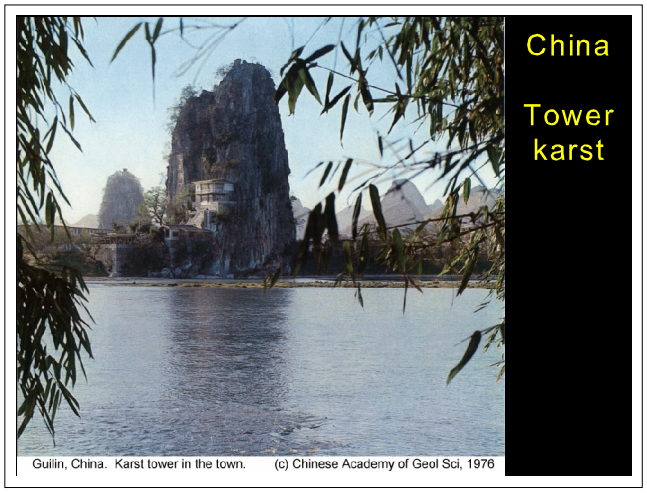
Opening outline

INTRO:
This covers various Australian Karst areas (biased to KGG visited areas) with a commentry on K style and Hydro - it is relevant to both GEO 450 & GEO 451.

The treatment will be regional and divided into the following main groups.

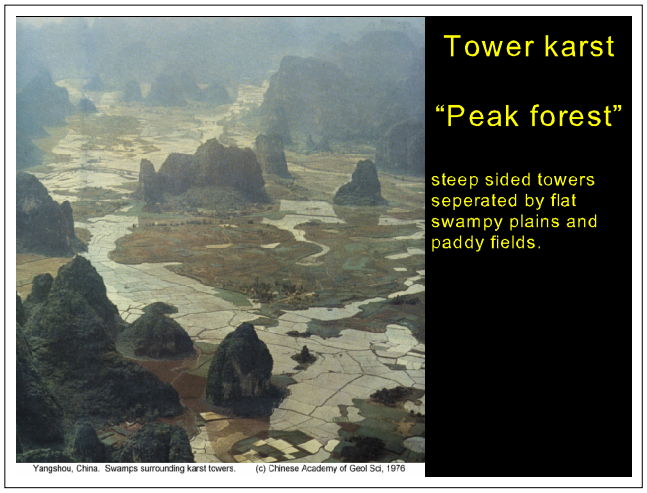
Hardrock = hard indurated limestones, generallly with limited matrix porosity
Softrock = soft non-indurated "sandy" limestones with good intergranular porosity
Pseudokarst = various types, but in particular I will talk about the karst-like hydrology of lava flows



China - tower karsts

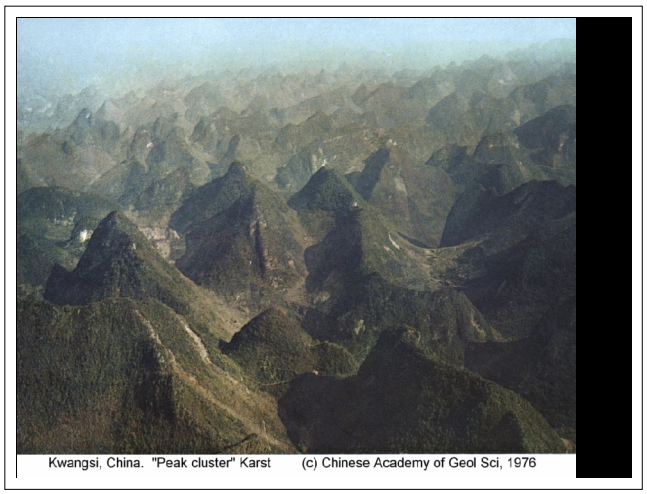
OVERSEAS:
The large tropical karst landforms are best seen overseas - eg China, IndoChina, Indonesia, PNG

Li River World famous tower karst
But NB the Chinese recognise a variety of types of TK.



This is "Fenlin" or "Peak forest", characterised by towers separated by flat swampy country

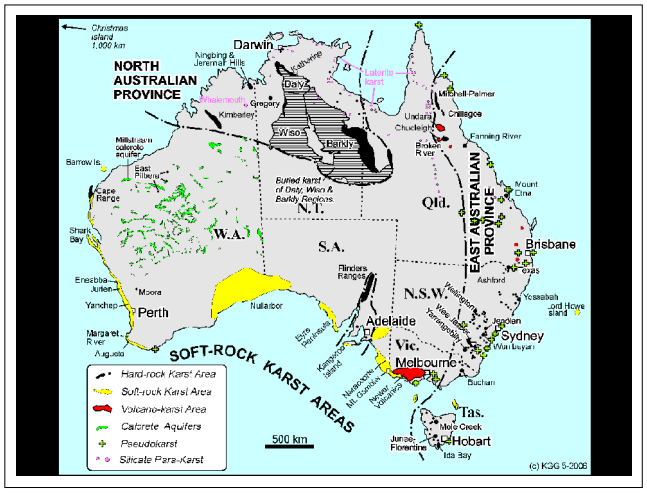
Original theories for the formation of TK were base on lateral undermining by acidic swamp waters. That is happening here.



Kwangsi, China. "Peak cluster" Karst (c) Chinese Academy of Geol Sci, 1976

This is "Fencong" or "Peak clusters" - it lacks the swampy plains between the towers and is an "all-slopes" terrain with conical peaks separated by polygonal depressions.

Solution is maximum in the hollows, high areas are too well-drained to hold water long enough to dissolve and so get left behind as peaks.



Aust karst MAP

Karst areas of Australia.

Christmas Island = Australia's only eg of oceanic island karst

Hardrock

NW Australia = flat lying lstn + tropical climate

Large areas of "covered" karst (K aquifers only)

East Aust = steep to mod dipping "impounded" karsts.

Tropical in North

Temperate to south.

Softrock

Tertiary calcarenites

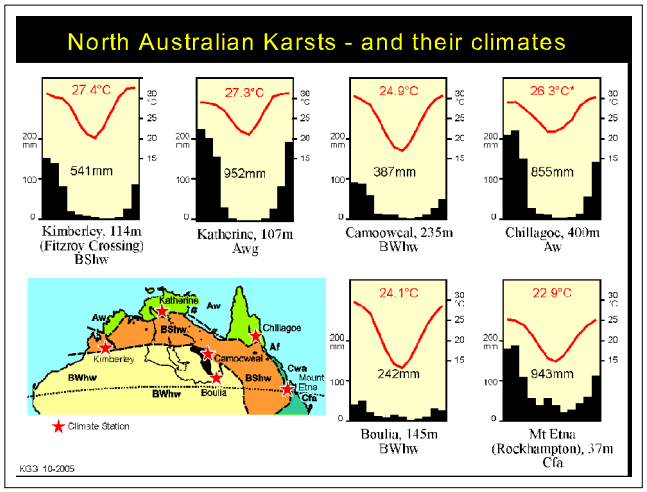
Syngenetic karst in Quaternary dune calcarenites

Calcrete aquifers

Pseudokarst

Lava caves and lava-flow hydrology

Silicate karst, laterite karst



North Australian karsts - tropical climates

Climate zones of the Tropical karsts.

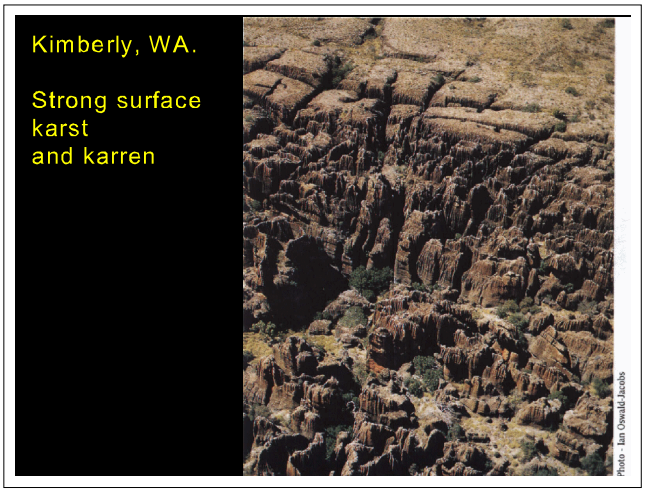
Monsoon with pronounced wet & dry seasons. Also becomes drier further inland.

Moving further down the east coast, climate becomes cooler, and also changes from a summer rain maximum through even rainfall in NSW to a winter rain in Vic & Tas.
Tasi is much wetter!

Kimberly

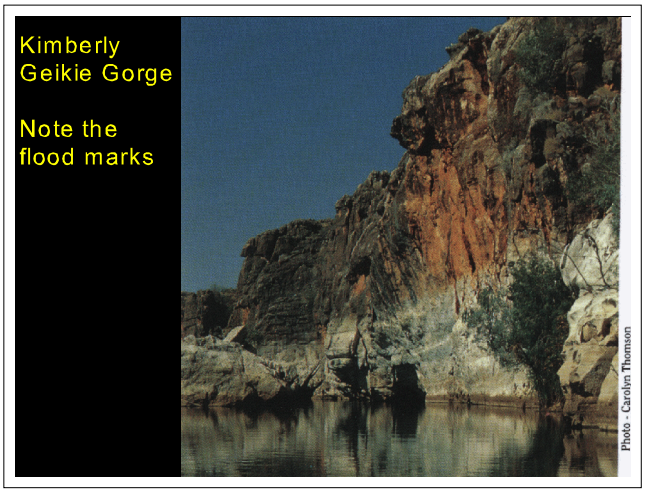
KIMBERLY, WA

* A Devonian Reef is exposed at the present surface. Superimposed drainage has cut gorges through it.
* Strong surface karren
* Well developed caves, including flooded caves beneath the level of the plain.

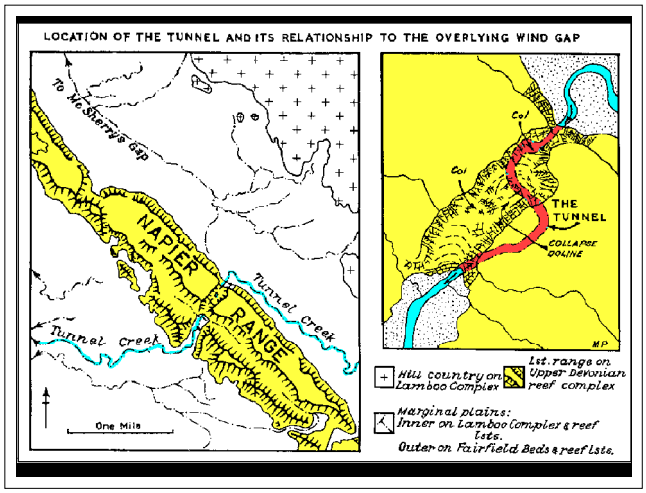


KIMBERLY, WA

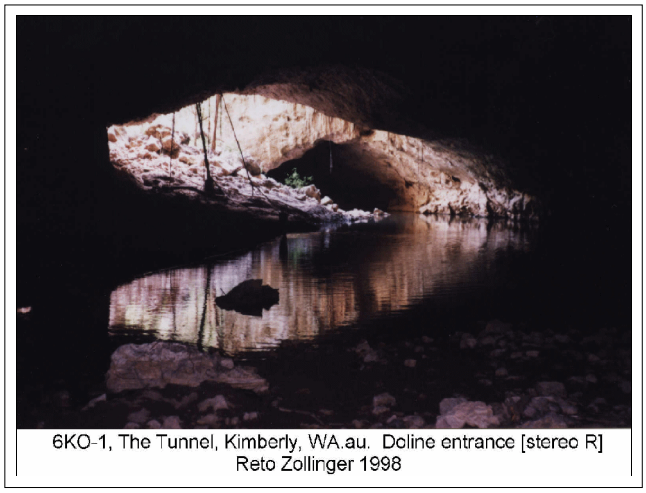
Strong surface karren, above Mimbi cave.
Note progressive incision from back (plateau) to front.



Geikie Gorge
Note high flood marks, left by wet season flooding (a feature of the monsoon climates).

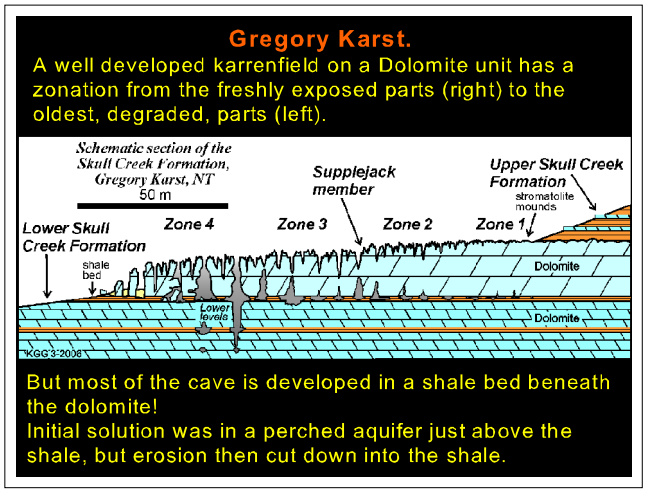


Tunnel Cave (map)
A prior stream which originally crossed the range in a high valley, has been captured underground and now runs through a cave.
See also next photo.



6KO-1, The Tunnel, Kimberly, WA.au. Doline entrance [stereo R]
Reto Zollinger 1998

Tunnel Cave - part of the underground streamway.



