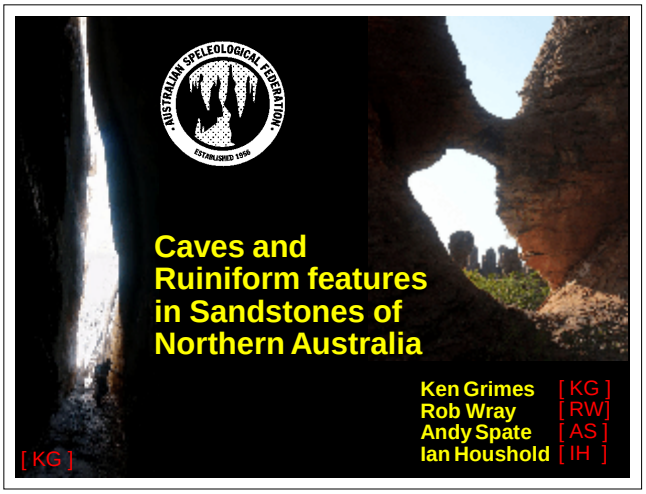
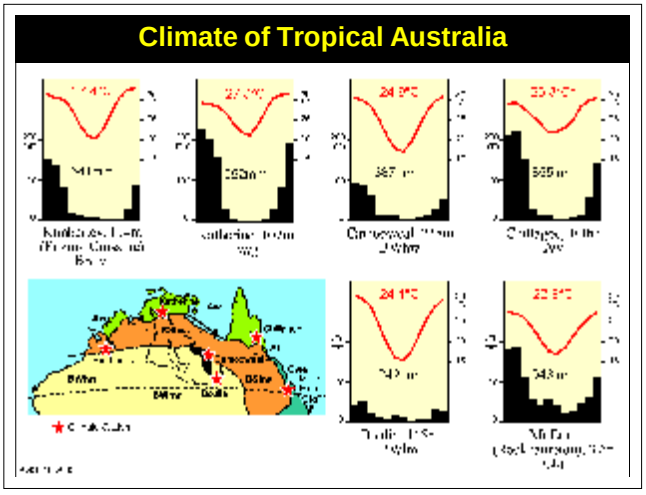


Caves & Ruiniform features in Sandstones of Northern Australia

Talk to ASF (Chillagoe, April 2011) and possibly to ACKMA (Tasmania, May 2011)

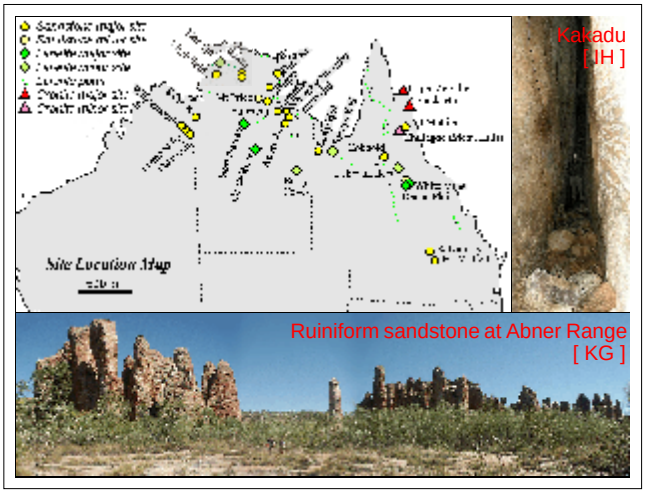
Red initials identify authors of photographs

NB for ASF this talk follows one on terminology of Karst-Parakarst-Pseudokarst & Ruiniform terrains. For ACKMA may have to say a few words about that at start.



N. Aust Location& Climate Map:

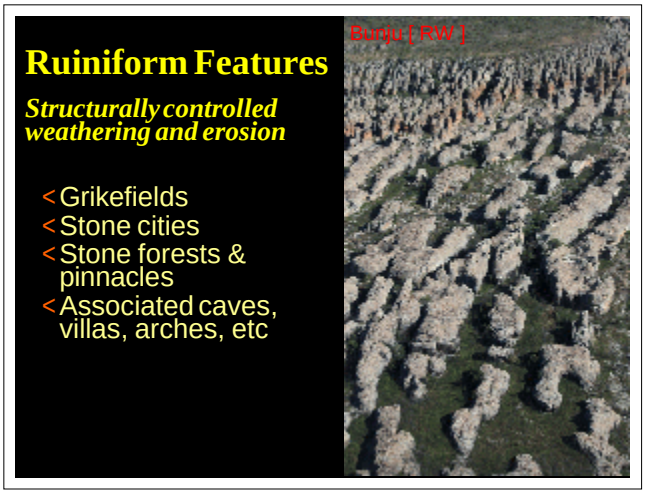
* Present Climate is tropical monsoon (wet-dry), past climates may have been wetter?
* Sandstones in WA, NT & NW Qld are Proterozoic, flat-lying, well-jointed, hard quartzites.
* Sandstones in eastern Qld are Mesozoic, flat-lying, and not as hard.



N. Aust Location Map:

Sandstone and other Para-K and Pseudo-K sites

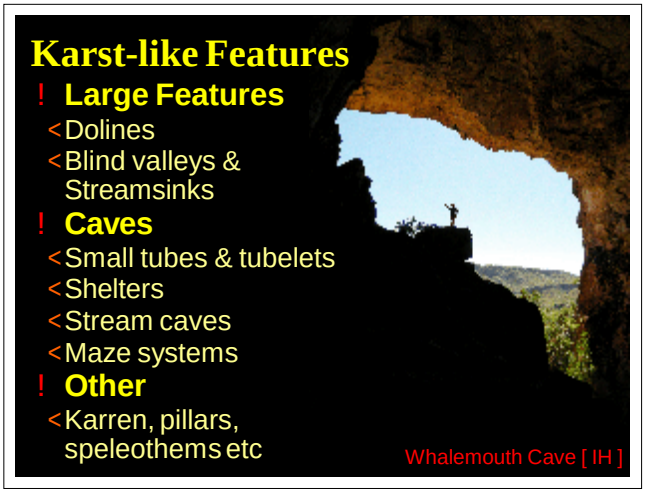
Top Right photo = joint-controlled fissure cave
Bottom photo = joint-controlled ruiniform terrain.



