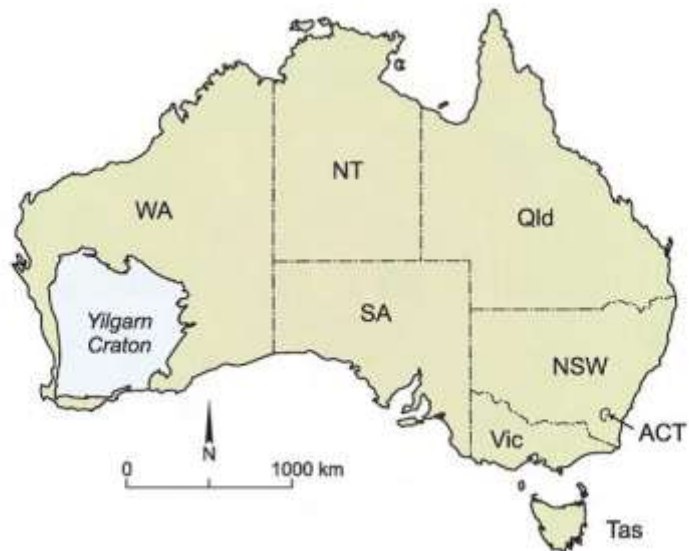


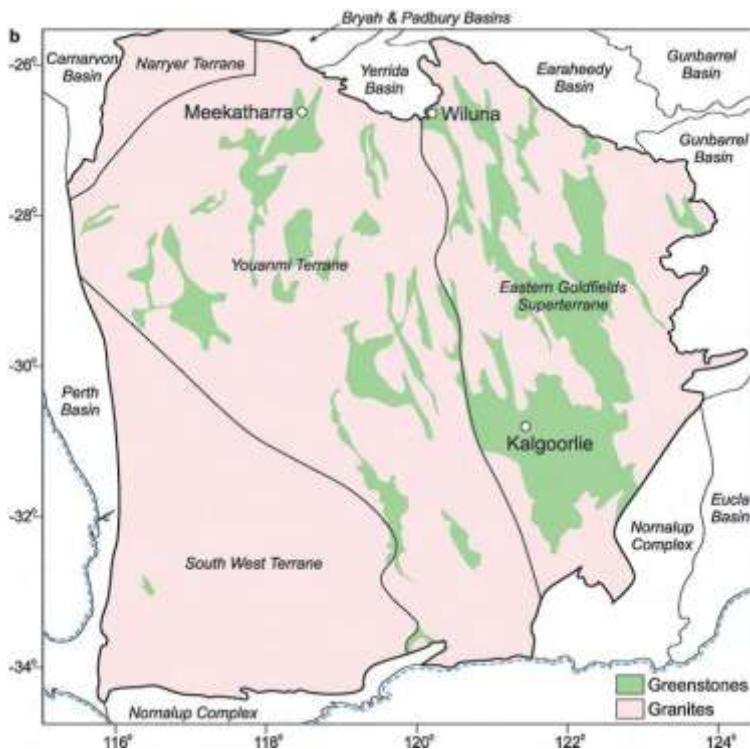
Yilgarn Craton: A case study in regolith formation

The Yilgarn Craton is one of the largest segments of Archaean crust on Earth. It has an area of about 657,000 km² (26% of WA) and is situated in the Precambrian Western Shield of Australia. Most of the Craton is believed to have been formed between 3,000 and 2500 Ma. The rocks and structures of the Craton appear similar over large areas, comprising in the main granites, gneisses and greenstones. However detailed mapping reveals regional differences which divide the Craton into a number of terranes. The South West Terrane (the area of the Craton closest to Perth) is a relatively high grade granitic, granitic gneiss and greenstone complex intruded by a series of dolerite dykes.