Gregory karst - section

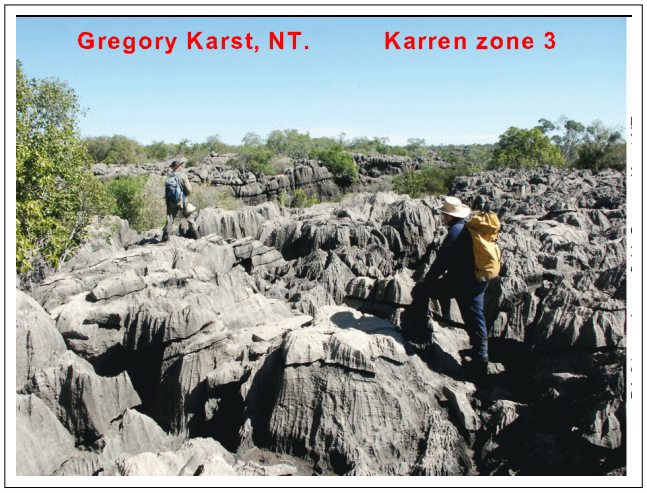
GREGORY KARST

Cross section shows the geology and karren zones and cave levels.

As the upper Skull Ck formation is progressively stripped off, the karren zones develop progressively deeper on the top of the Supplejack. At the oldest (left) edge, the grikes have cut down to intersect the caves and break the system up into giant grikes. The final stage is a 'rock city' of isolated blocks.

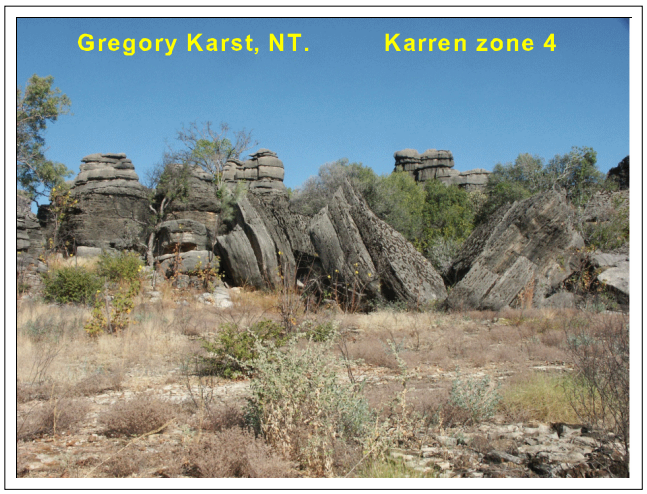
Underground the water initially ponds above the impermeable shale bed and dissolves small tubes there. As these get larger, mechanical erosion cuts down into the shale, and enlarges that area rapidly. So most of the cave is actually in the shale bed. Lower passage levels have formed adjacent to the surface gorges.

karren zone 1 -
freshly exposed Supplejack (with stromatolite mounds) has only small karren.

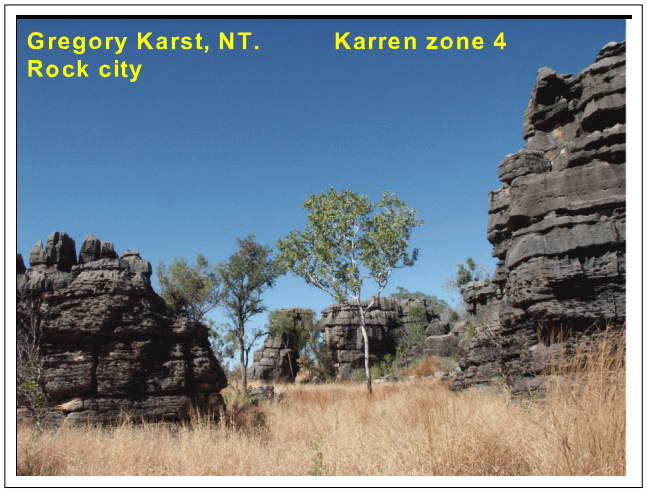


Surface karren **(zone 3)**

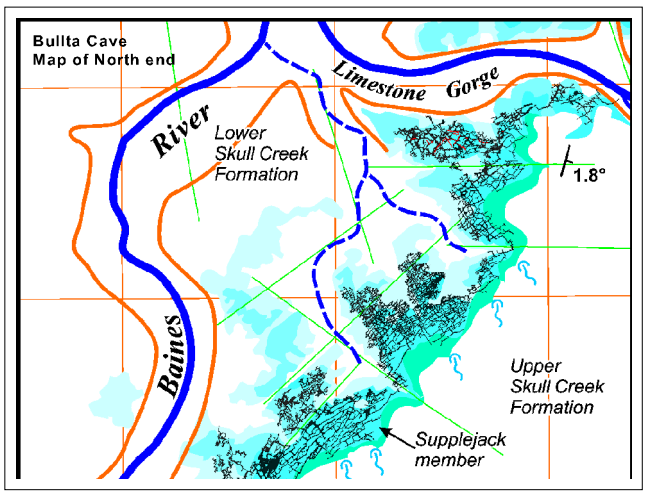
In **karren zone 4**, the cave passages become unroofed to form giant grikes.



At the outer edge, zone 4 breaks up into isolated blocks, which may be rotated.



The final stage is a "rock city" of isolated blocks.



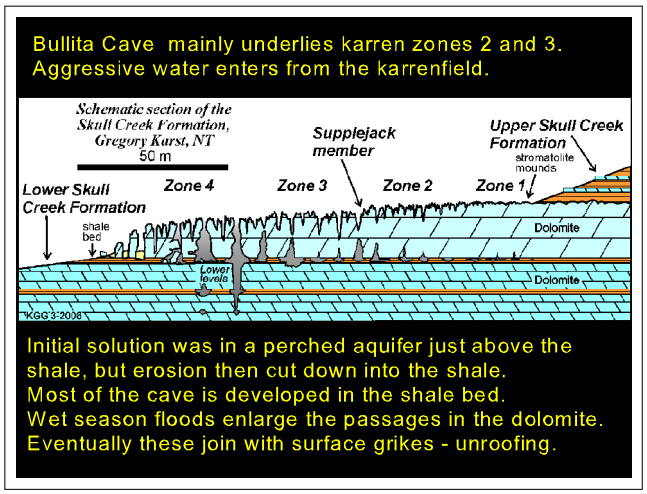
Bullita Cave map

Map of **Bullita Cave** (north part)

Note relationship of cave development to the surface karren zones (darkest colour = zone 1, lightest blue = zone 4).

Most of the cave is in zones 2 & 3, with passages becoming wider into zone 3.
Youngest passages are near the zone 1-2 transition (smaller inpenetrable tubes probably extend beneath zone 1)
Oldest passage (now being unroofed) are in zone 4.

Red passages are lower levels, near Limestone Gorge.



Gregory karst - section

GREGORY KARST

Cross section (again)

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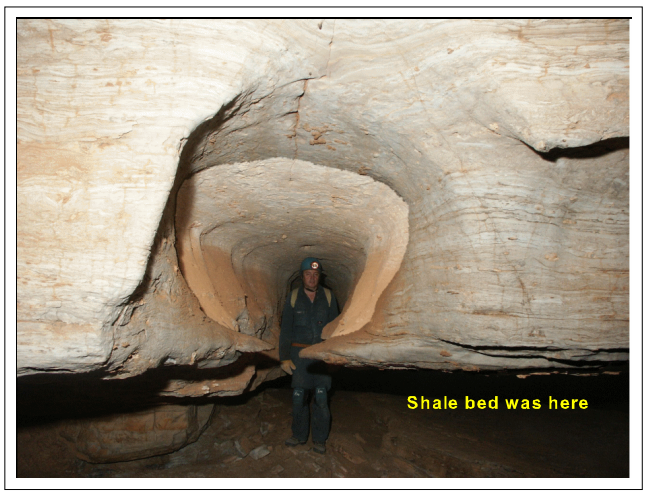
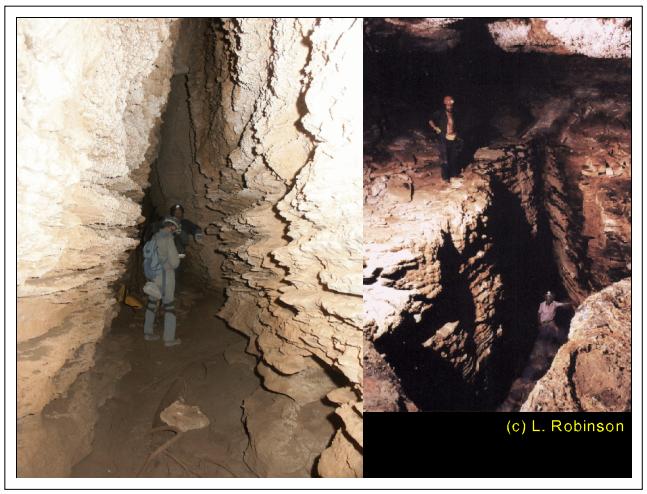
Lower passage levels have formed near the surface gorges.



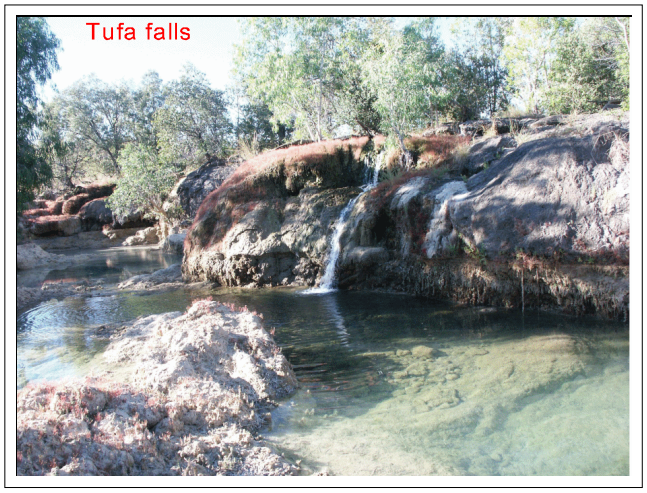
Initial phreatic tube formed just above the shale bed.
When turbulent flow commenced, it cut down into the shale bed by mechanical erosion and the tube is now abandoned.

Inverted-T passage.
The vertical slot is dissolved along a joint in the Supplejack dolomite.
Wet season inflows & floods continue to enlarge these fissures.
The horizontal undercut was mechanically eroded into the soft shale bed.
Note wet season stream channel on floor.



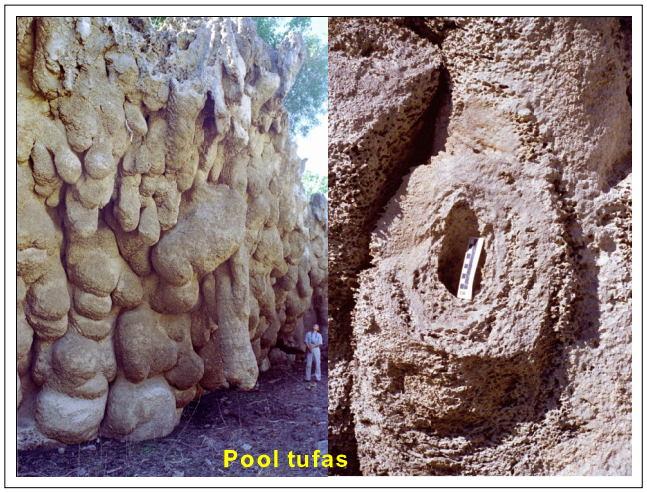
Left: Fissure passage within the Supplejack. Wet season floods have sculptured the dolomite bedding.

Right: Lower level development near the river gorge.
The upper chamber is in the shale bed.



Tufa dam (Gregory)

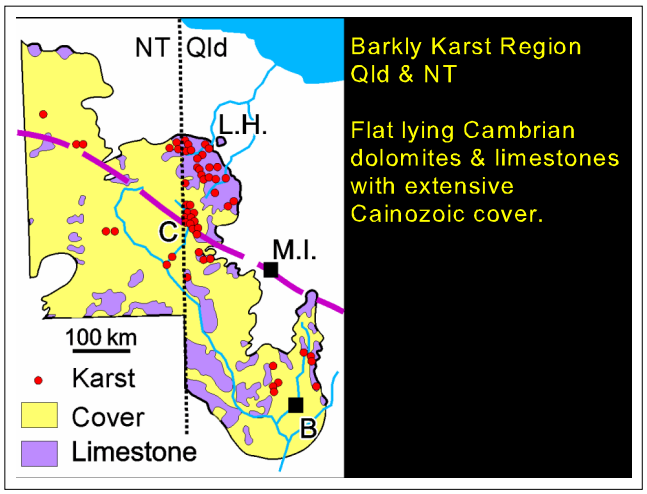
Tufa dam and falls in a creek in the Gregory karst



Pond Tufas - Elsie Ck, NT

Speaking of tufas...

Pond tufa in Elsie Ck, NT. (now drained or dried up)
NB resemblance to stromatolites in the Gambier cenotes



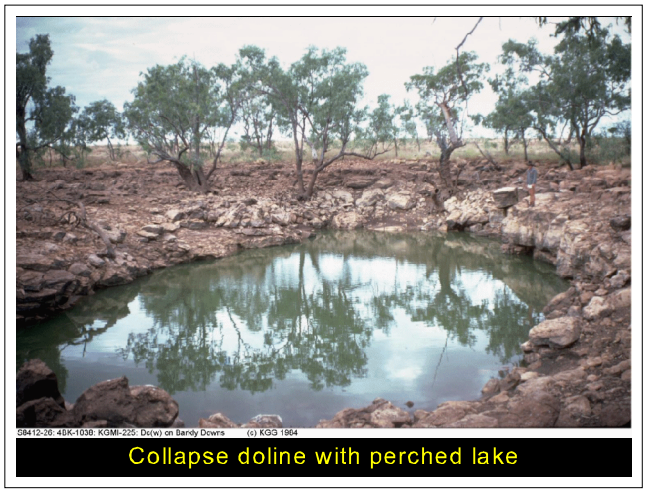
Barkly Karst

Barkly karst region map

A broad basin of flat-lying carbonates, with extensive younger cover (black soil, laterite and Tertiary and Mesozoic sediments)

Caves extend below the WT, which at Camooweal is abt 40-60 m below surface. Purple line is boundary between Arid & Semi-arid climate zones.

