THE BARKLY KARST REGION, NORTH-WEST QUEENSLAND.

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ABSTRACT

Although underlain by thick and widespread carbonate rocks, the Barkly Karst Region has a fully developed surface drainage and karst features are poorly developed. On the main tableland only isolated collapse dolines and associated caves occur, with the greatest density being near Camooweal. Underground drainage does occur but movement is slow. In the dissected northern margin there are several large grike fields and well developed karren, as well as dolines, caves, and karst springs. However, the dense surface drainage system is still fully functional in the wet season.

The main cave passage development might date back to wetter climates and higher water tables of the Tertiary. More recent karst development in the region has been retarded and the area is in an extremely youthful stage. The retardation is the result of the arid climate, the lack of relief, and the extensive black soil cover on the tableland which has restricted infiltration. None-the-less, individual caves can be quite large, with Kalkadoon Cave having 5400 m of surveyed passage, and many unexplored leads.

Biological interest lies in the crabs and rare bats which are found in the caves.

INTRODUCTION

The Barkly Karst Region extends from Queensland into the Northern Territory, and corresponds to the carbonate rocks of the Early Paleozoic Georgina Basin (de Keyser, 1974) and also to the geographical feature known as the Barkly Tableland (Stewart, 1954). This paper presents a survey of the karst features of that part of the Barkly Karst Region lying within Queensland, and between latitude 18°35'S and 21°00'S (see Fig 1). Karst feature are rare further to the south, but have been recorded as far as the Boulia area. The present paper is a revision of a previous unpublished assignment (Grimes, 1977a). It is based on air photo interpretation at the regional scale (Grimes 1974a), on several visits to the Camooweal and Lawn Hill cave areas with University of Queensland Speleological Society (UQSS) parties between 1974 and 1980, and on observations made during geological mapping in the region in 1983-84.

The regional geology and climate of the region will be summarized first to provide a background to the following detailed description of both the surface karst features and the caves. Finally some suggestions are made concerning the climatic and geological controls on karst development in the area. Discussion is limited mainly to the areas visited by the UQSS: the Camooweal area within the tableland, and the Lawn Hill area at the northeastern margin. These represent two styles of karst development in the area.

The earliest reports I have found on the caves are those of Keys (1900) and Danes (1911). More recent karst studies in the area have been restricted to a brief description of the surface karst and spring deposits at Riversleigh, south of Lawn Hill, by Williams (1978); and to various reports on cave exploration by the UQSS and other Speleological Groups (e.g. Bourke, 1970; Shannon, 1970; Halbert and Ellis, 1970; Pavey, 1972, 1974; Grimes 1975, 1977b, 1980; Jolly and Grimes, 1978; Canty, 1979; Little, 1986). Shannon, 1969 and 1970 summarizes exploration up to that time and lists earlier publications, including descriptions by Lamond (1968) of a number of outlying caves in Queensland and the adjoining parts of the Northern Territory, most of which have never been visited by speleologists. Dolines have been shown on some, but not all, of the 1:250 000 geological maps of the region; and caves and sink holes are described in several of the accompanying geological reports.

The region as a whole is referred to as the Barkly Karst Region (BK) in the Australian Karst Index (Matthews, 1985), but the Camooweal area (C), and the Colless Creek area (CK), which fall within the region, have been given separate listings and codes.

Most of the region is held under grazing leases, but there are National Parks in the Camooweal and Lawn Hill Gorge areas, which cover some of the caves and karst features.

The region has an arid (BWhw)[1] to semi-arid (BShw) climate with conditions becoming drier and more continental to the south. The effectiveness of the rainfall is limited by its summer incidence and by the fact that much of it falls in thunder storms followed by hot sunny conditions. During the Pleistocene the climate would have fluctuated, with the changes being most likely towards greater aridity during the glacial stages (when the Gulf of Carpentaria would have been largely dry), and conditions similar to or slightly wetter than the present during the inter-glacial stages. However, during most of the Tertiary, conditions would have been wetter and the country much more densely forested. Drier conditions similar to the present would only have appeared towards the end of the Tertiary, about 5 - 10 million years ago (Galloway and Kemp, 1984).

[1] *Koppen's climatic classes.*

Vegetation in the area varies from treeless grasslands on the black soils of the tablelands to open low woodlands on the limestones and other rock types. In the north, gallery forest follows the margins of the permanent spring-fed streams.

