Karst-like & Ruiniform Sandstone Features

Karst-like and Ruiniform Features in Sandstones in Tropical Australia.

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Introduction

Sandstone landforms in North Australia include caves, dolines, and ruiniform features such as giant grikes, stone cities and pinnacles.

The present climate is tropical monsoon(wet-dry), but past climates may have been wetter.

The sandstones in WA, NT & NW Qld are Proterozoic; hard, flat-lying, well-jointed quartzites. Sandstones in eastern Qld are softer and of Mesozoic age.

Terminology (as used in this poster)

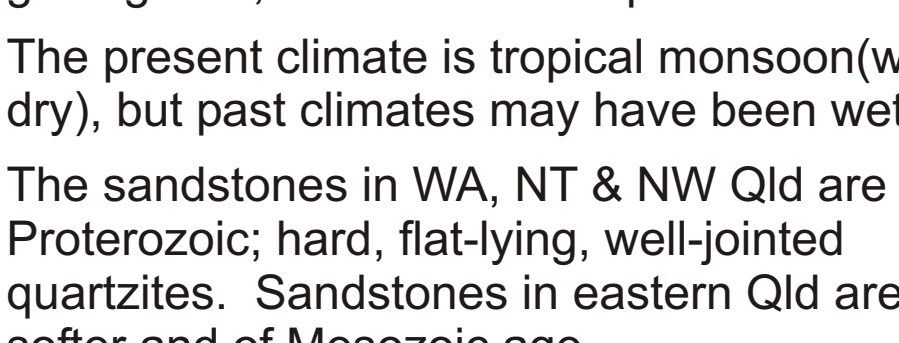
Karst-like features: caves, dolines, karren etc.

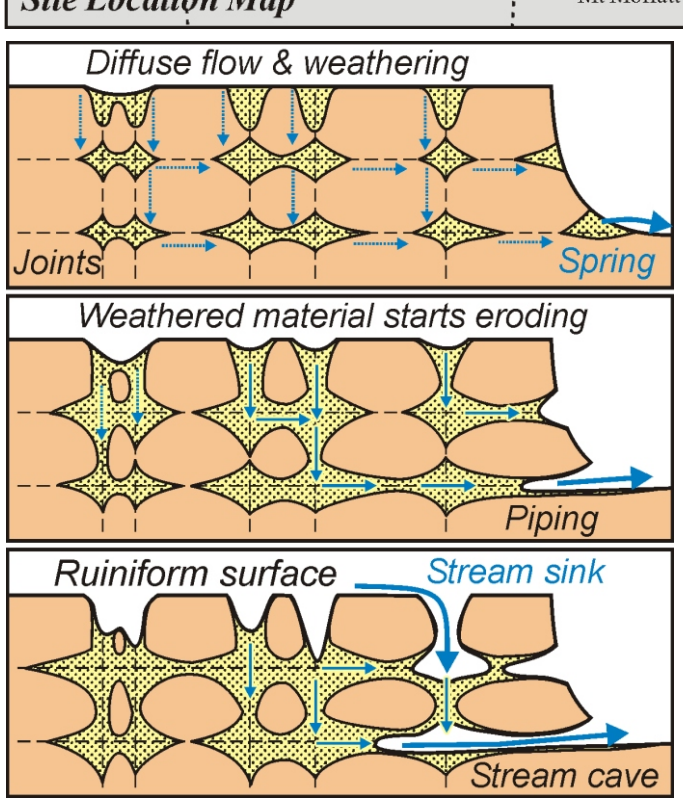
Karst: solution of carbonates (limestone etc)

Parakarst: solution of other rocks. May be *fast* (gypsum) or *slow* and incomplete (sandstone)

Pseudokarst: features formed by other processes.

Ruiniform: Structurally controlled features (grikes, stone cities etc)





Processes

Arenisation: Solution along the grain boundaries creates a packed sand that is easily eroded.

Structural guidance: Joints and bedding guide water flow, so localised zones are more strongly weathered (chemical weathering) to form "phantom" grikes and cavities. These zones can then be preferentially eroded by physical processes.

Erosion: physical removal of the weathered material (sand) by flowing water, wind etc. Includes underground headward erosion from springs (piping) form tunnels and, eventually, stream caves.

Case hardening: After exposure to air, some faces may be case-hardened, producing distinctive features (crusts, smooth joint surfaces, cavernous weathering).