Ruiniform Features:

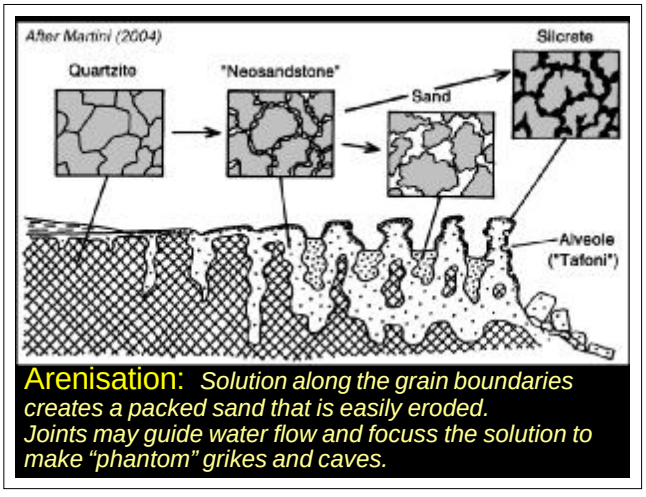
The talk will be about two themes:
Ruiniform features (listed here), and...
Karst-like features (next slide)

NB this is just a list of the various types of feature we will talk about



Karst-like Features:

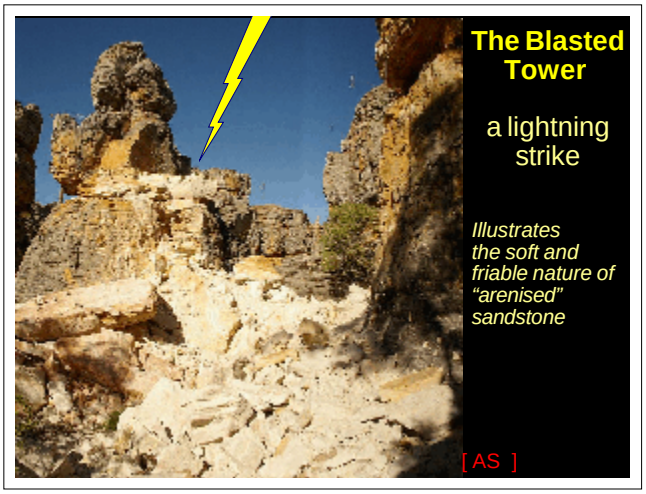
NB this is just a list of the various types of feature we will talk about



Arenisation: (after Jacq Martini)

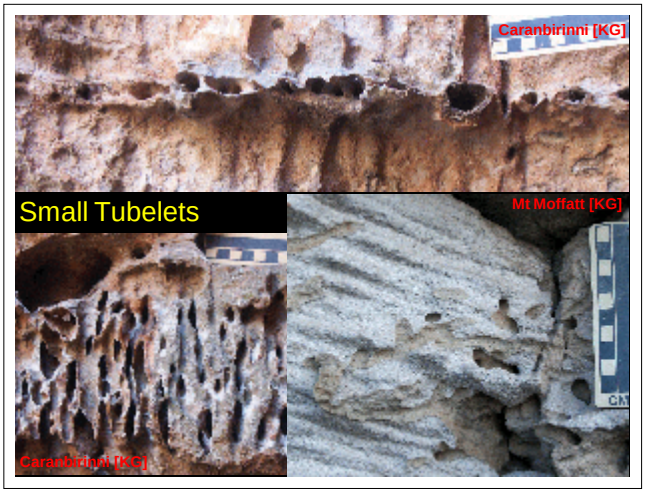
Water dissolves at the grain boundarys. This leaves loose grains, but are still interlocking. So are weak in shear but strong in compression (can hold up in a steep face, but don't poke sticks at them). May eventually disintegrate into loose sand and be eroded by water or wind. However locally can be resilicified (silcrete duricrusts & case-hardening).
NB solution is only the **first** step - producing "phantom" structtures. Most of the material is removed later by mechanical means.
Call it ParaKarst not Karst!

The Blasted Tower



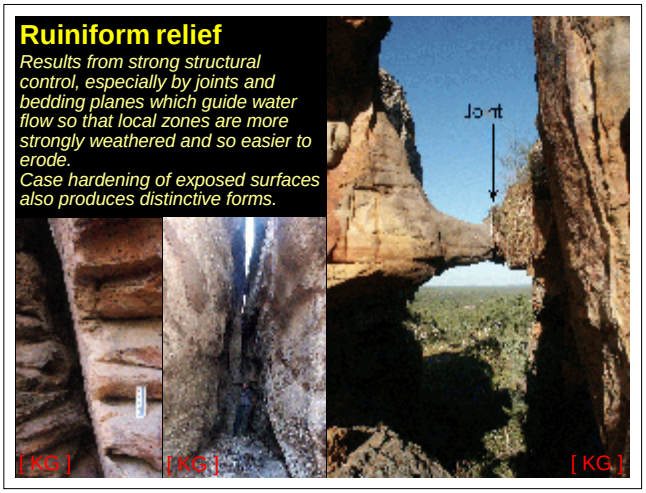
Lightning strike on arenised sandstone tower.
Rubble and heaps of loose sand indicate weak nature of the arenised "rock".

Small solutional(?) tubelets



These are evidence for solution of the quartz.
But are focussed (by bedding etc or just random paths) - not diffuse.
Correspond to the initial proto-caves in limestones (laminar flow?).
Prior to the turbulant breakthrough.