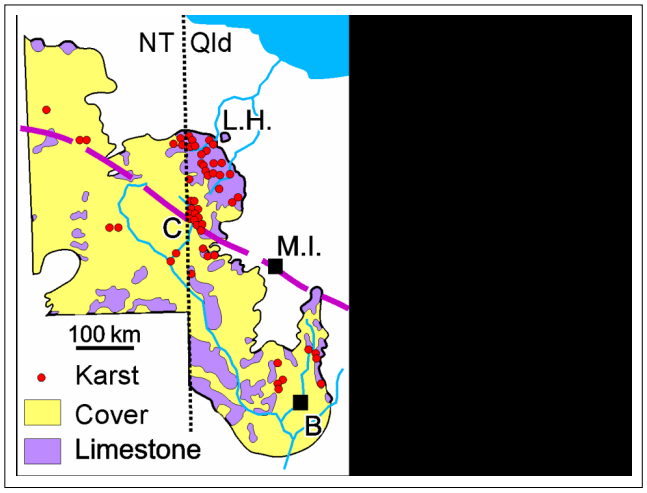
Spiral streamsink



Doline with perched lake (on a clay bed)
Regional watertable is much deeper

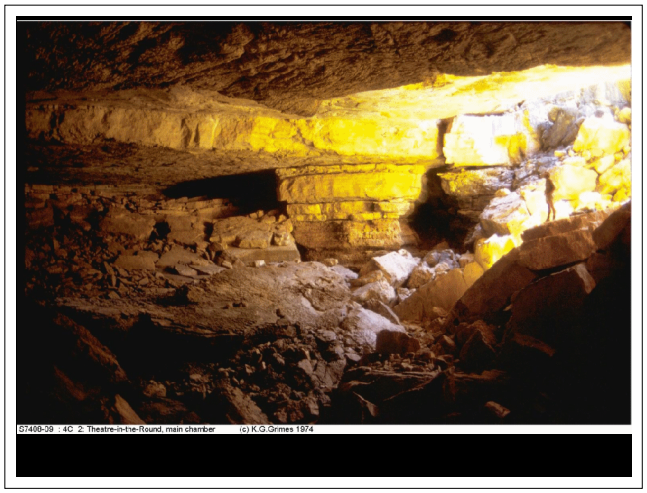
Bed of Georgina River (background) with set of 3 collapse dolines.
The one in the river is clogged with mud and has a perched lake.
A small surface channel feeds flood waters to an open collapse doline (right).
A third doline (left) connects underground to the second.

This is point input, but does it count as 'local' or 'external' ?

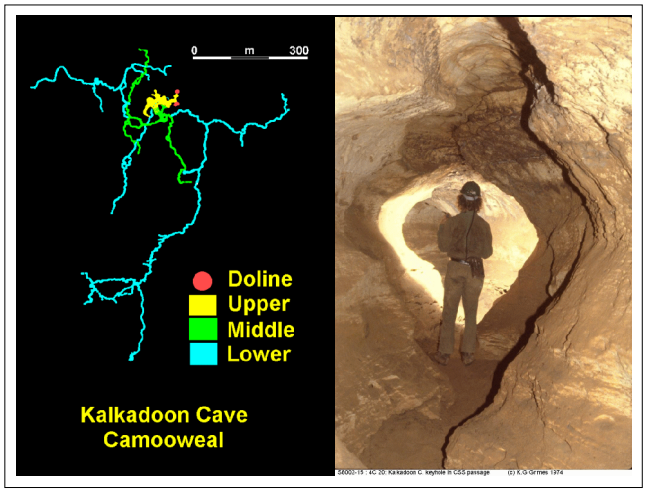


Map:
The river flows mainly on a clay surface cover - so does the point input to the doline then count as "external" ??

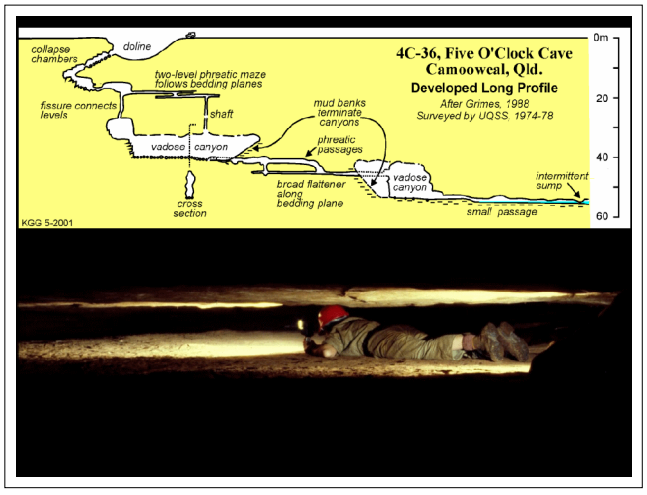
Ground view of the "point input" doline.



Typical large cave entrance

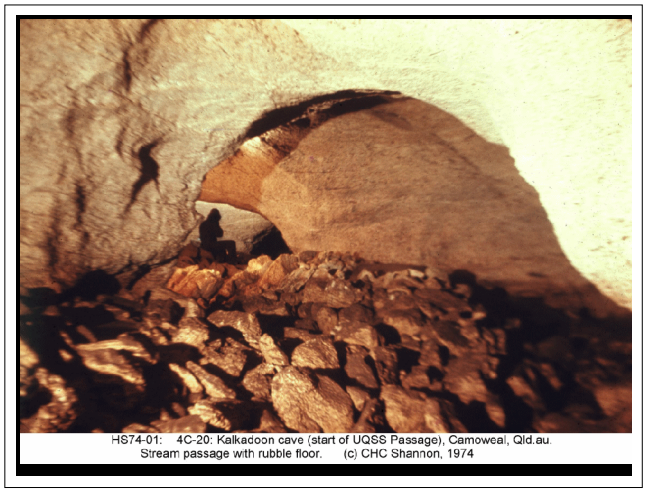


Map of Kalkadoon cave
A large multi-level system
Colour coded by levels.
Photo = one of the lower-level (smaller) passages, with a stream slot in floor and roof.



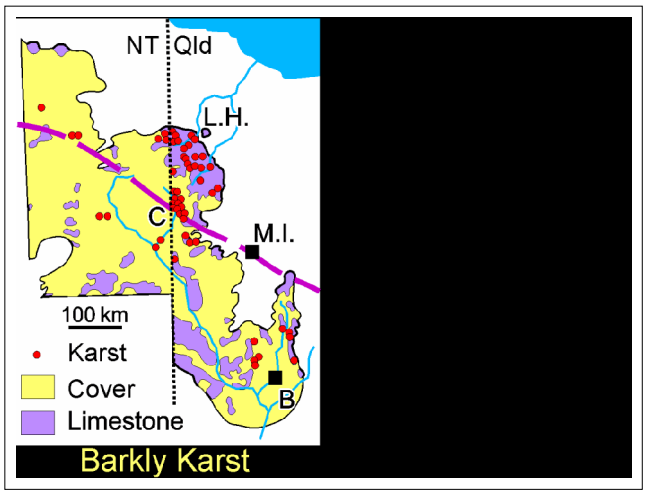
Profile of 5 o'clock cave. Showing multiple levels (old watertables?)
Lowest level has pool (at ~55m depth) = watertable?
Photo of a "flattener" level. = water table or soluble bed??

Two photos
Left = vertical fissure conecting two horiontal levels
Right = Large collapse chamber.



middle level passage, with rubble that may have been transported by wet season floods?

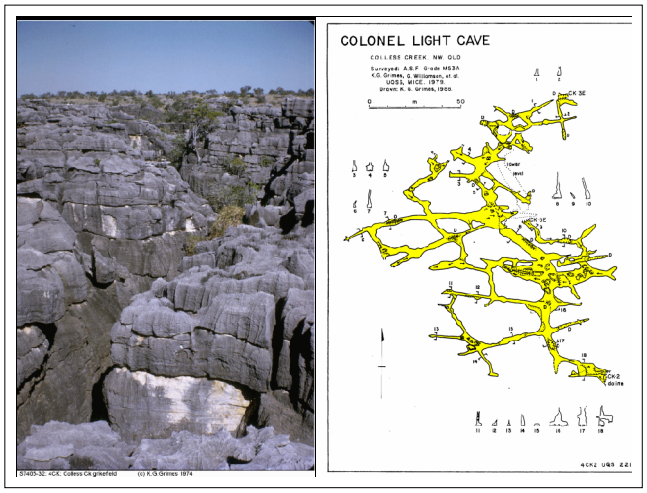
Water table pool, 50-60 m below surface.
This has been dived and leads to an extensive underwater passage



Map (again)

Now moving north to Lawn Hill, at edge of karst region

The Colless Creek grikefield.
Karren on a favorable bed.
Flat surface behind is a old (Tertiary) land surface. The present gorge has cut down from that level over the last 20-30 Ma.



Grikefield and map of joint-controlled cave that underlies it.

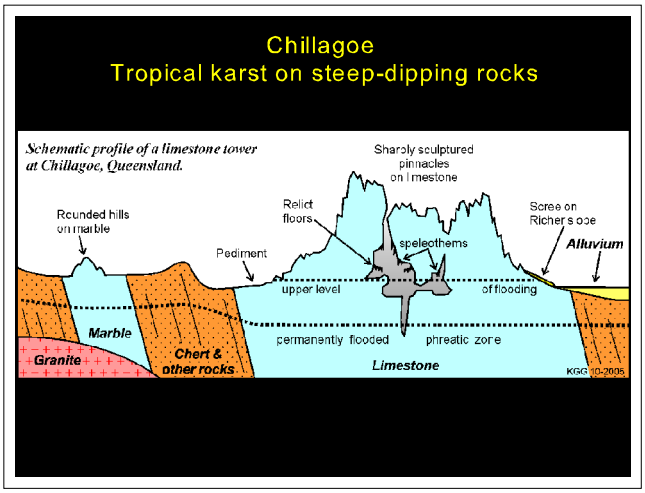
Many similarities to Gregory Karst here.

Tufa dam across Lawn Hill Creek
(within the sandstone gorge,
downstream of the limestone)

Detail of the tufa dam
Tufa forms preferentially in the
turbulant zone of the watrfall.

?

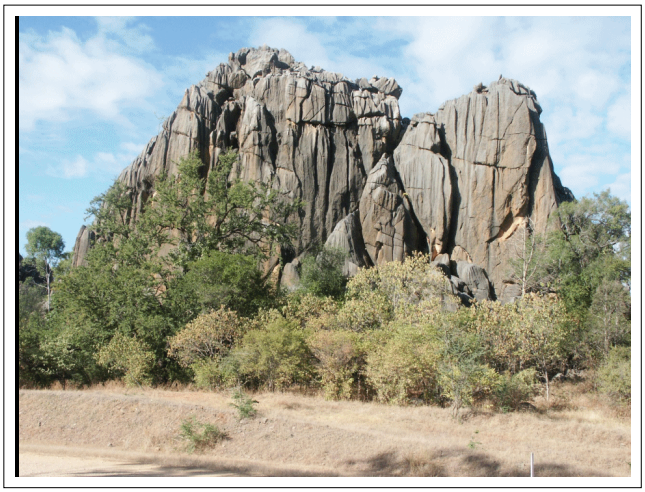
CHILLAGOE



Chillagoe

Cross section showing geology and towers
Also wet/dry season watertables
Granite intrusion forms marble - different style of tower.
Towers are riddled with caves, but little development beneath plain level.

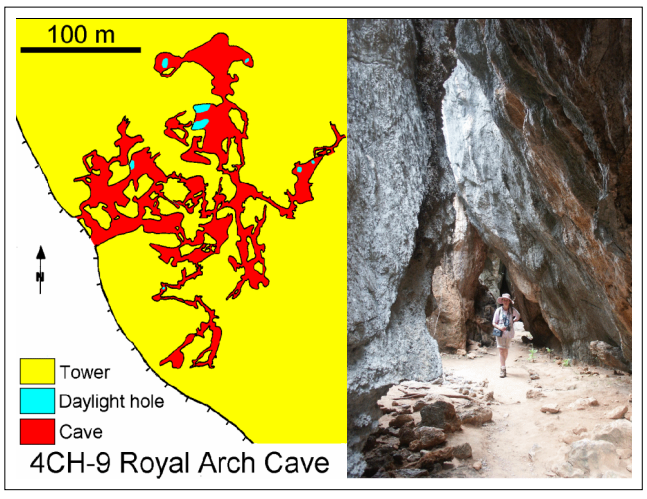
Aerial view of a limestone tower, and the surrounding flat plain - (alluvial in this case)



Limestone tower.
Note vertical wall karren

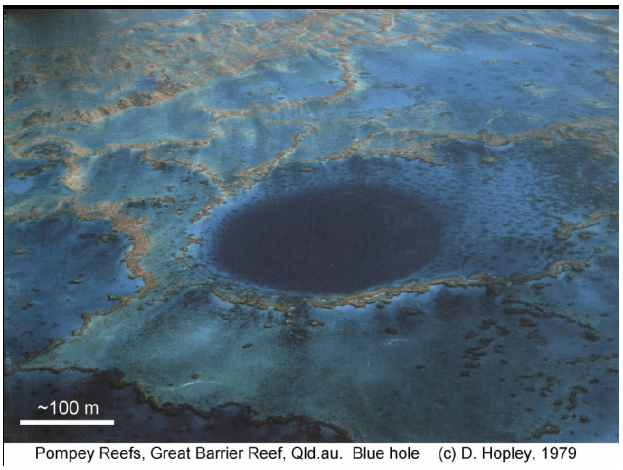
Toppled tower - undermined at the level of the plain (wet season flooding)

Pediment (with clints & soil-filled grikes) and a small tower in background.



