DELIVERING RESULTS

Department for Manufacturing,
Innovation, Trade, Resources and Energy

The Depth of Cover:
The Nature of Australian Regolith

Steve Hill

Steve.Hill@sa.gov.au

Government of South Australia
Department for Manufacturing, Innovation, Trade, Resources and Energy

PACE 2020 exploration mining energy global

SOUTH AUSTRALIA

Depth of Cover

A fundamental attribute of the cover and critical in exploration:

- Vertical distance to the domain of bedrock-hosted targets
  - Required drilling depth for bedrock sampling
  - Required drilling depth for cover sampling
  - Effectiveness of surficial geochemical expressions
  - Effectiveness and suitability of geophysical method / response within cover
  - Influence on geophysical expressions of underlying bedrock

This presentation: Context for Depth of Cover Discussion

1. **Variability of Cover Materials**

2. **Regolith Architecture: Zones and Interfaces in the cover**

1. Variability of Cover Materials

"Cover": material overlying geological setting of exploration target (typically overlying crystalline basement)

Regolith: Everything between fresh rock and fresh air

In situ: Material that has weathered in place. Still retains protolith structures, fabric and some degree of geochemistry(?).
AKA "saprolite", "saprock"

Transported: Sediments. Materials that have been mobilised and reorganised. Not <u>necessarily</u> linked to underlying protolith.

Pedolith: Reorganised by weathering / soil forming processes but not necessarily transported out of position. Can form on *in situ* and transported materials.

1. Variability of Cover Materials

Other ways to sub-divide / categorise cover materials

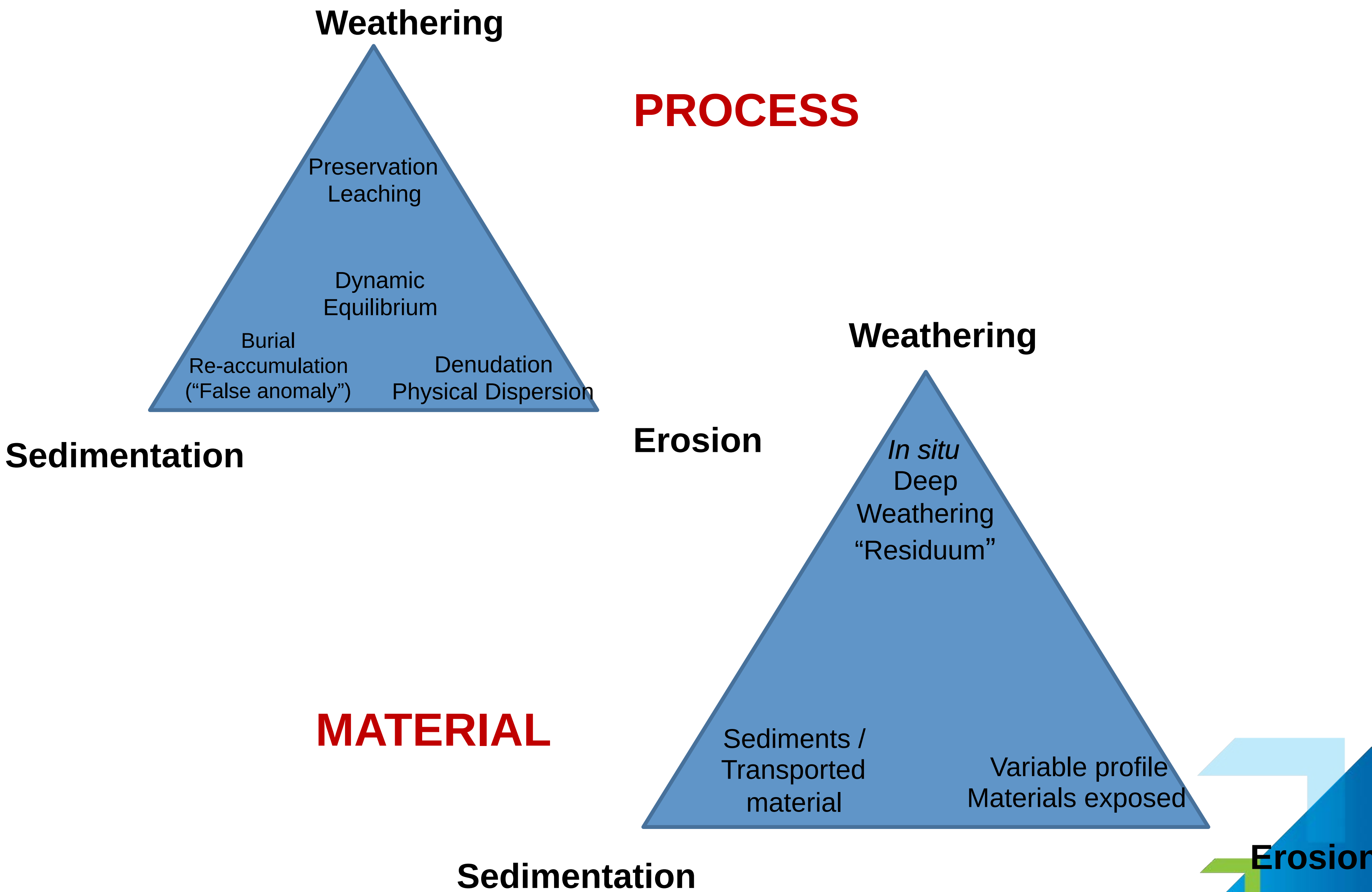
Lithological: what is the material composed of (e.g. grain size, colour, minerals, etc)

Genetic Process: how did the material form? E.g. weathered rock, alluvial sediment, colluvium etc

