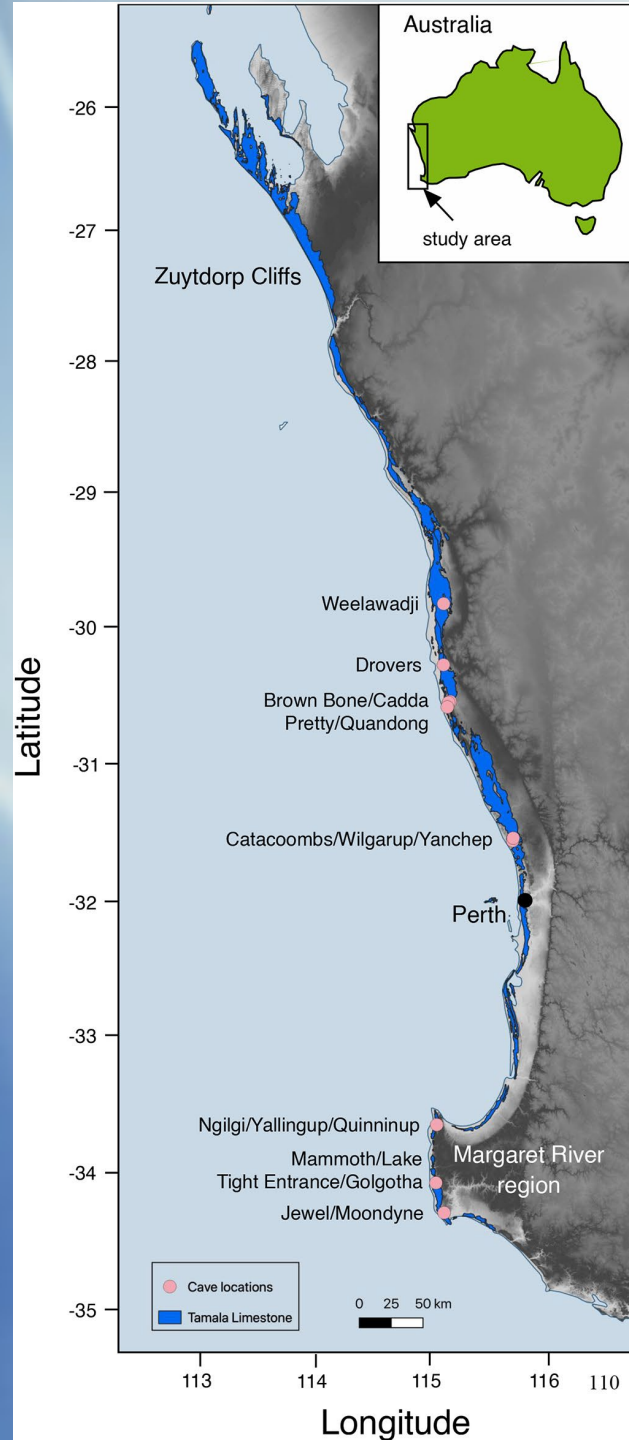


The Pleistocene Tamala Limestone in coastal WA – fossilised sand dunes, karst and cycles of climate change

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- The Western Australian coastline is flanked by one of the largest tracts of Pleistocene (2.6 million to 11,000 years old) aeolianites in the world.
- Known as the **Tamala Limestone**, this particular limestone consists primarily of cemented coastal carbonate dunes, termed either *aeolianite* or *aeolian calcarenite*.

- These elongate dunes generally formed parallel to the shore from primarily reworked shallow-marine biogenic carbonate sediments and were deposited during the Pleistocene as coastal ridges.