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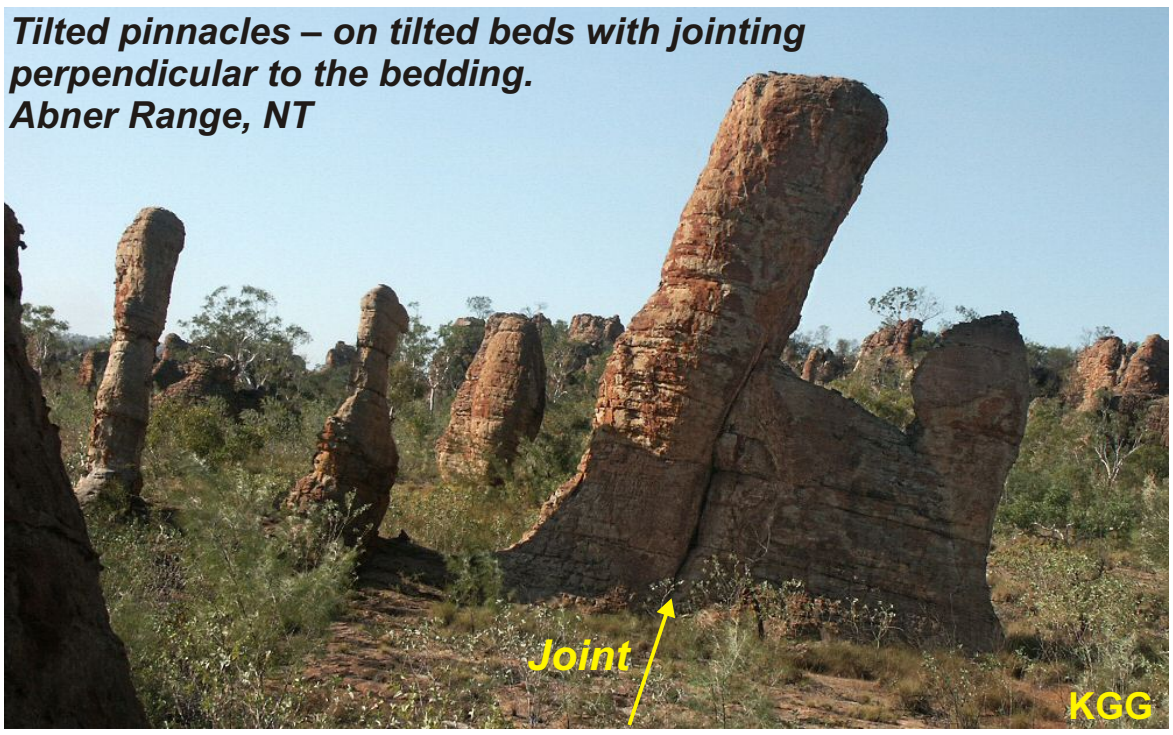
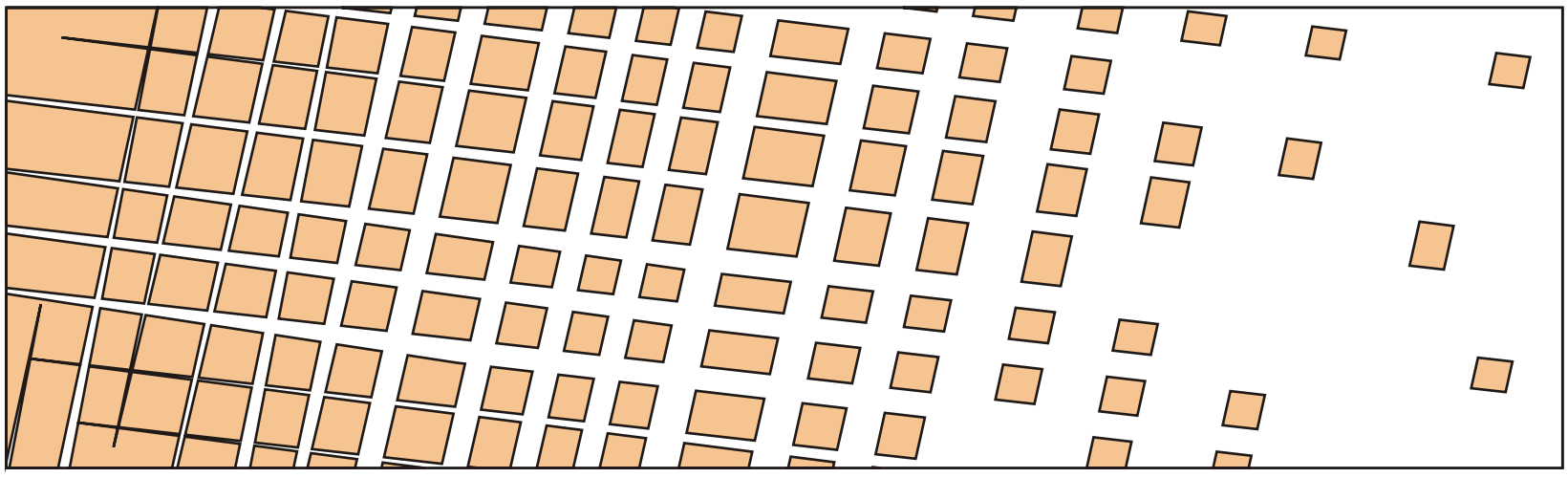
Ruiniform Features

Joints and bedding guide weathering and erosion of sandstone and other rocks to produce a distinctive “ruiniform” terrain with networks of grikes, stone cities, arches and pinnacles.

Karst features such as grikes and clints are “ruiniform”, but ruiniform features on their own should not qualify an area as “karst-like”. However, ruiniform terrain can contain karst-like features such as caves and sinkholes.



Tilted pinnacles – on tilted beds with jointing perpendicular to the bedding.
Abner Range, NT



[Above] *Progressive gradations between Giant Grikefield (GG), Stone City (SC), Stone Forest (SF) and Pavement with scattered Pinnacles (V+P).*
Ratios are those between the width of the streets (or low ground, shown in white) and of the blocks (high ground, shaded)

[Right] *A vertical joint has been preferentially weathered and eroded, as has the horizontal bedding. Some case-hardening can be seen on the joint wall.*

Stages in Ruiniform Development

[Right] Aerial view of the edge of a sandstone plateau (foreground). Weathering and erosion is first concentrated along joints to form small “*phantom*” grikes (the vegetated belts on deeper soil); these enlarge to giant grikes. Ongoing erosion widens the grikes into stone city streets and blocks and eventually the city blocks are reduced to stone forest & pinnacles scattered across a low-level pavement (seen at top right of photo).

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Stone City components

Blocks: the upstanding blocks of sandstone. The tops may be flat, domed, or dissected into smaller pinnacles and grikes.

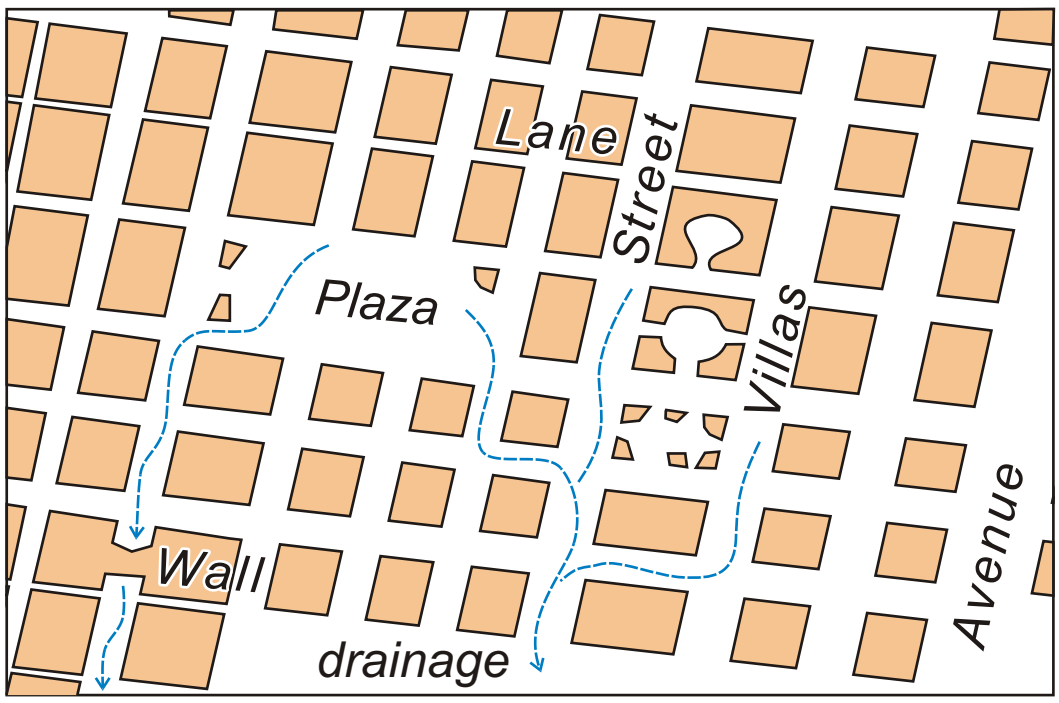
Streets: the eroded lines, sub-divided on a width basis into lanes, streets and avenues.

