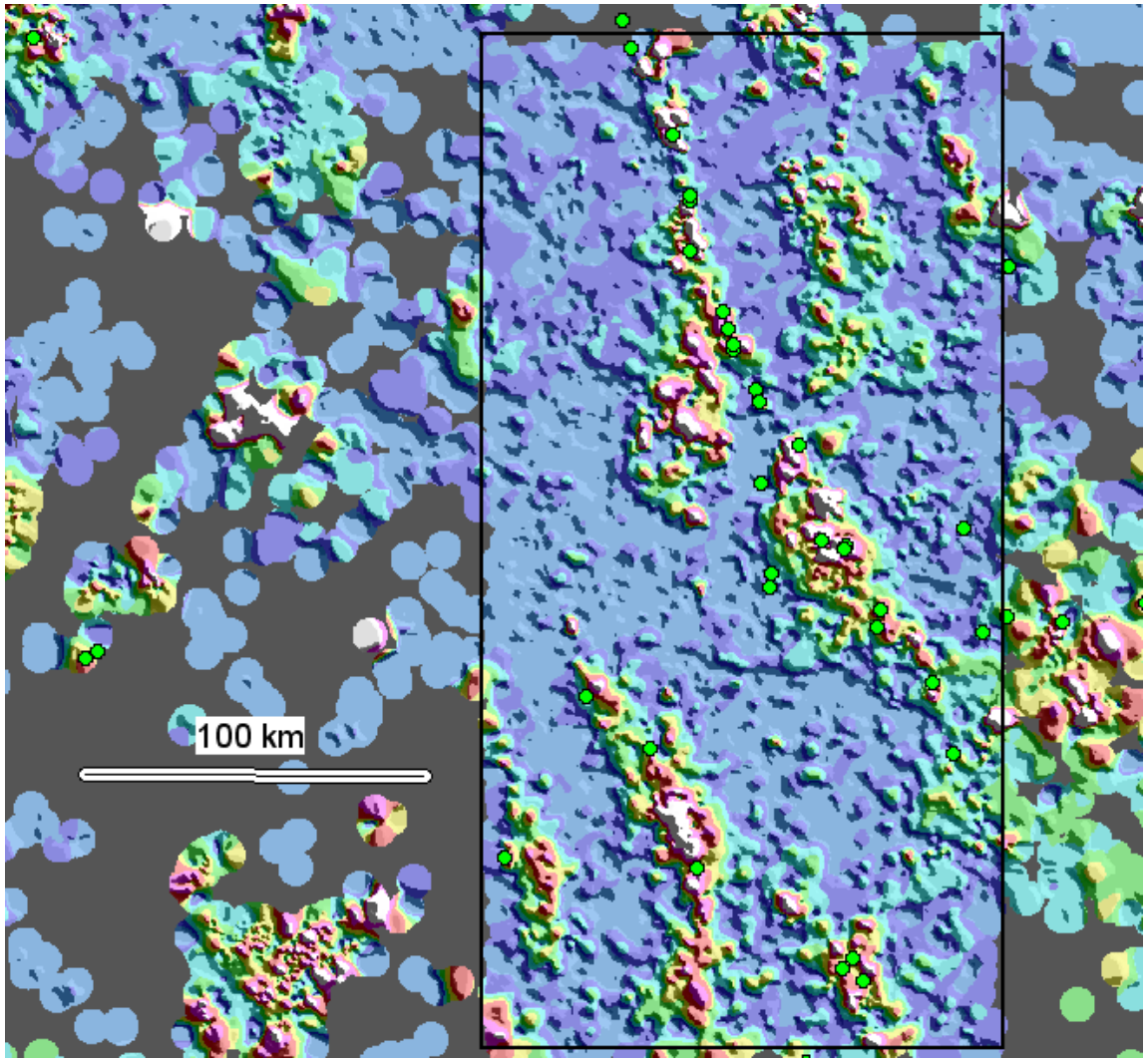
Residual;
Ferruginous,
Siliceous,
Calcareous
Duricrust

Erosional
Saprock
Saprolite
Fe-Saprolite

Depositional
Aeolian Colluvium
Sheetwash

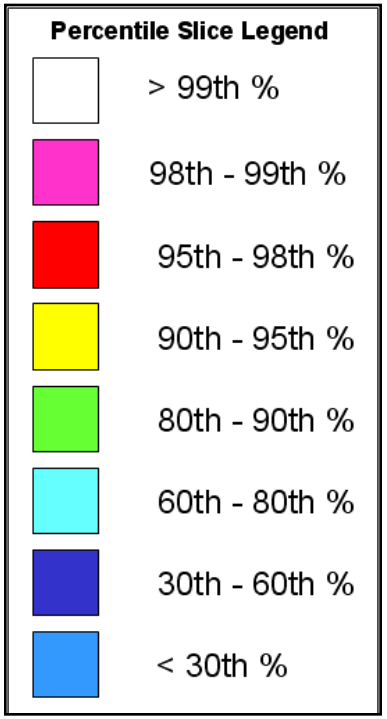
Depositional
Alluvial-Lacustrine Deposits

Public Domain Regolith Sampling SW Western Australia: n= 30,488



Ni Deposits and Occurrences

Percentile Sliced **Ni** (All Media – Raw)

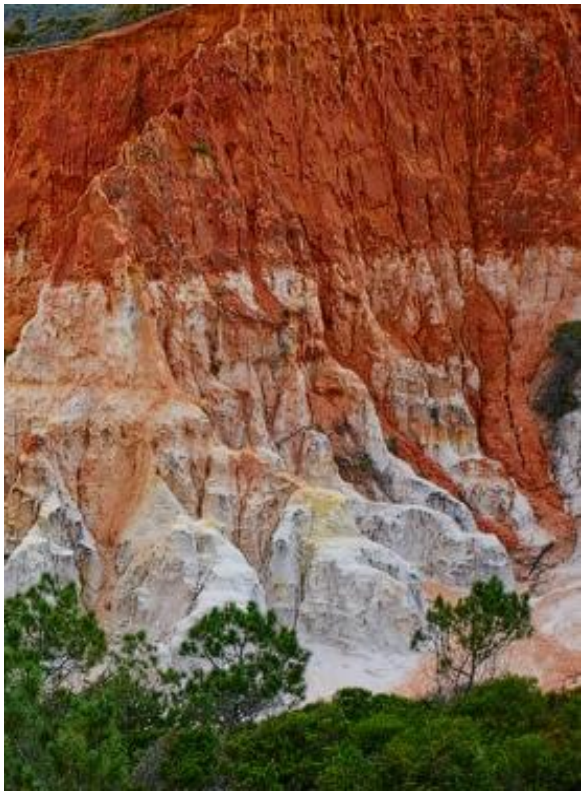


Analysis of Lateritic Sample Media

- Lateritic weathering leads to intense leaching and concentration through residual accumulation

- Lateritic materials therefore need both low detection and strong digestion to reveal the complete geochemical patterns

- They also require matrix matched standards (leached and ferruginous matrices)



Basic Exploration Suite

- Strong Total Acid Digest (4 acid)
- XRF is a option but may lack low detection limits required for some ore and pathfinder elements

- *Inductively Coupled Plasma Optical Emission Spectroscopy*

ICP-OES

Al, Ba, Ca, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, P, Sr, Th, Ti, V, Zn, Zr

