The Judbarra-Gregory Karst

Gregory Karst SIG

Introduction

Ken G. Grimes & Jacques E.J. Martini, 3-2011 v 3.0

Limestone Gorge, showing the main karrenfield on the Supplejack member, and the overlying upper Skull Creek Formation.

Location

The Judbarra Karst (previously known as the Gregory Karst) is part of the Judbarra-Gregory National Park, in the Northern Territory, Australia.

Geological Setting

The caves and surface karst are largely restricted to a thin (10-18 m,) but extensive, interbedded dolomite and limestone unit, the Supplejack member, of the flat-lying Proterozoic Skull Creek Formation. The rest of the Skull Creek Formation is less cavernous. [see separate page for details]

Surface karst (karren, tufa)

The strongly developed karrenfields on the Supplejack member have a zonation (shown in shades of blue on the geological map to right) which results from progressively longer periods of exposure at the surface. This starts with incipient karren development on recently exposed surfaces adjacent to the contact with the overlying Skull Creek Formation and continues through progressively deeper dissected karren to a final stage of "stone cities" and isolated pinnacles at the outer edge (Zones 1 to 4 on map). [*see separate poster for details of karren & microkarren*]. A variety of tufa deposits are common in the valleys and stream beds (Canaris, 1993).

The Caves

Extensive horizontal maze caves underlie the dissected surface, being best developed under karren zones 2 & 3. The Bullita Cave system has about 120 km of passage, and there are others with up to 34 km. Recent descriptions appear in Sefton (2006) and Martini & Grimes (in prep).

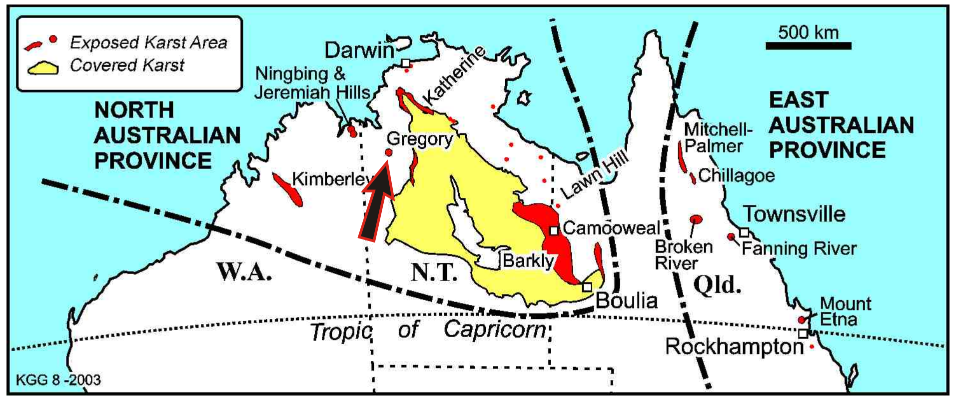
The caves are unusual in several ways: They are seasonally flooded shallow "epikarstic" systems intimately related to the surface karren, following the same trends, and eventually being destroyed when the surface grikes connect with the cave level and unroof the passages. Much of the cave volume is in a shale bed which appears to have been eroded mechanically and has perched the epikarstic watertable. Lower levels occur adjacent to the incised gorges. Present-day speleogenesis is restricted to the time of wet season flooding.

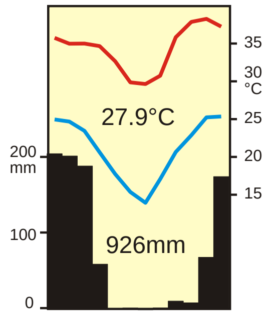
[*See separate pages for details of the cave form, and Speleogenesis*].

History of cave exploration

The exploration history is presented by Kershaw (2005) and Sefton (2006). Early cave exploration was done by BMR geological parties in the 1960s, Parks rangers in the 1980s and by the Top End Speleo Society (TESS) in 1987. However, the first systematic exploration and cave mapping was by a British Operation Raleigh Expedition in 1990 (Storm & Smith, 1991).

In 1991 TESS and CSS (Canberra) ran the first of what became regular annual expeditions to the area, involving speleologists from all over Australia. Various entrances to Bullita Cave were found over the following years and linked into a single large system. Recently these groups have combined as the Gregory Karst Special Interest Group of the Australian Speleological Federation (GKSIG).





Timber Ck

Climate

The area has a tropical semi-arid monsoon climate (BShw on the Köppen scheme) with an annual rainfall of 732 mm falling in pronounced wet and dry seasons. Monthly mean maximum & minimum temperature and rainfall variations are shown for Timber Creek, 50 km to the North.

References

Bannink, P., Bannink, G., Magraith, K., & Swain, B., 1995: Multi-level maze cave development in the Northern Territory. *in* Baddeley, G., [ed] *Vulcon Precedings. (20th Conference of the Australian Speleological Federation)*. Victorian Speleological Association, Melbourne. p. 49-54.

