The Gregory Karst

Northern Territory

Introduction

Ken G. Grimes, 4-2006 v 2.2

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

Location

The Gregory Karst is part of the 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 interebedded dolomite nd limestone unit, the Supplejack member, within 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 show 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 "ruined cities" of isolated pinnacles at the outer edge (Zones 1 to 4 on map). [*see separate pages for details of karren & microkarren*]

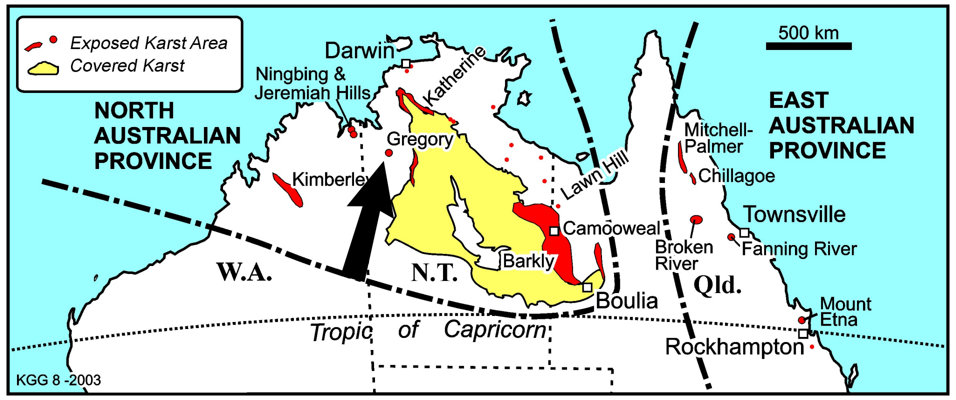
A variety of tufa deposits are common in the valleys and stream beds (Canaris, 1993) [*see separate page*].

The Caves

Extensive horizontal maze caves underlie the dissected surface, being best developed under karren zones 2 & 3. Bullita and Dingo Caves have about 100 and 50 km of passage respectively.

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 reach down to the cave level and unroof the passages. The bulk of the cave volume is in a shale bed which appears to have been eroded mechanically. Lower levels occur adjacent to the incised gorges. Speleogenesis is restricted to wet season flooding at present.

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

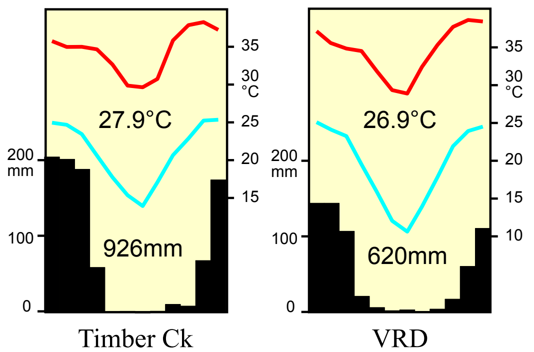


History of cave exploration

The exploration history is presented by Kershaw (2005). 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.

Climate



The area has a tropical semi-arid monsoon climate (BShw on the Koppen 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 N, and Victoria River Downs (VRD), 70 km ESE