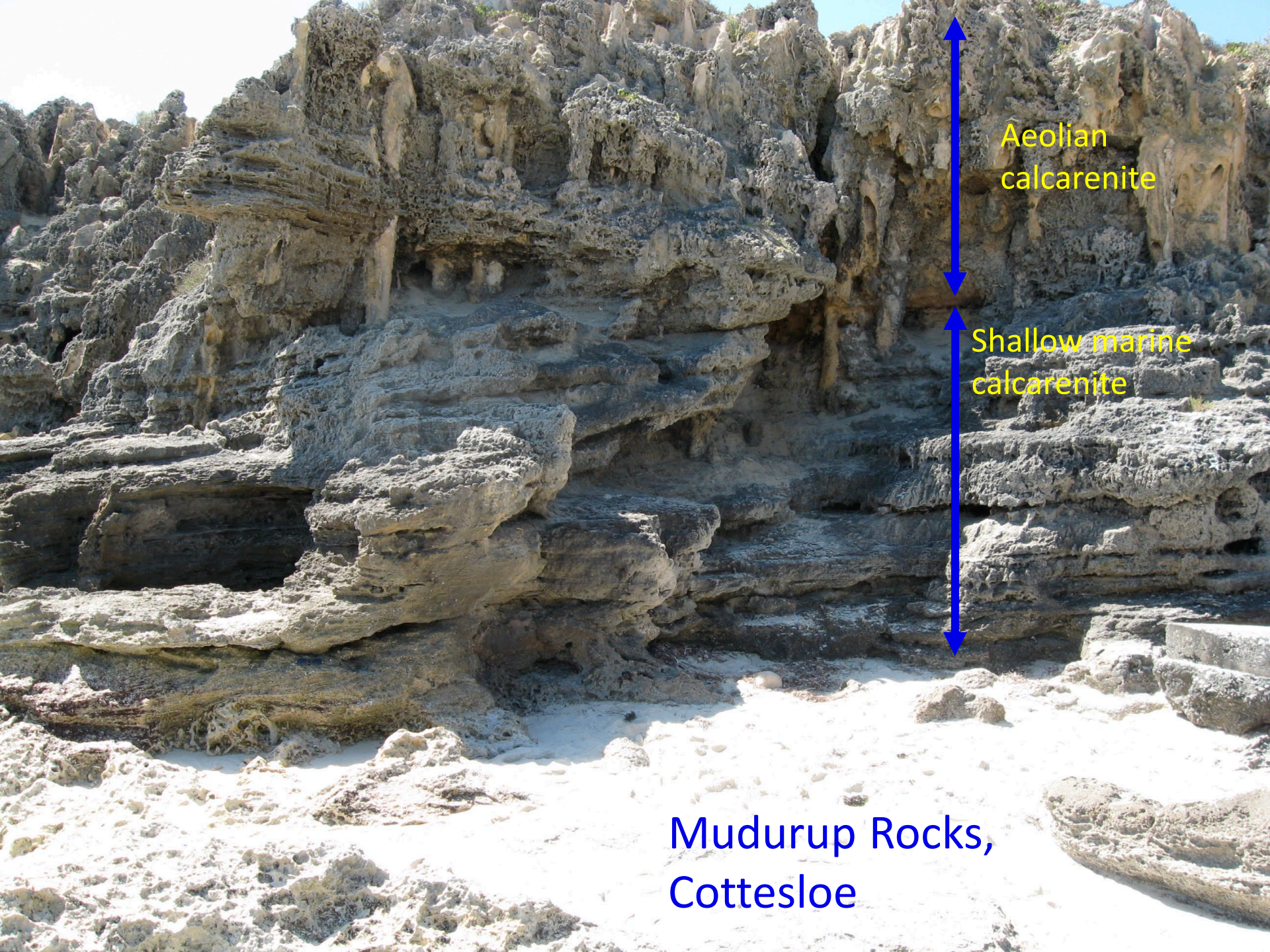


The dunes contain a variable amount of detrital grains (quartz, feldspar).



Internally the dunes typically show large-scale aeolian cross-bedding.