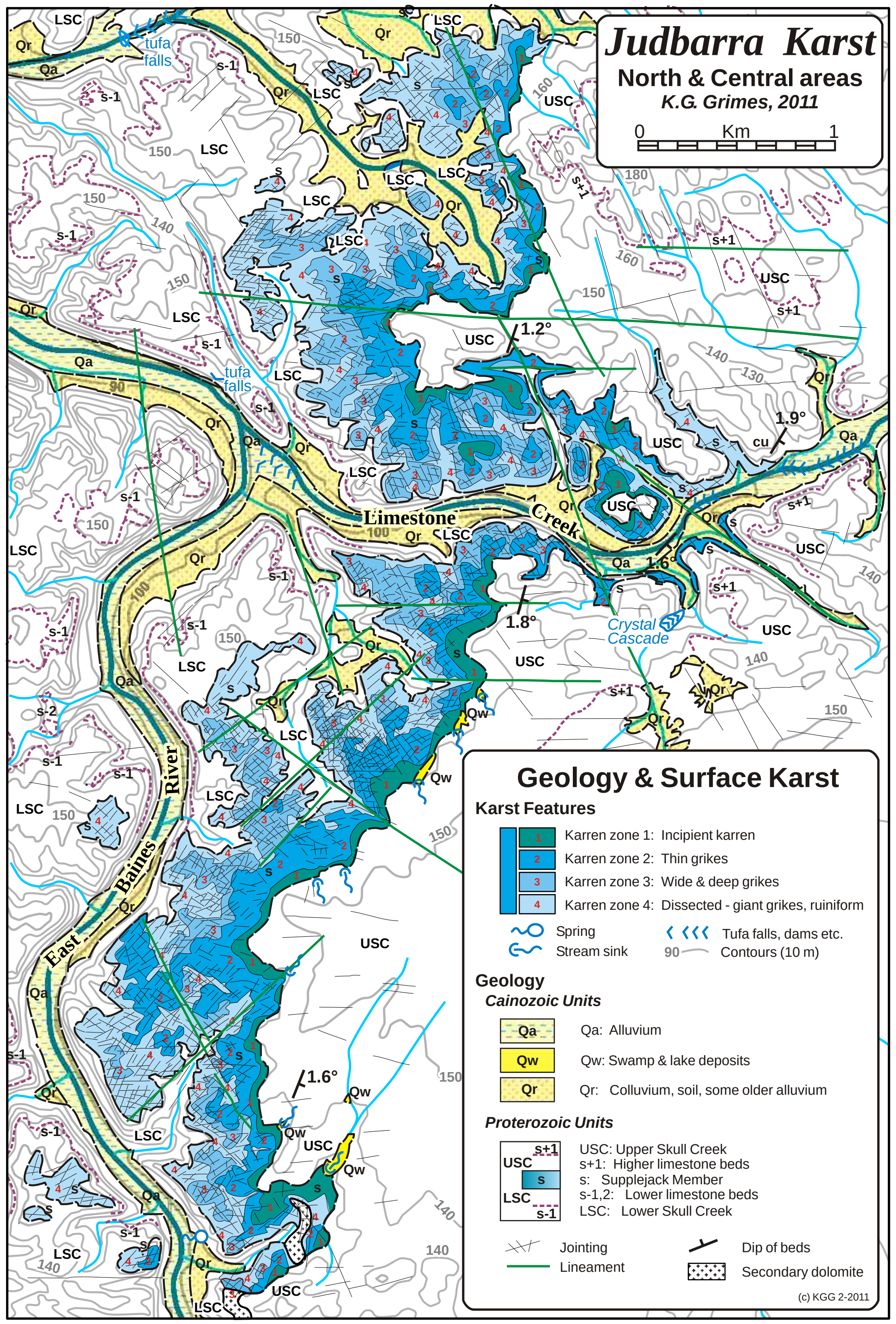
Canaris, J.P., 1993: *The tufa deposits of Limestone Gorge, Gregory National Park, Northern Territory*. B.Sc honours thesis, Department of Geology and Geophysics, University of Adelaide.

Kershaw, R., 2005: A Brief History of Surveying the Bullita Cave System. *in* Goede.A., & Bunton, S., (eds) *Cave Mania Proceedings*, 25th Biennial Conference of the Aust Speleo Federation, Dover, Tas. 53-58.

Martini, J.E.J. & Grimes, K.G., in prep: Epikarstic maze cave development: Bullita Cave System, Judbarra Karst, tropical Australia. *Helictite*, volume **41**.

Sefton, M. 2006. Bullita Cave System - Northern Territory: explorations in 2004 and 2005. *Caves Australia*, 169: p.20-26.

Storm, R. & Smith D., 1991: The Caves of Gregory National Park, Northern Territory, Australia. *Cave Science*.**18(2):** p 91-98.



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Geology

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The host rocks are part of the Bullita Group, of late Proterozoic age, 1.6 billion years old. The stratigraphic succession, from top down, is:

- The **upper Skull Creek Formation** is rhythmically inter-bedded: ~1m thick beds of out-cropping dolomitic limestone alternate with ~3m recessive beds of calcareous siltstone and shale. This unit has no caves and limited macro-karren (developed on the thicker limestone beds) but hosts the best-developed microkarren in the area.
- The **Supplejack member** is an 10-18m thick, thin to thick-bedded dolomite and limestone. Parts of the unit have thinly interbedded alternations of dolomite and limestone (calcite). The differential solubility of these forms deeply sculptured walls on some passages. Chert nodules and seams occur in some beds, and are etched out in outcrop and on the cave walls. The Supplejack forms the main karrenfield. The caves are mainly found in the lower half of the unit and in the underlying 3m thick "shale bed".
- The **"Shale bed"** is a sequence comprising: 0.3 - 0.5 m of thick-bedded dolomitic mudstone, above 2m of thinly-interbedded calcareous siltstone and shale, and then a lower 0.5m bed of dolomitic mudstone. Much of the cave volume is developed in the "Shale bed" and appears to be formed more by mechanical erosion of the soft material than by solution.
- The **lower Skull Creek Formation** is mainly a well-bedded very-fine-grained dolomite with another shale bed about 10m down. Some lower cave levels occur locally in this unit, including within the second shale bed.

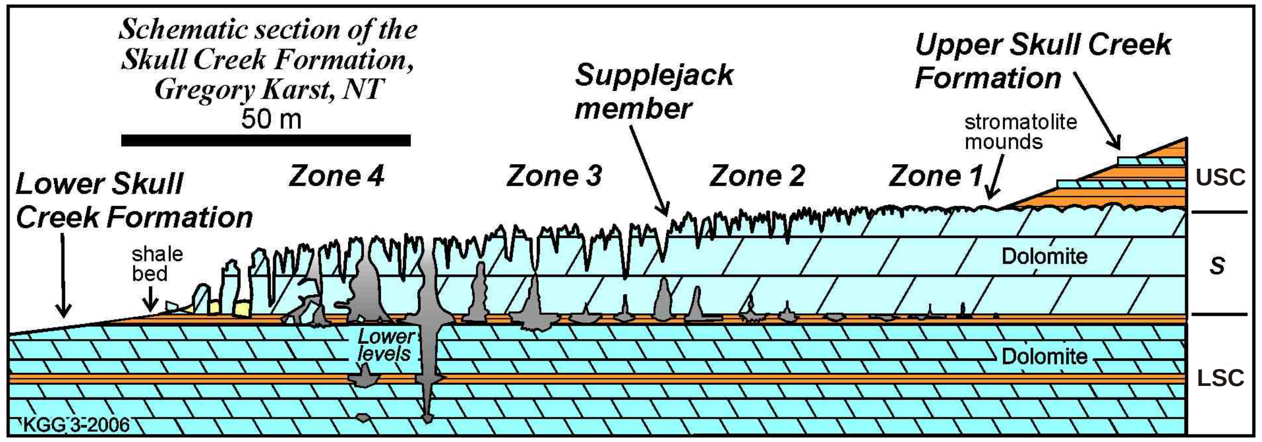
At the southern end of Bullita Cave there are areas of **secondary dolomitisation** of possible hydrothermal origin within the Supplejack. This pale, coarsely crystalline, dolomite has inhibited development of both surface karren and caves. Further south, extensive areas of this secondary dolomite occur and restrict karst and cave development to localised patches.