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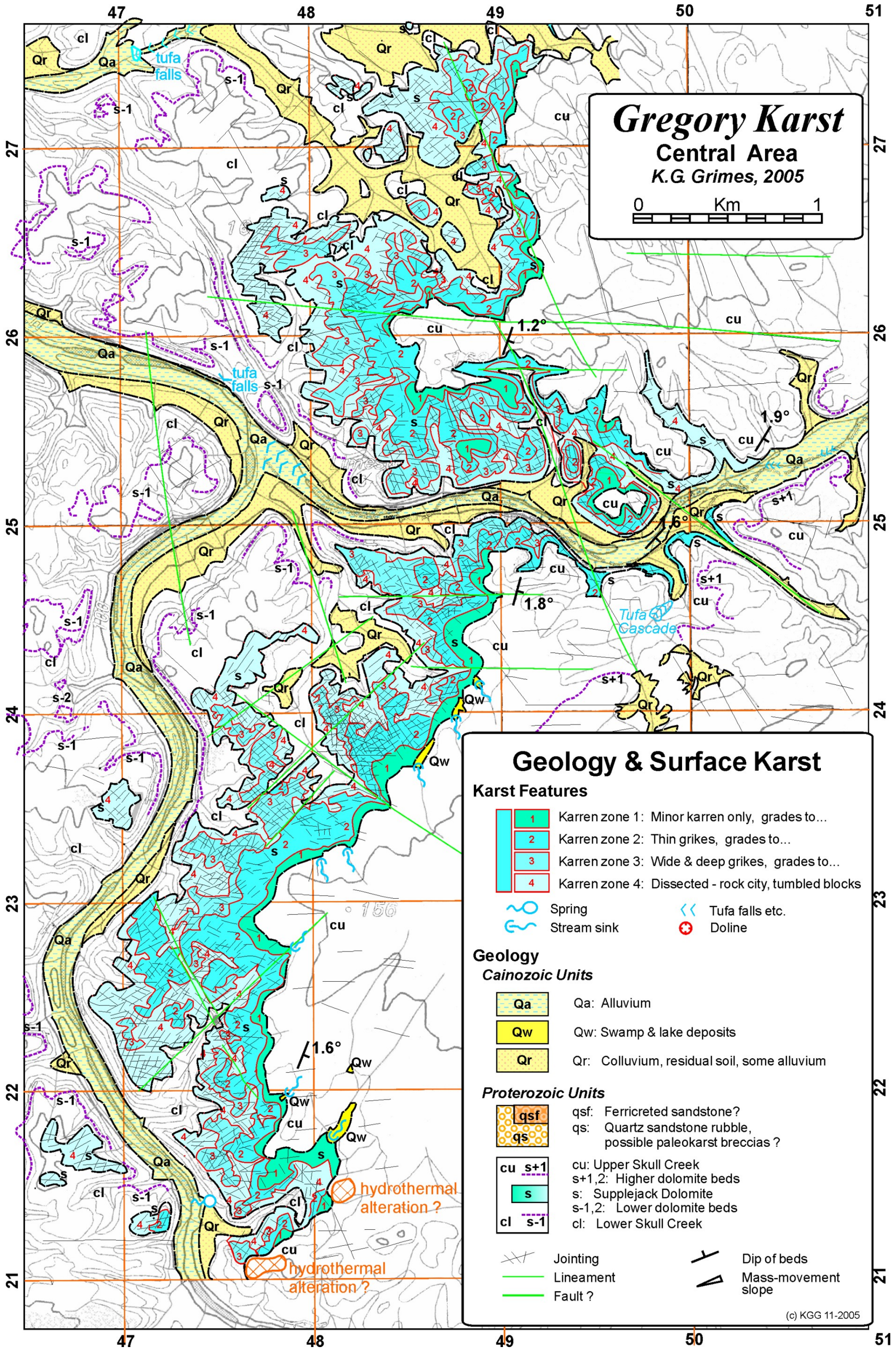

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Geology

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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 outcropping dolomitic limestone alternate with ~3m recessive beds of carbonated siltstone and shale (Martini, pers comm, 2006). 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 18m thick, thin to thick-bedded dolomite and limestone unit that forms the main karrenfield. The caves are mainly found at the base of this 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 thin-bedded carbonated siltstone and shale, and then a lower 0.5m bed of dolomitic mudstone (Bannink et al 1995, Martini, 2006). Most 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 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.

All the formations are well jointed and horizontal to gently dipping (1.2 - 2 degrees to ESE in the vicinity of Dingo & Bullita Caves). The joints guide the pattern of the karrenfield and also the maze caves beneath.

Martini (pers comm, 2006) noted that within parts of the Supplejack member there are thinly interbedded alternations of dolomite and limestone (calcite). The differential solubility of these resulted in deeply sculptured walls on some passages.