The regional geology is summarized in Fig. 1 and is presented in more detail in de Keyser 1974. The karst features are developed on the dolomite and limestone[1] lithosomes of the early Paleozoic Georgina Basin. The carbonates are generally flat lying, well bedded, and moderately to well jointed. Some folding has occurred in the Undilla area and near the basin margins. Through much of the region the carbonates are mantled by a thick heavy clay soil (black soil). East and southeast of Camooweal they are overlain by thin Mesozoic sediments and lateritic soils (Grimes, 1985). The laterite is developed on a mid-Tertiary surface (correlated with the Tennant Creek Surface by Grimes, 1974b) which existed over much of the area. This surface is characterized by both ferricretes and silcretes. Much of the siliceous lag gravel found on the surface in the Camooweal area probably is derived from these silcretes as chert is rare in the carbonate rocks exposed in the caves. This mid Tertiary surface was uplifted later in the Tertiary and dissection followed in the northern margins of the tableland, and is continuing at present with the dissected area slowly advancing southwards. The remainder of the tableland has suffered little erosion since the uplift. In the dissected Lawn Hill area the Tertiary surface is recognizable as a planar summit level surface. The meandering and bifurcating pattern of Lawn Hill Gorge is a superimposed drainage inherited from this surface.

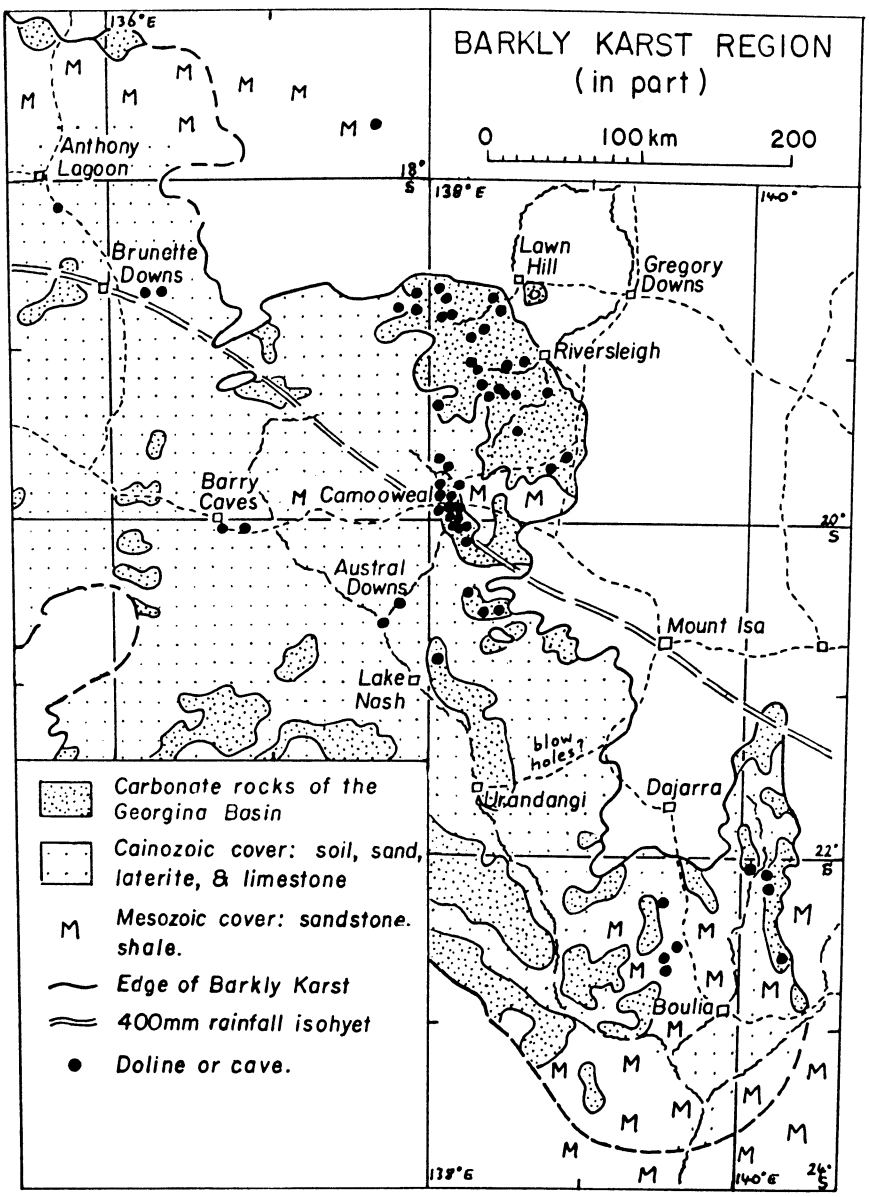

Figure 1: Barkly Karst region : Locality map.

