

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

William Humphreys, Chris Watts,
Remko Leys and Steve Cooper

Western Australian Museum,
South Australian
Museum, Adelaide University

South Australian Museum



Stable but dynamic Australia

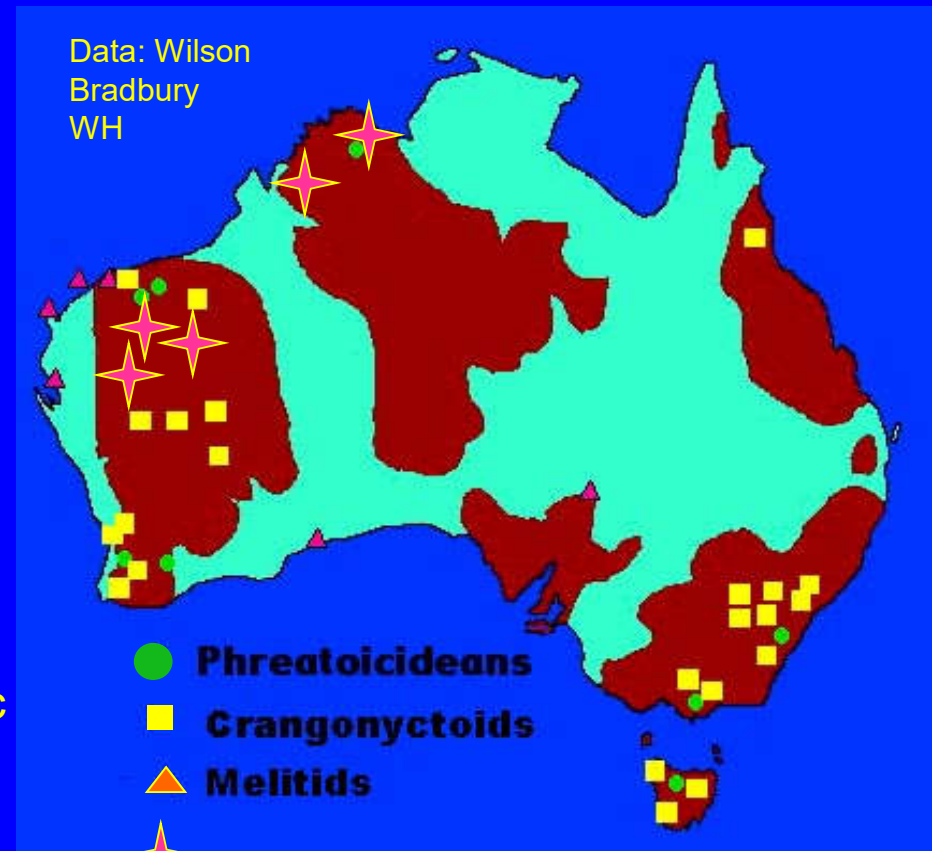
Emergent since Proterozoic

Cretaceous inundation

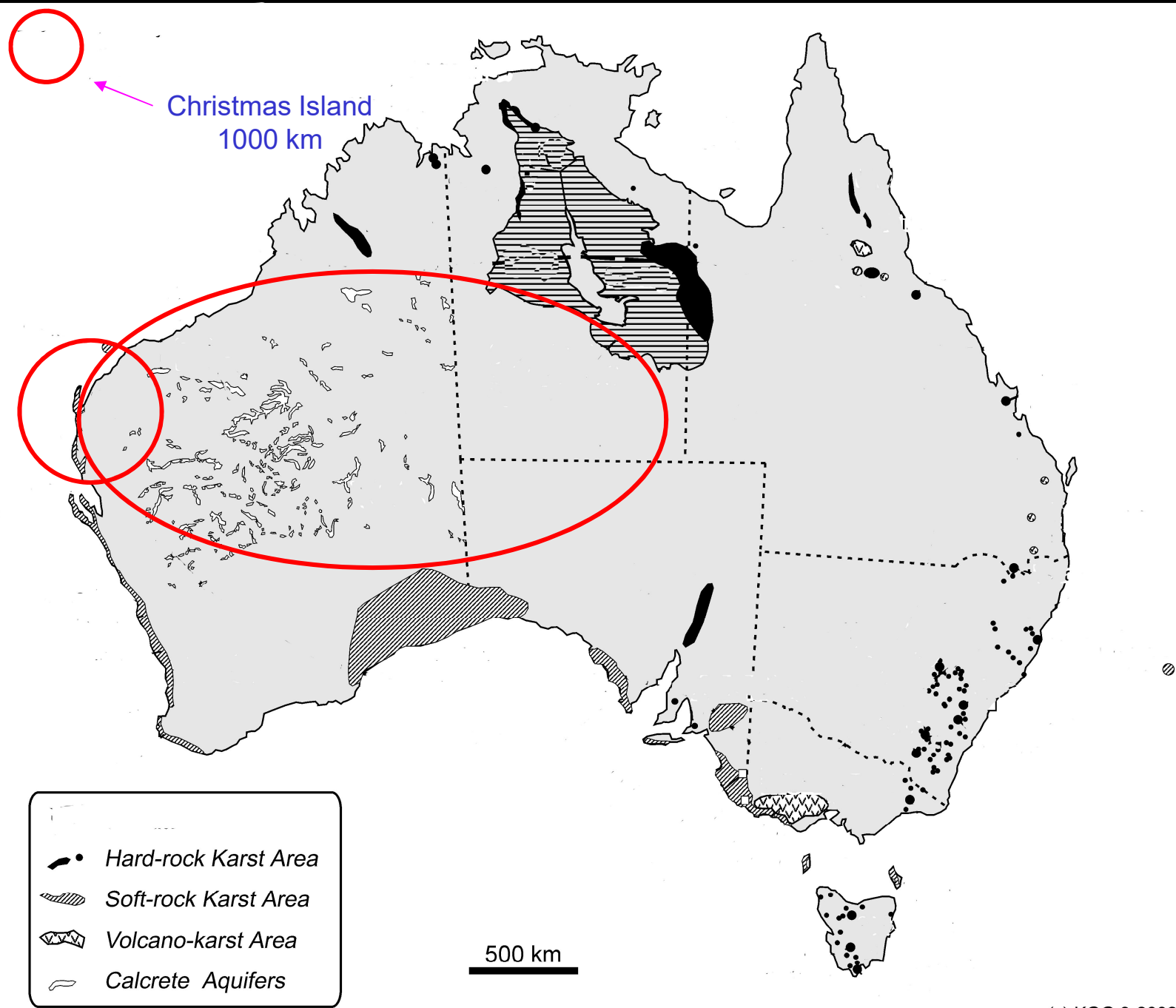
Islands of freshwater ancients
and shore colonisation.

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

changes geological
context:



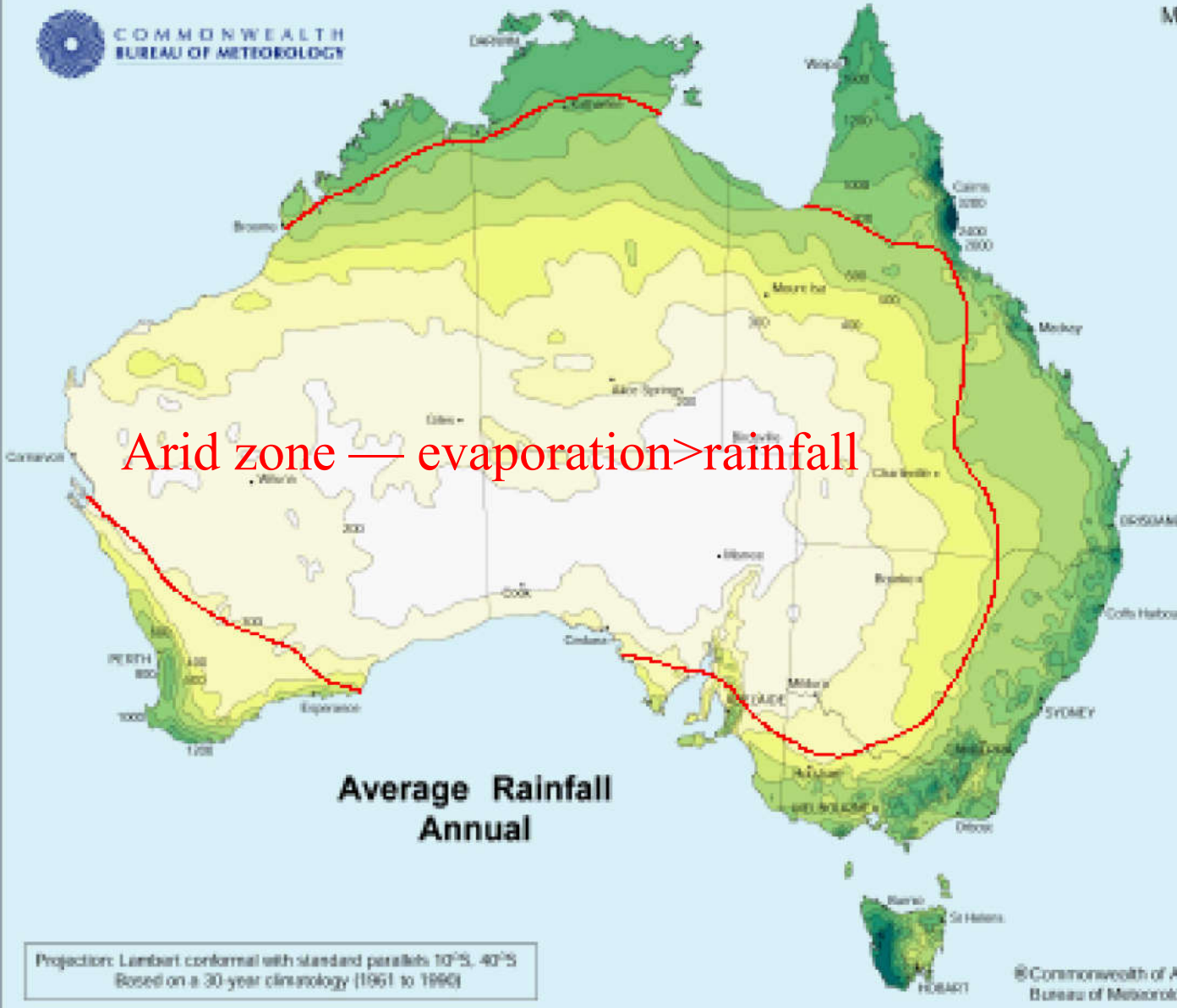
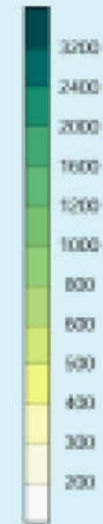
Tainisopidea





COMMONWEALTH
BUREAU OF METEOROLOGY

Millimetres



Arid zone — evaporation > rainfall

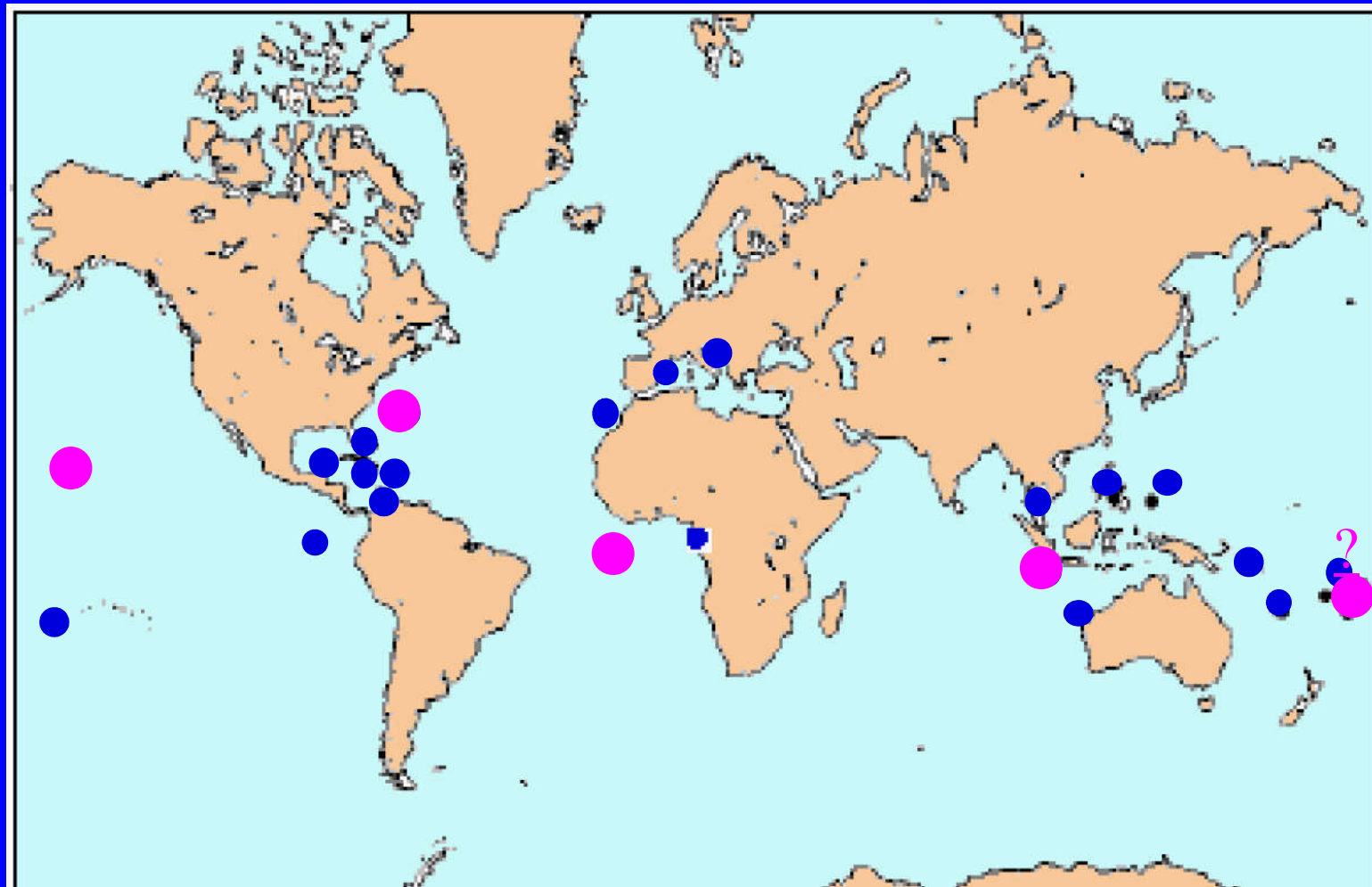
Average Rainfall
Annual

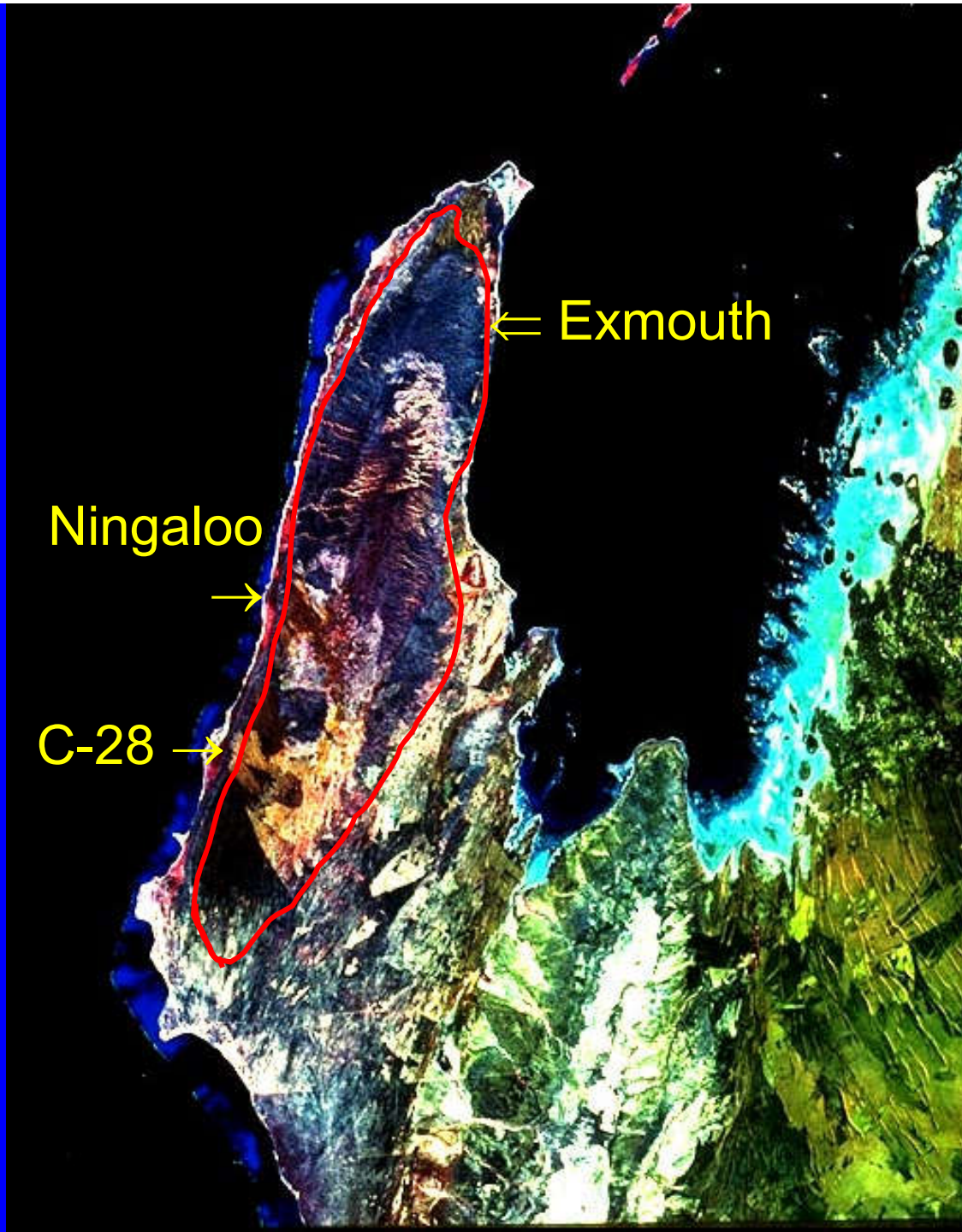
Projection: Lambert conformal with standard parallels 10°S, 40°S
Based on a 30-year climatology (1961 to 1990)