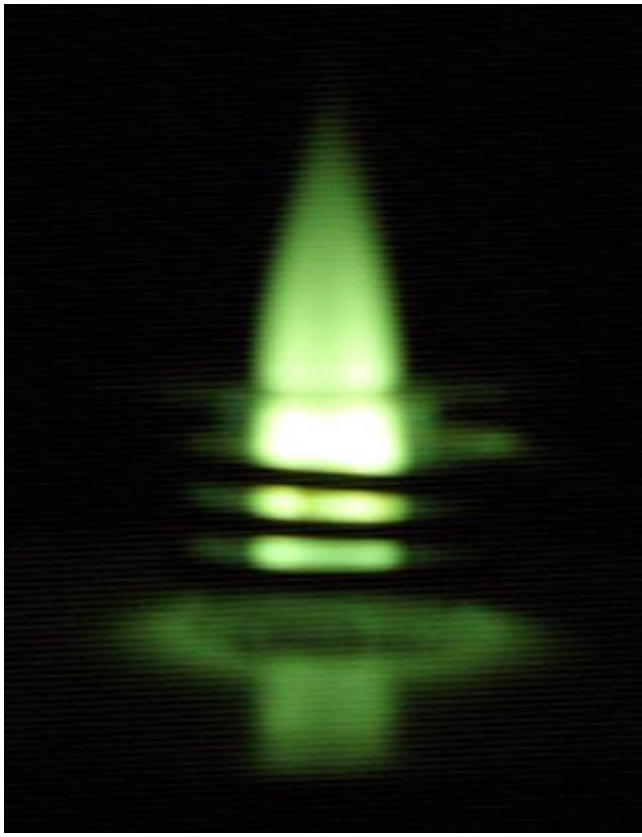
- *Inductively Coupled Plasma Mass Spectroscopy*

ICP-MS

Ag, As, Bi, Cd, Mo, Nb, Pb, Sb, U, W

Fire Assay (Pb collection, ICP-MS finish)

Au, Pt, Pd



Ore and path-finder elements

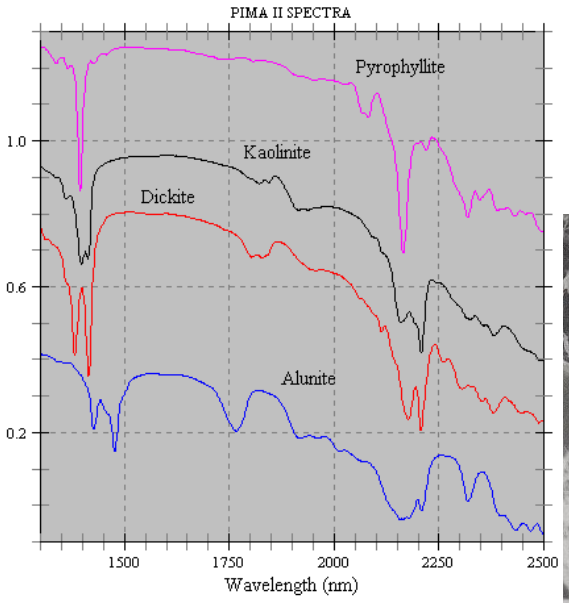
Lithochemistry + Transported Overburden ID

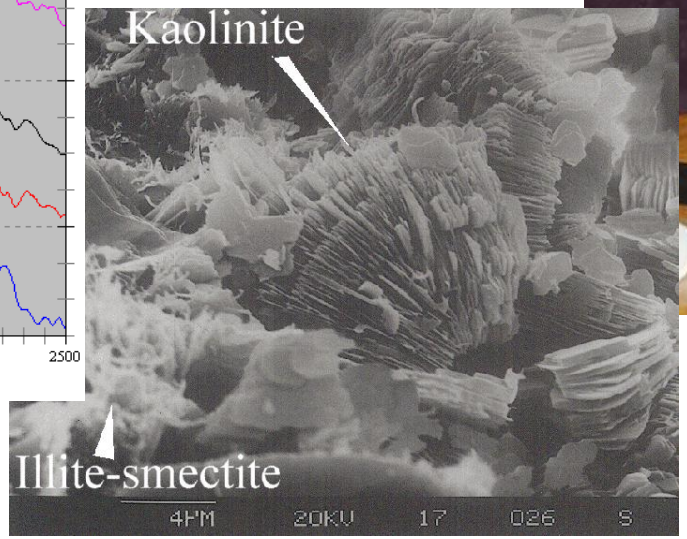
Basic Exploration Suite - Mineralogy

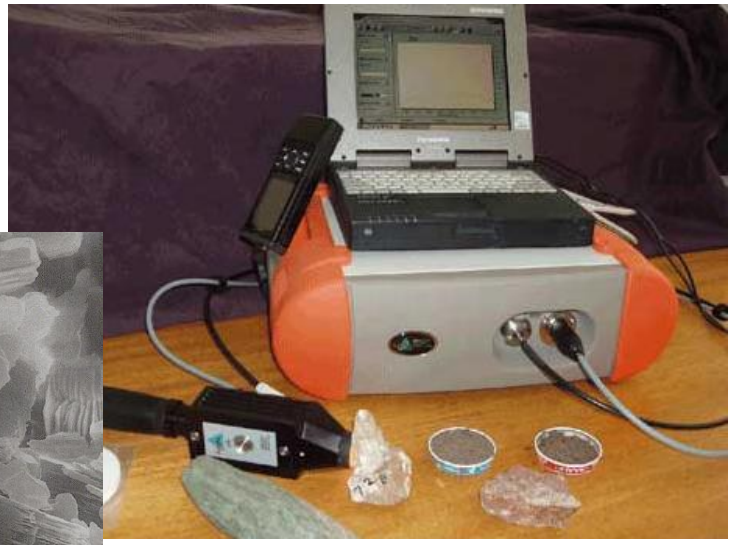
- Portable Spectroscopy (PIMA, Terraspec)

- Particularly applied to identification of transported overburden on leached saprolite which can be visually very similar. Illite crystalinity