Map of a typical cave within a tower.
Floor level is approx that of surrounding plain.
Numerous roof holes shown in blue.

Photo shows a partly unroofed passage - grading to a giant grike.



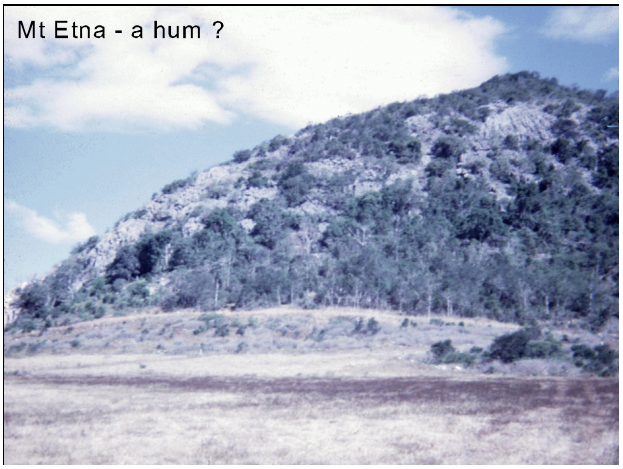
Pompey Reefs, Great Barrier Reef, Qld.au. Blue hole (c) D. Hopley, 1979

Great barrier Reef (Blue holes)

GREAT BARRIER REEF

Blue hole.

Formed as a collapse doline in reef limestone during last glacial low sea level, and flooded as the sea level rose to present.

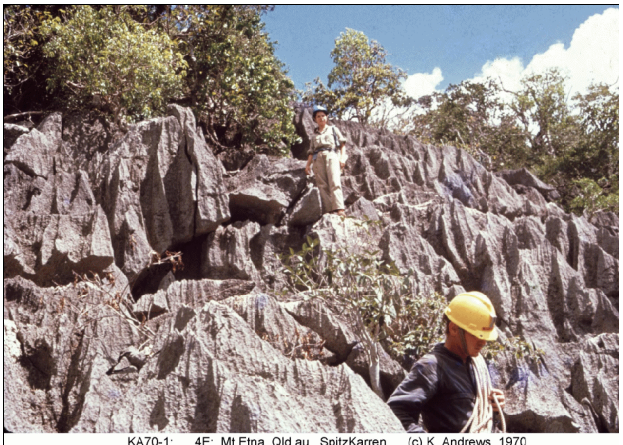


Mt Etna

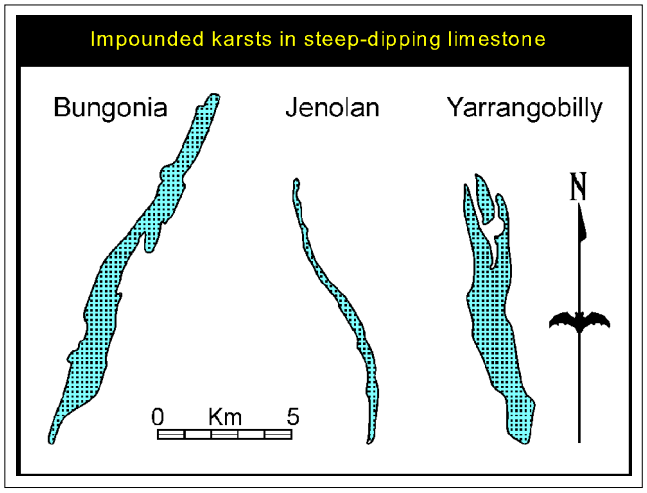
MT ETNA

Some call it a "hum".
This is at the Tropic of Capricorn -so only just "tropical"
The strongly developed karren are typical of tropical regions.

See air-photos in exercise


KA70-1: 4E: Mt Etna, Qld.au. SpitzKarren. (c) K. Andrews, 1970

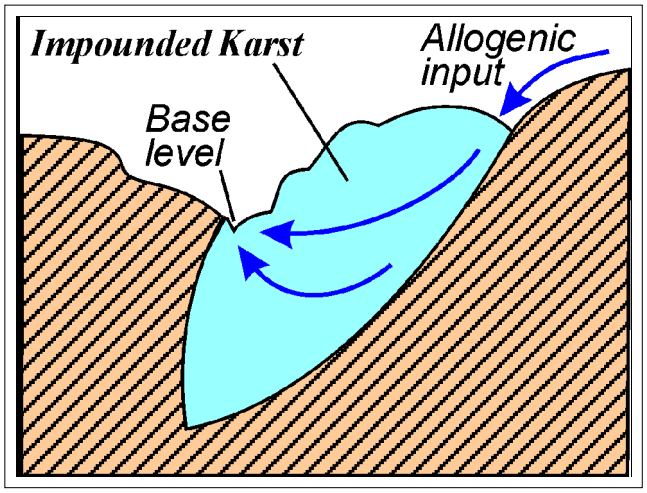
Karren on side of Mt Etna.



Impounded Karsts

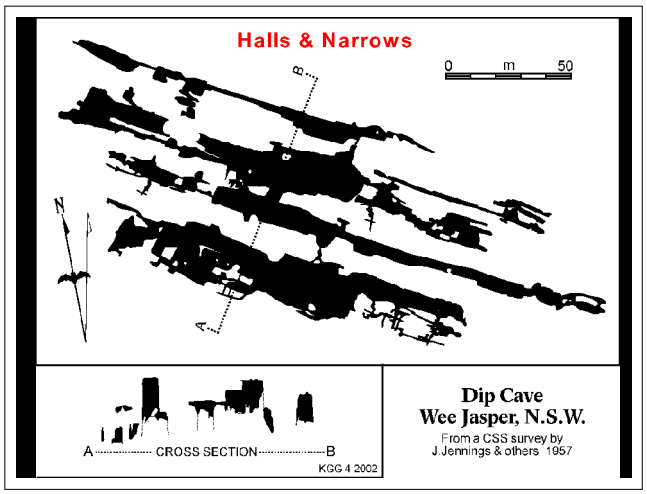
IMPOUNDED KARSTS of temperate Eastern Australia.

Maps of three karsts - each a narrow belt of steep-dipping limestone.
Jenolan would qualify as "Stripe karst" (L/W >3, best if L/W >30).



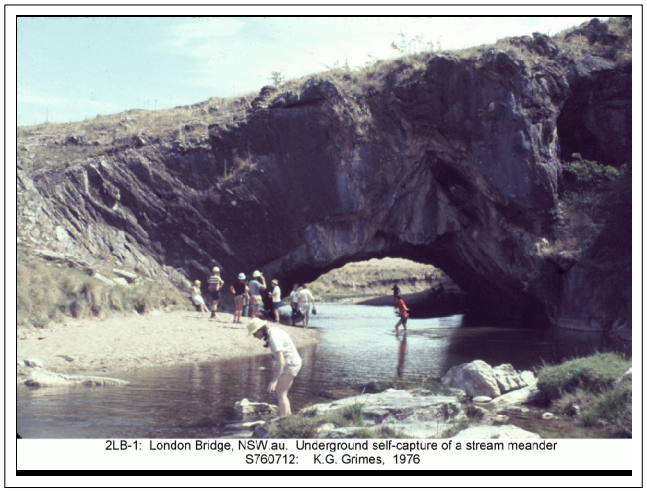
Impounded Karst - side view.

Allogenic input is of major importance.
Ongoing incision of the surface valleys provides the base level for output.
Throughflow is typically in stream caves.
Abandoned levels are common.



Halls & Narrows:

Where there is no strong flow to create linear stream passages the phreatic cave form reflects the lithology and structure.
In this cave the limestone is steep dipping. Some beds have dissolved out well to form the Halls.
The halls are connected by a few small "Narrows" cut through less-soluble beds.



London Bridge

London Bridge - near Canberra.
Underground capture of a surface meander loop. (The meander runs off to the left)

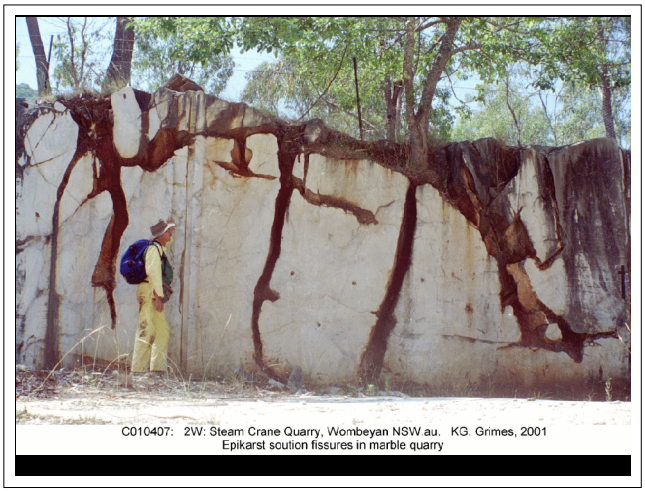
A small cave beneath the ridge captured the surface streamn flow and eventually left the old stream bed dry.

Yarrangobilly

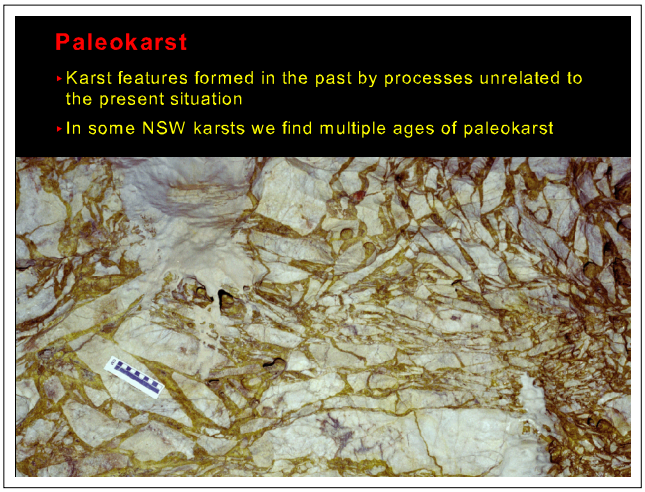
Yarrangobilly: Stream caves (old & present)...
Left: Abandoned stream passage. Scallops on the roof indicate prior flow. Stalactites follow a joint in the ceiling.
Right: Active stream passage in steep-dipping limestone.

Epikarst

Epikarst exposed in a quarry (Molong, NSW)
Soil-filled fissures and pipes.



Epikarst structures in a marble quarry at Wombeyan.
Partly soil-filled, partly open.

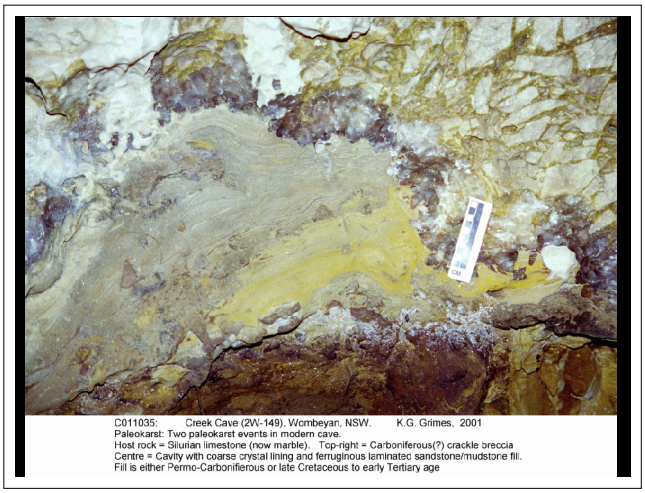


Paleokarst

Paleokarst

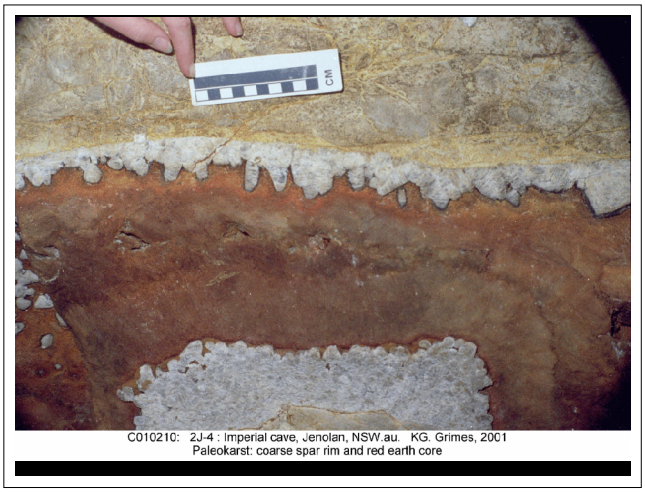
= *karst features formed in the past by processes that are not related to the present environment.*
* Borderline cases occur.
In NSW karsts, multiple ages can occur

Photo = "Crackle breccia" at Wombeyan
Solution has undermined the limestone so it broke up but only subsided a short distance.