© Commonwealth of Australia 2003
Bureau of Meteorology

Anchialine systems

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





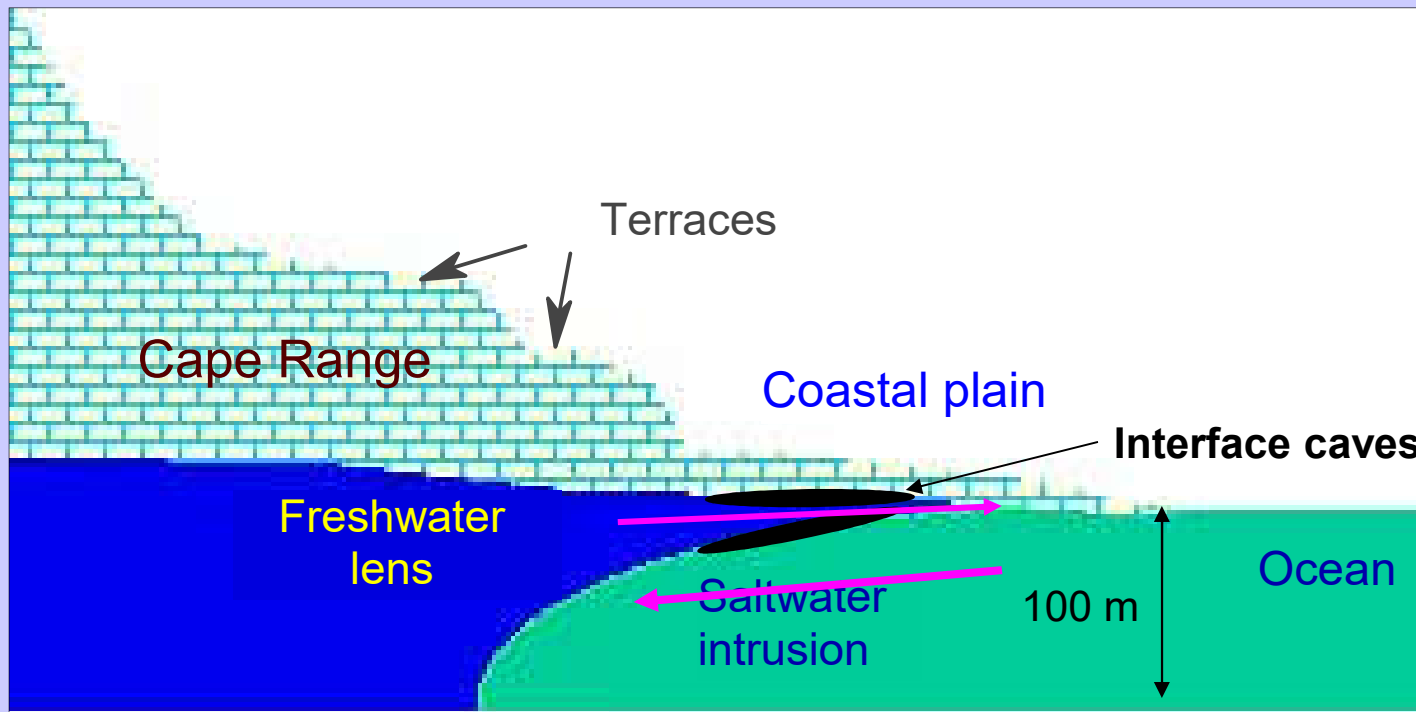
Cape Range peninsula

Bundera Sinkhole

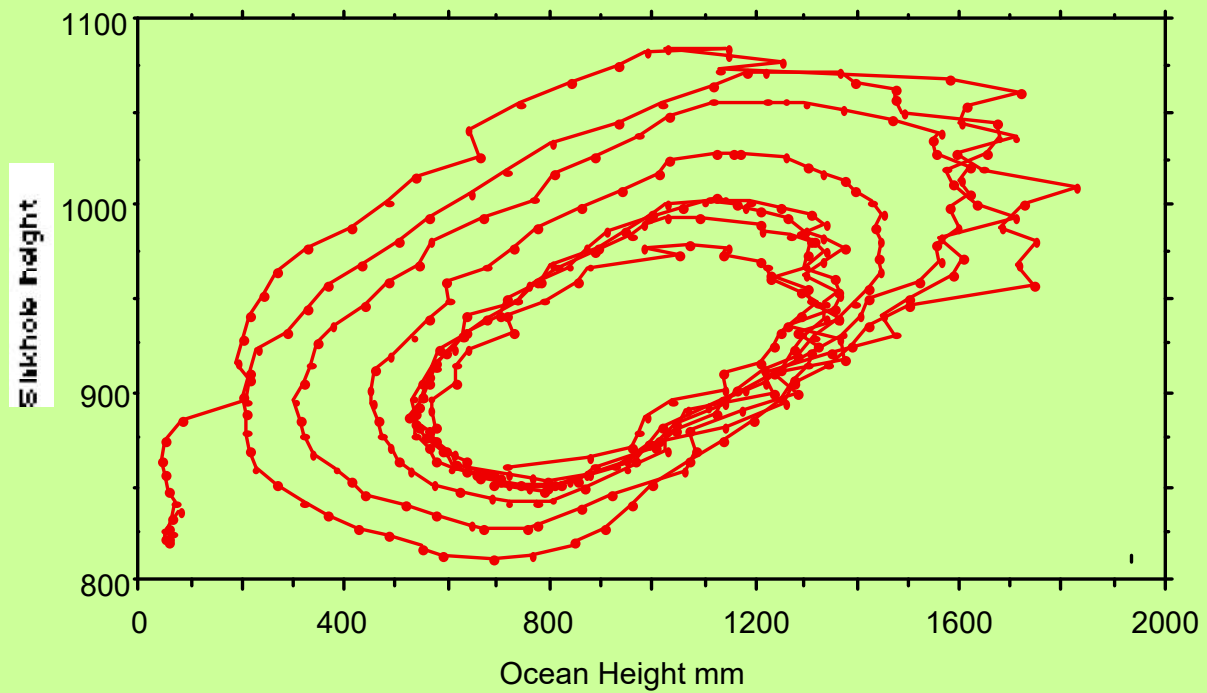
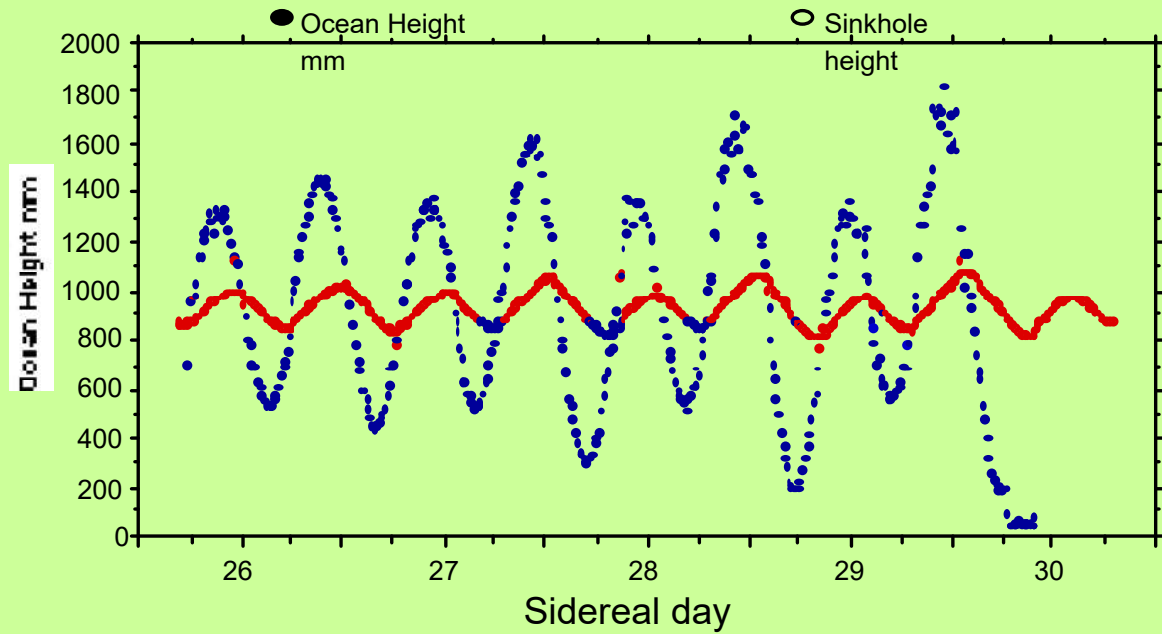
The most important biodiversity site in Australia



Cape Range — hydrological environment near the coast



Groundwater estuary

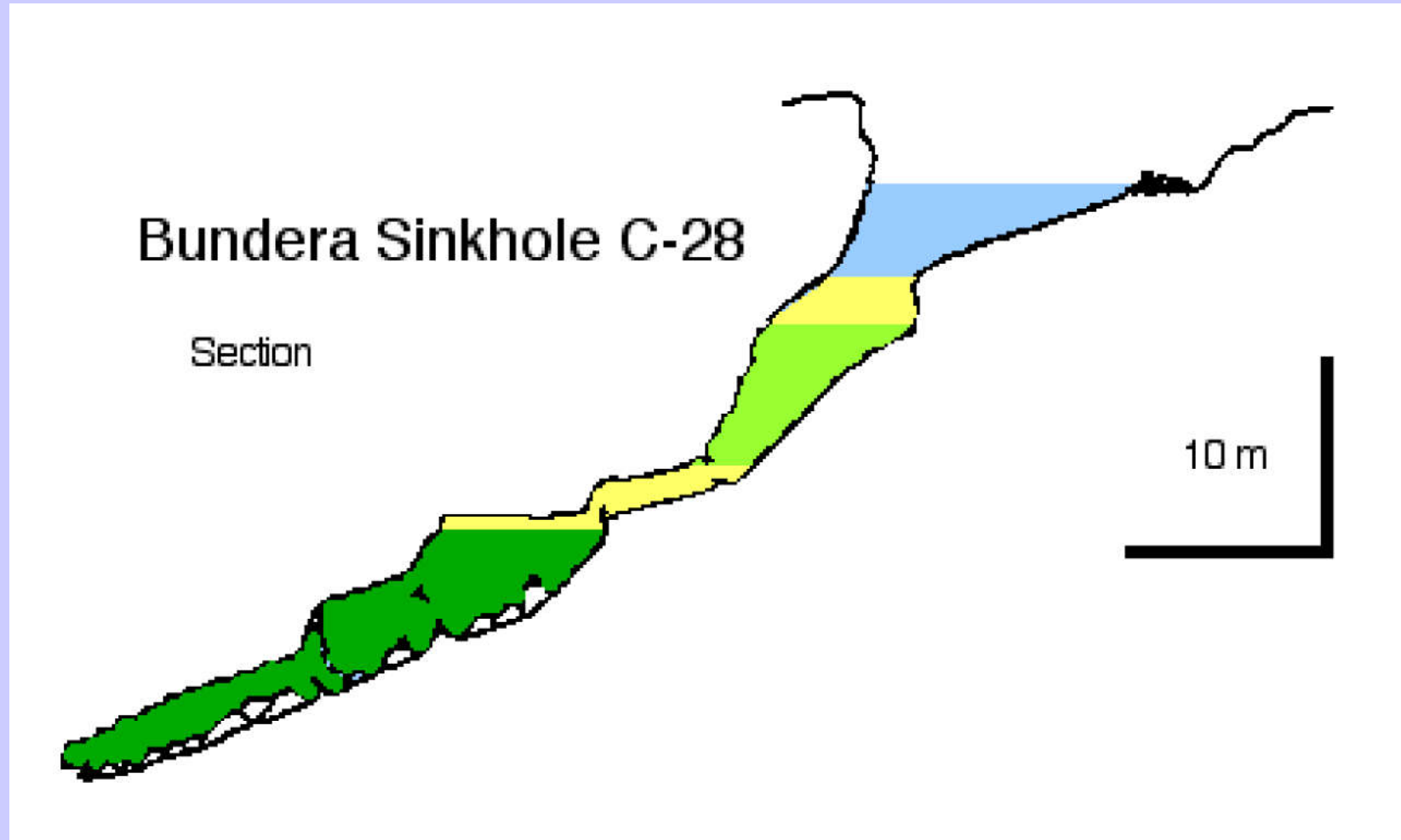








Bundera Sinkhole C-28

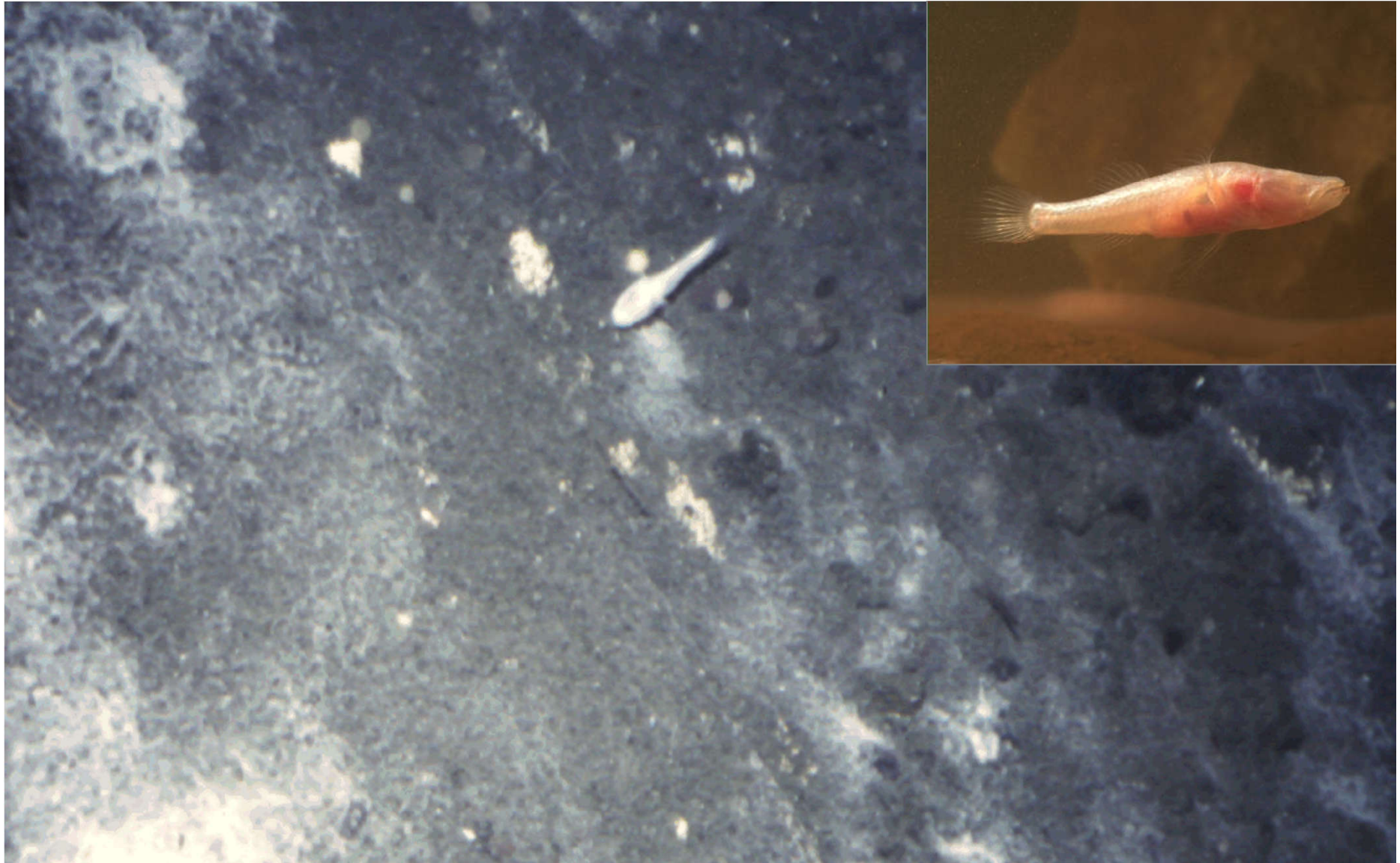




Large white gliding filamentous sulphur oxidizing bacteria (chemolithoautotrophs)