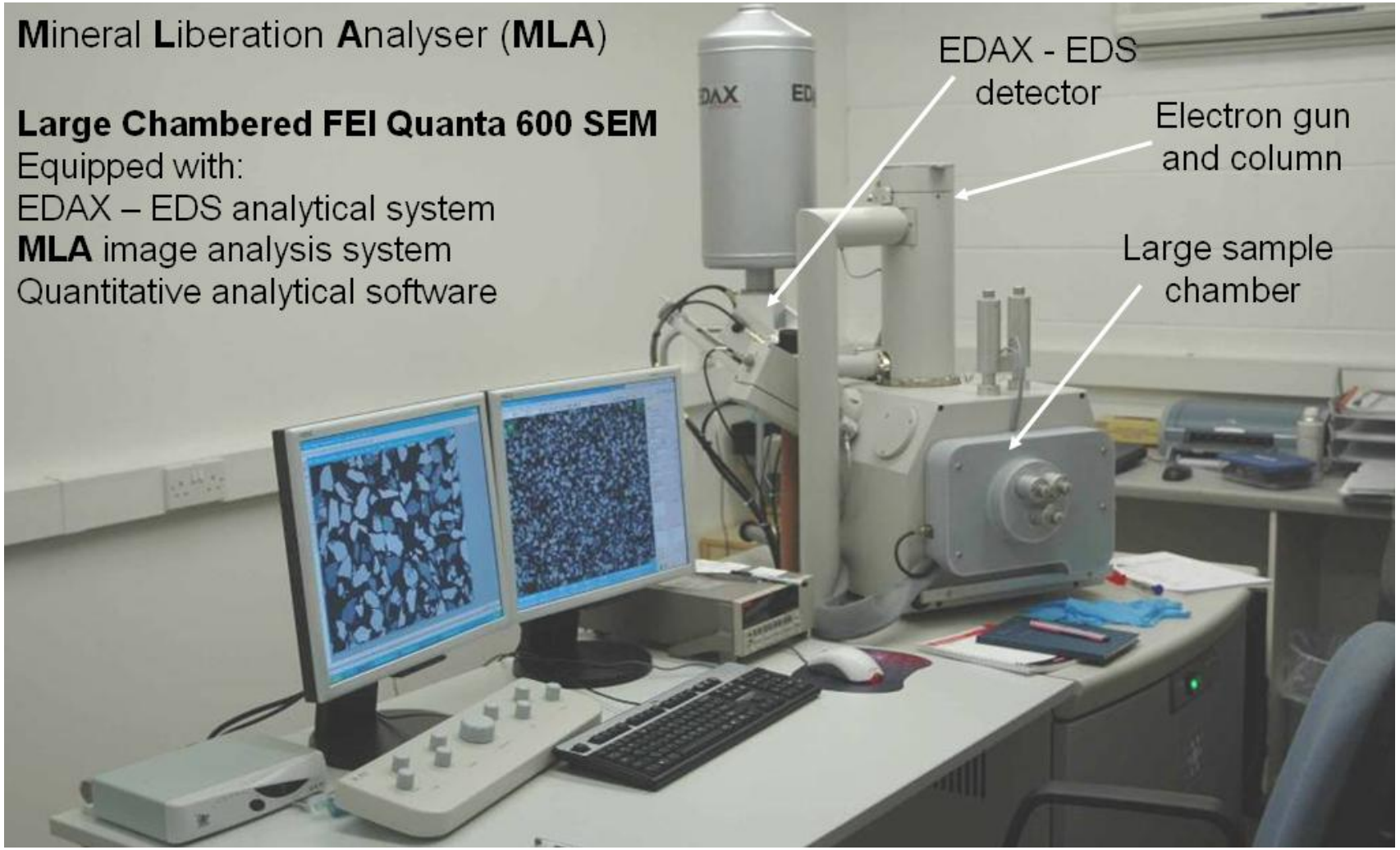
- Potential identification of alteration minerals preserved in saprolite / saprock







Our Microscopic Future.....



Mineral Liberation Analyser (MLA)

Approx
30,000
Grains
per block
(75-250um)

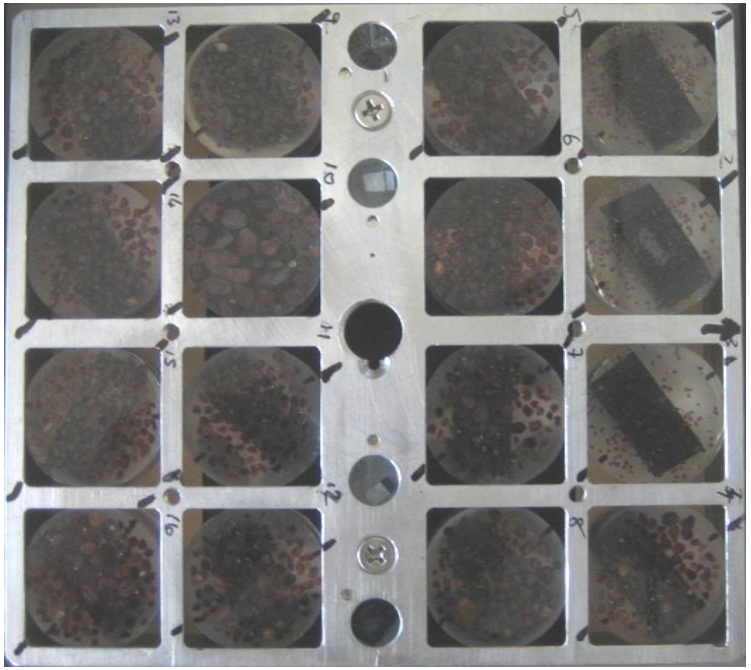
→ Modal Mineralogy

→ Mineral
Chemistry
High quality data
>1% detection
limit

→ Mineral associations

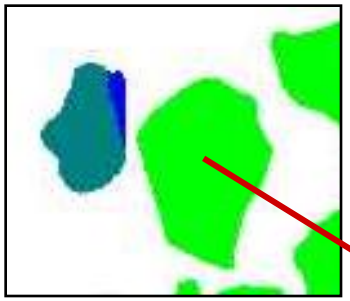
→ Chemical mapping

16 blocks
per
automated run

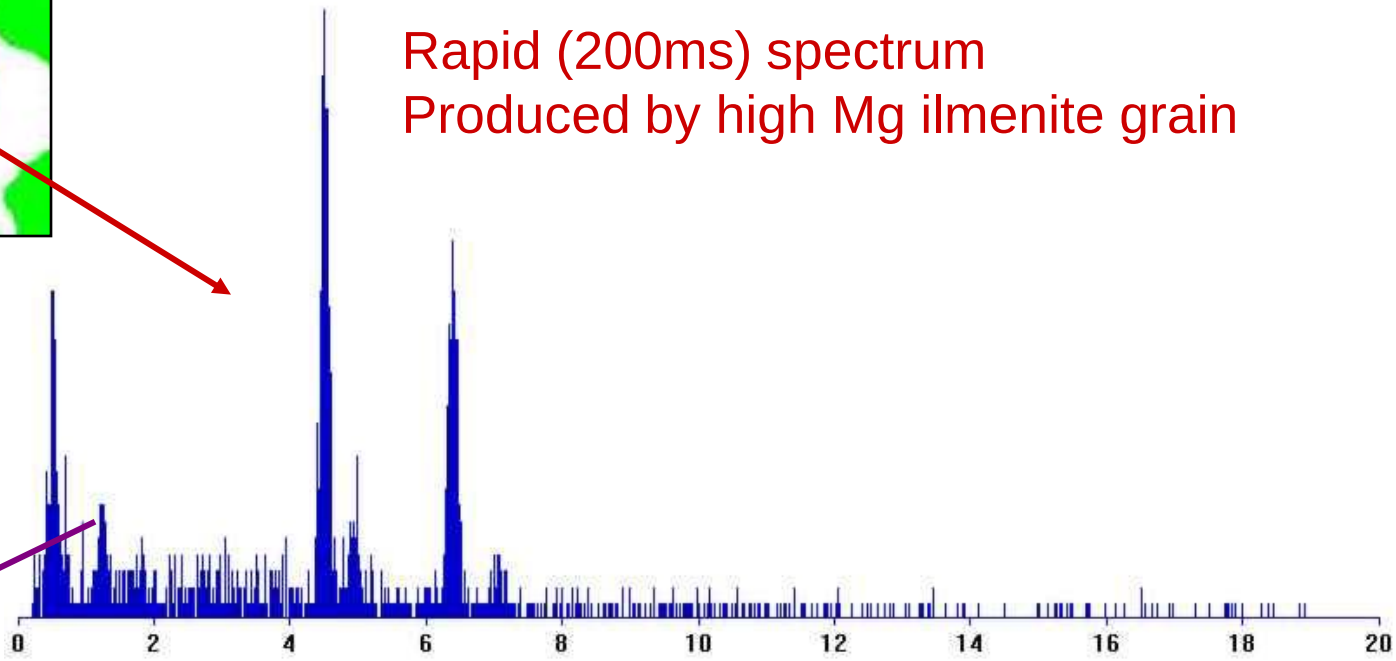


Mineral Liberation Analyser (MLA)