Sedimentary structures indicate deposition in subtidal, tidal and supratidal environments – e.g. stromatolites, edgewise breccias, shrinkage cracks, and pseudomorphs after gypsum and halite crystals.

All the units are well jointed and gently dipping (1 - 2° to ESE in the vicinity of the Bullita Cave system). The joints guide the pattern of the karrenfield and also the maze caves beneath. Some faults occur, but with only minor vertical displacements.

Stromatolites

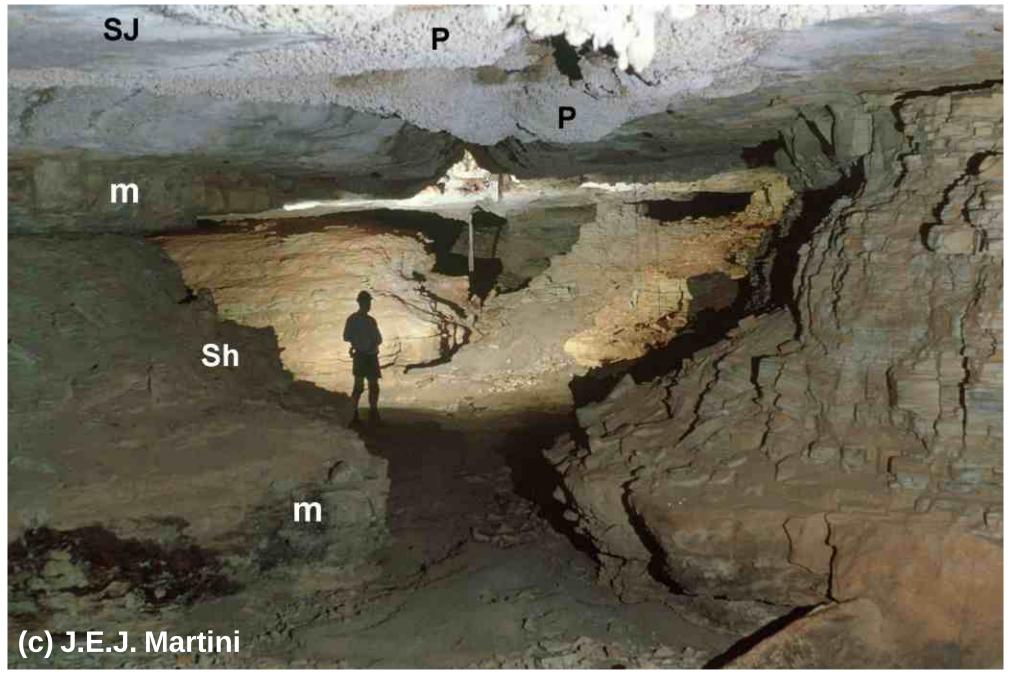
A variety of stromatolite forms (old calcareous algal colonies) occur throughout the sequence. There is a set of large well-developed stromatolite domes at the top of the Supplejack, which forms the surface of the zone 1 karrenfield.



⇧ *View across the karrenfield on the Supplejack member, with hills of upper Skull Creek Formation in background. This is recently exposed karren "Zone 1". The broad mounds within the karrenfield are stromatolites.*

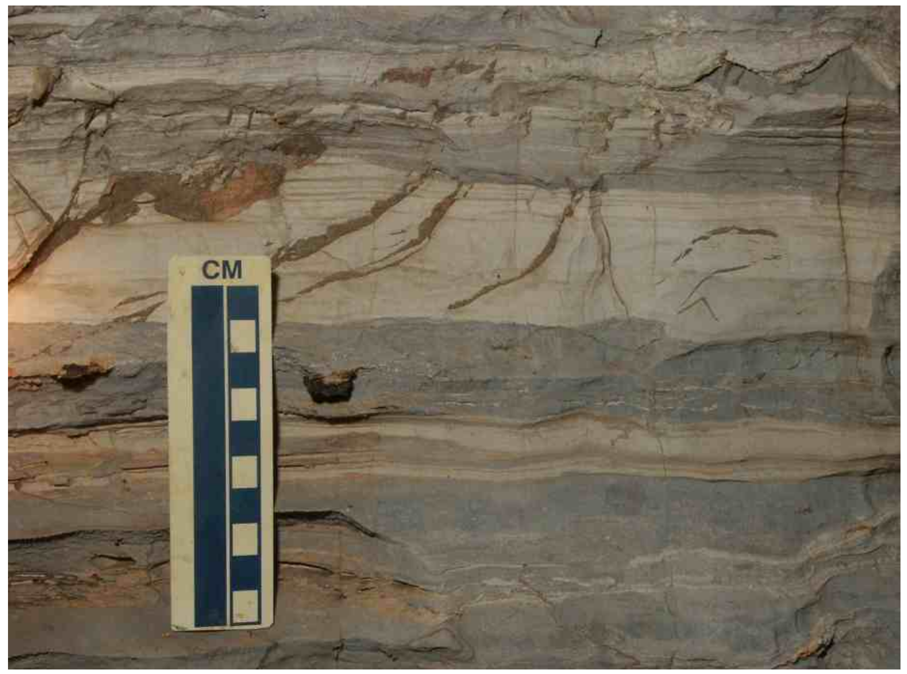
⇧ *Outcrop of Supplejack member. A thick-bedded sequence overlies thinner-bedded dolomite with many small chert nodules.*

⇩ *A small stromatolite.*



⇧ *The Shale Bed: is dominantly shale (Sh) but is bracketed at base and on top by more massive mudstone (m). The horizontal cave ceiling is the base of the Supplejack member (SJ). Note popcorn (P) deposited on both sides of crack in ceiling – which connects to the karrenfield above.*

⇩ *Thinly alternating beds of dolomite (cream) and limestone (grey) in the Supplejack member.*