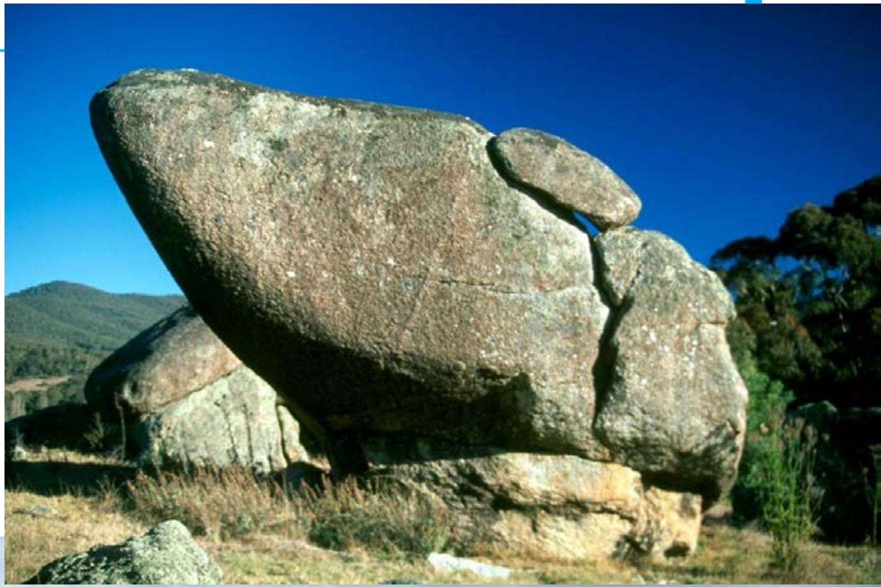
Stratigraphic: e.g. age, local stratigraphic names etc

Physical or chemical properties: seismic properties, chemical composition etc

Cover Processes and Materials



In situ (weathered materials)



In situ (weathered materials)

Thickness up to 100s metres

Considerable lateral and vertical variations, especially near structures and lithological contacts.

Contrasting physical properties from differential weathering of rock types … can help detect bedrock lithology changes

Increasing porosity with weathering leads to decreasing density. Lower saprolite density tends to facilitate gravity detection of deeply weathered areas.

Salinity and moisture will influence conductivity. Typically base of saprolite transition to fresh rock shows marked conductivity contrast

Seismic velocity contrast at base of weathering therefore can represent bedrock topography. Some indurated materials also show potential velocity contrast.

Transported (sedimentary) materials

Alluvial sediments

Alluvial sediments

Variable thickness and can form stacked / composite profiles ranging from metres to 10s and 100s metres thick.

Laterally constrained to valleys or channels but these can be unconstrained to produce expansive floodplains / braidplains / fans

Thicker accumulations may host palaeosols, and other indurations

Maghemite in some alluvial systems (magnetic noise and can effect EM)

Palaeodrainage can host saline groundwater – highly conductive

Transported (sedimentary) materials

Colluvial sediments

Colluvial Sediments

Variable thicknesses. Mostly metres thick but thicker accumulations along rangefronts.

Typically laterally restricted except for sheetflow (shallow overland flow) that can be thin but expansive.

Important local water storage and throughflow and discharge

Transported (sedimentary) materials

Aeolian sediments

Aeolian Sediments

Typically sands in plains and dunes.

Typical more prevalent at landsurface than vertically extensive sub-surface. (e.g. many areas thickness corresponds to dune height with underlying materials exposed in swales)

Thicker accumulation can include composite dune series with intervening palaeosols

Can be reworked into sheetflow sediments with little marked compositional change (e.g. red-brown sands reworked into red-brown sands)

Transported (sedimentary) materials

Lacustrine sediments

Lacustrine Sediments

Variable but typically 10s metres

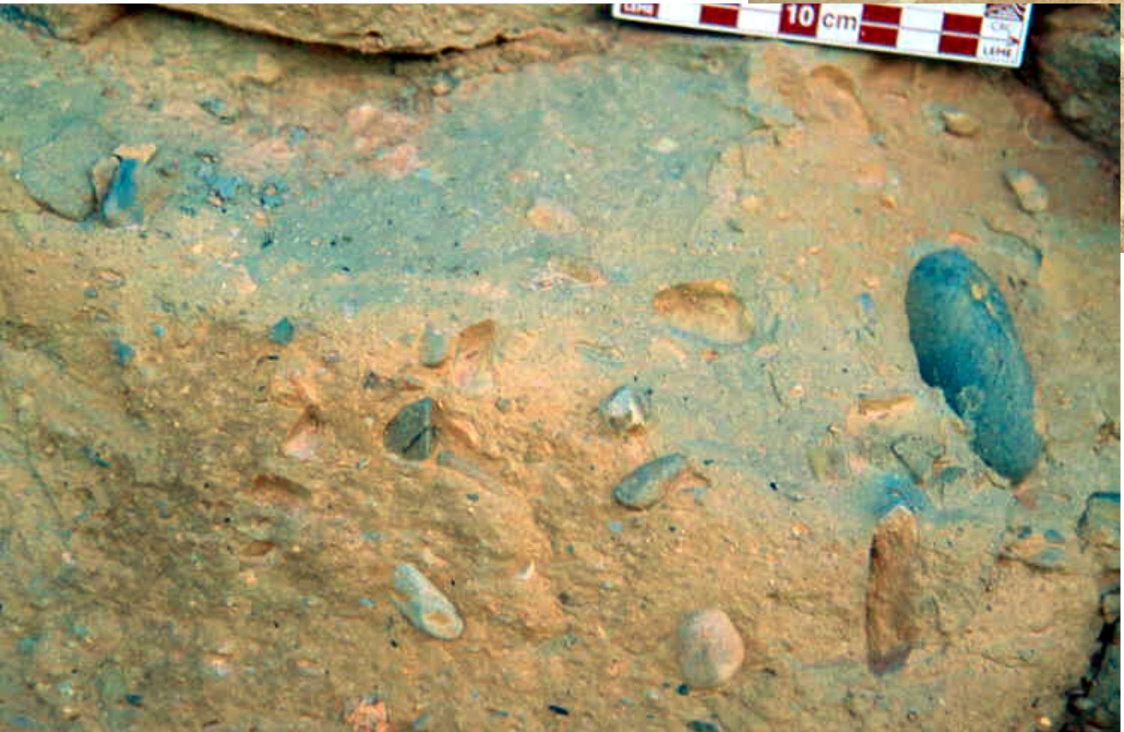
Typically laterally extensive planar features

Typically clay (e.g. smectite) with salts (e.g. halite). Can be organic-rich.