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Major geological features



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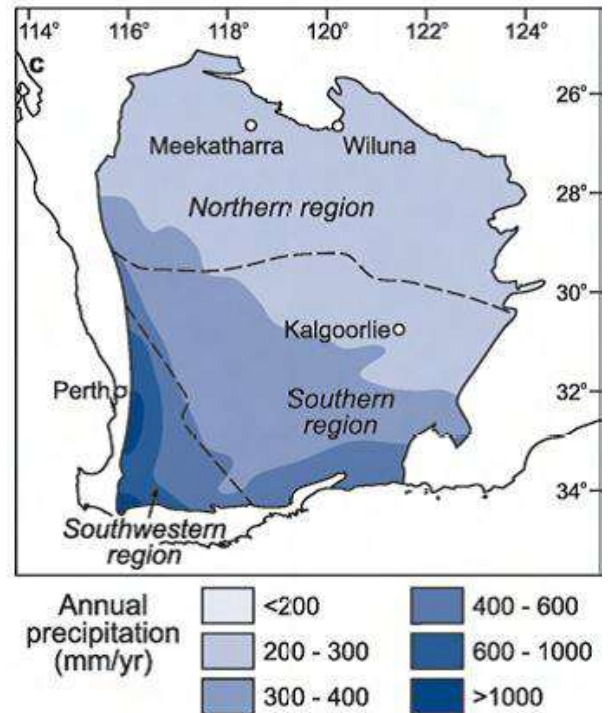
Physical relief

The Yilgarn Craton is generally flat apart from the south west margin where the Darling Range (Darling fault) separates the pre-Cambrian rocks to the east from the more recent sediments to the west. The low relief is broken by granite tors, breakaways, flood plains and broad shallow valleys. The river drainage is determined by a continental divide called the Meckering line – to the east drainage is inland; to the west and south it is towards the coast.

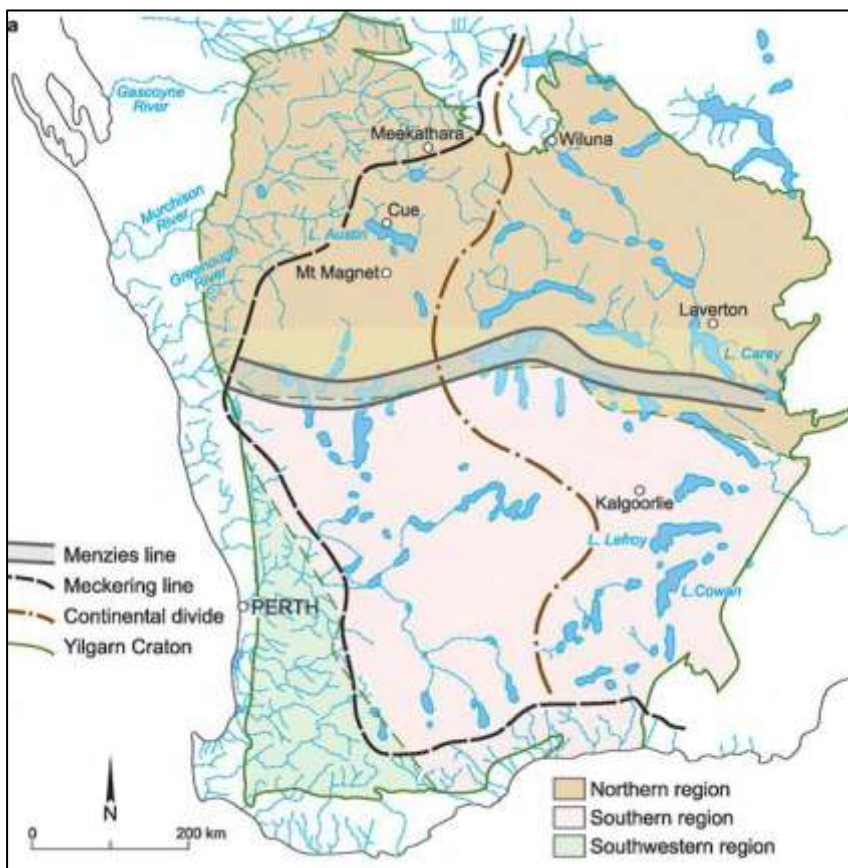
Climate

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The Menzies line divides the Yilgarn Craton into three broad regions – Northern, Southern and South Western. The South Western region has a Mediterranean type climate with hot dry summers and mild wet winters. Precipitation is 600 to 1000 mm pa. To the north and east the climate is semiarid with low rainfall, high evaporation and high temperatures.



Drainage map of the Yilgarn Craton



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Characteristics of the Yilgarn Craton

Table 1 Characteristics of the Southwestern, Southern and Northern regions of the Yilgarn Craton.