- Minerals identified by comparison of ED spectra with standards

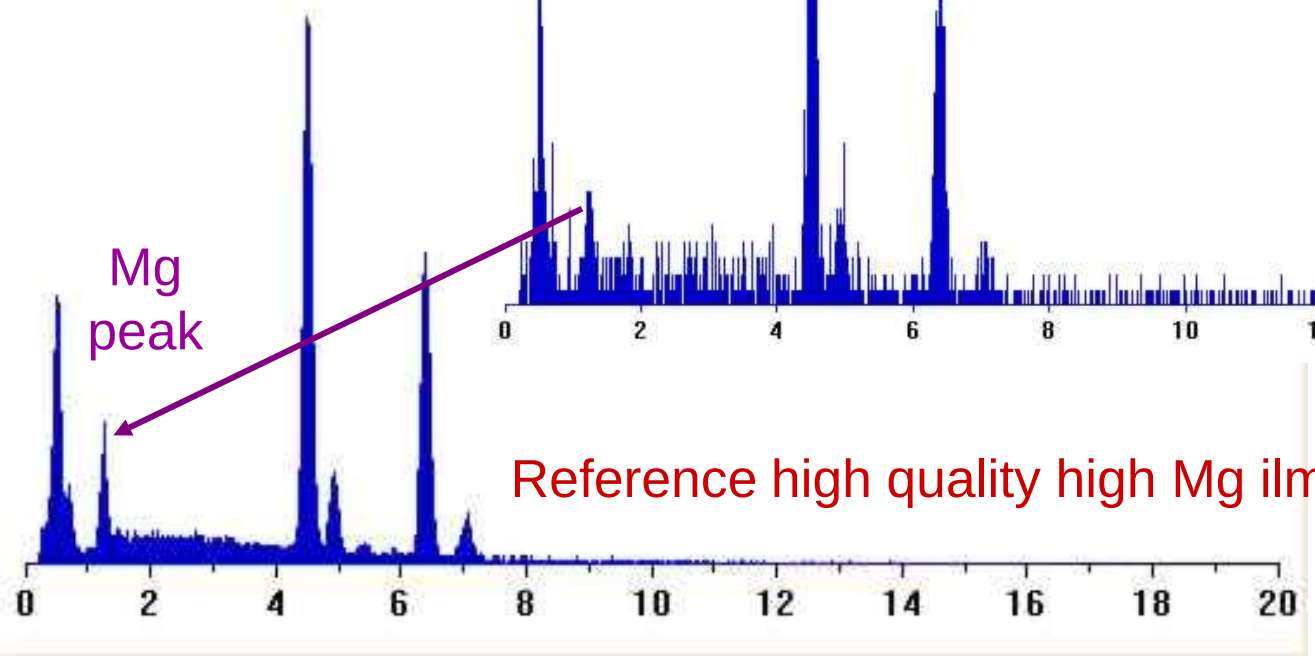


Rapid (200ms) spectrum
Produced by high Mg ilmenite grain



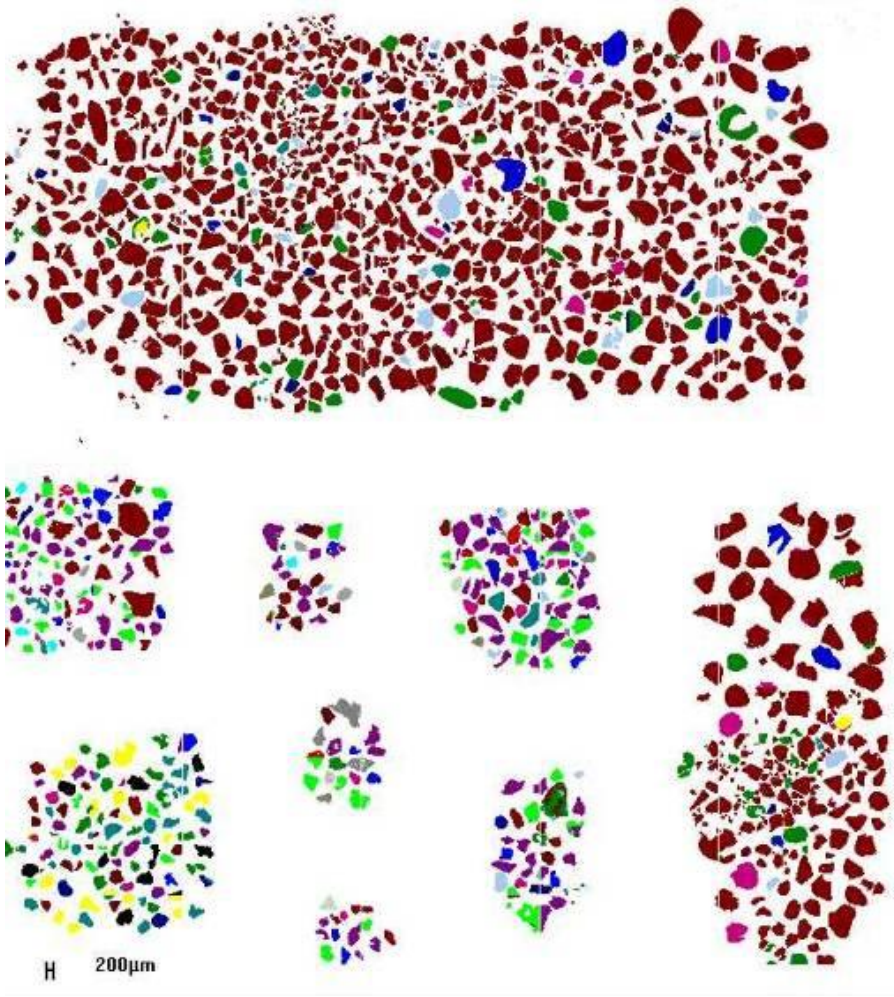
Mg peak

Reference high quality high Mg ilmenite spectrum



Mineral Liberation Analyser (MLA)