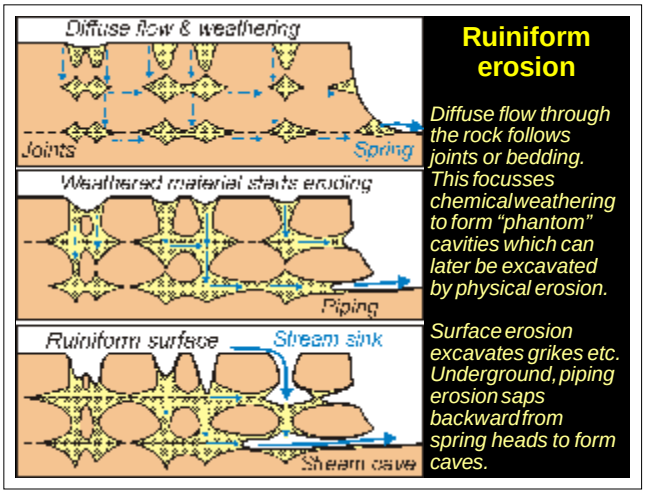
Top = horizontal; aligned along a bedding plane (Note cemented rims)
Left = sub-vertical aligned (joint plane?)
Right = 3-D network that ignores x-bedding.
NB smooth (SiO?) walls of tubes



Ruiniform Relief
Results from strong structural control (joints, bedding planes etc)

Joints and bedding guide water flow, so localised zones are more strongly **weathered**. (chemical weath)
These "phantom" zones can then be preferentially eroded. (physical)
Mention **piping** etc processes
After exposure to air, some faces may be **case-hardened**, producing distinctive features (crusts, smooth joint surfaces, cavernous weath).

Left = localised weathering along joint (vertical) and bedding (horizontal) followed by case-hardening of the joint face.
Middle = erosion of soft, arenised, sandstone along a weathered joint has opened a giant grike.
Right = in a street of a stone city the original guiding joint can be seen in the bridge (+ thin cemented zone).



Ruiniform erosion

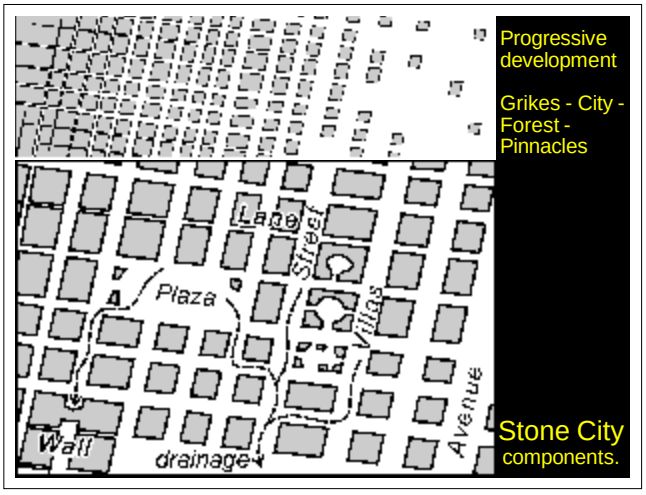
Development and excavation of "phantom" structures

Diffuse flow through the rock follows joints or bedding.
This focusses chemical weathering to form "phantom" cavities which can later be excavated by physical erosion.

Surface erosion excavates grikes etc. Underground, piping erosion saps backward from spring heads to form caves.

Stages in Ruiniform Development

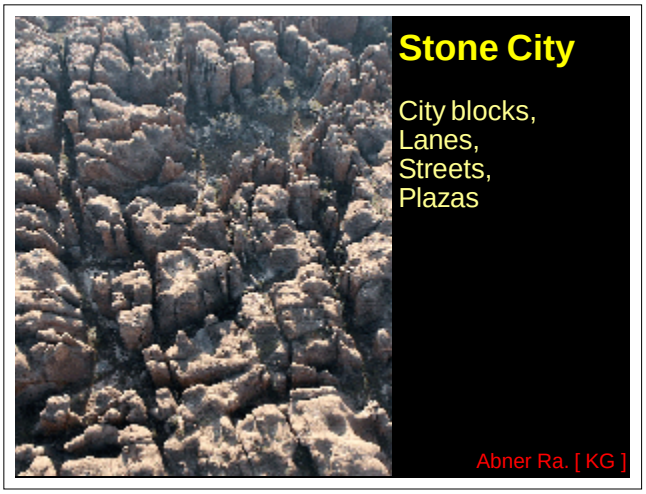
At edge of a sandstone plateau (foreground) weathering is first concentrated along joints to form "phantom" grikes (vegetated lines) which are then eroded to fprm, small, then large, **grikes**. Ongoing erosion widens the grikes into **stone city** streets and blocks, and eventualy the city blocks are reduced to **stone forest** & **pinnacles** scattered across a low-level pavement/pediment (in background).



Diagrams

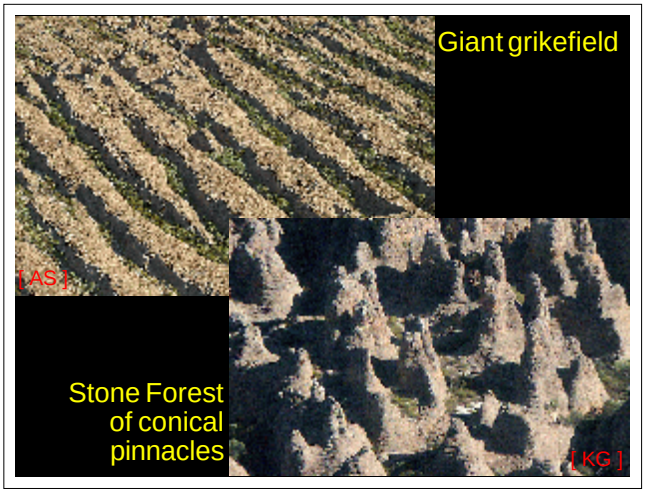
Top = progressive change from Grikes -> Stone City -> Stone Forest -> isolated Pinnacles

Bottom = OUR names for components of a SC. (next slide shows real-life egs ...)



Stone City detail:

City blocks between various sizes of lanes & streets and a "plaza" at top right.
Note how the city blocks have dissected tops with incipient pinnacles, villas etc.

