

Subterranean wetlands of arid Australia: remipedes, spelaeogriphaceans & diving beetles

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Western Australian Museum,
South Australian
Museum, Adelaide University



Stable but dynamic Australia

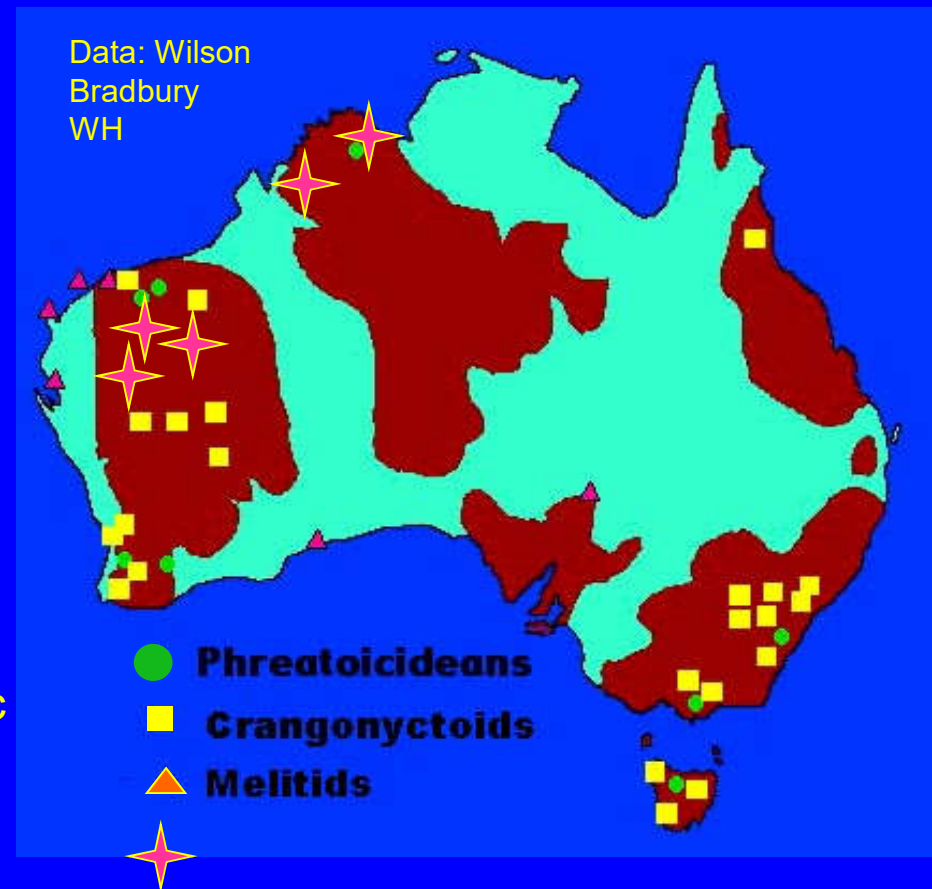
Emergent since Proterozoic

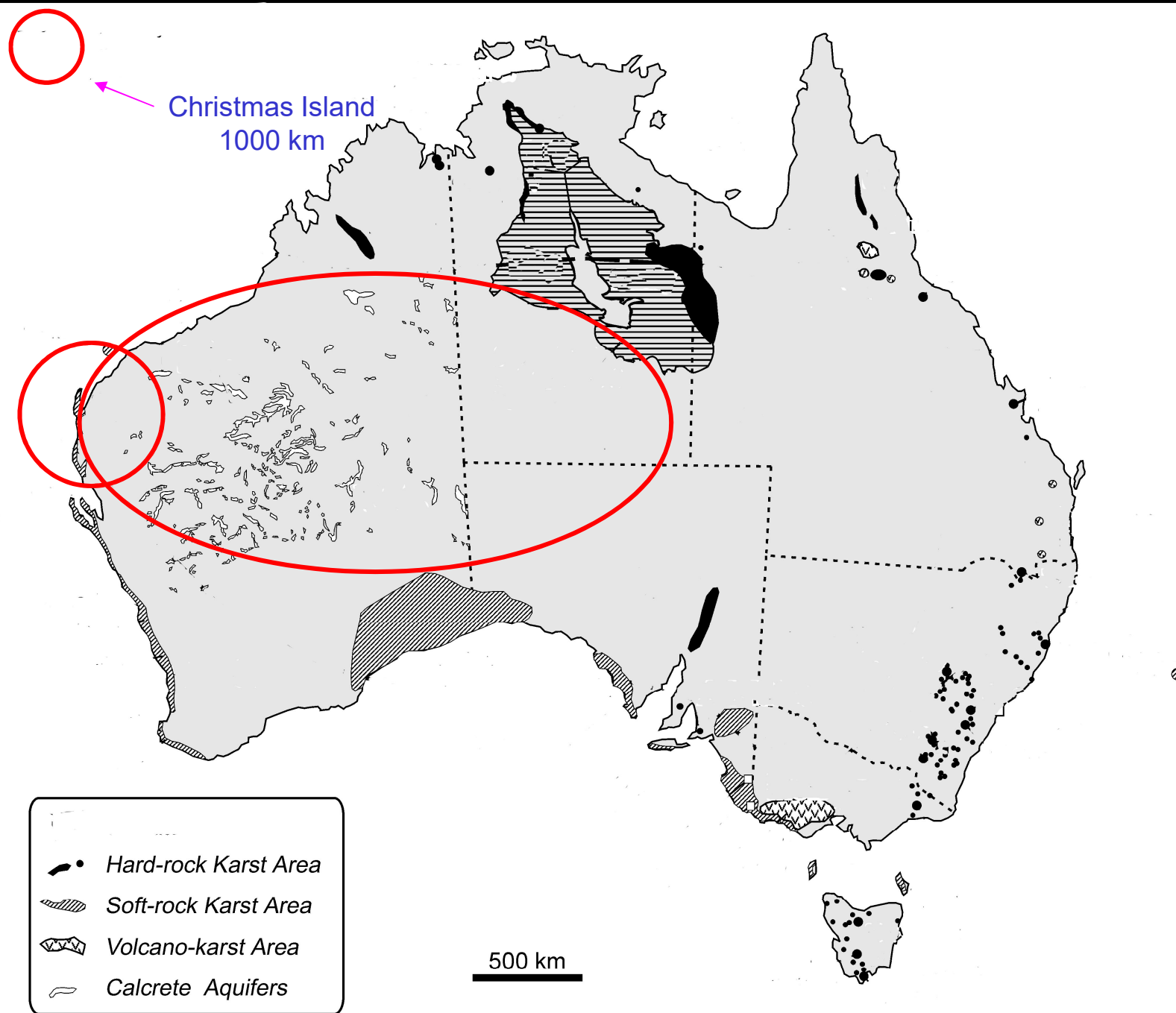
Cretaceous inundation

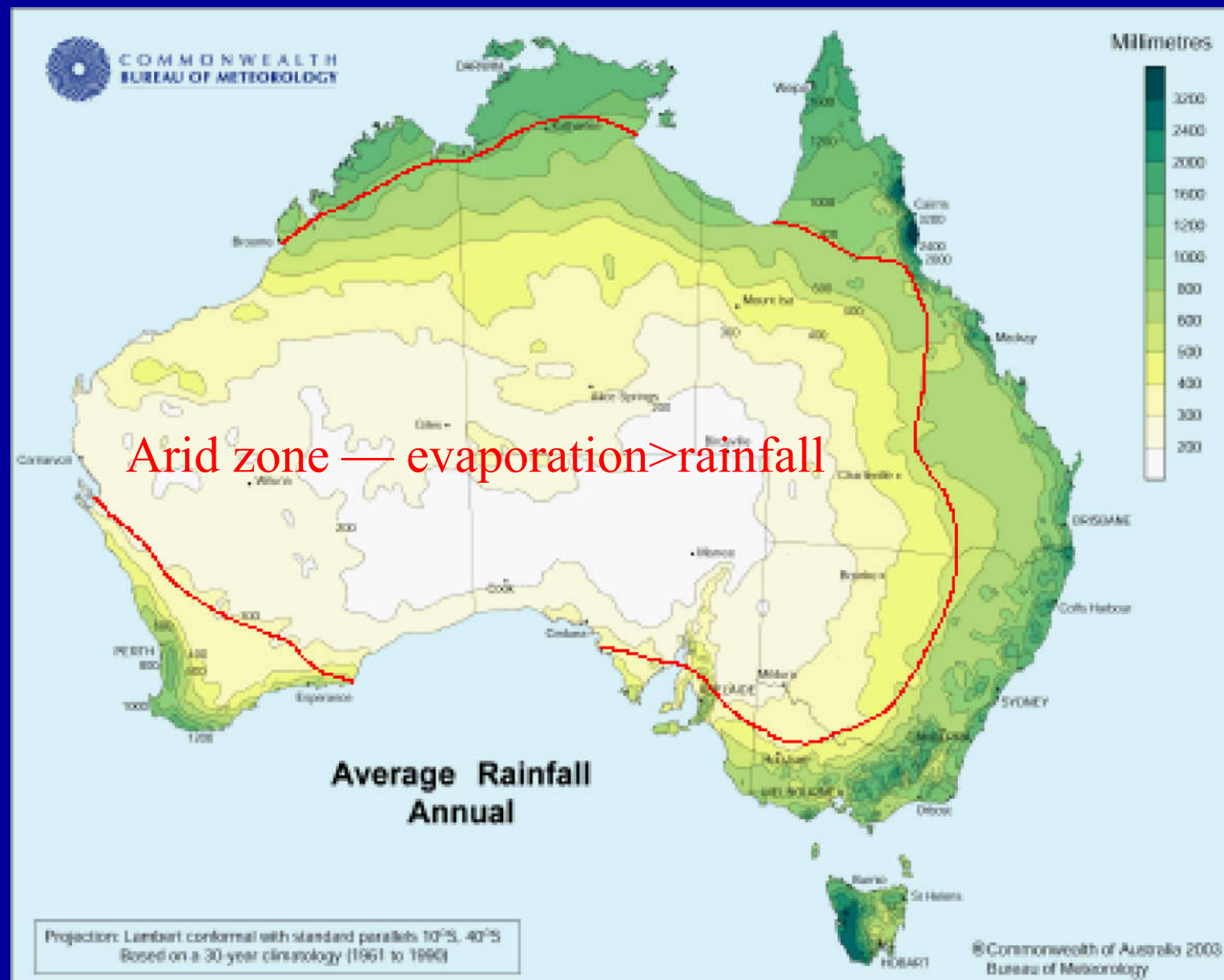
Islands of freshwater ancients
and shore colonisation.

Denudation: 6 km since Jurassic
12 km since Permian
(Belton et al. 2004)

changes geological
context:

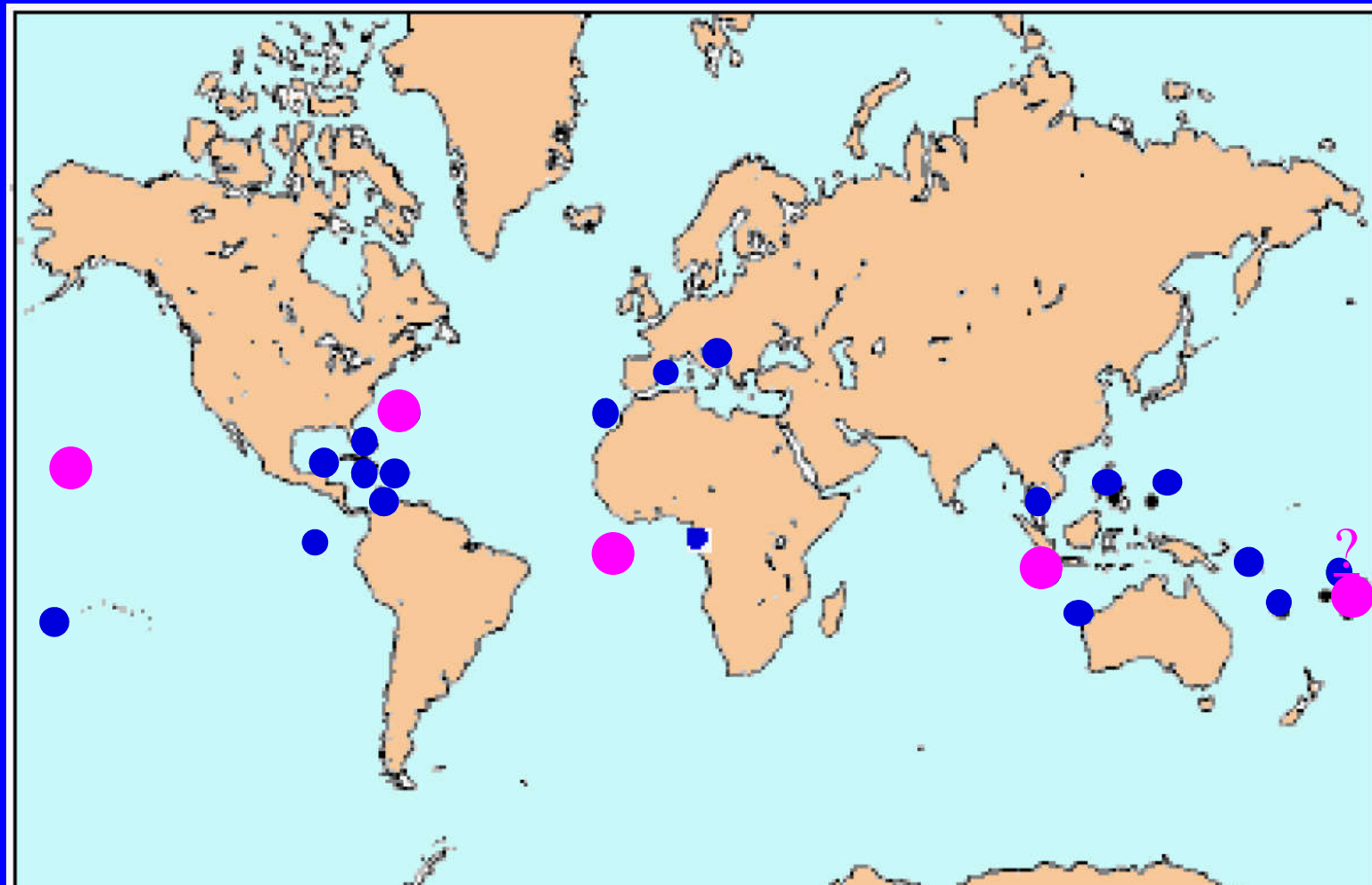


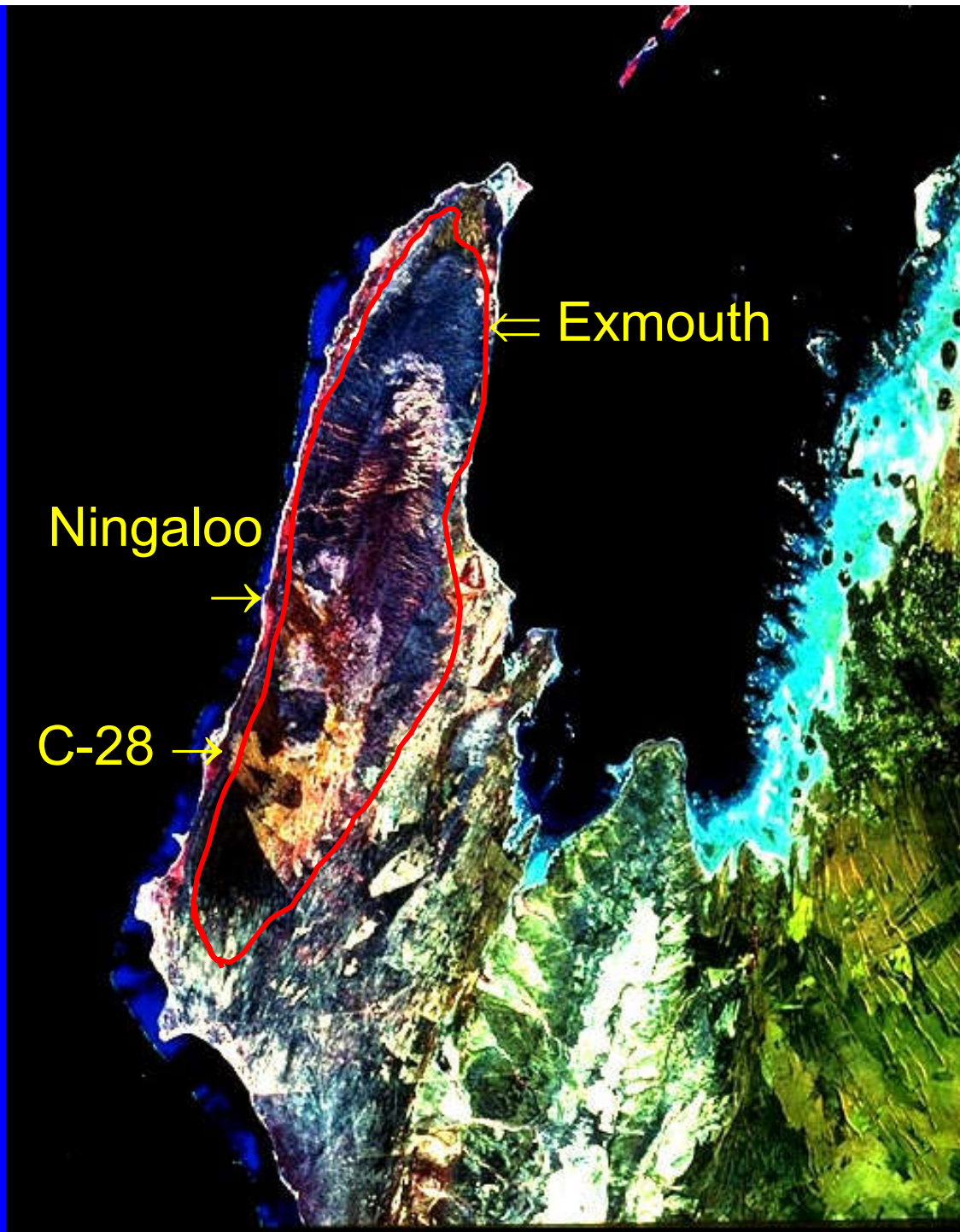




Anchialine systems

Circum-global distribution—tropics and subtropics
Epicontinental and oceanic anchialine systems
mostly in arid areas





