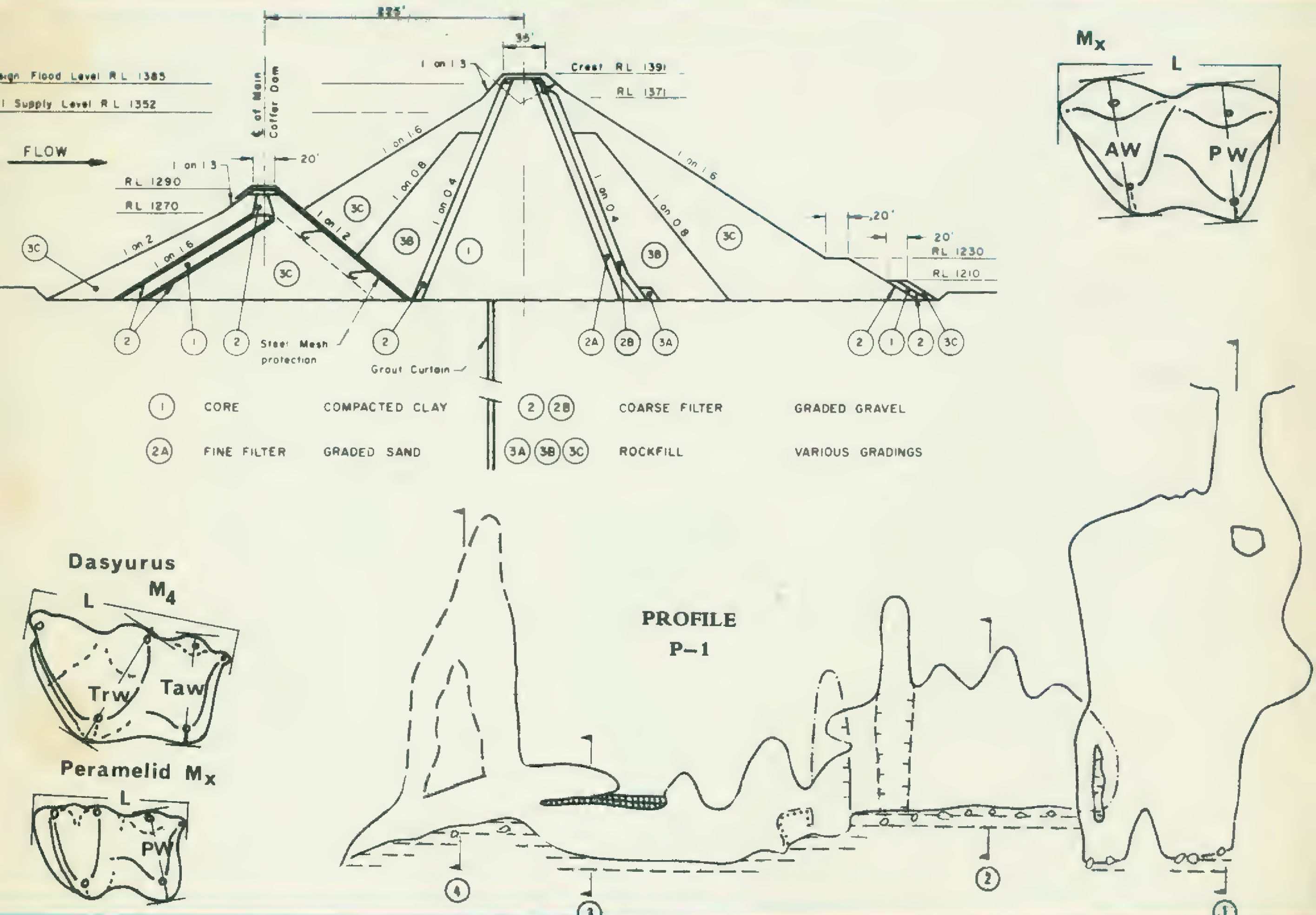
MEMOIRS

OF THE

QUEENSLAND MUSEUM



BRISBANE
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PREFACE

This part of the *Memoirs of the Queensland Museum* is devoted entirely to the Glenlyon Dam site. It covers the history of the area and of the development of the dam as well as the geology and natural history of the environs generally and of the Glenlyon cave systems in particular. The issue represents a co-operative venture of the Dumaresq-Barwon Border Rivers Commission, the New South Wales Water Resources Commission, the Queensland Irrigation and Water Supply Commission, the Geological Survey of Queensland and the Queensland Museum. Results follow largely from work undertaken during the construction phase of the dam and bring together information, much of it unrepeatable because of inundation of the area in question.

For this reason, the Queensland Museum wishes to acknowledge the financial support of the Dumaresq-Barwon Border Rivers Commission in enabling field studies to be undertaken and the results to be published.

Brisbane
May, 1978

ALAN BARTHOLOMAI
Director, Queensland Museum

Mem. Qd Mus. **19**(1): 1-4, [1978]

THE DEVELOPMENT OF THE GLENLYON DAM

DUMARESQ-BARWON
BORDER RIVERS COMMISSION BRISBANE

ABSTRACT

The Glenlyon Dam, named after a property first settled in 1844, was constructed under the authority of the Dumaresq-Barwon Border Rivers Commission to relieve irrigation problems of agricultural landholders along the Border Rivers. The dam has a storage capacity of 261 000 megalitres and, with an annual supply of 98 000 megalitres, the area to which assured irrigation water is available can increase from 2350 hectares to 14 570 hectares.