[1] The dolomites and limestones of the area can only be readily distinguished by laboratory tests, the term "carbonate" will be used here in a general sense for both lithologies.

PALEOKARST

During a recent geological mapping operation (Grimes 1985) I found float and a number of small isolated deposits of silicified quartz sandstone and laminated shale within the carbonate areas near Camooweal. These were in small areas less than 50 m across and surrounded by Cambrian carbonate rocks. The exposures were very poor and no contacts were seen, but the most likely explanation is that these could be paleokarst deposits in old dolines or caves. Their age is uncertain, and as both the Tertiary and Mesozoic land surfaces were very close to the present surface in this area, the features could relate to either. No fossils were found, but the induration suggests that they must predate the formation of the mid Tertiary duricrusts. Some soft laminated shale also occurs as rubble on the floor of the final big chamber of Spinifex Cave, well below the surface.

A Miocene deposit at Riversleigh, on the northeast margin of the region, fills an old valley incised into the Paleozoic carbonates. This contains an abundant vertebrate fauna (Archer, 1988), and although no definite cave sediments have been recognised, the presence of numerous bat bones seems to indicate the existence of some caves in the area at that time.

Opik, Carter & Randal (1973, page 4) reported isolated "Mesozoic" deposits within the carbonate rocks in the Camooweal 1:250 000 sheet area. These might be surface stream deposits, or might be filling karst depressions. The age control is poor in most cases.

THE KARST LANDFORMS

Surface Karst Features

Drainage:
In spite of the large area of carbonate rocks underlying the region, the surface drainage is almost completely integrated. In the northern, dissected, area there is an incised, closely spaced dendritic drainage system with channel densities of 3 - 5 per km (Grimes 1974b). Only a few blind valleys occur where streams sink into dolines. The largest of these valleys is only 700 m long. Underground drainage is evidenced by the springs near the edge of the region, but seems to be subordinate to the surface drainage.

On the undissected part of the tableland to the south the surface drainage is much less dense, averaging 0.7 channels per km, but is still fully integrated and again only a few blind valleys occur. The longest of these is an exceptional 3 km. Much of this area is covered by black soil. In this soil the rainfall pools locally in small gilgai, which reduces the run-off onto streams. The heavy clay also limits seepage downwards into the underlying rocks.

Small scale solutional sculpturing, karren:
Karren are best developed in the northern dissected area, probably because of the greater rainfall and the more extensive areas of bare limestone. They are most common in beds of strongly jointed carbonate rocks. In these the joints have been enlarged to form large grike fields with fissures up to 4 m wide and 10 m deep. The rocky pinnacles between the grikes have been serrated by solution flutes and other karren forms also occur. These grike fields probably have the best cave potential, as indicated by the preliminary exploration of the Colless Creek Grikefield (see below).

In the southern area karren are rare. Small grikes occur near some dolines. Solutional etching of fine structures in the rock is the main feature seen.

Dolines:
The distribution of large dolines in the area is shown in Fig 1. In all, more than 80 dolines greater than 50 m have been located in the region using high altitude air photos. Many of these have been checked for caves, and they are documented in the Australian Karst Index (Matthews, 1985). About half of the dolines checked in the Camooweal area contained caves, and some known caves are in small depressions not visible on the air photos. Some dolines in more remote areas still have not been checked.

The main concentration of dolines is in the Camooweal area (Fig 1), but even there the doline density of 0.47 per km^2 is less than the densities of between 0.57 and 2400 per km^2 reported in a world wide survey by Cramer (1941). In the northern area smaller solutional dolines occur in the grike fields, but their density has not been estimated. Isolated dolines and stream sinks occur as far south as the Boulia area (see Fig 1, and listing in Matthews, 1985).

The large dolines appear to be nearly all derived from the collapse of cave roofs. Smaller dolines are rare. Some intermediate size dolines with rubble walls have a central mud mound (e.g. 4C-1040). These may be the result of mud blocking the central (less well drained) area, while water is still entering the better drained rubble around the margins and keeping those areas clear.

Springs and tufa deposits:
Along the northern margins of the region permanent large springs feed the major streams which flow out of the dissected plateau. In these streams and in the adjoining flood plains calcareous tufa deposits have been built up by precipitation from the saturated waters (Williams, 1978). In Lawn Hill Gorge one such deposit has formed a narrow dam right across the gorge, with a 1 m waterfall.