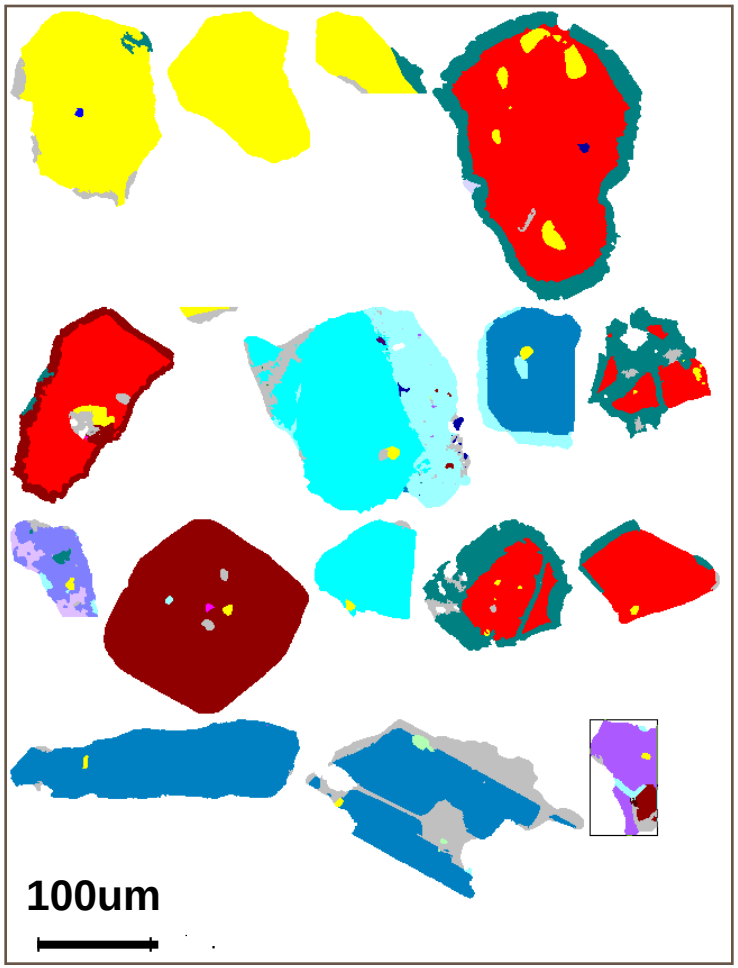
- Mineral classification map



	Reference Mineral	Area_%
11	Chromite6	67.44
5	Ilmenite5	5.53
9	Chromite4	4.43
20	FeOxide1	3.31
2	Ilmenite2	2.84
17	TiMagnetite1	2.49
12	Chromite7	2.19
24	Tourmaline1	1.92
10	Chromite5	1.85
26	Unknown	1.39
6	Chromite1	1.18
1	Ilmenite1	1.05
8	Chromite3	0.79
7	Chromite2	0.78
18	Rutile1	0.75
14	Corundum2	0.64
4	Ilmenite4	0.27
19	Rutile2	0.22
23	MnOxide1	0.19
3	Ilmenite3	0.19

Mineral Liberation Analyser (MLA)

- Cu Anomalous -80# Stream Sediment Sample – 120ppm Cu (Heavy Mineral Concentrate)



Bornite
Chalcopyrite
Pyrite

IronOxide
IronOxide_Ti
IronOxide_Altered
IronOxide_Other
Ilmenite

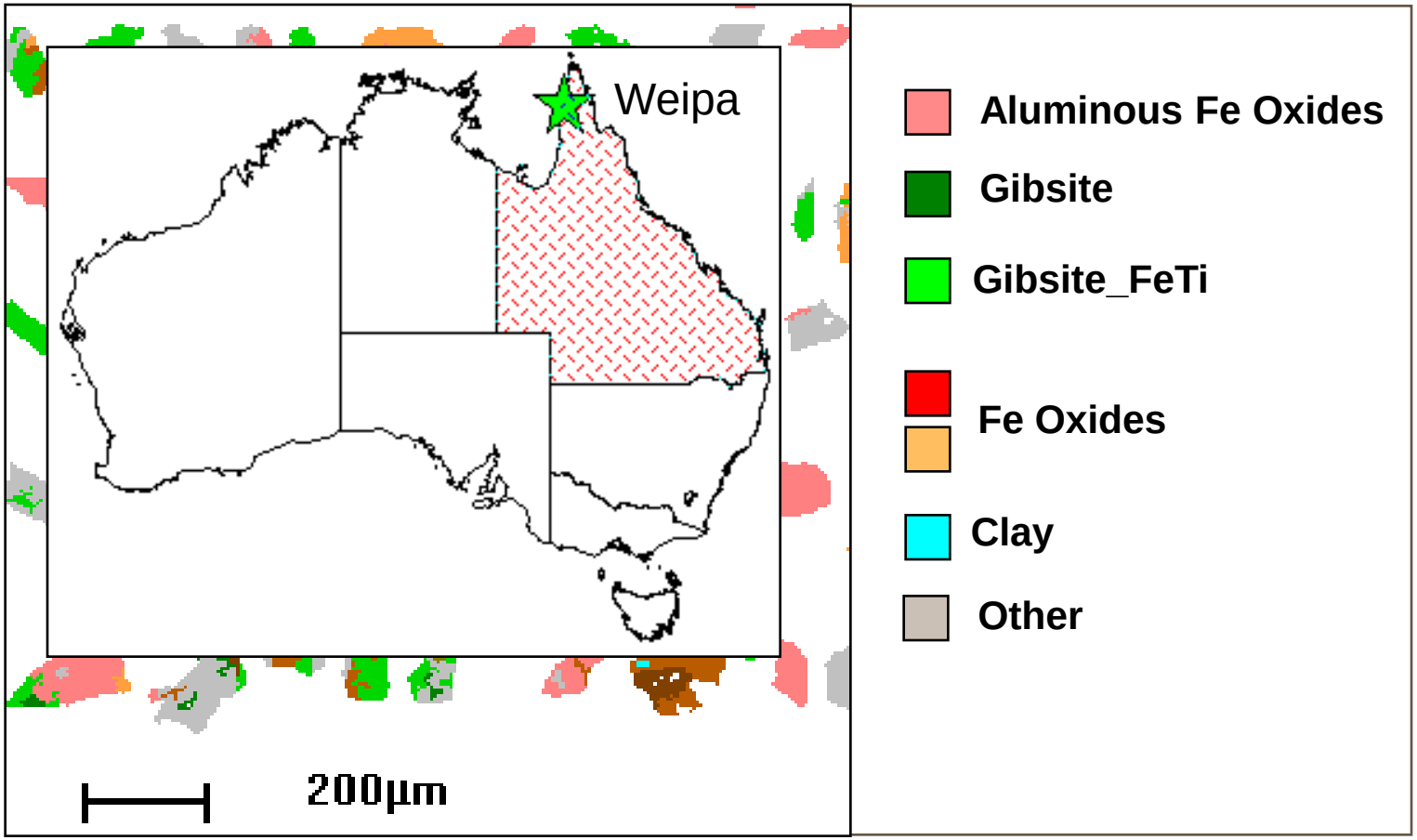
Aluminosilicates
Amphibole
Apatite
Augite

Chlorite
Clinozoisite
Feldspar
Phlogopite

Pyroxene
Quartz
Rutile
Other

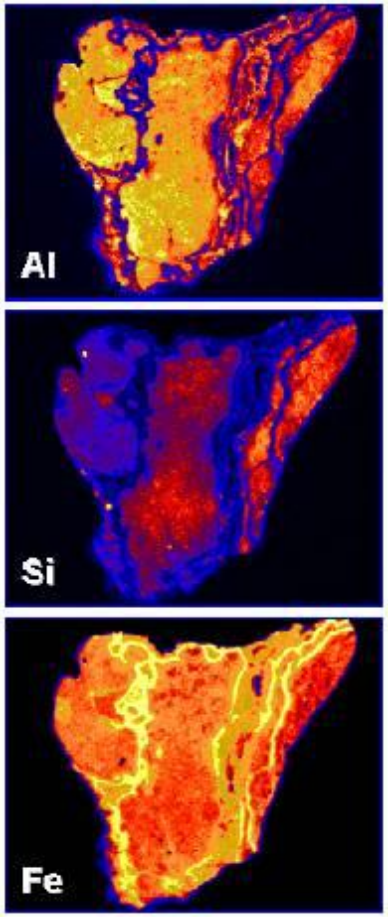
Mineral Liberation Analyser (MLA)