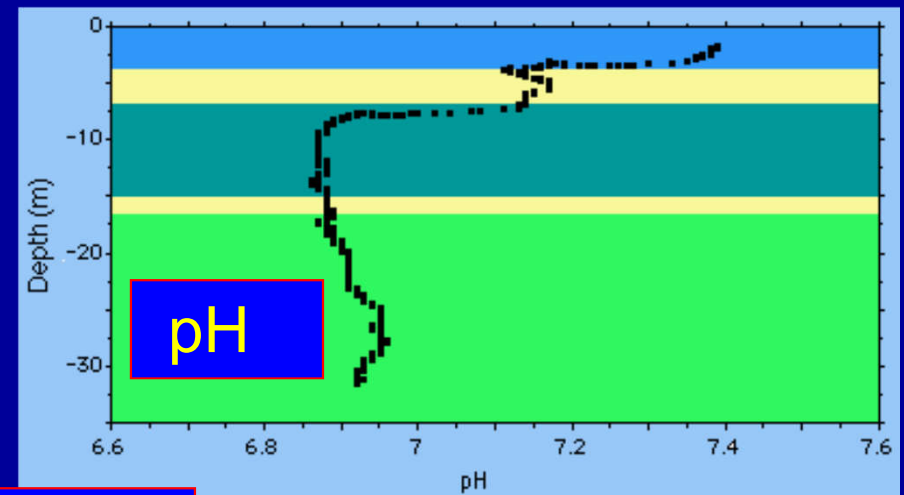
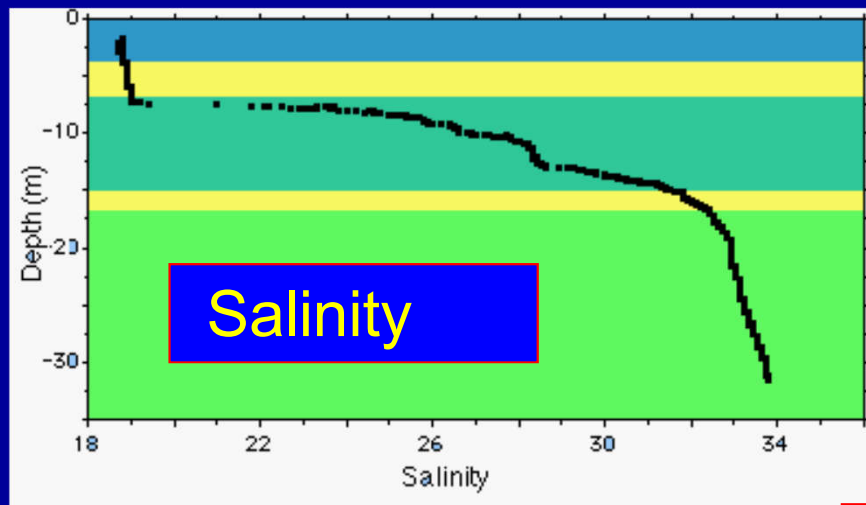
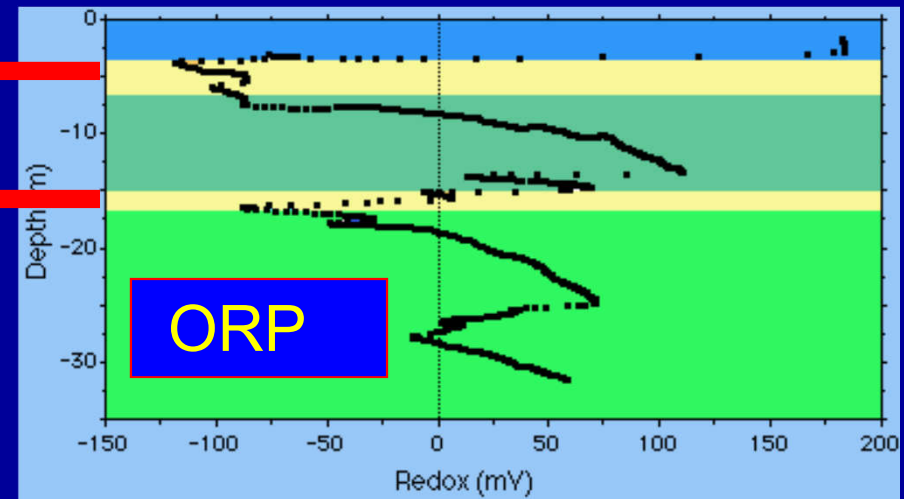
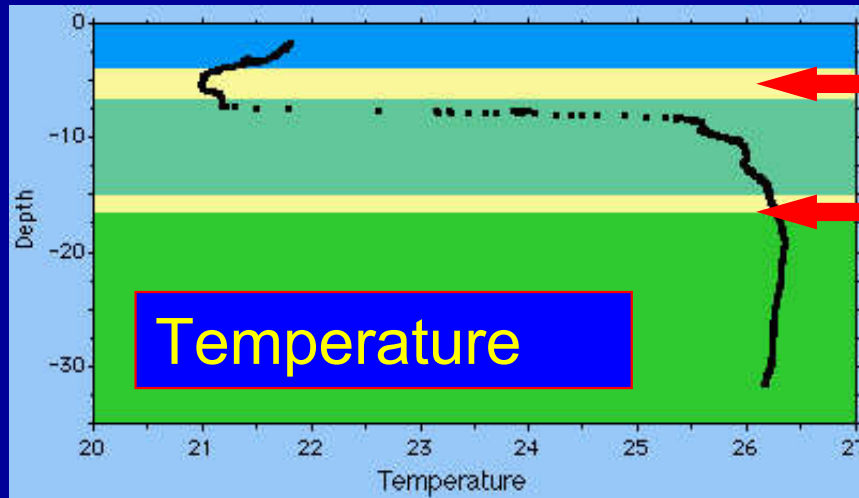
***Thioploca* tracking
the oxic / anoxic
boundary**



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

Australia Museum

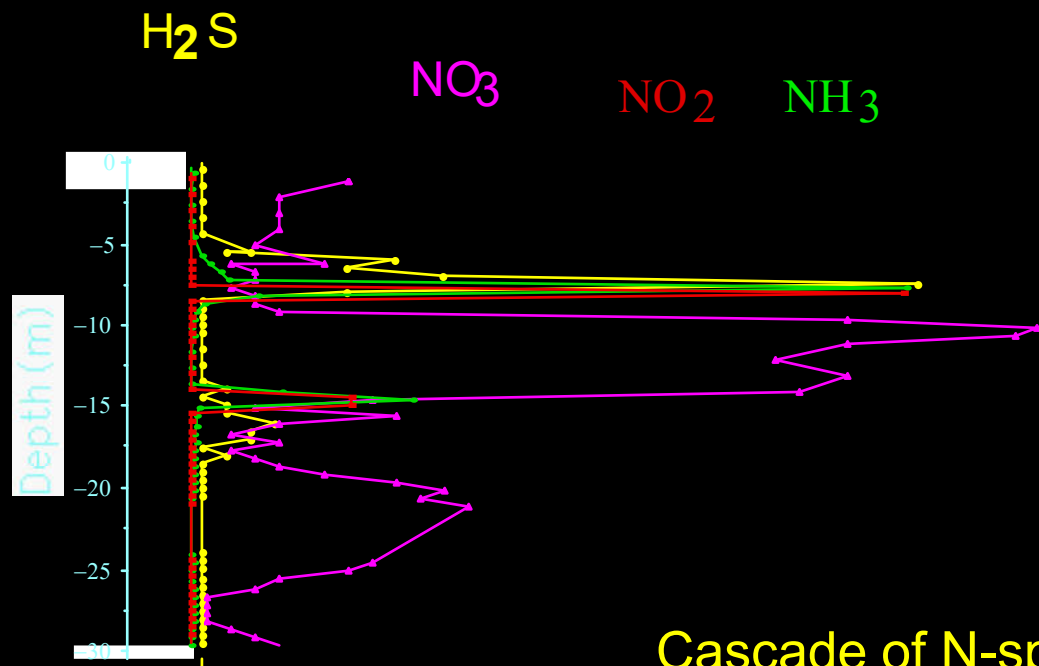
Gradients: Depth profile: Bundera Sinkhole



H_2S

A red arrow points from the H_2S label towards the left, indicating the direction of the gradient.

N-species profiles: Bundera Sinkhole



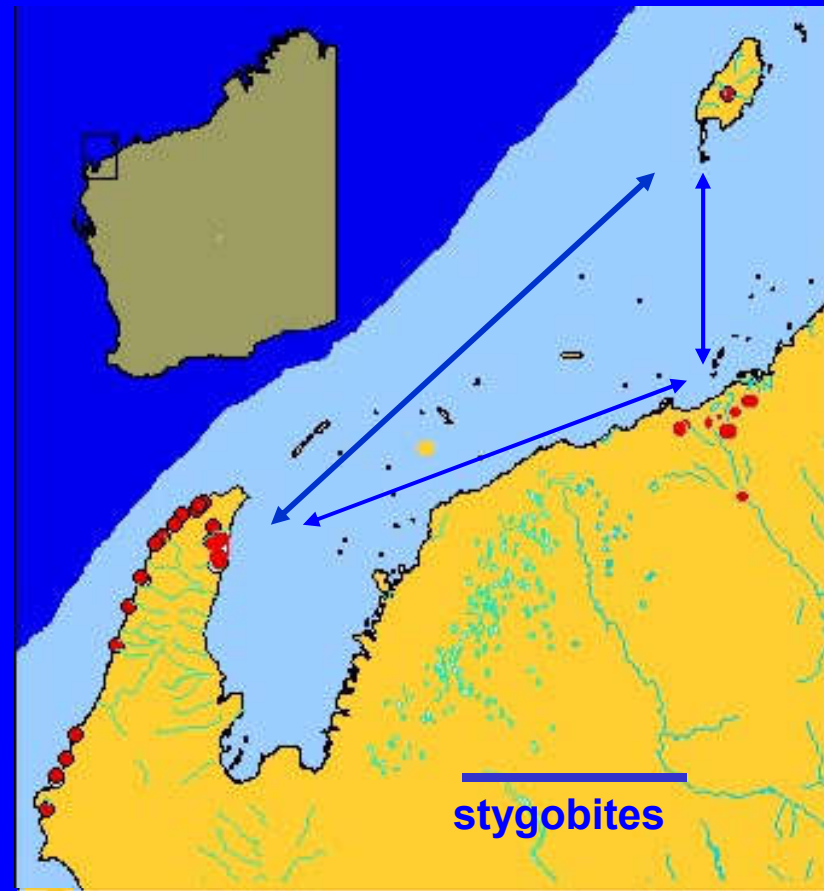
Cascade of N-species in upper few metres equivalent to the upper few mm of anoxic muds

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 troglifauna and elevated anchialine fauna



Fauna from Cape Range and environs anchialine system

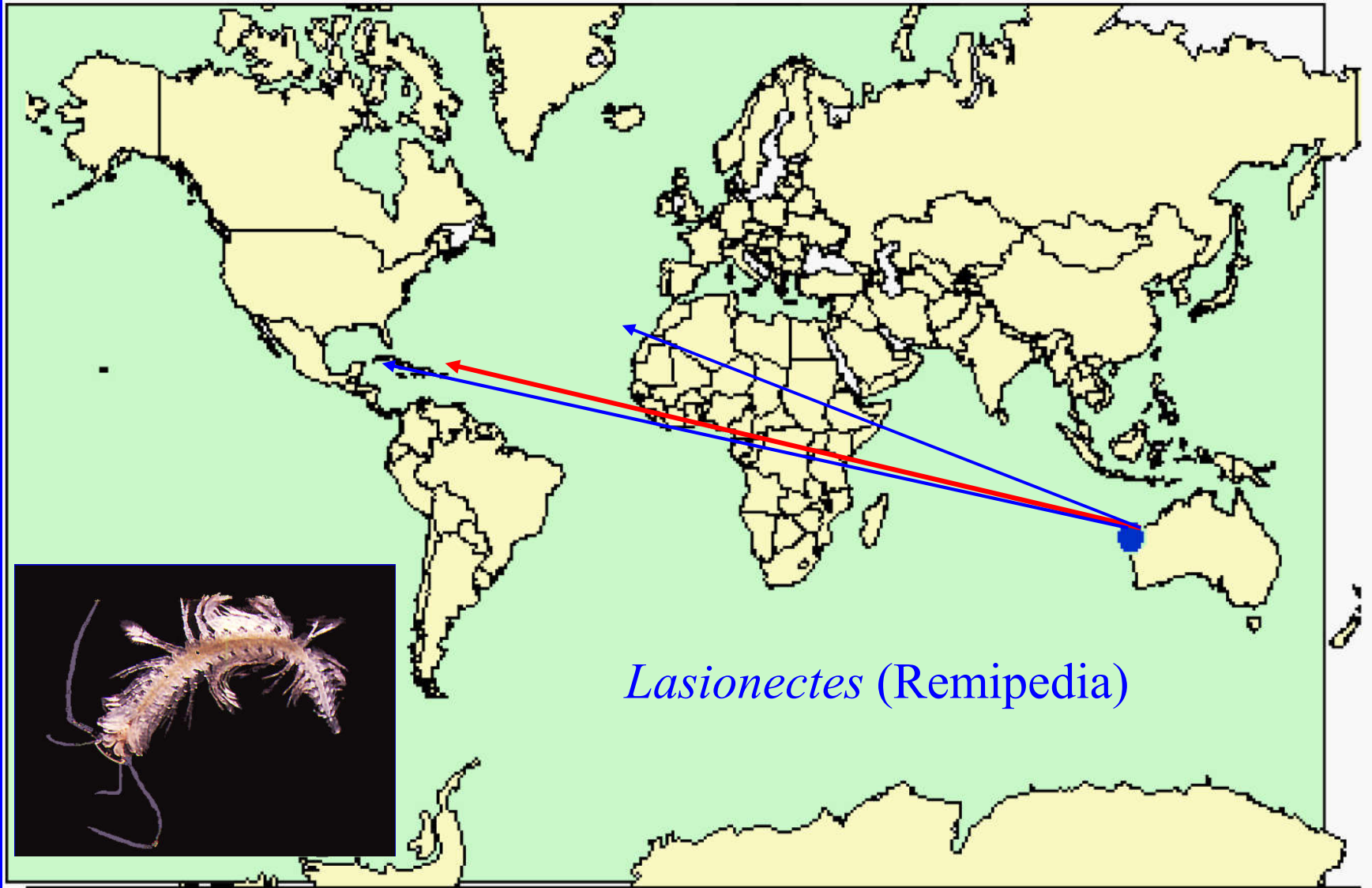
<i>Milyeringa veritas</i>	Perciformes: Eleotridae	1 of 2 stygobitic vertebrates in Oz	Bundera, CRP, BWI
<i>Ophisternon candidum</i>	Osteichthyes: Synbranchidae	1 of 2 stygobitic vertebrates in Oz	CRP
<i>Halosbaena tulki</i>	Thermosbaenacea: Halosbaenidae	New Order for SH	CRP, BWI, Pilbara
<i>Stygiocaris 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 thalanji</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