Subsurface Karst Features

Caves of the Colless Creek area (Lawn Hill Gorge National Park):

The Colless Creek grike field, west of Lawn Hill Gorge, seems to have good potential for extensive maze caves, but has not yet been properly explored. A number of short visits have found several small caves and one extensive one: Colonel Light Cave, (Grimes, 1978, 1979, Canty, 1979).

Fig 2 illustrates Colonel Light Cave (4CK-2). This is a horizontal joint-controlled maze system with 1350 m of surveyed passages. It comprises an irregular network of intersecting tall narrow passages, many of which connect via slots with the grikes on the surface. These connections are typically at passage junctions. The floor level is roughly horizontal, and covered with rubble except in the western passages where a sandy to silty floor shows signs of having been deposited by strong (wet season) currents. Solution undercuts are common

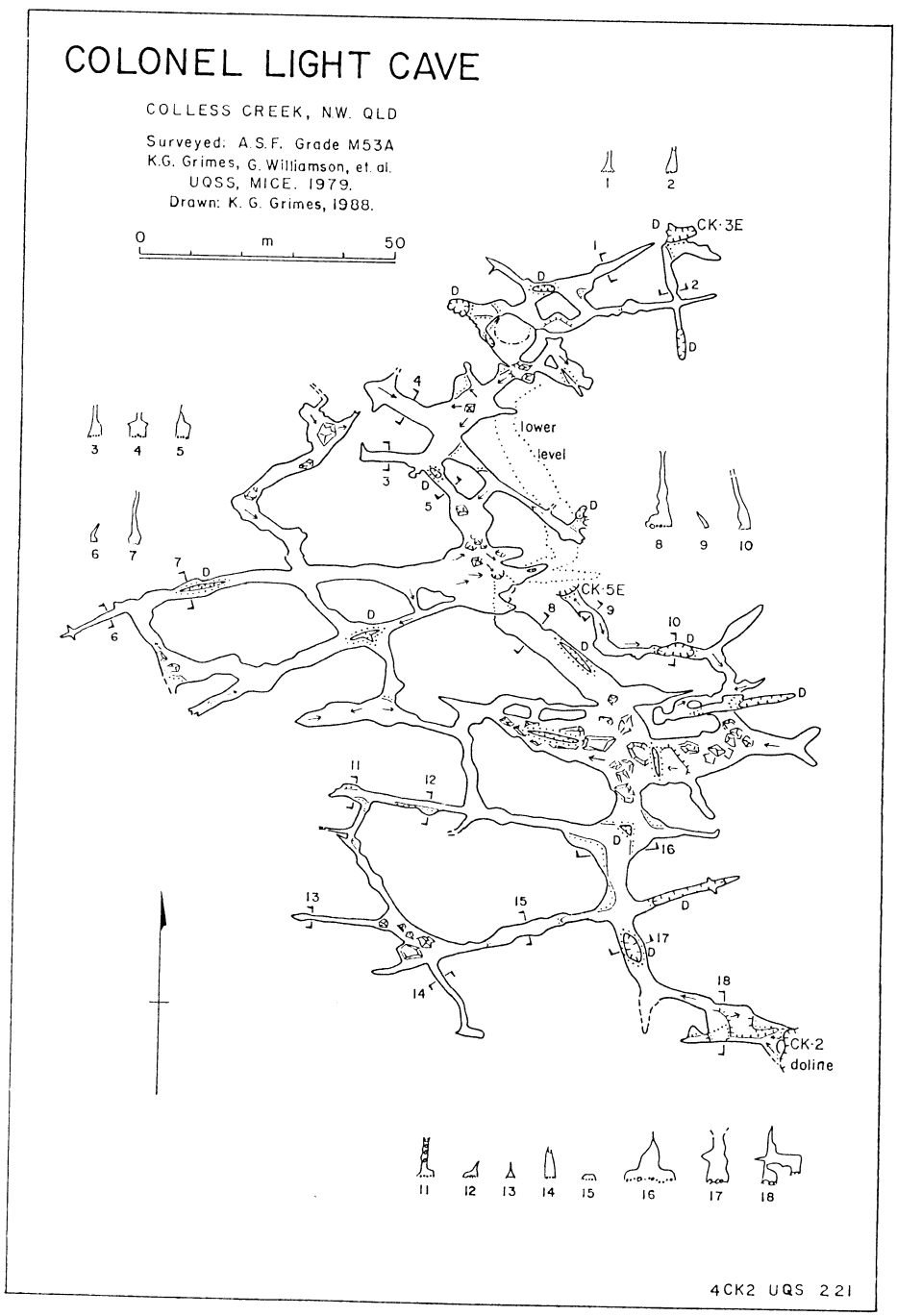

Figure 2: Colonel Light Cave (4CK-2), Colless Creek area.