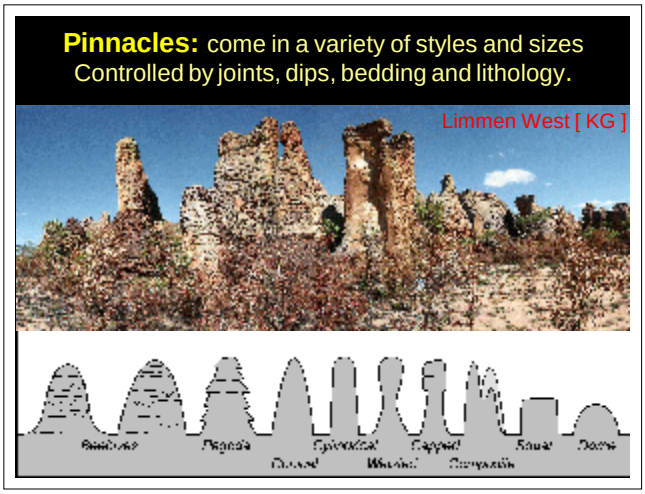


Top = Giant Grikefield
this e.g. has only a single joint trend.
Bottom = Stone forest of large conical pinnacles

Both at Bunju, NT

Isolated group of pinnacles on a sandstone pavement/pediment

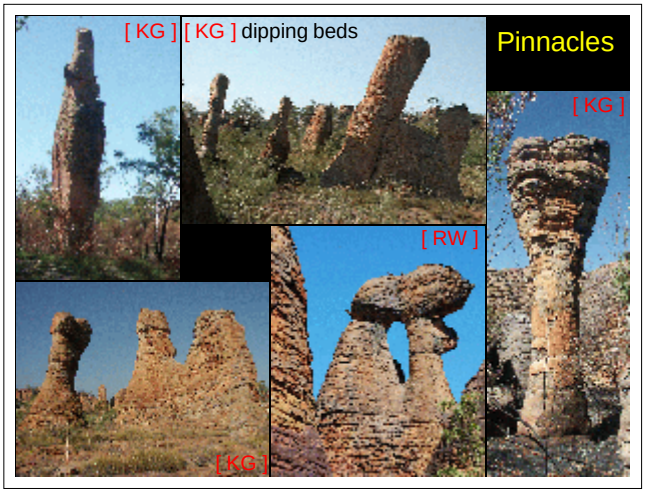
It is a dissected city block, with a hollow core and a small arch visible at back
NB veg lines following joints (phantom grikes)
1-3m wide Spinafex clumps for scale.



Pinnacles:

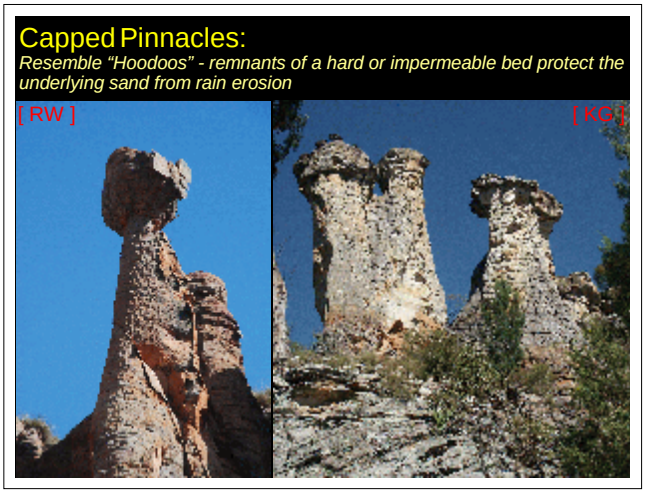
Come in a broad range of sizes and shapes.
Beehives are rounded and have sculptured surfaces (bedding + case-hardening)
Pagodas have deeply indented bedding slots
Capped Ps (see later) have a hard bed at top.

Andy Spate for scale in photo



Pinnacles:

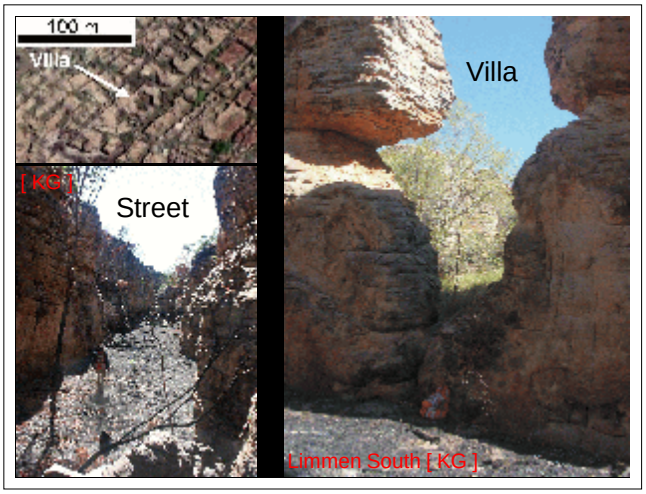
Assorted examples.
(from Abner Range & Limmen S & W)
Mid-top = dipping pillars, a result of dipping beds with dipping joints perpendicular to bedding. Erosion is joint-controlled.
Rightmost = this one was alone in middle of a city street



Capped Pinnacles:

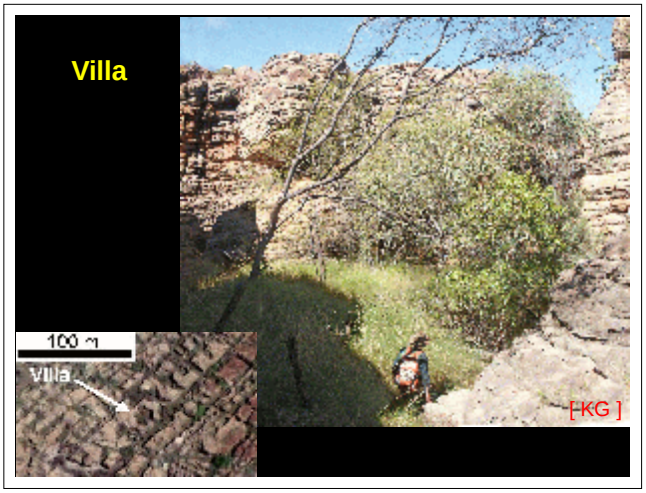
Resemble "Hoodoos" (sand pillars protected under boulders)
Remnants of a hard or impermeable bed protect the underlying sand from erosion by rain.
If so, Joints are not necessary, but may have contributed to the breakup of the overlying hard bed.
NB case-hardened joints on left photo

Villa



Top-left = Sat image showing Stone City with a Villa in centre
Bottom-left = street outside (SE of) the Villa. Villa entrance is half way down the street on left. After a bush-fire.
Right = looking from the street into the villa. Note that villa floor is 1 m higher than street level, and it has escaped damage by fire.
Next slide is inside the Villa...