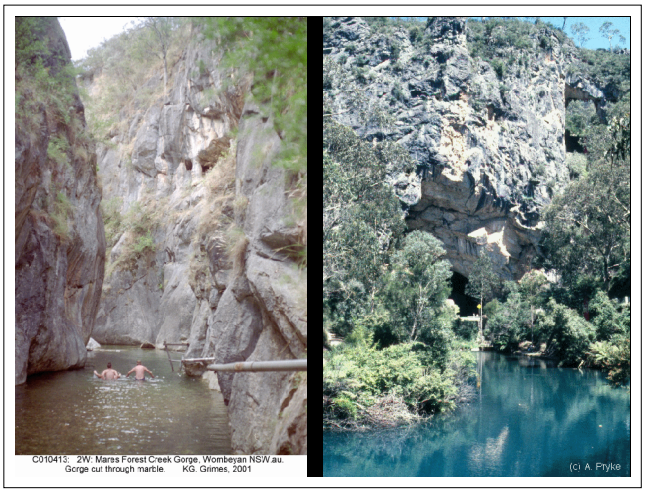


Complex multi-generation paleokarst - at Wombeyan

1: Silurian host limestone (now marble)
2: Crackle breccia (Carboniferous solution?)
3: later cavity, with coarse sparry rim and sediment infill (Permo-Carb OR Cretaceous-Tertiary?)
4: Modern cave cuts across them all.

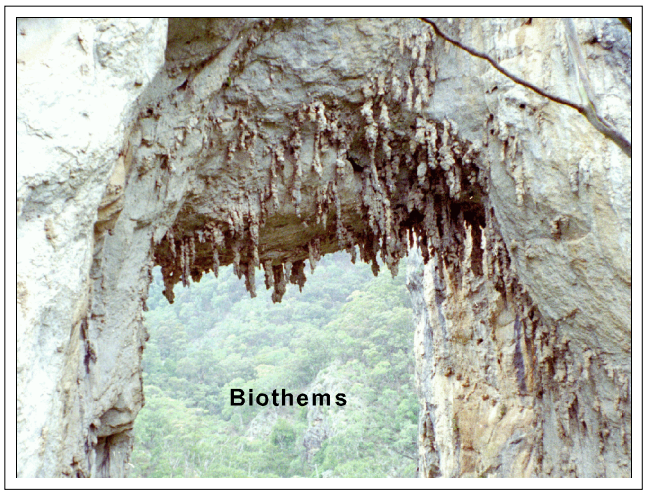


Paleokarst at Jenolan
An old cavity has a sparry lining and a red sediment fill. It is cut by the modern cave.



Strongly incised Fluviokarst reliefs in uplifted terrain.
Left = Gorge at Wombeyan
Right = Arch and pool in deep valley at Jenolan.

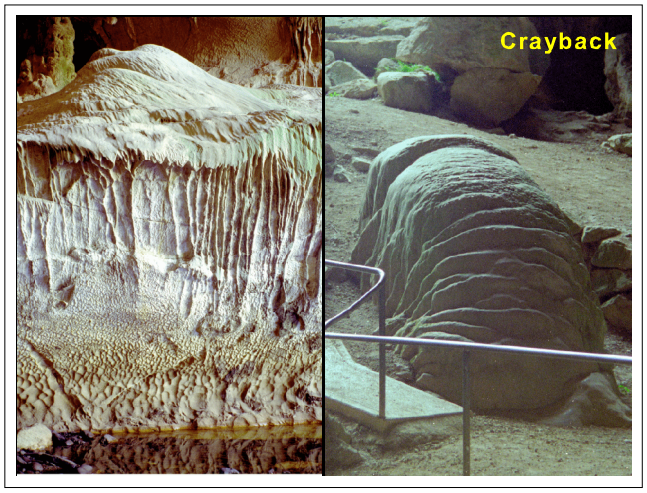
Gorges etc



Biothems

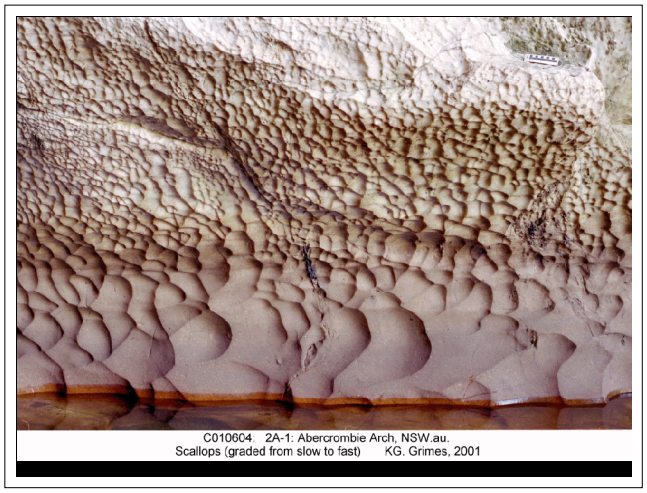
BIOTHEMS

Knobby stalactites in twilight (daylight!) zone. (Jenolan)
Organic growths (algae etc) influence the calcite deposition to produce knobby and porous speleothems.



"Craybacks" at Abercrombie Arch & Wombeyan.
Light-oriented, algal-influenced speleothem growth.
The elongated plan is also partly due to wind blowing the drips.

Also stream scallops below ...

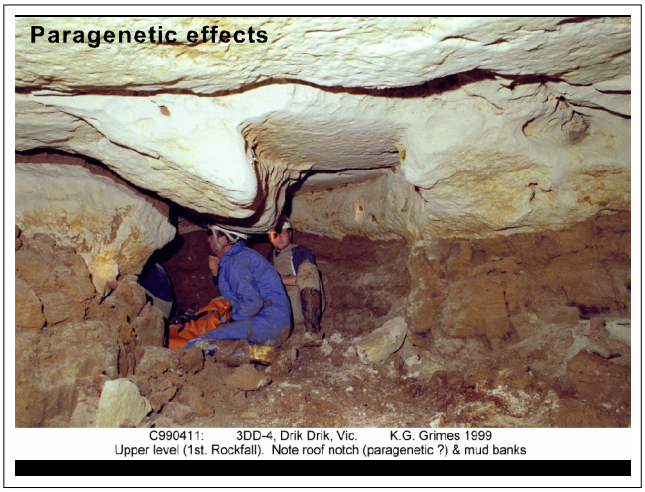


Vadose scallops

VADOSE FEATURES

Stream scallops (Abercrombie Arch)
Note large scallops at base = slow baseflow
Smaller scallops higher up = faster flood flows.
Light is from right, and flow is from right to left
10 cm scale at top right.

Keyhole section
Usually regrded as indicating vadose incision of a slot beneath an initial phreatic tube.
But in some cases similar shapes can result from upward paragenetic processes (stream peached on top of a sediment bank) - see next photo



Mud-filled passageway (see mud banks on each side) - Drik Drik, Vic.

The roof slot might be paragenetic - resulting from a stream forced against the roof by the build-up of the mud. A later flow has partly removed the mud.

Possible paragenetic half-tubes following an inclined wall - these may have formed by water following the contact between the limestone and a sediment fill that has since been removed. (Wombeyan)

Half tubes in the roof of Victoria Arch - Wombeyan.
Possibly paragenetic, or perhaps remnants of phreatic tubelets following an early inception horizon.

"Anastomosing tubes" in horizontal slots. Wombeyan caves.

NOT paragenetic as are in solid rock.
Are these proto-caves, following an inception plane?
OR are they the result of flood waters invading a crack in the wall of an existing cave?

?

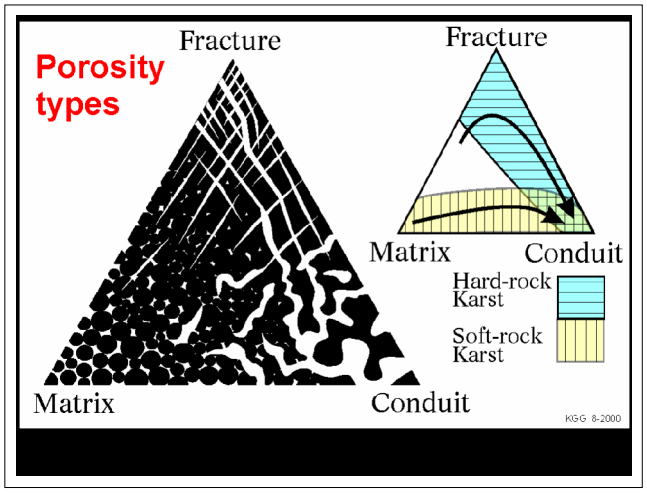
Any Questions
?

Soft- rock Karst

SOFT ROCK KARST

Overview

see also poster ...

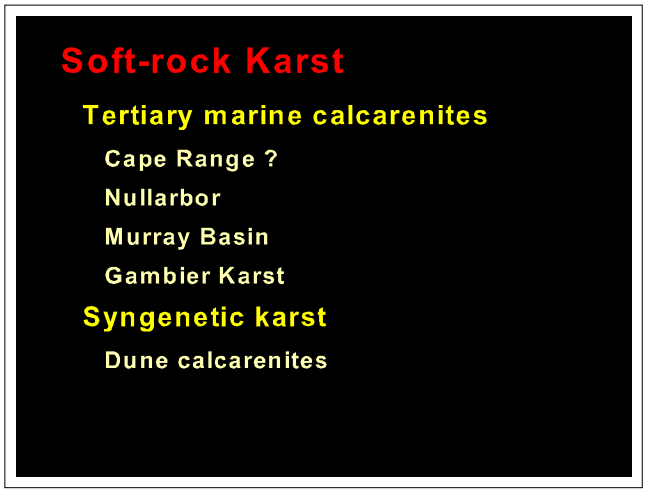


Porosity

Porosity types.

Softrock limestones have abundant "primary" matrix porosity, and can evolve towards conduit porosity without fissures.

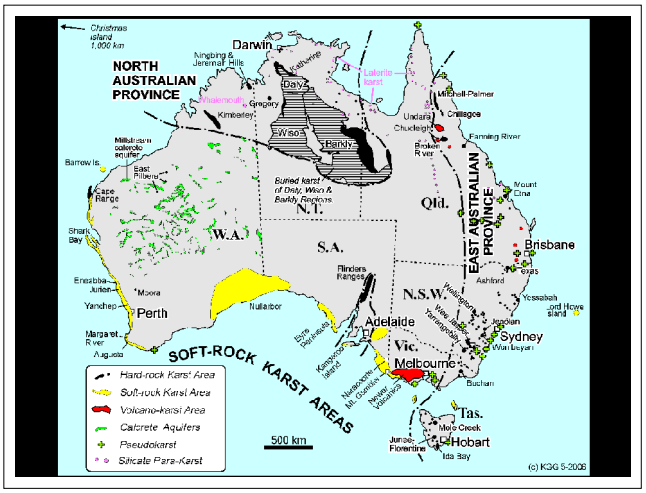
Hardrock limestones have lost their matrix porosity long before they are exposed at the surface and karstified. They start of with a fissure porosity which enlarges and evolves into conduits.



Soft Rock Karst

SOFT ROCK KARST

Australian Areas



Aust karst MAP

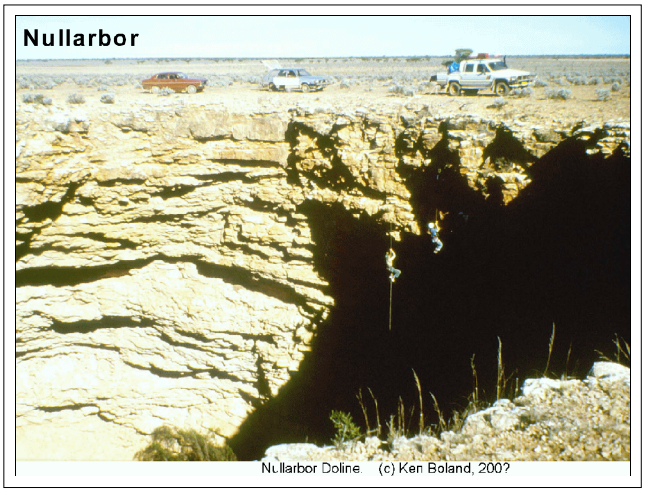
Karst areas of Australia.

Softrock

Tertiary marine calcarenites

Syngenetic karst in Quaternary dune calcarenites

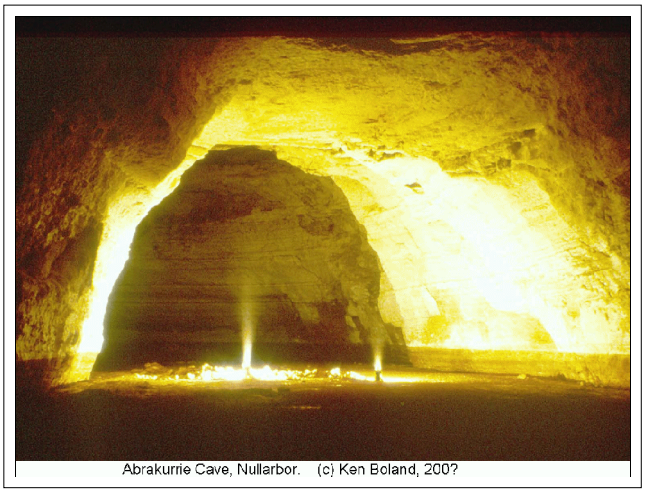
Calcrete aquifers



Nullarbor Doline. (c) Ken Boland, 200?