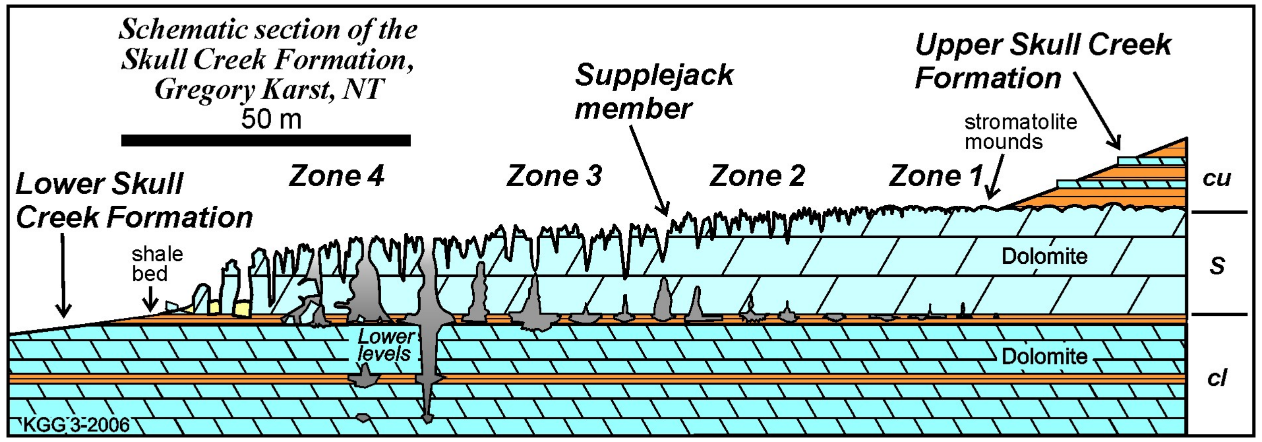
Sedimentary structures indicate deposition in subtidal, tidal and supratidal environments - e.g. the stromatolites, edgewise breccias, shrinkage cracks, and pseudomorphs after gypsum and halite crystals.

Chert nodules and seams occur in some beds, and are etched out in outcrop and on the cave walls.

At the southern end of Bullita Cave Martini reports a secondary dolomitisation of possible hydrothermal origin. This has inhibited cave development.

Stromatolites

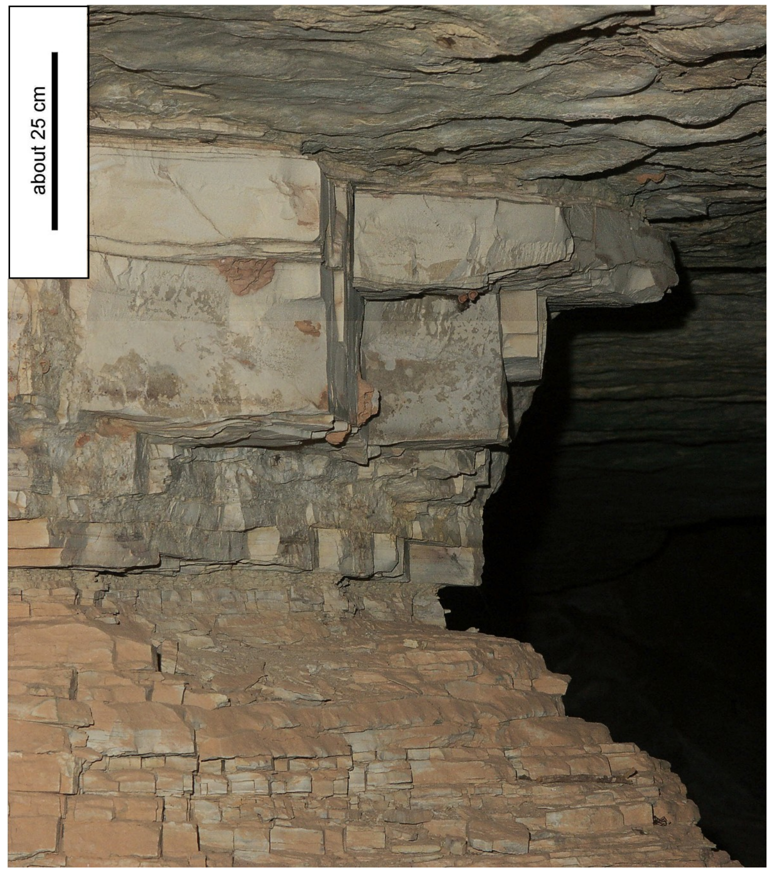
A variety of stromatolite forms (old calcareous algal colonies) occur throughout the sequence. There is a set of large well-developed stromatolite domes at the top of the Supplejack, which forms the surface of the zone 1 karrenfield.