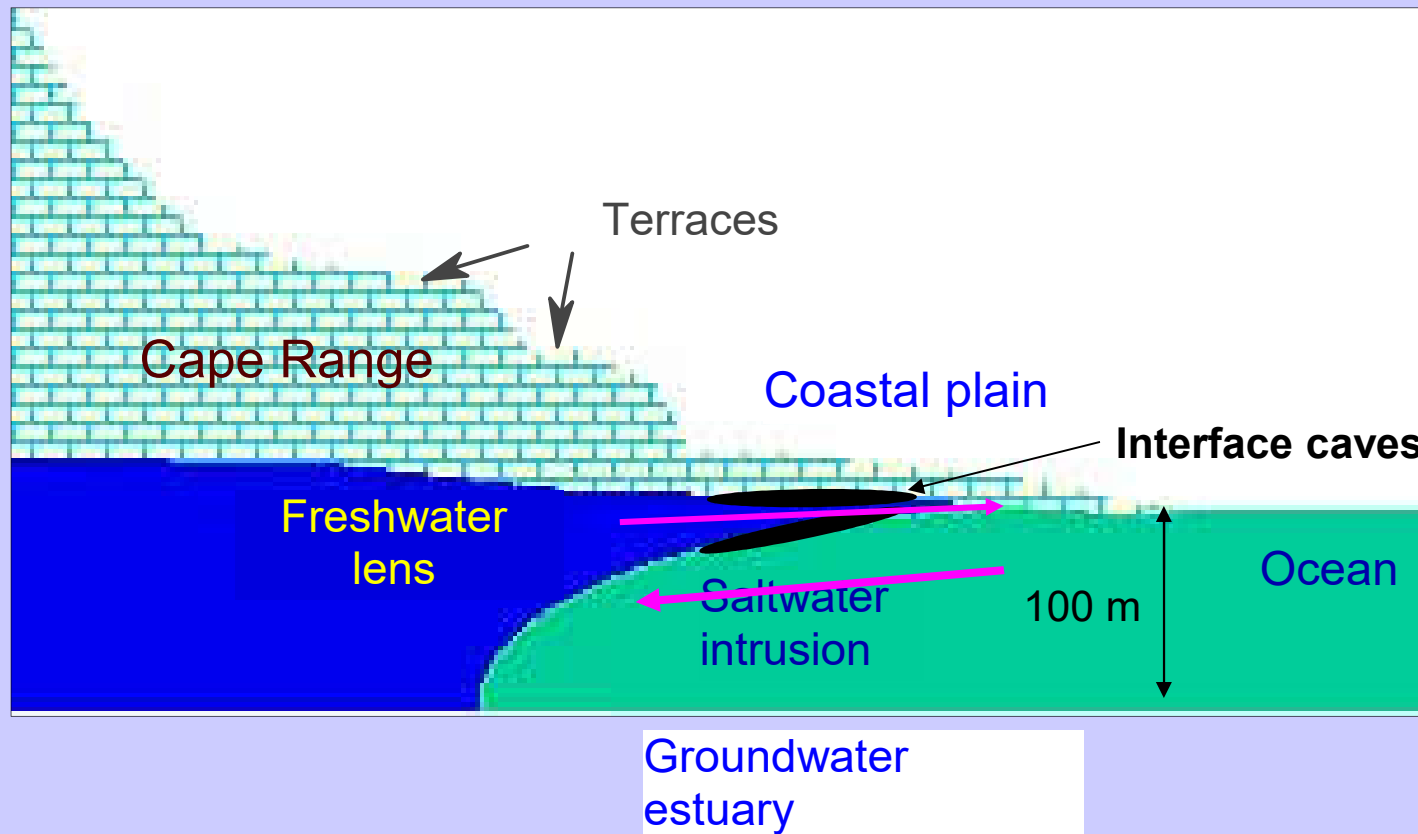
Cape Range peninsula

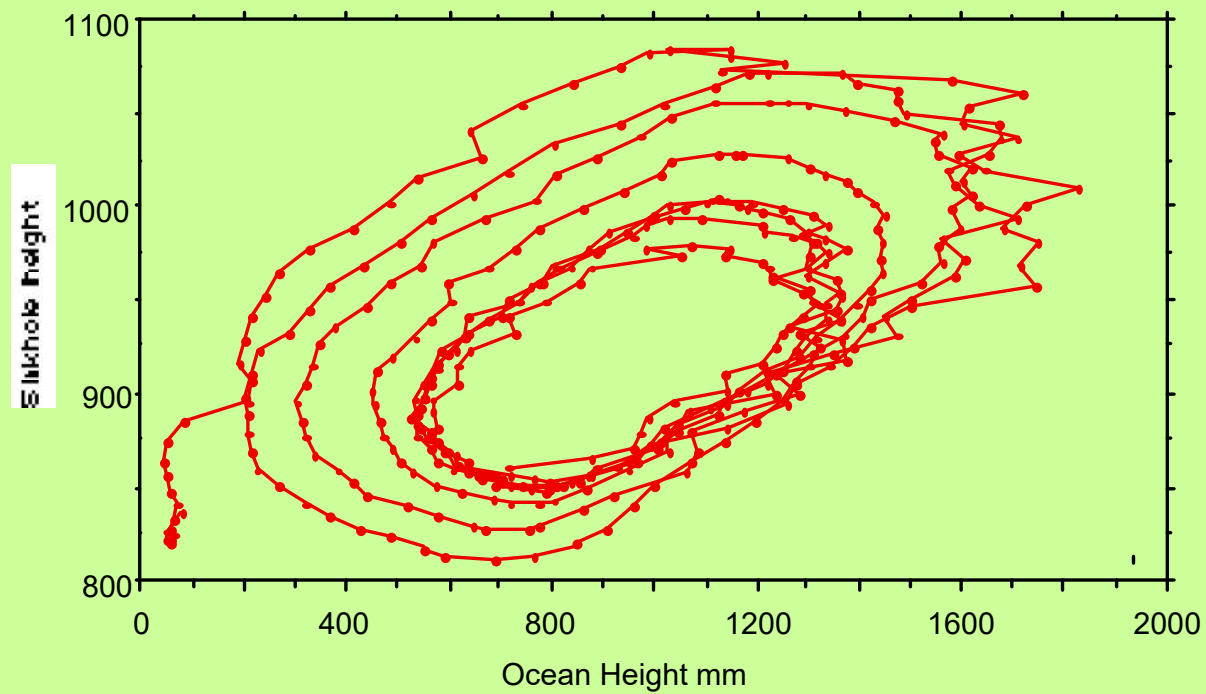
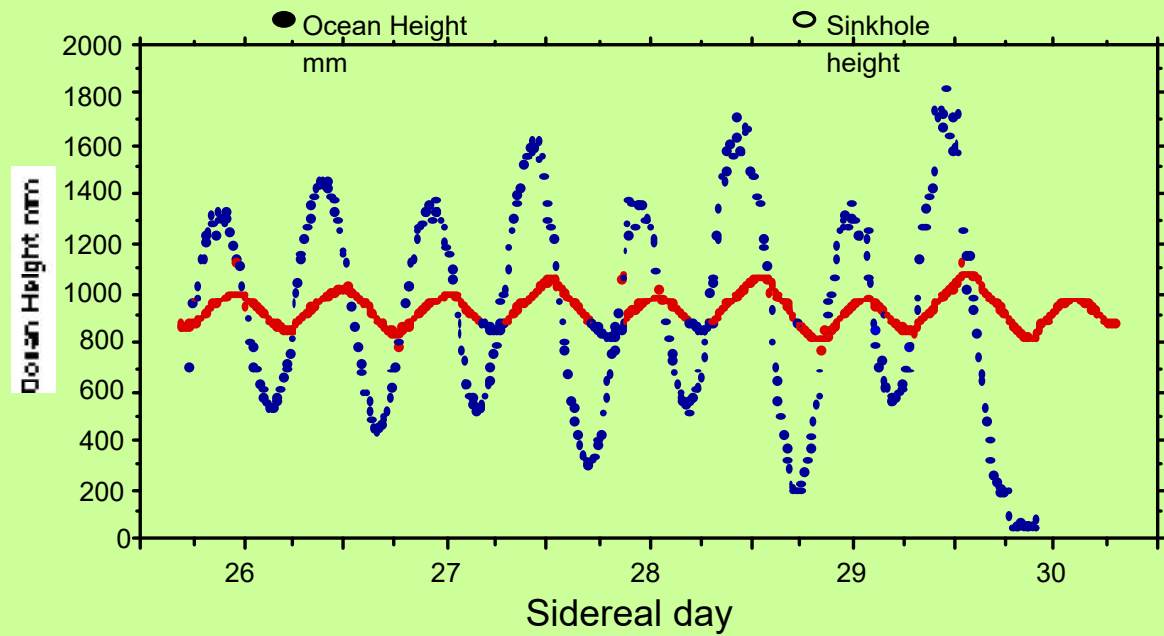
Bundera Sinkhole

The most important biodiversity site in Australia



Cape Range — hydrological environment near the coast



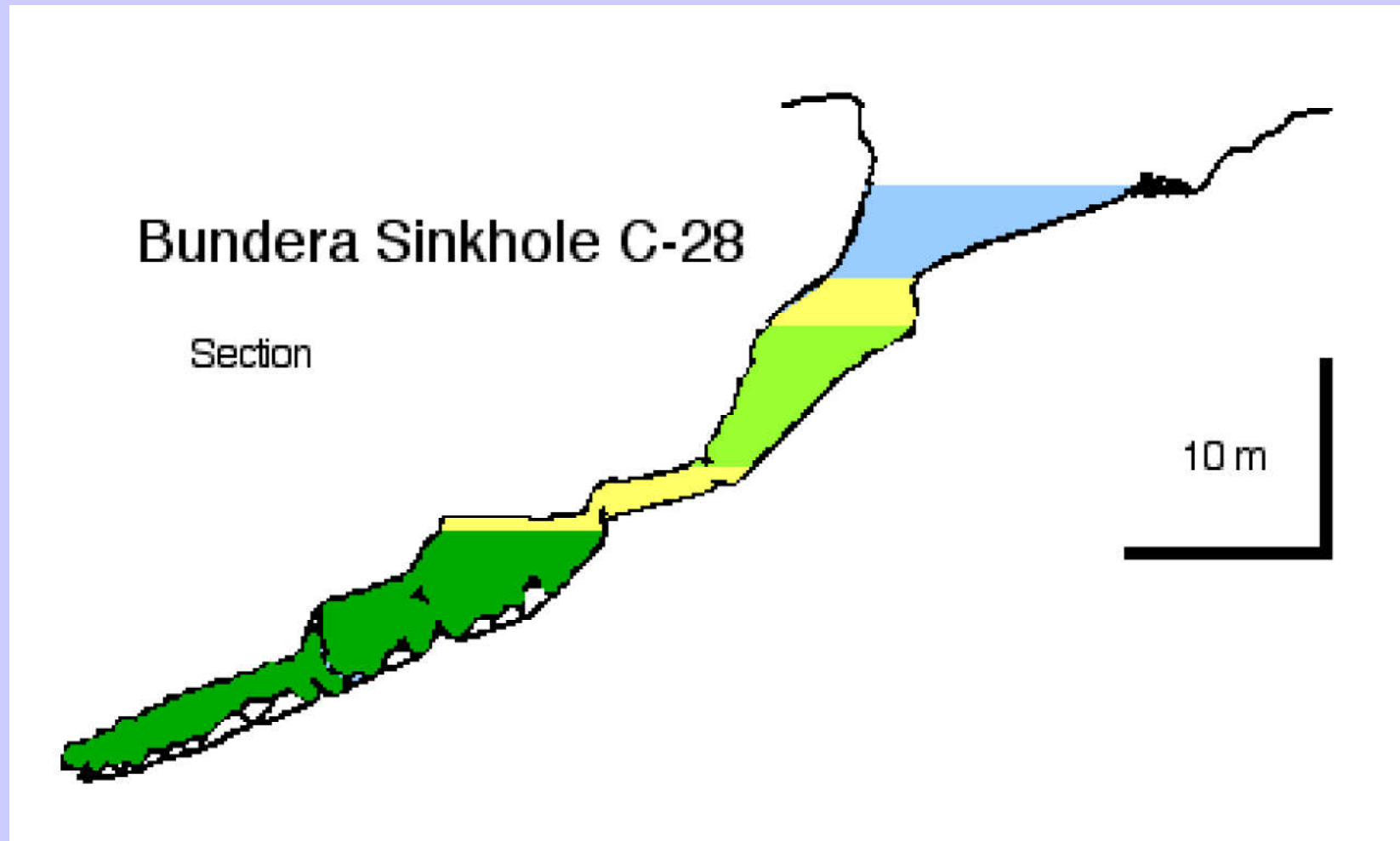








Bundera Sinkhole C-28

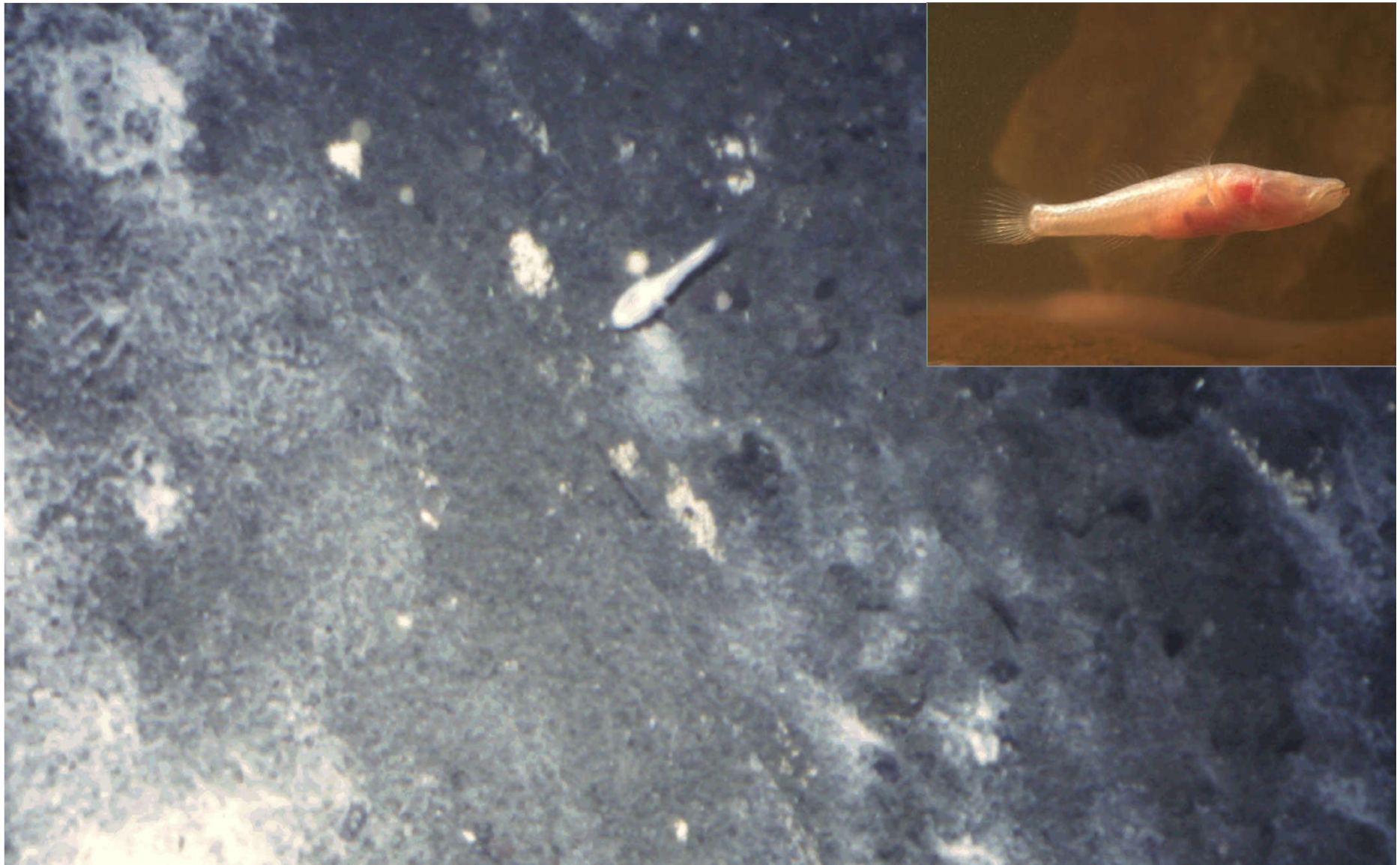




Large white gliding filamentous sulphur oxidizing bacteria (chemolithoautotrophs)

