

# The Pagodas of the western Blue Mountains – geoheritage just out of waiting ...

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# Why just out of waiting?

- Ignored by European society for almost 200 years – at best seen as ‘rocky outcrops’ and a source of ‘black crinkly’ bushrock
- Its geodiversity value slow to be recognised – e.g. 1991 Dept Mineral Resources called them ‘pergolas’
- Most of the pagoda country has no protection
- Very little research regarding the formation of this amazing landscape
- Still waiting for full recognition of their value

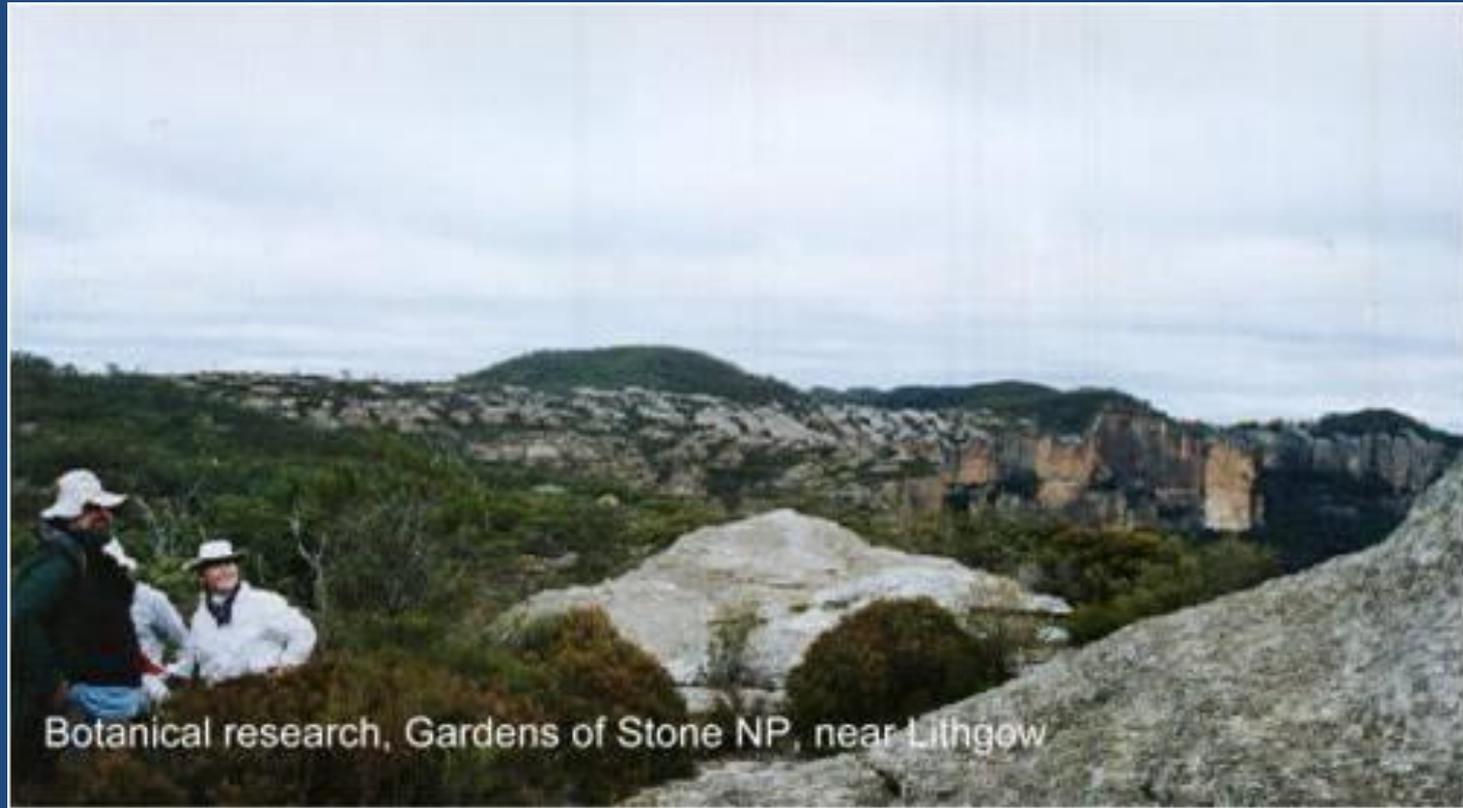




‘they are kind  
of nice ...’  
Bushwalker, early 1980s



# A biodiversity hotspot



Some rare and threatened species – *Darwinia* spp.,  
*Leucochrysum graminifolium*, *Banksia penicillata*,  
*Philotheca obovalis*, *Pseudanthus divaricatissimus*,  
*Leionema scopulinum*, *Prostanthera hindii*

# A haven for biodiversity and geodiversity



Pagoda Daisy,  
*Leucochrysum*  
*graminifolium*

A geo-bio synthesis – the  
geodiversity determines the  
biodiversity (pagodas and swamps)



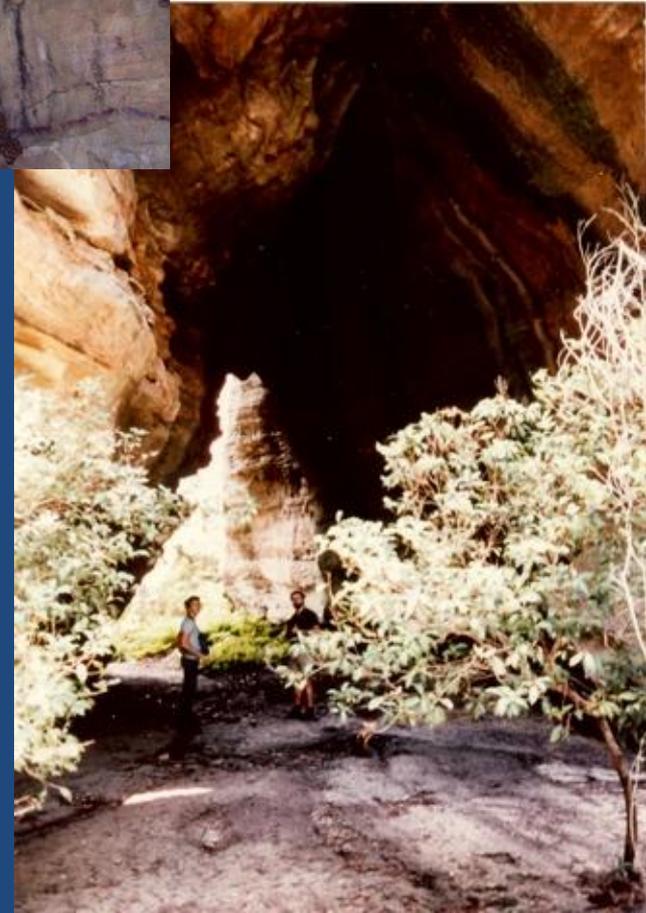
New species *Leoinema*  
*scopulinum*, found on pagodas  
around Lee Ck, NW Wollemi NP a  
few years ago



# Geodiversity wonderland



'Pagodas are a distinct geomorphological landscape unit' Dr Russel Blong, Macquarie Uni, 1980s