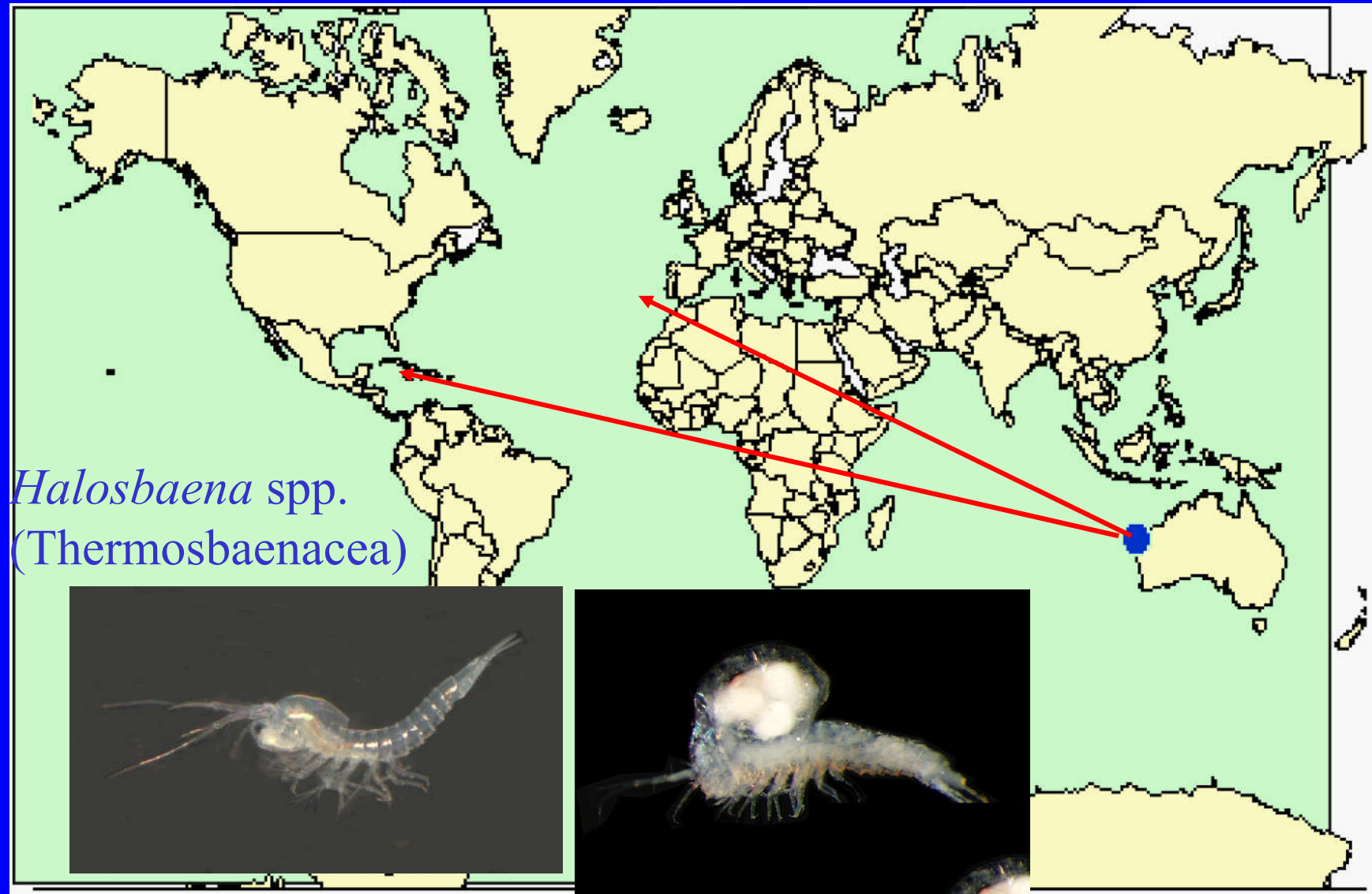


Lasionectes: Remipedia



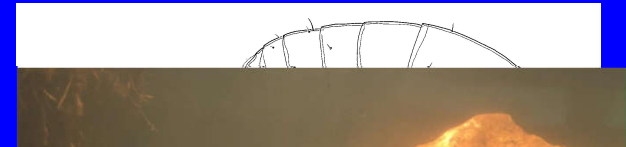
Lasionectes (Remipedia)

Affinities of the anchialine fauna



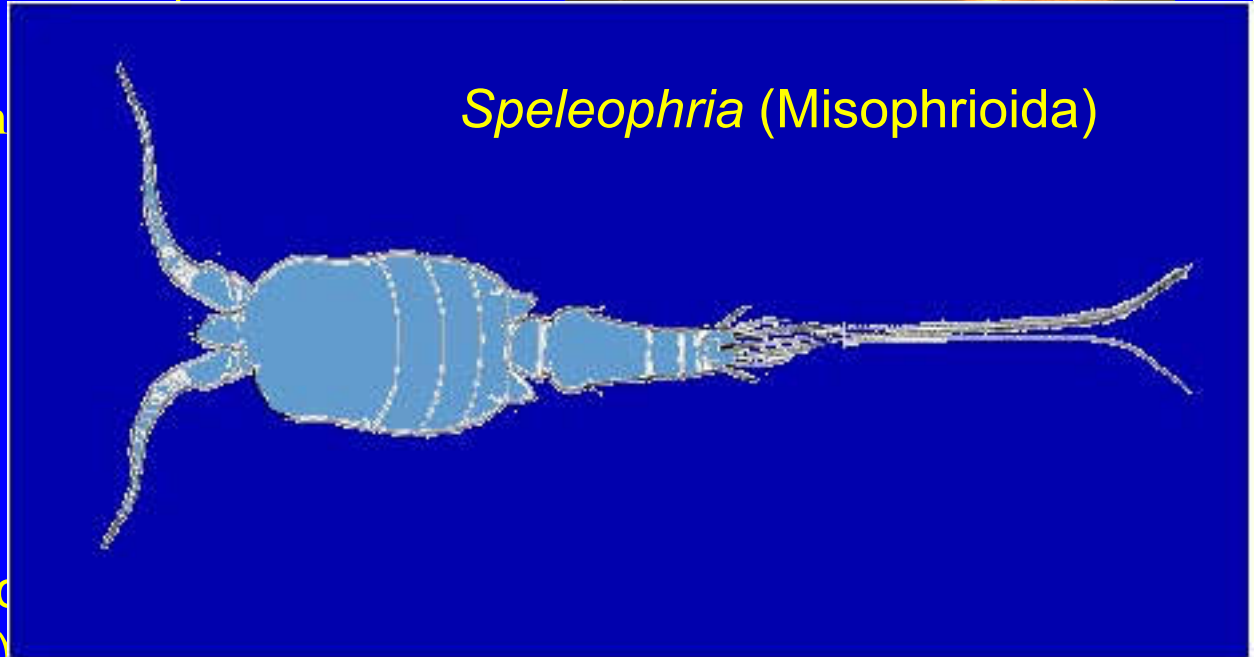
Variations on this theme in:

Bunderia cf *Enantronoides*
Epacteriscidae (Calanoida)



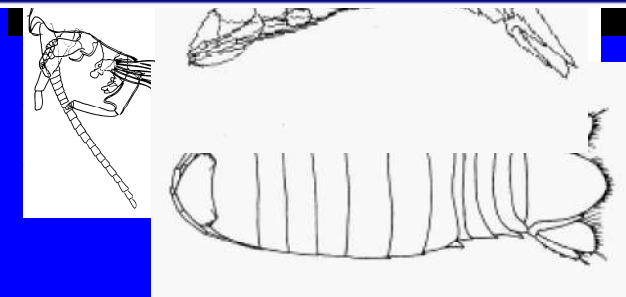
Ophisternon : Synbranch

Speleophria (Misophrioida)



Danielopolina (Ostracod)
Thaumatocypridoidea)

Stygocyclopia (Calanoida)



Haptolana (Isopoda: Cirolanidae)

Danielopolina (Thaumatoocyprididae) Danielopol *et al.* 2000.

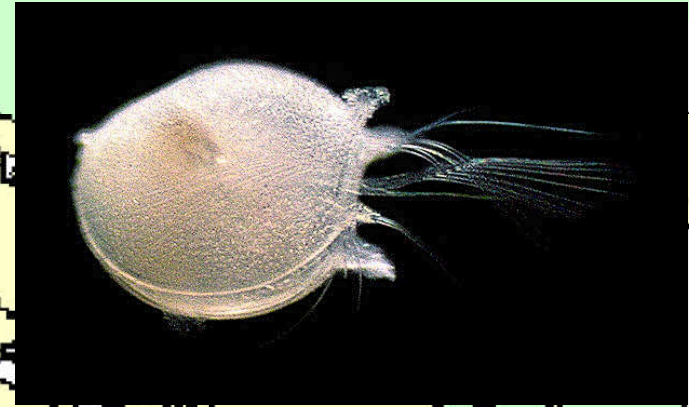
Pokornyopsis feifeli

Upper Jurassic

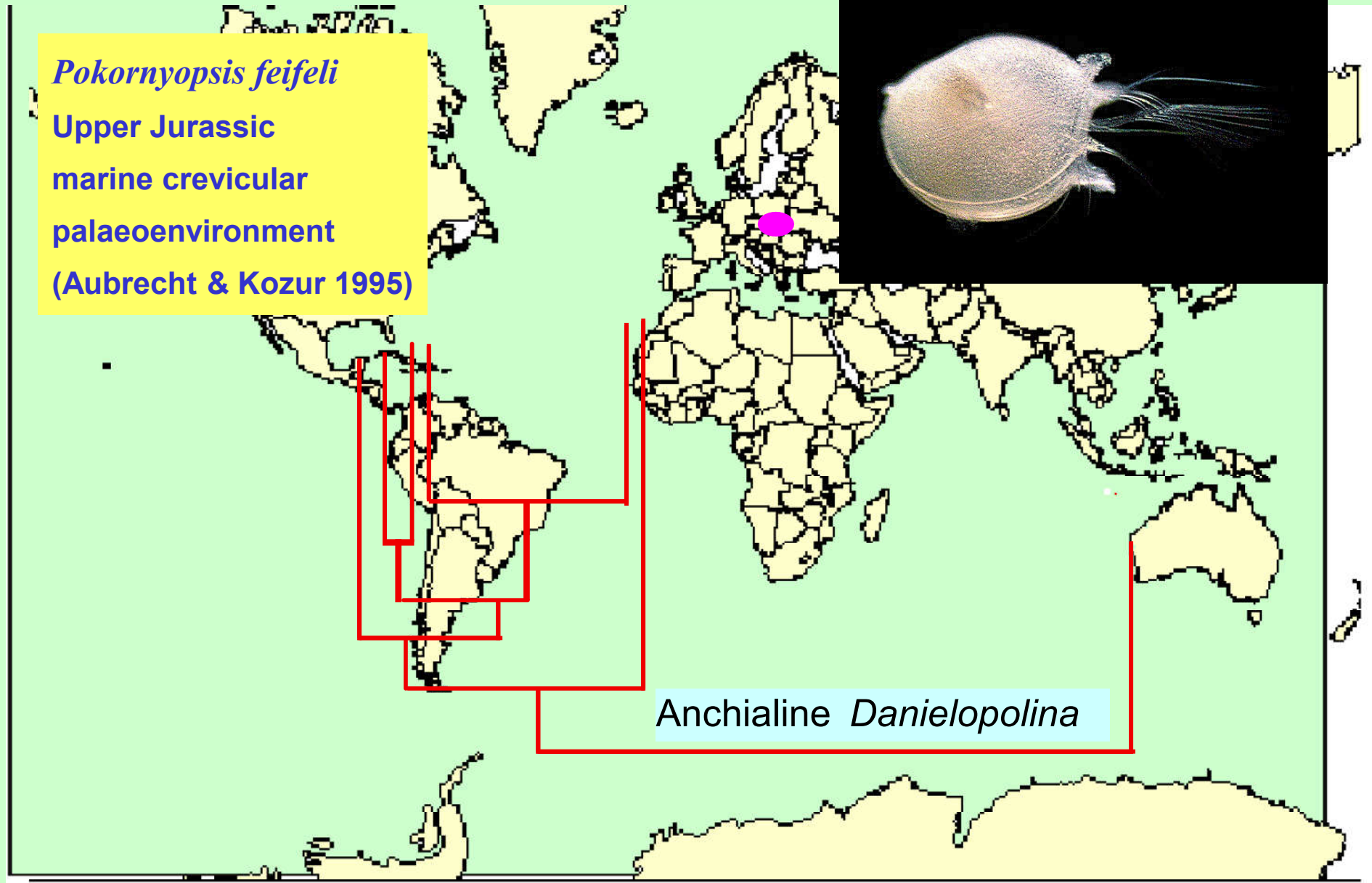
marine crevicular

palaeoenvironment

(Aubrecht & Kozur 1995)