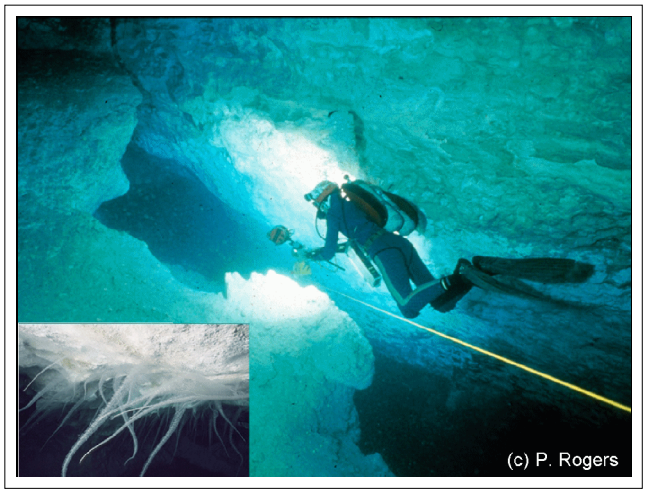
NULLARBOR:

Flat desert karst - soft marine calcarenite
Wetter climates in past (Tertiary)
Large collapse dolines lead to large deep caves
But also shallow caves that are complex phreatic mazes.
Surface caprock and a small-scale spongy porosity

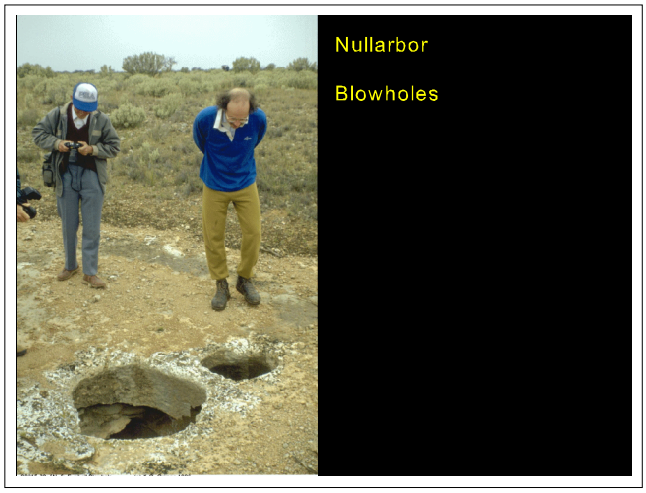


Abrakurrie Cave, Nullarbor. (c) Ken Boland, 200?

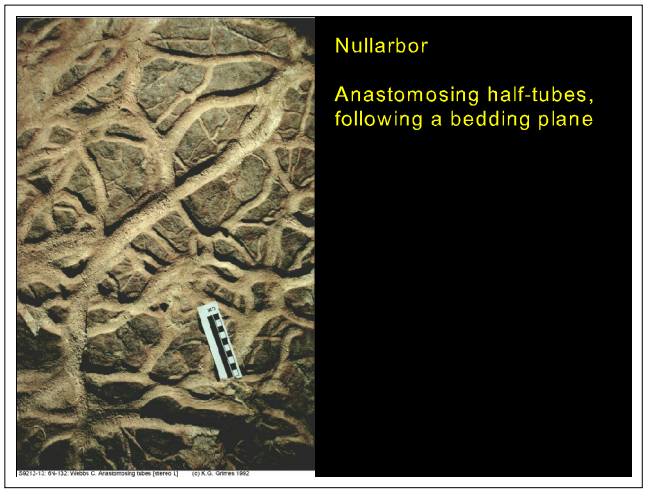
Nullarbor - large deep cave.
(water mark is abt 2m above floor)



Many caves (or parts of caves) are beneath present watertable.
Salt water - oddball biology and chemistry (chlorides, sulphates etc)



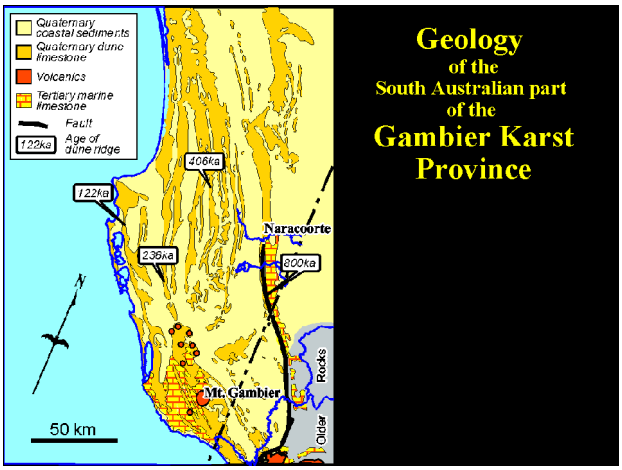
Nullarbor Blow holes
Air movement = spongey solutional porosity beneath caprock + barometric pressure changes.



Anastomosing half-tubes following a bedding plain. (Nullarbor)
These are the initial stage in speleogenesis.

Those that first pass the size threshold (~1-2cm) enlarge faster to form the main cave passage, while the others are left to stagnate.

GAMBIER KARST

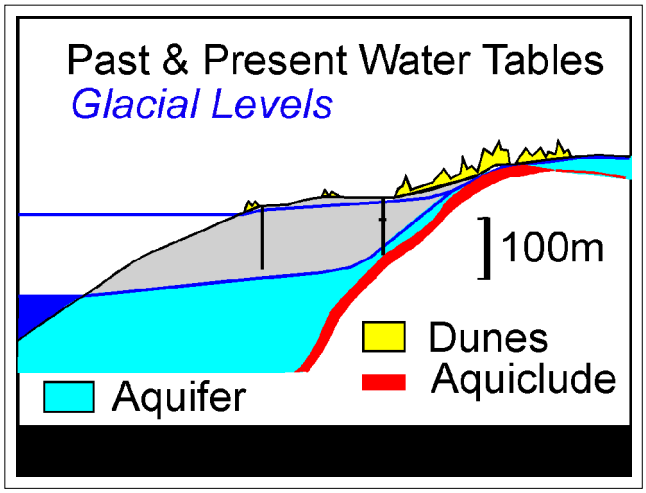


Gambier Karst map

Geol map - showing >800ka sequence of coastal dune limestones,.
Also areas of older Miocene marine calcarenite.
Both are cavernous.

A flooded Uvala on the Naracoorte Plateau.

Collapse doline + rubbish dump + pines

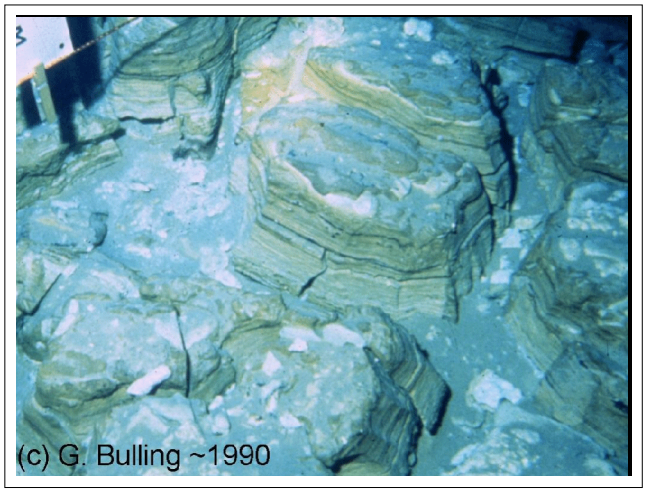


Water-table changes

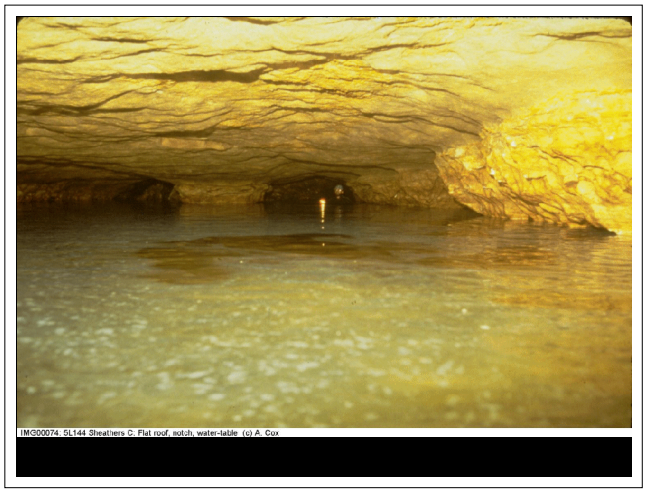
Past and present sea levels and how they influence cave development,

Large pasages form at depth during lower stands.
These may be partly drained at the peak of the glacial low sea level, and start collapsing.

Rising water floods these.



Submerged mudcracks in a cave near Mt Gambier. These are in an earlier laminated mud (pool deposit) Indicate a sea-level-controlled sequence of ...
* cave flooding (the mud)
* then draining and drying (the cracks)
* then reflooding (present water)



Example of changing watertable with surface vegetation change:

When first found this cave was flooded and was explored by cave divers.
As the pine plantation on surface grew the water level dropped.
The present level is another metre below that shown here.
When the pines are harvested the water will probably rise again.

Glenelg R

Glenelg River:

Incised into limestone plain.
Local karst drainage is into the gorge as small stream caves.
Note Solution notch cut at river level (which is microtidal here)

Stream cave feeding into Glenelg River.

DD-4 at Drik Drik (in uplifted block beside Glenelg R., Victoria).
A stream cave with incised vadose canyon.
Note asymmetrical notches = meandering stream cuts, not stillstands (which would be paired)
This cave (and its stream) spirals over itself!

Right = Mud stalactite with tripod base. Possibly mud coated cobweb??

Town Cave, in the centre of Mt Gambier city.
Originally the towns water supply (and still connected to the regional aquifer)
Now a storm water inflow and polluted. The photo was taken just after a shower of rain.
There is a "centrifugal filter" which catches solid rubbish, but not liquid pollutants (eg oil etc from cars, or fuel spills from a nearby service station)

Springs

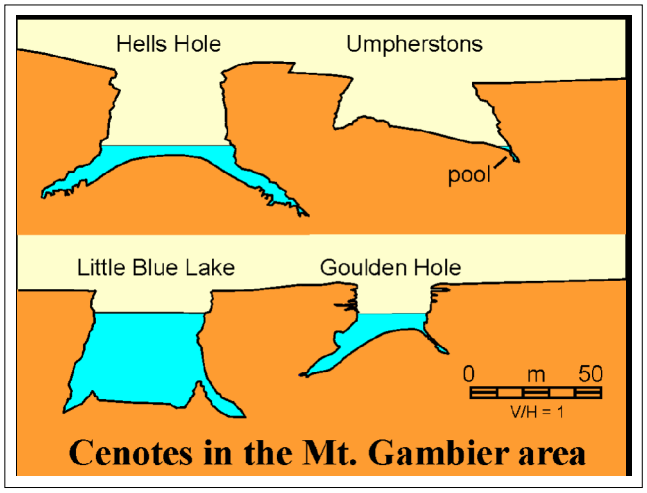
Spring - on the beach
Offshore springs also reported by fishermen

Ewans Ponds - a major spring (1.1 kl/sec) welling up in three flooded dolines.
The cleared land was originally ti-tree swamp.

Cenotes

Cenotes:

Flooded collapse dolines. The lake is at the level of the regional water table.

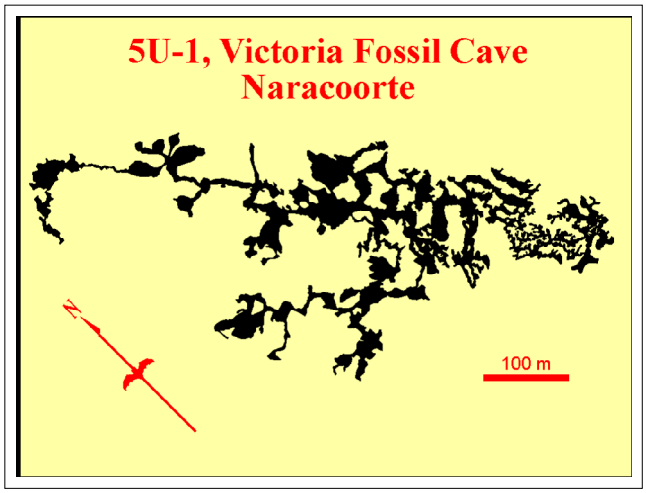


More cenotes - showing variety.

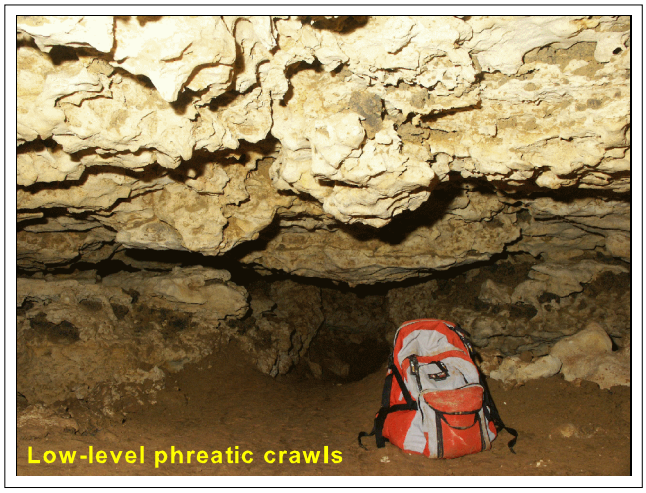
WT becomes higher towards coast

Stromatolites

Stromatolites
Formed underwater, but exposed on the wall of a cenote by a recent (post 1900) drop in the watertable.