Plazas: open areas where a city block has been lost to erosion.

Villas: courtyards within city blocks, connected to the streets by narrow openings or tunnels. The walls can be 2-10m thick, and the floor is commonly several metres higher than the street outside.

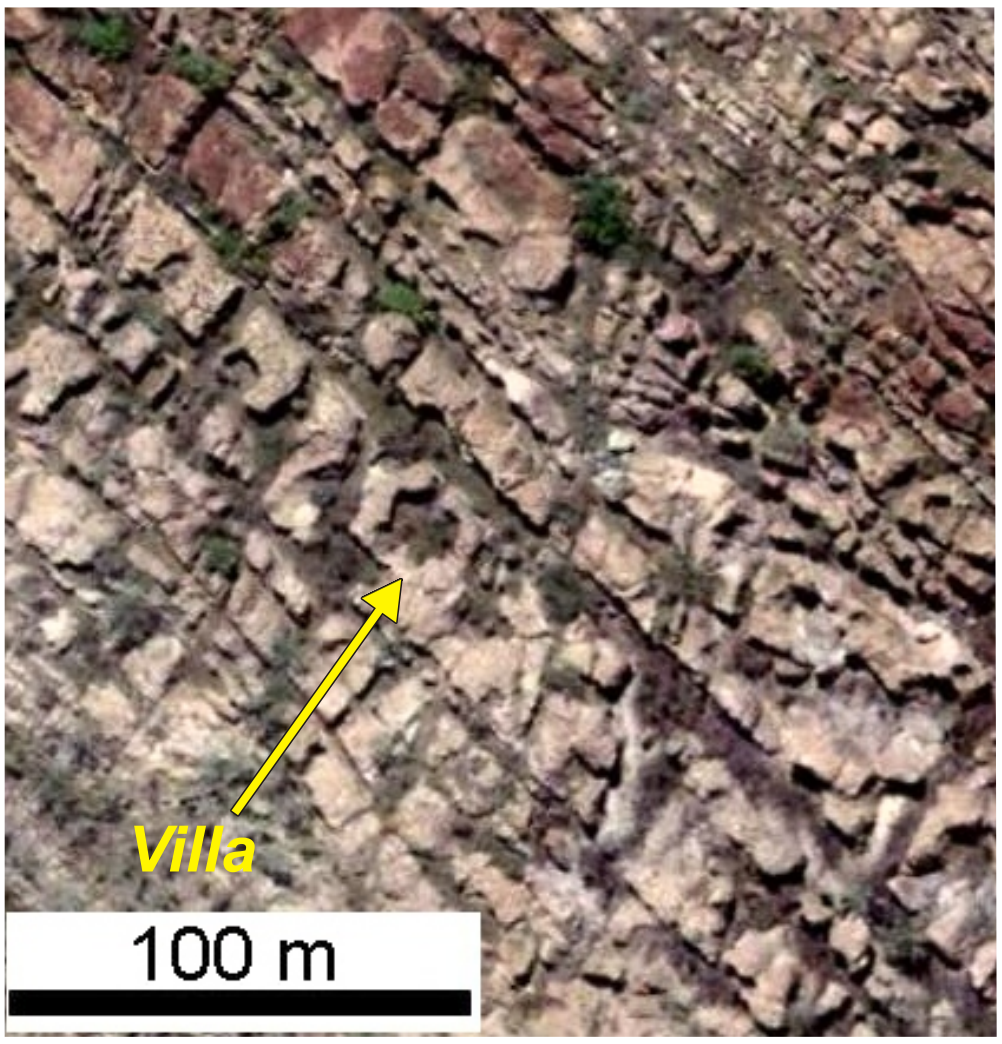
Barrier Walls: Walls across a street that block drainage. Water passes through a narrow fissure or small tunnel, or beneath a bridge.

Tunnels and caves: Tunnels may run through walls or between villas. Caves can form as overhangs or shelters, or as mazes within larger city blocks.



Components of a Stone City. Blocks are shaded

Stone city *with blocks, streets, narrow lanes, and a villa (arrowed). Satellite image.*