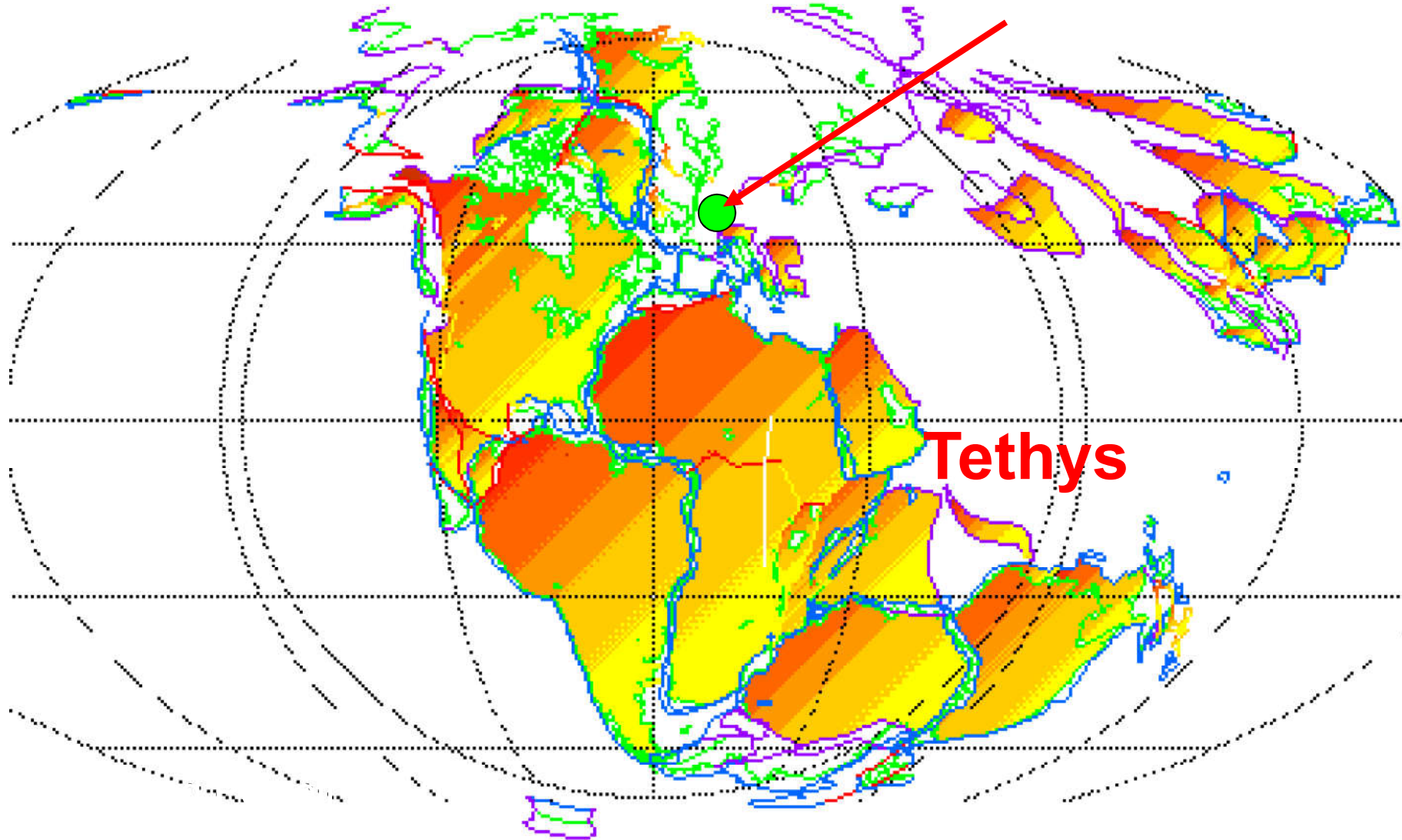
Anchialine *Danielopolina*



Tethys 1

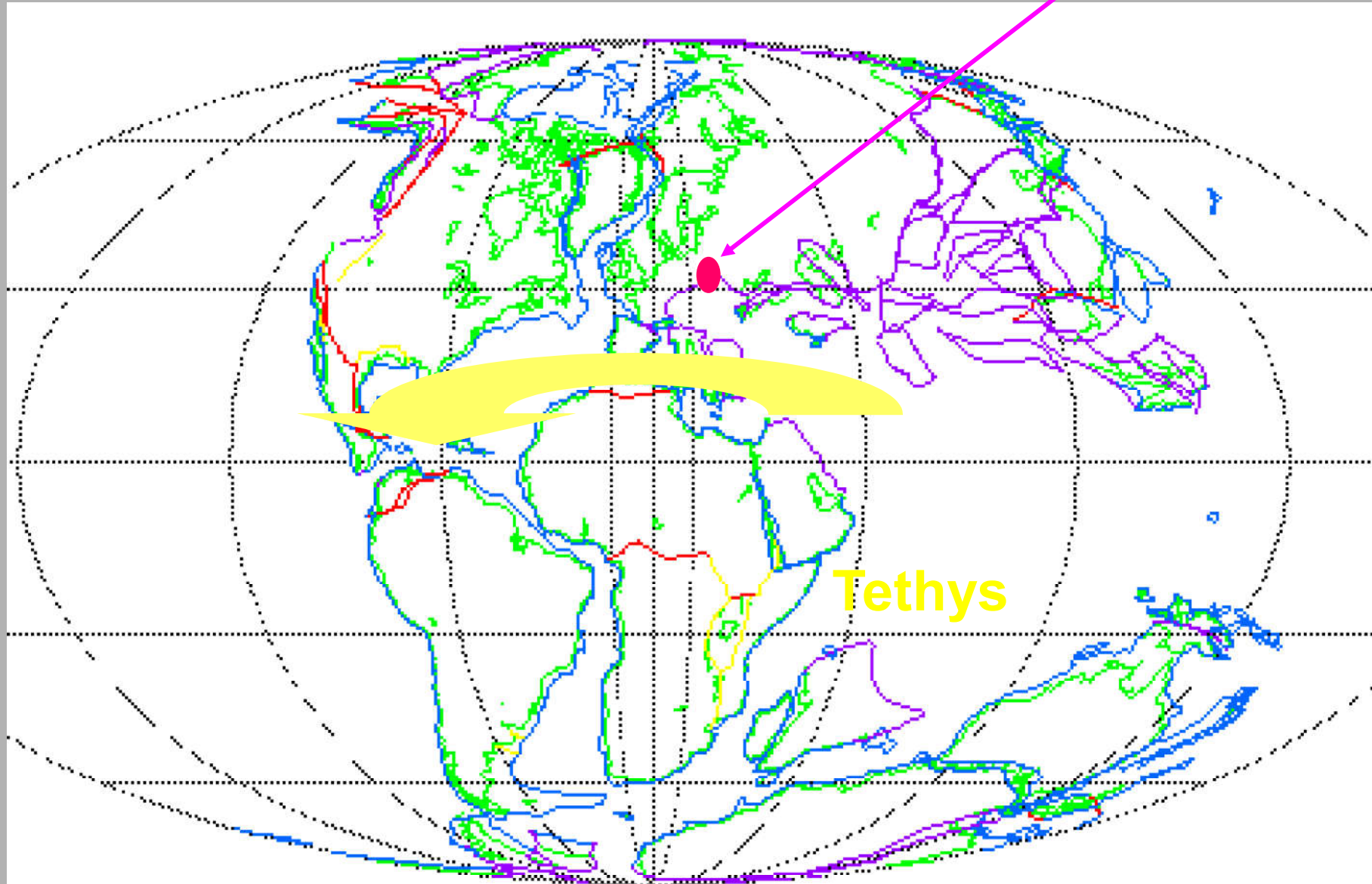
Plate positions 175 Ma

Pokornyopsis feifeli



Atlantic opening 110Ma

Pokornyopsis feifeli



Recent developments

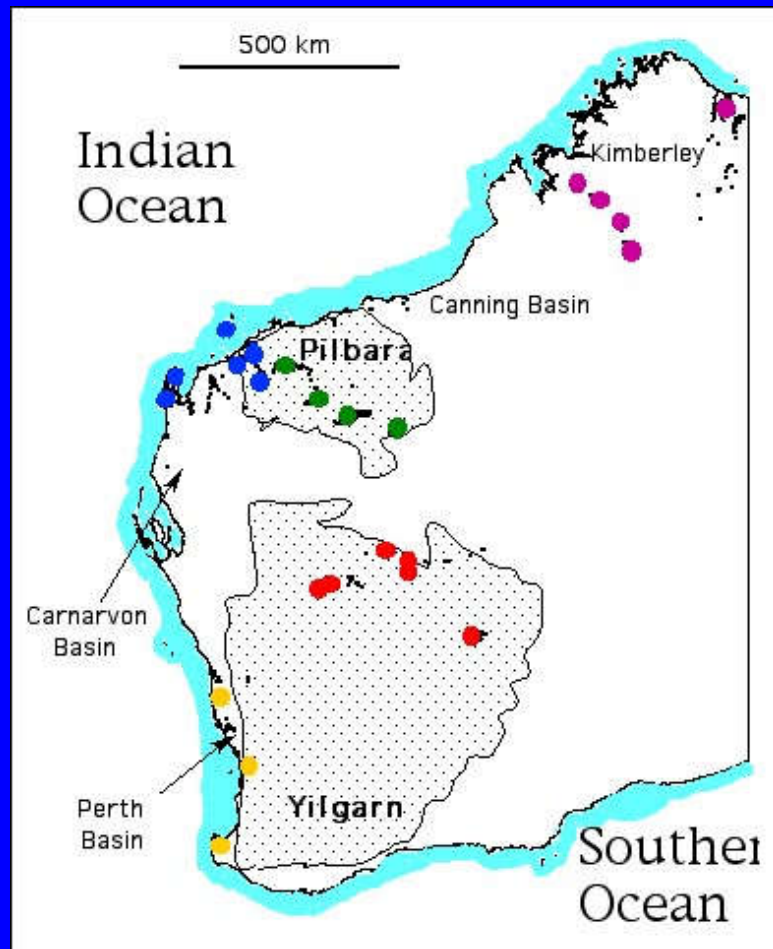
- Tethyan fauna on Christmas Island, a sea mount island
- *Microceratina* (Cytheruridae) spread through the Tethys Sea (Namiotko et al. 2004)
First description of soft parts of this Miocene genus

Danielopolina
(Thaumatocypridoidea)



Enigmatic

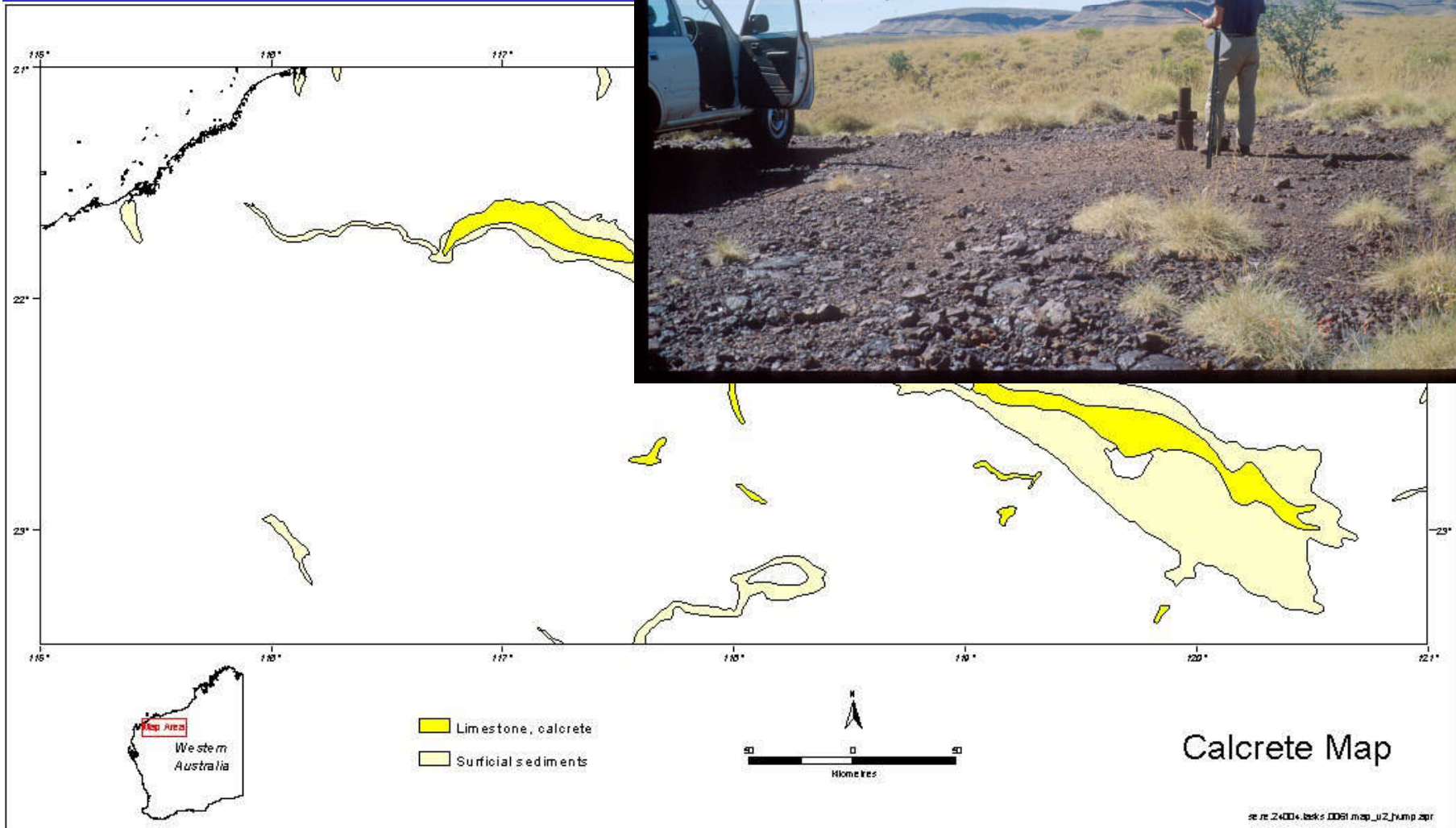
Western Shield



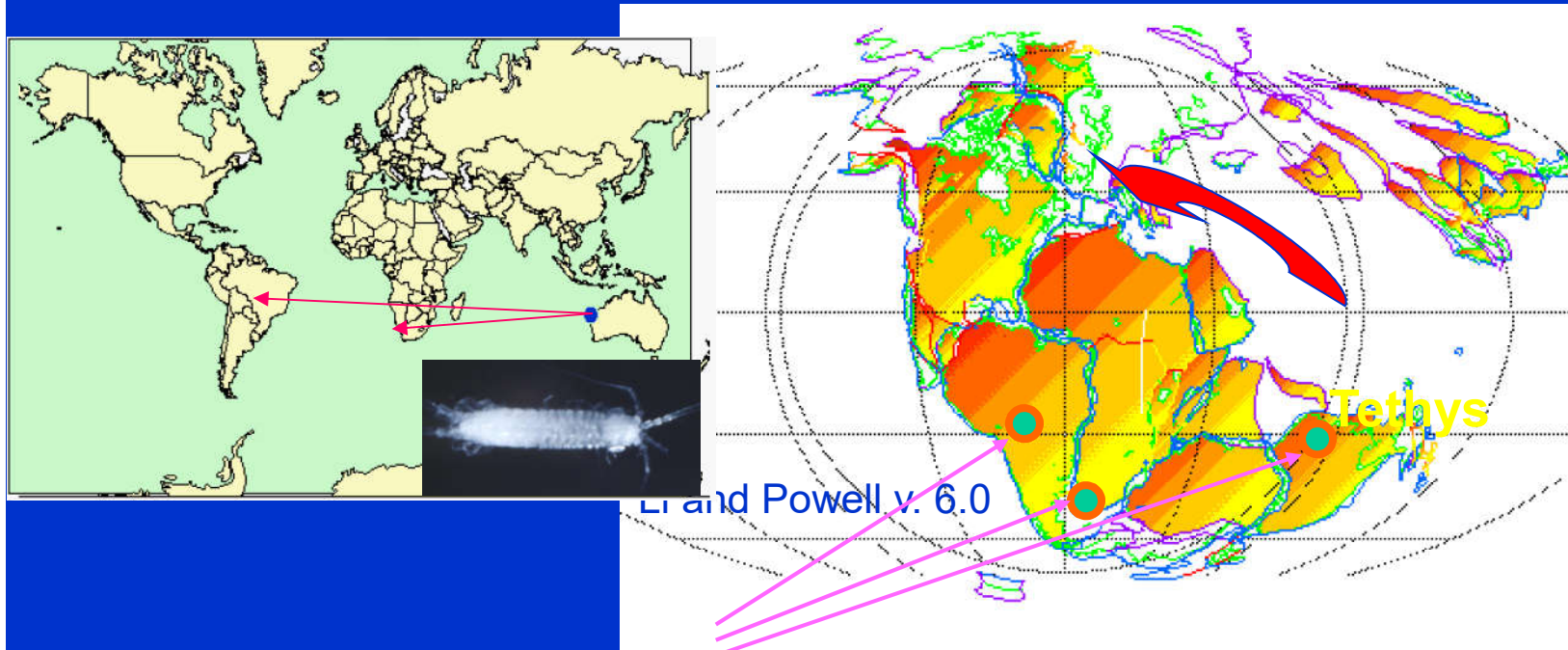
Pilbara: cyclone affected arid region with episodic rainfall



Western Fortescue Plain aquifer: lacustrine limestone



Spelaeogriffacea



Spelaeogriffacea

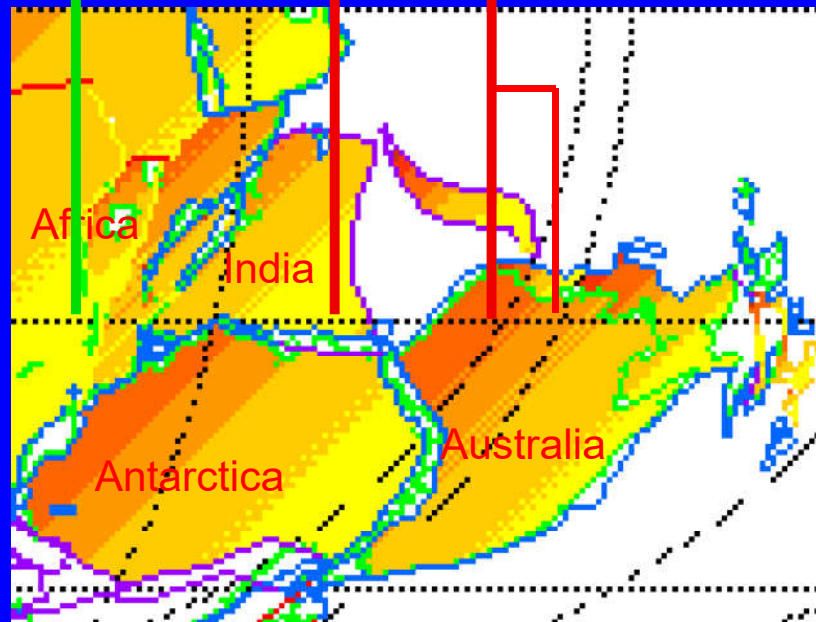
Water mites Mideopsellinae

Arrenuroidea: Mideopsidae

Cave and interstitial habitats

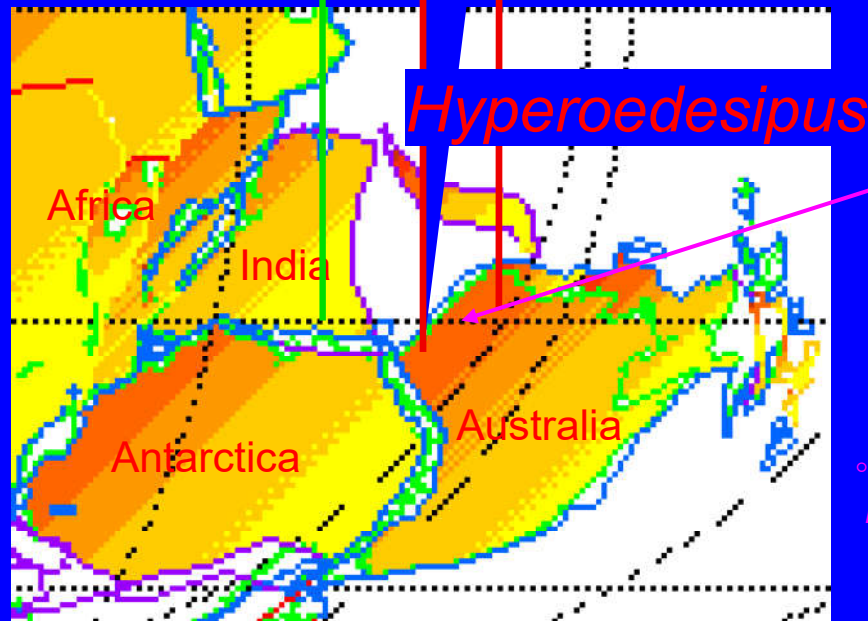
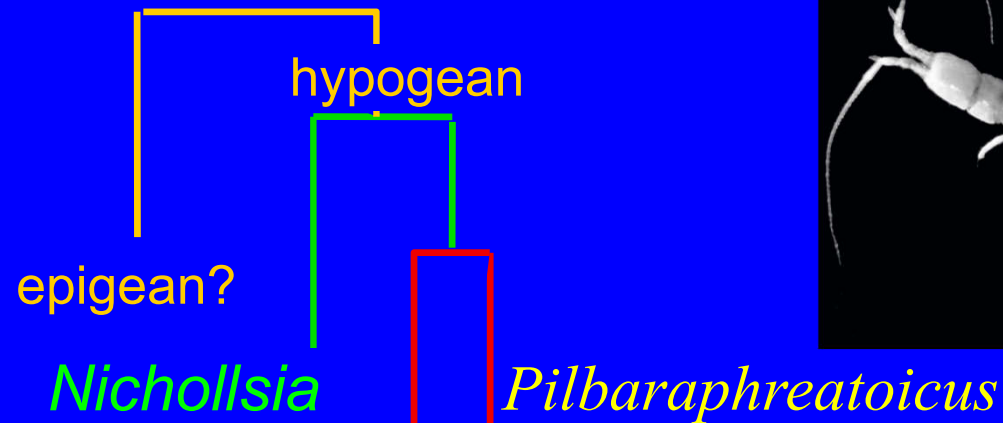
Mideopsellides

Tiramideopsis



Data from Harvey 2001

Phreatoicida: Hypsimetopodi



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

Forcing a change in geological context?