↑ *View across the karrenfield on the Supplejack member, with hills of upper Skull Creek Formation in background. The broad mounds within the karrenfield are stromatolites.*

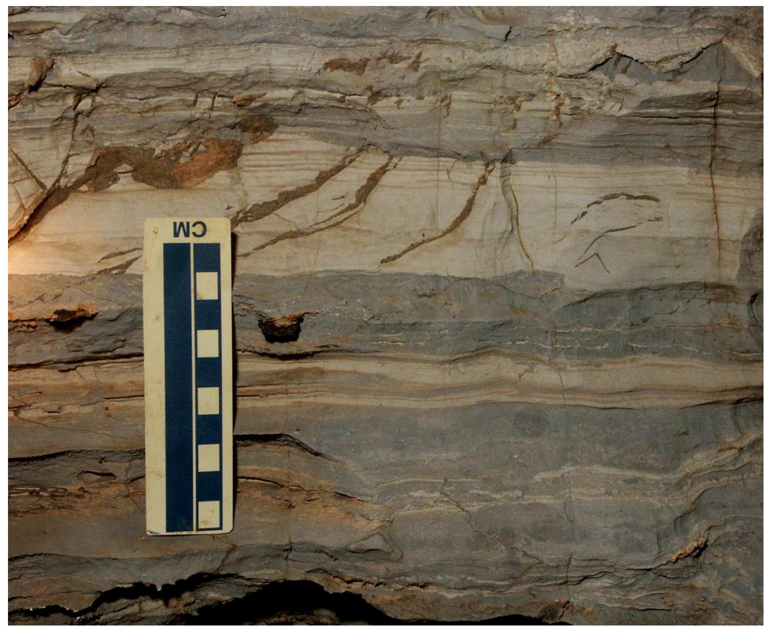
↑ *A small stromatolite.*

The Shale Bed: →
The flat roof is the base of the Supplejack member.
Beneath that is a thick-bedded mudstone, and then the main thin-bedded shale and siltstone.



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

↓ *Alternating beds of dolomite (cream)and limestone (grey) in the Supplejack member.*



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The Caves

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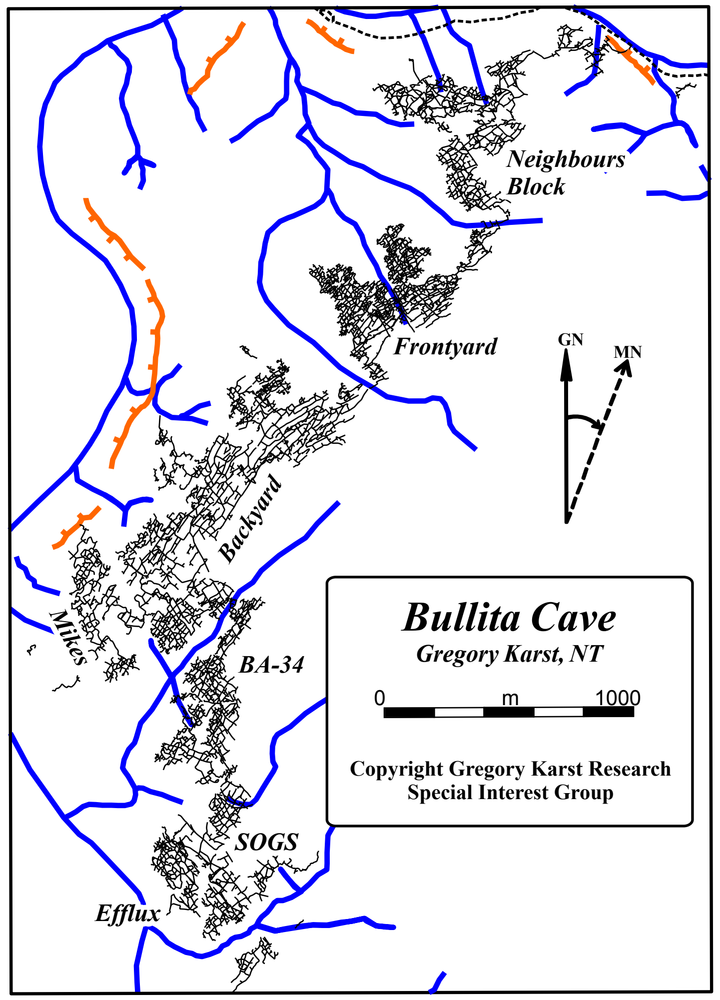
🠅 *Inverted-T passage, with a roof fissure following a joint in the Supplejack, and a broad slot cut in the shale bed below.*