The well established tobacco growing industry along the Dumaresq River in both New South Wales and Queensland suffered disastrously during 1940 from the effects of drought. Failure of water supplies brought determined and widespread agitation for the construction of a large capacity storage reservoir on the Dumaresq or the provision of a series of low level weirs to enable water supplies to be obtained during critical periods of low rainfall.

In succeeding years, as the area of tobacco increased, the demand for Government water conservation measures increased – so much so that in 1942 support was gained of the Australian Agricultural Council.

General investigations of the Border Streams had indicated a topographically suitable dam site at Mingoola, immediately below the confluence of Pike Creek and the Mole River with the Dumaresq River.

In 1943 a conference of senior officers of Government Departments from New South Wales and Queensland recommended an engineering investigation be undertaken as early as possible into a proposal which involved the construction of a large storage at Mingoola to provide a regulated flow of water downstream.

After further discussion between representatives of both States during which agreement was reached on administrative policy, the New South Wales - Queensland Border Rivers Agreement was realised. The Agreement was subsequently ratified by the Parliament of both States and the New South Wales - Queensland Border Rivers Act came into force on 1 July 1947.

The agreement had three main provisions.

(i) The construction of certain works on parts of those portions of the Severn, Dumaresq, Macintyre and Barwon Rivers which constitute part of the boundary between New South Wales and Queensland for the furtherance of water conservation, water supply and irrigation in those States.

(ii) The cost of the works and of administration was to be borne by the States in equal shares and water made available as a result of the works should be available to the States in equal shares.

(iii) A body, to be known as the Dumaresq - Barwon Border Rivers Commission, was to be constituted, and charged with the duty of giving effect to the Agreement. The Commission would comprise three members, one member to be appointed by each State and the Chairman, a person not in the service of either State, to be appointed by the Premiers of New South Wales and Queensland.

Major works proposed included the construction of a dam on the Dumaresq River and the construction of six to twelve weirs to meet irrigation requirements along the rivers. Provision was also made for the construction of not more than four regulators in the effluent streams from the carrier rivers and for the taking over of the existing weirs near Mungindi and Goondiwindi by the Dumaresq - Barwon Border Rivers Commission.

INVESTIGATION AND DEVELOPMENT

Investigation and development of the scheme was undertaken by the Commission through the resources of the participating State Water Authorities. By 1960, a further four weirs (Bonshaw, Cunningham, Glenarbon and Boomi – the last mentioned in conjunction with a regulator) had been completed, but although the weirs provided some storage on the river, the supply available in periods of low flow was still insufficient to meet the irrigation requirements of the existing riparian landholders who obtained supplies by pumping directly from the river.

Hydrologic analyses indicated that an insignificant additional supply would be available from further weirs unless provision was made for a major storage upstream to regulate flows. Because it was uneconomical to provide more weirs without a major storage, alternative sources of irrigation supplies were investigated.

Field investigations of the groundwater potential in the area were carried out in the years 1958–1960, the cost of which was shared equally by the two States. In 1965 a joint State report* on the investigation concluded that while satisfactory stock watering supplies were available in the area, considerable variation in groundwater quality existed, and it could not be guaranteed that significant numbers of landholders would obtain worthwhile supplies for general irrigation. Subsequent investigations indicated that larger groundwater development was feasible with better extraction techniques, but the estimated supply was still far short of that needed, and the Commission and the States concluded that large scale groundwater development was not a viable economic alternative to the provision of a major upstream storage.

Detailed investigation of the Dumaresq site had shown the foundation conditions to be unsuitable and the Commission shifted its attention to the tributaries further upstream where more attractive sites, but for smaller storages existed. A geophysical survey was made at the sites of Pike Creek and the Mole River and preliminary comparative estimates were prepared to determine the relative economy of providing one large storage at Mingoola or two smaller storages on the tributaries. Following exploratory drilling, a Commission report** dealing with alternative storage proposals and possible amendments to the existing agreement was submitted and an amending agreement was executed between the States.

PROVISION FOR CONSTRUCTION OF DAM ON PIKE CREEK

The 1947 New South Wales-Queensland Border Rivers Act was amended on 4 November 1968. The amendment provided, among other things, for (1) the construction of storages on Pike Creek (Queensland) and the Mole River (New South Wales); (2) for the investigation and, subject to approval of the State Governments, construction of further weirs on the Border Rivers and works for the improvement of flow and of distribution of flow in the streams which intersect the New South Wales-Queensland border West of Mungindi; and (3) that the time of commencement of construction of the Pike Creek Dam be subject to the approval of the parties concerned, and the decision to construct the Mole Creek Dam be subject to approval by the States after considering the recommendations of a report by the Commission into the practicability of such a dam.

In the 1970/71 financial year, the State Governments authorised expenditure to cover the cost of detailed investigation and design of the Pike Creek Dam. In the 1972–73 financial year the States formally agreed that the Dam be constructed at an estimated cost of $14 million and that construction commence on 1 July 1972.

NAME OF DAM

The Commission considered it appropriate that the name of the dam should commemorate a name closely associated with the history of the area.

In an attempt to determine the location of the dam in relation to the original Mingoola and Glenlyon holdings, the commission consulted the records of the Oxley library in Brisbane, the Queensland State Archives, and the Mitchell Library in Sydney, and held discussions with descendants of early settlers of the area. The earliest reference found to the boundary between these holdings was in the Queensland Government Gazette of 28 January 1871, and this is presumably the original eastern boundary of Glenlyon, established when the holding was taken up by Alexander McLeod in 1844. It was described as:

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* *'Progress Report on Groundwater Investigation of Dumaresq River alluvium A.M.T.M. 25 to A.M.T.M. 110' –Irrigation and Water Supply Commission — June 1965.*

** *'Report on Works Proposed under The New South Wales-Queensland Border Rivers Agreement.' - Dumaresq Barwon Borders Rivers Commission — March 1961.*

. . . the watershed (separating Pikes Creek and the Severn River) southerly to a tree on Pikes Creek marked broad arrow over M, then by the left bank of that creek downwards to its junction with the Severn River.