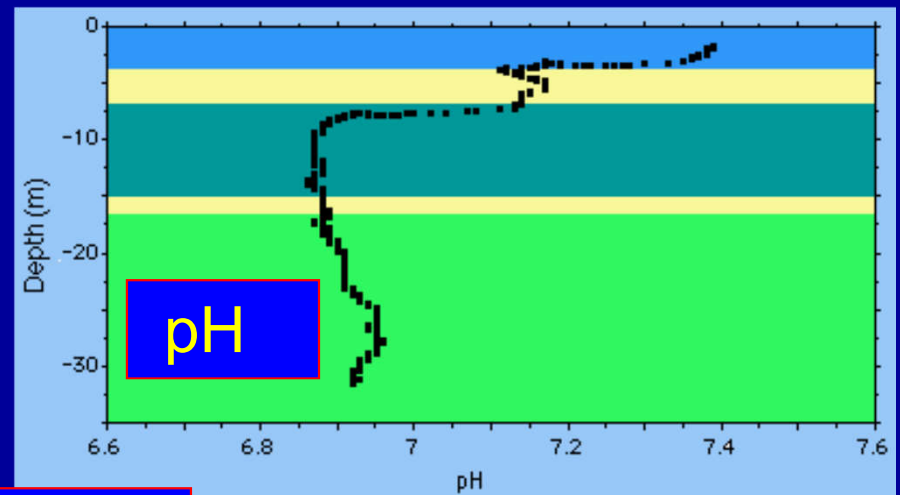
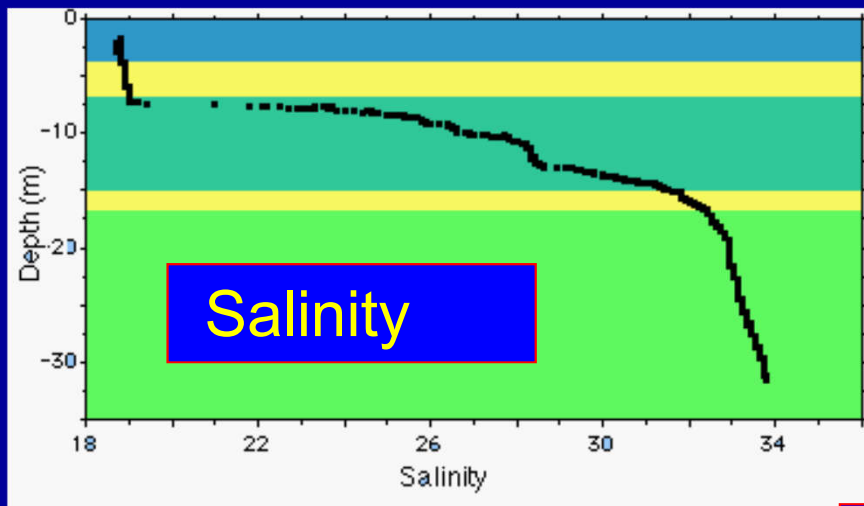
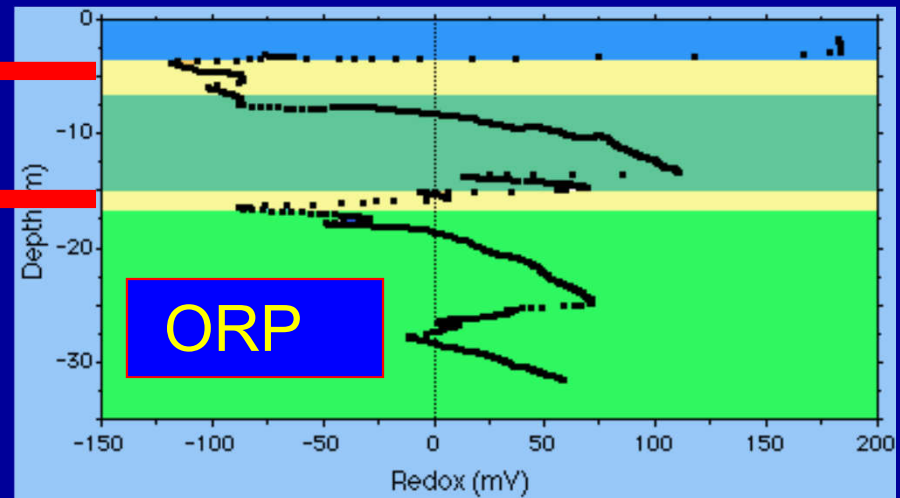
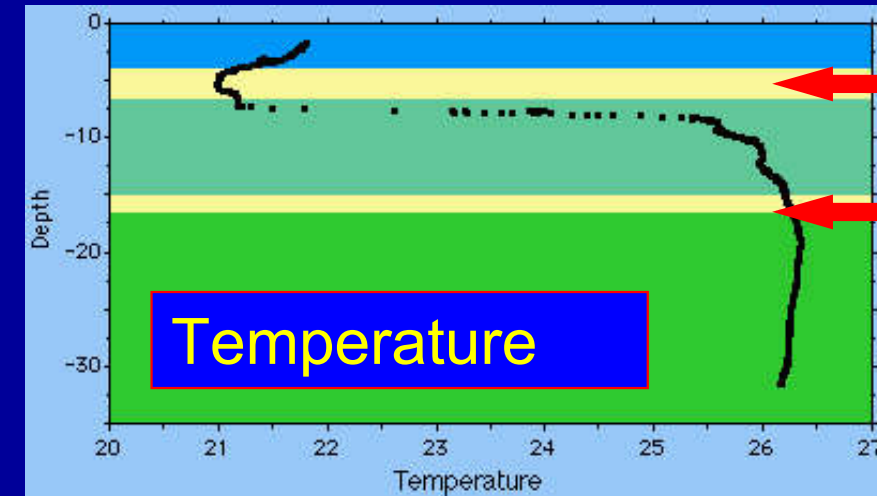


***Thioploca* tracking
the oxic / anoxic
boundary**



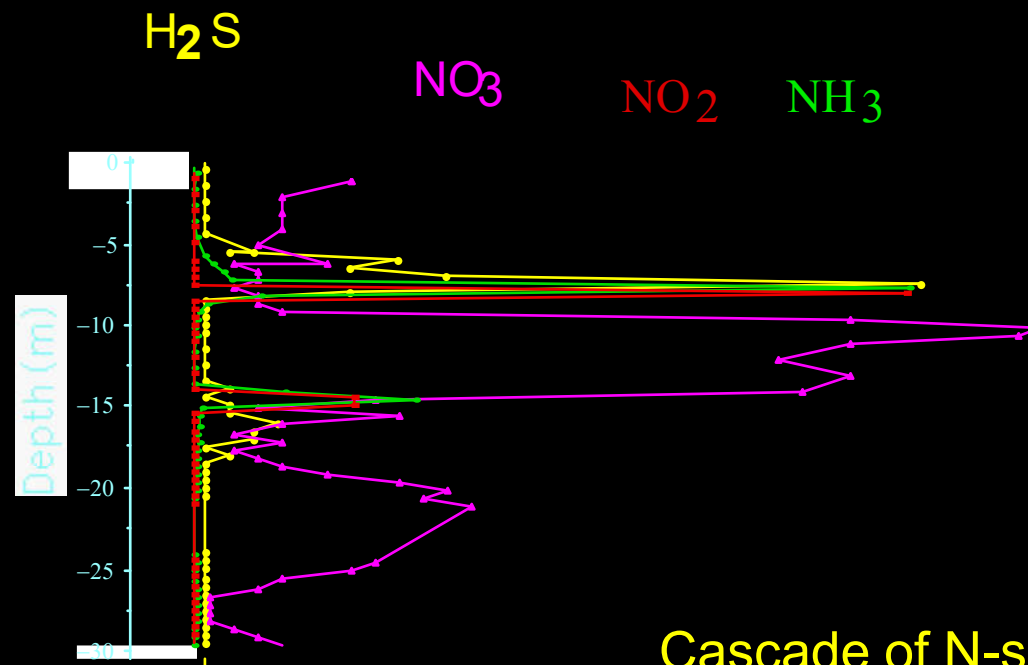
Motile filaments (*Beggiatoa* spp.) on sediments and attached filaments on solid surfaces (commonly *Thiotrix* spp). Photo: Stefan Eberhard, Western Australia Museum

Gradients: Depth profile: Bundera Sinkhole



H_2S

N-species profiles: Bundera Sinkhole



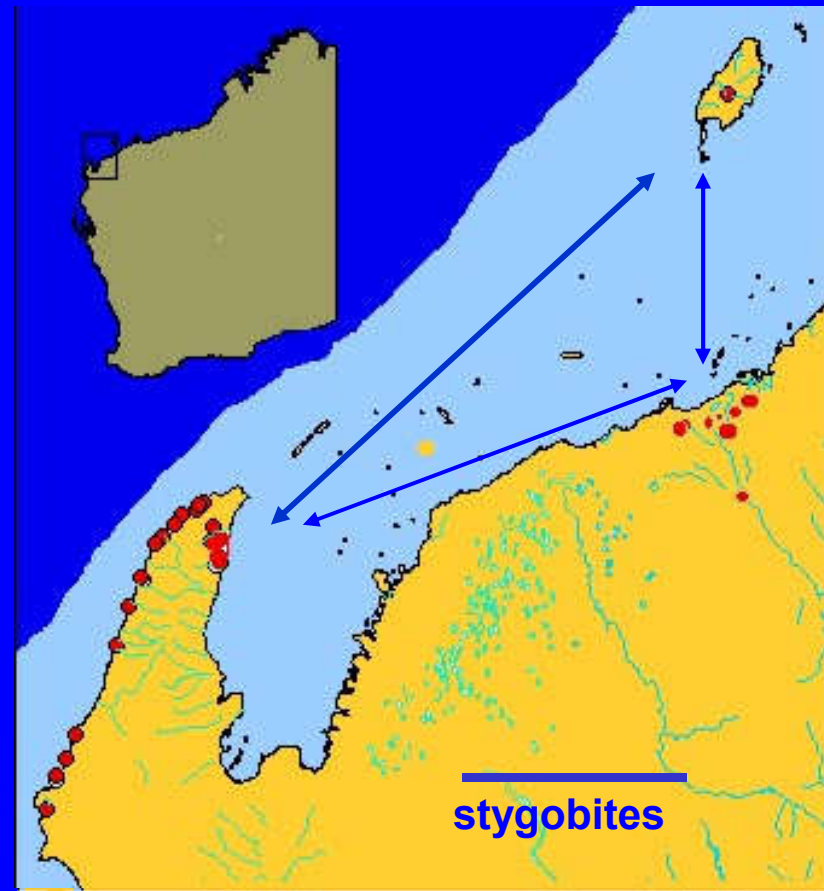
Cascade of N-species in upper few metres equivalent to the upper few mm of anoxic muds

Remiped anchialine fauna

- Structure highly predictable (~ generic composition)
- Characteristically with atyid shrimps, thermosbaenaceans, hadziid amphipods, cirolanid isopods, remipeds, thaumatocypridid ostracods.
- Many copepods (epacteriscid, pseudocyclopiid, and ridgewayiid calanoids, halicyclopine cyclopoids, speleophriid misophrioids, superornatiremid harpacticoids.)
- Only known from NW Australia, Canary Is, northern Caribbean (Grand Bahamas Banks, Cuba, Quintana Roo, Yucatan)

Holocene marine transgression

Holocene — rise from ~150 m drowned karst platforms, fragmented troglafauna and elevated anchialine fauna



Fauna from Cape Range and environs anchialine system

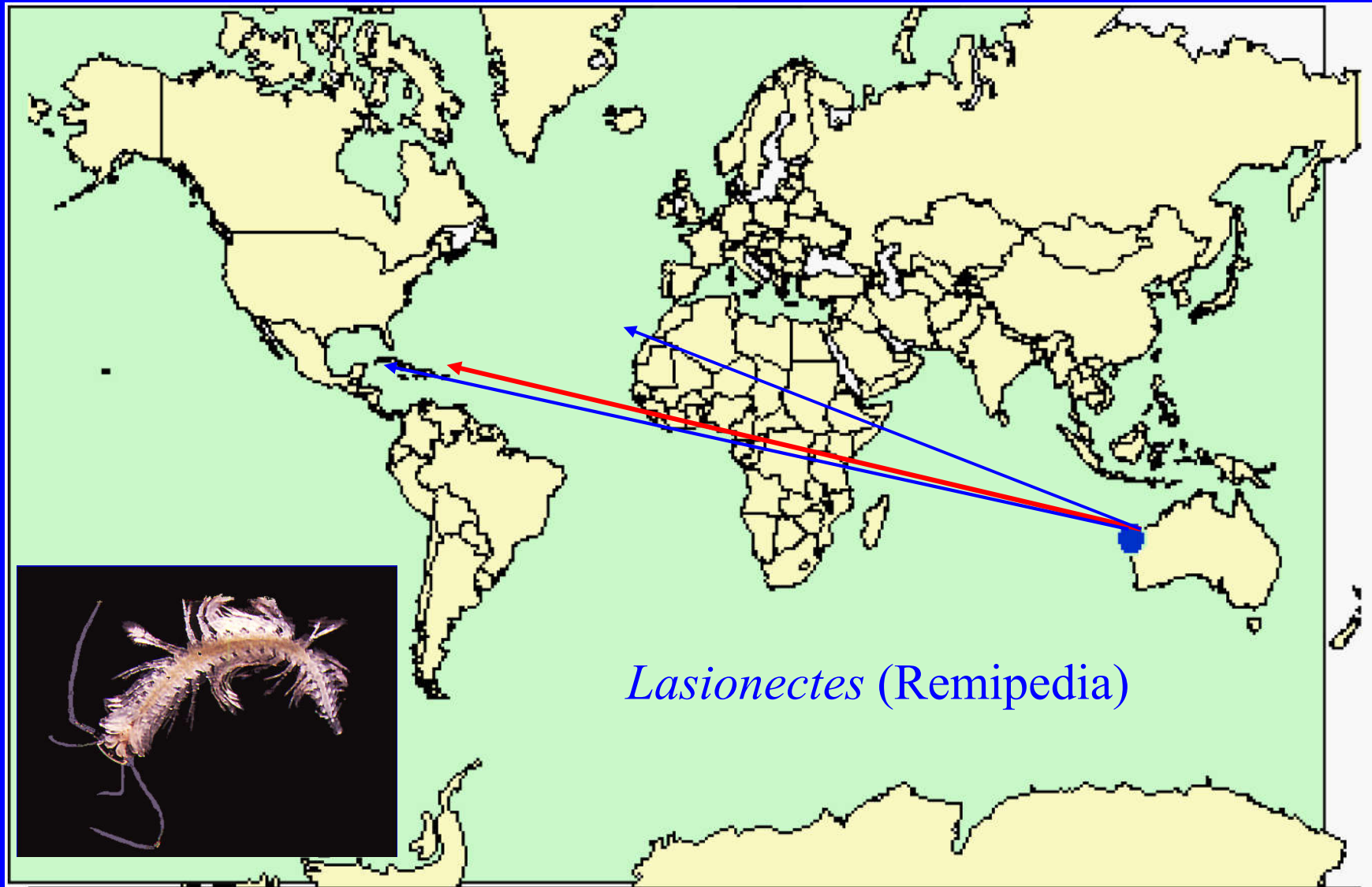
<i>Milyeringa veritas</i>	Perciformes: Eleotridae	1 of 2 stygobitic vertebrates in Oz	Bundera, CRP, BWI
<i>Ophisternon candidum</i>	Osteichthyes: Synbranchidae	1 of 2 stygobitic vertebrates in Oz	CRP
<i>Halosbaena tulki</i>	Thermosbaenacea: Halosbaenidae	New Order for SH	CRP, BWI, Pilbara
<i>Stygiocaris stylifera</i>	Decapoda: Atyidae	New genus, endemic	Bundera, CRP, BWI, Pilbara
<i>Stygiocaris lancifera</i>	Decapoda: Atyidae		CRP
<i>Haptolana pholeta</i>	Isopoda: Cirolanidae	New gen. for SH	CRP, BWI, Pilbara
<i>Halicyclops longifurcatus</i>	Copepoda: Cyclopoida: Cyclopidae		CRP
<i>Phyllopodopsyllus wellsi</i>	Copepoda: Harpacticoida	New genus for Oz Only stygal sp in gen.	CRP

Fauna from suboxic section of Bundera Sinkhole

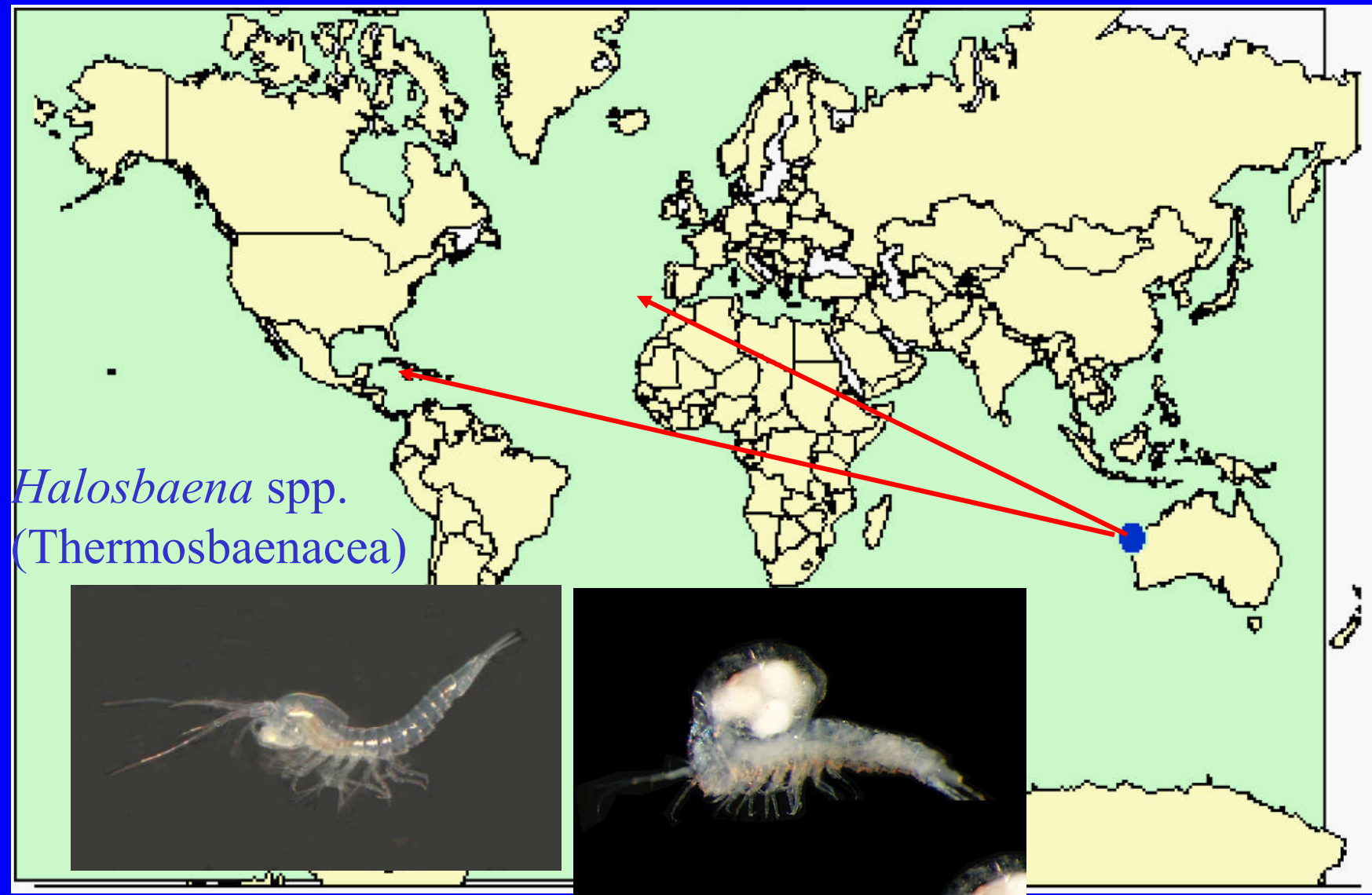
<i>Prionospio thalangi</i>	Polychaeta: Spionidae	Only stygobite in genus
<i>Danielopolina kornickeri</i>	Ostracoda: Halocyprida: Thaumatoocyprididae	New Family for SH
<i>Lasionctes exleyi</i>	Remipedia: Nectiopoda: Speleonectidae	New Class for SH
<i>Liagoceradocus branchialis</i>	Amphipoda: Hadziidae	
<i>Bunderia misophaga</i>	Calanoida: Epacteriscidae	New Family for SH
<i>Speleophria bunderae</i>	Copepoda: Misophrioida: Speleophriidae	New Order for SH
<i>Stygocyclopia australis</i>	Calanoida: Pseudocyclopiidae	New Family for Oz



Lasionectes: Remipedia

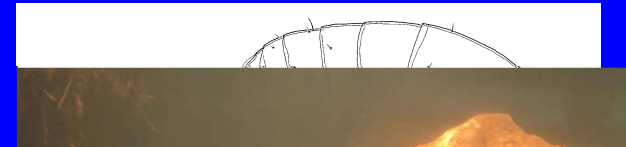


Affinities of the anchialine fauna



Variations on this theme in:

Bunderia cf *Enantronoides*
Epacteriscidae (Calanoida)



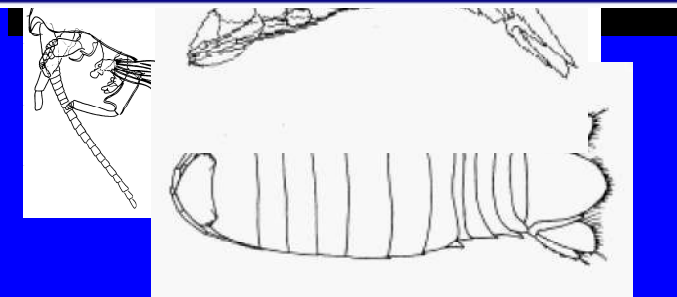
Ophisternon : Synbranch

Speleophria (Misophrioida)



Danielopolina (Ostracod)
Thaumatocypridoidea)

Stygocyclopia (Calanoida)



Haptolana (Isopoda: Cirolanidae)

Danielopolina (Thaumatocyprididae) Danielopol et al. 2000.