Villa (2)



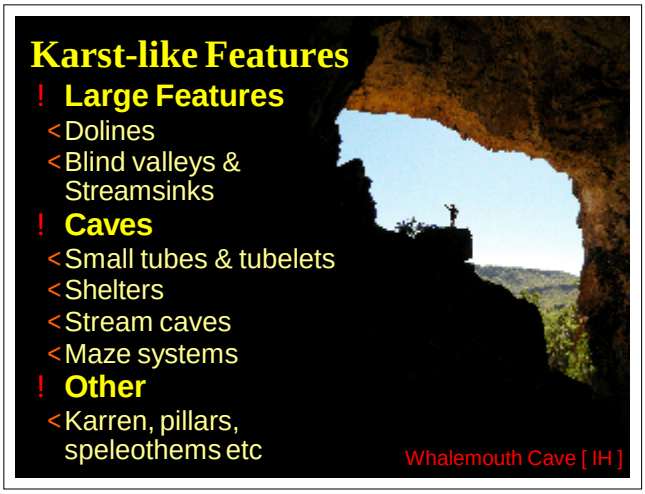
Inside the villa, showing walls (~5m thick) and flat, grassed, floor.

Villas seem to form by either a diffuse case-hardening effect on the outer walls, or a localised arenisation of the central part of the block. Not sure which (both?)

Villa (3)

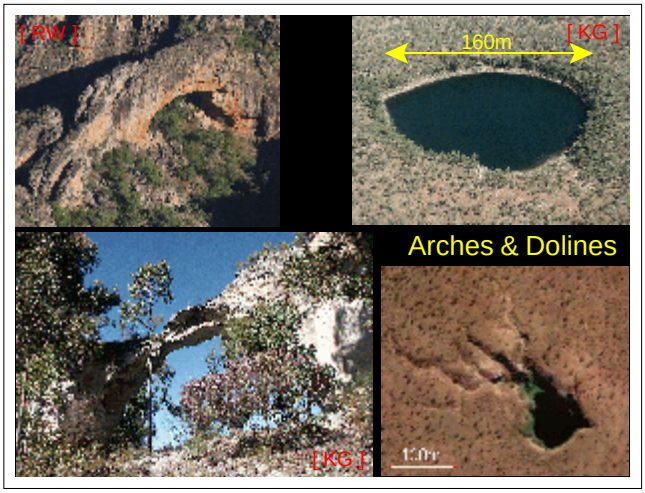
Some villas are entered via tunnels through the walls, rather than open gaps in the wall.

Karst-like Features:



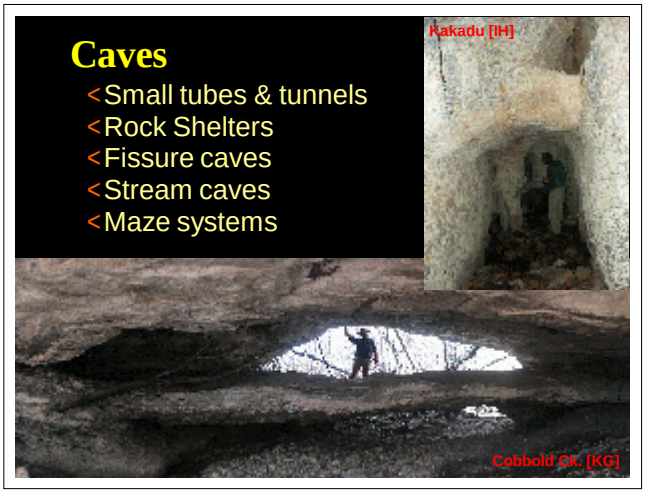
Just list the various types of feature we will talk about

Dolines & Arches



Top-left = Big arch at Kakadu
Top-right = Cenote in Bath Range area (sandstone may have carbonate cement)
Bottom-left = Narrow Arch (Mt Moffatt)
Bottom-right = Satellite image of Nhumby-Nhumby doline/cenote (Borroloola). Sstn overlies dolomite - so may be subjacent K? There are also collapse dolines in Sstn on Newcastle Range (NW of Bullita Cave), these also are sstn over subjacent dolomite

Caves (introduction)



List of types

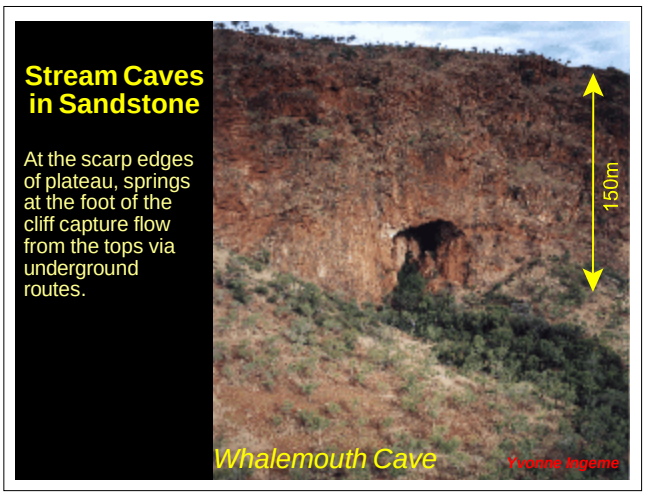
Right = Joint-controlled outflow cave at Kakadu (a simple 'fissure' cave)
Below = Short stream cave at Cobbold Creek. NB resistant sstn bed bridging the passage.

Caves:
Small horizontal tubes and tunnels (all in Mz sstn of central Qld)
All formed by piping of arenised "phantom" tubes.

Top = flow focussed along a bedding plane
Left = horizontal tube unrelated to bedding (but note fine joint)
Middle = larger tube drilled through a pinnacle! (tube formed first, below the surface, then pinnacle formed as surface eroded down?)
Right = small tunnel through a sandstone wall (follows joint?)