	Southwestern Region	Southern region (South of 'Menzies Line')	Northern region (North of 'Menzies Line')
Average Rainfall	1000 mm	200 – 400 mm	200 mm
Vegetation	Eucalyptus (Jarrah)	Eucalyptus (Salmon gum dominated)	Acacia (Mulga dominated)
Annual potential evaporation	1400 – 2000 mm	<3300 mm	>3300 mm
Rainfall seasonality	Winter maximum	Winter Maximum	Summer maximum
Groundwater	Moderate to low salinity	Saline hypersaline	Moderate to low salinity
Soils	Acid to neutral	Neutral to alkaline	Neutral to acid
Landform	Undulating plateau, high relief	Gently undulating terrain, low relief	Gently undulating terrain, low relief
Pedogenic calcrete	Minor to absent	Abundant	Minor
Groundwater calcrete	Absent	Minor	Common
Red-brown hardpan	Absent	Minor	Common
Sand and ferruginous gravel plains	Common	Common	Moderate
Ferruginous duricrust	Extensive, gibbatic	Patchy, kaolinitic	Common, kaolinitic

(after Butt et al., 1977, Anand and Smith, 1993).

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Mineral ore deposits

The Yilgarn Craton is one of Australia's major mineral areas with a large percentage of Australia's gold and nickel mining. It also contains about 30% of global known gold reserves, 20% of nickel reserves and 80% tantalum reserves. It hosts:

- VHMS (volcanic-hosted massive sulphides)
- Bauxite
- Tin, Tantalum and Lithium
- Uranium
- Iron Ore (Hematite)

Regolith and landscape formation

It is generally thought that the Yilgarn Craton represents an erosion surface of late Proterozoic age which has been altered by weathering, erosion and sedimentation. This has produced a variety of landscape features with a series of complex regolith profiles.

Influence of climate

There are four broad stages in the history of landscape and regolith formation in the Yilgarn. These are based on long term changes of climate.

Tropical (humid and hot) climates

- Intense chemical weathering
- Vertical movement of minerals by leaching and eluviation

- Residual material with deep regolith profile

Arid Climates

- Erosion and sedimentation
- Horizontal movement of sediments.
- Transported material with a shallow regolith profile

Climate history

Period	Age (My)	Climate
Quaternary	1.8 - 0	Temperate to warm. Semi-arid to arid
Mid-Miocene to Pliocene	15 - 1.8	Warm to sub-tropical; Aridity increasing. Cooler after 1.5 My
Palaeocene to mid Miocene	65 - 15	War to sub-tropical; Seasonally humid. Savanna or Mediterranean
Mesozoic	230 - 65	Temperate to warm. Mostly humid
Late Permian Late Proterozoic	280 - 270	Glaciation Glaciation

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Extensive weathering

Palaeozoic and Mesozoic

During this time there appears to have been extensive weathering. However glacial erosion in the Permian has removed much of the evidence. The only remaining features from this time are probably major river systems represented by current chains of salt lakes. In the Cretaceous a humid and sub-tropical climate existed that would have caused extensive chemical weathering. This resulted in the formation of saprolite overlain by laterite.

Late Cretaceous and early Tertiary

Variations in climate produced changes in sea level. Lower sea levels allowed the formation of incised valleys. But in times of higher sea levels these valleys were filled with sediments following marine incursions.