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The Judbarra-Gregory Karst

The Caves

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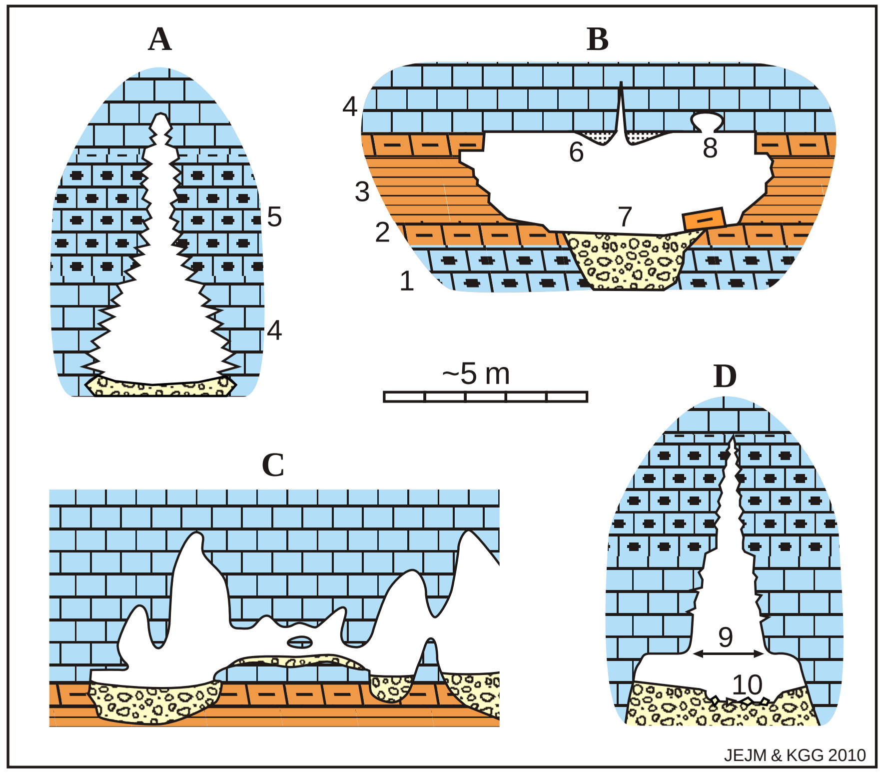


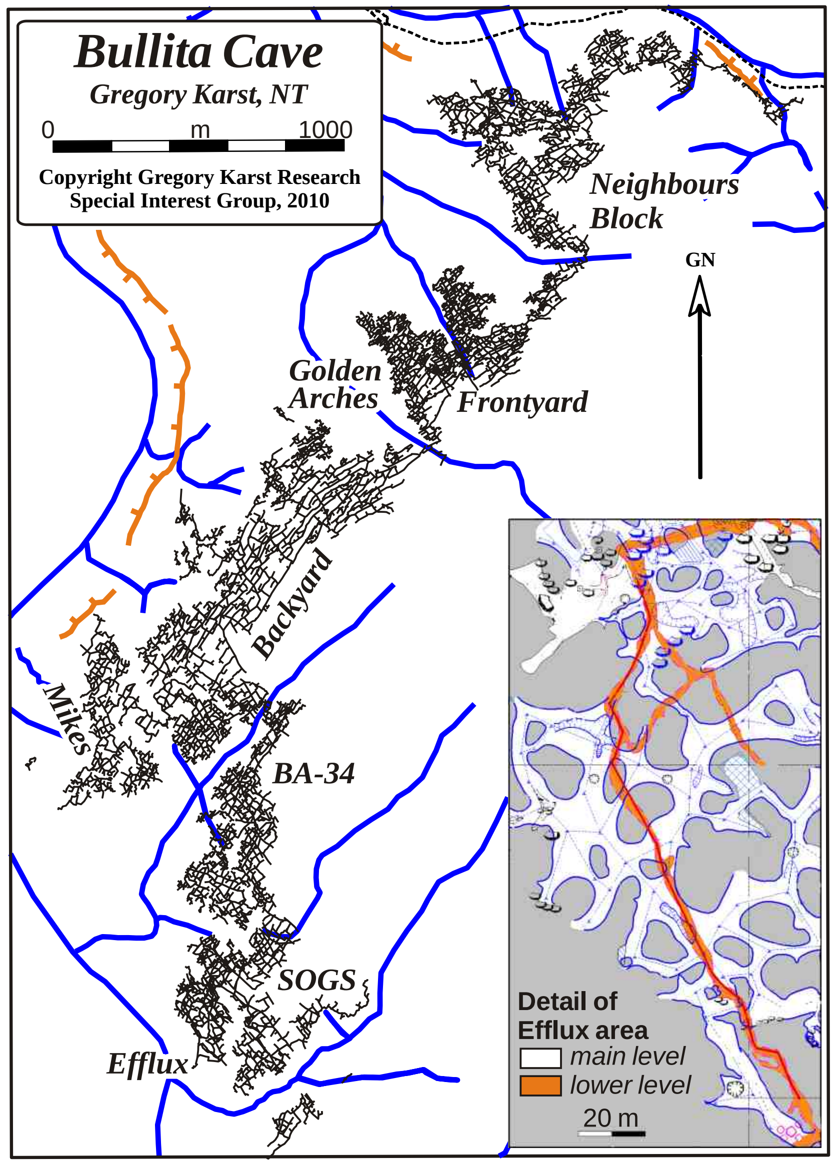
⇦ ***Types of passage section.***
A: ledgy A-form passage;
B: rectangular shale passage;
C: phreatic passages;
D: tented passage showing bevelled wall undercuts and incipient ledges

Lithology:
1) dolostone, more or less cherty;
2) dolomitic mudstone;
3) dolomitic siltstone and shale;
4) dolomitic limestone;
5) cherty dolomitic limestone;
6) popcorn / coralloids;
7) alluvial and residual filling;
8) "omega" tube.
9) bevel at old watertable
10) stream bed

A-section fissure within the Supplejack. ⇨
Note sharp ledges, a response to differential solution of thinly interbedded dolomite and limestone.

⇩ ***"Phreatic" passages within the Supplejack, several metres above the shale bed (the sharp undercut at bottom of photo).***

⇧ *"Tented" passage and undercut of shale bed.*



The Caves

The caves form extensive horizontal, multi-level, joint-controlled, maze systems. Passage junctions typically occur every 15-30 m. Bullita Cave has an extent of 4-5 km (see map), and its total passage length in 2010 was 120 km (± 5). There are several other caves between 10 and 34 km. Bullita cave is divisible into sectors, separated by narrow connections (often a single tight passage). The individual sectors have distinctive properties.