G.D.F. Wilson, *Australian Journal of Earth Sciences*, 2002.
pers. Comm. 2002.

Groundwater calcretes



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

Gascoyne palaeovalley

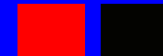


Photos: Remko Leys

Palaeovalleys constrained landscape evolution and groundwater flow



**Groundwater
Calcrete**



**Divide of
Archaean rocks**

Yilgarn calcrete stygofauna

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

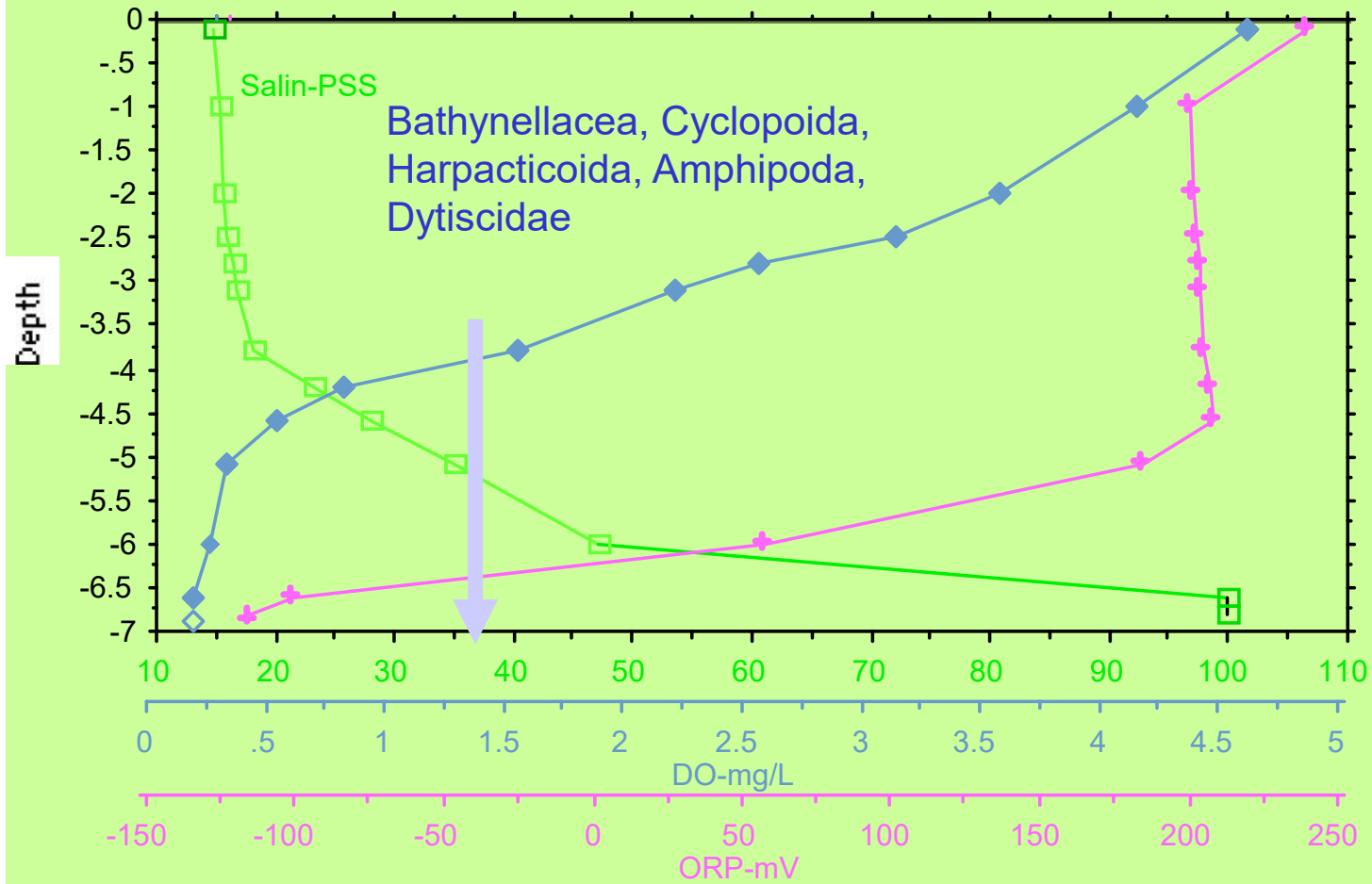


Groundwater
calcretes are
associated
with salt
lakes
(playas)



Windarra calcrete near salt lake

cf. anchialine systems



Routine
purgings of
bores
destroys
biologically
important
information

.

Subterranean waterbeetles (Coleoptera: Dytiscidae)