Other sediments

Coastal sediments

Glacial sediments



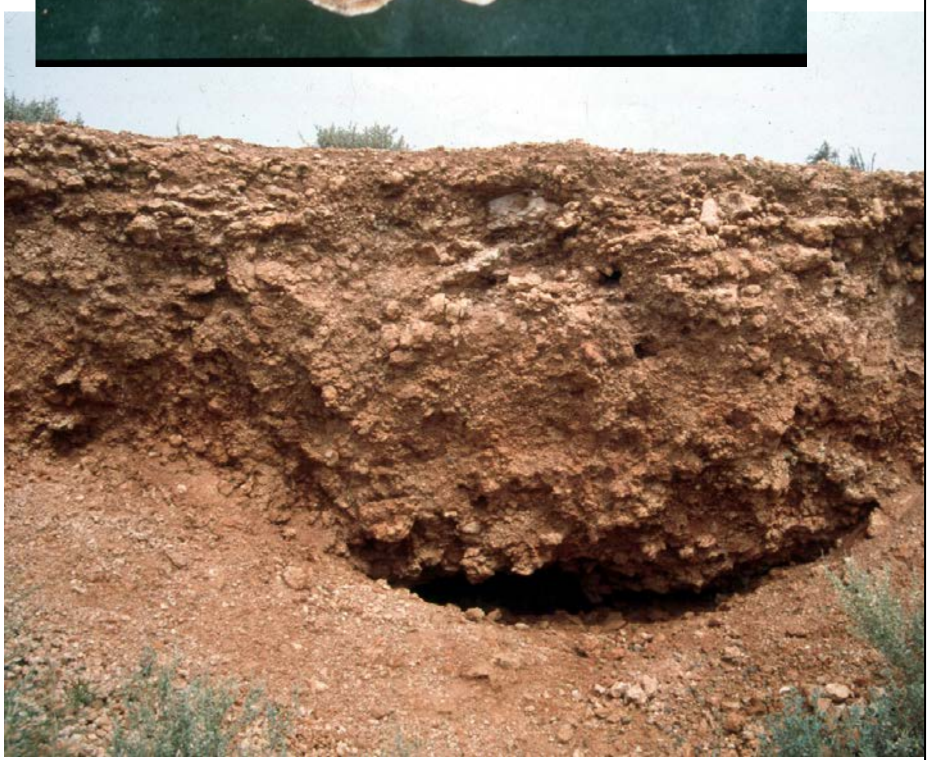
Indurated Materials

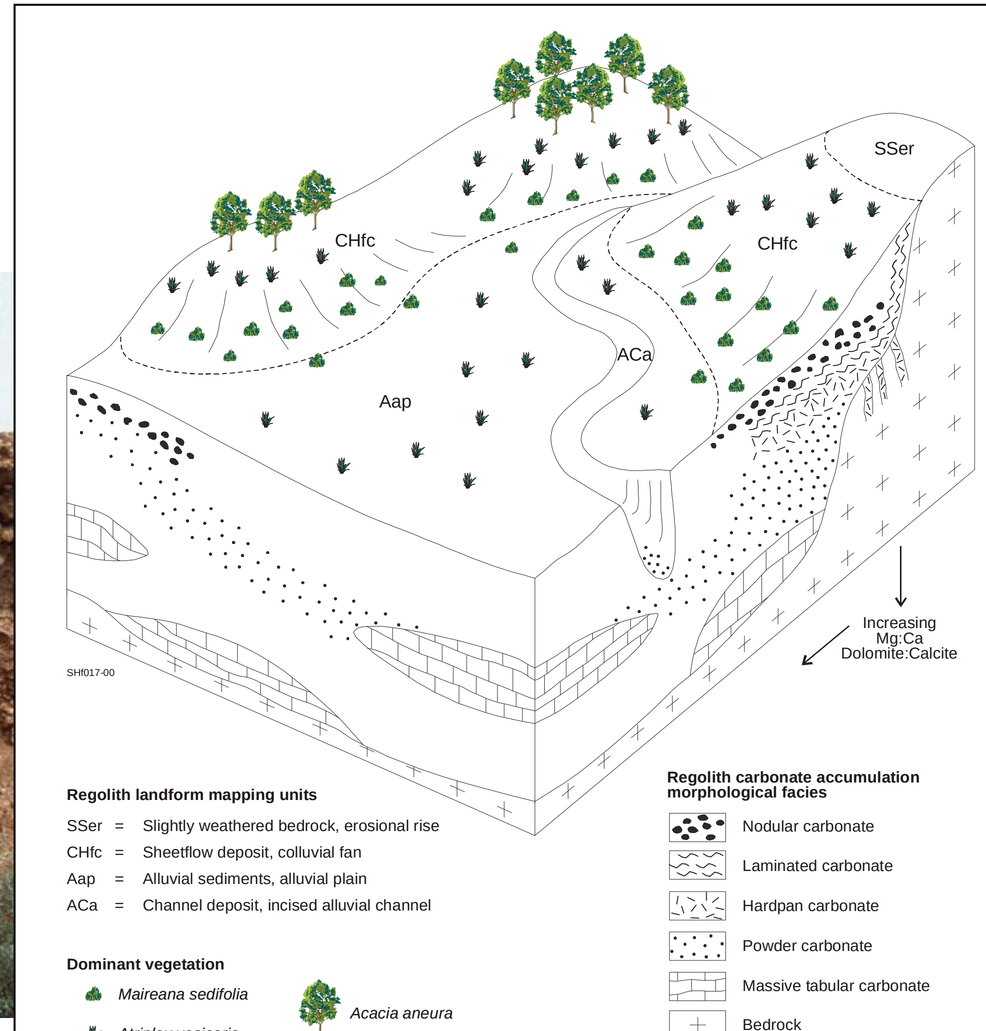
Elements commonly concentrated in the landscape / cover due to weathering and their associated induration…

- Iron (ferricrete)
- Silica (silcrete)
- Calcium carbonate (calcrete)
- Aluminium (bauxite)
- Gypsum (gypcrete)
- Sodium chloride (halite)

Can be responsible for changes in physical properties in cover. E.g. conductivity, density changes

Calcrete – calcium induration (Broken Hill)





Ferricrete – iron induration (forming today at Darwin)