Mt Eliza (Kqarta Gar-up), Perth



Aeolian
calcarenite

Shallow marine
calcarenite

Mudurup Rocks,
Cottesloe

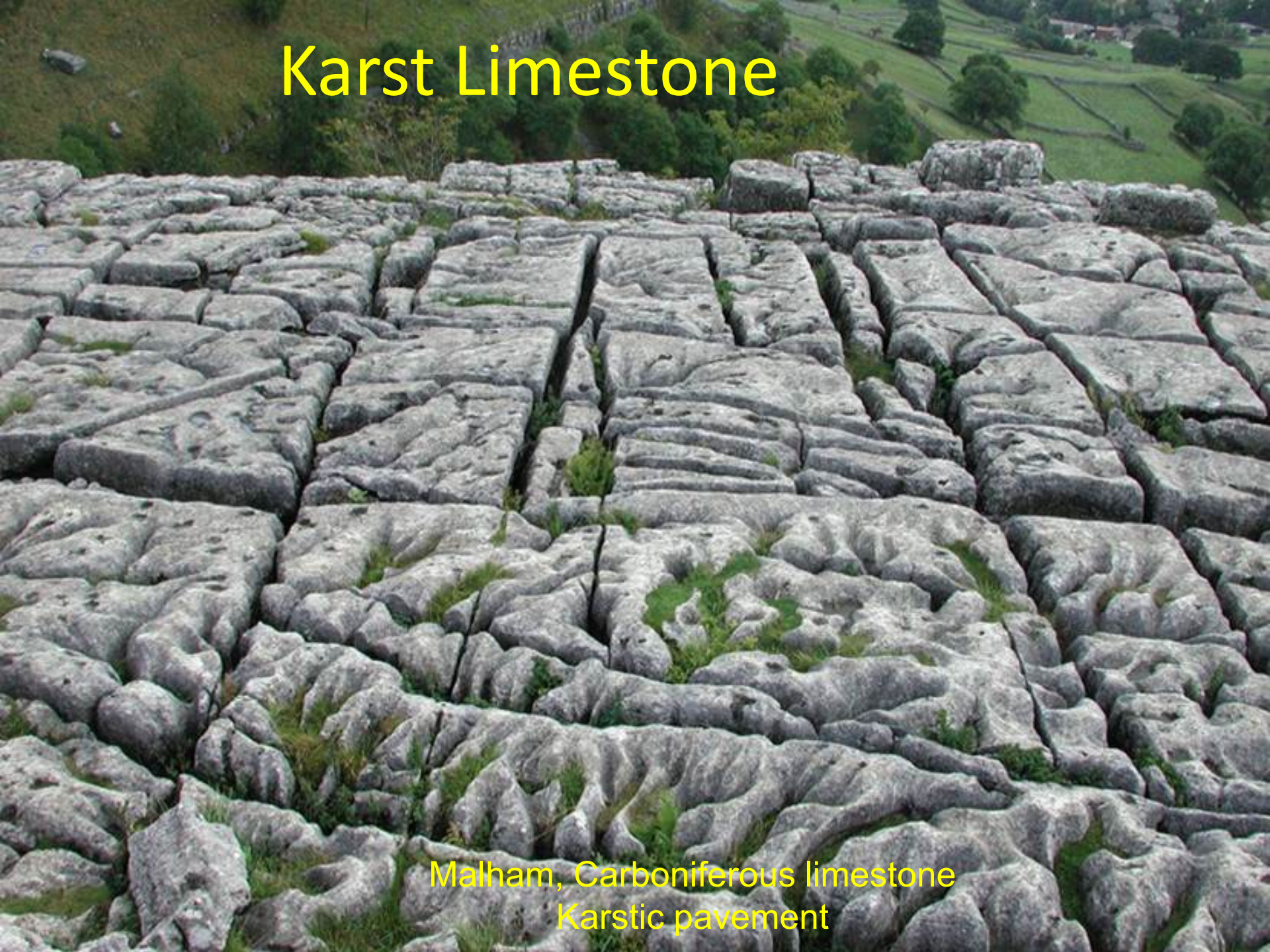


An unconformity of up to 1 billion years with 100,000 yr old Tamala Lst deposited on Precambrian granites south of Gracetown

What is Karst?

Deeply weathered limestone terrain formed by the chemical dissolution of the limestone by acidic rainwater and groundwater, resulting in the formation of structures like solution pipes and caves, clints and grykes, and caves

Karst Limestone

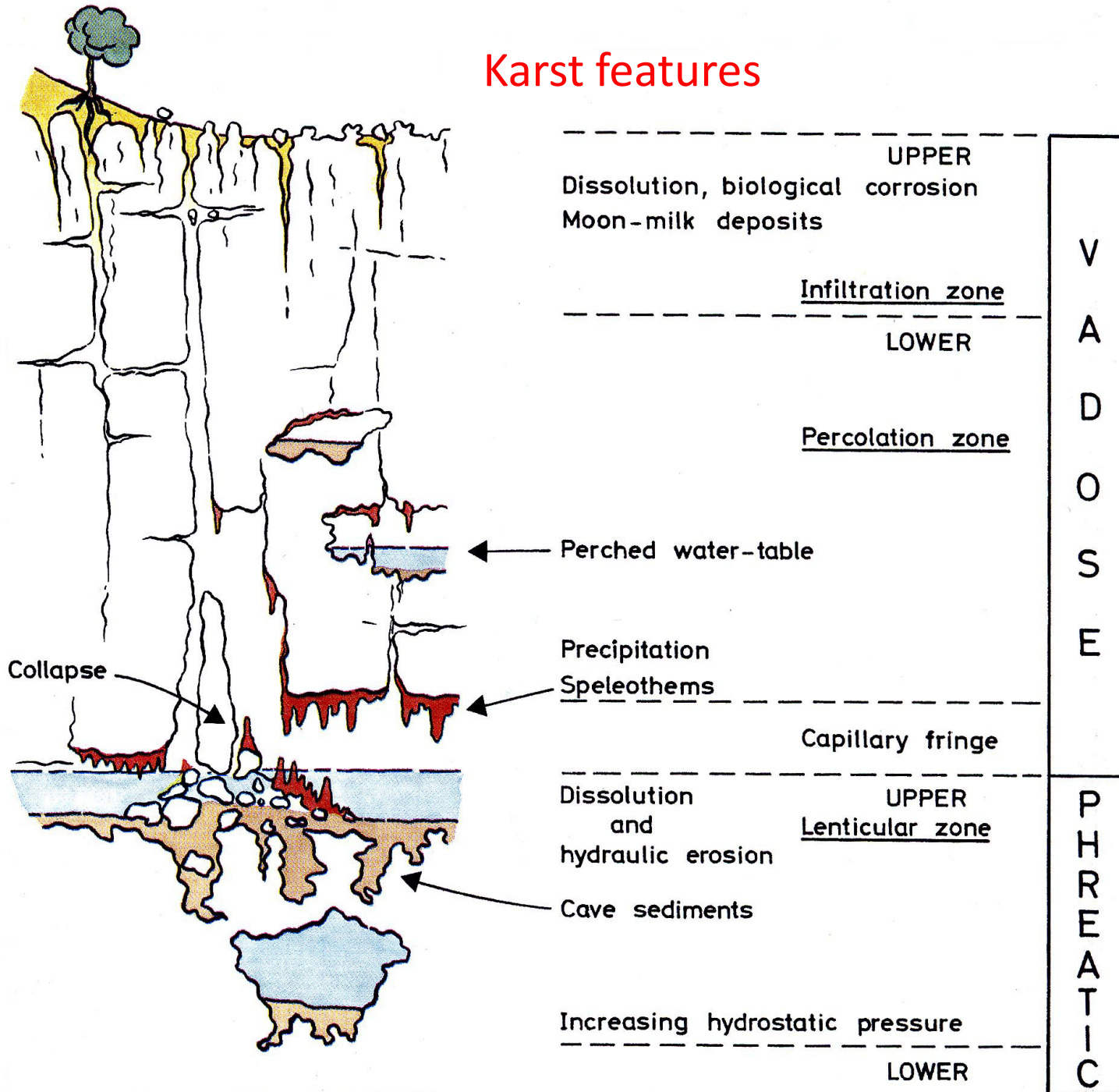


Malham, Carboniferous limestone
Karstic pavement



- Tamala aeolianite showing high porosity.
- Majority of carbonate grains formed of the more soluble form of CaCO_3 , aragonite.
- Consequently rapid dissolution.
- But strong seasonal climate of hot dry summers and cool wet winters promotes cementation of CaCO_3 as calcite.
- Known as syngenetic karst development.