The dam, and the entire storage area is thus situated on the western side of this boundary, in the Glenlyon holding, and the name Glenlyon Dam was recommended to, and approved by, the two States and the Queensland Place Names Committee.

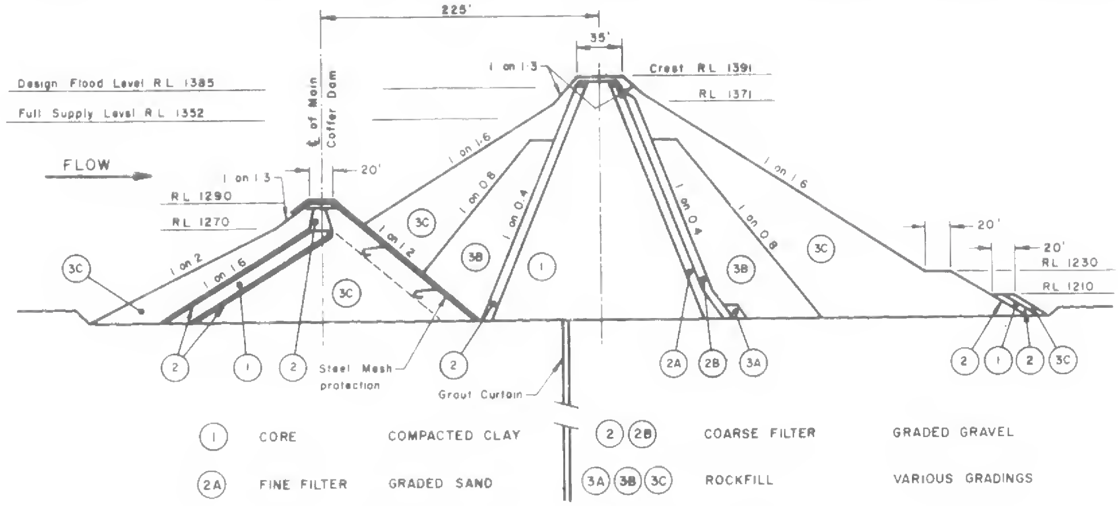
STRUCTURE AND CAPACITY

The dam is an earth and rockfill structure, 61 metres high, has a storage capacity of 261 000 megalitres, and commands a catchment area of 1326 square kilometres (Fig. 1). The embankment required a total of 915 000 cubic metres of rockfill, 385 000 cubic metres of impervious core material, 128 000 cubic metres of filter material and some 10 720 cubic metres of concrete aggregate.

The spillway consists of an ungated concrete crest of width 74·4 metres discharging into a partly lined concrete channel which will pass flows back to the stream.

The outlet works are designed to utilise the 3·66 m diameter concrete lined diversion tunnel used during construction and will provide releases commensurate with downstream irrigation requirements. These works comprise on intake tower constructed at the upstream portal of the diversion tunnel, the tunnel itself, and a valve house at the downstream portal to regulate outflows.

Glenlyon Dam provides an annual assured supply of water for irrigation at Mingoola gauging



SECTION THROUGH EMBANKMENT

GLENLYON DAM

STATISTICS

CATCHMENT AREA	1326 km²	512 sq miles
STORAGE CHARACTERISTICS –		
CAPACITY	261 000 Ml	212,000 ac/ft
SURFACE AREA	1 750 ha	4,300 acs
LENGTH ALONG PIKE CK	27 km	17 miles
PRINCIPAL DIMENSIONS –		
HEIGHT OF EMBANKMENT ABOVE BED	61 m	200 ft
LENGTH OF EMBANKMENT CREST	445 m	1,460 ft
WIDTH OF SPILLWAY	74·4 m	244 ft
VOLUME OF FILL IN EMBANKMENT –		
CLAY	385 000 m³	503,000 c yds
FILTER	128 000 m³	167,000 c yds
ROCK	915 000 m³	1,196,500 c yds.
TOTAL	1 428 000 m³	1,866,500 c.yds.

VOLUME OF CONCRETE (TOTAL)	10 720 m³	14,020 c yds
TUNNEL	3 540 m³	4,630 c yds
INLET TOWER	1 470 m³	1,920 c yds
OUTLET WORKS	970 m³	1,270 c yds
SPILLWAY & BRIDGE	4 740 m³	6,200 c yds
DIVERSION TUNNEL :–		
LENGTH	254·5 m	835 ft
DIAMETER AFTER LINING	3·66 m	12 ft
OUTLET WORKS :–		
HIGH CAPACITY OUTLET DIA.	1 500 mm	60 ins
LOW CAPACITY OUTLET DIA	600 mm	24 ins

FIG. 1: Statistics of the Glenlyon Dam.

station of 98 000 megalitres, shared equally between Queensland and New South Wales. The manner of distribution of released water from the dam is a matter for the individual States. It is envisaged that principal use will be made by individual riparian landholders pumping directly from the river.

Schemes such as community pumping, and reticulated channel development of lands away from the river are considered not economically justified in the short term, but these will probably prove viable in the longer term.