at the base of the passage walls, indicating an old standing water level, about 15-20 m below the surface, and some distance above the present creek level. There is an incompletely explored horizontal lower level which, at about 45-50 m below the surface, is close to the present creek level. Speleothems are more common than in the Camooweal area to the south, but are still far from abundant when compared with those in humid karst areas.

The formation of the upper level cave passages must predate, or be contemporary with, the early stages of incision of the gorge; and the undercuts might indicate a still-stand in the incision. The Miocene fossil-rich deposits of the Carl Creek Limestone, near Riversleigh (Archer, 1988), occur in a valley which has been cut into the Tennant Creek Surface to a similar depth to that of the passages in this cave, and might well be contemporary. The fossils indicate that the Miocene climate was much wetter than the present, which would have aided karst development. The lower level is close to the present floor of the gorge, and may therefore be younger than the late Tertiary uplift and incision of the area.

Caves of the Camooweal area:
This is the area in which most exploration has been done. Of the 56 dolines and stream sinks listed for this area in the Australian Karst Index, 26 contain known

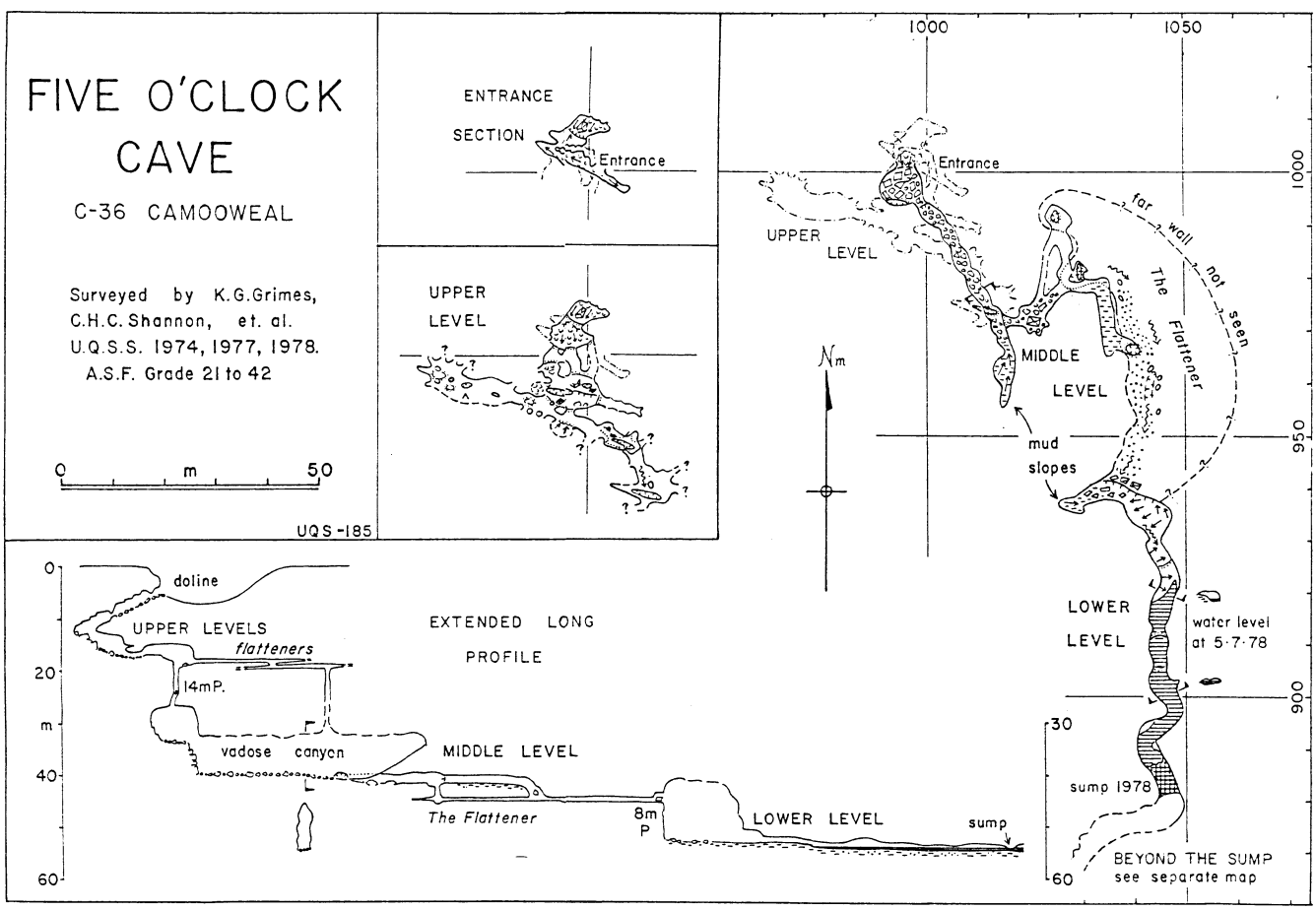

Figure 3: Five O'Clock Cave (4C-36), plan and long profile of main section.

caves (Matthews, 1985). For a bibliography of cave descriptions up to about 1980 see the listings in Matthews; I will cite only more recent publications here.

The caves vary from short cavities in rock pile to large systems having up to 5.4 km of mapped passage. Figs 3 and 4 illustrate a typical large cave found in the area.

In general the caves comprise alternating vertical shafts and long horizontal sections. The major passages are up to 10 m or more in diameter. The systems appear to have developed in the phreatic zone with control by either bedding or successive levels of the water table, or both. The bedding is sub-horizontal, which makes it difficult to distinguish the effects of bedding from water table effects. Nothephreatic conditions are indicated by mazes and in the smaller scale by sponge-works of small centimetre-sized tubes. Some of the more soluble beds have been almost completely removed to leave extensive "flatteners". Since draining there has been modification and enlargement of the major passages by vadose flow. Vadose seepage seems to have had only a minor effect, and speleothems are rare.

In many of the larger caves in the area, the entrance chamber and initial passages are large, but these lead to a series of smaller bifurcating low level distributary tunnels which radiate away from the entrance area.