Karst features



Surface solution pipes



Ngilgi Cave



An extreme karst landscape



Aeolianites - products of dissolution & cementation



- Carbonate sands on shoreline are blown ashore as dunes.
- Once stabilized by vegetation, partial dissolution by acid water.
- Become lithified by subsequent calcitization.
- Importance of seasonal extremes of Mediterranean climate.
- Role of plant roots & mycorrhizal fungi.
- Subsequent erosion.



RHIZOLITHS

fossil roots

Presence of organic acids around roots, enhanced by presence of mycorrhizal fungi around roots. Produce oxalic acid. Causes dissolution, then facilitates reprecipitation of CaCO_3 around root as calcrete.

Results in preferential hardening of the limestone.

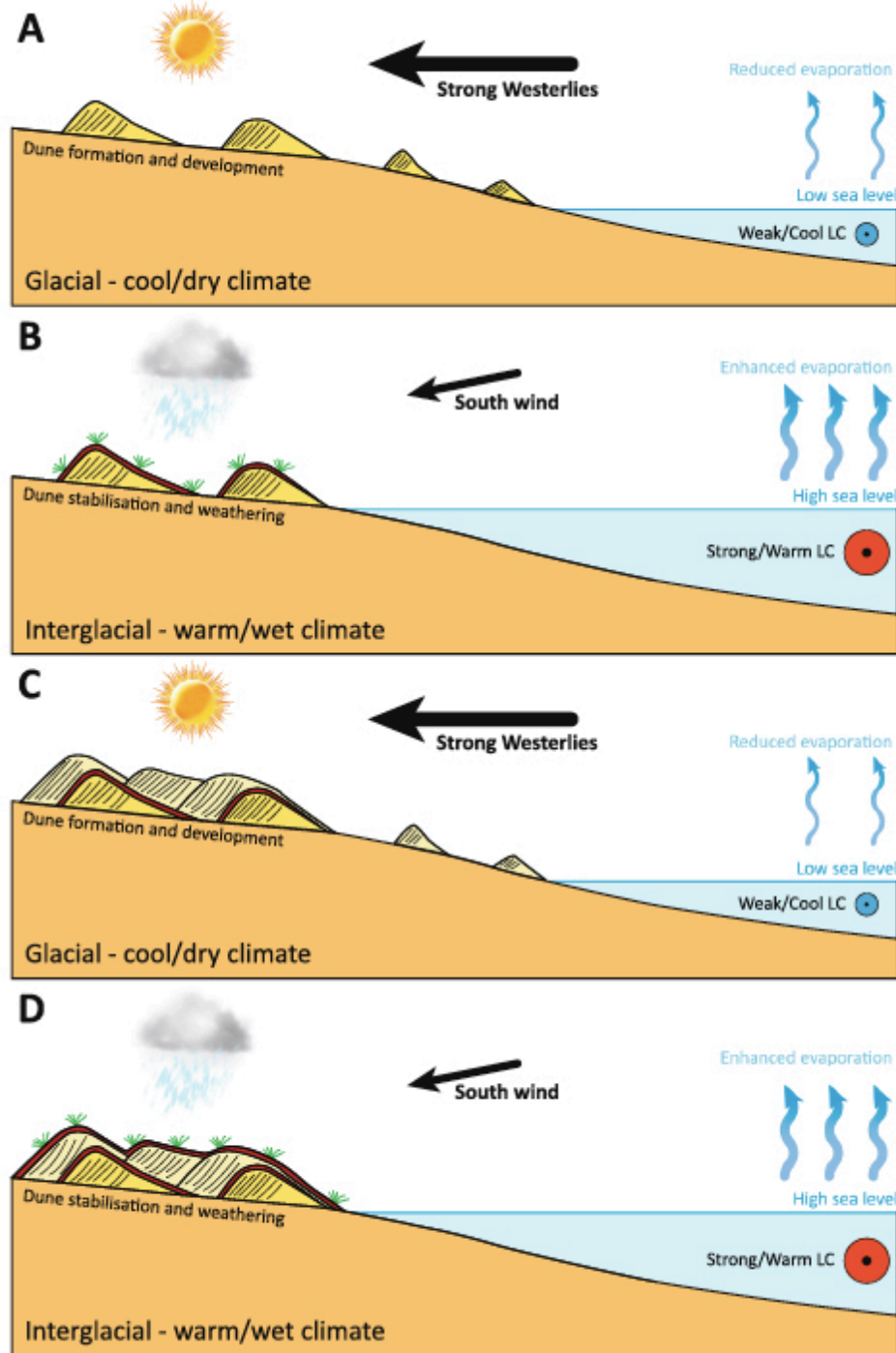
Observed at Bald Head in late 18th/early 19th centuries by Vancouver, Flinders, Darwin.

Rhizoliths forming in periodically mobile dune. Recent deflation exposed the rhizoliths - Pinnacles Desert.





- Depositional discontinuities are marked by palaeosols and (palaeo)karst features.
- Depositional intervals broadly follow glacial and interglacial cycles of the Pleistocene.