ANTICIPATED BENEFITS

The Border Rivers area is subject to low rainfall (480 to 660 mm per annum) and erratic and unreliable streamflows. In April 1973 there were 215 pumps in New South Wales and Queensland licensed to irrigate a total of 4900 hectares along 497 kilometres of the Border River System between the dam and Mungindi (where the river ceases to be the Border). Some 82 of these licenses, involving 2550 hectares of irrigation, were unable to pump during periods of low flow, and only some 133 licenses involving 2350 hectares had an assured supply. These low flow conditions occurred for 200 days or more in 11 of the 27 years 1920–1946, with a maximum of 320 days in 1923; and for 170 days or more in each of the 10 years 1935–1944.

The supply of water from the dam will stabilise this situation and allow assured supplies of irrigation water for 14 570 hectares, an increase of 12 220 hectares over the 1973 figure.

Social and economic benefits expected to accrue from the scheme include: (a) the opportunity for landholders along the river to expand irrigation production which can be adapted to meet changing market situations; (b) integration with existing livestock production over a broader area, with provision of a large pool of annual fodder close to the grazing areas for supplementary and/or drought fodder; (c) decentralisation, by arresting drift of population from the project area; (d) additional advantages in increased business activity and retail trading in the area; and (e) a recreational facility for swimming, boating, water skiing and picnicing.

Mem. Qd Mus. **19** (1): 5-16, pl.s. 1-2. [1978]

THE GLENLYON REGION, SOME FACETS OF ITS HISTORY

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ABSTRACT

Following exploration of the area by A. Cunningham, and later by P. Leslie, the settlement of Glenlyon run from 1840 is followed in detail. Some of the history of Pike's Creek, Mingoola, and Texas runs is also included. The discovery and later exploration of the Glenlyon or Texas Caves is discussed. Reference is made to the early development of the tobacco growing industry at Glenlyon and Texas, in association with the formation of Texas town. The history of mining in the area is given with emphasis on the Silver Spur mine.

EXPLORATION

In 1827, botanist-explorer Allan Cunningham passed around the area of this study on his discovery trip to the Darling Downs (Russell 1888, pp.77–126; Hamilton 1961, pp. 323–42; and Steele 1972, pp. 215–24). Journeying north from Segenhoe, Cunningham and his party of six convicts crossed the river now known as the Dumaresq (named by him Macintyre Brook) near the present location of Beebo, west of Texas. He then passed northeast to the Darling Downs, around the area now occupied by Glenlyon Dam. On his return journey he came upon a stream which he believed to be his Dumaresq River. This, according to Hamilton (1961, p.335) is the Mole. He followed this northwest, and on 2 July, 1827, came to its junction with the present Dumaresq (or Severn) River. At this point he was almost in sight of the mouth of Pike Creek, on which Glenlyon Dam now stands. Cunningham followed the Dumaresq River until it changed direction towards Texas, then he turned south and left the area of interest.

Thirteen years elapsed before the next exploration of the area. Squatters gradually moved north through New South Wales to just south of the Queensland border. By 1840, two squatters, Garden and Bennett occupied one of the southern tributaries of the Dumaresq River. Russell (1888, pp. 164–71) quotes from information received from Patrick Leslie in 1878, which Leslie based on his own written records. Leslie and a convict servant, Peter Murphy, left Garden and Bennett's on 8 March, 1840. He describes the first exploration of the Glenlyon Dam area:

'On the morning of the 14th of March, crossing the Severn River, we came on the junction of a large stream nearly opposite the junction of the Mole and Severn. This was afterwards called Pike's Creek. We followed this creek up a considerable distance (encamping several nights)'.

SQUATTERS

From 1840 on, exploration and development of the area was in the hands of the squatters. Government Gazettes listed some of the holders of licences to depasture stock beyond the limits of location, and later the holders of leases of Crown Land. Unfortunately, often the leaseholder was only involved financially, while someone else worked the property. More detail can sometimes be found in reports of the Commissioners of Crown Lands, held in the State Archives. Another major source of information is the published reminiscences of those actually working the properties (e.g. De Satgé, 1901, and Gunn, 1937).

GLENLYON, EARLY HISTORY

The original holdings of the Glenlyon run encompass most of the present Dam area. Early references give the name as Glen Lyon, probably after the glen in Perth, Scotland (the Times Atlas 1967, p. 92). Glenlyon was taken up by Archibald Garden on 17 July 1840, and he held a licence to depasture stock on Glenlyon until mid 1844 (Archives Office, N.S.W., ref. 4/91–108, 4/112) with licence numbers 40/158, 41/681, 42/766 and 43/60. His licence to depasture, without the name of the run, was published in the New South Wales Government Gazette (1840 and 1843). From the Archives Office of New South Wales (ref: X816) the Commissioner of Crown Lands, George James MacDonald, provided a description of Glenlyon dated 26–27 February 1841, which indicates that Glenlyon was held and worked by A. Garden, with one hut, nine residents, ten cattle, one horse, 3000 sheep; It extended for ten miles and was six miles from the nearest adjoining Station.

As there is no trace of a depasturing licence in Garden's name for 1844, it seems likely that the property was vacant when Alexander McLeod (Plate 1A) and his family, with his son-in-law Richard Wright (Plate 1B), arrived in search of land. In the book 'Terrica Inglewood Queensland', (Anon, n.d.) which was probably based on information supplied by Roderick McLeod, one of Alexander's sons, it is stated that '. . . they camped about seven miles from Mingoola, in the vicinity of Glen Lyon, which place they later took up'. Scott McLeod Walker, the present owner of Glenlyon and a great grandson of Alexander McLeod indicated (Walker, pers. comm. 1975) that Roderick, who would have been a teenager when they arrived on Glenlyon, recountered that the first campsite was on the creek flat in front of the cave now known as Main Viator Cave, where they grew grain for bread, probably the first agricultural endeavour in the area.