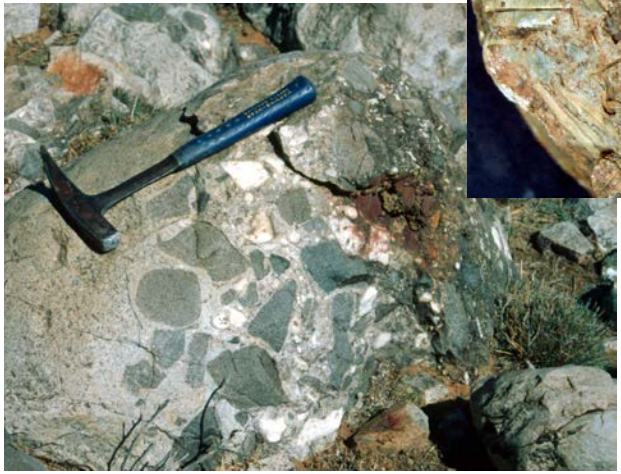
Ferricrete – iron induration (Mt Magnet WA)

Ferricrete – iron induration

Maghemite forms from magnetite weathering and geothite heating (e.g. fires). Typically reworked into drainage depressions

Thorium abundantly hosted with iron oxides

Silcrete – silica induration



Gypcrete – gypsum crust (Lake Eyre)

Halite – sodium chloride crust (Lake Eyre)

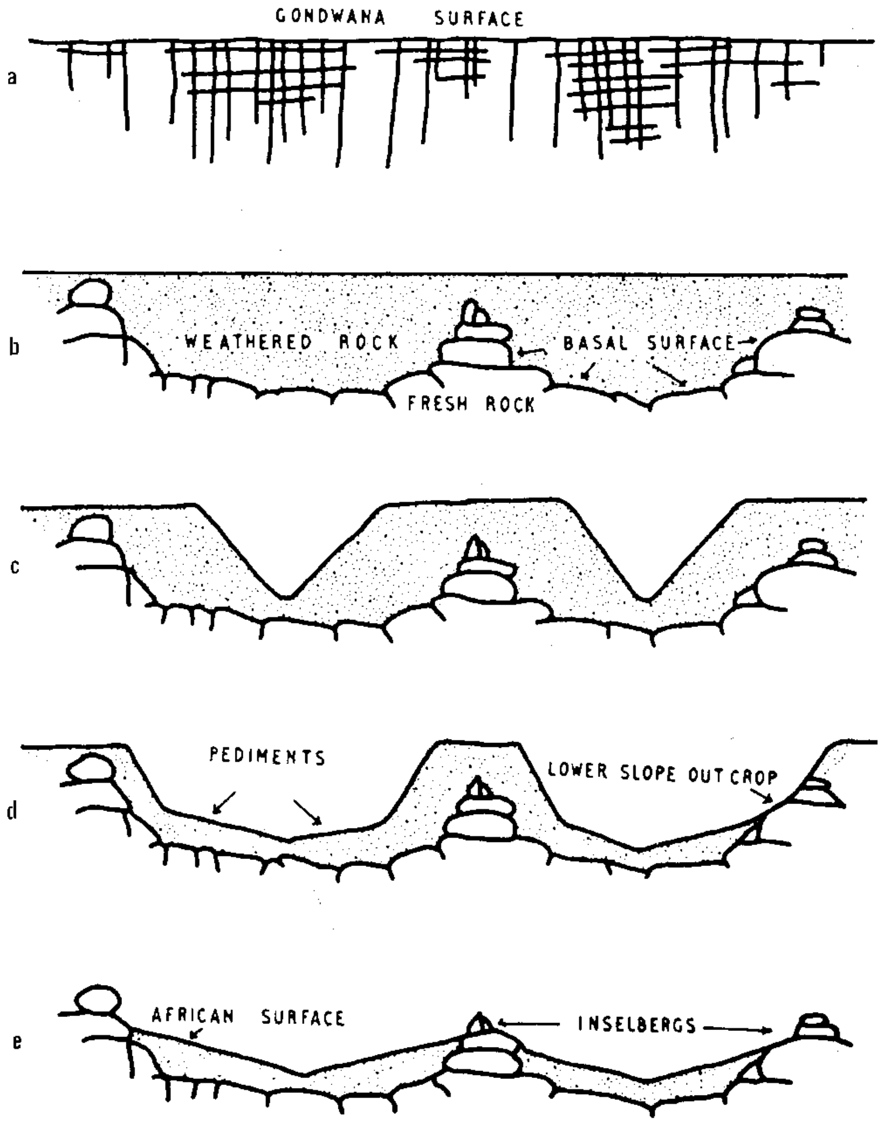
2. Regolith Architecture: Zones, thicknesses and interfaces in the cover

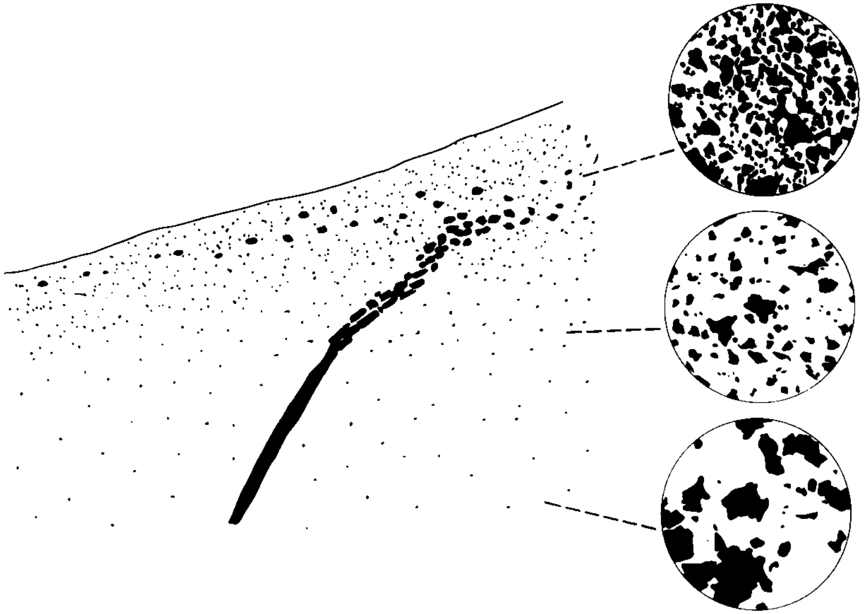
How the variable cover materials can be arranged spatially (vertically and horizontally)