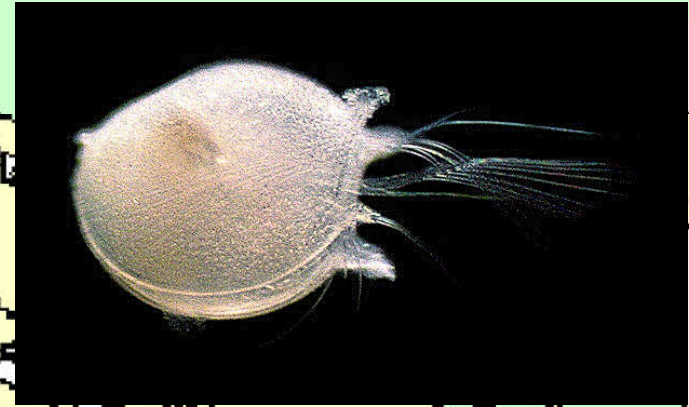
Pokornyopsis feifeli

Upper Jurassic

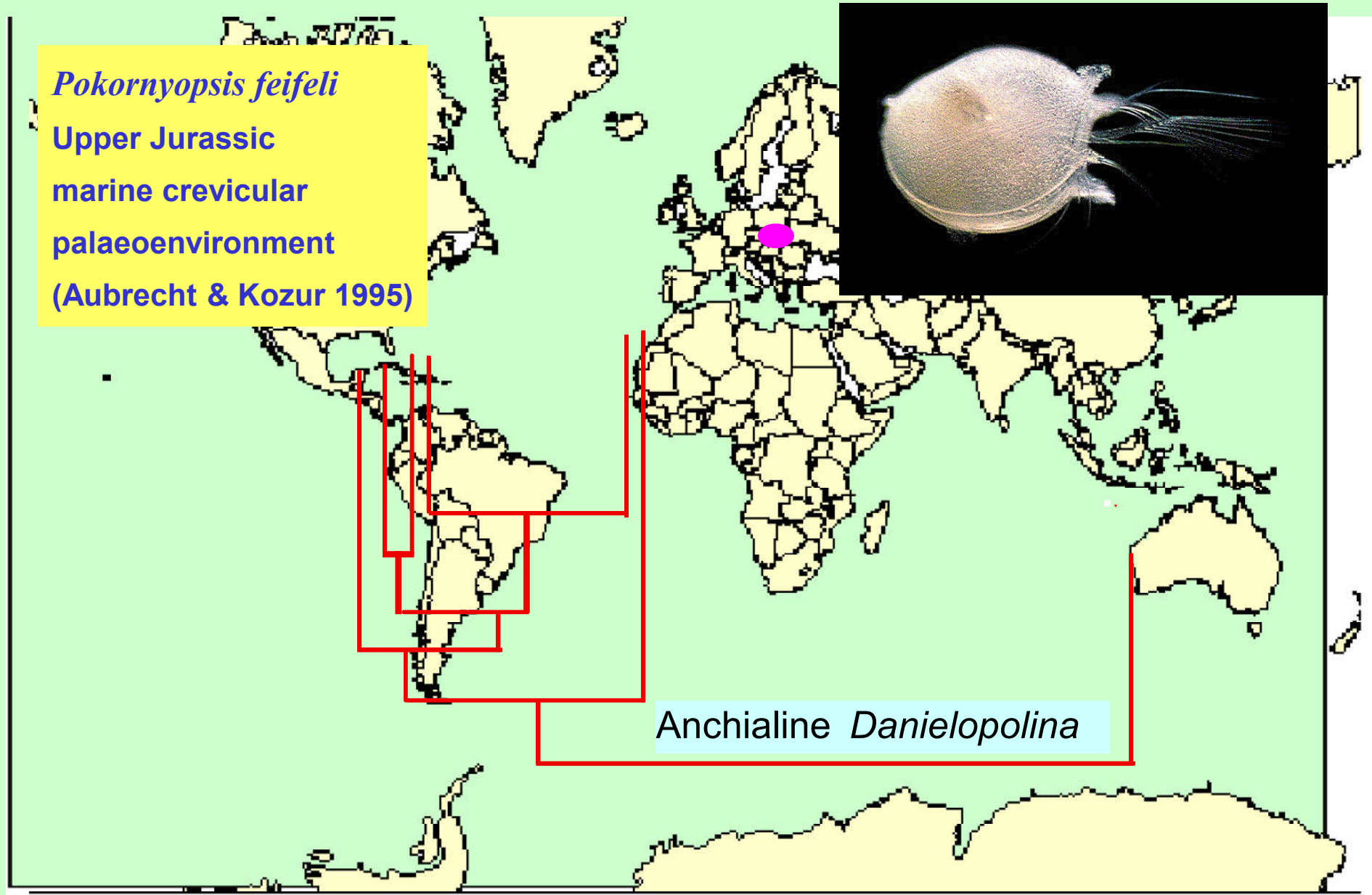
marine crevicular

palaeoenvironment

(Aubrecht & Kozur 1995)



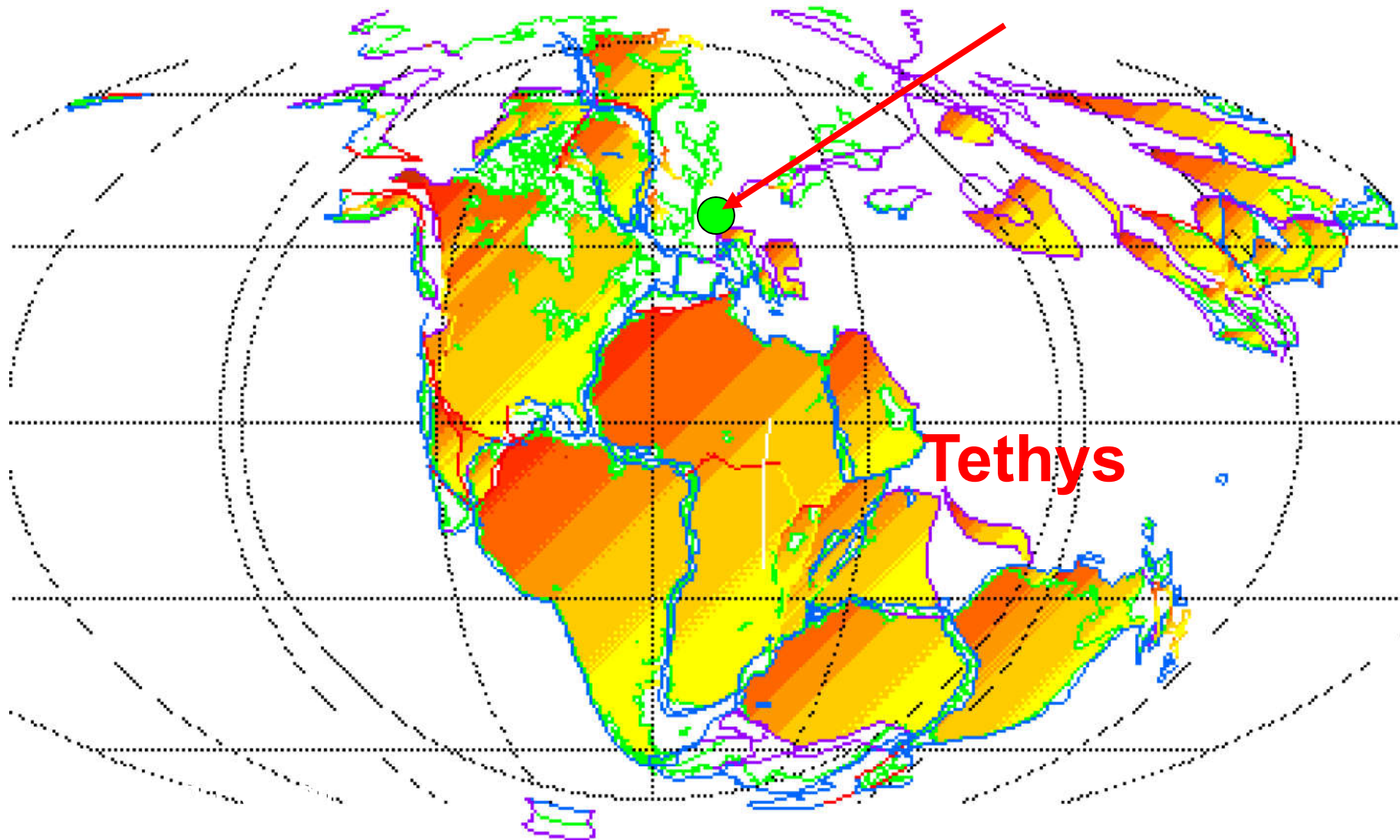
Anchialine *Danielopolina*



Tethys 1

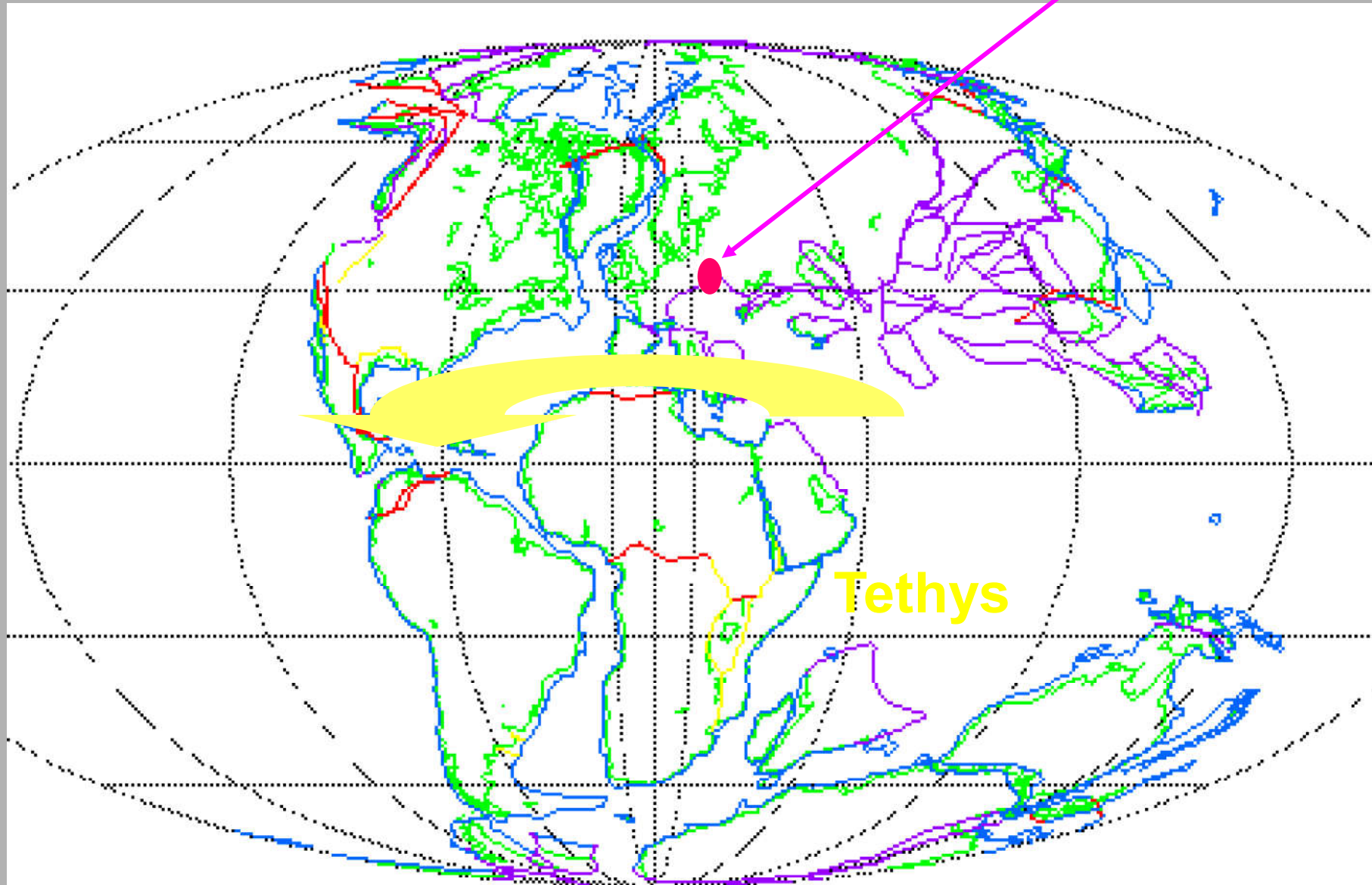
Plate positions 175 Ma

Pokornyopsis feifeli



Atlantic opening 110Ma

Pokornyopsis feifeli



Recent developments

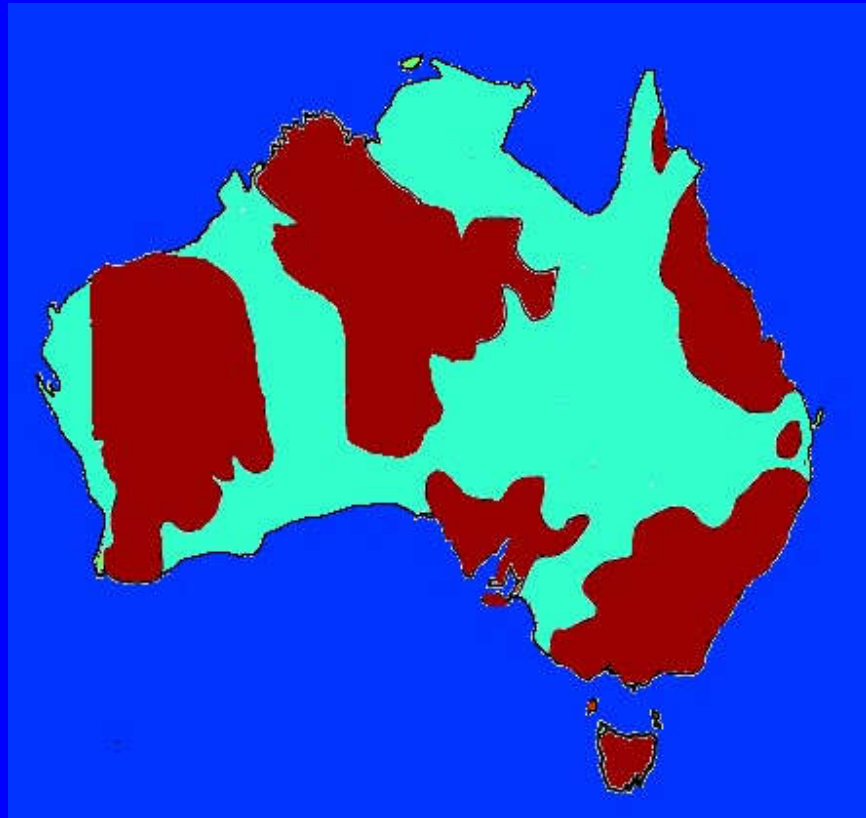
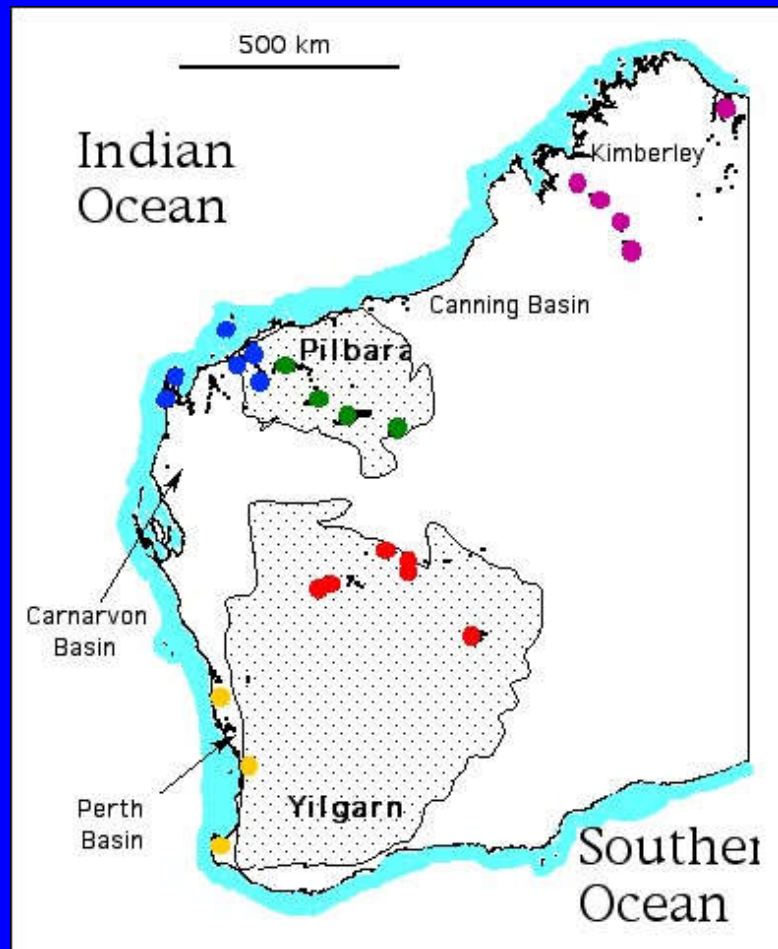
- Tethyan fauna on Christmas Island, a sea mount island
- *Microceratina* (Cytheruridae) spread through the Tethys Sea (Namiotko et al. 2004)
First description of soft parts of this Miocene genus