Rock Shelters are numerous

But interest is mainly for their Aboriginal heritage (art, occupation, etc)

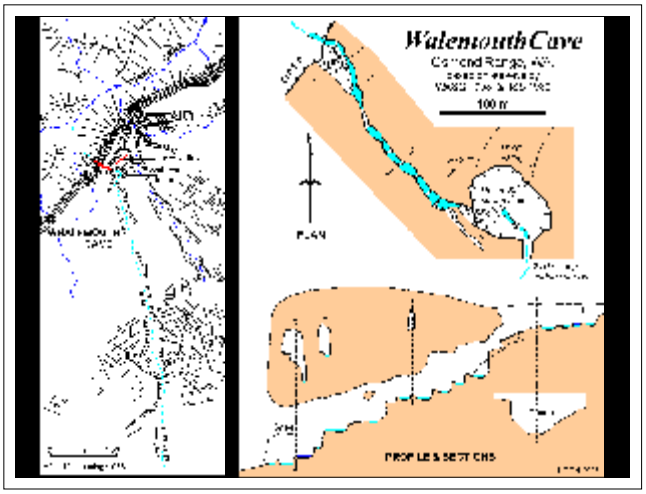


Stream Caves

Whalemouth Cave is the largest and most spectacular stream cave.

Whalemouth is a large through-flow stream cave developed in quartz sandstone.
Outflow chamber is a 60m high & 30m wide hole in 150m cliff.

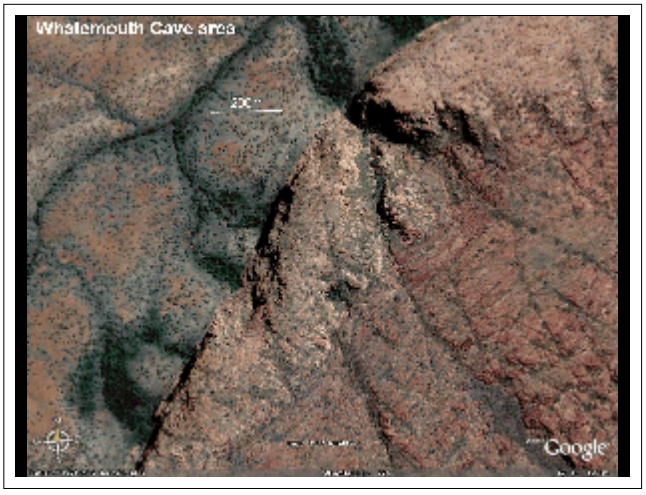
Whalemouth cave (maps)



Surface map: 2.5km surface stream sinks into cave. Abandoned dry valley.
Underground capture.
Wet season floods, dry season only small flow (but still a sporting cave)

Cave map: A series of waterfalls & plunge pools. Large size, fissure-like.
220m length, 120m vertical

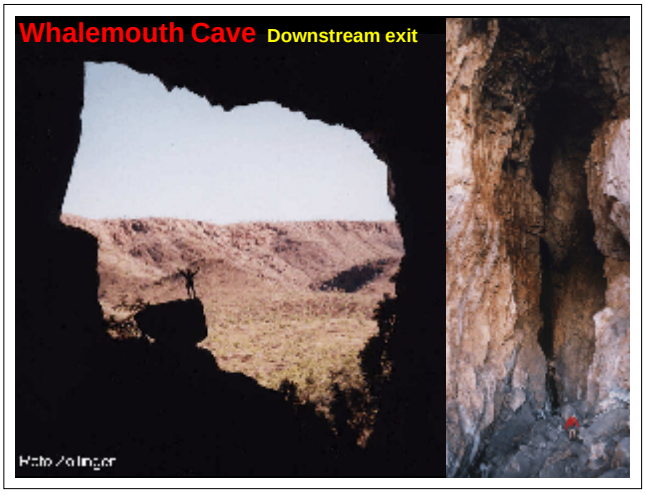
Satellite image:



Showing plateau top, stream sink, and efflux stream

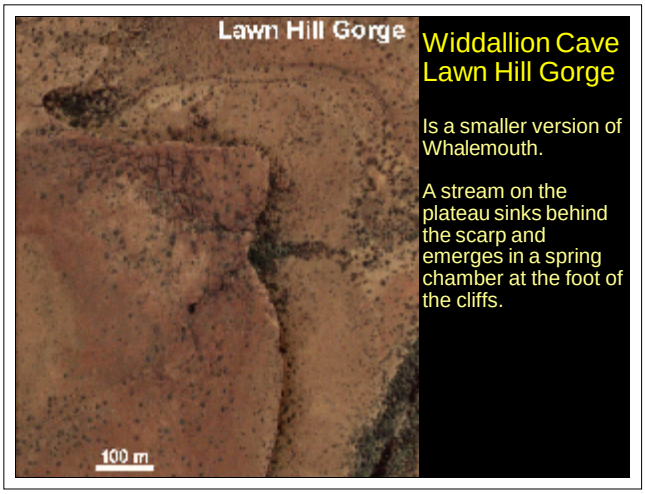
Note other spring-fed streams - presumably no open caves?

Downstream Entrance:



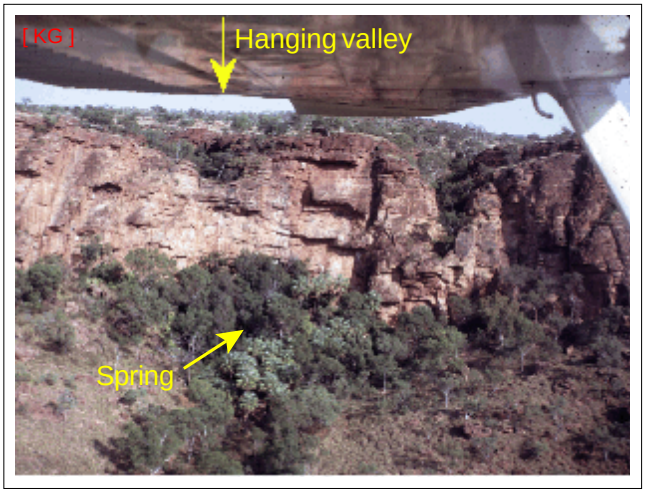
Left = looking out of large exit chamber (with fissure below).
Right = Looking back inside at start of narrow fissure passage

Lawn Hill Gorge parakarst.