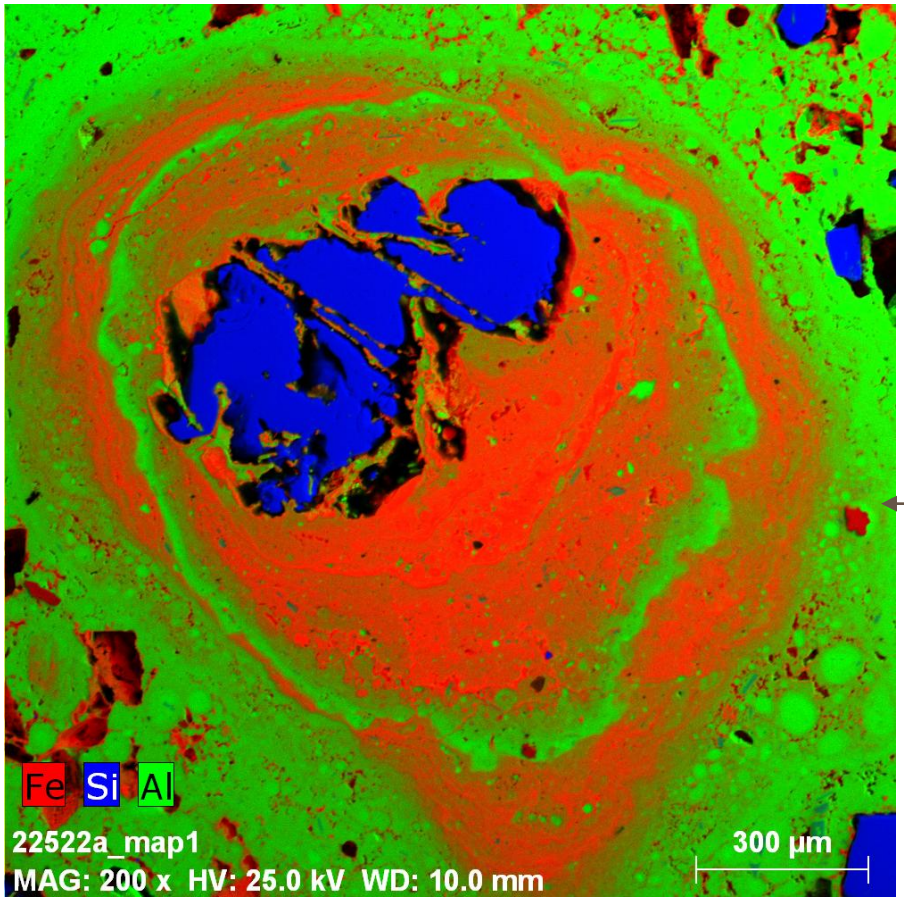
- "Stream sediment" sample from a deep lateritic weathering terrain in NW Queensland, Australia.

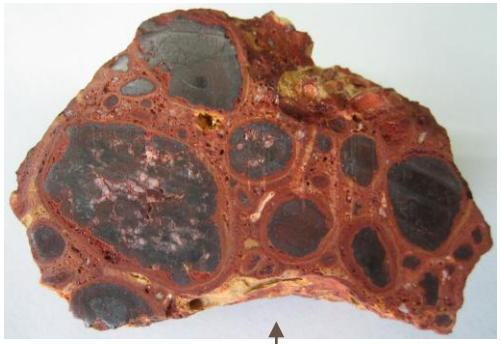


Mineral Liberation Analyser (MLA)

- Some of the resistate Fe-oxides associated with known bauxite occurrences have distinctive chemical compositions



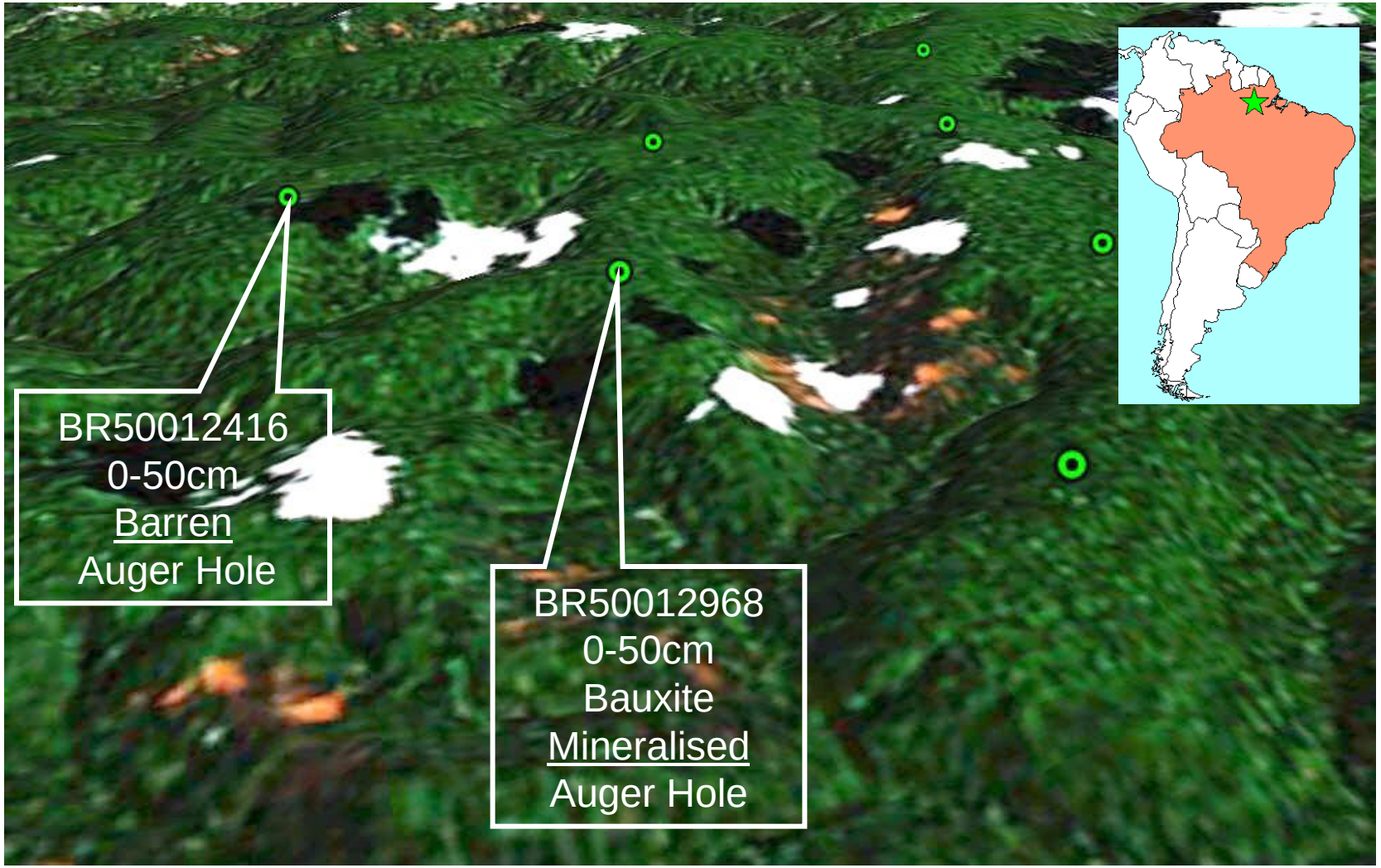




Darling Range Bauxite
Huntley Deposit
Ironstone

Mineral Liberation Analyser (MLA)