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 current total passage length is 103 km (± 5). Dingo Cave is about 50 km and several others are ~10 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 in Dingo Cave and at the northern (Neighbour's) and southern (SOGS) ends of Bullita. Towards the eastern contact with the overlying Skull Creek formation the passages become smaller and impassible.

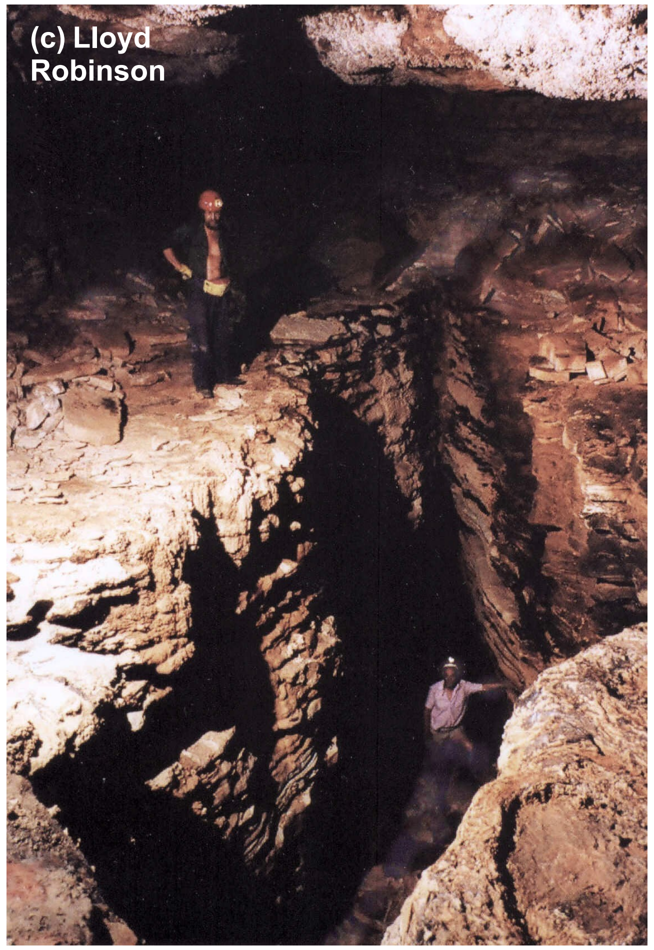
There are some typical passage forms, partly tied to the rock types [*see Profile sheets for examples*]: Most common are narrow fissure passages and "tented" (inverted T) passages that have an upper fissure in the Supplejack, and a broader undercut in the underlying soft shale bed. Broad chambers or flatteners form in places, up to 3m high with a flat roof at the base of the Supplejack and 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 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. The latter can be difficult to find. 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 entrance is via the "efflux". Tree roots are common beneath the fissures that connect to the surface.

Speleogenesis:

Speleogenesis involves the strongly seasonal rainfall with wet season flooding, structural and lithological control (especially the shale bed) and the history of surface erosion. *This is described in a separate page.*



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

🠅 *A-section fissure within the Supplejack. Note sharp ledges – a response to thinly interbedded dolomite and limestone.*

🠇 *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 coraloid growths.*

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Speleothems

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The Pundulite, a stalagmite hanging into an intermittent wet season pool.

A gypsum(?) flower in Claymore Cave - possibly indicating sulphide minerals in that area.

Decoration (speleothems)

These 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. This suggests formation 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: light-oriented spikes and grooves dissolved by algae and small solution ripples.