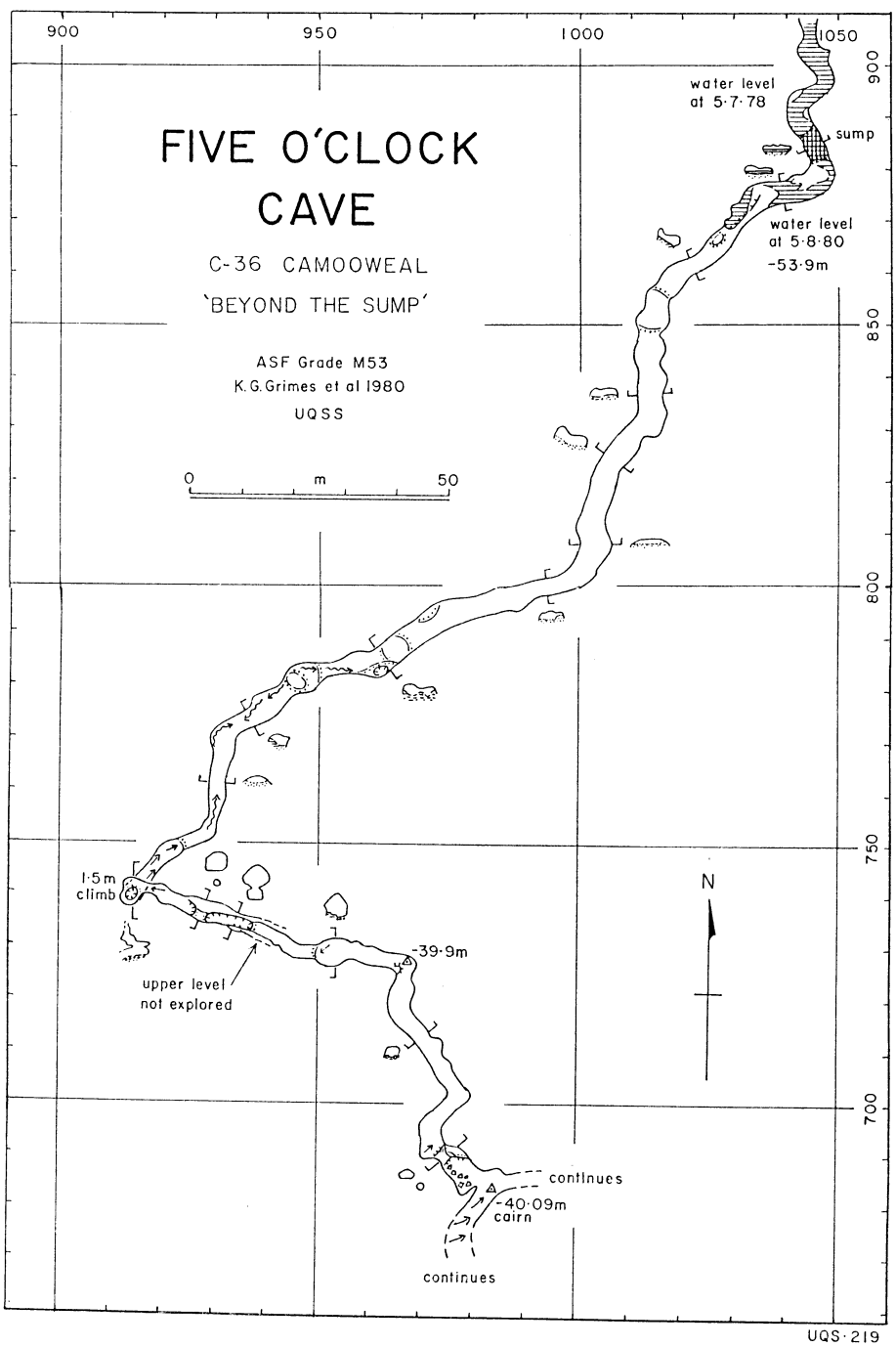

Figure 4: Five O'Clock Cave, plan of the section beyond the sump.

These are typically long, low (0.5 to 1.5 m), muddy, hot and humid tunnels which either terminate in a mud sump, or continue beyond the present limits of exploration (The "Sod It, Let's Go Home" point - Pavey, pers. comm.). It seems that aggressive surface water is entering the system at a single point: now the doline, but initially probably an area of outcrop which was not sealed by black soil, or which was adjacent to a rise from which surface water was being channelled. From this entrance point the water is distributed downwards and outwards in a radial pattern through the underground passages, which are largest near the source and smaller further out. However, the final small low-level passages maintain consistent diameters over long distances, even when bifurcating.

The different styles of passage development and their genesis are illustrated by **Five O'clock Cave (4C-36)** which shows the greatest diversity of forms (Figs 3 and 4). This cave has several levels, probably related to major still-stands of the water table, but bedding control is also obvious in mazes and flatteners.

The entrance passage and initial chamber are dominated by breakdown at the margin of the doline which overlies the cave. The upper level Maze (largely unsurveyed) and the Flattener in the middle level are low horizontal sections developed nothephreatically along soluble beds. The upper level Maze has two levels, only one metre apart vertically - indicating two soluble beds. The Flattener is a single horizontal slot less than 1 m high, and about 50 m long, with only occasional pillars remaining to support the roof.

The vertical fissure connecting the upper and middle levels, and the chamber beneath it, may have been initiated phreatically, following a joint, but they have been enlarged by vertical vadose flow (this would be a waterfall in the wet season).