A depasturing licence was taken out on 8 November 1844 (Harslett and Royle 1972, p.13), in the names of Alexander McLeod and Richard Wright. Alexander remained on Glenlyon for about a year after which time the property was worked by his eldest son Donald and Richard Wright, until Alexander returned some years later ('Terrica Inglewood Queensland').

In the N.S.W. Government Gazette (1849, **2**, p.1212) Glenlyon is described as follows:

'No. 129. McLeod and Wright; Name of Run — Glen Lyon; Estimated Area -- 38,400 Acres; Estimated Grazing Capabilities — 12,000 Cattle.

'The Glen Lyon run is 10 miles long and 6 miles broad, there is about one third of it of little use, it being a stoney and ridgy country, it is bounded on the north by an understood boundary line between Mr. Trevethan's Station, and the Glen Lyon Station; on the east by the dividing range between Pike's Creek and the River Sovereign; said range running to the turn of said creek, and under the junction of a small branch of a creek, on the opposite side called the Little Plain or the Oakey Creek, where there is a marked tree line; and on the south and west from the said marked tree, and by a dividing range running between the Glen Lyon Station, and the River Sovereign to the head of the McIntyre Brook.'

PIKE'S CREEK

There is a local legend reported by Gunn (1937, pp. 77–8) and supported by Howarth (1957), that W. B. Fitz, manager for Captain Pike, of Pikedale is supposed to have stolen Pike's Creek by cutting down the marked trees on the Glenlyon boundary and marking new boundaries north and south to define Pike's Creek. Gunn suggests this must have been about 1859. Howarth quotes an 1850 Crown Lands Commissioners description of Pikedale as indicating the original boundary.

Although an interesting anecdote, there is little else to support the legend. Reference to Mr. Trevethan's Station noted above, and the fact that in the N.S.W. Government Gazette (1847, **1**, p. 574) Pike's Creek is stated to be leased by Ewen Campbell and in 1848 (N.S.W. Government Gazette 1848) by A. Trevethan, together with the fact that in 1852 A. Trevethan transferred the lease of Pike's Creek to Captain John Pike (N.S.W. Government Gazette 1852), all tend to contradict the legend. These references all indicate that Pike's Creek was taken up by 1847, and there is no evidence of Fitz holding a depasturing licence before 1847, nor is there any official indication of boundary disputes with Pikedale or Glenlyon. Pike's Creek was named after Captain John Pike of Pikedale Station, according to Place Names Board records.

MINGOOLA

Another run adjoining Glenlyon is Mingoola (also spelt Mangola or Mengoola). The present Glenlyon Dam wall lies close to the original boundary between Glenlyn and Mingoola. Mingoola was probably taken up in 1840 but the first published record found is in the N.S.W. Government Gazette (1845) when the licence was held by William Morgan. At some stage the lease was transferred to S. A. Donaldson, and in 1854 F. R. Chester Master purchased both Mingoola from Donaldson, and Glenlyon from McLeod and Wright (N.S.W. Government Gazette 1854). Alexander McLeod subsequently moved to Gladfield run near Singleton (Anon, n.d.) while Richard Wright, his wife, and large family moved to Ipswich (Ware 1971).

GLENLYON, DEVELOPMENT

Oscar De Satgé worked on both Mingoola and Glenlyon during 1855 and recorded his experiences (De Satgé 1901, pp. 42–52). Mingoola was the headquarters of operations, running only cattle, while Glenlyon ran sheep. Glenlyon was still at this time 'in the rough'. The sheep overseers were Headley and Dunlop, two Scotsmen. There were yards for lambing sheep, the sheep were washed under primitive conditions prior to shearing which took place on rough slabs under a bark roof. Few capital developments had been made to Glenlyon at this time. Exactly when Chester Master sold his lease is unknown, but in April 1859, a transfer occurred from the Bank of New South Wales to A. Walker (N.S.W. Government Gazette 1859).

From available records (Queensland State Archives CLO/13 and LAN N69) A. Walker transferred the lease to Henry Davis in 1861. Davis mortgaged to Edward Lotze and James M. Larnach whose names appear on the lease for 1861. In 1862 there is a transfer back to Davis, then to Alex Heywood Richardson. In 1868 the lease went to the Australian Joint Stock Bank of Sydney although Davis was still working the property at this time (Official Post Office Directory 1868). In 1871 the lease was taken by Thomas Walker. From discussion with Scott Walker, it seems that Henry Davis probably worked Glenlyon throughout 1861–71. He was certainly responsible for building the fine home (Plate 2A) still occupied by the owners of Glenlyon. The results of the Census of 1871 give an indication of the great development at Glenlyon under Davis (Votes and Proceedings 1872) when there were twenty-three dwellings, and a population of sixty-one, including twenty females.

Financed by Thomas Walker, Glenlyon was worked by William Henry Walker and H. S. Harden until W. H. Walker pulled out in 1877.* In January 1876, Glenlyon was divided into two runs; Glenlyon in the north and Emu Vale in the south. This was necessary to conform to the legal requirement that no single run should have an area of more than 100 square miles, whereas at that time the total Glenlyon run was estimated at 161 square miles (Queensland State Archives M173.421/26 and LAN N69).

Harden continued to work Glenlyon after 1877. Under the Crown Lands Act of 1884, the two adjoining runs had to be consolidated, again as Glenlyon. In 1886, the southern section was resumed for closer settlement, while Thomas Walker retained 77 square miles in the north, as Glenlyon (Queensland State Archives LAN N69).