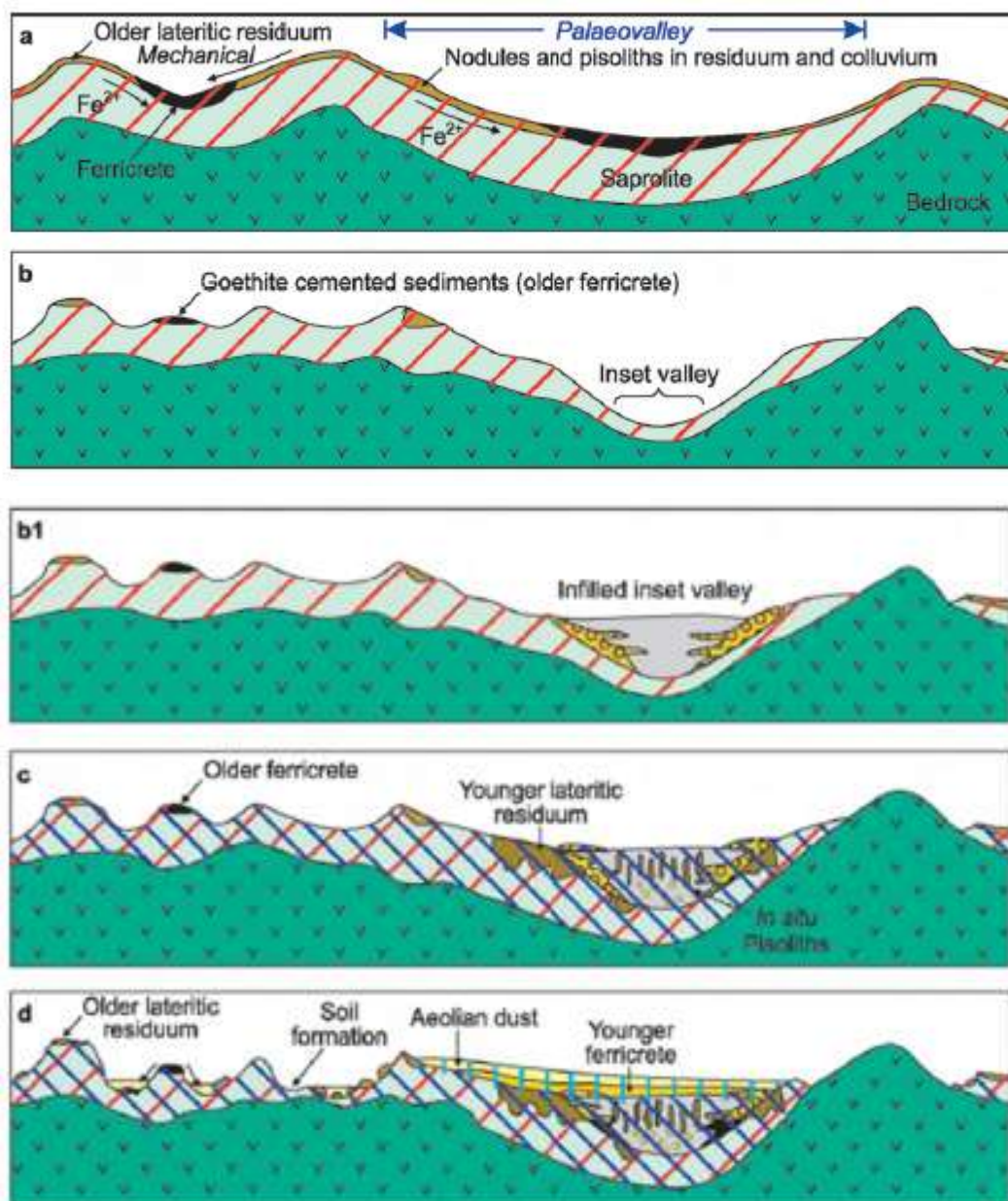
Eocene to early Miocene

Chemical weathering in a mainly humid subtropical climate continued. This resulted in further oxidation of the regolith and increased break down of the landscape.

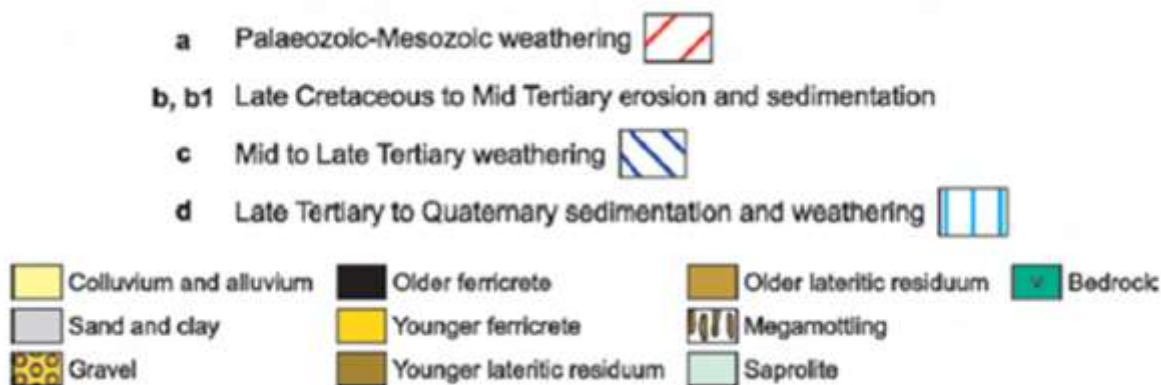
Late Miocene to present

A more arid climate caused further weathering and erosion. At the same time tectonic uplift resulted in rejuvenation of river systems. This caused the formation of deeper valleys, more sedimentation and further development of laterite and bauxite. Under these arid conditions ground water became more saline and there was an increase in the extent of salt lakes.