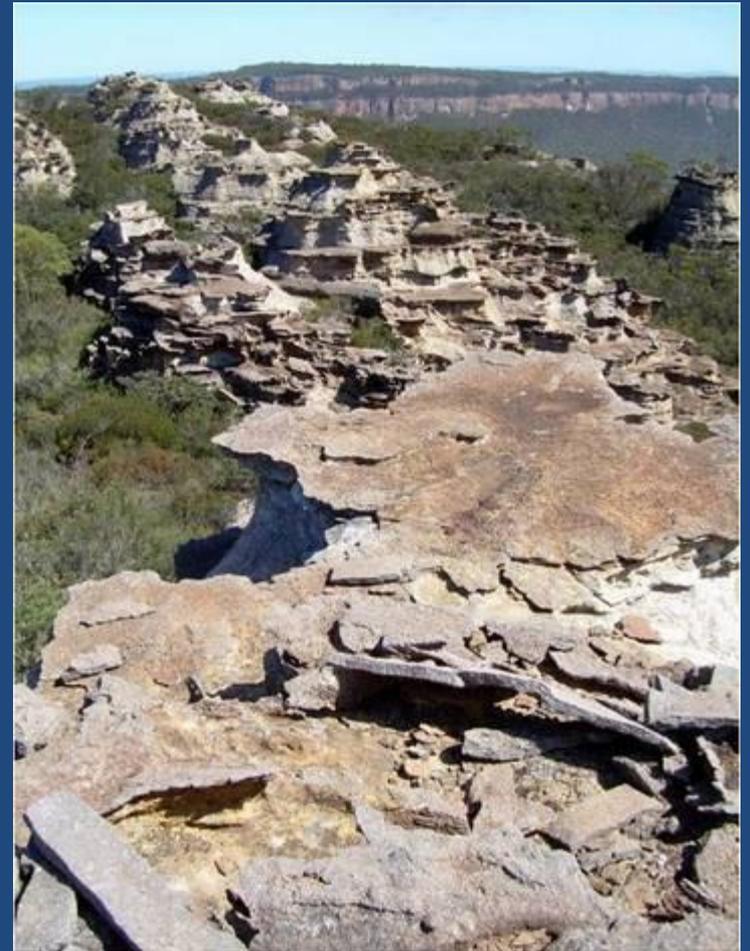


# What forms pagodas?

- Found in course grained Banks Wall and Burra-Moko sandstones in Narrabeen Sandstone
- Differential weathering - the ironstone protects underlying soft sandstone.
- Formation of ironstone banding *needs research* as under debate
- Unique in terms of *degree* of ironstone banding.



# 'Smoothies' and 'platies'

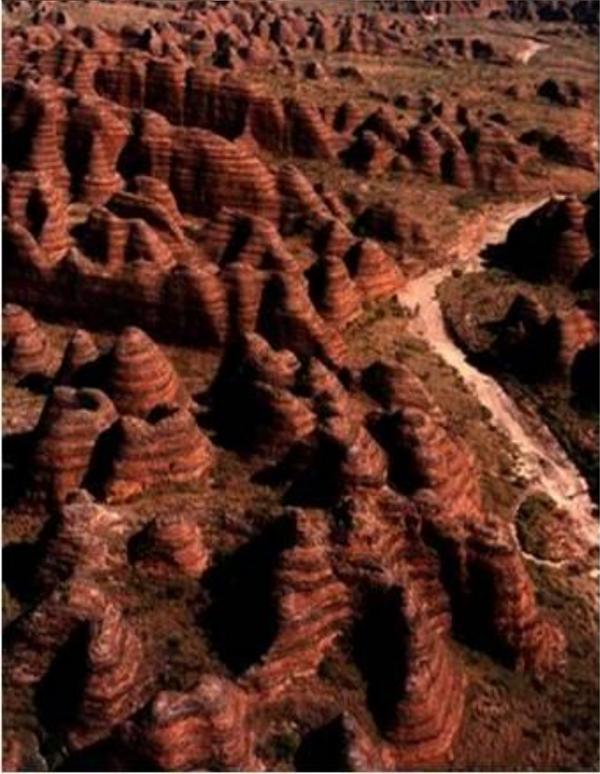


Smoothies with some iron  
banding, near Baal Bone Gap



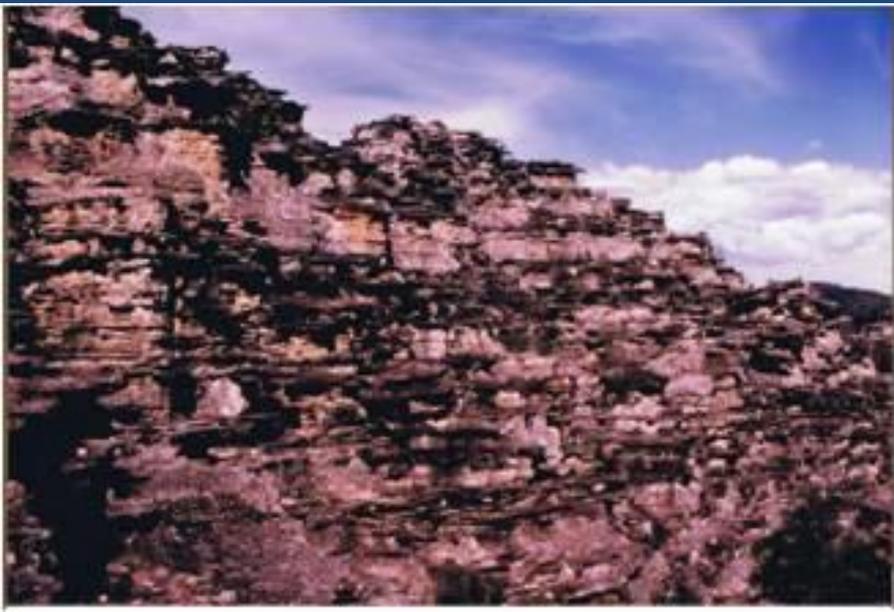
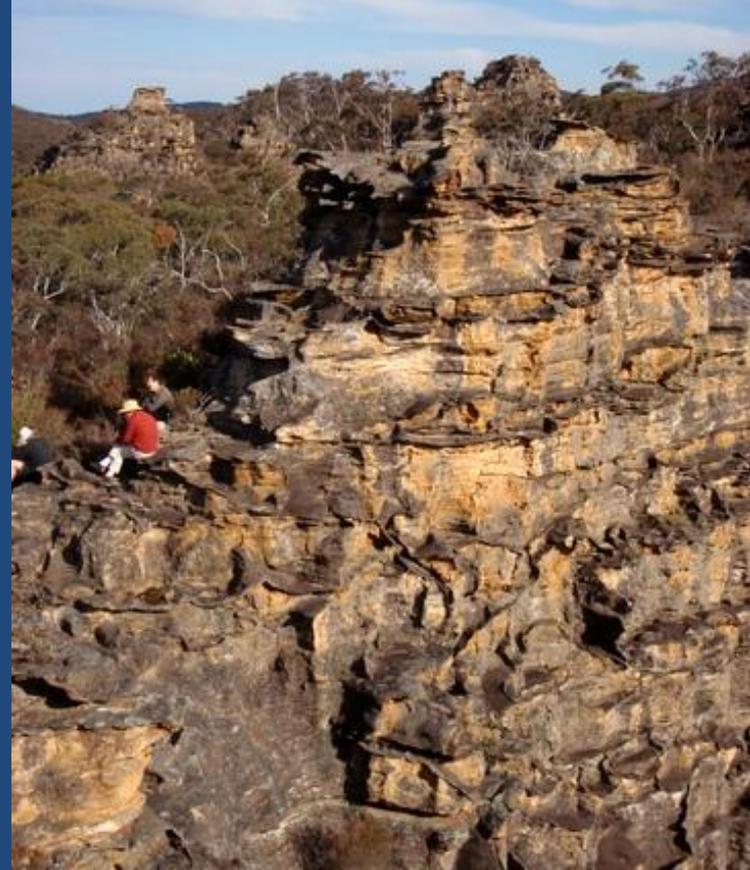
# Temple of Doom, Newnes Plateau (part platy and smoothie)





Smoothies similar to other beehive erosional features – Bungle Bungles (left), Budawangs (top left) and Valley of the Moon, Bolivia (above)