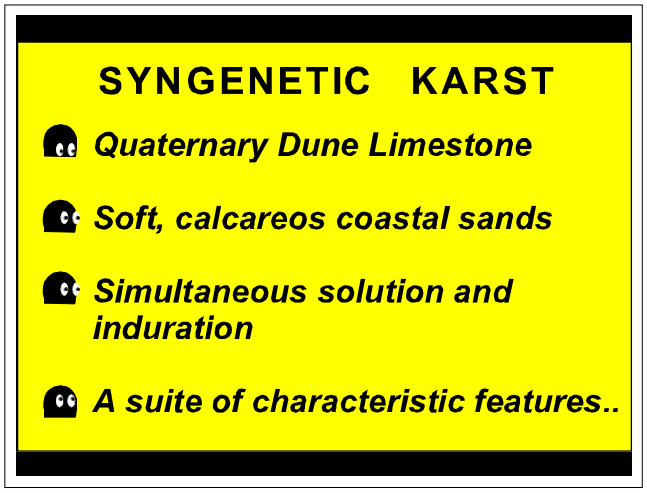
Map of 5U-1
Note moderate joint control of this horizontal phreatic maze.
The big chambers are collapse domes.



Low-level horizontal crawlway mazes with strong phreatic sculpturing.
Formed at an old WT level.

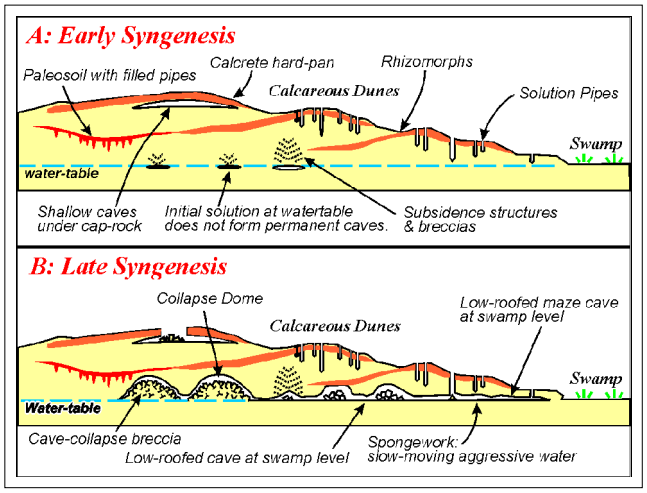
High-level chambers.
Many are collapse domes (see later), but some are large phreatic chambers formed at an earlier, higher, WT.
Roof is only 1-2m thick - so where did the big speleothem columns come from??

= Blanche cave, Naracoorte



SYNGENETIC KARST

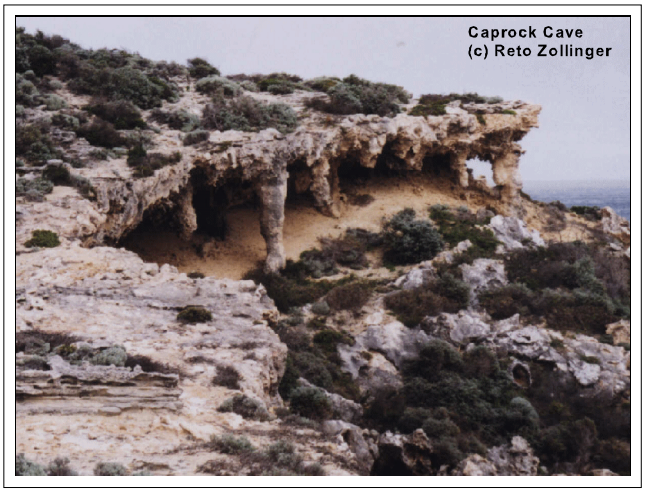
SYNGENETIC KARST:
Overview



SYNGENETIC KARST
Typical features of
1: Early syngenesis (dune sand still too soft to hold up a cave roof - except under the caprock band near surface)
2: Late syngenesis (limestone now hard enough to support caves).

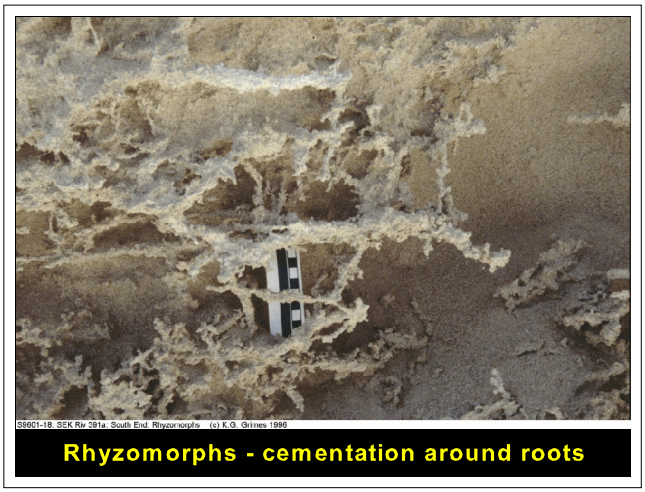
Caprock

Forms very early by cementation near base of soil zone



Caprock caves

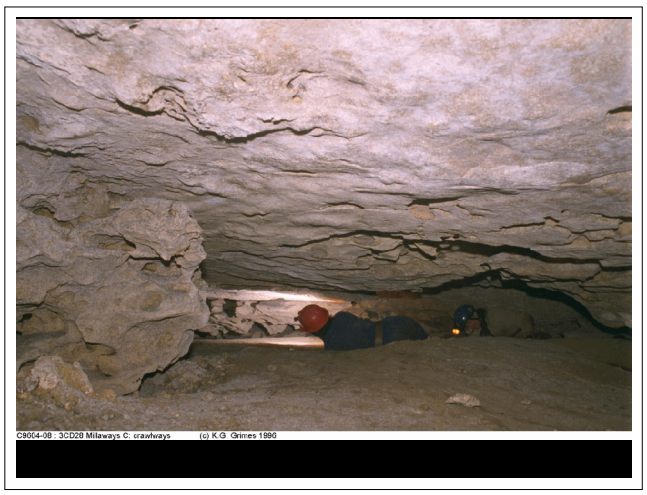
Not common.
Formation = Either
(1) subsidence of soft sand downwards (solution at depth)
(2) Exposure in a cliff or stream bank, and removal of soft sand (this example).



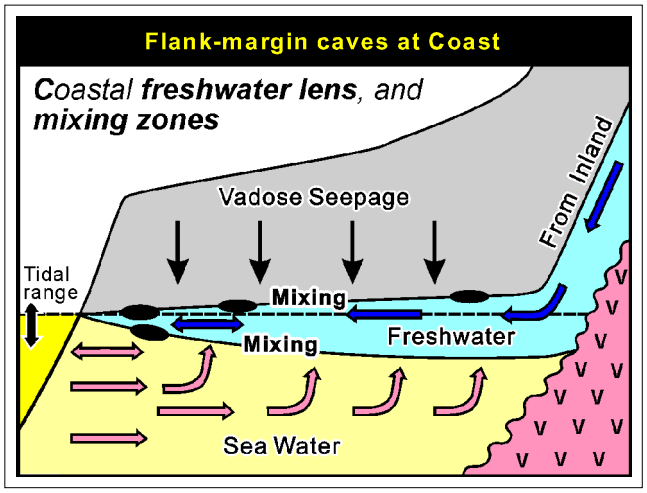
Rhyzomorphs
= cementation around roots forms hard tubes.
Erosion of the soft sand exposes them.

Soft sediment deformation in Early Syngenesis

* Originally flat-bedded beach sand.
* Partial cementation to form unconnected plates
* Solution below undermined the plates which subsided and rotated.
* Later cementation has solidified the whole thing
* So a later stable(?) cave could develop by ongoing solution.

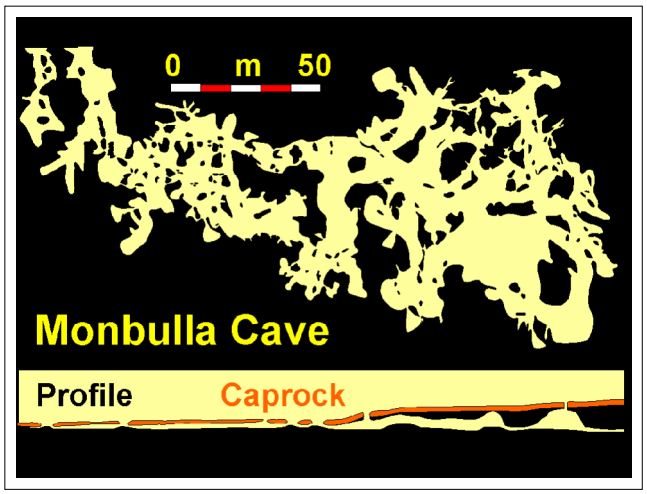


Low chambers with horizontal ceiling are typical of solution at a watertable: Either ...
* aggressive swamp water, or
* the freshwater lens near a coast.

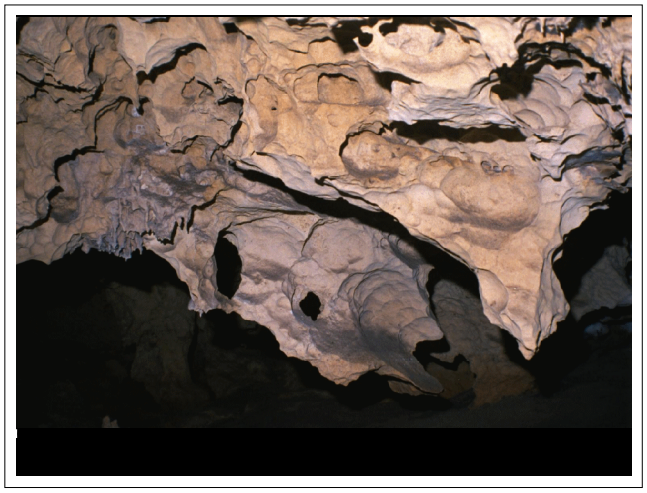


Flank-margin caves - formed at the coastal fresh-water wedge.

The FW wedge floats on salt water. Mixing corrosion at both top & bottom (but bottom may be a diffuse zone)
At coast flow is fastest and the two zones combine - maximum cave development there.



Monbulla C
Typical horizontal syngenetic maze cave.
Formed at watertable in the flank of a dune and adjacent to a swamp

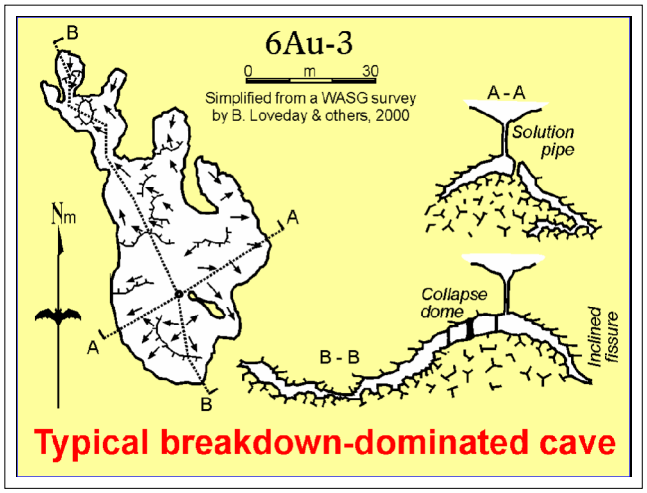


Spongework sculpturing
A result of slow moving aggressive phreatic water.

Speleothems:

LEFT: extensive areas of straws are a result of the good matrix porosity - percolation water moves down uniformly, rather than being focussed along joints.

RIGHT: re-solution of speleothems - changing watertables tied to glacial-interglacial sea level changes.
1: High WT: Dissolves the chamber
2: Low WT: Drains chamber, Formation of speleothems
3: High WT: Flooding and re-solution of prior speleothems
4: Low WT: Drains the chamber again and allows human entry.
This last stage may have post-dated European draining of the area.



Breakdown

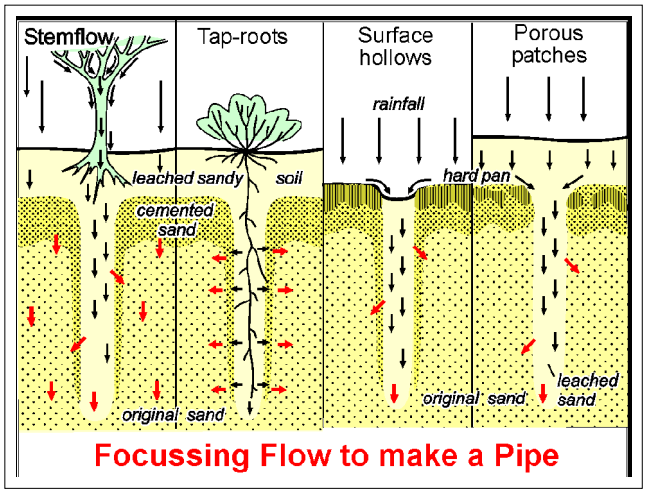
Collapse modifications are common in Syngenetic (and soft-rock) caves. Collapse domes and "inclined fissures" (on side of a dome)

Original solutional cave is down out of sight.

Cross section of a collapsed cave (in a quarry)
Original cave in lower dark area (which is cave mud) has mostly collapsed.
The rockfall has "stoped" upwards to form a new rubble cave several metres higher.
Note dome-shaped outline.