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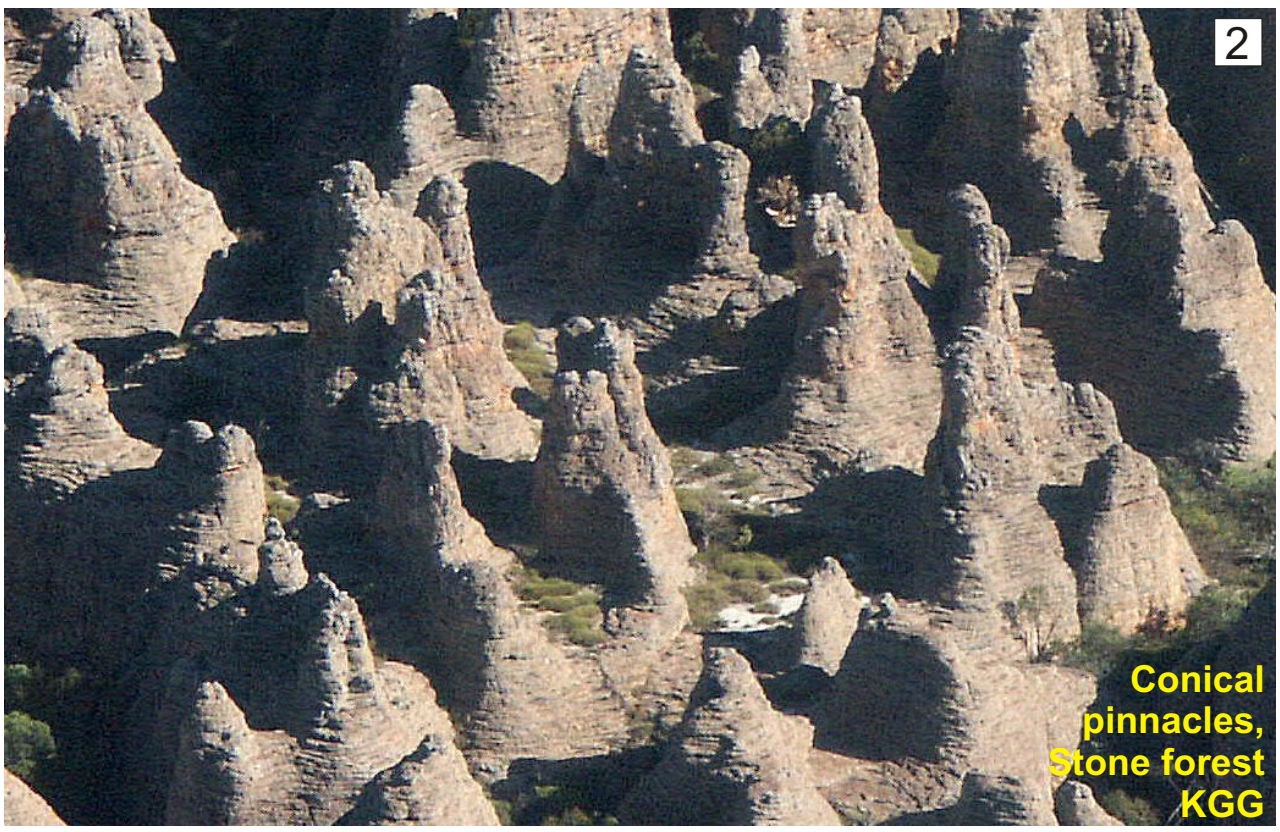
Pinnacles: Come in a great range of sizes and shapes. They can be in stone forests [2] or as isolated clumps and individuals [1,3,5] on flat pavements. Some have caps of more resistant sandstone [4, 6]. Smooth, case-hardened skins are common [6].



Karst-like & Ruiniform Sandstone Features

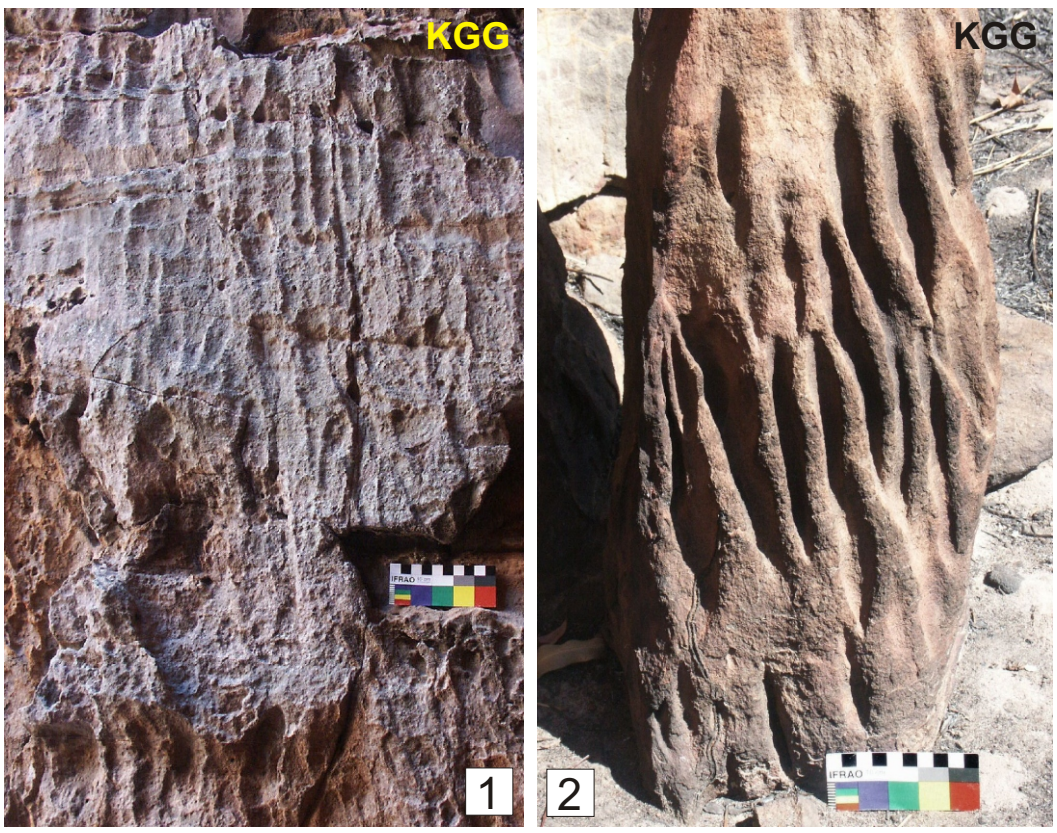
Karst-like features

Small Tubelets are the initial solutional form; resulting from focused flow along joints or through the porous sandstone.