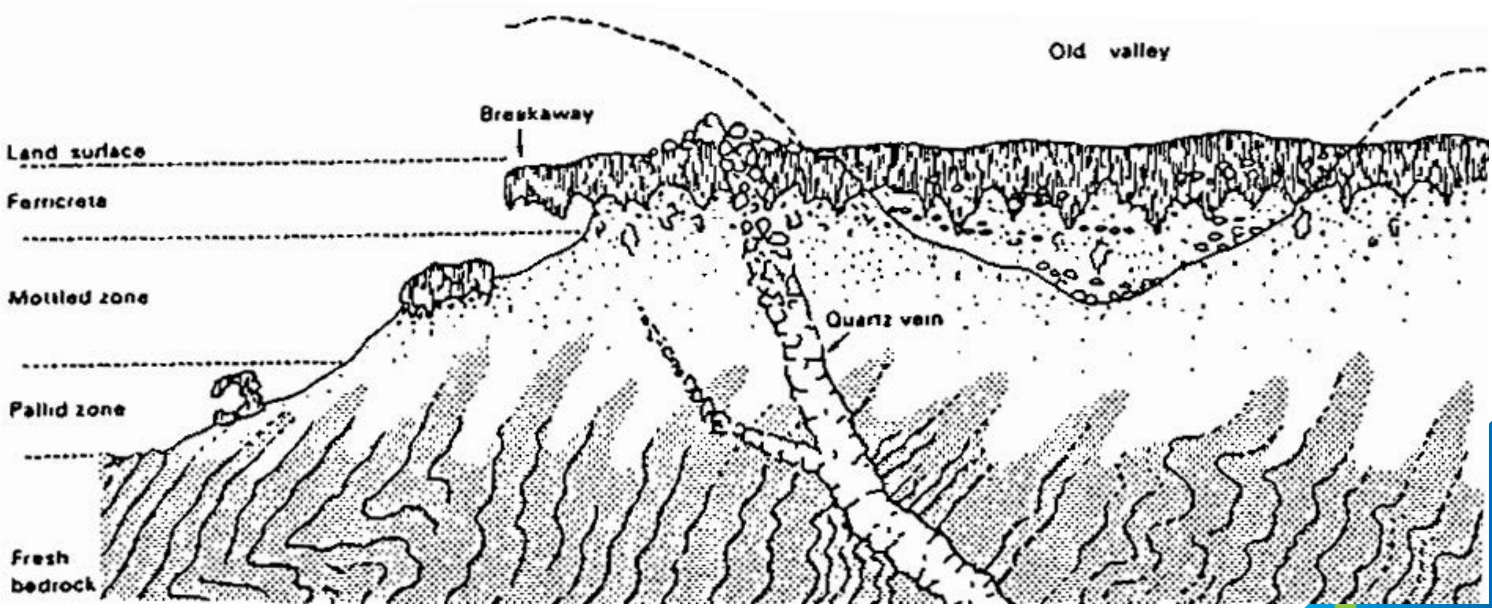
HILLSIDE REGOLITH PROFILE

e.g. Weathering Profile in Granites

Weathering and weathering profiles

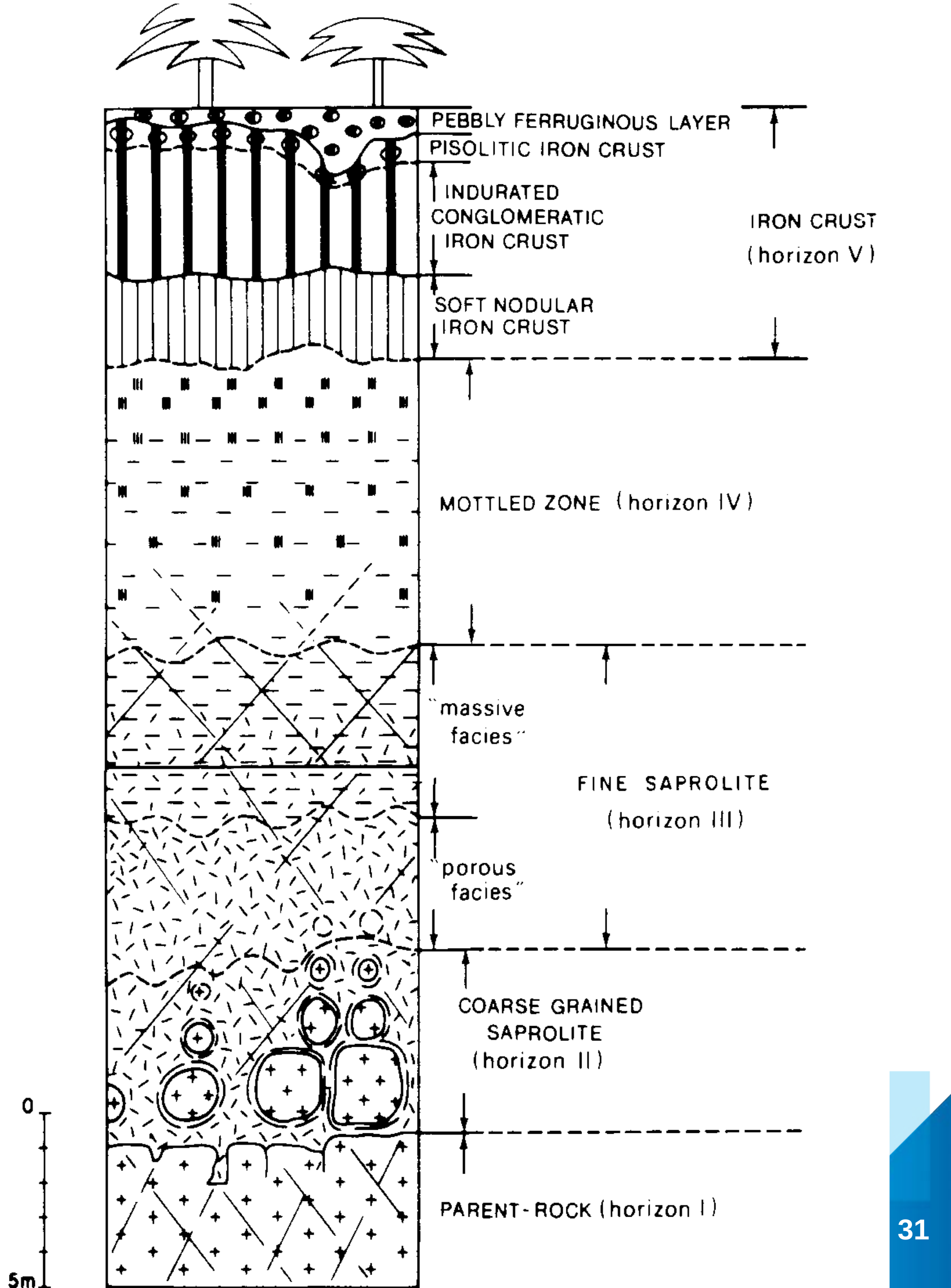