Tjirtudessus



Now *Limbodessus*



Nirridessus



Liodessus

Dytiscidae



*Nirripiriti
arachnoides*

L. compactus

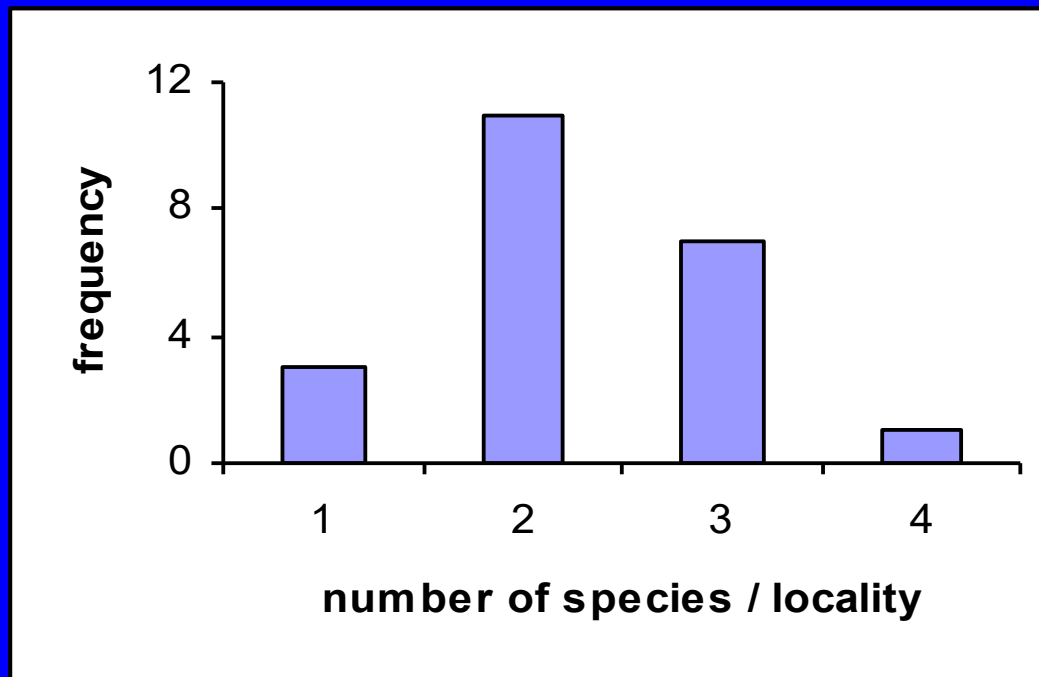


*Limbodessus
macrotarsus*



Photo: C.H.S.Watts

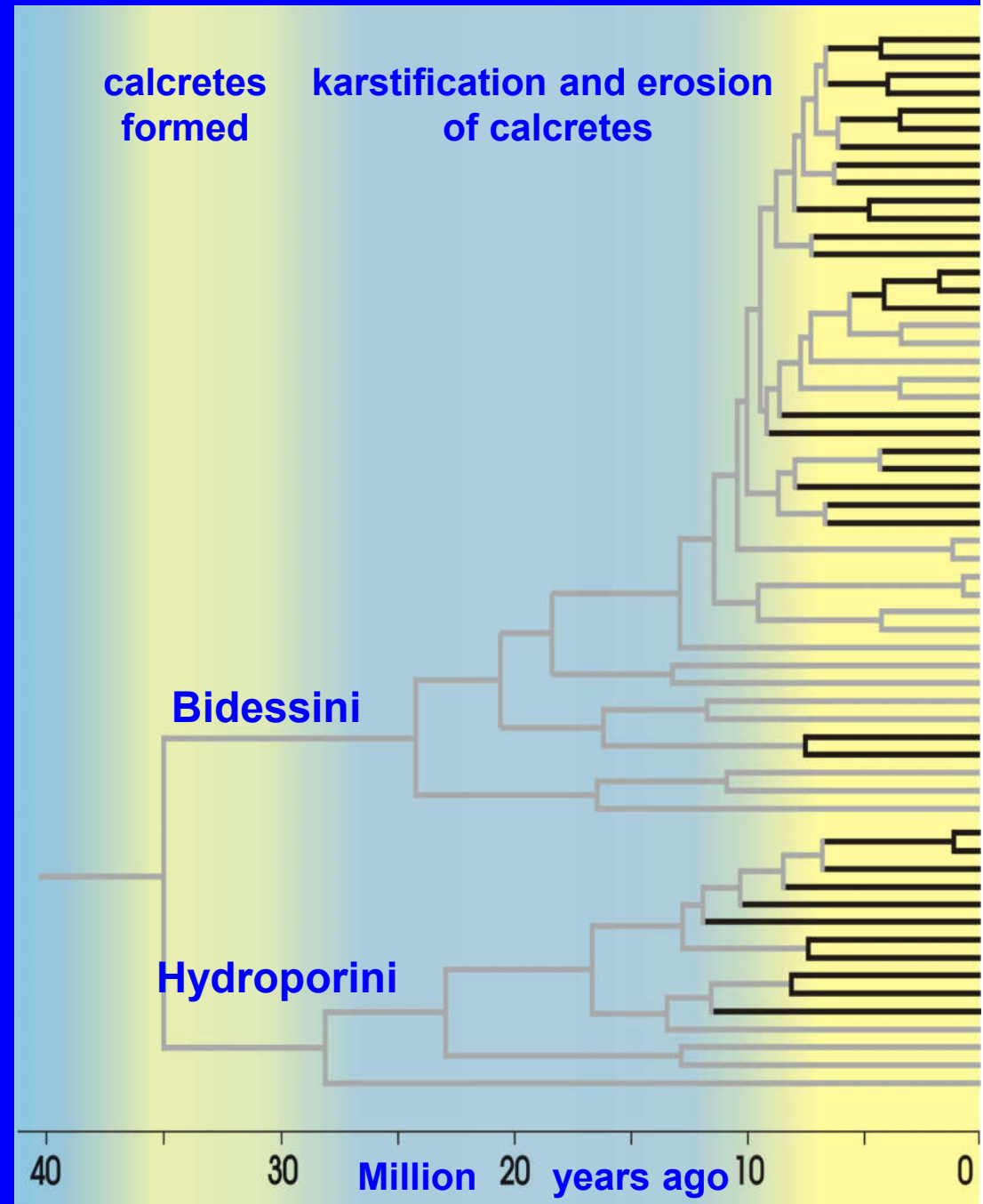
Summary of taxonomic data



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

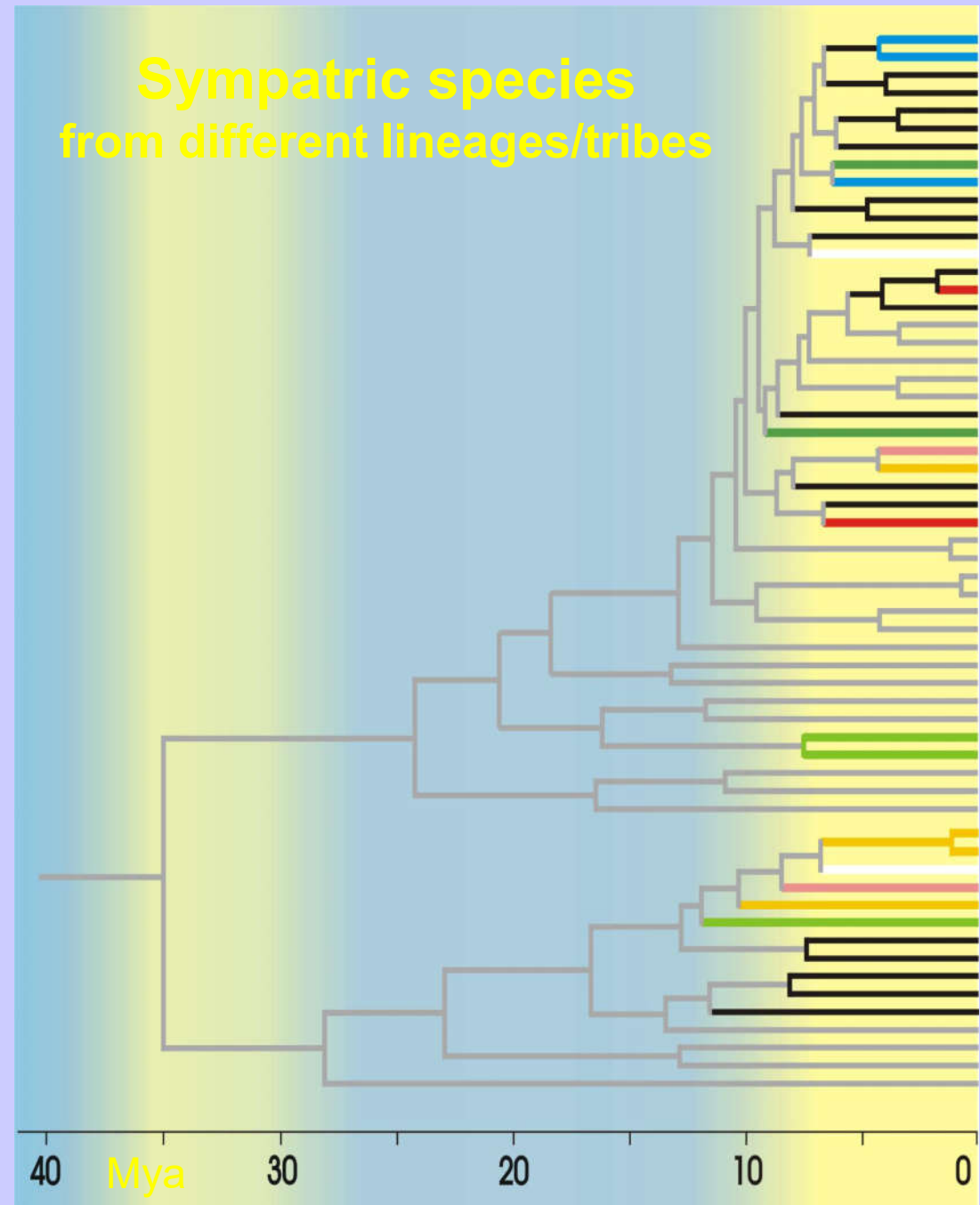
Yuinmery

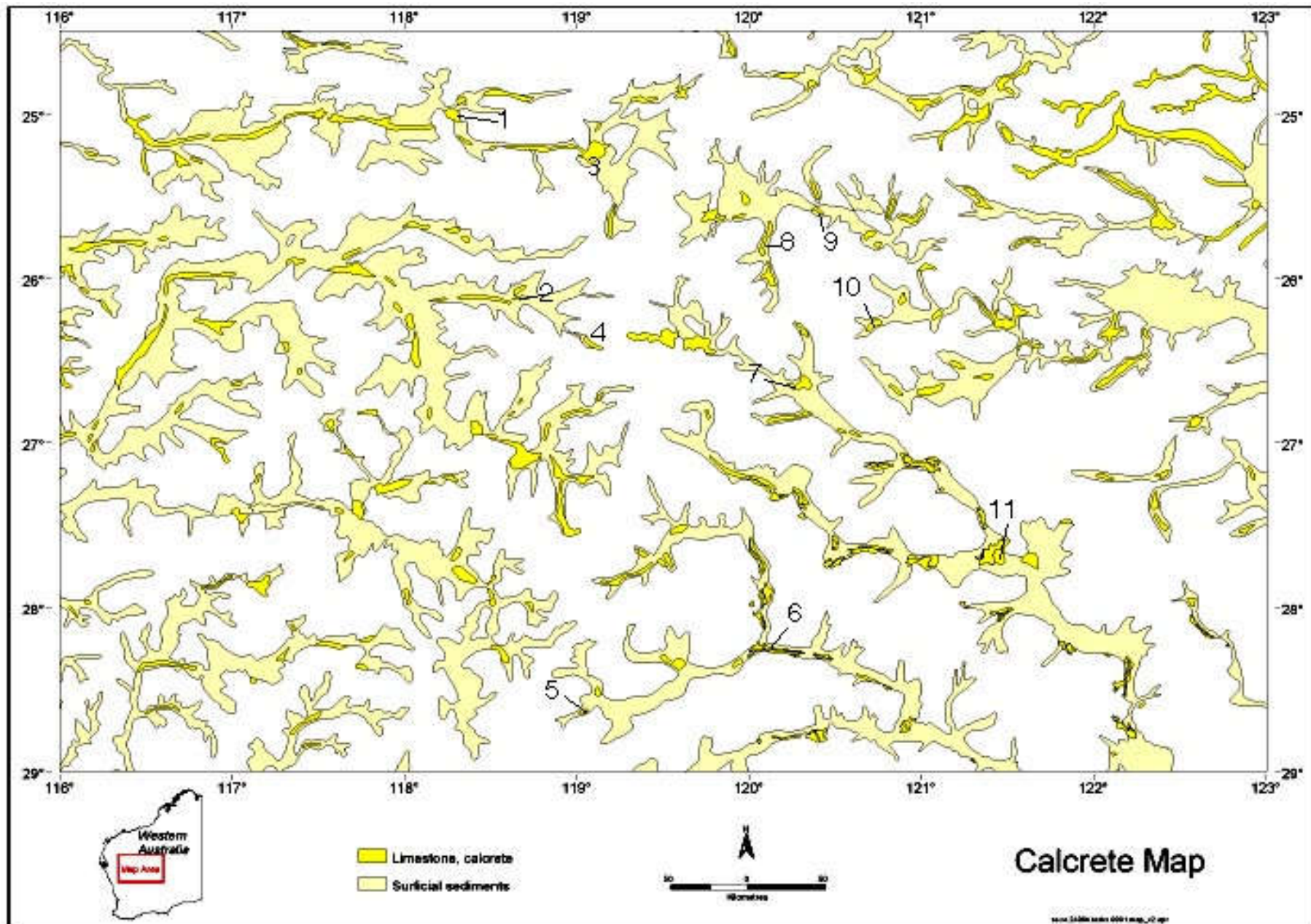
Depot Springs

Three Rivers

Pinnacles

- multiple ancestral species colonised the same calcrete

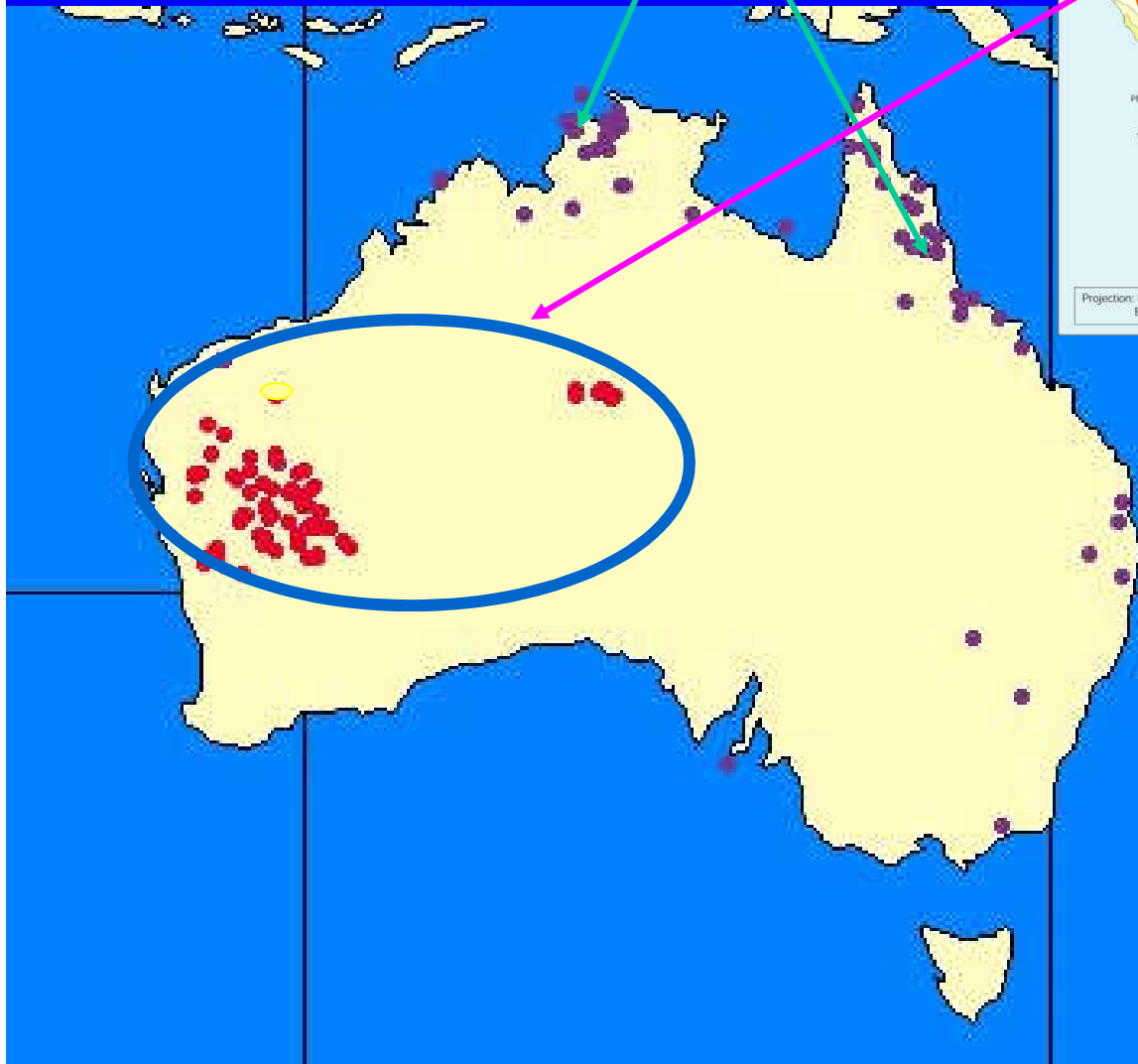
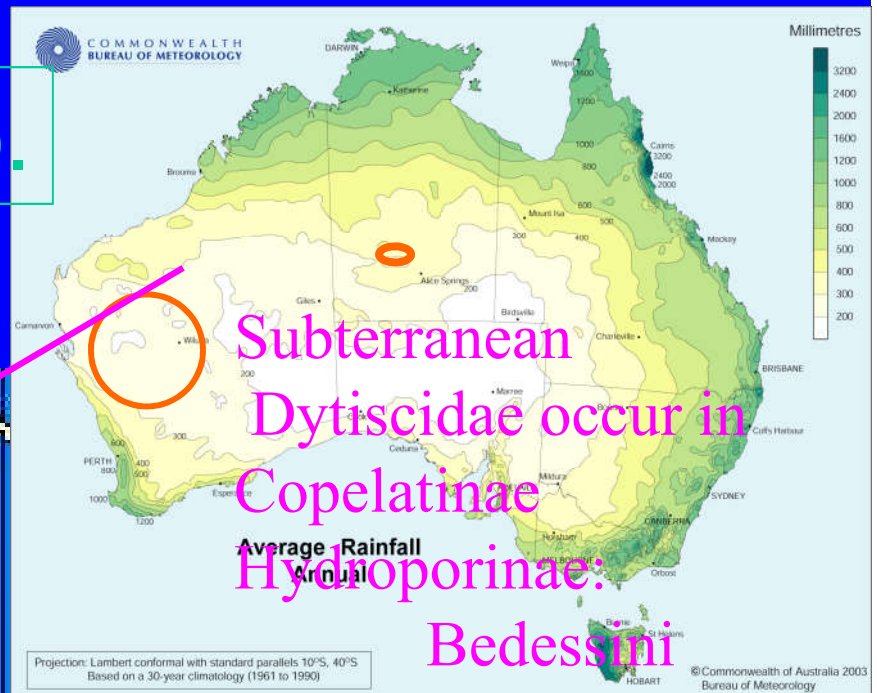




350,000 km² – 2/3 size France

Dytiscidae

Bidessoides 8 spp.



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

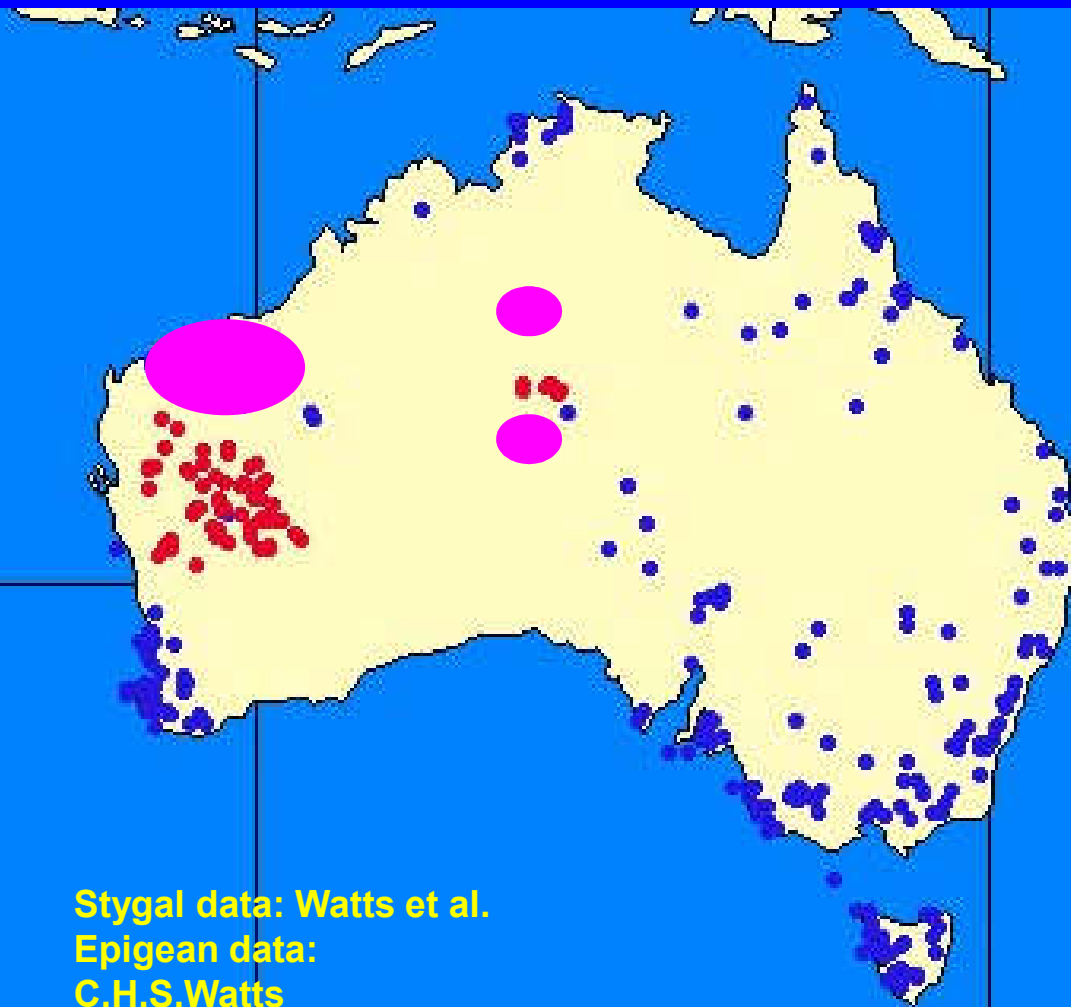
Poraster 8 spp.