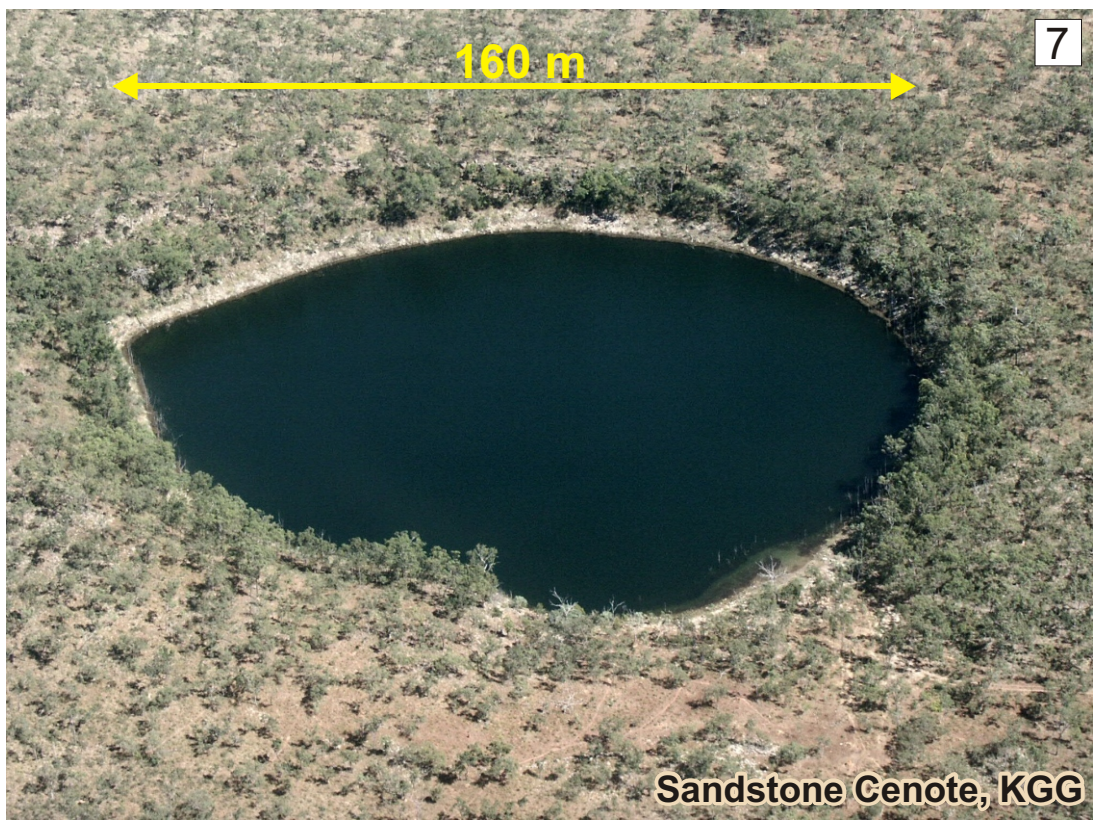
Horizontal Tubes are similar but slightly larger, and probably form in two stagees: an initial focused arenisation to form a "*phantom*" tube, followed by piping erosion of the loose sand to create an open tube.

Dolines form by collapse or subsidence above large cavities. Some may be over "subjacent" limestone beds. Some extend beneath the watertable to form cenotes.

Karren sculpturing may result partly from solution and partly from erosion by water running down rock faces.



Above: Karren sculpturing *on sandstone face and pillar*
Left: Small tubelets: [3] *along a joint, with cemented rims,* [4] *3-dimensional network,* [5] l*arger horizontal tube,* [6] *a larger tube through (and predating?) a small pinnacle*.
Below: Collapse dolines: [7 & 8] *cenotes.*



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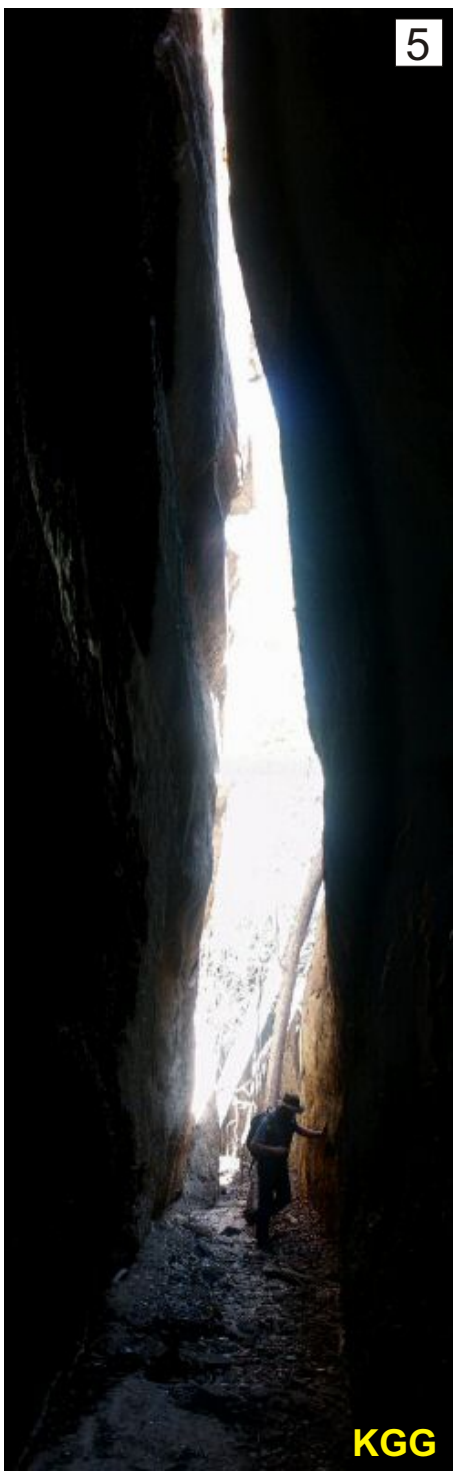
Caves & Speleothems

Speleothems are mainly of amorphous (opaline) silica and form small coralloids [1] or coatings. Less common are other minerals such as limonite (hydrated iron oxide) and organic materials. The orange flowstone [2] appears to be a combination of organic and mineral material.

Small Caves include rock-shelters, small tunnels through walls in stone cities [3], fissure systems [4 is an outflow system] some of which grade from giant grikes [5], and small stream passages [6].

Larger Caves include the big stream caves, such as Whalemouth [next page] and Widdallion, and the poorly documented maze caves at Kakadu and possibly elsewhere.