Regolith landscape model for the inland Yilgarn Craton



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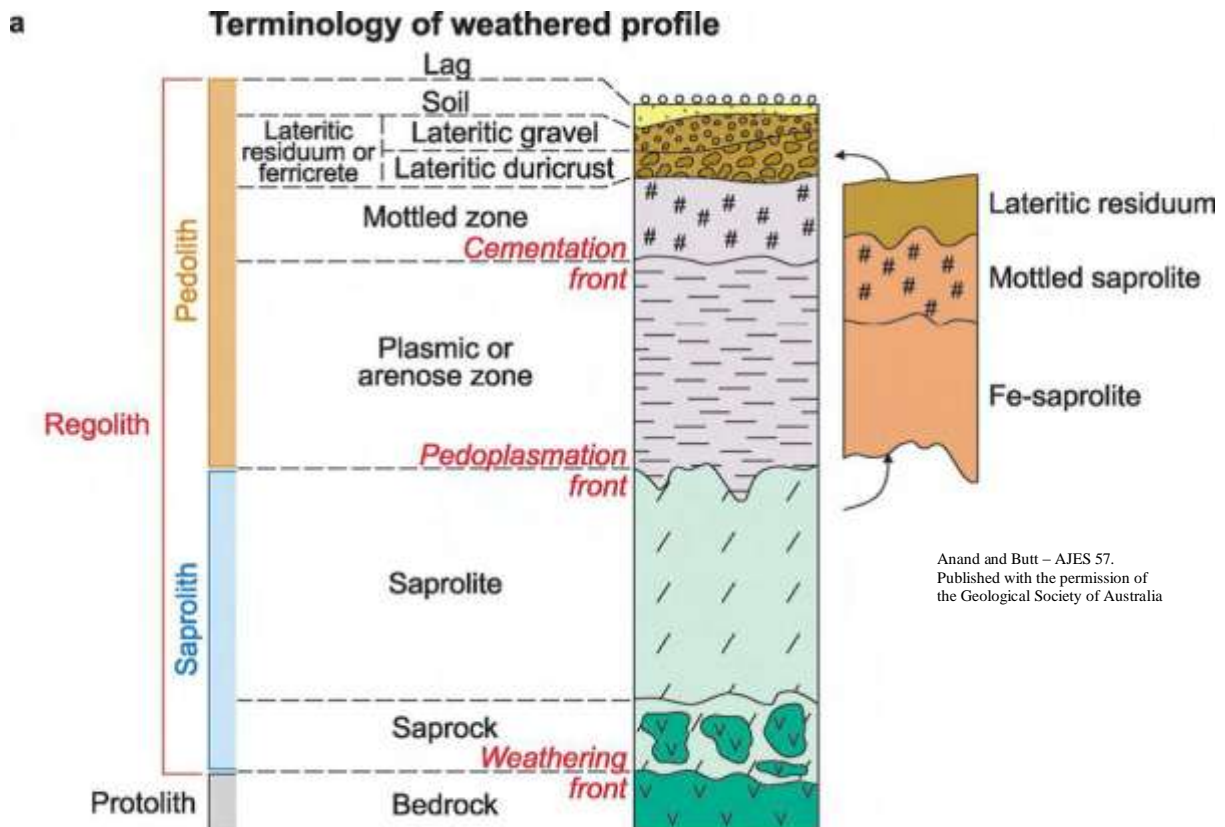
Lateritic weathering

The type of regolith is a result of several factors:

- Bedrock – lithology and structure
- Tectonic history and topography
- Climate – past and present
- Erosion and deposition
- Groundwater
- Biological activity

A deep regolith profile will only develop where the rate of erosion is less than the downward movement of the **weathering front**.

Lateritic weathered profile



Influence of geology

The weathering front can be as deep as 200m. The depth is controlled by:

- Lithology
- Structure – shearing, schistosity etc
- Landscape location

- Overlying sediments at time of weathering

Profiles over mafic and felsic rocks are deep whereas those over granite, dolerite and ultramafics are shallower.