Donald Gunn worked Glenlyon (Gunn 1937, p. 88). He was certainly residing there on 2 January 1886, when he was listed as a Justice of the Peace (Queensland Government Gazette 1886). The lease remained in the name of Thomas Walker until his death in September 1886. The lease was then held by his executors J. T. Walker, Joanne Walker and A. Archer, until its transfer to Anna Sophia Gunn and Donald Gunn on 25 February 1890, and on 26 August, 1890 the lease was transferred to H. L., W. E., A. G. and V. M. White of Scone (Queensland State Archives LAN/AF 203). Samuel Cobb managed Glenlyon for the Whites. The Cobb family believe that he may have initially been in partnership with the Whites (Cobb 1975). There was further improvement made to Glenlyon in this period. The new twenty-stand shearing shed, still standing in 1976, was built about 1892 (Walker, pers. comm. 1976), and the records of the Department of Education indicate that Glenlyon school opened officially on 1 May 1899, further lessening the hardship of the pioneering life.

In August 1900 the lease on Glenlyon was transferred to Roderick McLeod (Plate 1c) thus returning the run to the family that came there originally in 1844. The run was managed by W. Donovan until 1908 (Walker pers. comm. 1976) when Roderick's daughter Enid married and the run was transferred to her. Further areas were resumed from Glenlyon in 1902 and 1907 (Queensland State Archives LAN/AF 203). In 1939 Scott McLeod Walker took over Glenlyon, and still works it today, from the home built by Davis in the 1860s.

The most recent resumptions from Glenlyon were those required for the new Dam. It is ironic that, because Glenlyon is above the Dam, it lost its irrigation licence on completion of the Dam, which is aimed at providing irrigation, but only for holdings downstream from the dam.

CAVES

Public interest in the Glenlyon Dam project was aroused particularly because of the limestone caves in the area to be flooded by the Dam.

Although the caves are in the tribal area of the Kambawal (Tindale 1974, pp. 173–4) there is no

* Womens Historical Association, plaque on Glenlyon homestead, 1966.

known evidence of aboriginal use of the caves. Two of the major caves were certainly known to the McLeod's after their arrival in 1844 (Walker, pers. comm. 1975). Since that time, the caves, locally referred to as Glenlyon Caves, were visited occasionally by local residents for picnics. A selection of signatures and dates recorded from the walls of Main Viator Cave (Grimes, pers. comm. 1976) includes the earliest discernable entry 'George Green 1892'. Other notable names include 'D. D. Gunn 1908', and the Jeffrey family in 1924. The Jeffreys held the lease on Mingoola from 1874 (Jeffrey 1975).

Detailed knowledge of the caves was gathered through the activities of the University of Queensland Speleological Society (Formed in 1960, Bourke 1970, although exploratory trips had been made in 1959, Bourke 1969). The first major exploration of the caves in the area occurred in August 1961, and since that time, scientific and mapping trips have continued. The Queensland Museum's Geologist accompanied one of these trips. The caves were given names. Main Viator Cave was named after the run which was selected from the resumed part of Glenlyon, as Grazing Farm No. 151, by F. D. C. Gore in June 1888 (Queensland State Archives, M173. 421/26). The name Viator was not applied until C. F. Walker took over the lease in 1926 and changed the name from The Glen (Queensland State Archives, LAN/DF 4365D). The Glenlyon System was named after Glenlyon run. In August 1967, a third major cave was discovered. Its first entry (VR-2) was dug out by hand by H. Shannon, R. M. Bourke and Margot Greenhalgh. Its discovery '. . . transformed Texas from a minor caving area into one worth fighting for' (Bourke 1975). The new cave was named Russenden Cave after Grazing Homestead 3630, taken from Glenlyon's holdings in the late 1940s by E. and F. M. Filmer (Walker, pers. comm. 1976).

Press announcement of the Pike Creek Dam project started a strong move by the Speleologists for the conservation of the caves. This culminated in the publication of 'The Case against the Pike Creek Dam' (U.Q.S.S. 1973). Mapping and study of the caves continued, and after the temporary flooding in February 1976, several new areas opened by the water in Main Viator Cave were mapped (Shannon 1976). On 23-24 October 1976 the Society visited the Caves, by canoe. Main Viator was flooded but Russenden was still dry (U.Q.S.S. 1976). By March 1977, the water was up to the ceiling of Russenden's main chamber (Shannon 1977).

TOBACCO

Apart from early mention of graingrowing on Glenlyon, Scott Walker recalled (pers. comm.) that until the 1950's traces of the buildings used by Chinese tobacco growers could be seen across Pike Creek from Glenlyon homestead. These were believed to date from the 1890s. Texas has been the centre of the local toabacco industry for many years, but the earliest history of this industry is still under study by the Texas Historical Society, who have so far traced the industry back to 1876–7 (Glassen 1976).

Muir (1969–71, p.8) states (without quoting a source) that '. . .by 1865 tobacco cultivation had spread from Tamworth in northern New South Wales to Texas in Queensland.' It seems more likely that Chinese miners, who came to the Stanthorpe area as early as 1872, turned to tobacco growing and spread the activity throughout the region (Wadham 1967, pp.109–10; Harslett and Royle 1972, pp.43, 69).