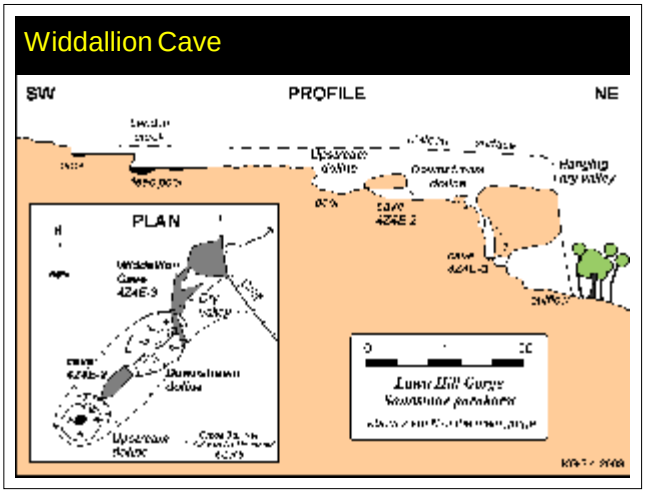


About 2 km N of main gorge.

Sandstone plateau with a stream that sinks into a vertical shaft before reaching edge
Blind valley, stream sink into shaft, small cave & spring.



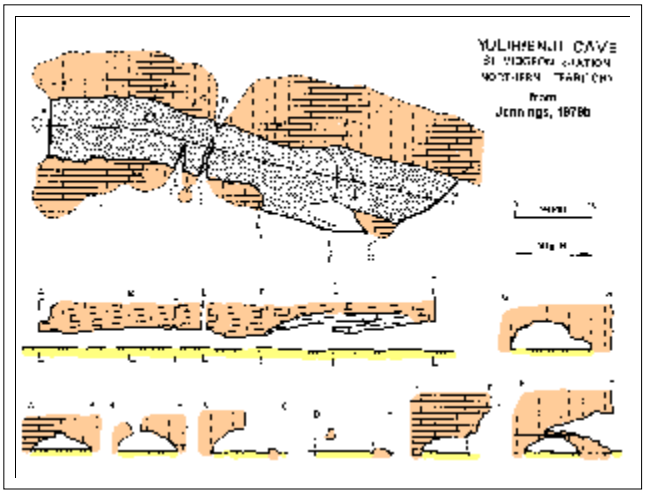
Shows hanging valley (arrowed) & spring below (hidden by vegetation)



Profile of valley & cave:

Two dolines (& small connecting cave) are floored by solid rock.
Stream then sinks into pit & fissure leaving a dry hanging valley.

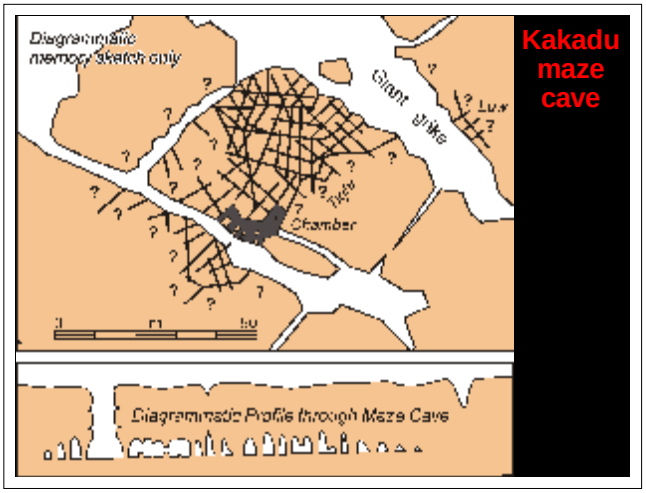
The cave is a set of vertical fissures with small pools.
Large exit chamber at bottom.



Yulirienji Cave (Abandoned stream cave?)

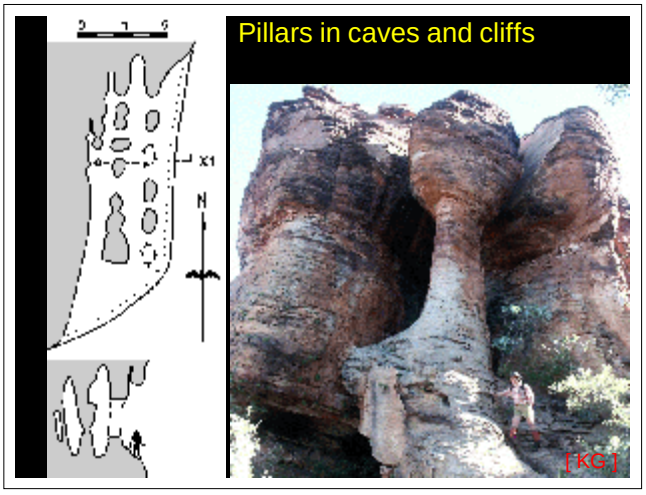
Cave is about 8 m above present creek, and runs for 50 m lengthwise through a qtz sandstone ridge (map on next slide).
Joe thought it was an old stream cave - he might be right.
Denudation chronology suggests a late Tertiary age.

Map & profile. 50m Long.



Maze Cave at Kakadu

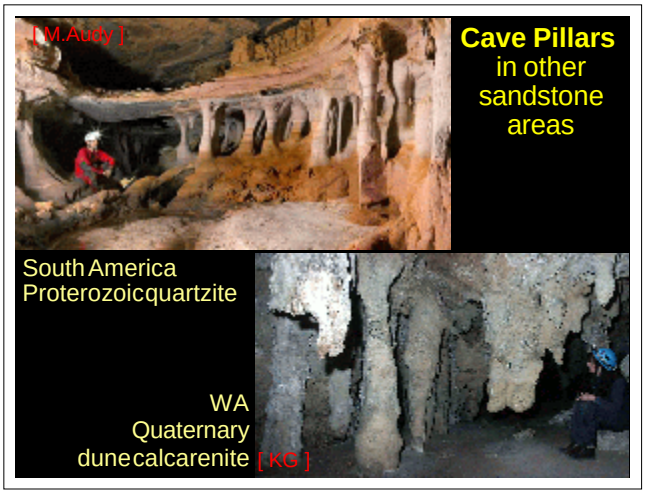
NB difficult access (due to both position & permissions), we only had a brief look.
Map is just a diagrammatic sketch.
A dense horizontal maze, following a susceptible sandstone bed, with strong joint control.
Numerous pillars



Cave of the Pillars, Kakadu

Distinctive cylindrical pillars may be a result of early diagenetic cementation by focussed vertical vadose flows through the porous sand.