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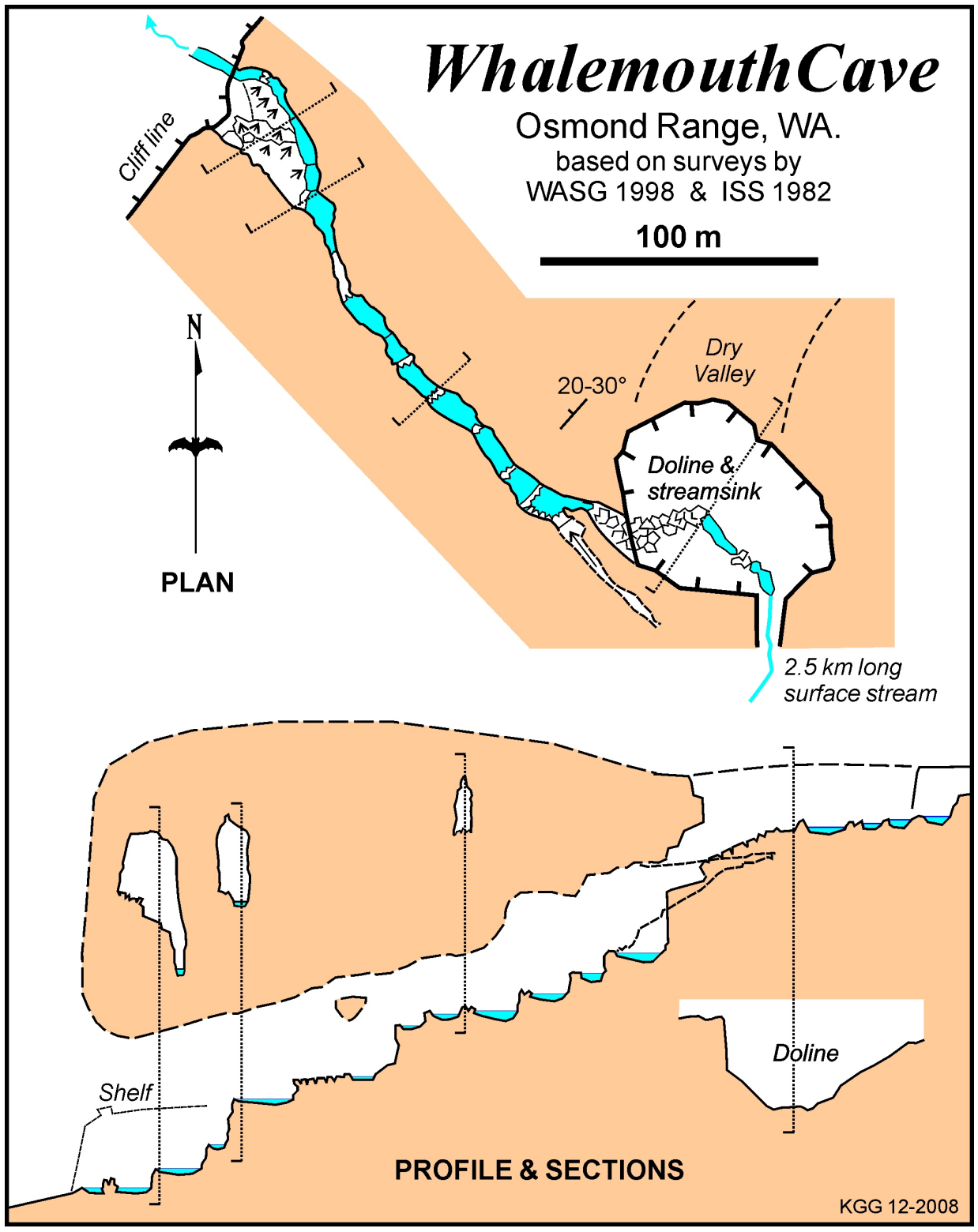


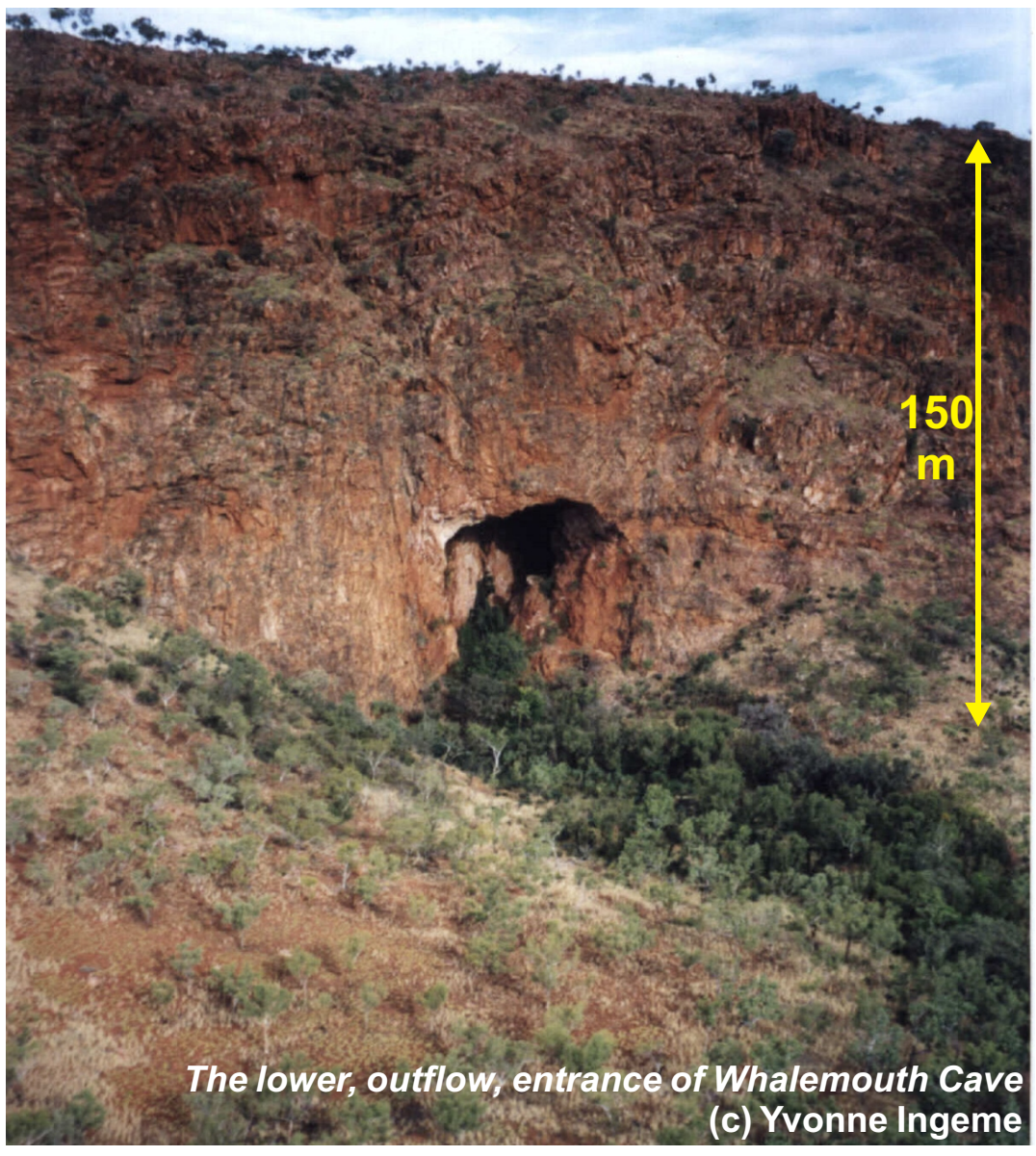
Whalemouth Cave is a large through-flow stream cave.