Danielopolina
(Thaumatoocypridoidea)



Enigmatic

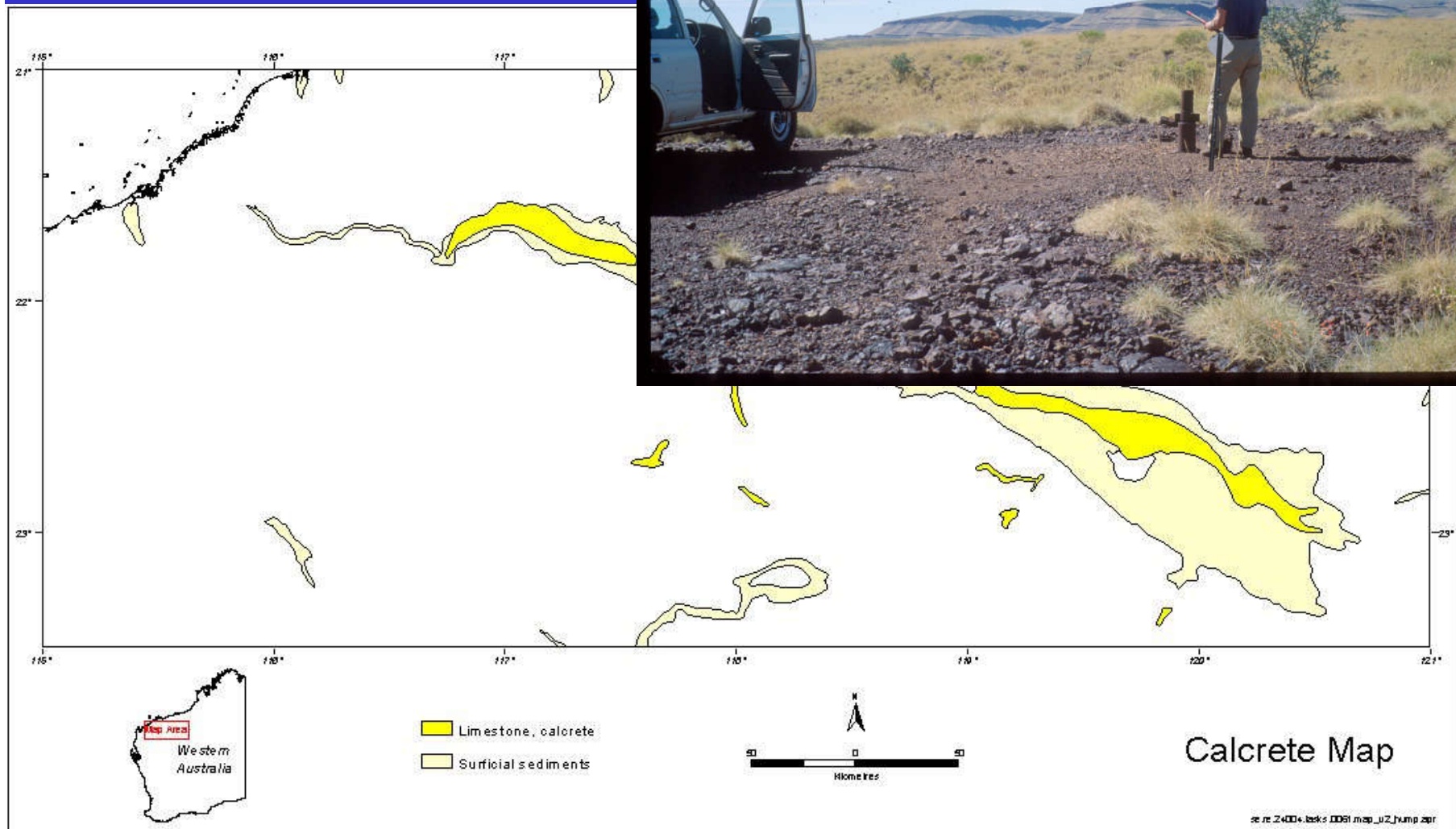
Western Shield



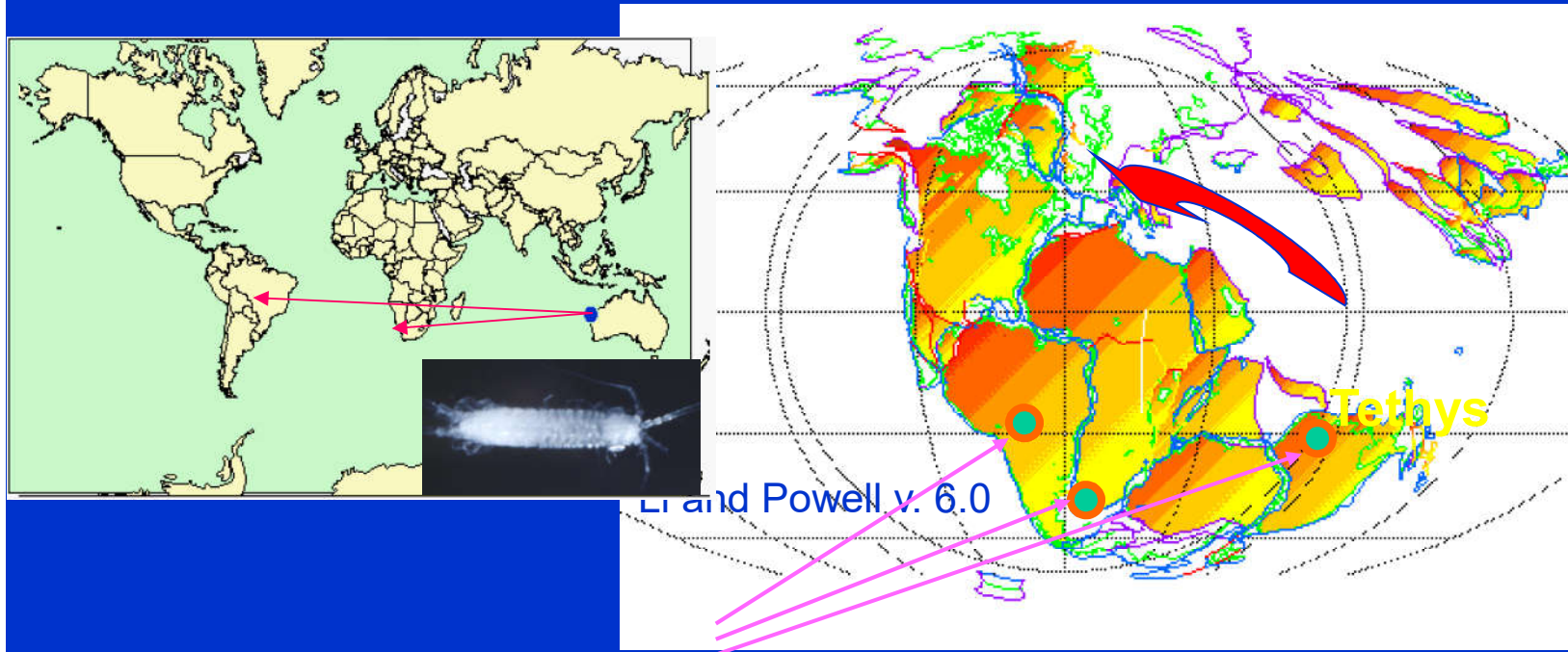
Pilbara: cyclone affected arid region with episodic rainfall



Western Fortescue Plain aquifer: lacustrine limestone



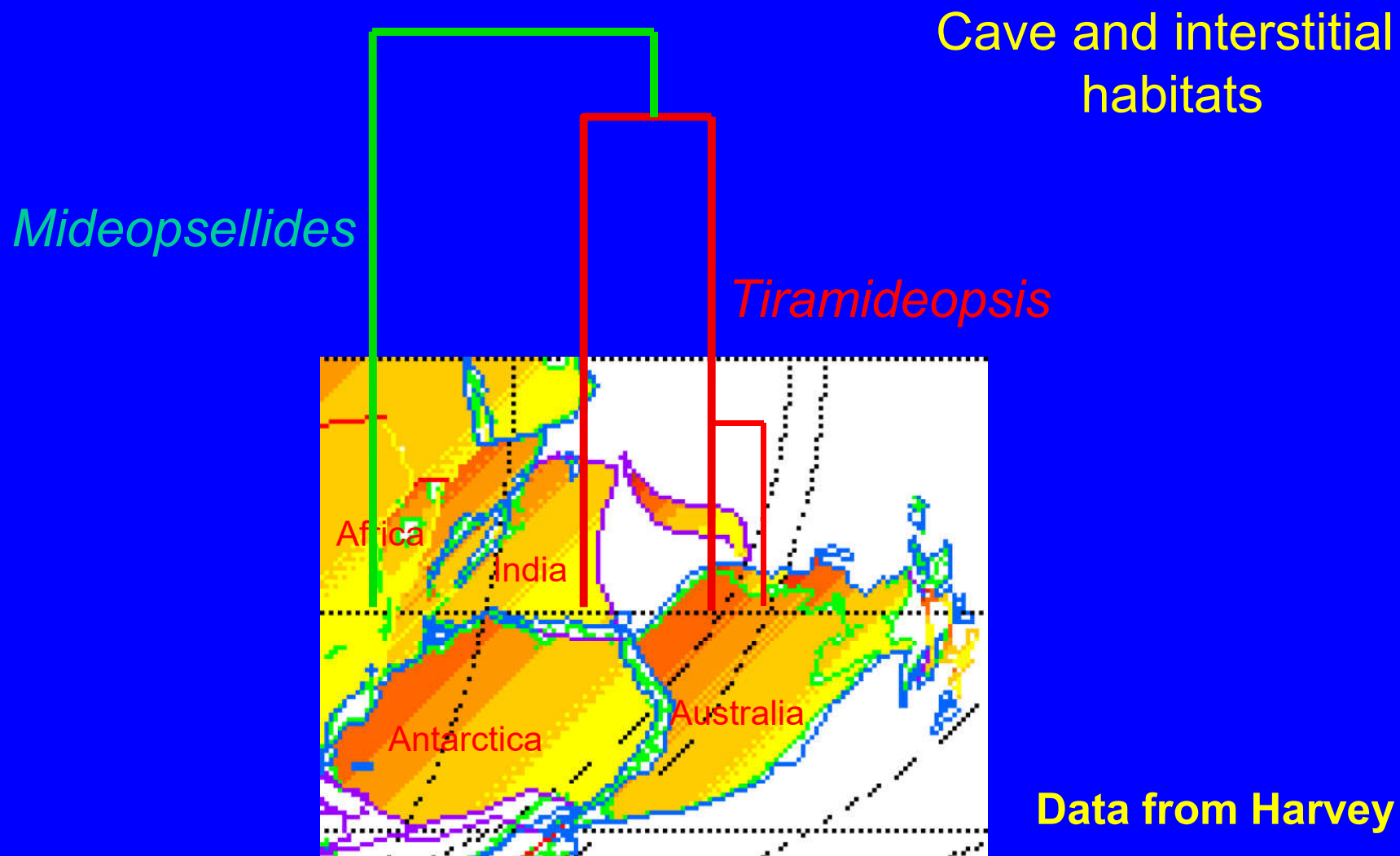
Spelaeogriphacea



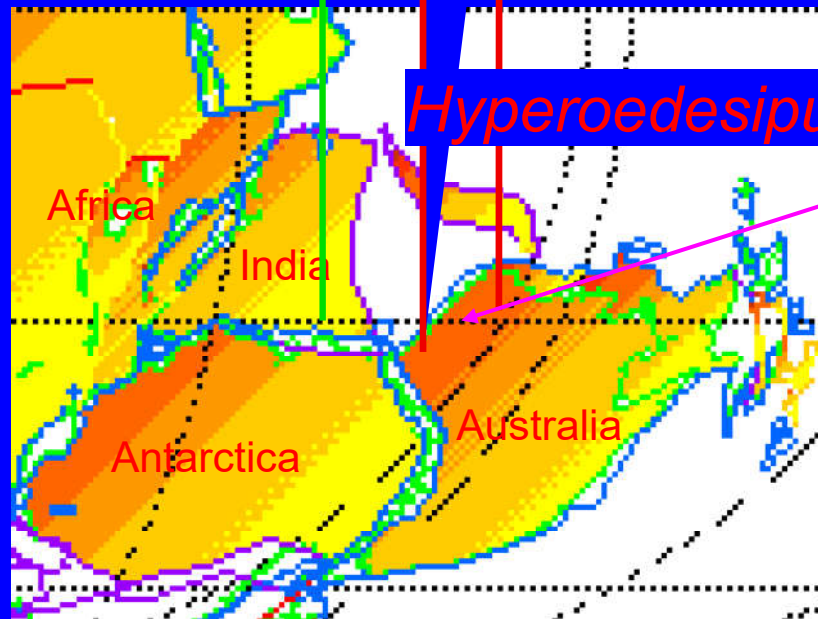
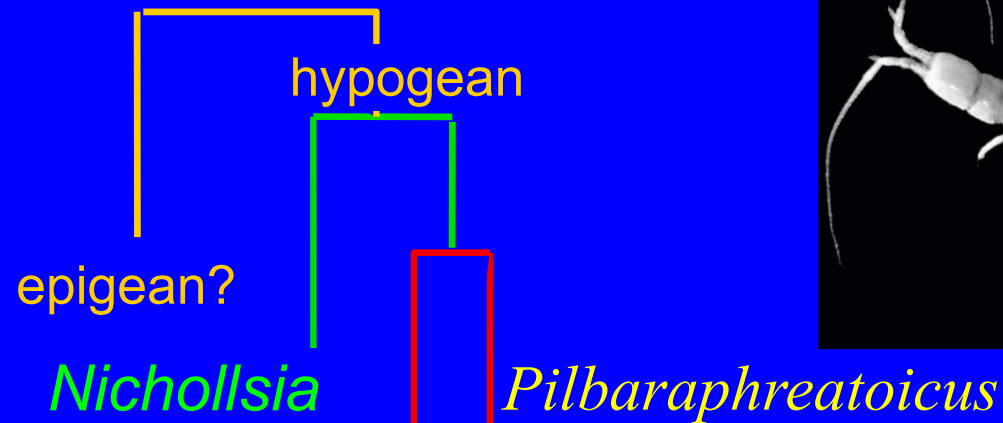
Spelaeogriphacea

Water mites Mideopsellinae

Arrenuroidea: Mideopsidae



Phreatoicidea: Hypsimetopodi



°Since Jurassic denudation processes removed ~5 km of cover rock.

Forcing a change in geological context?

G.D.F. Wilson, pers. Comm. 2002.
°Kohn, et al. 2002. Australian Journal of Earth Sciences 62.