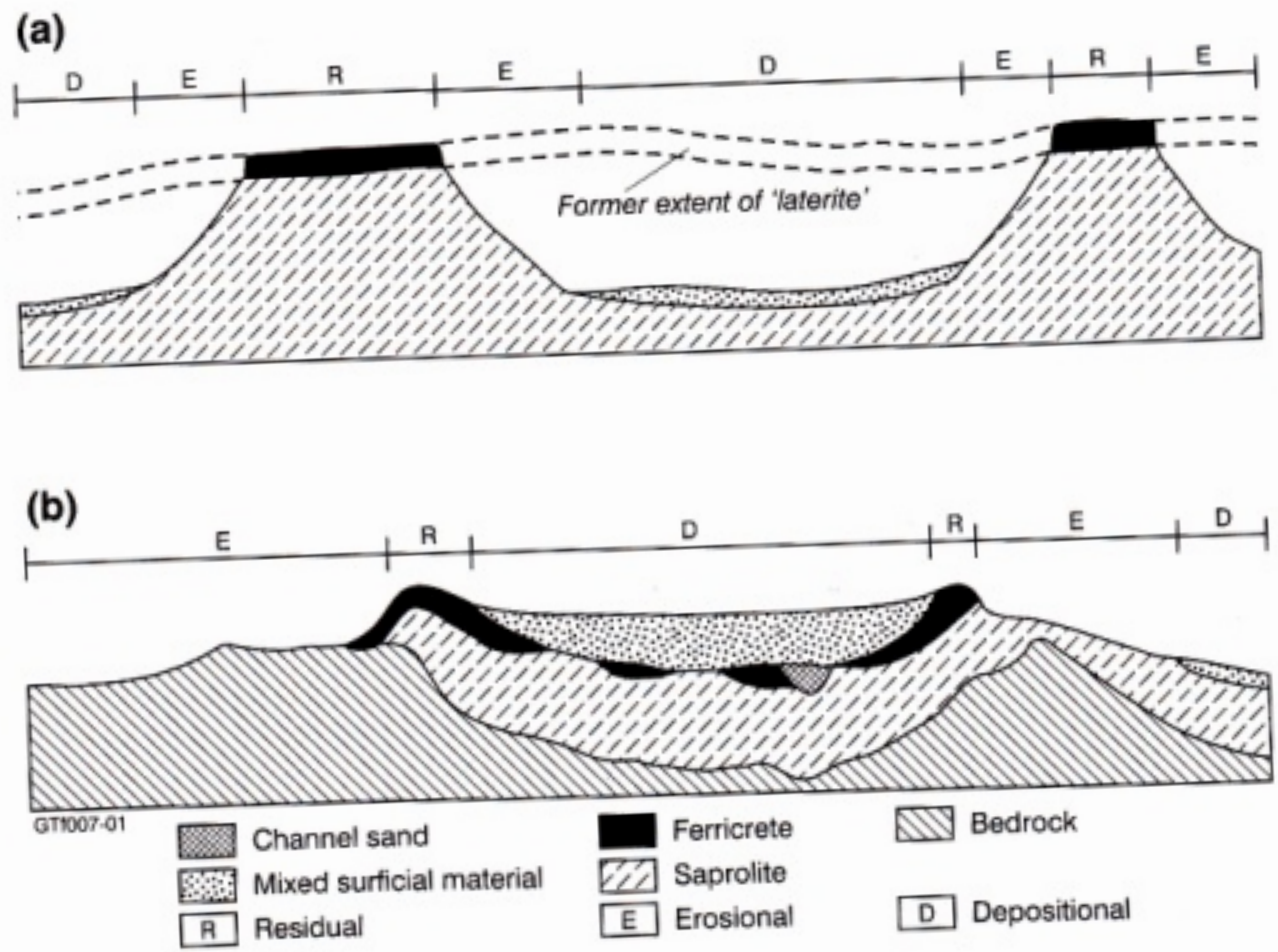




Old valley
Breakaway
Land surface
Ferricrete
Mottled zone
Quartz vein
Pallid zone
Fresh bedrock