Processes in an arid climate

- Arid conditions (e.g. mid-miocene)
Slower rate of weathering
- Lowering of water table
- Reduction in vegetation and biomass
- Instability of land surface
- Increased erosion
- Erosion offset by less surface run off
- Hard duricrust formed

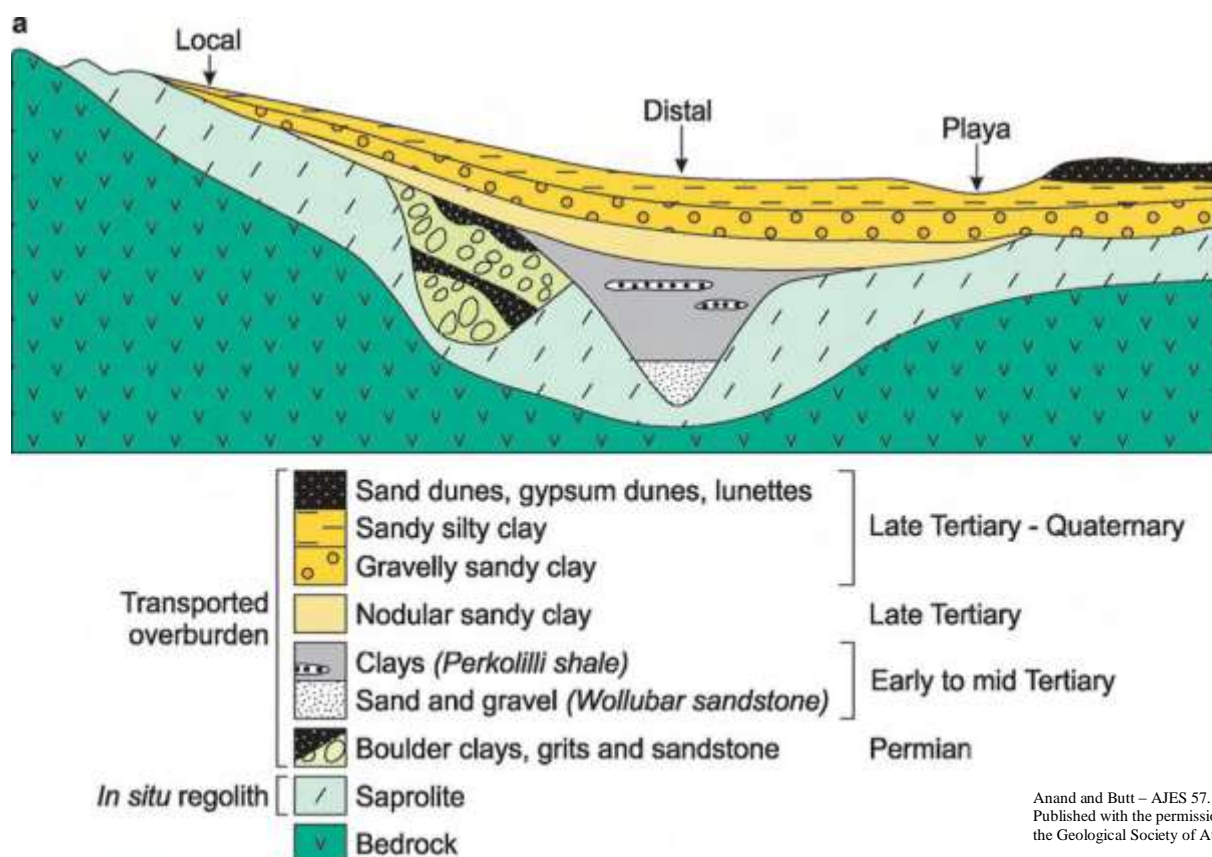
Profiles with characteristics of arid climates above those from humid conditions

Base Level movement

Relative height of **Base Level** can change as a result of land movement (isostatic adjustment) and/or sea level movement (eustasy).

If the land rises or the sea level drops **rejuvenation** occurs and rivers will have more energy. This will increase the rate of erosion and hence the depth of valleys.

In the Eastern Yilgarn **Inset Valleys** are found in the regolith. These Inset Valleys were formed in the late Cretaceous and can be 1000m wide, many kms long and have 100m of sediments of varying age.