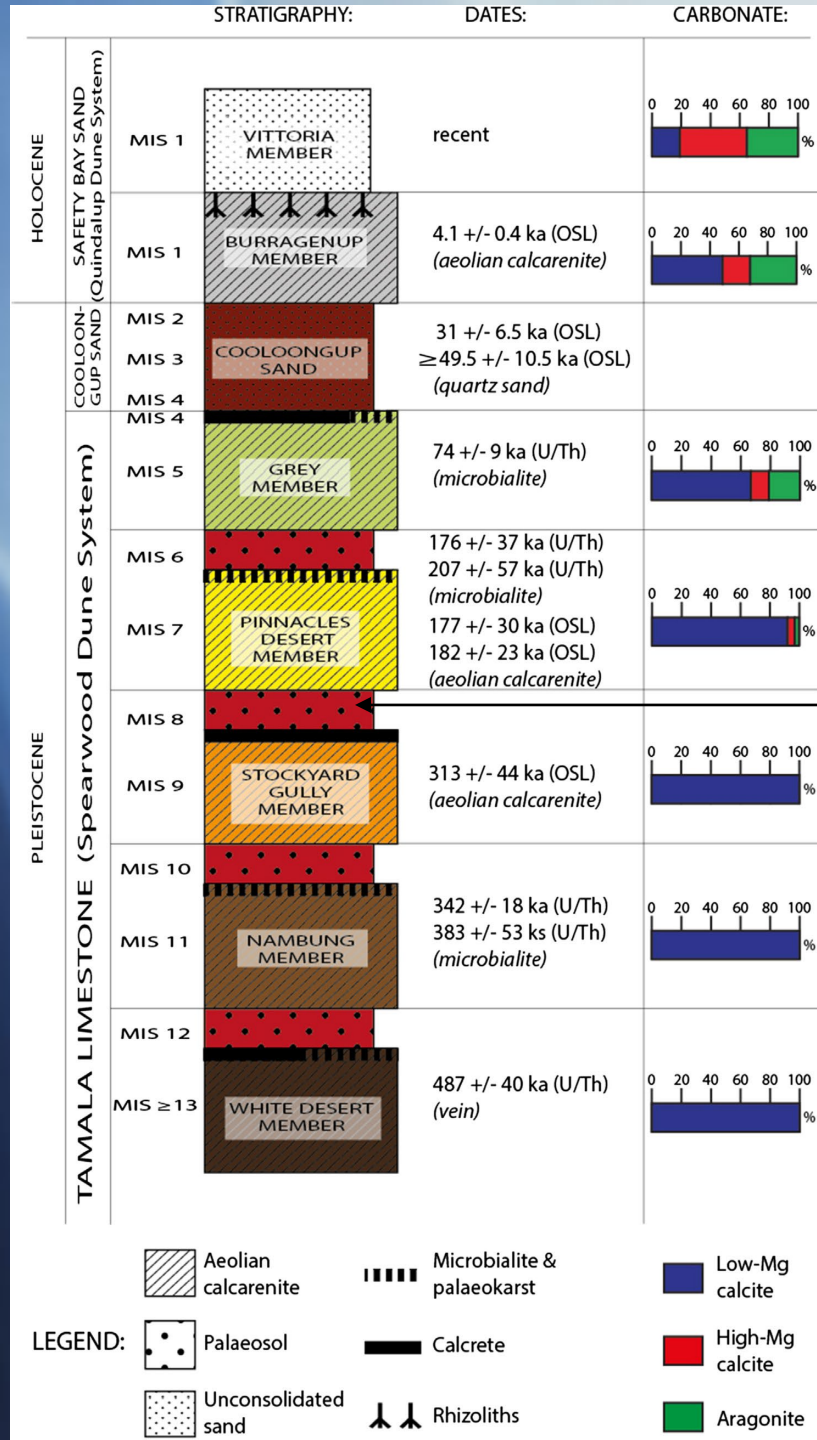


- Tamala Limestone generated by glacial and interglacial cycles.
- Cyclicity of approximately 100,000 years.
- During glacial periods, sea level about 130 metres lower than during interglacials, such as today.
- Dune sands generated during dry glacials and blown inland.
- Stabilised by vegetation and lithified during interglacials.