Butt & Zeegers, 1992

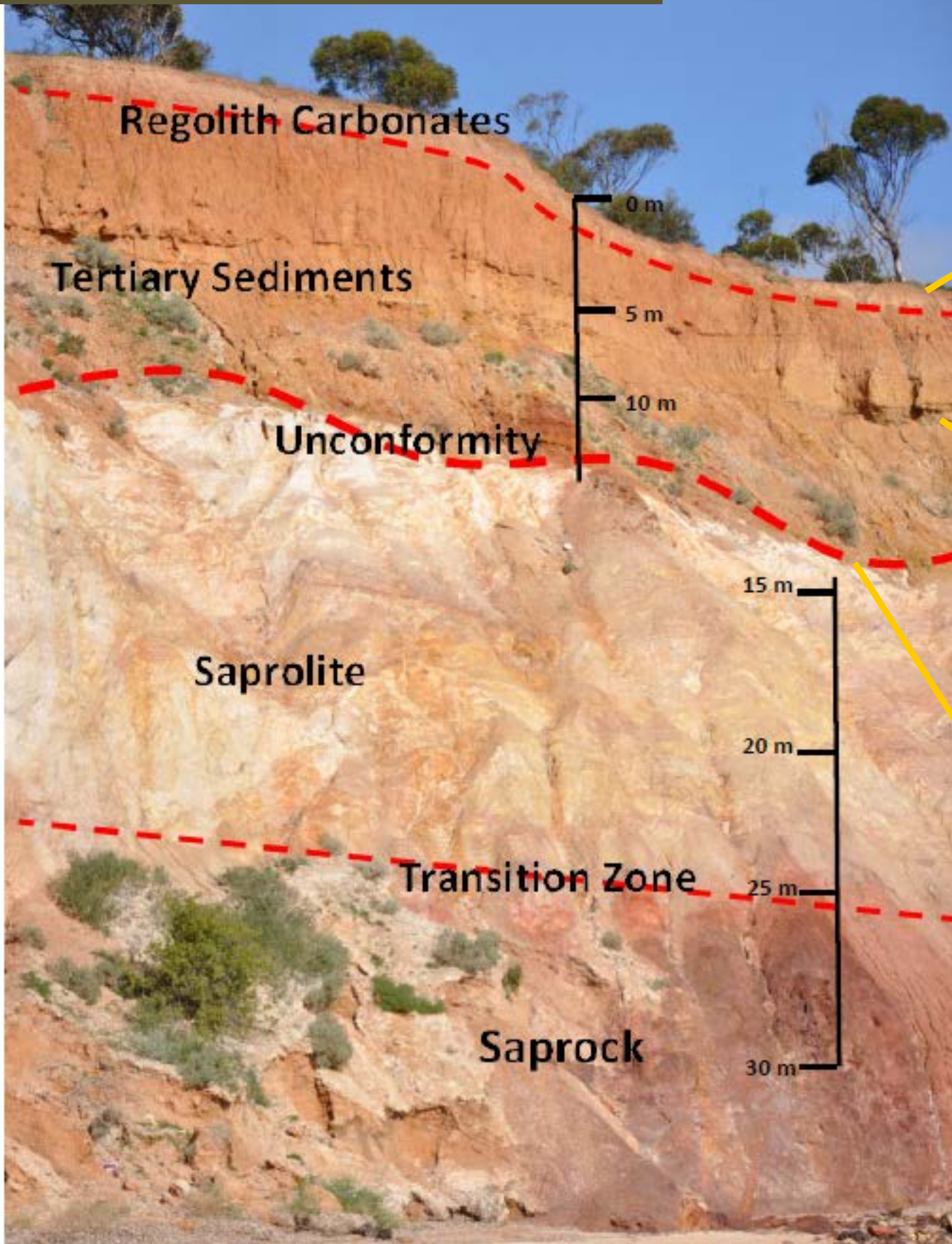



(a)
D
E
R
E
D
E
R
E
Former extent of 'laterite'
(b)
E
R
D
R
E
D
GT1007-01
Channel sand
Mixed surficial material
R Residual
Ferricrete
Saprolite
E Erosional
Bedrock
D Depositional

Interfaces within deep cover...

- Physical Interfaces
  - Unconformities
  - Lag deposits
  - Resistate Minerals
- Chemical Interfaces
  - Groundwater
  - Redox fronts
  - Induration zones/horizons
- Biological Interfaces
  - Root zone
  - Micro-organisms
  - Hydrocarbons / lignites