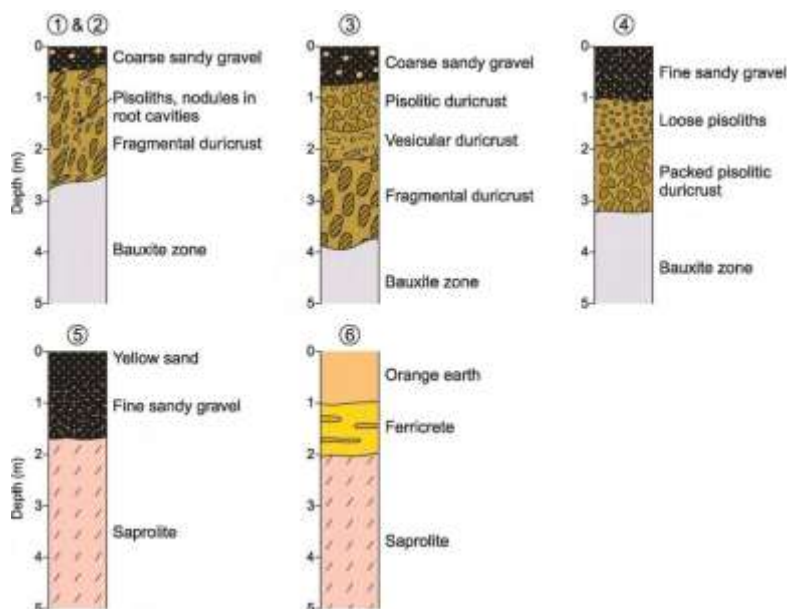
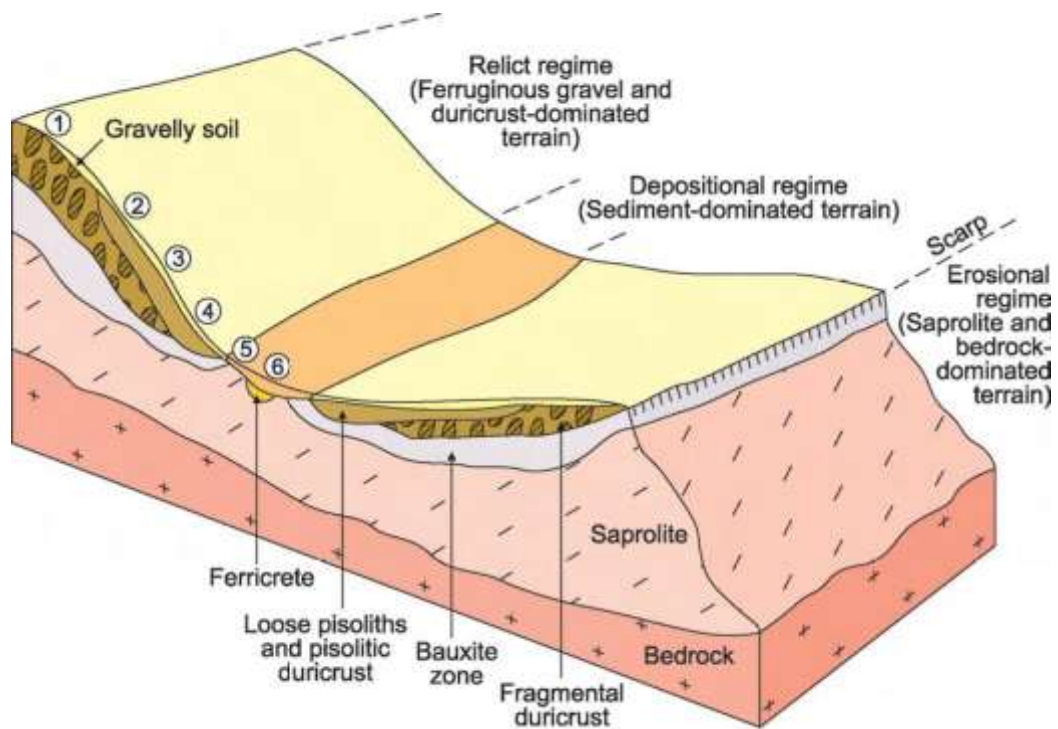


South Western region

In this region the Darling Range separates the inland eastern plateau from the western coastal plain. The range has high relief which is dissected by steep valleys. This is a result of rejuvenation along the Darling Fault in the post-Eocene.

A well-developed profile with a lateritic duricrust covers much of the area. The Mediterranean climate with high winter rainfall and warm temperatures has produced a high biomass. As a consequence weathering is very active. The duricrust is leached and rich in aluminium oxides. This is the source of Bauxite.