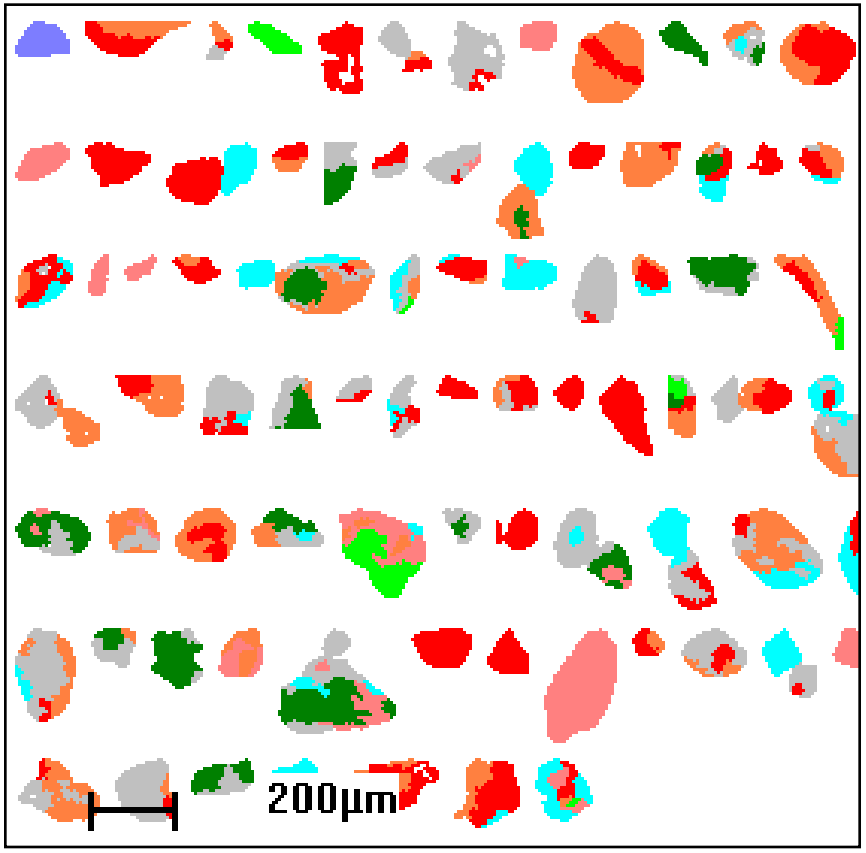
- Direct detection of bauxite profiles - Curua Bauxite Discovery, Brasil



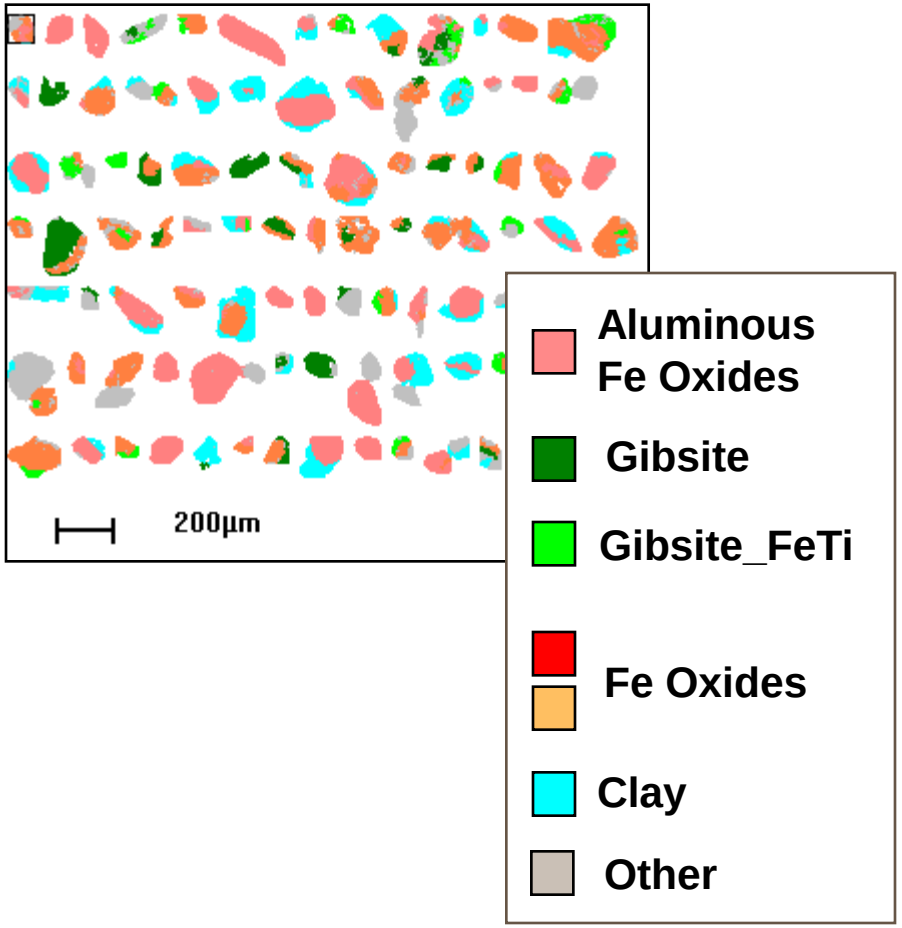
Mineral Liberation Analyser (MLA)

- Direct detection of bauxite profiles - Curua Bauxite Discovery, Brasil

BR50012968 - Mineralised



BR50012416 - Barren

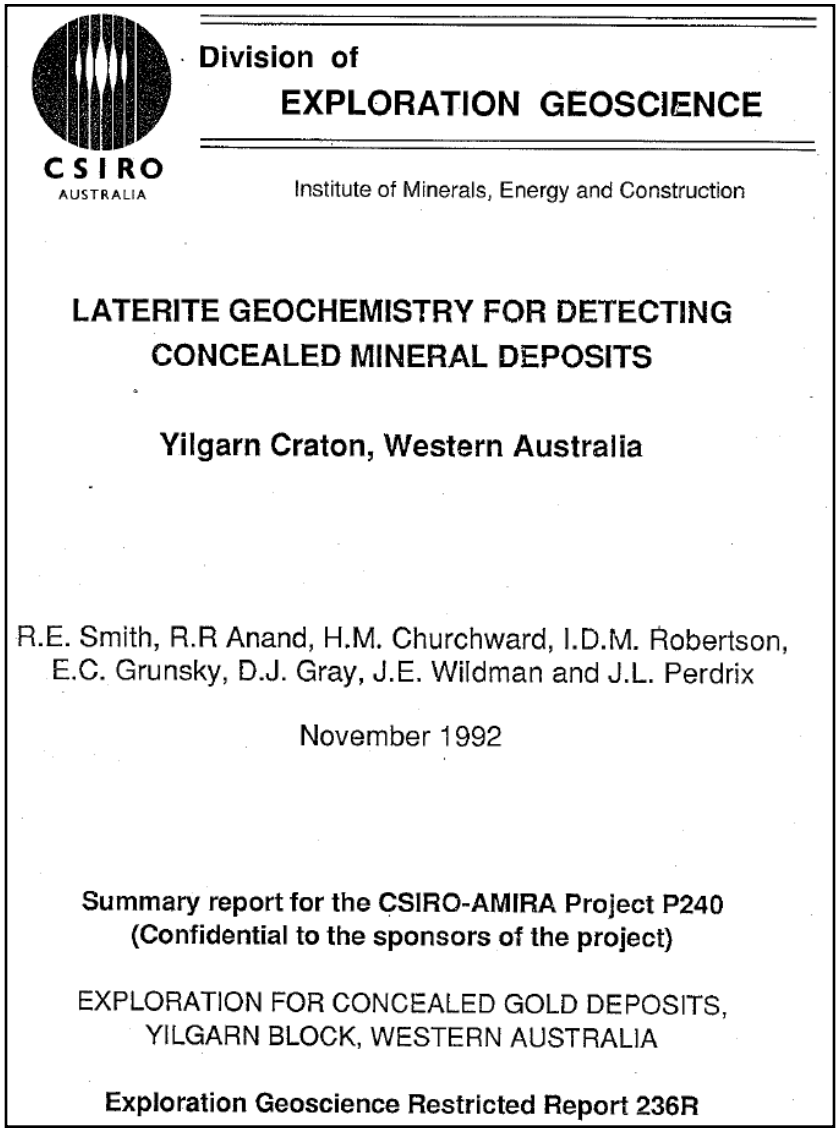


Conclusions 1

- Lateritic weathering impacts exploration globally

- Lateritic weathering processes lead to the progressive volumetric reduction of the regolith profile, the total destruction of rock fabric, and dramatic modification of geochemical composition, presenting a significant challenge to mineral explorers