Most of the caves are at a single level (the base of the Supplejack and the underlying, 3 m thick, crumbly shale bed), but entrenchment to lower levels occurs at the northern (Neighbour's) and southern (SOGS) ends of Bullita and in other caves nearby. The lower level passages are smaller, narrower and form simpler networks than those of the main level. Towards the eastern contact with the overlying Skull Creek formation the yoinger passages are smaller and impassible. To the west the older passages become unroofed and form giant grikes.

Passage types:

There are some typical passage forms, partly tied to the rock types: Most common are narrow A-section fissure passages [A on diagram to left] and "tented" (or inverted T) passages [D] that have an upper fissure in the Supplejack, and a broader undercut in the underlying soft shale bed. Passages in the shale bed tend to have a rectangular form with a flat ceiling at the base of the Supplejack [B]. These can enlarge into broad flat-roofed chambers or flatteners with isolated pillars of the flaggy shale unit (reminiscent of a pillar-and-stall mine). The roof of these chambers commonly is crossed by joint fissures rising into the Supplejack. Small cylindrical "phreatic" tubes and pockets occur in the higher levels [C] and appear to be a preliminary stage of cave development prior to incision into and beneath the shale bed. Those immediately above the shale bed may have an omega (Ω) cross-section.

Entrances:

There are numerous daylight holes in the roof, but few accessible entrances. A typical entrance is at the degraded (western) edge of the karst (a cliff line or stone city complex with giant grikes) and involves a short climb up, and then a drop down a rubble, soil and leaf-litter ramp into the cave. These ramps may help pond water within the cave during the wet season. Some entrances are from the karrenfield via giant grikes, collapsed chamber roofs, or shafts. One low-level entrance is via the "efflux". Tree roots are common beneath the fissures that connect to the surface.

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The Caves

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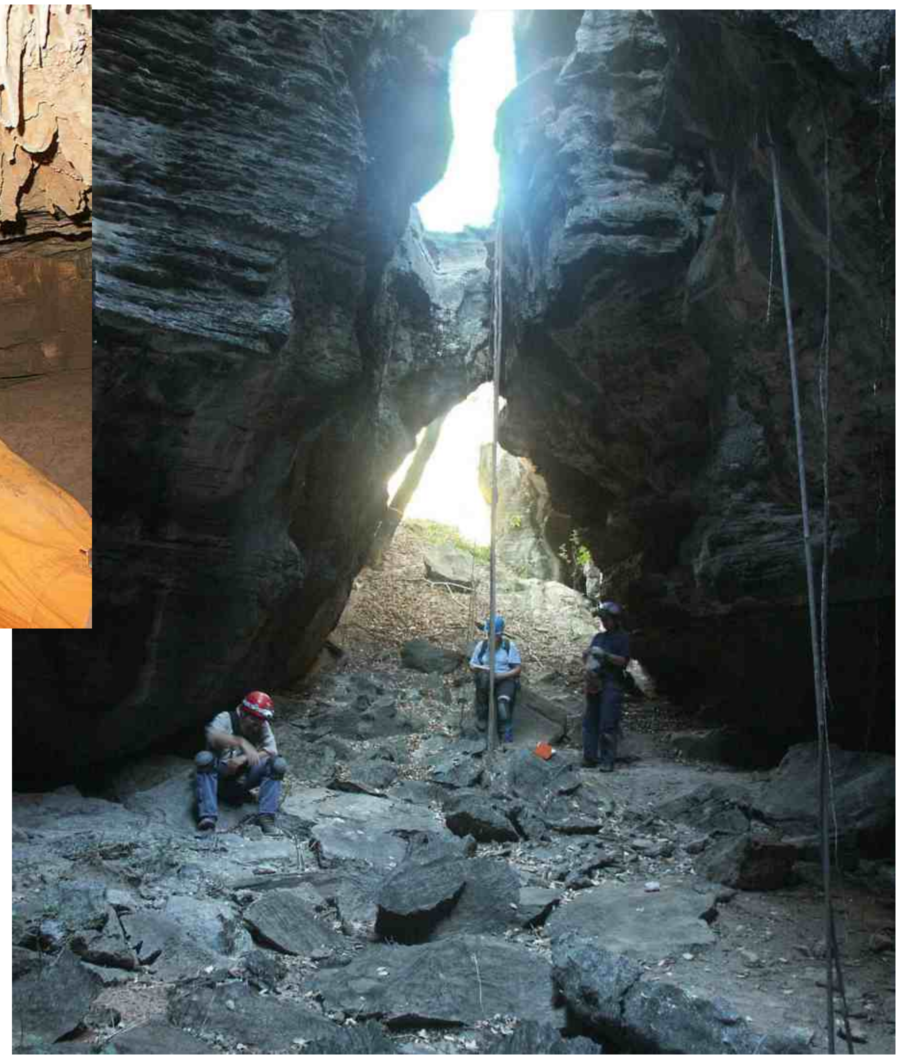
Distinctive geomorphic features of the caves:

- Extensive, horizontal, dense maze systems at shallow depth. An epikarst system with mainly vertical autogenic inputs. Plan form is controlled by joint patterns and depth control is by lithology and lithology-controlled hydrology.
- The extent of the cave system is restricted to that of the karrenfield.
- Lateral change in passage style corresponds to the surface karrenfield zonation with the main development under zones 2 and 3. Zone 1 has only small incipient passages, generally impenetrable, and beneath zone 4 the oldest passages are unroofed or destroyed.
- The age of the currently seen cave system is diachronous, from the present (zone 1, "youth") to early Pleistocene (zone 4, "old age").
- Vertical zonation (levels).
  - High-level, within lower portion of the Supplejack. An early stage formed in a perched aquifer above the shale bed, with subsequent joint-controlled enlargement by vertical vadose flow and widening of lower parts by seasonally ponded water.
  - Main development was along the shale bed beneath the Supplejack, with rapid erosion of the incompetent shale bed and passage widening rather than deepening.
  - Lower levels in the Lower Skull Creek occur mainly in proximity to the incised gorges.
- "Levee" formation in zone 4 causes wet-season ponding within cave.