Platy pagodas, not  
so similar to other  
rock formations



# Platies





**The Lost City**



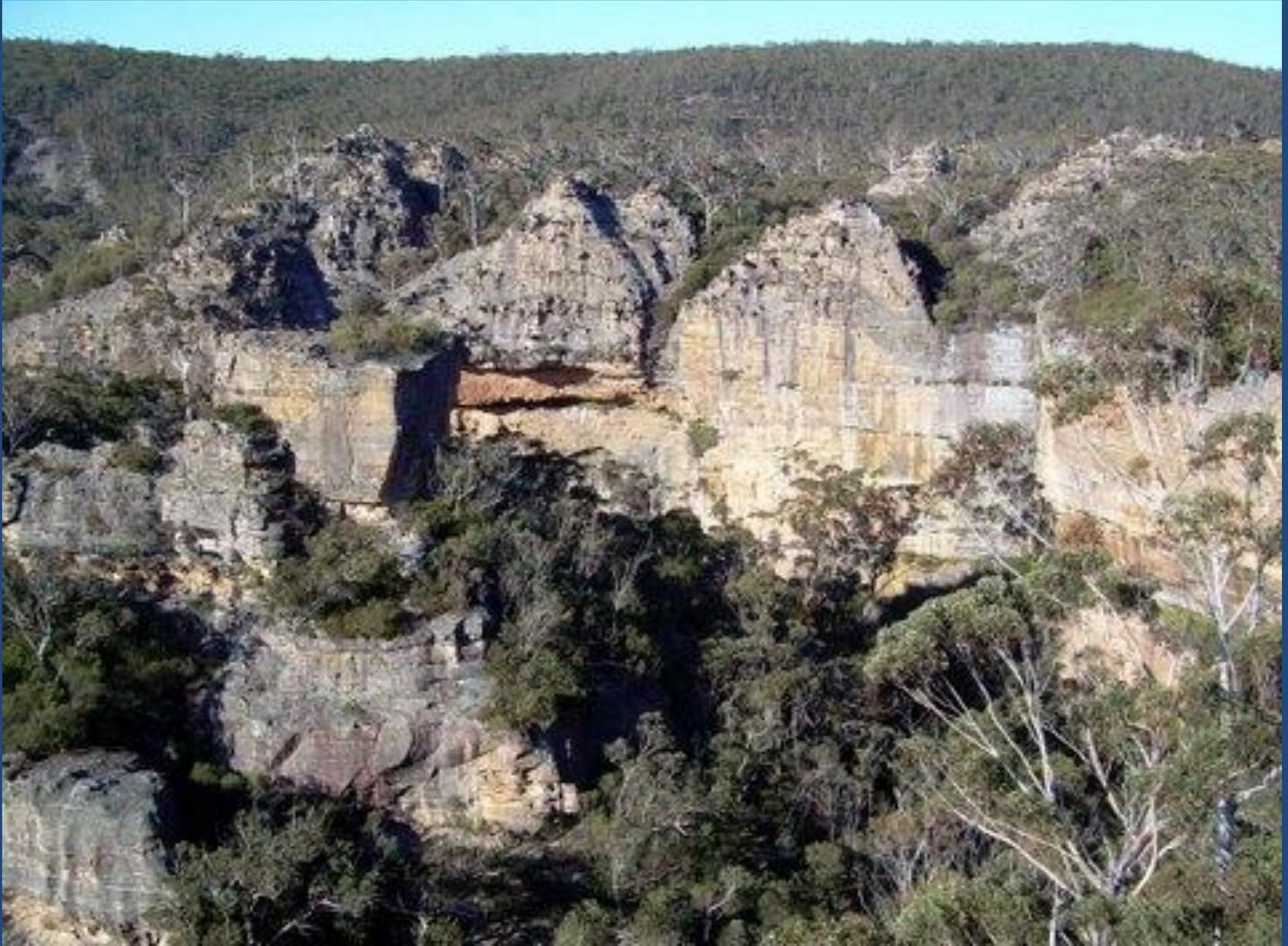
**Carne Creek Gorge**



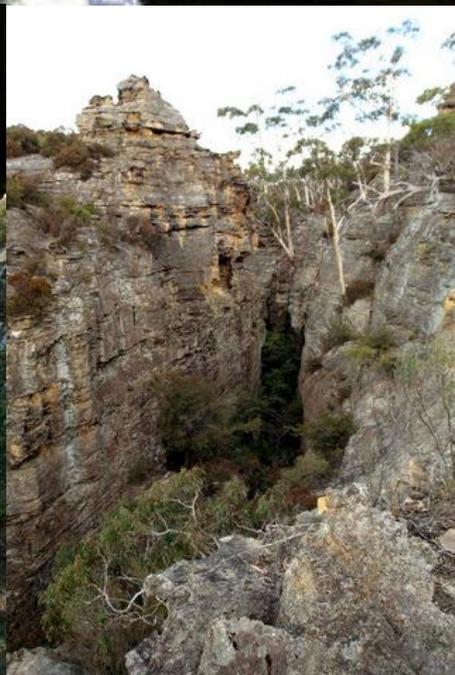
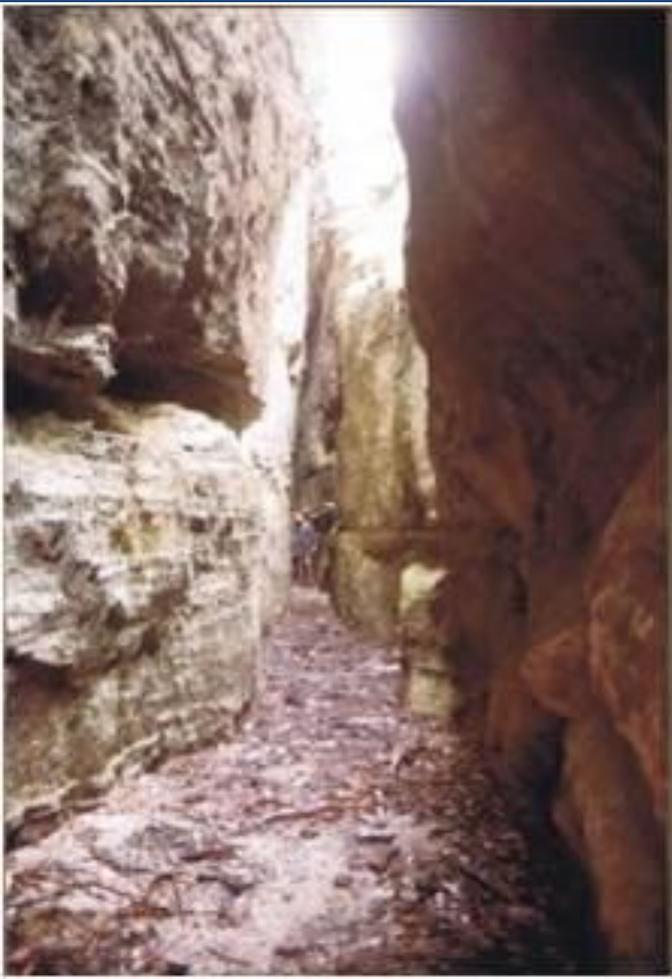
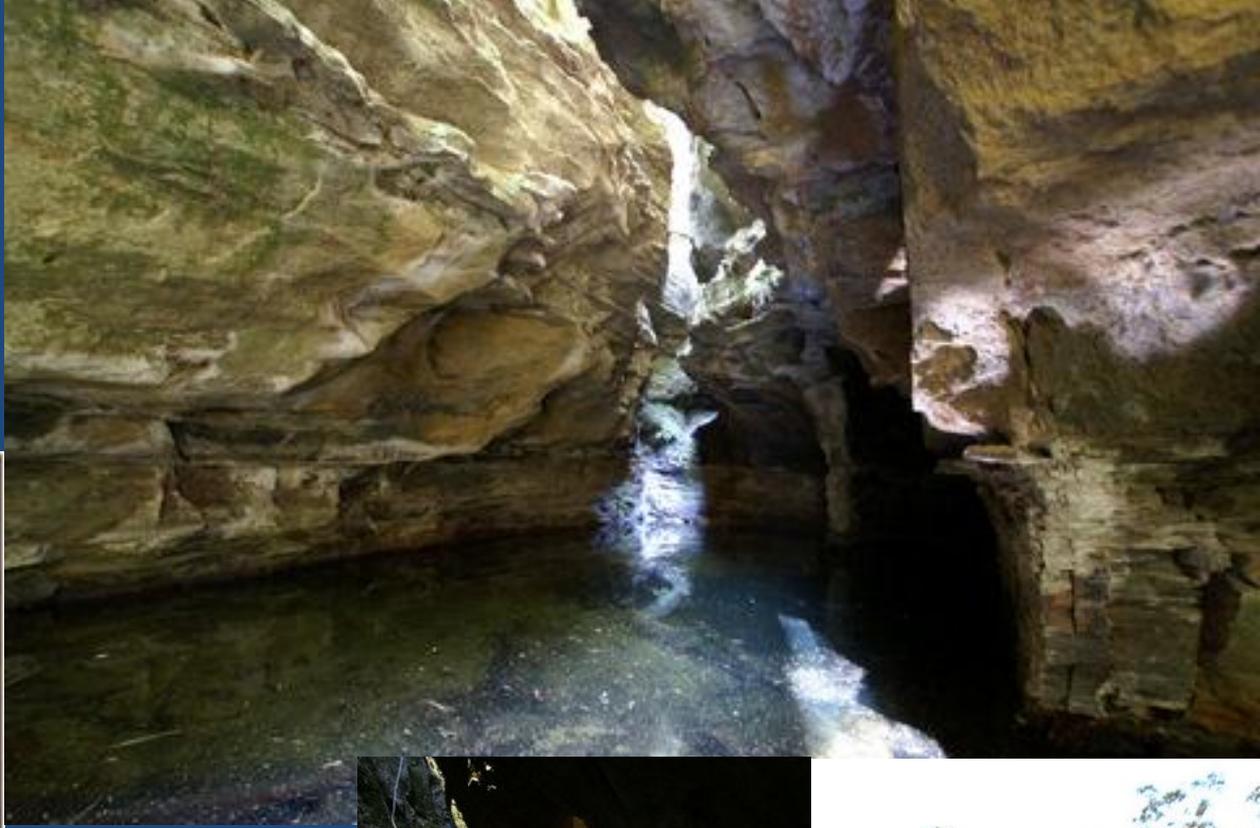
# Platy pagoda, Rock Island, Newnes Plateau