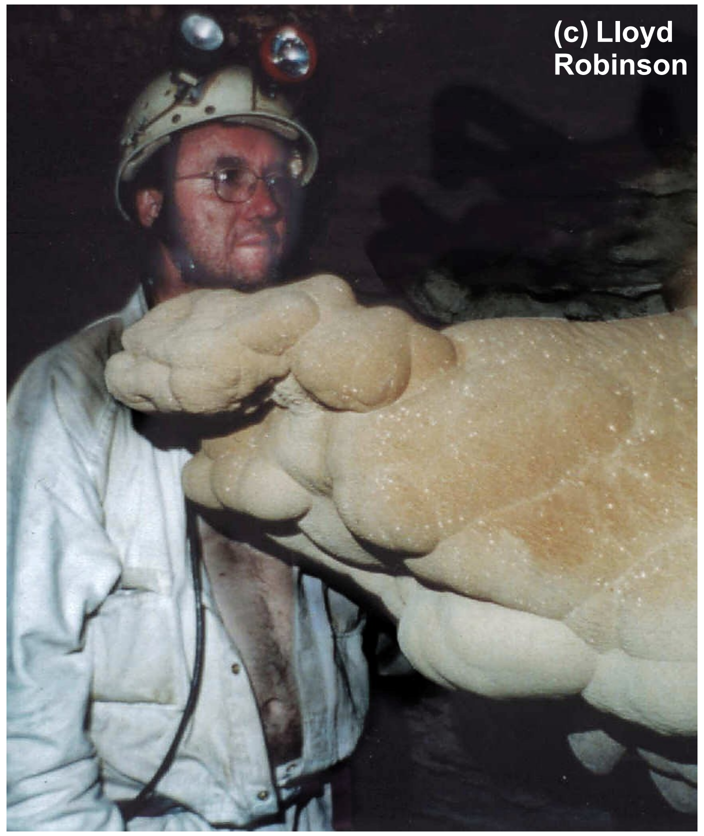
Unusual cave minerals, e.g the gypsum flowers found in Claymore Cave (south of Bullita) might reflect local sulphide deposits.

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

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

Coralloid deposits in a ceiling bell-hole.

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



Coralloids and other formations.

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Speleogenesis

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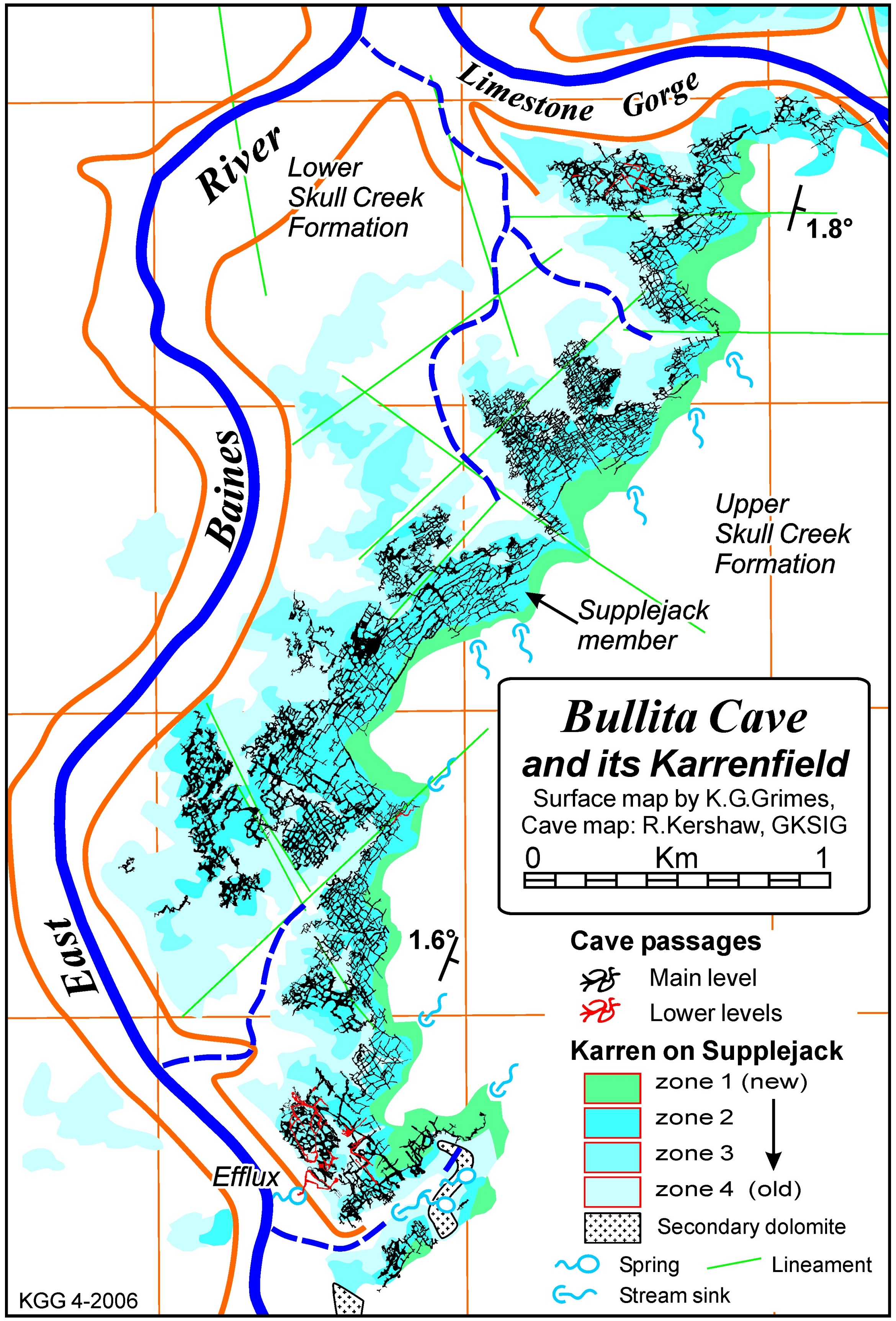