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



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

Oniscidea

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

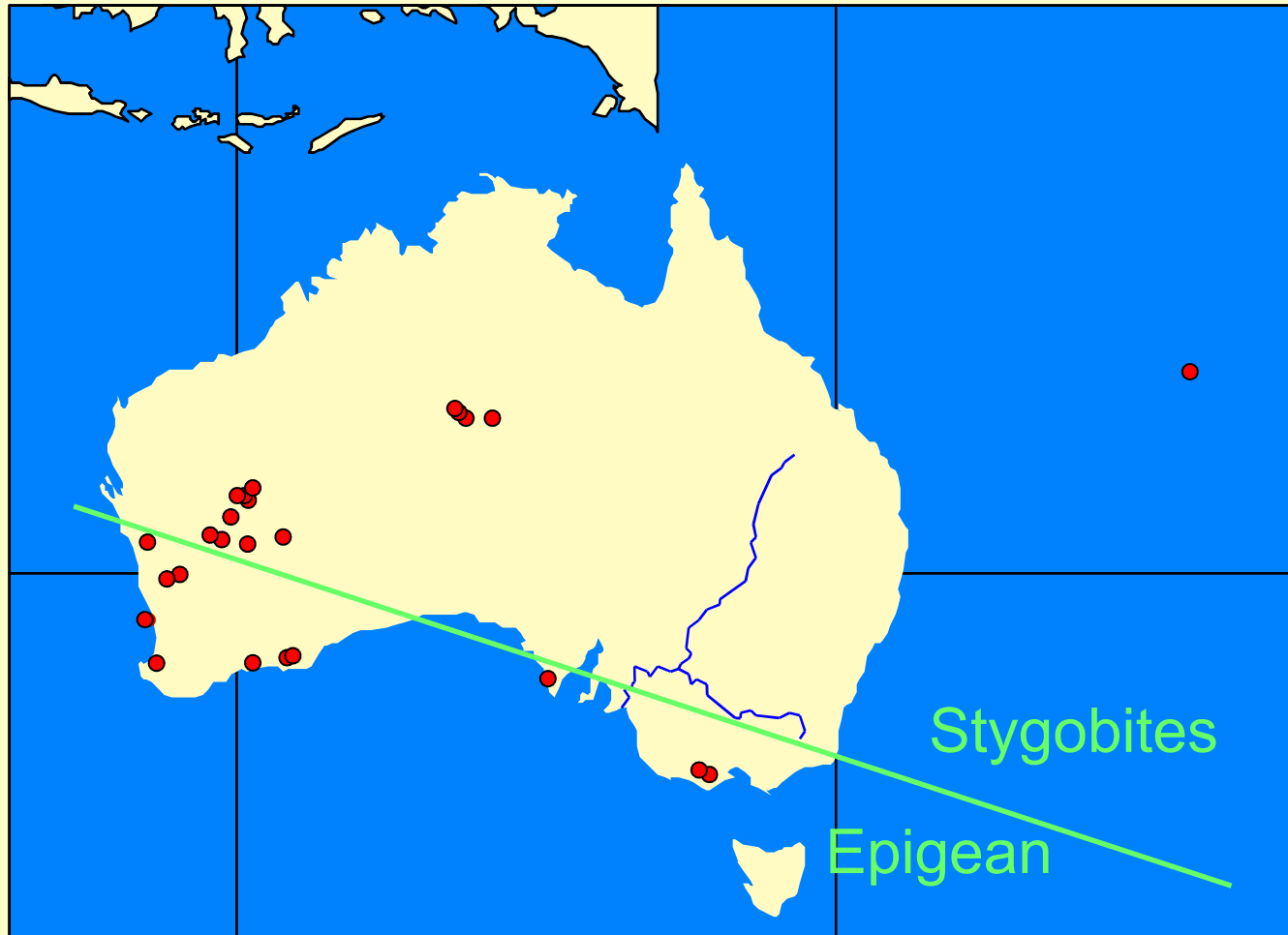


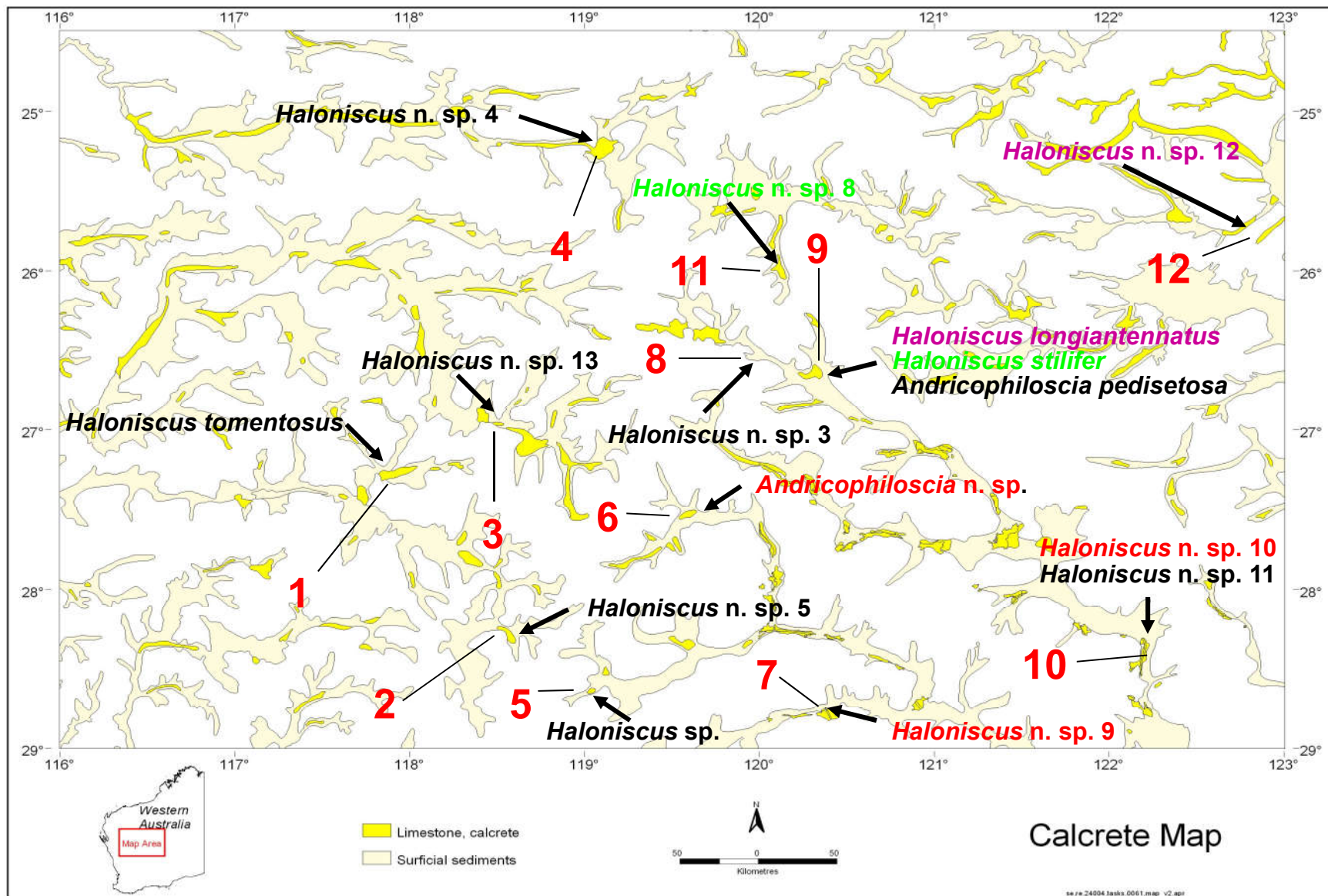
Haloniscus searleii
Lake Keilambete, VIC



Haloniscus n. sp. 12
Carnegie, Jimmys Well, WA

All collection sites





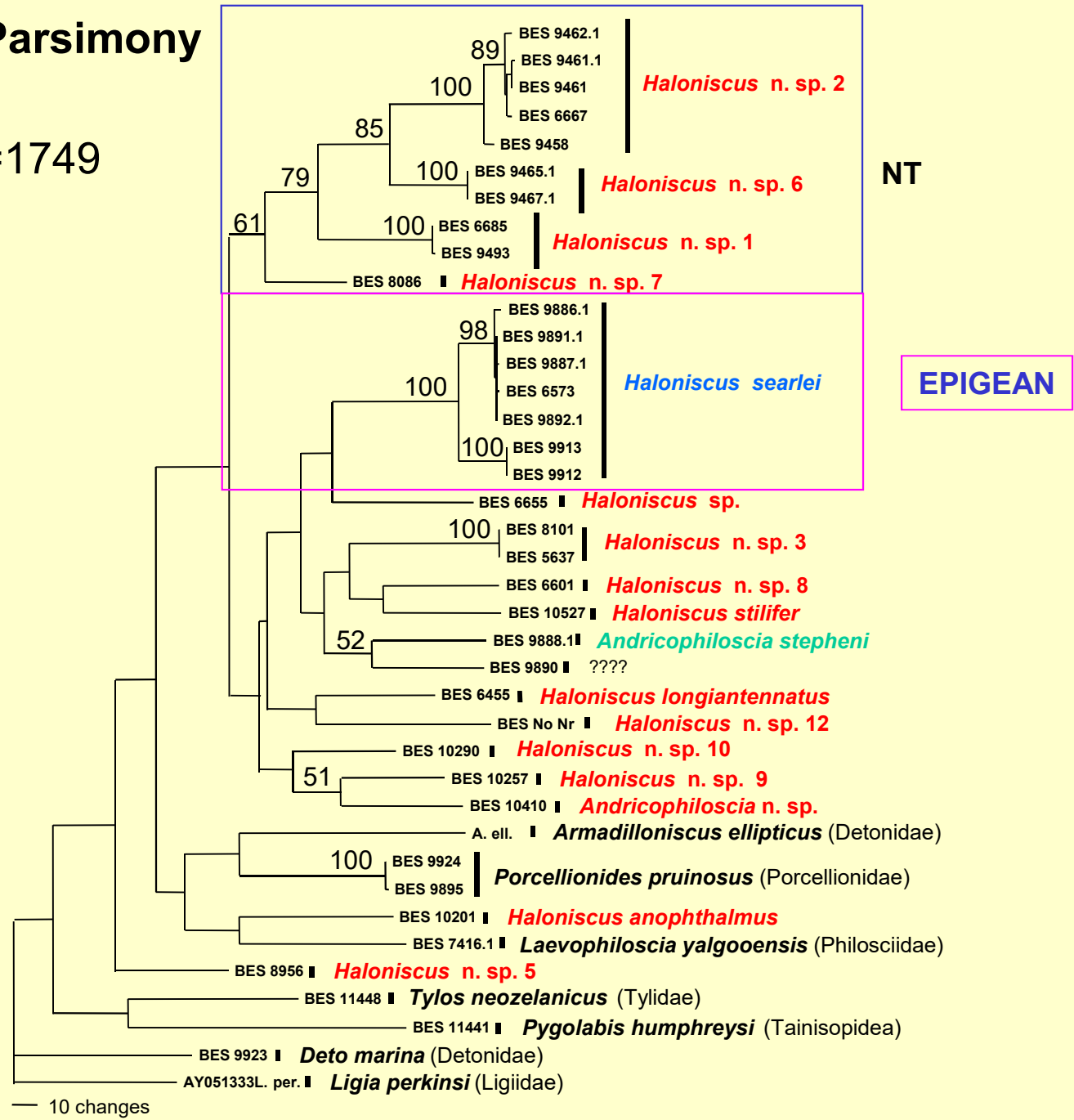
Yilgarn Region (Western Australia)

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



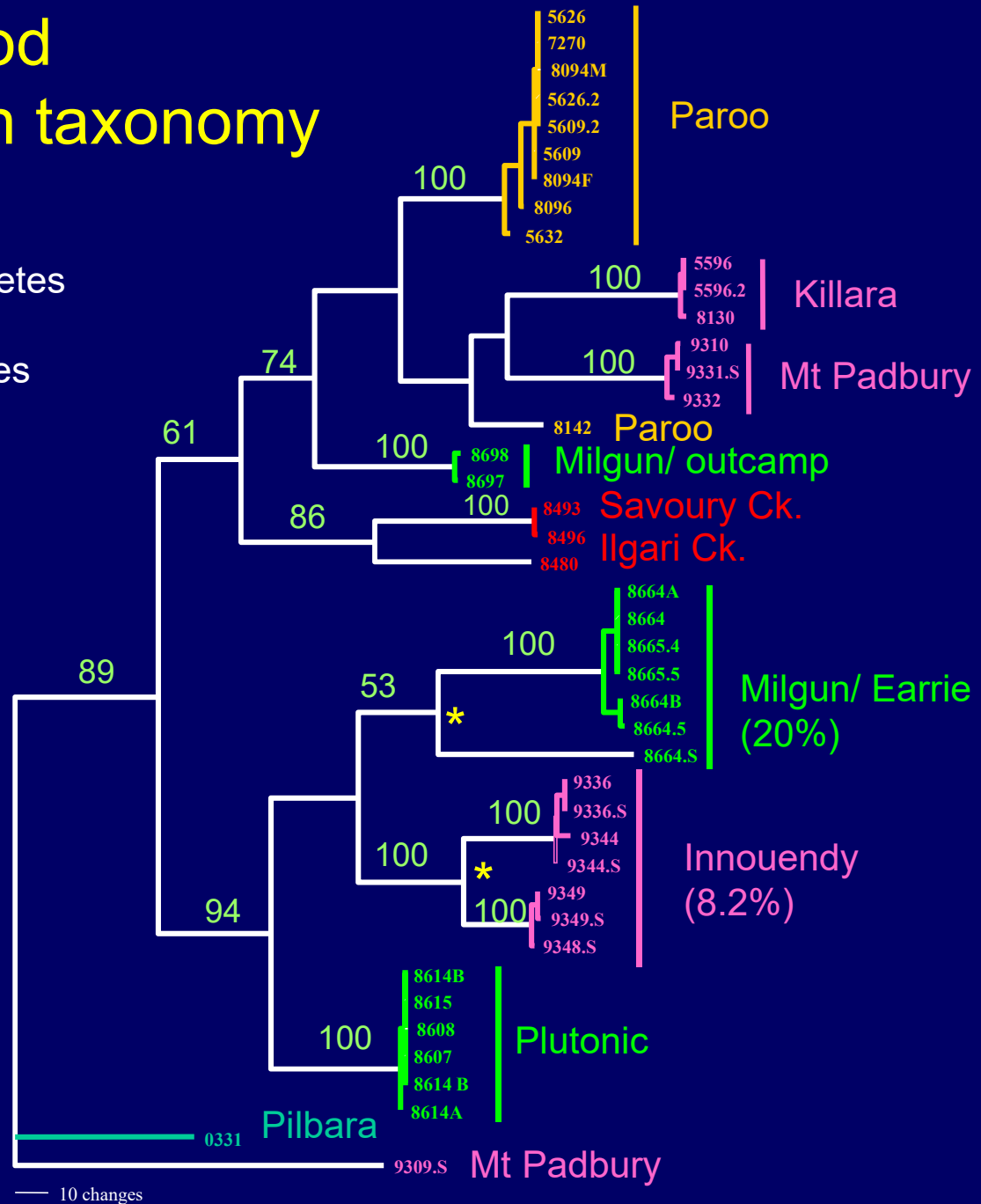
Preliminary amphipod phylogeny: unknown taxonomy

- 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)

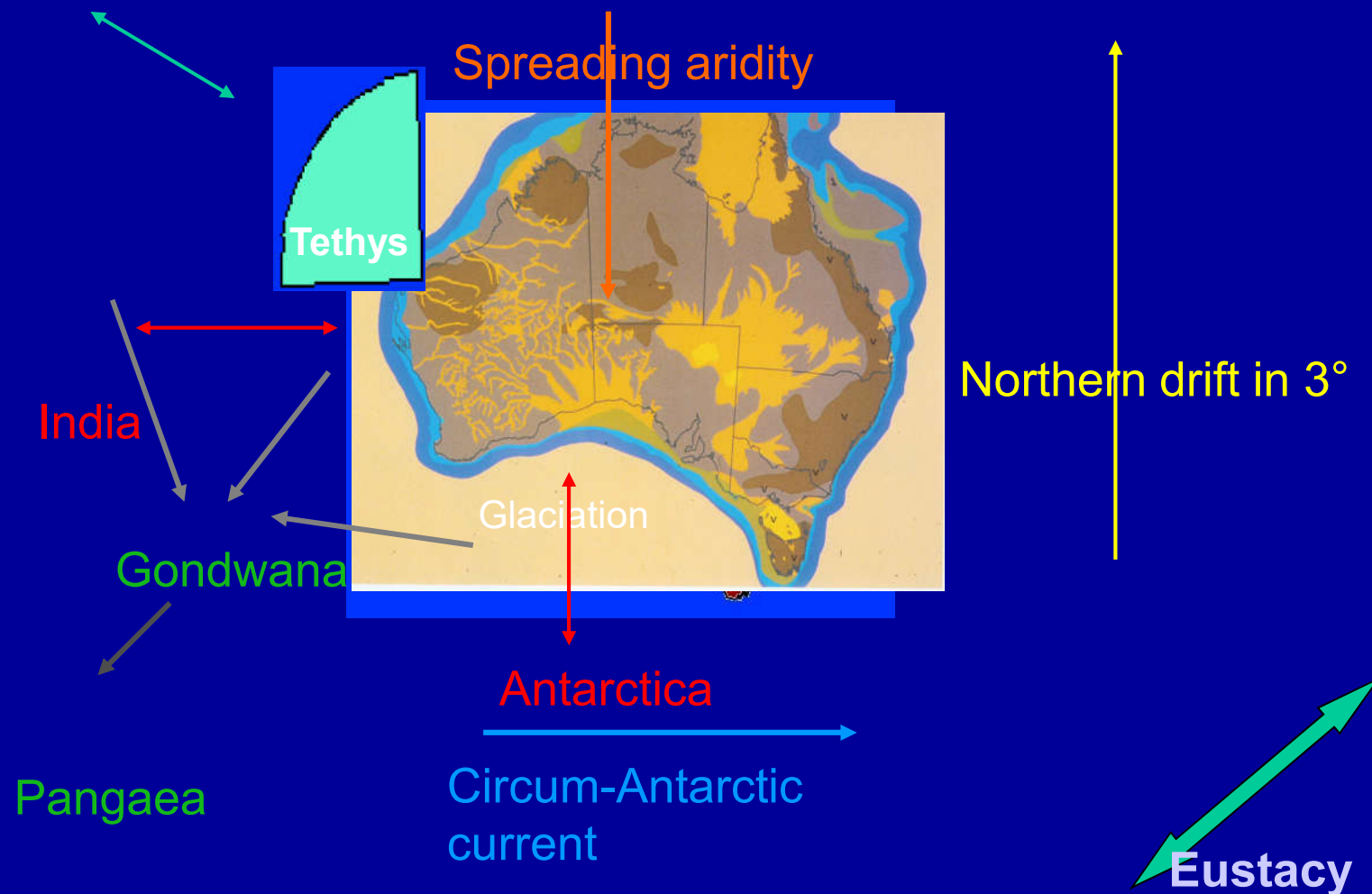
- 1-2 species / calcrete?



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



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Graphics:
Ken Grimes



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

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Management