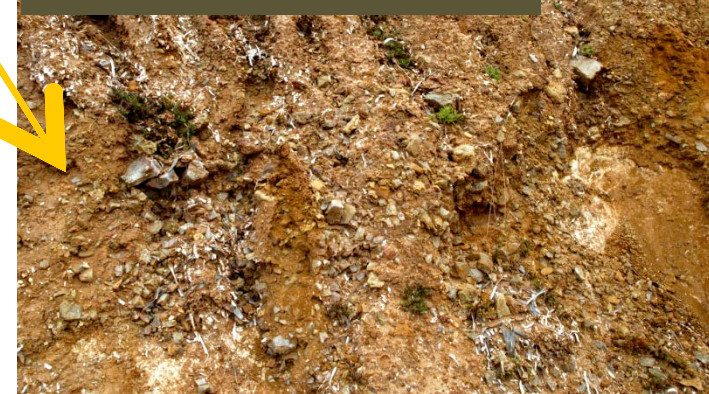
Hillside Deep Cover Profile



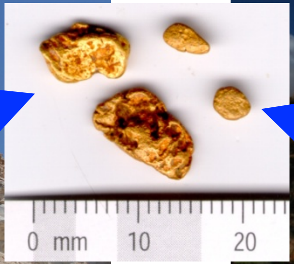
Calcrete vs Limestone

Redox Interfaces

Base of Sediments



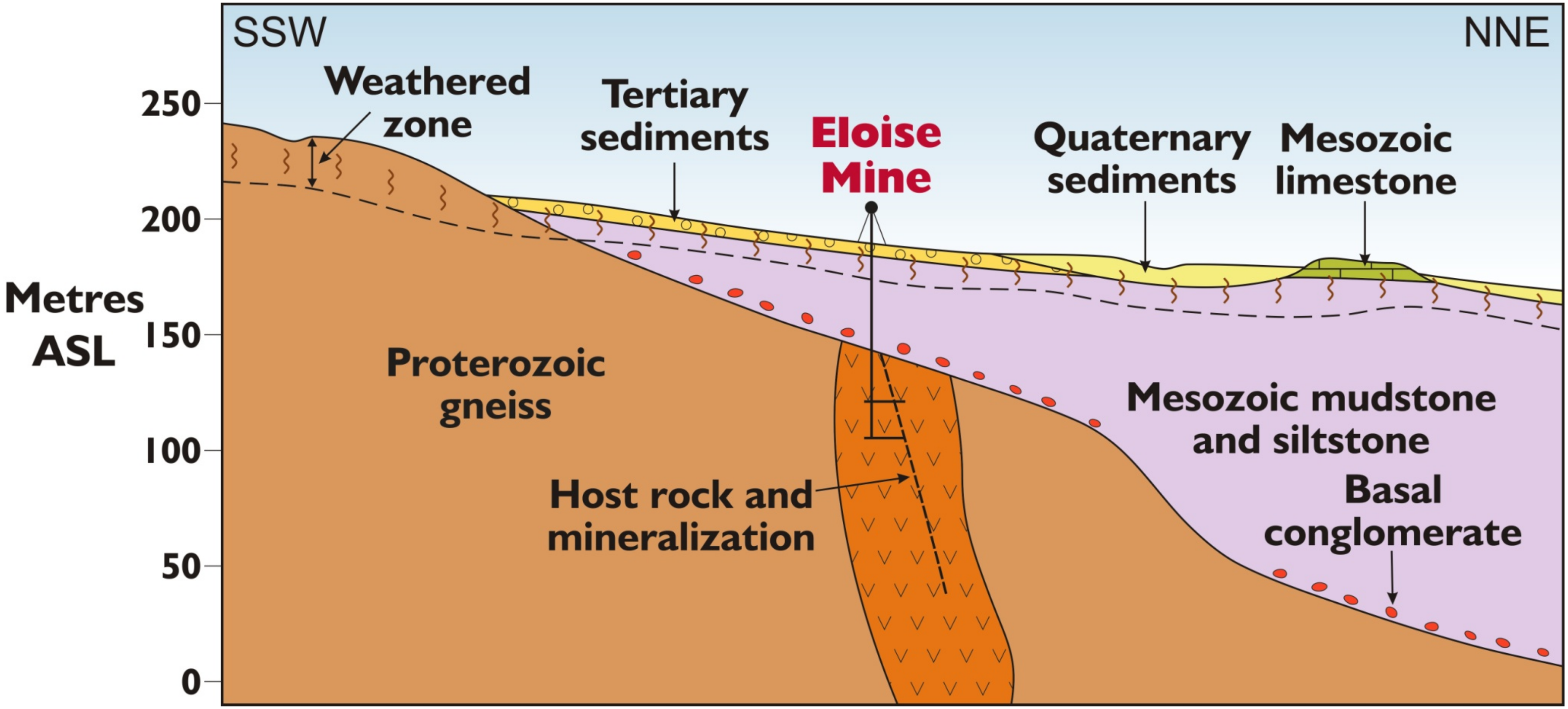
Physical interfaces - examples



(Photos S.Hill)

Regolith cross section: Eloise deposit, Qld

(Ravi Anand & Ian Robertson, CSIRO)



Anand and Robertson

Gawler Craton Redox Fronts


Hillside, modern beach sediments


Mt Toondina, Permian cover


Jacinth, “Red Loam”


Stuart Shelf, Mesozoic cover

Key zones in exploration

Top of fresh rock (weathering front)

Top of weathered rock (top of saprolite) / Basal Unconformity

Base of transported cover

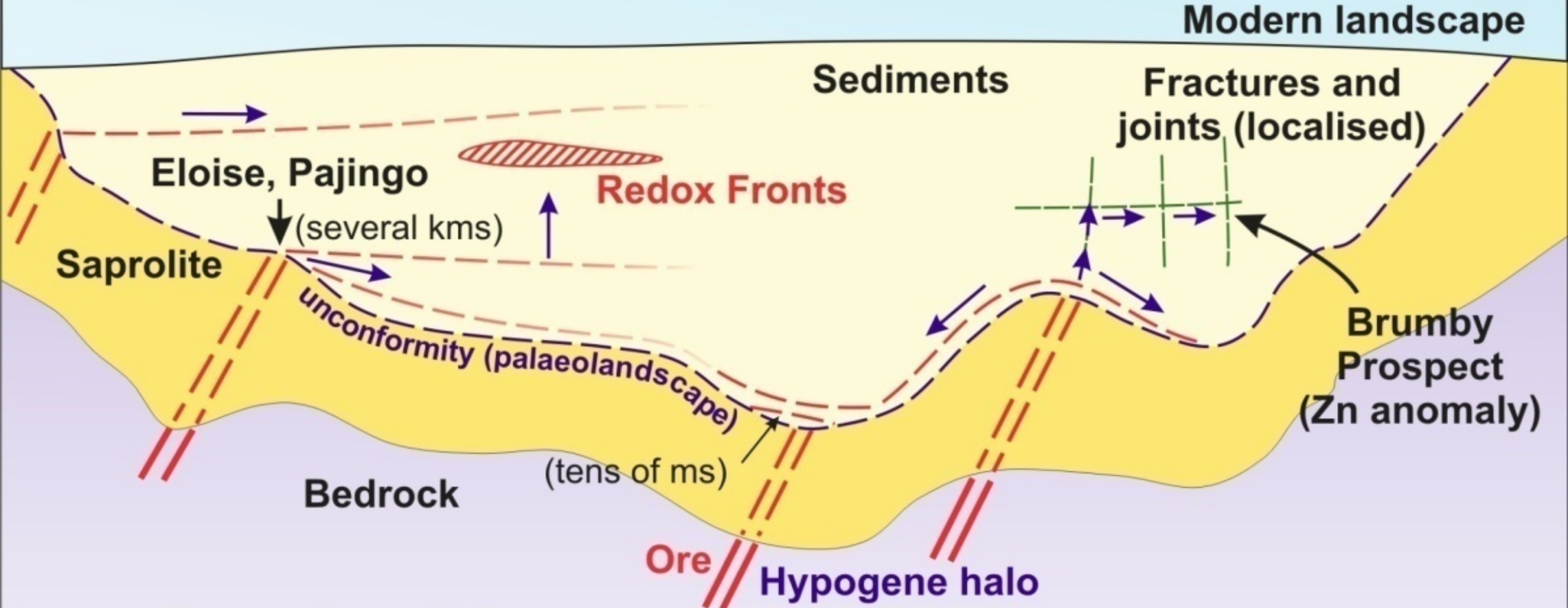
Redox Interfaces

Indurations

Unconformities

Palaeosols

Exploration in deep (100-300m) transported cover environments



Research needed

- ***Identification of palaeosurfaces (e.g. Cambrian, Mesozoic, Tertiary): geophysics, drilling***
- ***Understanding of regolith and sedimentology of cover sequences***
- ***Secondary dispersion of ore body: palaeosurfaces (including heavy minerals), redox fronts, fractures and joints and other selected features within cover sequences***
- ***Hydrogeochemistry***

RRAs075-08

R Anand

Concluding comment

Petrophysical properties of cover (regolith)?

Some examples but fragmentary data

In situ measurement of petrophysical properties?

Disclaimer

•*The information contained in this presentation has been compiled by the Department for Manufacturing, Innovation, Trade, Resources and Energy (DMITRE) and originates from a variety of sources. Although all reasonable care has been taken in the preparation and compilation of the information, it has been provided in good faith for general information only and does not purport to be professional advice. No warranty, express or implied, is given as to the completeness, correctness, accuracy, reliability or currency of the materials.*

•*DMITRE and the Crown in the right of the State of South Australia does not accept responsibility for and will not be held liable to any recipient of the information for any loss or damage however caused (including negligence) which may be directly or indirectly suffered as a consequence of use of these materials. DMITRE reserves the right to update, amend or supplement the information from time to time at its discretion.*