The town of Texas took its name from the Texas run. By October 1840 (Russell 1888, p.197) John McDougal had a run on the Severn, and in 1847 he is listed as holding a licence to depasture on Texas run (N.S.W. Government Gazette 1847, p.576), probably the same run. Texas town was surveyed under instructions dated October 1875 (Lands Department Map). In Baillier's Queensland Gazetteer (Whitworth 1876, p.185) Texas is described as having, '. . . no mills nor manufacturers . . .' and '. . . land suitable for agriculture in the neighbourhood, but it is not yet open for selection'. A copy of a report, held by the Texas Historical Society (Ross 1886) shows that by then 100 acres were under tobacco and Mr Edgar Greenup operated a tobacco factory.

Agricultural activities were listed in Votes and Proceedings of the Queensland Parliament. The earliest reports for Texas may be included in the Inglewood District (Queensland Government Gazette 1873), for which tobacco is first mentioned in 1881 (Votes and Proceedings of the Queensland Parliament 1882). Texas is listed separately for the first time in 1896, with 482 acres under tobacco (Votes and Proceedings of the Queensland Parliament 1897).

At this time the Government regarded the industry as of sufficient importance to appoint Mr R. S. Neville as Tobacco Expert to the Department of Agriculture (Queensland Agricultural Journal 1897). In 1901 Mr Neville established a temporary State Tobacco Farm at Texas (Queensland Agricultural Journal 1901).

A letter from Mr Stephen H. Jennings (Jennings 1972) indicates that the company he worked for, W. D. and H. O. Wills, built a tobacco handling shed in Texas about 1907 to take leaf produced by Chinese growers. This was converted to a Stemmery in 1908–9 and closed down about 1916–17. This work was managed by Jenning's father. In 1909–10 an area named 'Raleigh' was leased by W. D. and H. O. Wills and a village built to accomodate English immigrants sponsored by the company through the Queensland Government. Crops of tobacco were planted in three seasons from 1911 to 1914, but lack of farming experienced by the immigrants, coupled with tobacco diseases and poor seasons led to the failure of this unusual experiment in sponsored migration.

Probably because of the war, by 1918 the area under tobacco in the whole Inglewood-Texas area was only 172 acres, largely in the hands of the Chinese (Queensland Journal of Agriculture 1920). Since then the fortunes of this industry have continued to fluctuate, gradually moving into the hands of European and Australian growers.

MINING

Apart from the State Arsenic Mine at Jibbenbar, which operated from 1918 until about 1930 providing prickly pear poison (Harslett and Royle 1972, p. 49), the only other major mining venture was at Silver Spur. Other deposits of copper, silver etc. were located at a number of sites and some were worked briefly (Skertchly 1898; Ball 1904; and Robertson 1972). In 1888 copper was found on Glenlyon itself but no major working of the deposit appears to have occurred (Department of Mines 1888).

The reports by Skertchly, Ball and Robertson cited above and reports by Saint-Smith (1913) and Ball (1918) provide some brief history of the discovery of the Silver Spur mine and much of its complex geology. The most complete history of the mine was published in the Stanthorpe Border Post (1925) in a series of at least four unsigned articles from 11 December 1925. Two of these articles (11 December and 31 December 1925) have survived in the hands of Mrs L. Boyce of Toowoomba. Her father Edgar Hall was the driving force behind Silver Spur mine and was almost certainly the author of the newspaper articles.

The ore deposit was discovered by a fencing contractor, John White, through surface traces of copper ore, and a syndicate was formed with operators of the nearby Texas Copper Mining and Smelting Company mine, who arranged for a Mr Valentine to sink an exploratory shaft. Very little copper ore was found and work was abandoned.

Mr Dodgson, editor of the Border Post, on a visit from Stanthorpe inspected Valentine's shaft and, on his advice, a sample of the ore was sent to Messrs Stokes and Hall in Brisbane for assay. The assay indicated over 200 ounces of silver to the ton.

As the copper syndicate abandoned work, the claim was 'jumped' and a lease applied for and granted to John Quinn. This was Mineral Lease No. 54 taken out on 1 October 1892 (Queensland State Archives MIN/05). Pressure from members of the original syndicate resulted in the formation of a new group under Mr C. N. McKenny, Manager of the Texas run.

Edgar Hall was asked to advise on the mine and visited the site in November 1892. During that visit, McKenny, a keen horseman, suggested the name Silver Spur for the mine. Little work was done by the new group and Edgar Hall was given the option to work the mine, which he took over on 1 May 1893. He had the help, until 1902, of his partner in the Brisbane assay firm, Mr H. G. Stokes, whose work as Mine Manager was highly praised by the Government Geologist, S. B. J. Skertchly (1898, pp. 88–9). The mine (Plate 2B) was in almost continuous operation from 1893 until 1913. During this period 94,000 tons of ore were treated, yielding 2,100,000 ounces of silver, 4208 ounces of gold and some lead and copper.

Transport of equipment and products, as well as the complex nature of the deposit and ore, was a problem. According to Mrs Boyce, the company offered to pay for a railway branch line from the South-Western Railway. Parliament passed a Bill authorising construction of the line by the State, in 1914 (Ball 1918, p. 153). Unfortunately this was not carried out. A line was eventually built, in 1930, to Texas (John Oxley Library). The mine worked intermittently between 1916 and 1926 (Robertson 1972, pp.20–1) but in the 1930s the company was wound up (Boyce, pers. comm. 1976). Since then others have taken an interest in the area. A trial shipment of 159 tons of ore in 1952 yielded 31 ounces of gold and 9,329 ounces of silver (Robertson 1972, pp. 20–1). More recently, in 1975 Mount Carrington Mines Ltd. were investigating the area. At its peak, Silver Spur was a significant town (Plate 2C) with a school and later a church, but now few buildings remain.