Groundwater calcretes



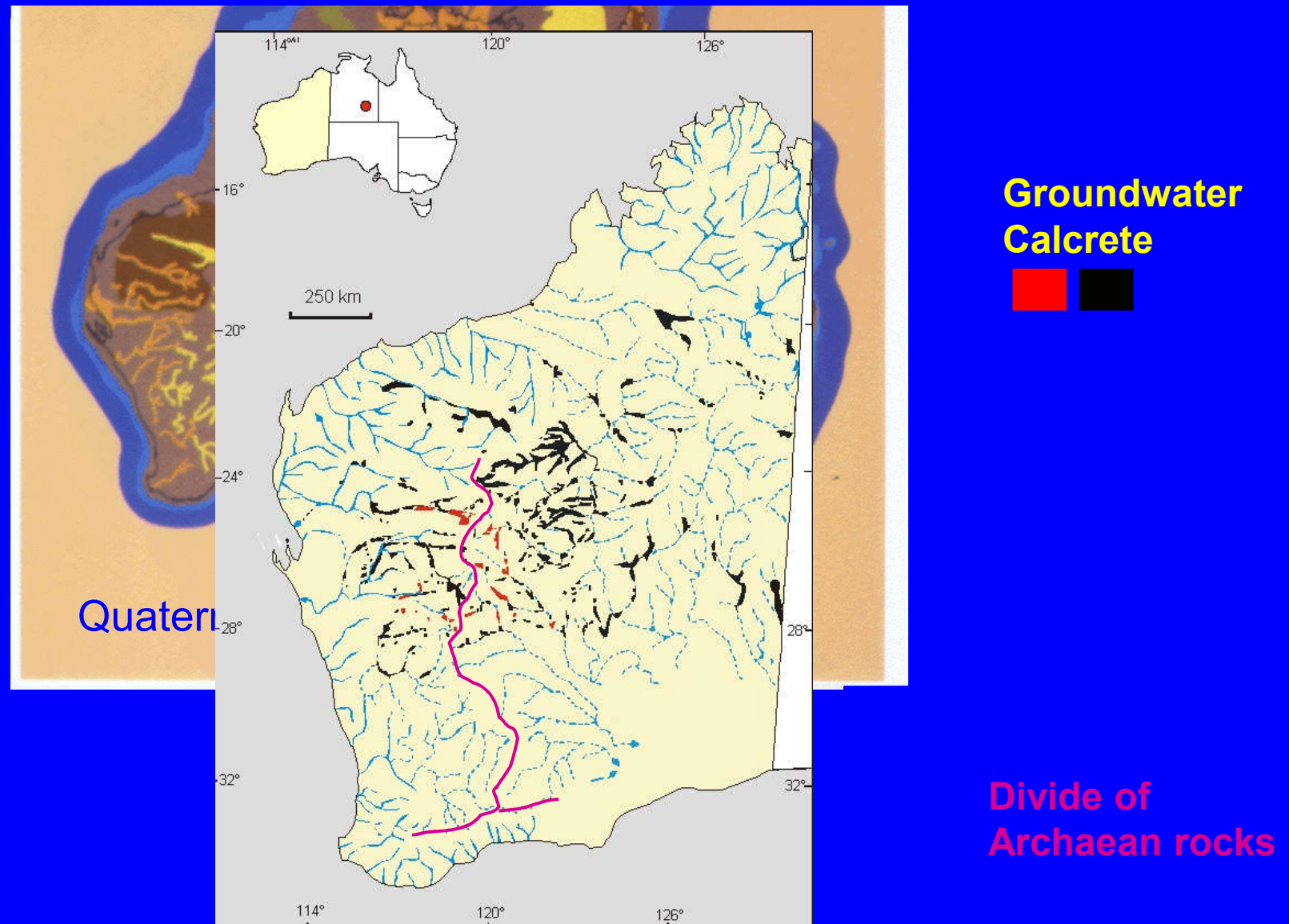
Shallow, thin (~ 10 m)
carbonate deposits in
arid zone associated
with palaeovalleys

Gascoyne palaeovalley



Photos: Remko Leys

Palaeovalleys constrained landscape evolution and groundwater flow



Yilgarn calcrete stygofauna

- Diving beetles (Dytiscidae)
- ‘Terrestrial’ isopods (Oniscidea)
- Bathynellacea
- Amphipoda
- Ostracoda
- Copepoda

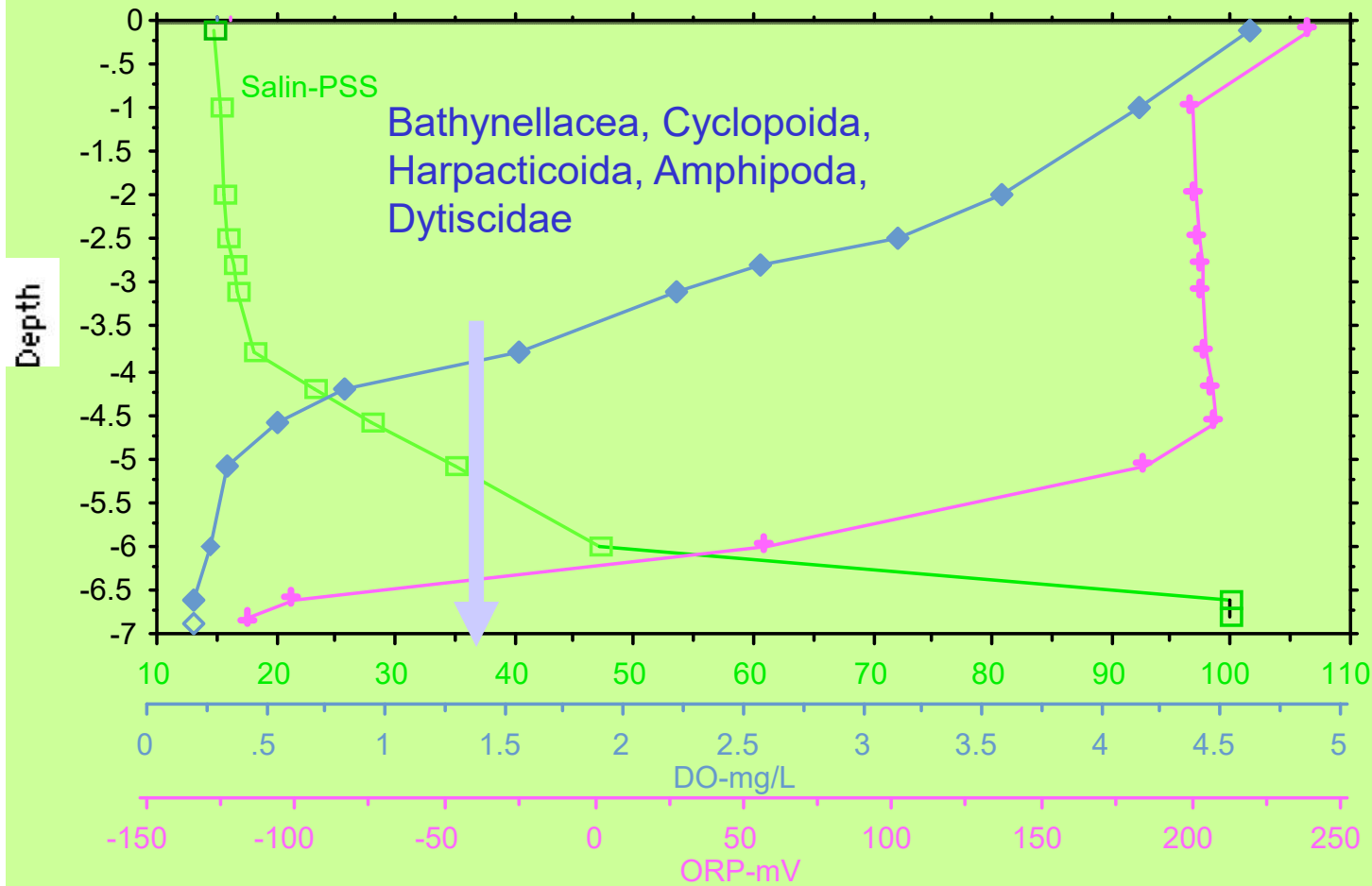


Groundwater
calcretes are
associated
with salt
lakes
(playas)



Windarra calcrete near salt lake

cf. anchialine systems



Routine
purging of
bores
destroys
biologically
important
information

.

Subterranean waterbeetles (Coleoptera: Dytiscidae)



Tjirtudessus



Now *Limbodessus*

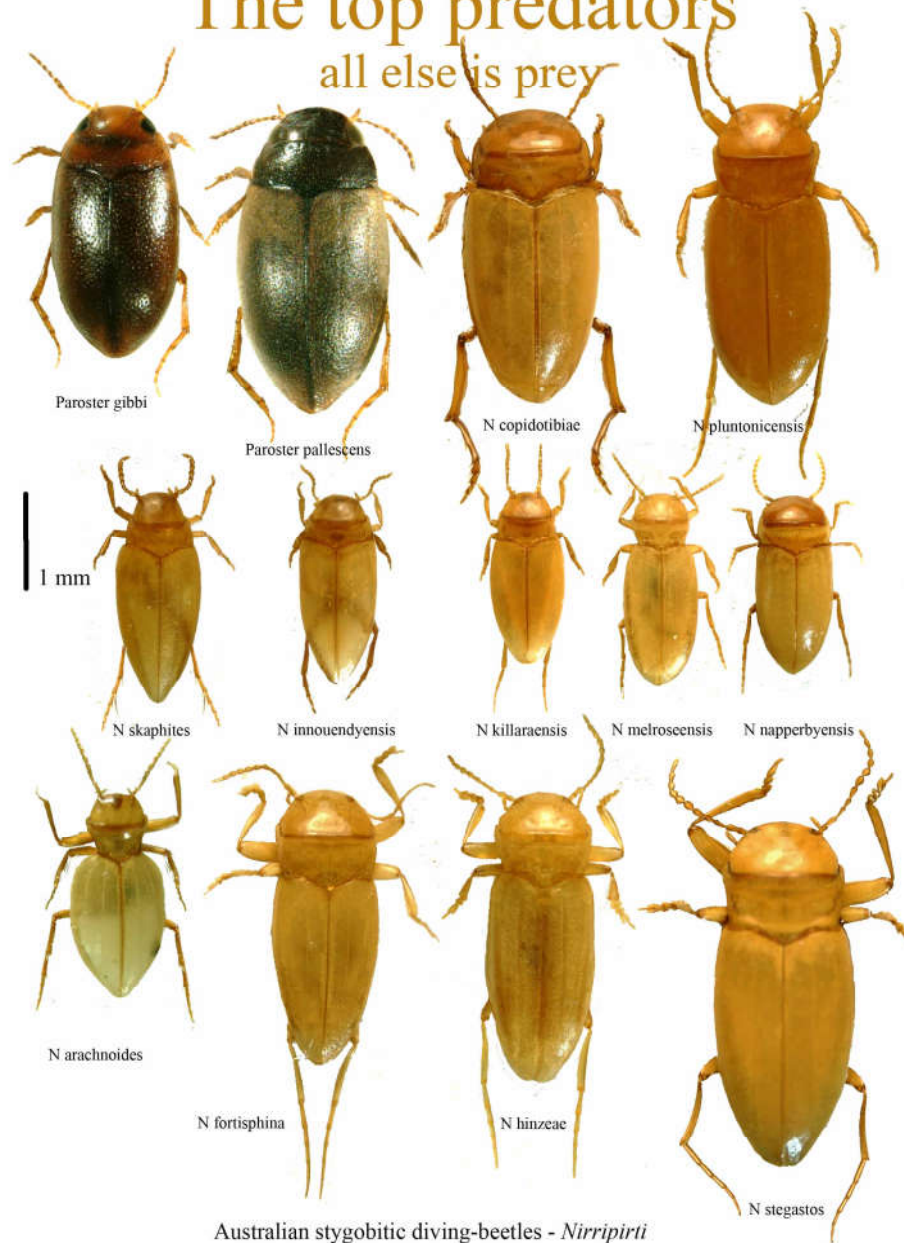


Nirridessus



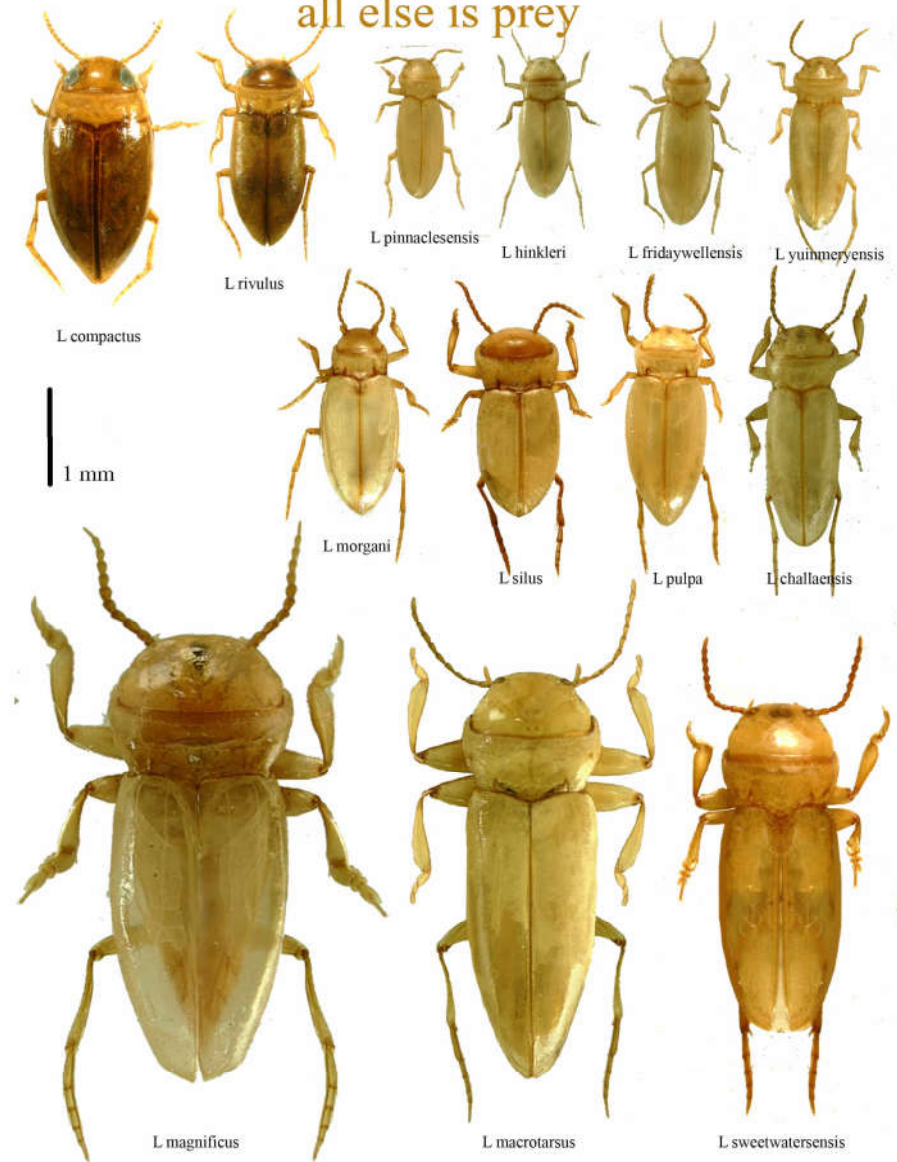
Liodessus

The top predators all else is prey



Australian stygobitic diving-beetles - *Nirripi*

The top predators all else is prey



Australian stygobitic diving-beetles - *Limbodessus*

Dytiscidae



*Nirripiriti
arachnoides*



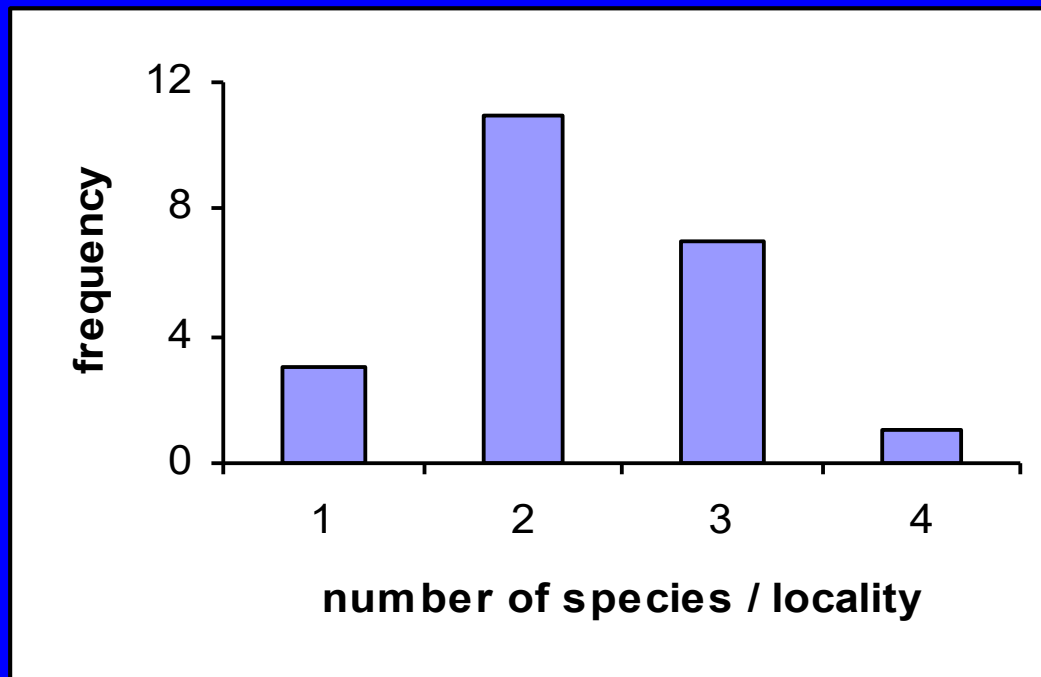
L. compactus



*Limbodessus
macrotarsus*

Photo: C.H.S.Watts

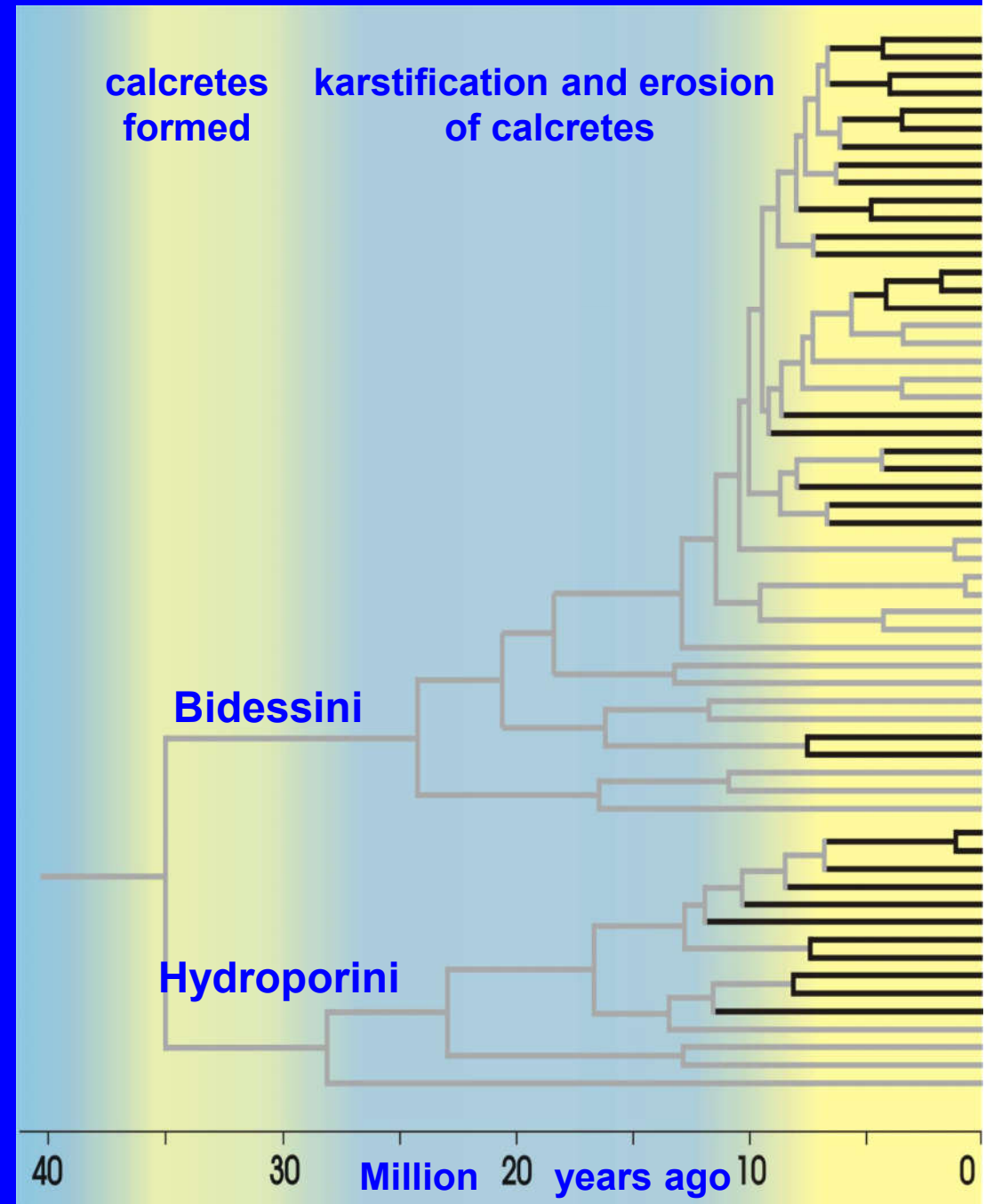
Summary of taxonomic data



Waterbeetle phylogenetic tree

mitochondrial DNA

- 36 subterranean lineages (in **black**)
- 23 surface lineages (in **grey**)
- Average climatic conditions:
blue: relatively humid
yellow: arid
- subterranean lineages
< 10 million years old