# Platies near Wolgan Falls, Newnes Plateau



Often associated  
with slot canyons



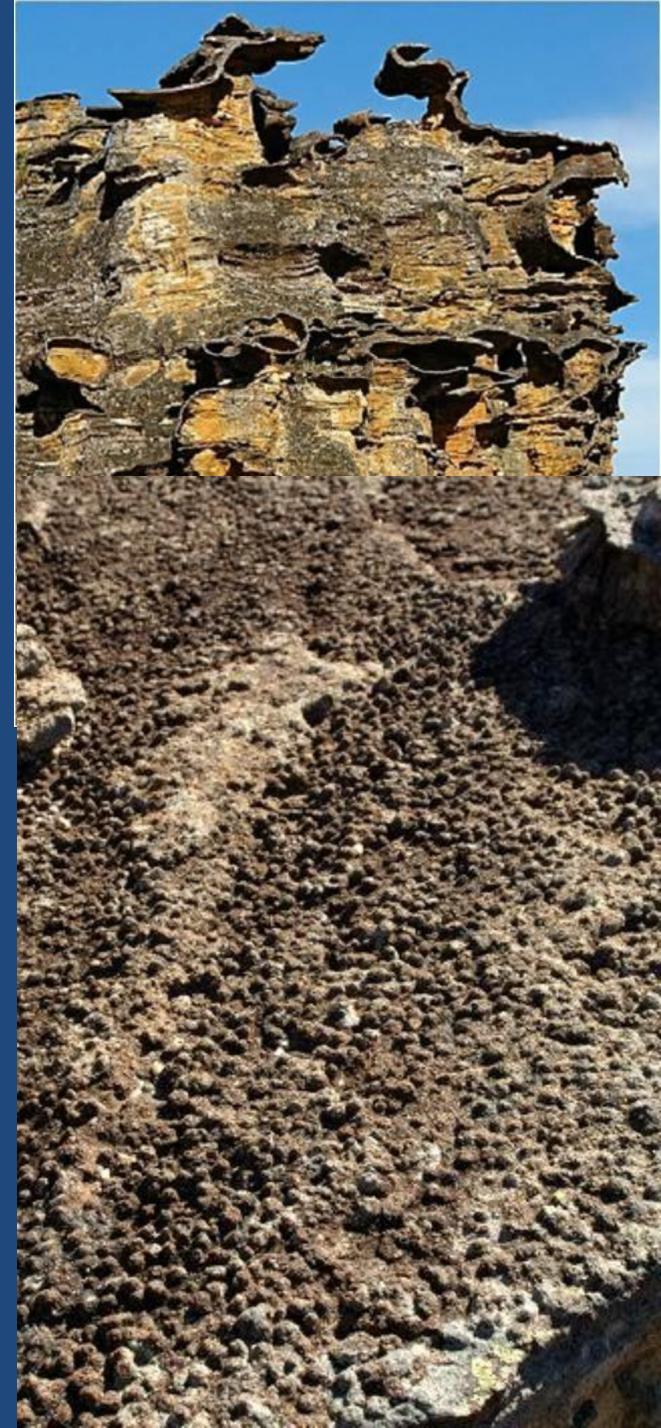
And  
caves ...



# Odd shapes!



Dragon skin  
(right)





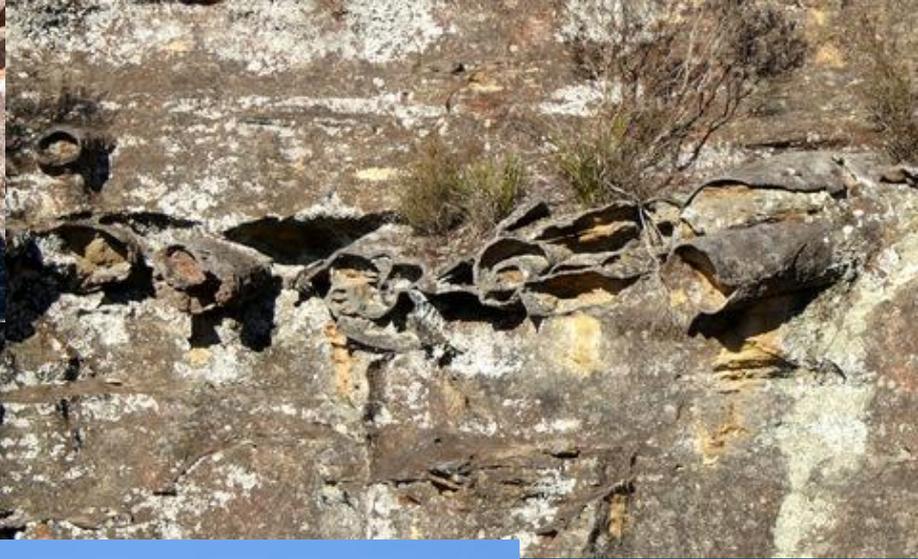
Ironstone sculptures  
(Gooches Crater left, and  
near Stargate Tunnel  
below)



# Where does the iron come from?

- Overlying basalt that has leached iron into the underlying sandstone?
- Hydrothermal vents from basalt intrusions?
- Iron films leached from sand grains in sandstone itself?