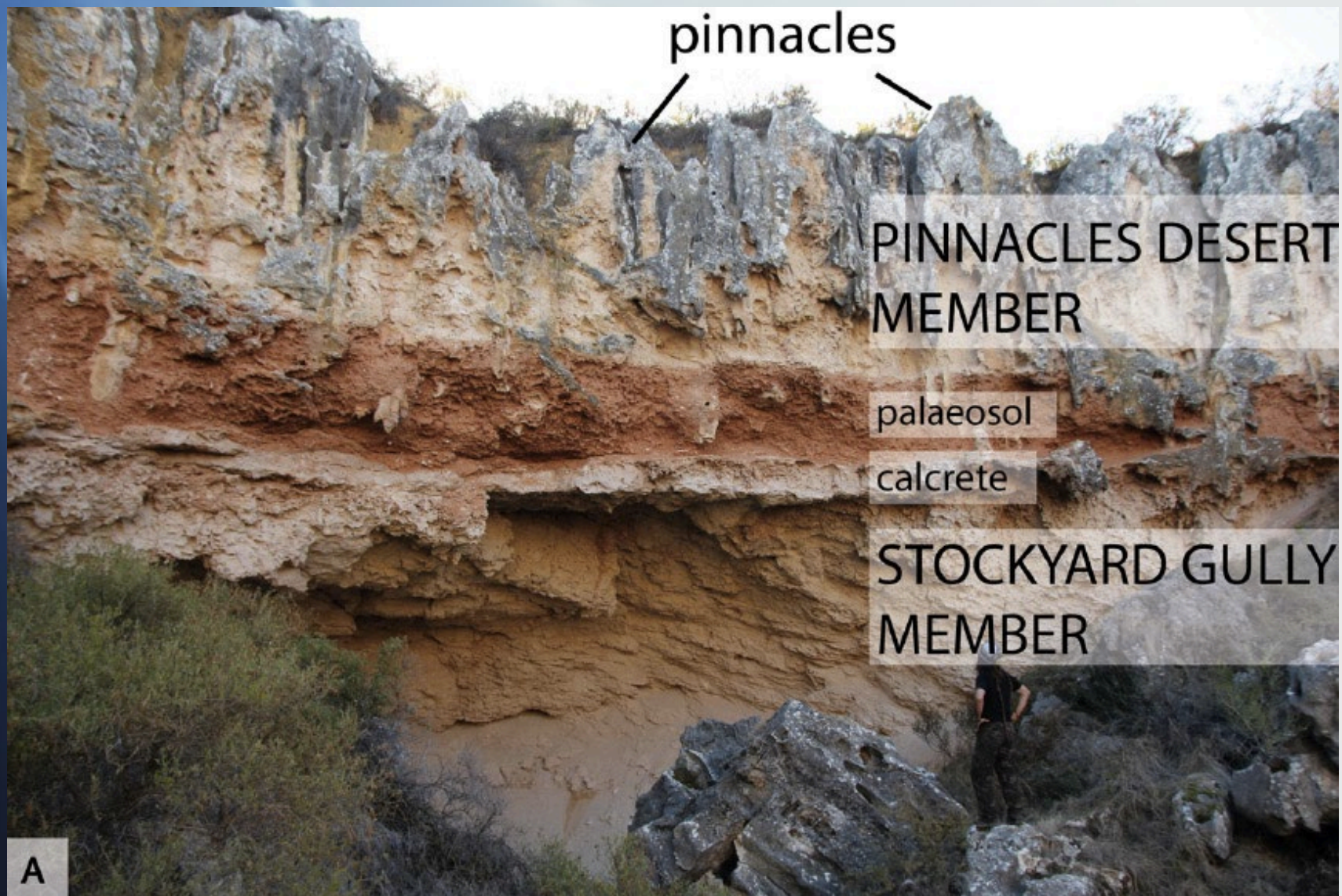


Recent dune becoming stabilised

100,000 yr old Tamala Lst



MIS = Marine Isotope Stage
OSL = Optically stimulated luminescence



Fossil remains from palaeosols



Extinct fossil wombat,
Vombatus hacketti



Extinct fossil kangaroo,
Protemnodon sp.



Fossilised pupal cases of weevil
Leptopius ?duponti

The landsnail *Bothryembrion*

Leptopius duponti



Field Guide to the
Insects of Tasmania



Nest of pupal cases
of weevil *Leptopius*

KARSTIFICATION



Solution pipes and incipient pinnacle formation Mt Eliza, Perth.

SOLUTION PIPES



Solution pipes in calcrete south of Mudurup Rocks, Cottesloe

- Extend from 2 to 9 m below surface.
- As dissolve insoluble quartz sand accumulates in pipes.
- Secondary precipitation of layers of calcrete around pipe.
- Trees and shrubs important in their formation. Water down trunk concentrates at base, extreme dissolution below plants.
- Any depression with accumulation of leaf litter increases water acidity and dissolution.



Pinnacle in residual
quartz sand
(Cooloongup Sand) –

*Banks of the Swan River,
Pt Resolution, Dalkeith*



Solution pipes with residual quartz sand and incipient pinnacles.
Banks of the Swan River, Pt Resolution, Dalkeith



Weathering by development of solution pipes. These enlarge and merge leaving isolated pinnacles coated in secondary redeposited carbonate – calcrete.