Waterbeetle phylogenetic tree

mitochondrial DNA

- localities:

Austin Downs

Cunyu Mineral Bore

Cunyu Sweetwaters Well

Yuinmery

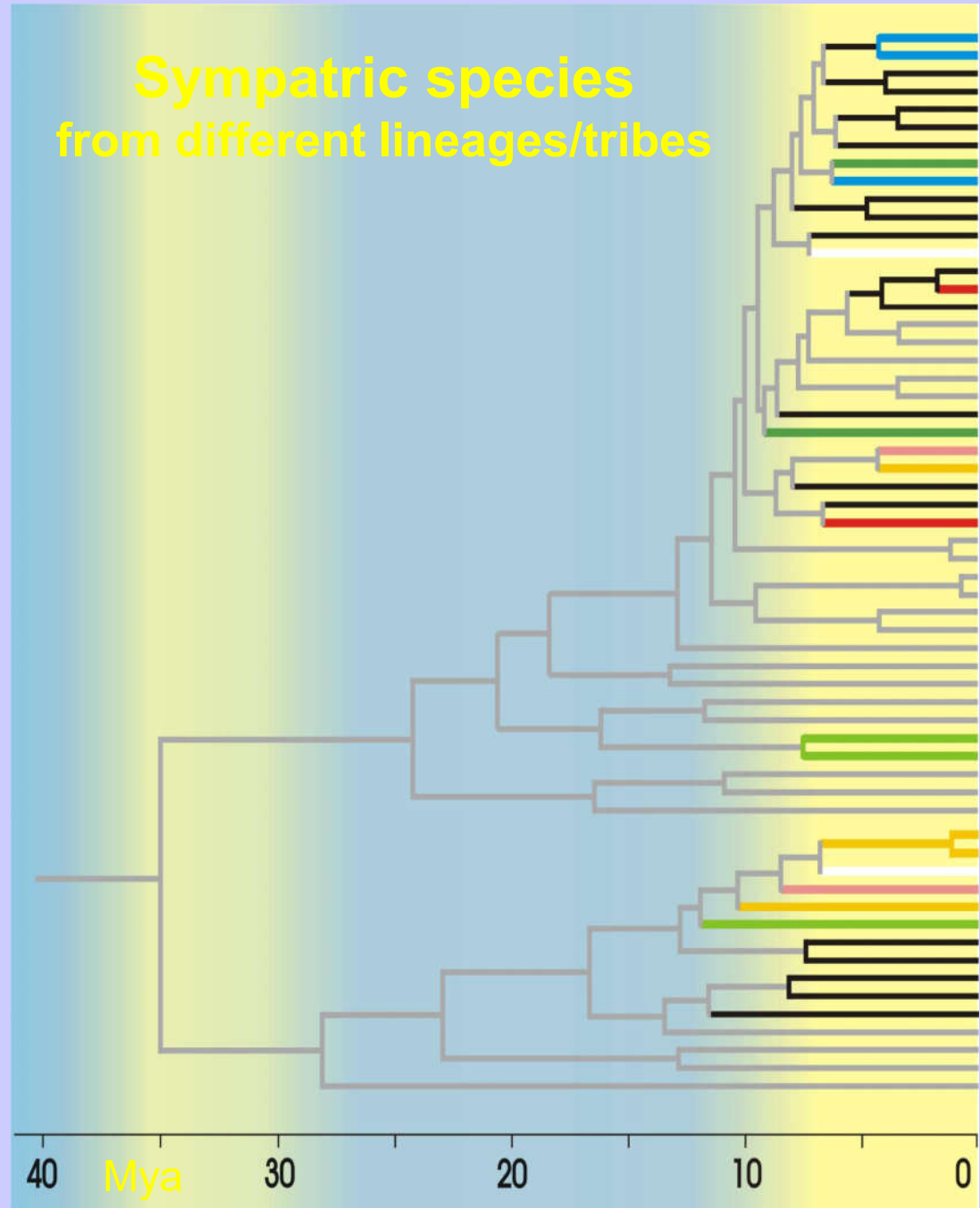
Depot Springs

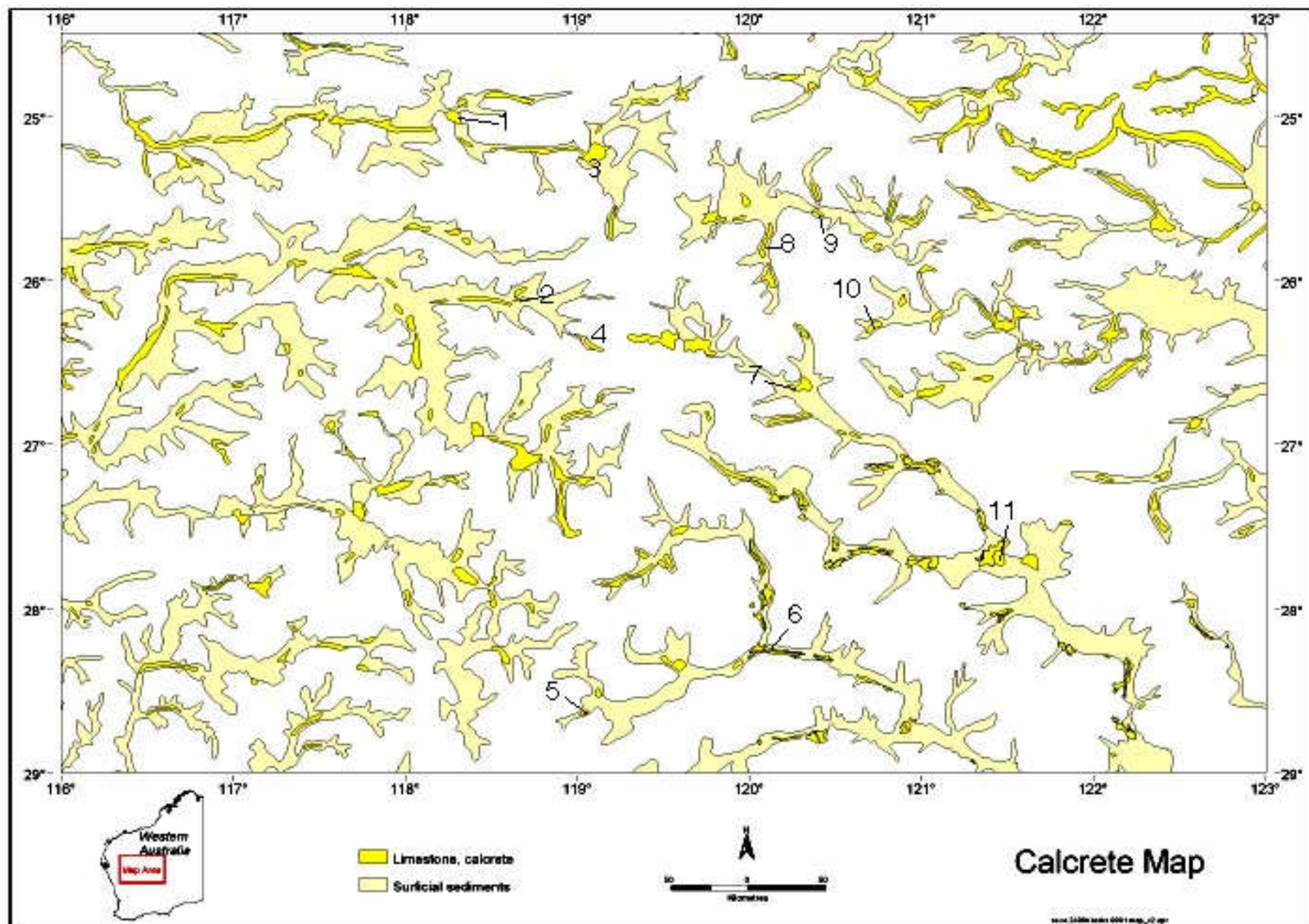
Three Rivers

Pinnacles

- multiple ancestral species colonised the same calcrete

Sympatric species
from different lineages/tribes

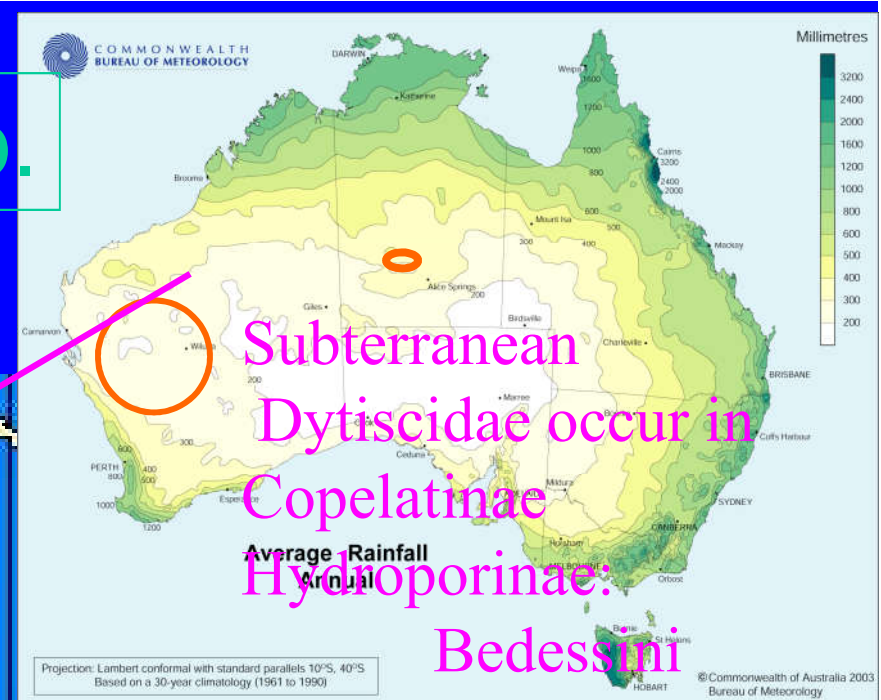




350,000 km² — 2/3 size France

Dytiscidae

Bidessoides 8 spp.



Stygal data: Watts et al.
Epigean data:
C.H.S. Watts

Poraster 8 spp.

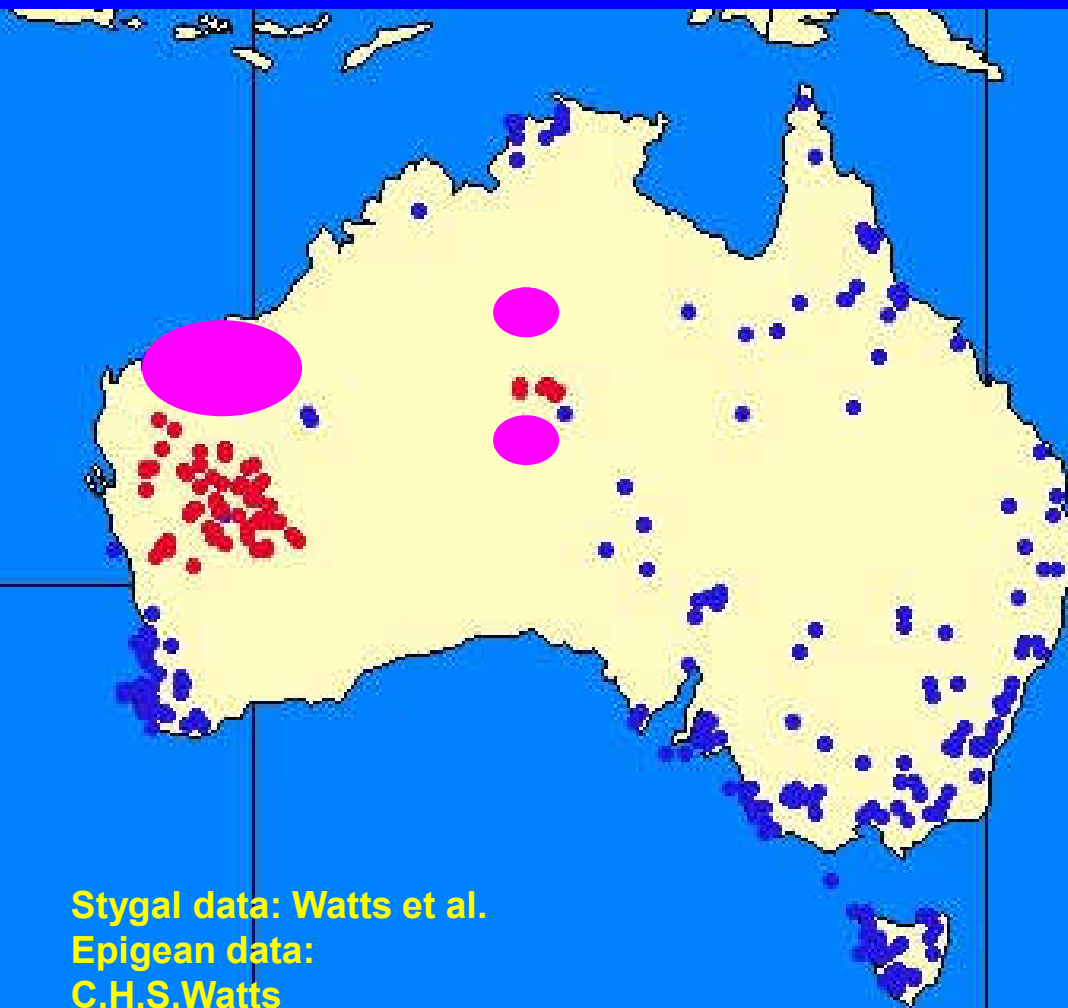
1, All subterranean species are within the arid area.

2, Not all calcretes within arid area have stygobitic dytiscids.

3, Epigeal species largely occur outside the arid area

4, Aridity + calcrete necessary but not complete requirement for stygal dytiscids

Stygol data: Watts et al.
Epigeal data:
C.H.S.Watts



Oniscidea

- 19 species belonging to 2 genera :
- *Haloniscus* 17 species
- *Androphiloloscia* 2 species