# Piping

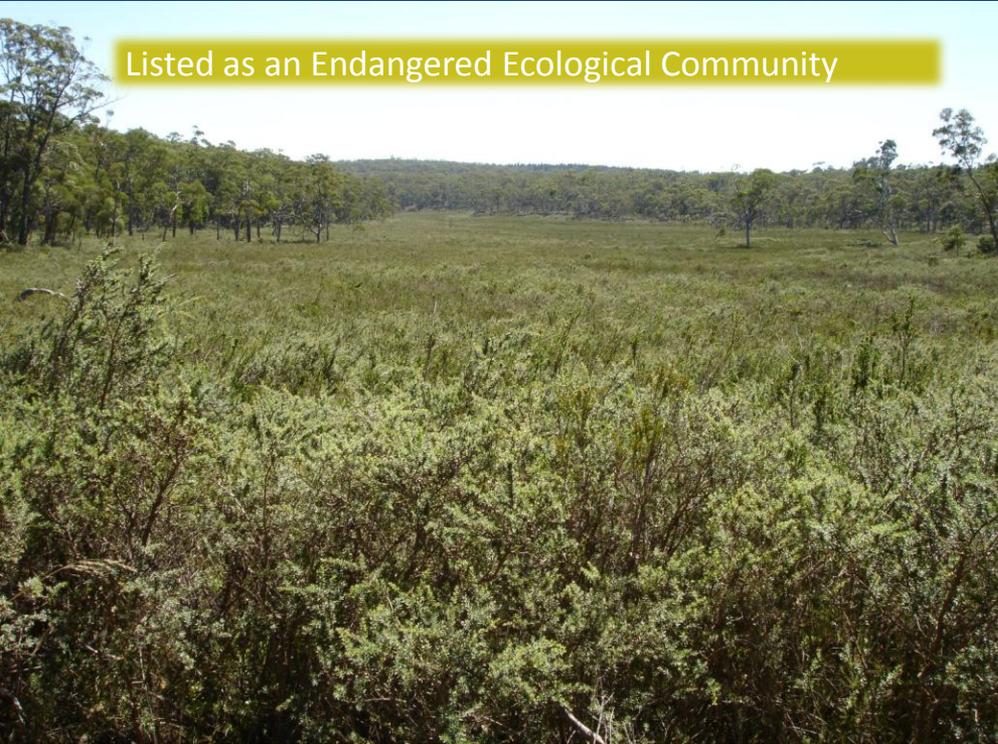


# Importance of swamps – e.g. Gooches Crater



# Newnes Plateau Shrub Swamp

Listed as an Endangered Ecological Community



*Boronia deanei*

*Grevillea acanthifolia*



Giant Dragonfly



© Ian Baird

Blue Mountains Water Skink



© Ian Baird

# Hypotheses re ironstone formation

- 1) Iron precipitated while sediments laid down or soon thereafter
  - hydrothermal input of iron-rich waters when sediments laid down - unlikely
  - 'slumping' of surfaces in a 'soft' state. – observations do not fit
- 2) Hydrothermal vents from basalt intrusions. Seen elsewhere but does not fit with geology of Blue Mountains
- 3) Fulgurites caused by lightning strikes (see: <http://www.thunderbolts>) – does *not* tally with evidence
- 4) Buried landscapes - pagoda shapes are buried landscapes (dunes?) – does not conform with observations (smooth pagodas weather quite quickly)
- 5) Iron precipitates later through percolation
  - percolation along bedding or cross-beds; more permeable due to grain size variations, plus percolation of iron-rich water down
  - Does not explain ironstone sculptures or why iron banding *crosses* bedding planes
  - percolation of iron-rich water from former swamps into strata?
  - bacterial mediation - doing what exactly?

Ironstone banding near Gooches  
N.B. Not a fulgurite!



# Hypothesis 5 – swamps and iron movement

## 3 Interesting Observations

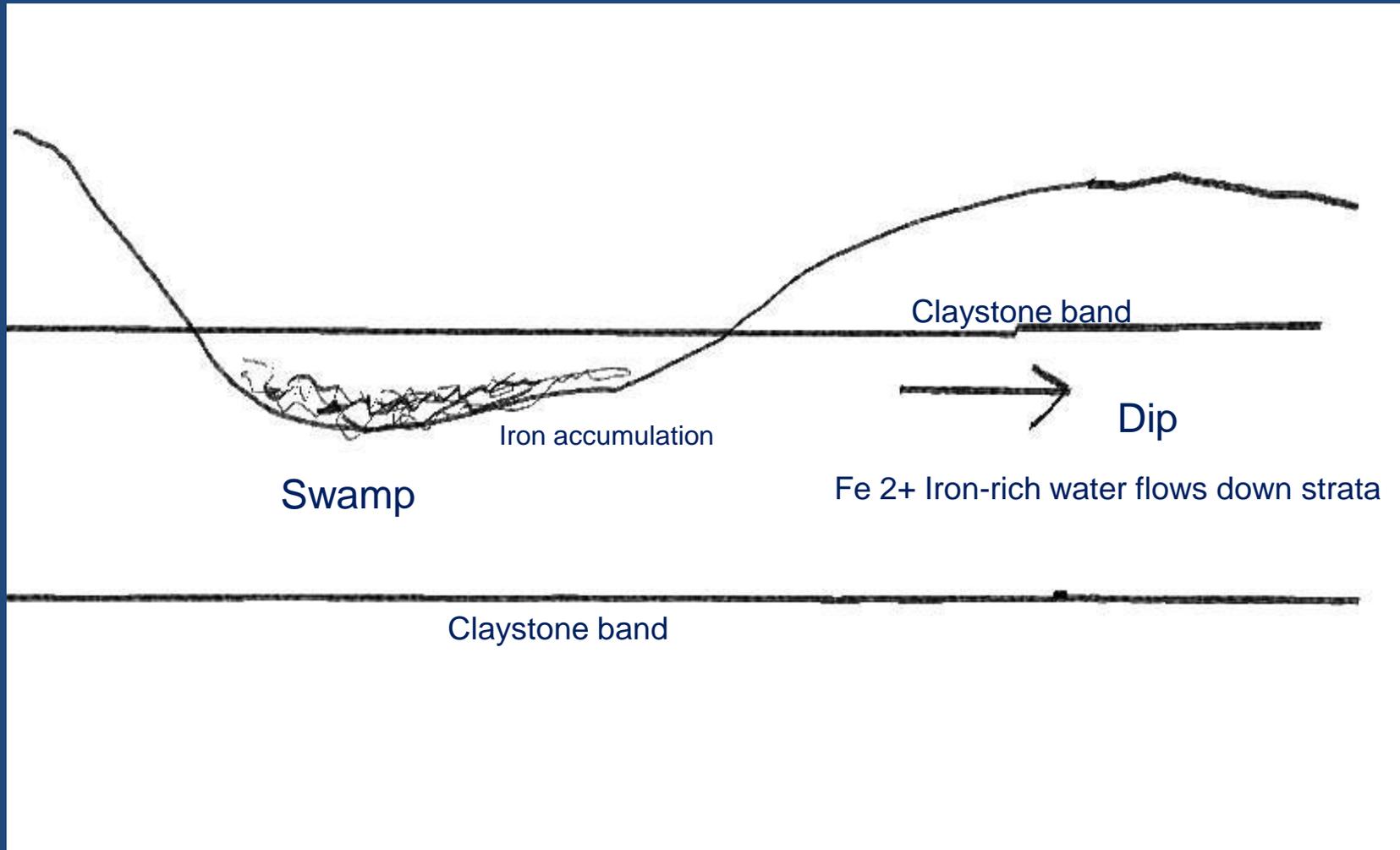
Some swamps in pagoda country (e.g. Long Swamp Creek) have high iron levels with large amounts of flocculated iron present on surface. Reducing environments lower down in swamp can produce  $Fe^{2+}$

- Claystone bands separate strata, where one strata has pagodas and the other does not. Does this mean iron-rich water could enter one strata but not another?
- If you map pagoda clusters their distribution is not unlike a drainage pattern of existing long shrub swamps on Newnes Plateau.