The downstream entrance is a 60m high hole in a 150 m high red sandstone cliff (see photo). The upstream entrance is in a doline and takes water from a 2.5 km surface valley on the plateau (Jennings, 1983).

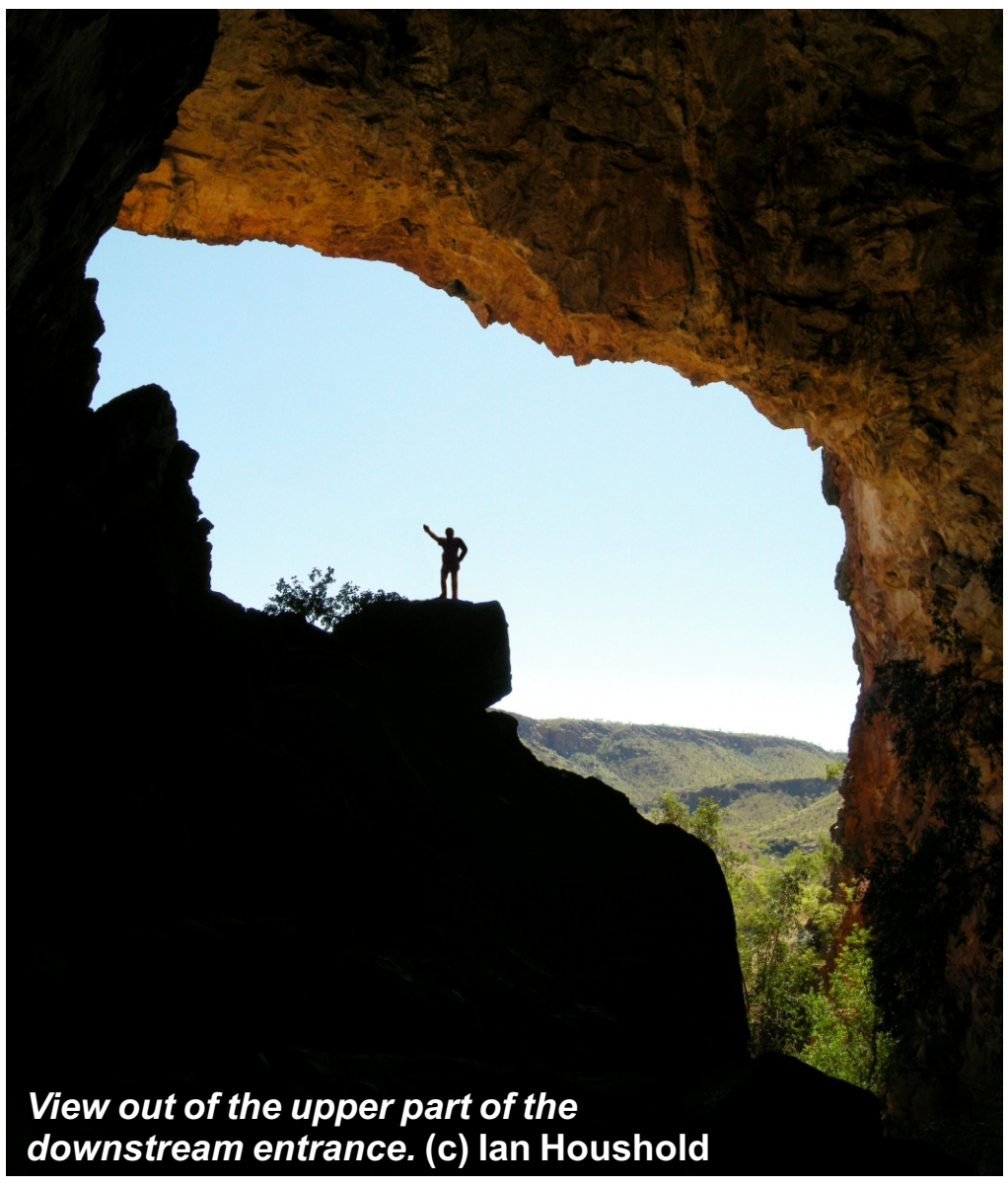
The cave is a descending fissure about 220 m long, with a series of vertical falls separated by plunge pools up to 4 m deep and rubble mounds. There is obviously a strong flow during the wet season, but the dry season stream is small. Access is difficult and requires ropes and swimming.
Elsewhere on the plateau there are stone cities, blind valleys and sinkholes.

Reference:

Jennings, J.N., 1983: Sandstone Pseudokarst or Karst? in R.W.,Young & G.C. Nanson (eds) Aspects of Australian Sandstone Landscapes. *Australian & New Zealand Geomorphology Group Special Publication, No* **1**. pp. 21-30.