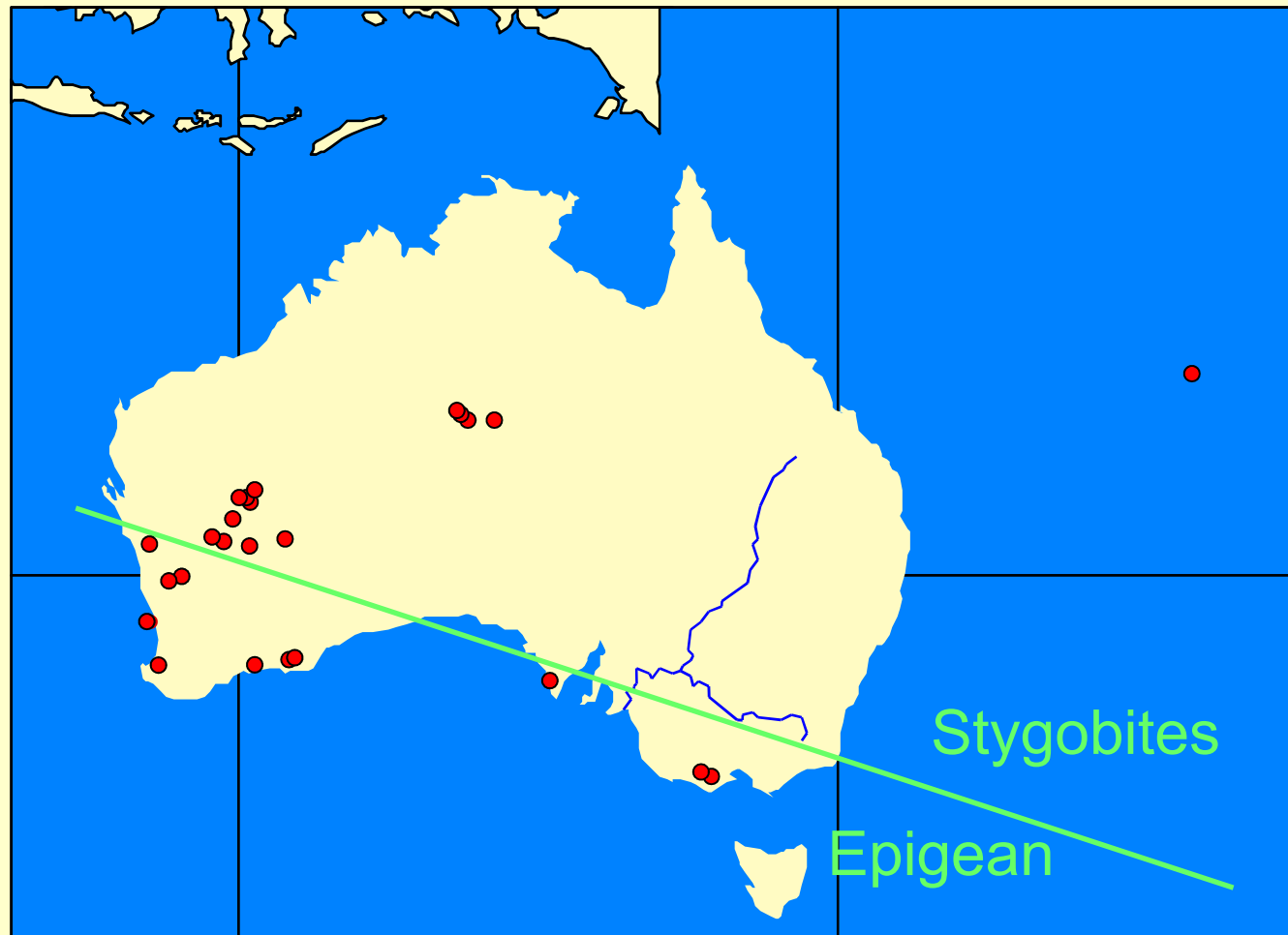


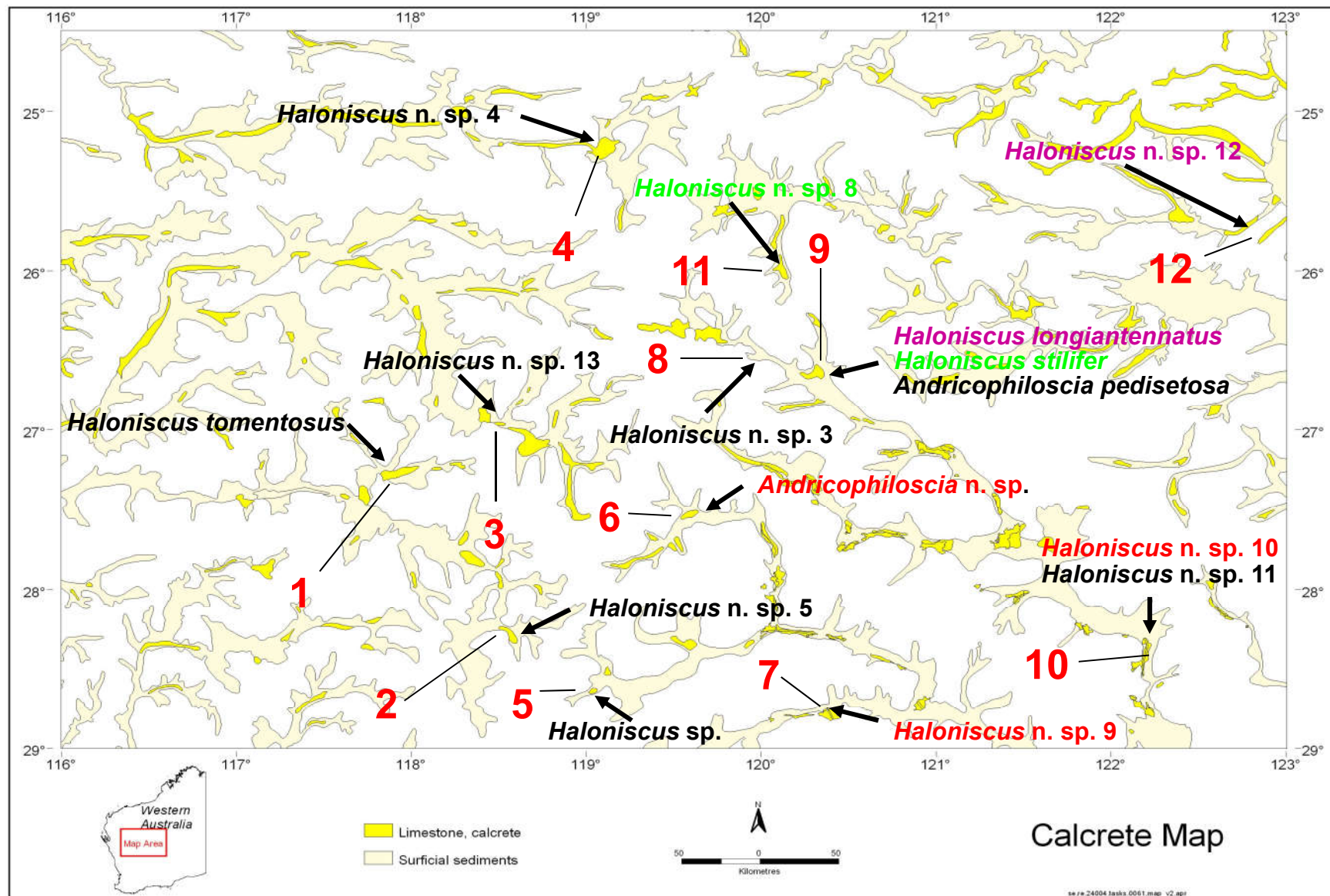
Haloniscus searlei
Lake Keilambete, VIC



***Haloniscus* n. sp. 12**
Carnegie, Jimmays Well, WA

All collection sites





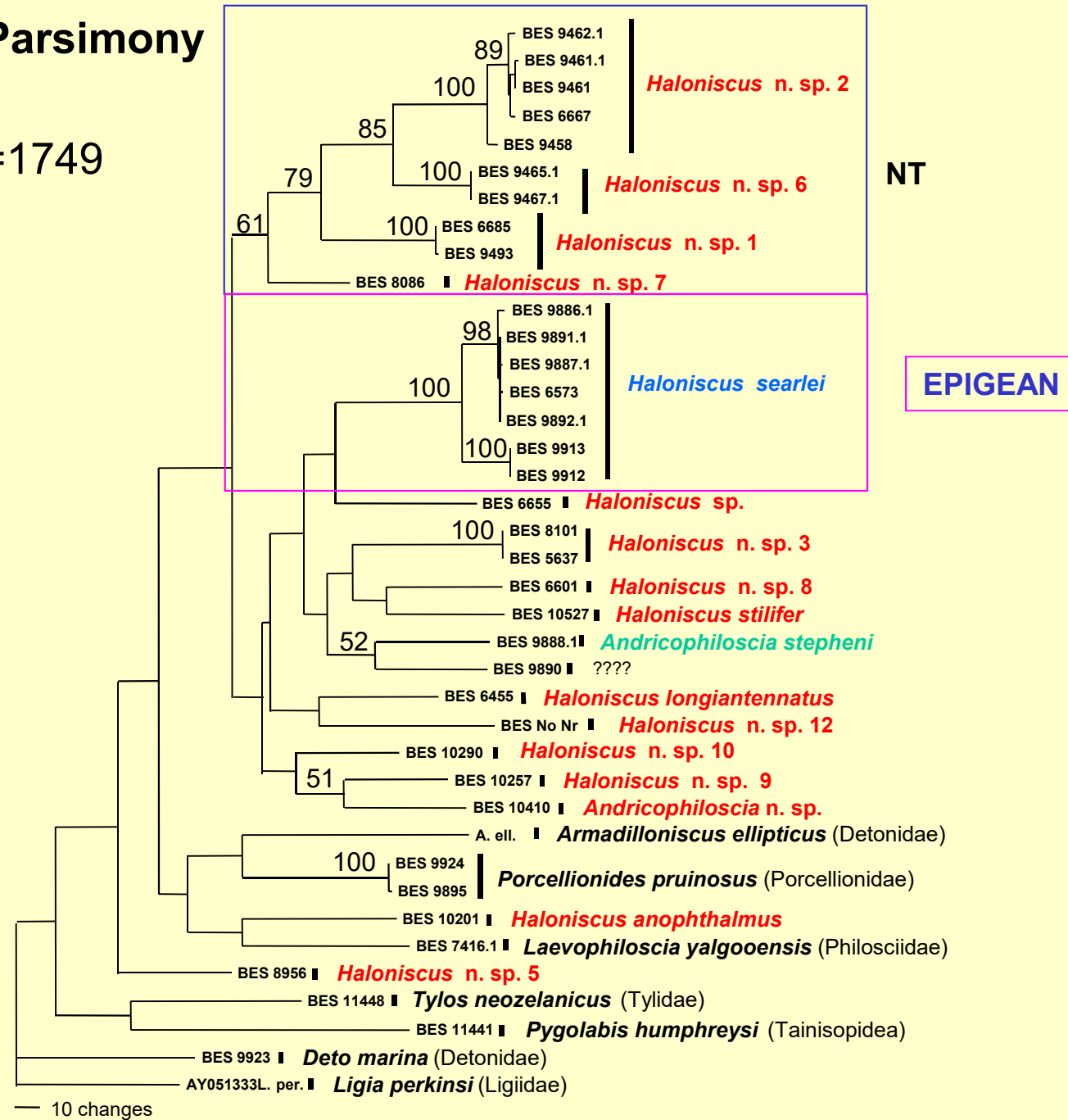
Yilgarn Region (Western Australia)

MURCHISON: 1, Old Cue; 2, Windimurra; 3, Yarrabubba. GASCOYNE: 4, Three Rivers. RAESIDE: 5, Yuinmery; 6, Lake Mason; 7, Perrinvale. CAREY: 8, Bubble Well; 9, Uramurdah; 10, Laverton Downs. CARNEGIE: 11, Jundee South; 12, Jimmys Well.

(Map based on 1 : 2,500,000 Hydrogeological Map of Western Australia 1989 compiled by D.P. Commander)

Maximum Parsimony

Length=1749

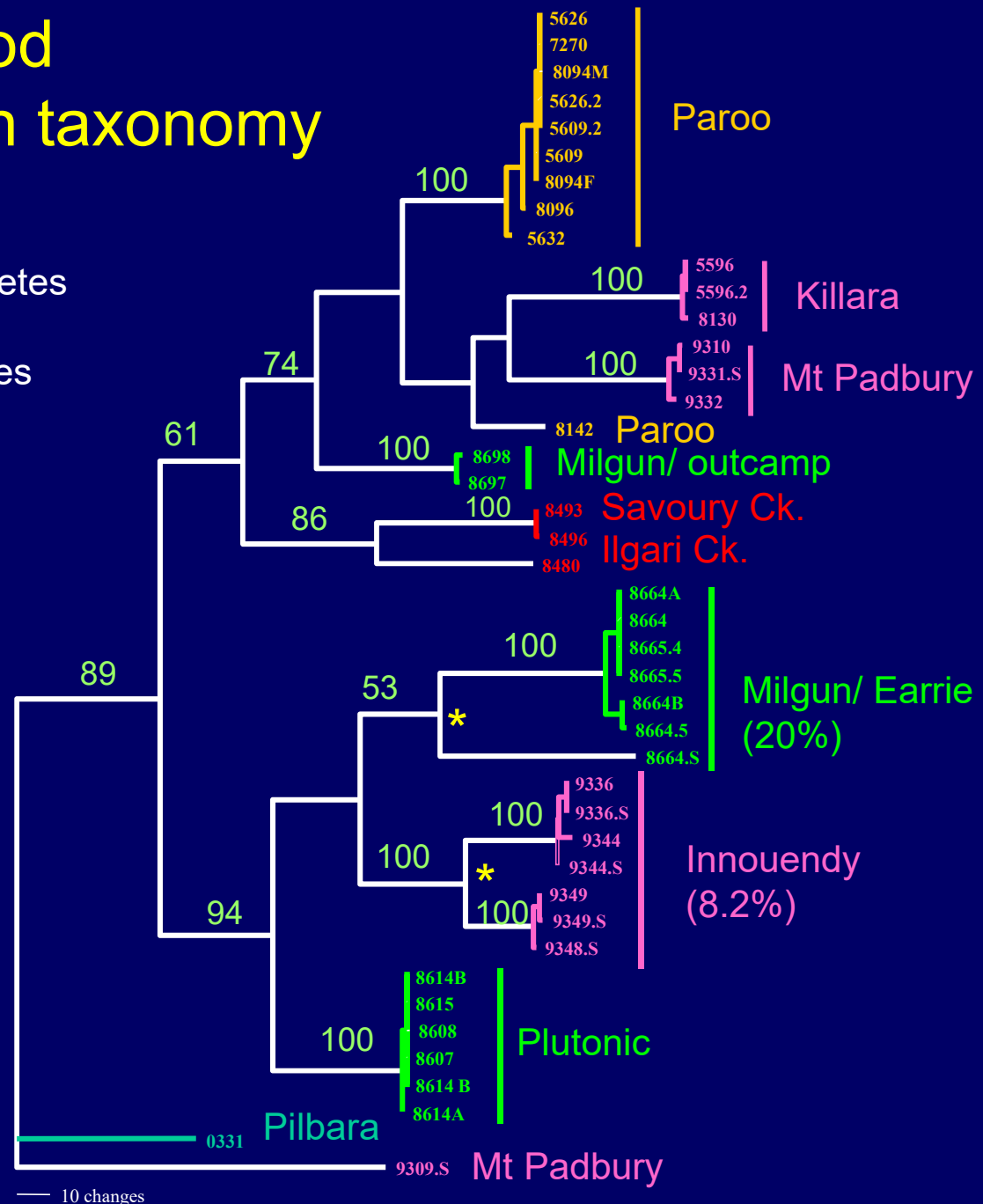


Preliminary amphipod phylogeny: unknown taxonomy

- N = 43 amphipods from 9 calcretes
- 650 bp of *CO1* gene
- 1 of 2 Maximum Parsimony trees of length 1005

- strong bootstrap support for distinct mtDNA lineages in each calcrete.

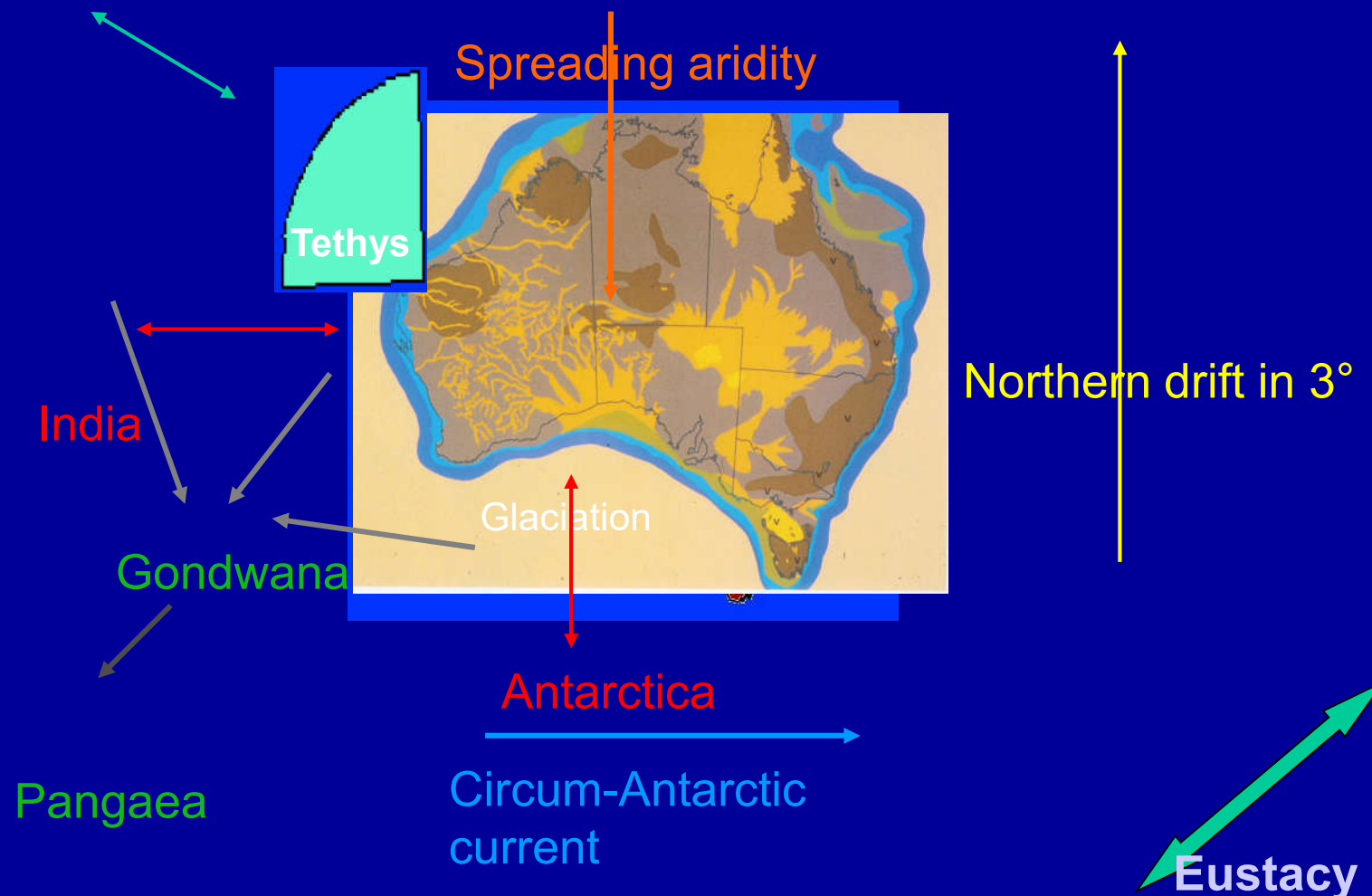
- * evidence for distinct mtDNA lineages in sympatry: K2P divergences of 8.2%-20% (~3-9 my ago)
- 1-2 species / calcrete?



Summary

- Anchialine
- Procaridid
- Remipede
- Enigma
- Lacustrine calcrete
- Groundwater calcrete (fresh and saline)
- ALSO
- Fractured rock
- Shallow regolith
- Karst
- Alluvial
- Characterisation of subterranean wetlands infancy

Geographic factors and arid zone subterranean fauna



Acknowledgements

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K. Saint — DNA

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Graphics:
Ken Grimes



Photography: Douglas Elford, Stefan Eberhard, Andrew Poole, Paul Hosie,

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