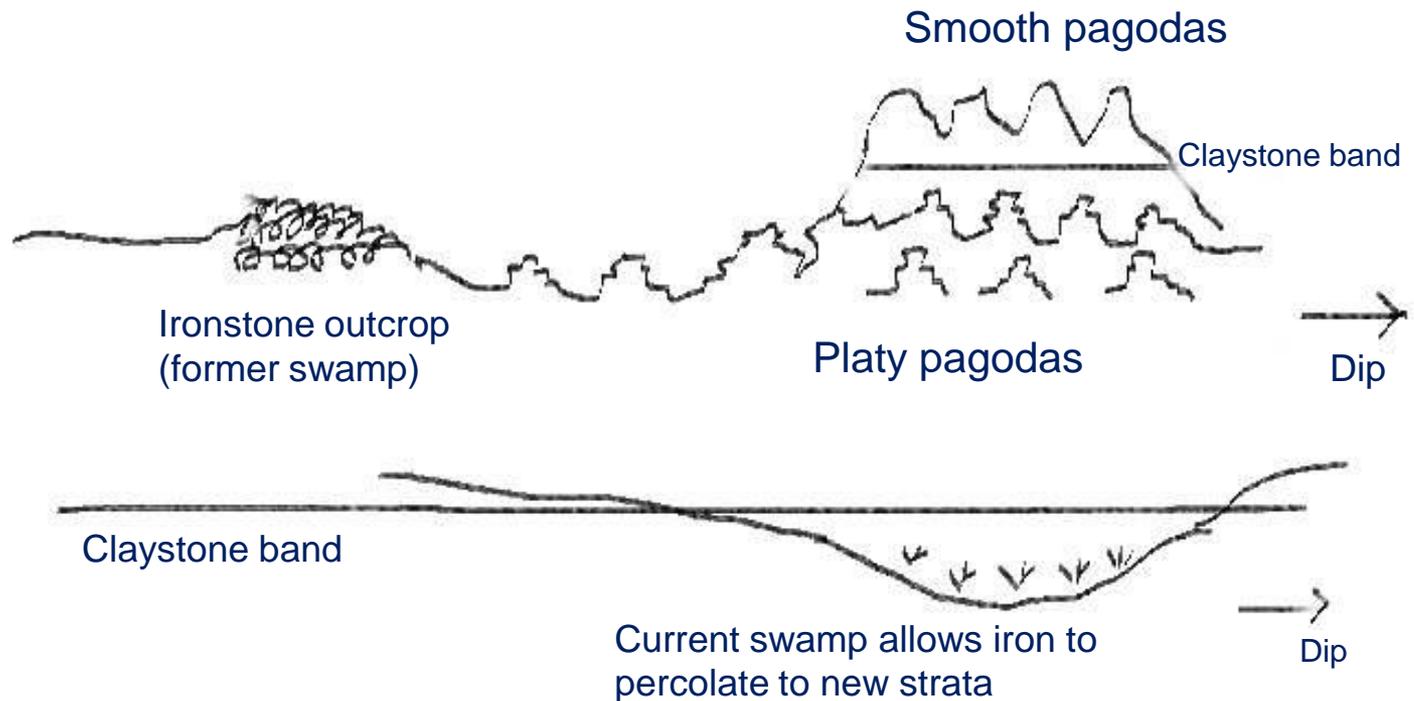
Pagodas near Bungleboori Ck



# How platy and smooth pagodas *might* form – past geological history



# How platy and smooth pagodas might form - today



Pagoda formation may be ongoing?

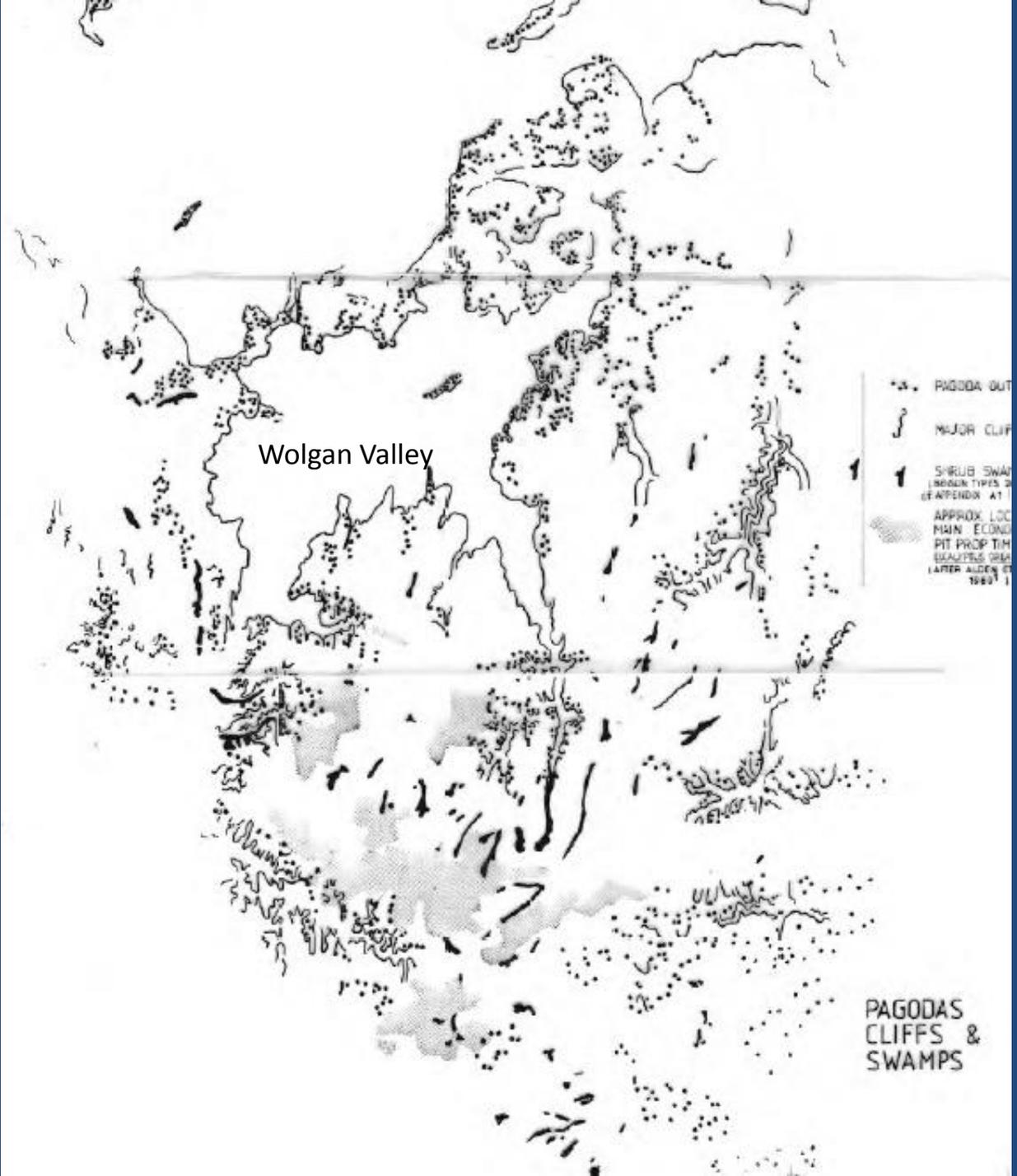
# Platies below smoothies (Pt Cameron)



Sand 'lake' formed due to slot canyon collapse, demonstrating fairly rapid erosion from smooth pagodas (Pt Cameron)



Hypothesis: Do pagoda clusters mimic former swamp drainage lines? Black shows existing swamps, dots show pagodas



# That the low be raised on high? Inversion of topography?

- Iron movement in landscape – pagodas to creeks to swamps where percolates along strata nearby
- Iron precipitation due to pH and Eh changes, where oxygen-rich water meets reduced  $\text{Fe}^{2+}$  - 'roll fronts'
- May be along bedding planes or along weaknesses such as joints as well as along roll fronts
- May also be due to ***bacterial action***. Water flow from swamps may carry organics that feed bacterial colonies in porous sandstone. These then precipitate iron (may explain piping)
- Swamp deposition of iron may explain why there are masses of iron in some places (fossilised swamp itself) but only banding of iron in others nearby, where reduced iron travels down a porous strata.