The large meandering canyons of the middle and lower sections may have commenced as dynamic phreatic tubes near the water table of the time, as indicated by their horizontal meandering ceilings, but have cut down to the present floor by vadose flow as they were drained. The two sections are separated by a mud plug, presumably beneath an old entrance. The "Sump", about 54 m below the surface plain, is higher than general for the present regional water table. In 1977 and 1979 this was terminal, though the water was lower in 1979. However, following a series of dry years, by 1980 it had lowered sufficiently to allow penetration into the start of a long tunnel that continued beyond the limits of exploration (only the first 350 m were surveyed (Fig 4), but exploration by MICE[1] penetrated well beyond that point). By 1986 the water level had risen again so that a short duck under was required (Little, 1986). The length of this sump would be very sensitive to water levels, and it should be approached with care. Beyond the sump, the final phreatic tunnel, varying from 1-4 m high, runs more or less horizontal for the first 250 m, but then rises steeply to a level about 40 m below the surface and continues as a larger passage on that level to a junction at the present limit of the survey.

THE KARST HYDROLOGY

Some of the dolines have short surface streams flowing into them and two (4C-1008 and 1042) take flood waters from the Georgina River and Nowranie Creek respectively. There is evidence from flood debris that the caves sometimes fill almost completely during the wet season. However, the preservation of footprints in low level passages indicates that this has not happened over the last ten years. Some flooding seems to have occurred in Kalkadoon Cave at least since the early 1960s when groups of cavers from MISS[2] are known to have entered it (Calder, 1961) as we saw no footprints on our first visit in 1974.