These pillars are common. They seem to form in specific beds, which also tend to be cavernous. Possibly early diagenetic cementation by focussed vertical vadose flow?



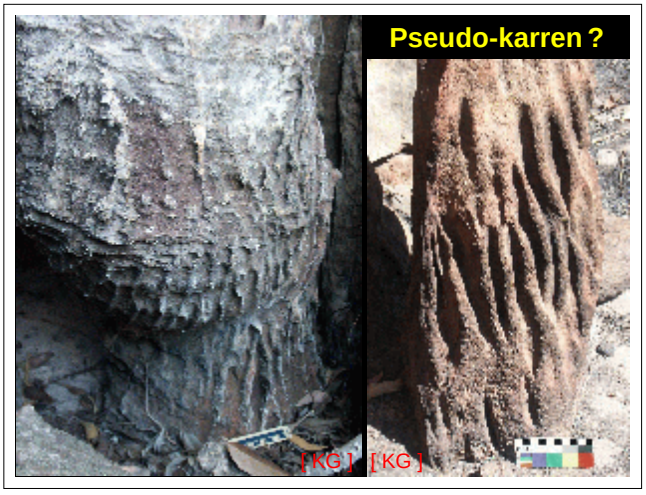
Pillars in other areas

Focused vertical flow seems to be involved in both cases, and also in laterite karsts and other host materials.

Top = in a susceptible bed in Proterozoic quartzites (Venezuela, South America)
Bottom = cemented sand pendants and pillars in Quaternary dune calcarenite in SW WA (Witchcliffe Cave)

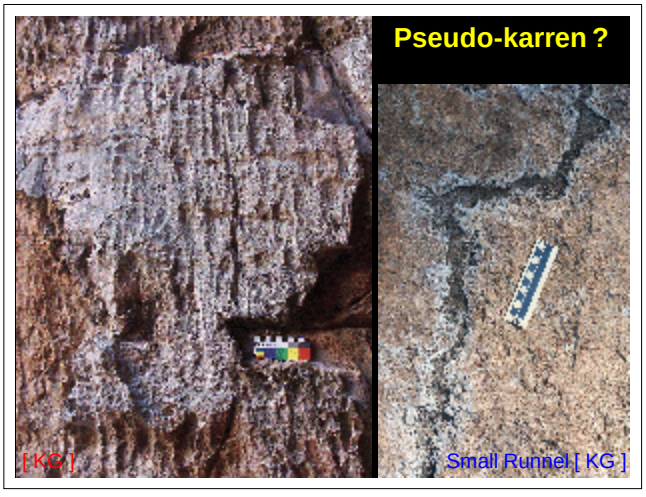
Focussed cementation could contribute to some small sstn pinnacles?

cf my talk on Laterite karst.



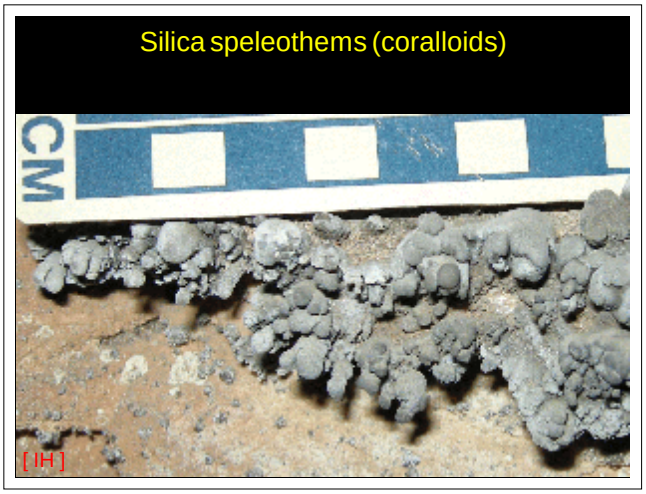
Sculptured Pillars = "Pseudo-karren"

Sculpturing by vertical water flow(?)
NB resemblance to spelethem shapes on left photo!



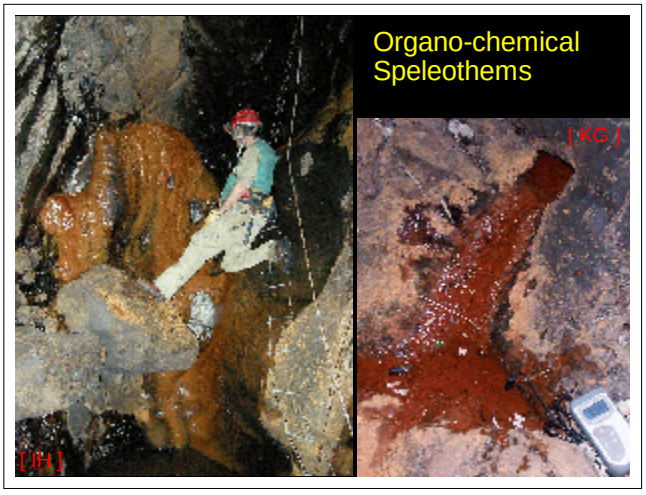
Pseudokarren

left = vertical fluting on a sandstone wall
right = small runnel cut into a sandstone pavement. White is a thin silica deposit forming levees.



Silica Speleothems

Small coralloids such as this were moderately common in most caves.



Ogano-chemical speleothems within Widdallion cave
Left = orange flowstone within cave (soft surface, harder core).
Right = orange flocculated material in spring in upper entrance.
Analysis of spring material =
37% iron and other acid-soluble mineral
31% combustable organic material
32% other material (acid insoluble, non-combustable)
Rob Wray said "probably composed of biological mediated (bacteria, etc) oxidised iron materials".

END

NB I have booked
30 minutes for this talk (excluding question time)
10 mins for introductory talk onterminology
20 mins for "Laterite Karst" talk