# Iron movement



Caves near Gooches Crater, Newnes Plateau, showing iron movement, banding and future tubes

# Recognition as Geoheritage

- Pagoda country covers around 53,000 Ha. 1977 National Trust proposed a 'Pinnacles National Park' but no action taken
- 1985 Colo Committee/ Colong Foundation/ Federation of Bushwalking Clubs propose 'Gardens of Stone' NP
- 1992 Airly Commission of Inquiry into proposed mining lease on Airly and Genowlan mesas in Capertee Valley. The Department of Mineral Resources replied to a statement saying they did not recognise the geodiversity value of the area, by saying 'That is not true, we do accept the value of the Pergolas ...'
- At that Inquiry it emerged that there had been **124** cliff collapses in Baal Bone Colliery and **55** in Angus Place colliery over a 2-3 year period
- Gardens of Stone National Park created in 1994 covering only 11,780 Ha. Missed out on most of Newnes Plateau – biodiversity hotspot of Blue Mountains. Missed out on Genowlan/ Airly – the 'Three Hundred Sisters'



Genowlan/  
Airly

Gardens of  
Stone Stage 2

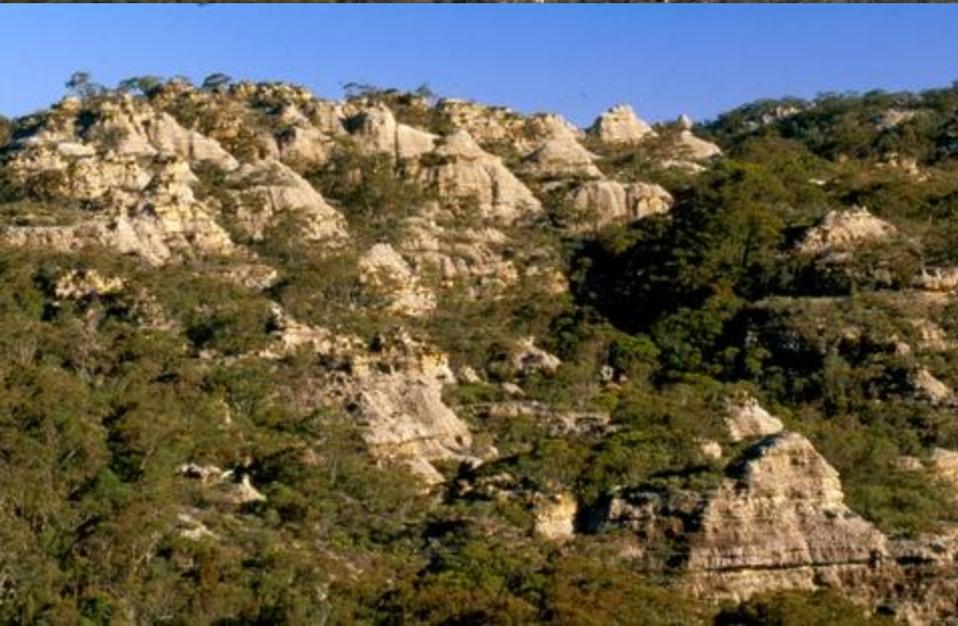
Ben Bullen  
SF section

Newnes Plateau

Lithgow



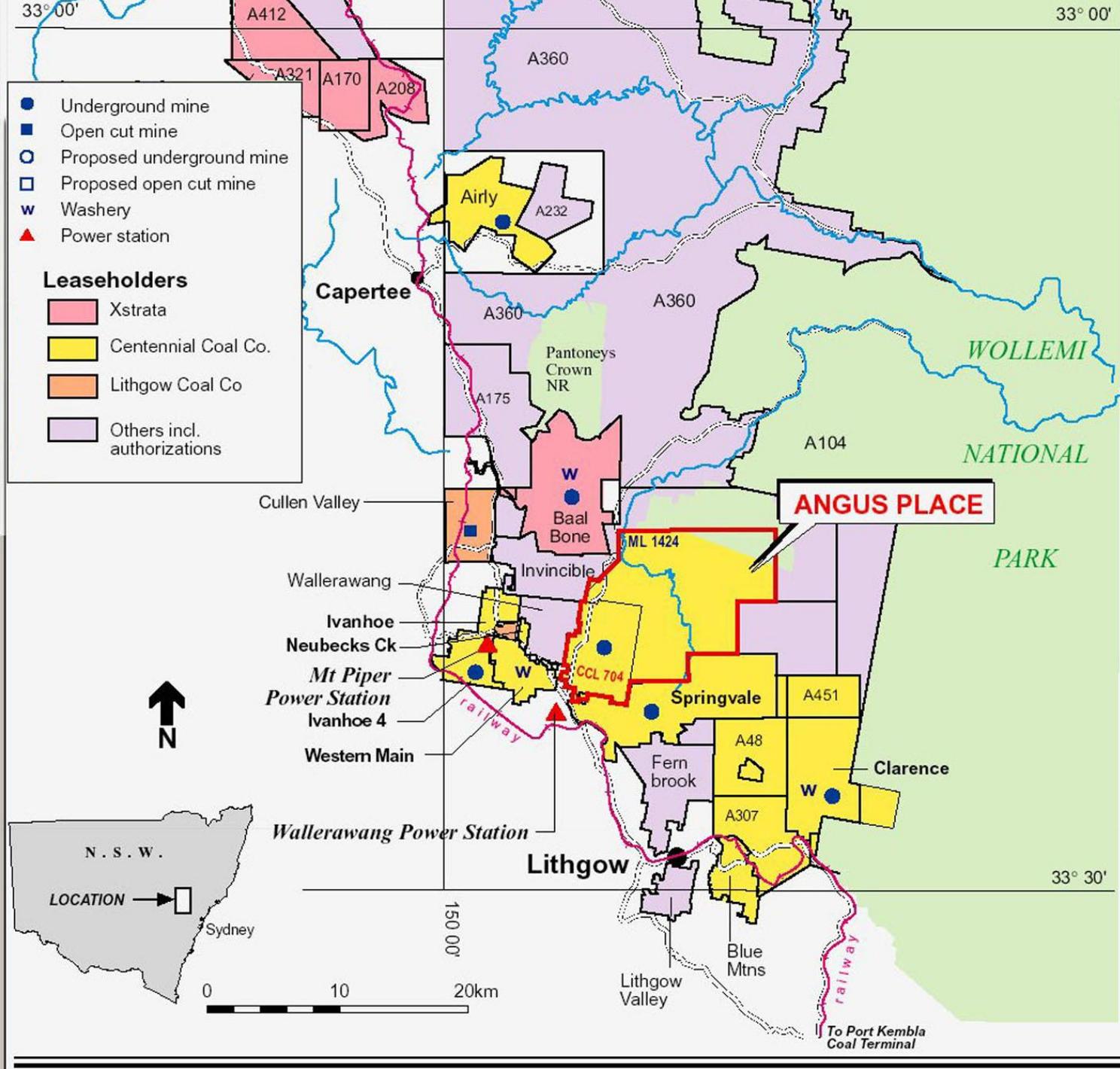
# Genowlan Mountain – the ‘Three Hundred Sisters’. State Conservation Area in waiting ...