The lower, outflow, entrance of Whalemouth Cave (c) Yvonne Ingeme



View out of the upper part of the downstream entrance. (c) Ian Houshold

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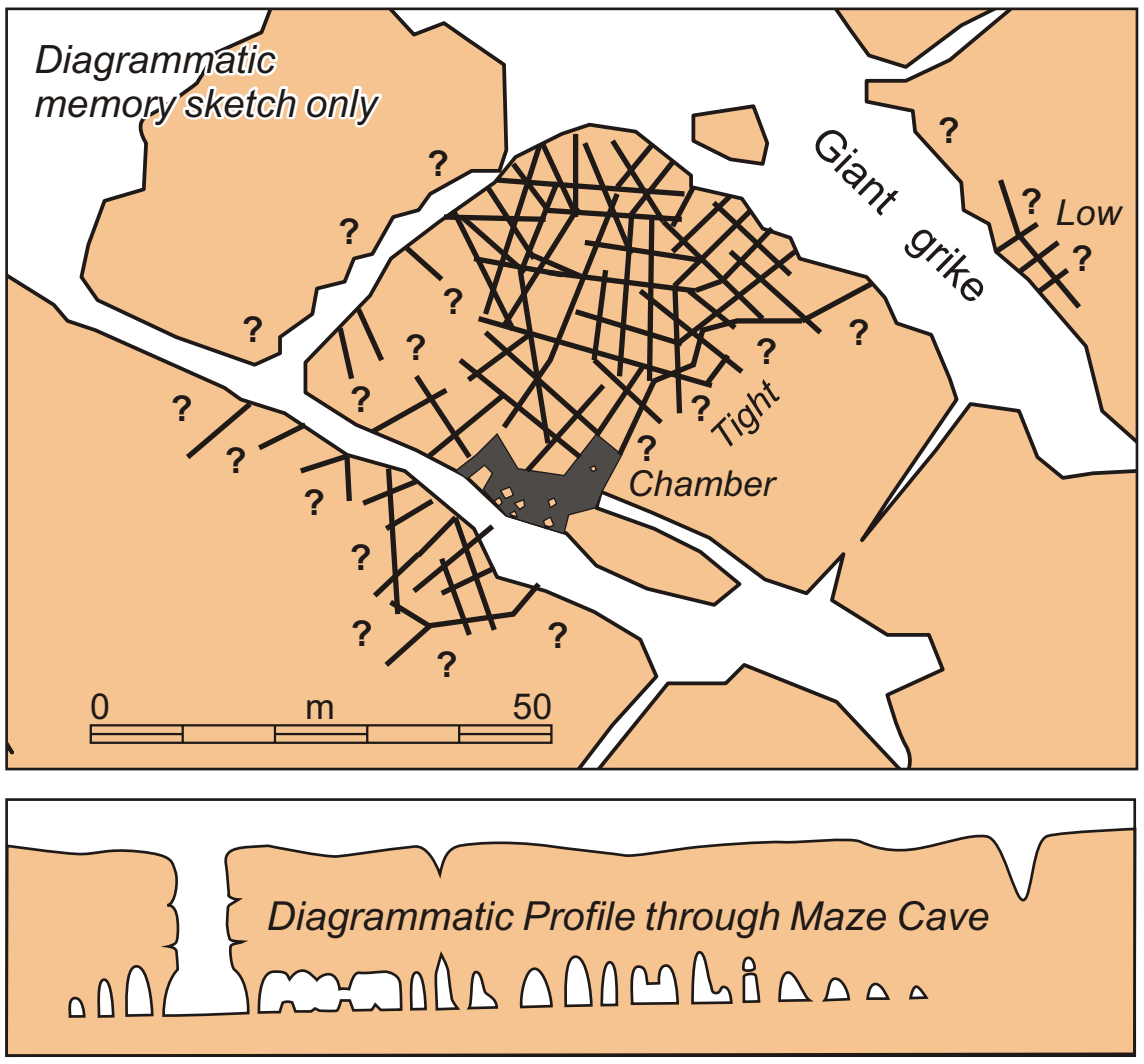
Maze Caves:

These may be relatively extensive, but little is known of them at present because of the difficulties of access.

In several areas we saw entrances from the air, but have only entered one of significance.



This maze, at Kakadu, is a horizontal system apparently restricted to a specific susceptible sandstone bed. We saw pillars and cave entrances in cliff exposures of the same bed nearby.

The cave is a dense maze with branches every 3-5 m [map] and narrow passages several metres high and a metre wide, but shrinking to crawlways away from the grike entrances. Walls and ceilings tend to be smoothly rounded, with some pockets and bridges across the passages – giving a "phreatic" appearance. Some softer beds have been eroded to form horizontal notches. The system is horizontal and the floor has water-washed cobbles and a water-mark indicating wet-season flows 10-20cm deep in places.

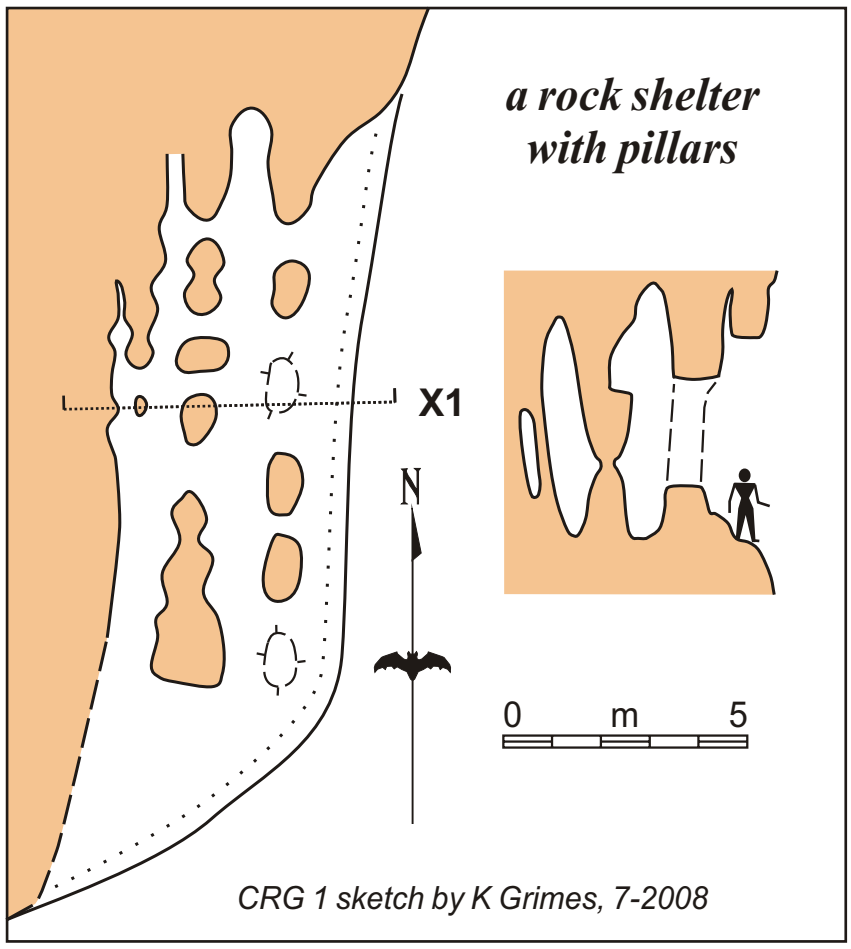
A large chamber has formed at the southern end (see map) as a result of coalescence of several passages. Remains of the prior walls can be seen as pillars, roof pendants and bollards.

Unfortunately, I have not yet been able to get permission to publish photos of these caves.

Pillars such as this are common in the maze caves. KGG

Pillars of sandstone are a distinctive feature of this type of cave and are also seen in cliffs elsewhere in Kakadu and also in other areas. Similar pillars occur in the sandstone caves of South America.

These pillars seem to be the result of vertically focussed cementation of the sandstone, possibly not long after the sands were deposited (in the Proterozoic). The less-cemented sandstone has later been eroded, leaving the pillars – a variation on the "*phantom*" preparation of grikes and tubes during arenisation.



CRG 1 sketch by K Grimes, 7-2008