Youth to Old Age:

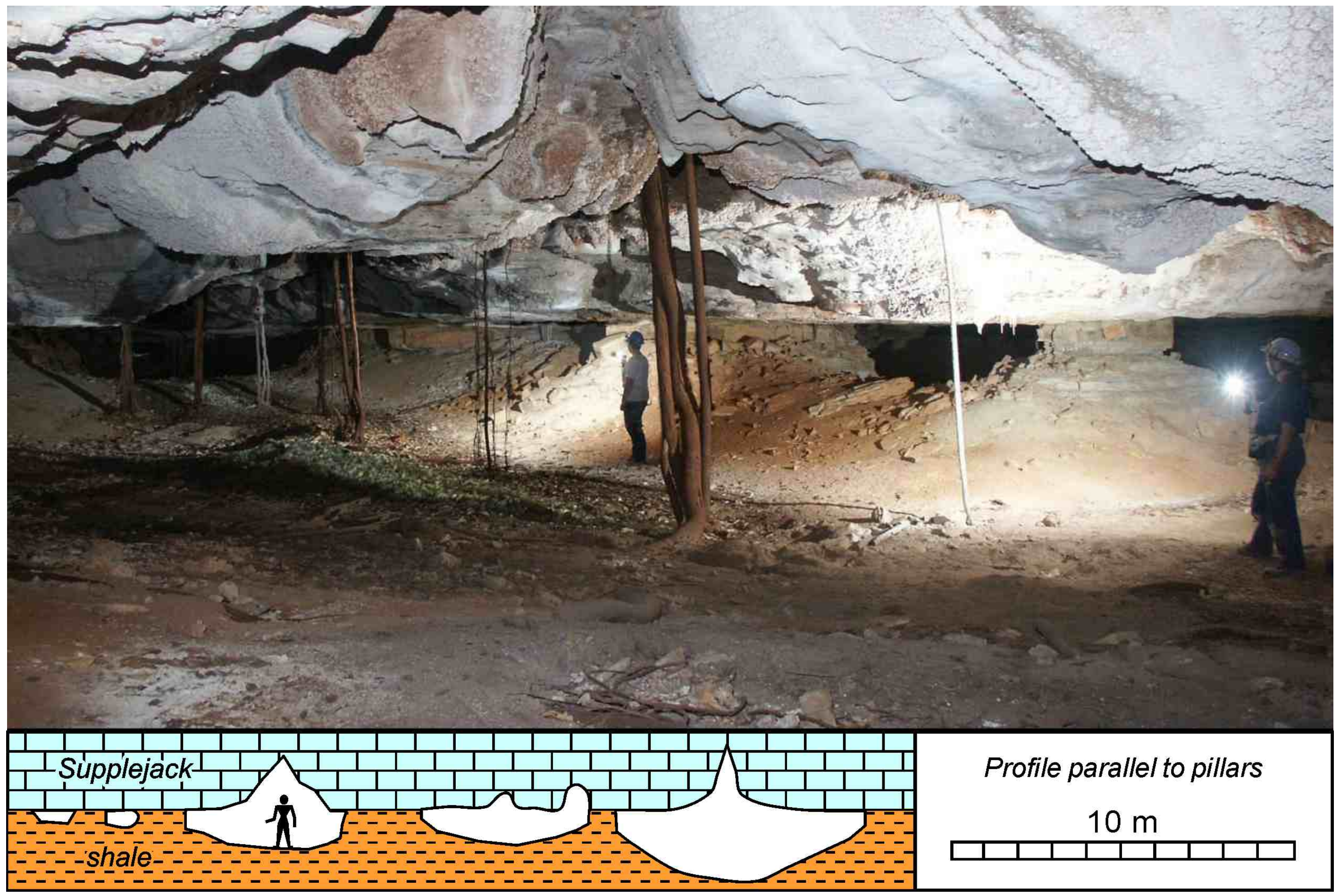
⇦ Small passage at advancing edge of the cave, beneath karren zone 1. (10 cm sale bar)

⇧ Low passage with stream channel at eastern edge of the cave

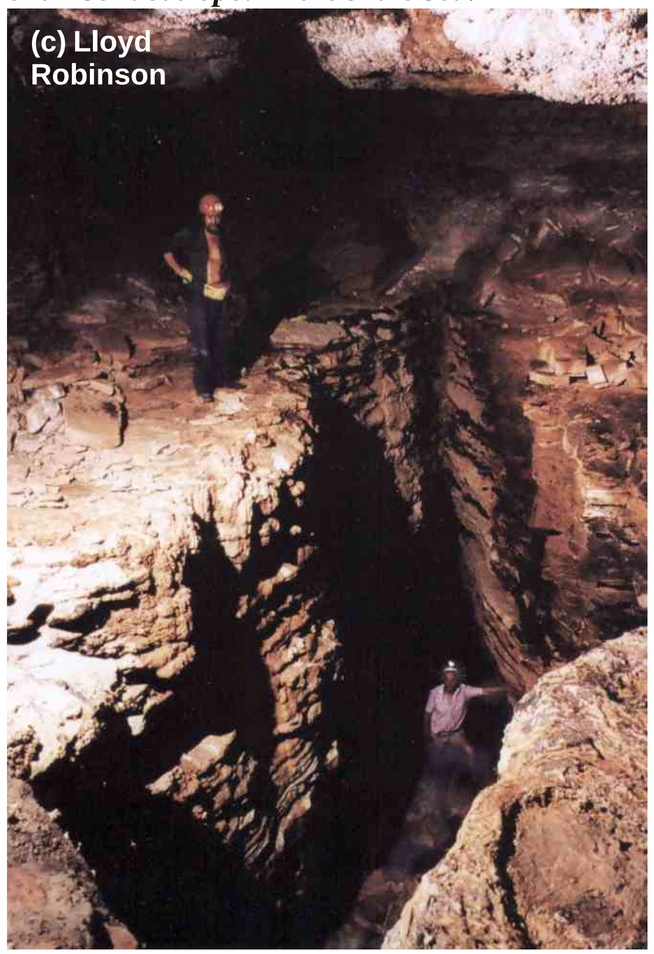
⇨ Partly unroofed passage at western edge of the system. Note the mound of sediment and rubble in background, which dams the wet-season flood waters within the cave.

⇩ Inverted-T passage, with a roof fissure following a joint in the Supplejack, and a broad slot cut in the shale bed below.