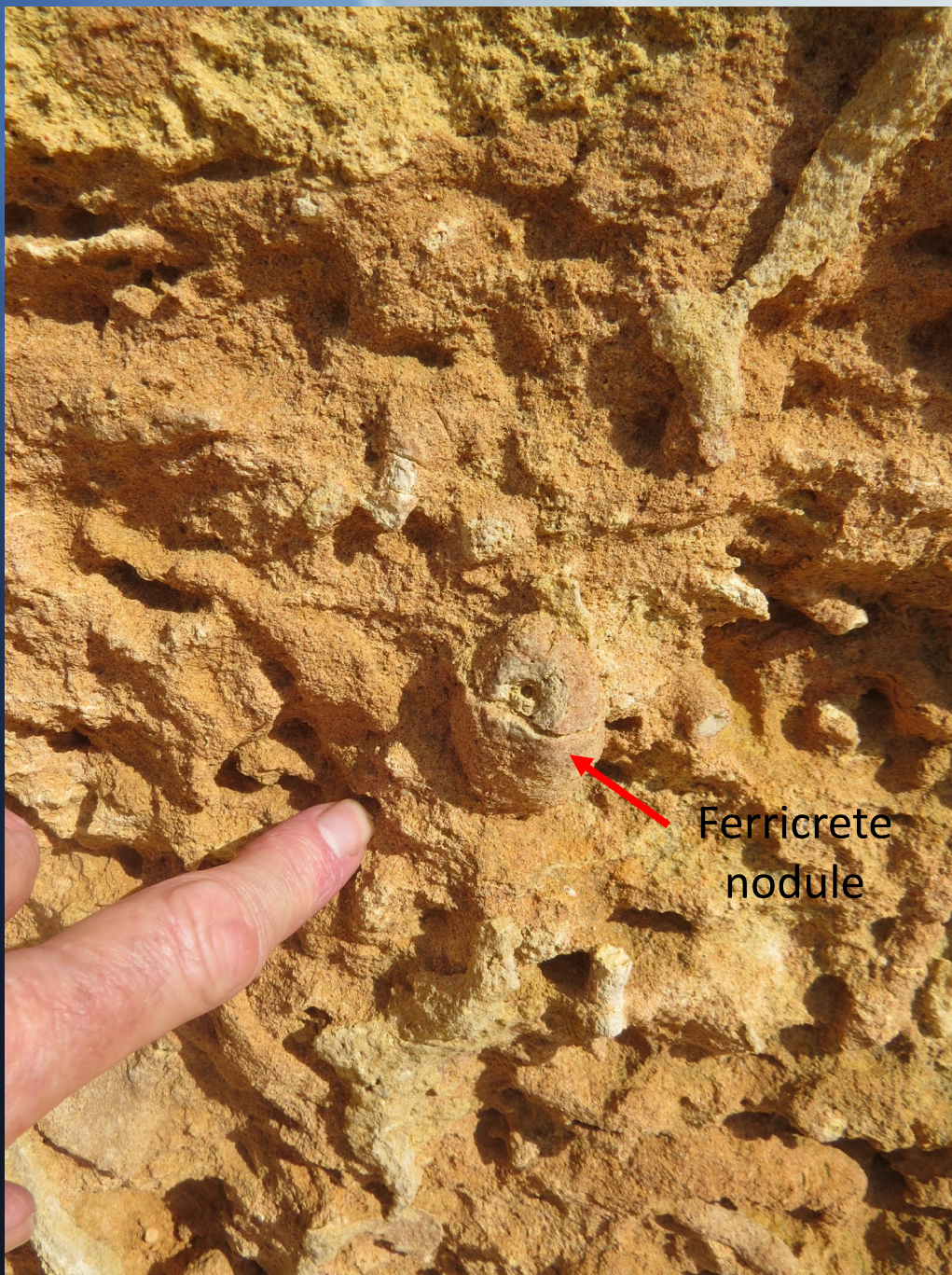
Calcrete layered peeling off exposing dune bedding within to show these were limestones that formed subaerially. The original aeolianite wrapped like a sausage roll by calcrete that lined the solution pipe that has now disappeared.



Original continuous lithified carbonate dune (aeolianite) subsequently severely weathered (karst weathering). Insoluble quartz develops as modern 'dunes' between pinnacles

So when did the Pinnacles and other karst features in the Tamala Limestone form?





- The development of the extreme karst landscape in the Tamala Limestone, as exemplified by the Pinnacle Desert, was driven by unprecedented period of extremely high and prolonged rainfall about 100,000 years ago.
- This based on recent research led by Matej Lipar dating ferricrete nodules found attached to side of pinnacle.
- It has been suggested that this was the wettest interglacial period in the past 500,000 years.