Regolith landform relationship in the Darling Range



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Summary

It is difficult from the surface regolith to tell what the bed rock is underneath.

It is crucial to distinguish residual material from transported material.

Distinct palaeo-climates can be determined.

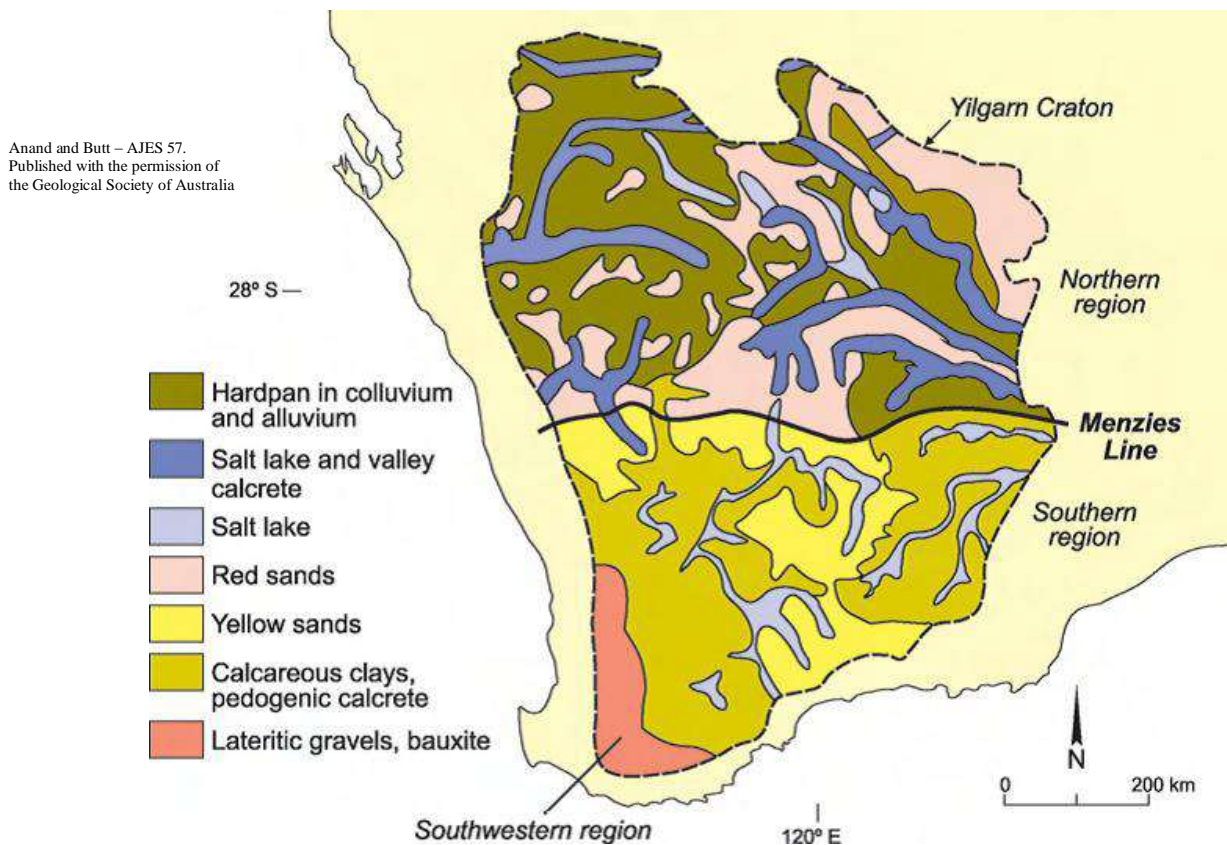
The regolith profile of the Yilgarn Craton is distinctive and complex.

The Menzies and Meckering lines are important boundaries.

The regolith is the result of many related processes and factors.

Key words – Yilgarn Craton, regolith, base level, rejuvenation, landscape evolution, weathering, leaching, bauxite.

Distribution of landforms and regolith for the Yilgarn



Sources:

1. Anand and Butt. A guide for mineral exploration through the regolith in the Yilgarn Craton, Western Australia. Australian Journal of Earth Sciences 57 pp 1015 to 1114.
2. Exploring Earth and Environmental Sciences Stages 1, 2 and 3. Editor Dianne Tompkins.
3. The assistance of CSA Global in preparation of this case study PowerPoint is gratefully acknowledged