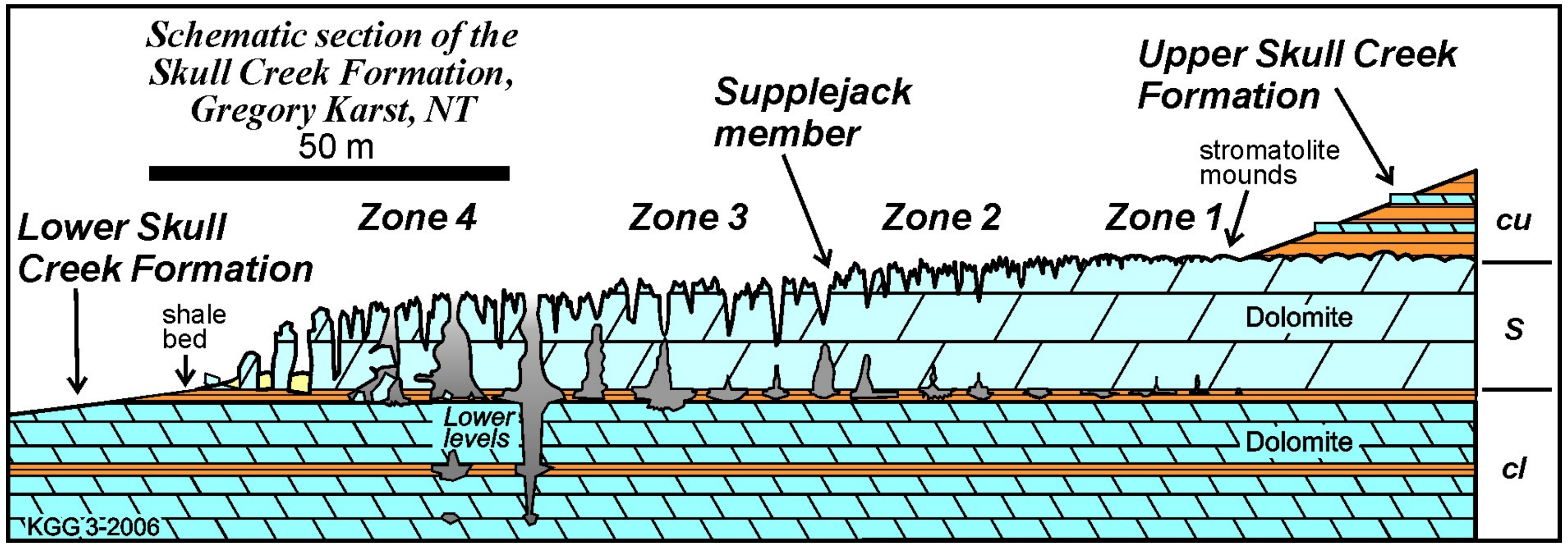

Speleogenesis of Bullita Cave

The speleogenesis is still being worked out. What follows is based on the model of Bannink et al 1995, together with discussions with Jacques Martini and other members of the GKSIG in the field and my own observations.