In the Camooweal area the regional water table is between 70 and 75 m below the plain, and terminal lakes occur at this level in many of the deeper caves.

At first sight it would seem that the springs in the northern dissected margin of the area might be the outflow points for water which entered the ground at Camooweal. However, Randal (pers. comm.) says that the regional water table is below the level of these springs which must therefore be fed by local rainfall seepage. The regional slope of the water table, as shown by water bores, is to the south and water movement must be in this direction (Randal, 1967, 1978; and pers. comm.). No springs have been reported from the southern part of the Georgina Basin and the water may eventually leak vertically into the overlying aquifers of the Great Artesian Basin.

CAVE BIOLOGY

There has been little in the way of systematic biological studies. However, the trip reports of parties visiting the area contain numerous brief reports on insects, crabs, bats, owls, and snakes; such as the report on a light trap in Kaiser Creek (4C-12) by Wellings in Halbert and Ellis, 1970.

The main biological interest in the caves of the region lies in the bats and the crabs.

Hamilton-Smith (1978) has listed bat sightings in the region. In the Lawn Hill area he reports *Taphozous georgianus*, and *Hipposideros ater* in the caves, and a species of Nicticeius in the palm trees of the Gorge. From the Camooweal area he reported *Macroderma gigas*, (the pale phase of which has been sighted in a number of the caves) and *Rhinonycteris aurantius* in

[1] *Mount Isa Cave Explorers (1975 - c.1985).*

[2] *Mt Isa Speleological Society (c.1954 - c.1966).*

Kalkadoon Cave. This last was identified from bones, but live specimens have since been caught (Little, 1986). Canty (1979) photographed a dark phase of *M. gigas* in Ridgepole cave, west of Colless Creek, and there are unconfirmed reports of it at Colless Creek.

The crabs are less interesting than one would suppose, as they are a species of freshwater crab *(Parathelphusa transversa)* which is common in the surface water holes in the region. They are washed into the caves during the wet season, but seem to survive quite successfully within those caves which have permanent pools - if the number of sightings, and the presence of numerous burrows in Niggle and Barwidgee Caves are any indication. It is not known whether they are breeding in the caves.

CAVE CLIMATE

Halbert (1970) has made the only detailed study of the cave climates at Camooweal; in which he made a theoretical division of the caves into four meteorological types. Generally speaking the deeper parts of the caves have a non-varying hot and humid climate, while nearer the entrance/s they are cooler and dryer, and show more variation with time. Halbert reported a maximum of 100% humidity and 28.3°C (in Tods passage, Niggle Cave). I have since recorded higher temperatures in Kalkadoon of 29.5°C and 100% RH at the CASA-BSG junction (Grimes, 1980) and 30.5°C in UNSWSS passage (Grimes, 1979); and I once came down with a mild case of hyperthermia at the far end of CASA. On a couple of occasions, when cavers entered a new chamber or passage, the (presumably supersaturated) air condensed suddenly on their breath and fogged the whole area up in a few minutes.

DISCUSSION

Given that the area is underlain by an extensive layer of carbonate rocks, one is struck by the relative paucity of karst features and the dominance of surface drainage.

An explanation is that the karst cycle in the area has been retarded and is still in a youthful stage of development: extremely youthful in the south and only a little more advanced in the north.

The area is an uplifted mid Tertiary peneplain and the present drainage is inherited from this plain. Some excellent examples of superimposed drainage occur in the Lawn Hill Gorge area. Most of the higher levels of the caves may have developed during the wetter climates of the early and mid Tertiary, and would have been drained during the late Tertiary uplift. Some lowering of the water table may also have been due to the onset of the drier climates at the end of the Tertiary.

Karst development since the late Tertiary uplift of the peneplain has been retarded by several factors. The most obvious factor is the arid climate, which has restricted the development both because of the lack of water and because of the paucity of vegetation which could provide a source of carbon dioxide in the water. The slightly greater development in the north results from a combination of: the more active subsurface drainage because of the greater relief at the margin of the uplifted tableland; the more humid climate; and the lack of black soil cover, which has been stripped off. The impermeable black soils of the tableland would have inhibited the penetration of rainwater into the underlying rocks. It is notable that the area of densest doline distribution, near Camooweal, is one in which there is outcropping limestone, and in which more porous lateritic soils occur instead of the black soils.

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