⇩ The Hermitage Grange: a large room formed in the shale bed. Note the shale pillars in the background. Tree roots descend via fissures from surface grikes. The white roof is largely coated by coralloid growths.



⇩ Lower level trench dropping beneath a chamber developed in the shale bed.



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Speleogenesis

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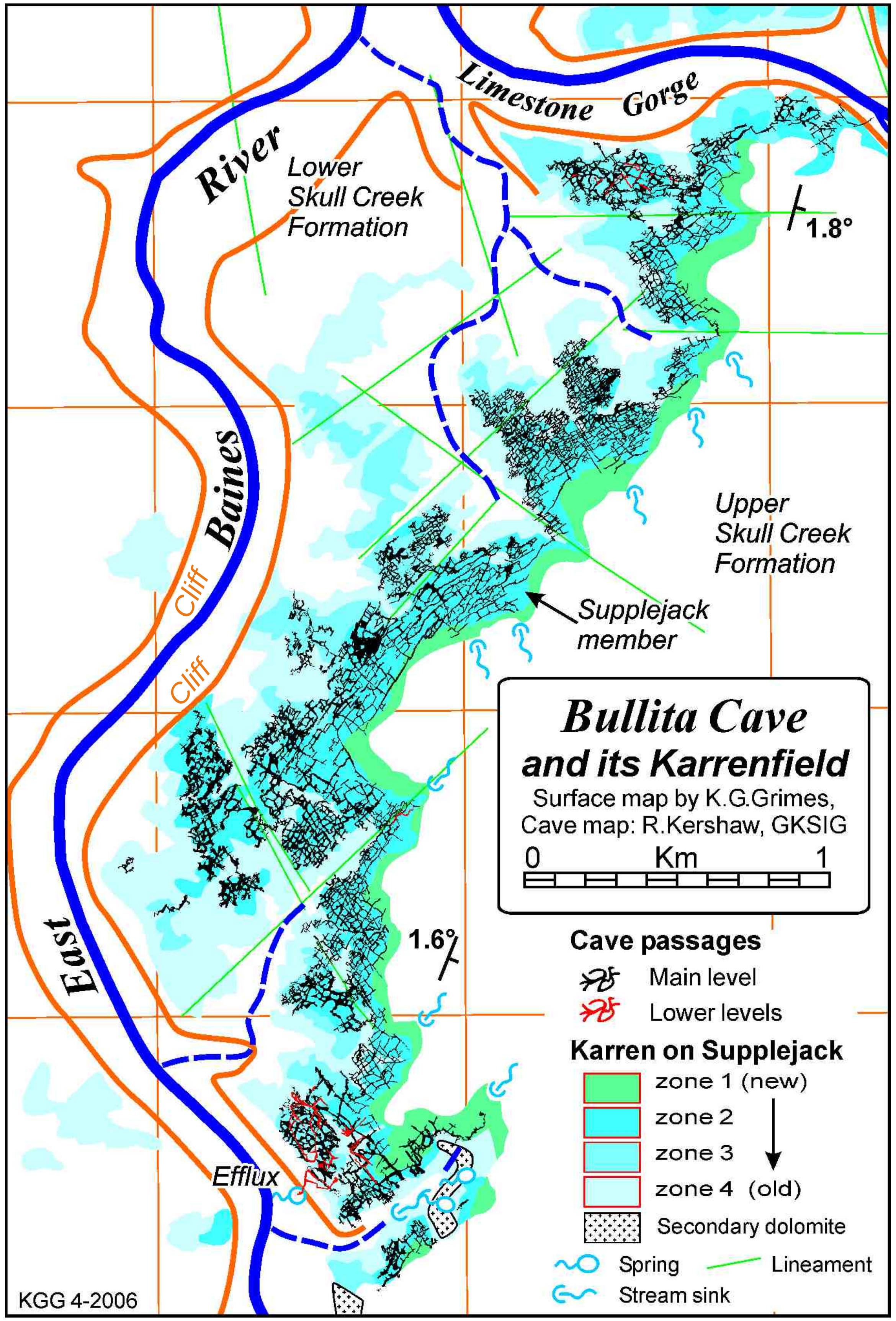
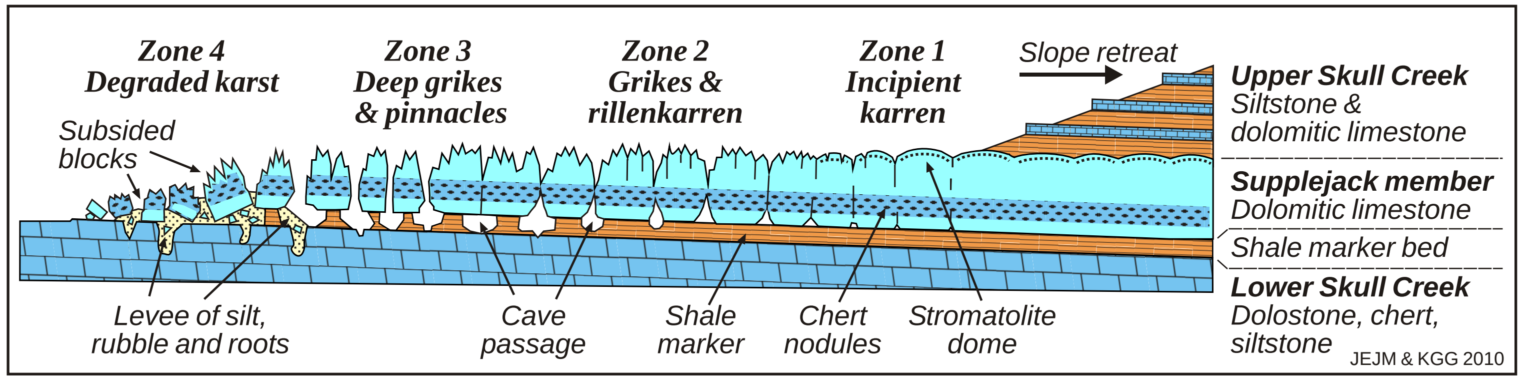




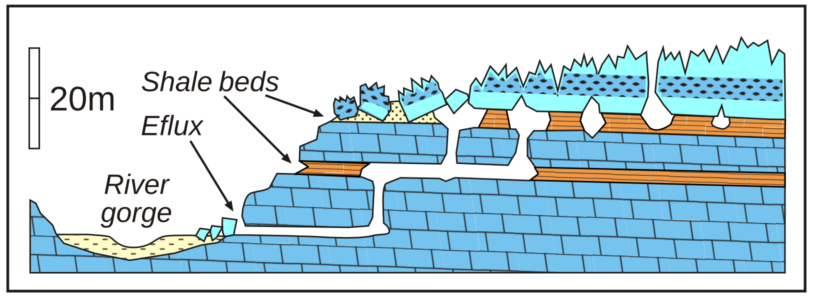
Speleogenesis of Bullita Cave

Bullita Cave is the largest of a group of extensive, horizontal, joint-controlled, dense network maze caves which are epikarst systems lying at shallow depth beneath a well-developed karrenfield. The karst and its caves are restricted to the outcrop belt of a thin bed of sub-horizontal, thinly interbedded dolostone and calcitic limestone – the Supplejack Member of the Proterozoic Skull Creek Formation. Karst is further restricted to those parts of the Supplejack that have escaped a secondary dolomitisation event.