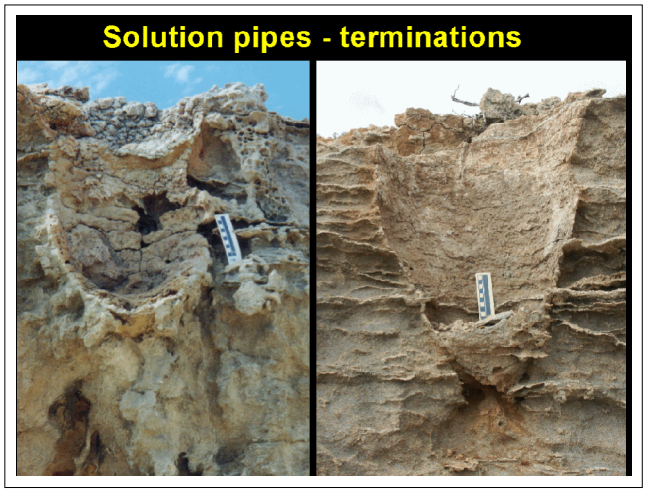
Solution pipes

Solution Pipes:
Vertical cylindrical pipes, +/- cemented rims.
May be hollow or have a fill (generally of red soil from above)
Can be in dense fields, or isolated.



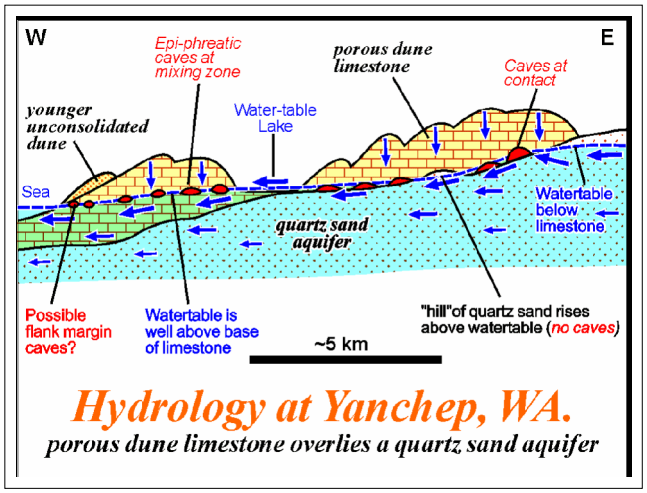
Pipes result from focussed vadose flow and solution.
The 4 different ways of focussing flow can all occur, singly or in combination.

Black arrows = aggressive water (dissolves the pipe),
Red arrows = saturated water (cements the sand)



Pipe terminations
A major argument against the "petrified forest" concept
(NO roots !).

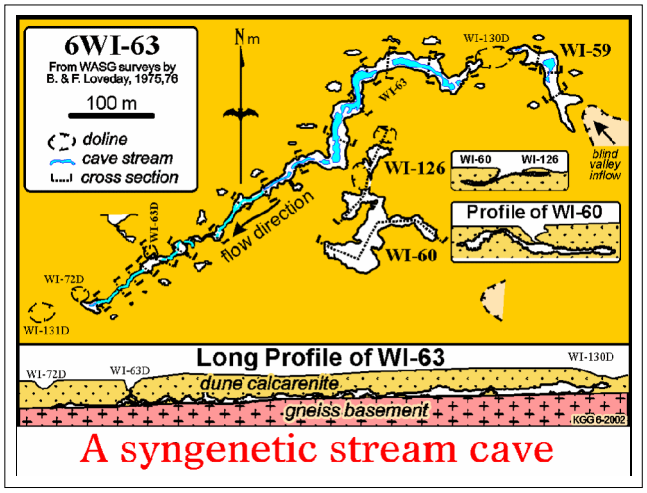
Soil Cone:
Pipes connect to the surface and transfer surface soil (and animals and bones) to the cave.



Yanchep hydrology

Yanchep hydrology - An unusual situation.

Aggressive water enters the porous limestone from below and dissolves caves at the contact.
Increased porosity there holds the WT at that level, until get closer to coast where Sea level becomes controlling factor.

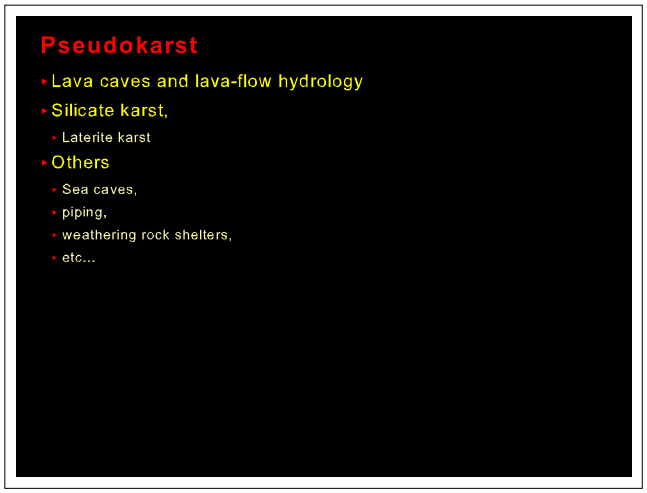


A stream cave following inpermeable gneiss basement

WT perched above basement.
Flow followed hollows on the granite (old vallies buried by the dune)

Result is a linear cave - distinct from the mazes which develop from non-directional flow through porous sand.

Note reducing x-section size away from entry point of the allogenic water = loss of aggressivity as water becomes more saturated.



Pseudokarst

Pseudokarst

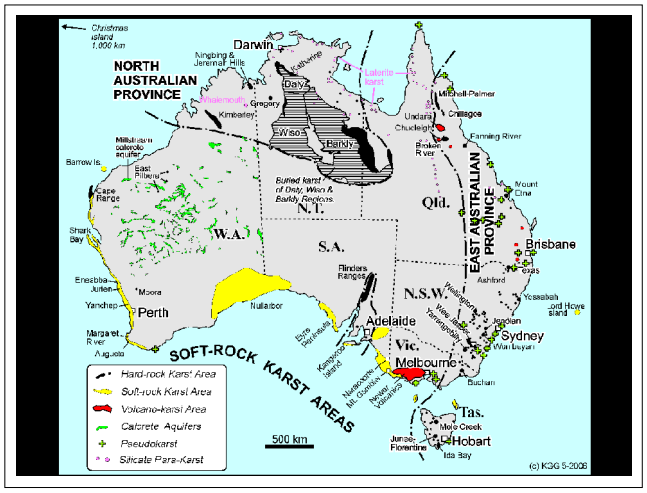
Lava caves and lava-flow hydrology

Silicate karst,

Laterite karst

Others

Sea caves, piping, weathering rock shelters, etc...



Aust karst MAP

Karst areas of Australia.

Pseudokarst

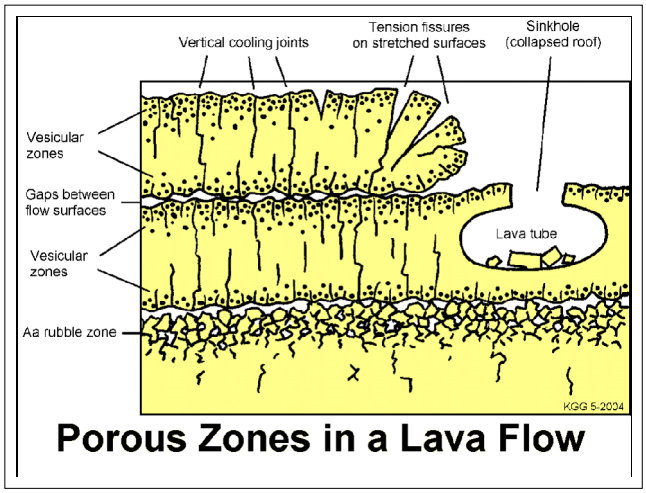
Lava caves and lava-flow hydrology

Silicate karst, laterite karst

Others (sea caves, piping, weathering rock shelters, etc...)

Lava Crust, with molten lava in tube below.

Example from Hawaii.



Porous Zones in lava flows (groundwater)

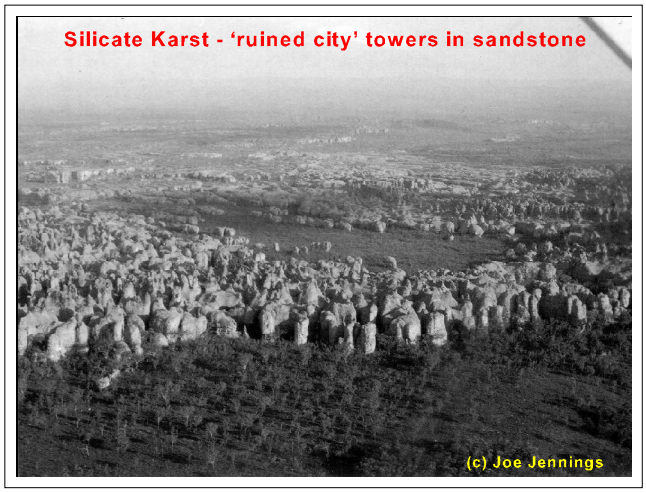
Ground-water in lava

Groundwater is stored and moves through porous zones in basalt flows.

* Vesicles (gas bubbles)
* Cracks (cooling, or from bending of the lava crust)
* Gaps between flow units
* Rubbly Aa lavas
* lava tubes

Stream sink in lava

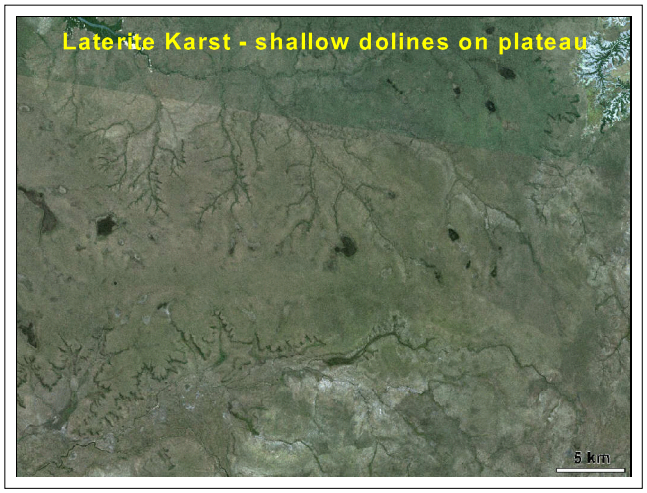
Note strong flow into the pool in foreground (about 5-6 L/sec).
There is no surface flow out of pool, the creek channel is dry beyond here.
Water can be heard sinking beneath lava boulders at arrow.
Re-appears from springs further downstream.



Silicate Karst

SILICATE KARST

Solution of quartz and other silicate minerals (eg clays)
Especially common in tropical climates but can occur elsewhere - eg Sydney sandstones.
Results: surface towers, pinnacles, 'stone cities', and small karren.
Also caves (eg Whalemouth cave - see poster).



Laterite Karst

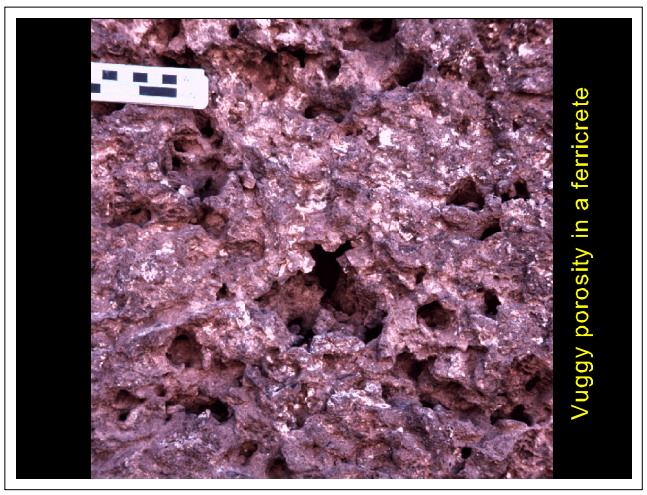
LATERITE KARST

Common on flat-lying laterite plains & plateau.
"Deep weathering" over a long time can dissolve minerals and remove them - providing porosity and undermining the surface. But the weathering profile is typically only 10m or so deep, so no deep drainage and few caves.

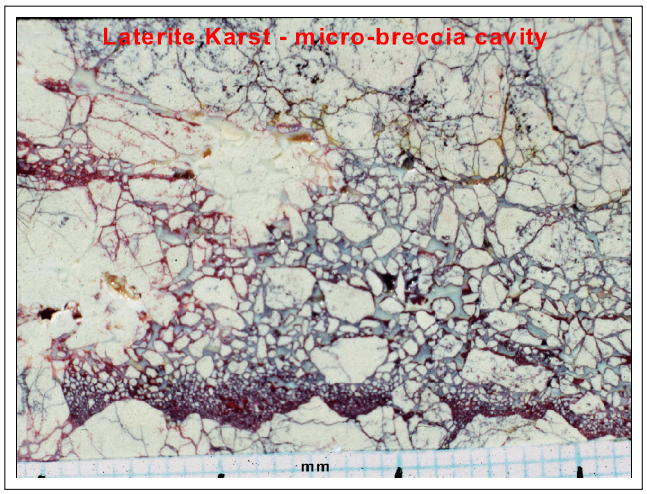
This landsat image shows broad, but shallow, "dolines" on a laterite plateau. These "pans"are commmon over much of tropical Australia.

Solution pits in a laterite weathering profile.

A loose, sandy, surface soil has been artificially removed.



Vuggy porosity developed in a ferricrete - part of a bauxite weathering profile.
In a mine pit at Weipa.
Locals say in wet season there are strong flows out of these vugs.



Solution of clays etc forms cavities and the remaining material breaks up to form a breccia (cf. crackle breccia). Fragments have been settling into the cavity and continuing to dissolve - leaving a dark red area of insoluble residue (iron oxides?) at the base.

This small scale effect is analogous to much larger cave chambers where breakdown blocks fall into pools of aggressive water and dissolve.