Genowlan Point – geo and bio diversity.  
Endangered heathland and *Pultenaea*



# Coal mines of the Western Coalfield near Lithgow

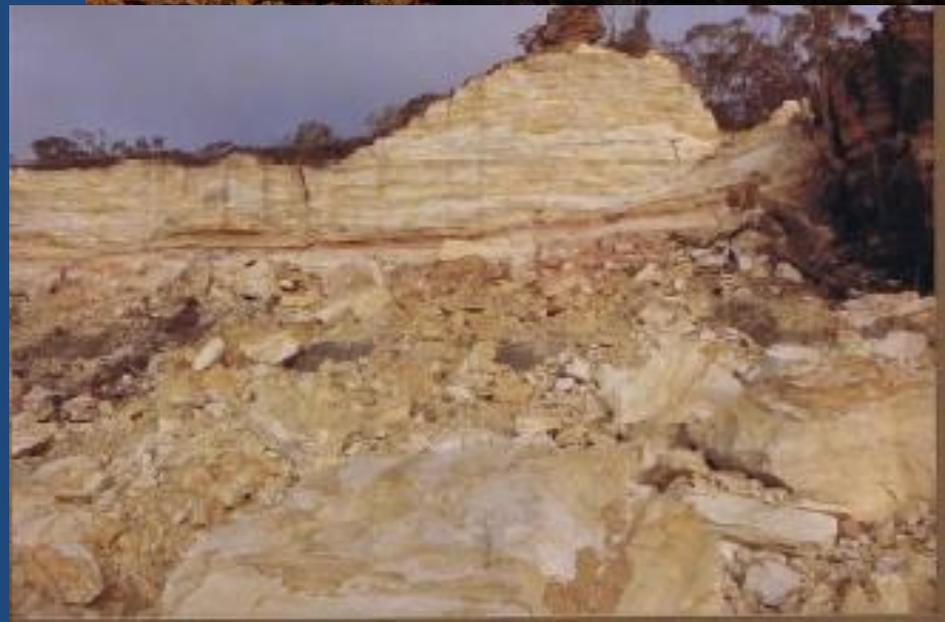
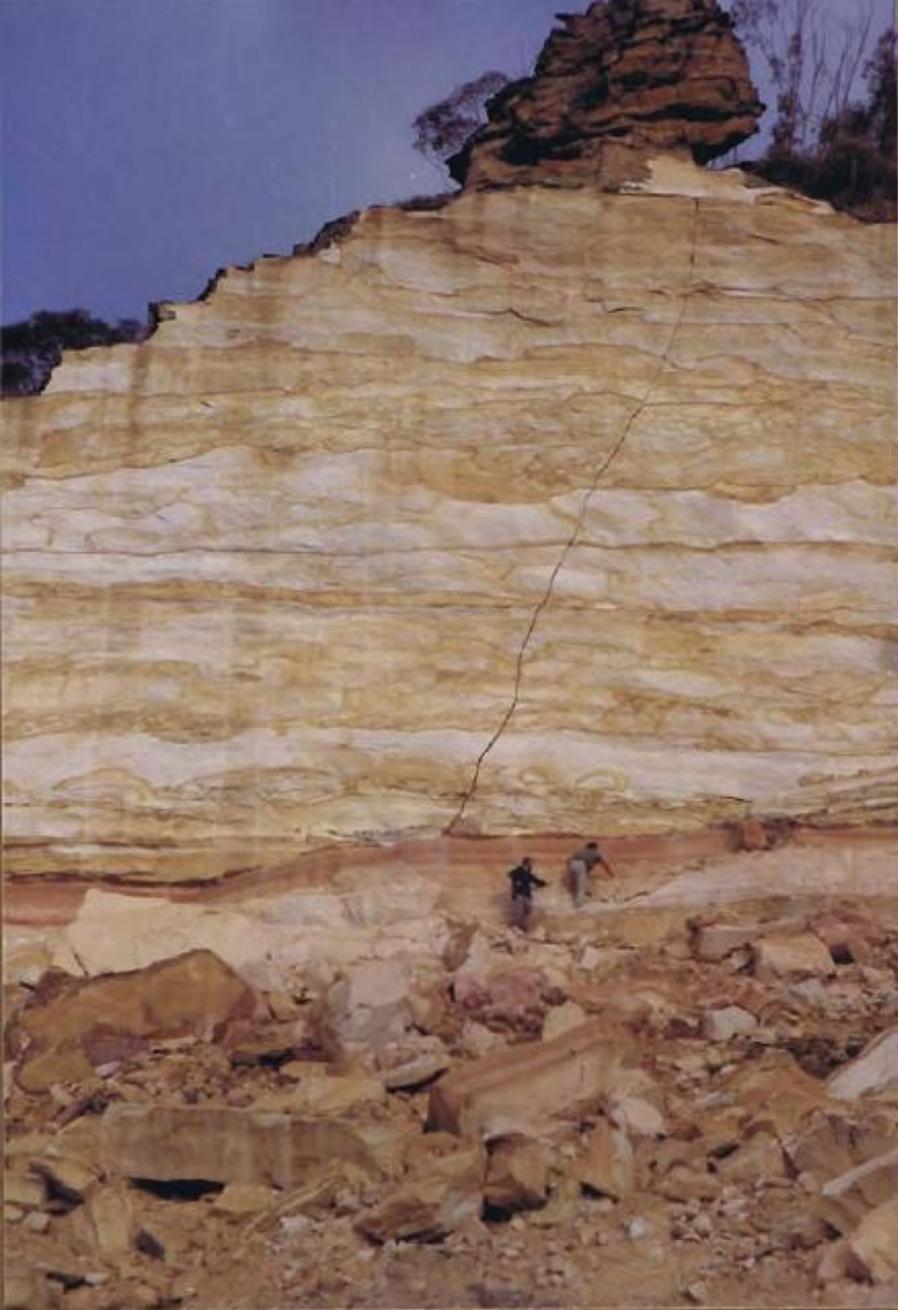


# Impacts from underground coal mining:

- Cliffs falls, rock cracks and crevasses
- Swamp death
- Stream death
- Stream pollution
- Unsightly infrastructure



Huge cliff collapse, Angus Place Colliery, early 1980s. Below Clarence Colliery



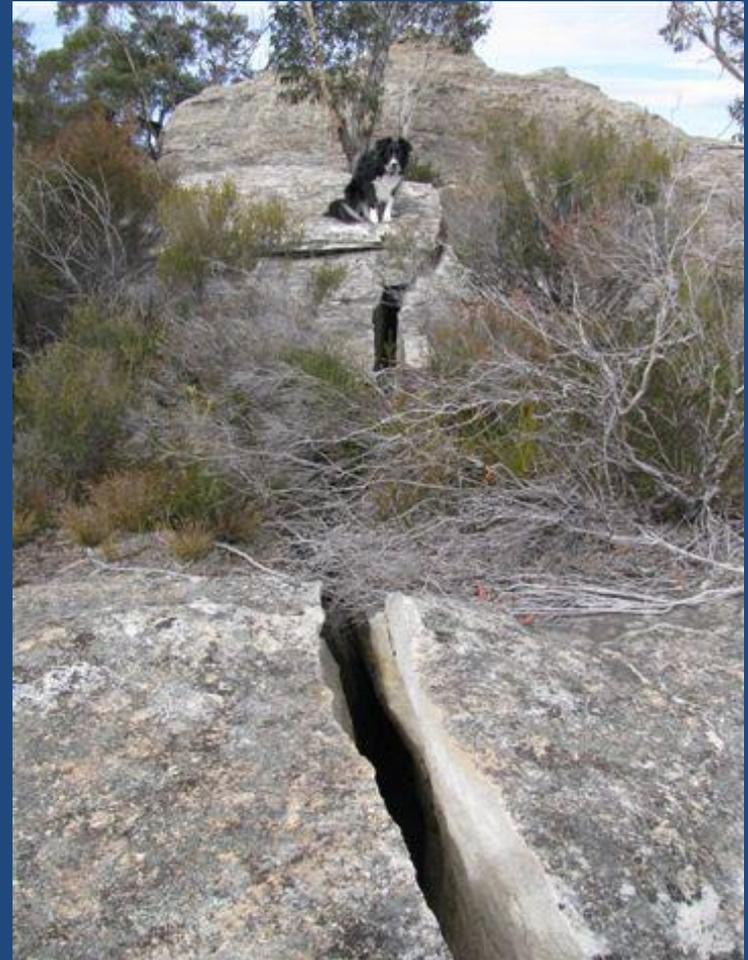
# Damage to cliffs



- Removal of the coal seam by intensive longwall methods can produce cliff collapses.
- The surface is dropped up to 1.5 metres
- Cliff Protection Zones should prevent mining under and near cliffs.

Cliff collapses – Baal Bone Colliery, 2009

# Gaping crevasses



Baal Bone colliery

# Swamp death



**Long Swamp on Coxs River headwaters dead patch (note Blue Mtns swamps are endangered ecological communities under EPBC Act)**

# Swamp death upstream of crack



**East Wolgan Swamp dying due to salinity – Springvale Colliery.**

# Stream death – Springvale Colliery



Water from mine discharge disappears down a large crack



The crack when the 14 megalitres a day discharge is turned off

# Stream pollution – Springvale Colliery



**Hyper-saline water discharged below Junction Swamp (which is also dead)**

# Other threats



Trampling of pagoda  
landforms by walking (above)  
Mining of friable sandstone  
(right) (half a billion tonnes on  
Newnes Plateau)

# Geoheritage of pagodas coming of age?



- Need for research to find out *how* pagodas are formed, especially formation of ironstone banding and sculpture masses. Related study of slot canyons also needed. Both useful to re-nominate as World Heritage for geodiversity value
- Protection of pagodas and swamps needed from subsidence due to longwall and pillar and bord coal mining
- Creation of the Genowlan/Airly State Conservation Area
- Creation of the rest of Gardens of Stone 2 (NP and SCA), especially Newnes Plateau section