The karrenfield and underlying cave system are intimately related and have developed in step as the Supplejack surface was exposed by slope retreat. Both show a lateral zonation of development grading from youth to old age. Small cave passages originate under the recently exposed surface, and the older passages at the trailing edge become unroofed and/or destroyed by ceiling breakdown as the, by then deeply-incised, karrenfield breaks up into isolated blocks and pinnacles and eventually a low pediment surface.

Vertical development of the cave has been generally restricted to the epikarst zone by a 3 m bed of impermeable and incompetent shale beneath the Supplejack which first perched the watertable, forming incipient phreatic passages above it, and later was eroded by vadose flow to form an extensive horizontal system of passages 10-20 m below the karren surface. Some lower cave levels in underlying dolostone occur adjacent to recently incised surface gorges.

Profiles of the cave system:
Above: the general case, with development at and immediately above the shale bed,
Below: Incision to lower levels beside the gorges.



Speleogenesis is also influenced by the rapid, diffuse, vertical inflow of storm water through the karrenfield, and by ponding of the still-aggressive water within the cave during the wet season – dammed up by "levees" of sediment and rubble that accumulate beneath the degraded trailing edge of the karrenfield. The soil, and much biological activity, is not at the bare karren surface, but down on the cave floors, which aids epikarstic solution at depth rather than on the surface.

While earlier hypogenic, or at least confined, speleogenic activity is possible in the region, there is no evidence of this having contributed to the known maze cave systems. The age of the cave system appears to be no older than Pleistocene.

Wet season stream channel, with a bed load of angular fragments eroded from the shale bed. Note shale pillar on left.

This omega-shaped (Ω) "phreatic" tube, just above the top of the shale bed, records an early stage of speleogenesis, prior to the erosional cutting down into the softer shale.

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Speleothems

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⇧ ***The Pendulite, a stalactite hanging into an intermittent wet season pool.***

⇩ ***A gypsum flower in Claymore Cave - possibly indicating sulphide minerals in that area.***

Speleothems are not abundant, but do provide some clues to cave development.

Coralloids (popcorn or cave coral) are the most common form, coating the walls and ceilings. This reflects the well-ventilated nature of the cave – enhancing both CO_2 diffusion and evaporation from thin films of water. It is common to find a band of white corraloids along each side of a roof fissure or shaft. These form by evaporation of seepage water moving out of fissures and tubes at the end of the wet season. At the peak of the wet the water coming down the fissures is aggressive and redissolves the corraloids within the fissure – forming a sharp edge.

Some speleothems show evidence of past pools or wet-season flooding (e.g. the Pendulite & the clouds in the Drain) or old floor levels bridging passages. Microgours with irregular, knobby, cave pearls ("golf balls") could indicate small flows and puddles.

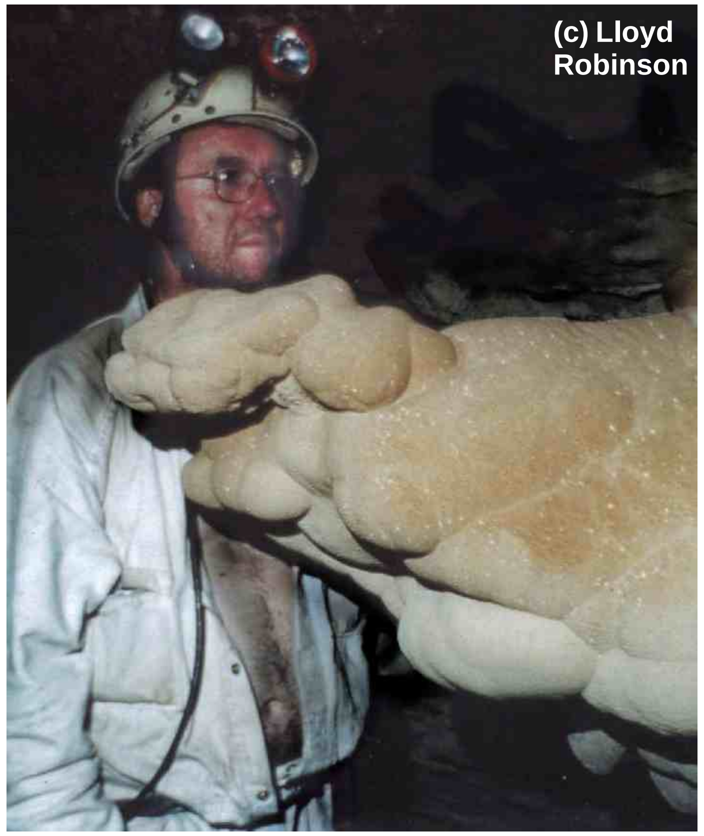
The twilight zones of the numerous entrances have some knobbly speleothems (biothems) that incorporate algal and other organic growths. Also in the twilight zone are special speleogens: phototropic (light-oriented) spikes and grooves dissolved by algae, and small solution ripples.

Unusual cave minerals, e.g the gypsum flowers found in Claymore Cave (south of Bullita), might reflect local sulphide deposits.

⇩ ***Microgours and a coralloid cave pearl ("golf ball")***

⇧ ***A band of white coralloid deposits following the edge of a roof fissure.***

⇩ ***A possible Cave Cloud formed in a past pool in The Drain.***



⇧ ***Coralloid deposits in a ceiling bell-hole.***

⇦ ***Phototropic spikes beneath a daylight hole.***

⇩ ***Coralloids and other formations.***