- Pioneering work by CSIRO in the early 90's demonstrated that geochemical exploration techniques can be effectively applied in lateritic terrains



CSIRO AUSTRALIA

Division of
EXPLORATION GEOSCIENCE

Institute of Minerals, Energy and Construction

LATERITE GEOCHEMISTRY FOR DETECTING CONCEALED MINERAL DEPOSITS

Yilgarn Craton, Western Australia

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November 1992

Summary report for the CSIRO-AMIRA Project P240 (Confidential to the sponsors of the project)

EXPLORATION FOR CONCEALED GOLD DEPOSITS, YILGARN BLOCK, WESTERN AUSTRALIA

Exploration Geoscience Restricted Report 236R

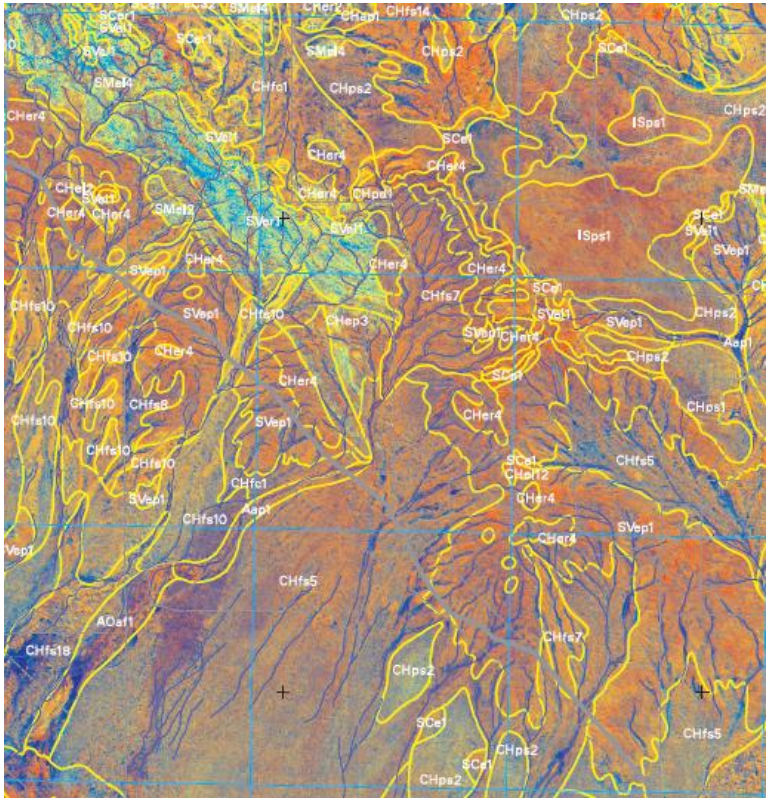
Conclusions 2

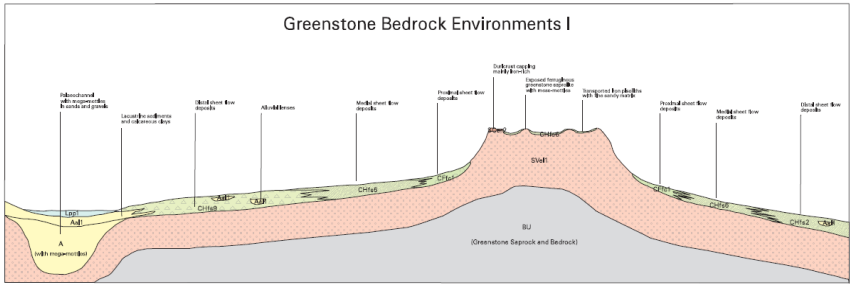
- Basic regolith mapping (**R**esidual-**E**rosional-**D**epositional) provides essential context for geochemical exploration surveys

- The more ferruginous **R**esidual (relict) materials are excellent sample media which generate a broad, multi-element geochemical halo

- Ferruginous components of the **E**rosional zones are also viable sample media but most saprolite is intensely leached and anomalism may be completely absent, low level or in highly immobile elements

- There are no reliable surface geochemical techniques to “see through” **D**epositional cover



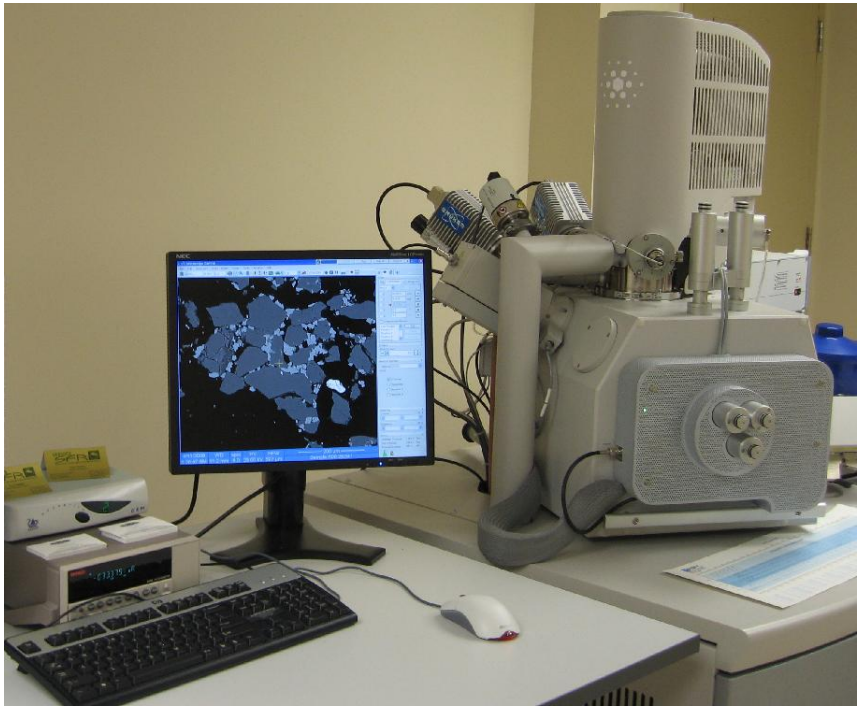


Conclusions 3

- A strong digest and a low detection limit multi-element analytical suite is required

- PIMA or Terraspec mineralogy is very useful in lateritic terrains, particularly for identifying depositional materials

- The MLA offers exciting new analytical capacity to identify minerals in geochemical samples very rapidly and investigate the chemistry of selected phases if required.



Obrigado!