Factors are: the geological setting (lithology and structure); the hydrology and the denudation history.

One suggestion is that this is a special type of epikarst cave.

Speleogenesis involves progressive exposure of the Supplejack Member by slope retreat and seasonal water input both diffusely via the karrenfield and as lesser allogenic input at the upper edge of the karrenfield.

The present cave shows all stages from youth to old age within the width of the karrenfield (100-500m). The youngest parts, beneath zone 1, have incipient small conduits forming beneath recently exposed parts of the Supplejack. The oldest parts are at the western edge, in zone 4. Here the passages are unroofed and the cave breaks up into giant grikes and a stone city.

However, the occurrence of lower levels is controlled by adjoining valley relief, in particular the history of incision of the river and Limestone Creek. These lower levels are probably relatively young.

Lithological control by a 3m thick shale bed that is mechanically eroded by wet season flood waters is an important part of the speleogenesis - most of the cave volume is developed within this shale bed. The shale bed may also have controlled the level of initial phreatic speleogenesis by providing a perched watertable with mixing. The omega-shaped (Ω) tubes in the roof of the larger chambers may have formed at that stage. Once these initial tubes become large enough to carry strong flows, mechanical erosion cut down into the shale bed and then sideways to create larger passages, which follow the pattern of the initial joint-controlled tubes in the overlying dolomite.

Martini recognised a secondary dolomite in the south which has inhibited cave development there, and formed perched watertables.

Wet season flooding may be significant, particularly in the mechanical erosion of the shale bed. The rubble mounds at the degraded edges of the cave may act as dams ponding rain water within the cave.

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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Tufa deposits

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Waterfall over a high tufa dam into a deep plunge pool. ↑

Tufa stalactites in a constructional cave in the tufa waterfall shown above. ↓

Tufas

The tufa deposits of Limestone Creek have been described and mapped by Canaris (1993).

Tufa is a porous carbonate deposit precipitated from saturated water. It typically forms in areas where turbulence assists in degassing of CO_2 (e.g. at a waterfall) but can also be assisted by a variety of micro-organisms.

Canaris reports two ages of tufa deposition in Limestone Gorge: relict tufas and modern tufas.

Relict tufas dated at 8-10,000 BP indicate a period of wetter climate. They are extensive in the alluvial flats beside the creek. they are from 0.5 to 3m thick and are well indurated.

Following a drier stage, the modern tufas began growing in the present creek channel about 1600 BP. The photos are all of modern tufas. These are more porous, but show better preserved forms. They form transverse barrages across the present channel, and form stepped terraces on steeper slopes, including large waterfalls.

The "Crystal Cascade" is a water fall (active during the wet season) with tufa deposits. The colour is due to a thin coating of finely crystalline calcite which coats greyer algal and carbonate material that in turn coats the rock. This sparkly white coating looks fresh, and possibly reforms at the end of each wet season. The algal crust material beneath the crust forms curls 5-10 mm thick. Leaves and other organic material are incorporated. There are also some tufa rims and pools. Above the falls the tufa is all a dull grey colour, not white.

In several places seepage water runs out from the Supplejack - Skull Creek contact across the slabs at the top of the Supplejack (karren zone 1). This forms small "paddy-field" terracettes of two types. A constructional form has small rounded tufa ridges a few cm high and wide damming the terracettes. The other type appears to be wholly solutional in form and comprises shallow steps (trittkarren) with or without low rims.

The "Crystal Cascades" are a thin white crystalline coating over grey organic tufa steps. Note the curled flakes of algal material on right. ↑

Detail of above: white crystal tufa with embedded leaf. →

Tufa "paddy-field" terracettes formed by seepage water moving over a gentle surface. ↓

↓ ***Soft spongy modern tufa.***