Thanks to Matej Lipar of the
Slovenian Academy of
Sciences and Arts

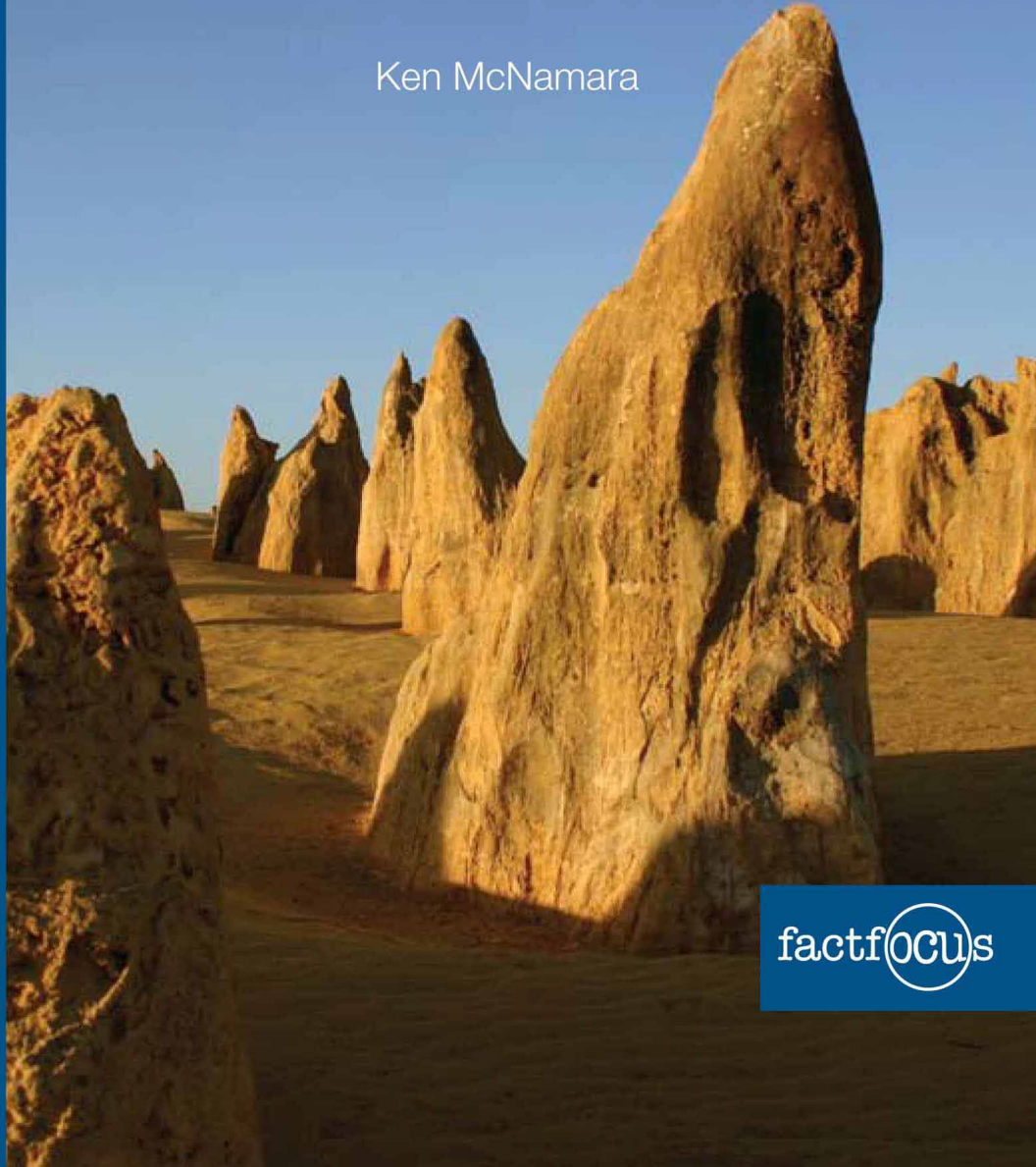
Pinnacles

Ken McNamara

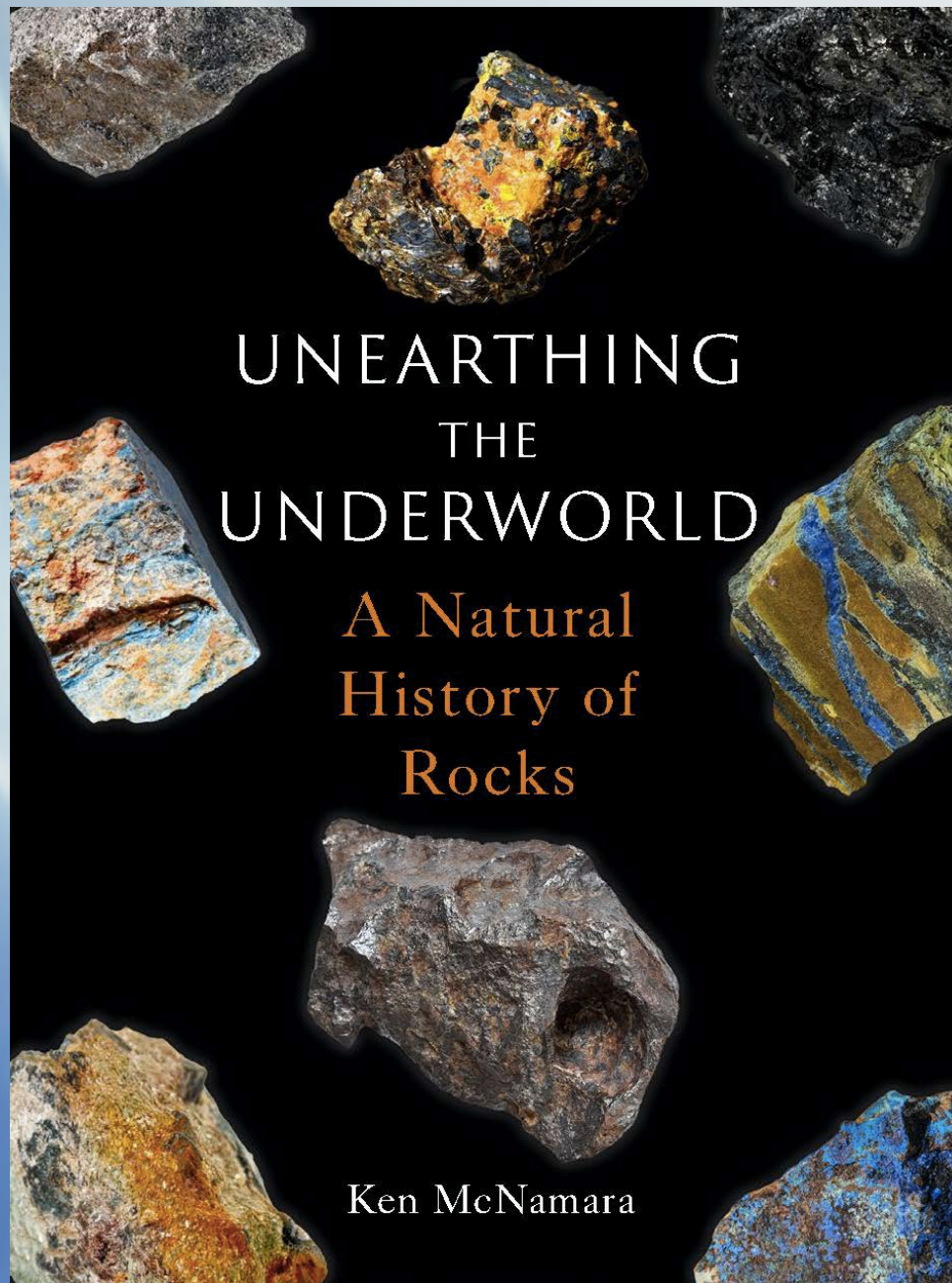
Western Australian Museum

Pinnacles

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