ACKNOWLEDGMENTS

Mr and Mrs Scott McL. Walker of Glenlyon provided considerable help and hospitality. Of the many people who had previously provided information to Scott Walker, mention should be made of S. H. Ware, Mrs T. Cobb, A. W. Cameron and G. S. Jeffrey. Mrs G. Wright, Mrs C. Glassen, L. R. Jeffrey and other members of the Texas Historical Society were most helpful. Mrs L. Boyce, Mrs J. Harslett and T. Muir also provided considerable assistance. The staff of the John Oxley Library, the Fryer Library, the Mitchell Library, the Archives Office of N.S.W. and the Queensland State Archives all provided valuable assistance. Photographs were loaned for copying by S. Walker, L. R. Jeffrey and Mrs L. Boyce.

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PLATE 1

FIG. A: Alexander McLeod, lessee of Glenlyon 1844–54.

FIG. B: Richard and Ann (McLeod) Wright. Six of Ann's thirteen children were probably born on Glenlyon. These were the pioneers.

FIG. C: Roderick McLeod, son of Alexander, purchased back Glenlyon in 1900.

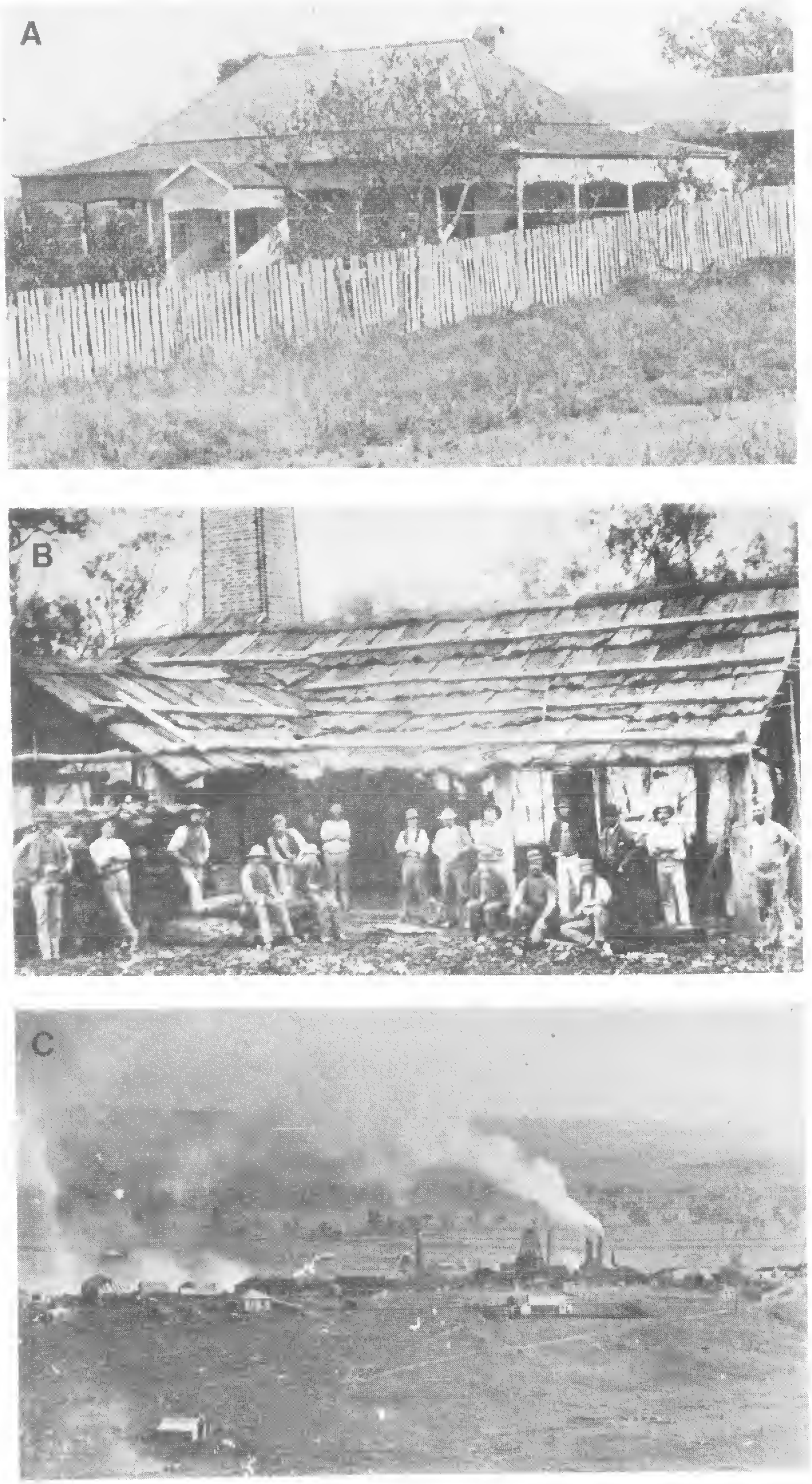

A


B


C

PLATE 2

FIG. A: Glenlyon homestead before 1900.
FIG. B: First smelter at Silver Spur 1894.
FIG. C: Silver Spur from the northeast *c.* 1911.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THE GEOLOGY AND GEOMORPHOLOGY OF THE TEXAS CAVES, SOUTHEASTERN QUEENSLAND

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ABSTRACT

The Texas Caves are in the only significant karst area in southeast Queensland. The caves occur in Carboniferous limestone lenses within the Texas Beds of the New England Fold Belt. Pleistocene stream incision exposed the limestones and allowed cave development to begin in late Pleistocene times.

The partly collapsed Glenlyon Cave System is a subterranean cutoff of a meander spur of Pike Creek. High energy stream passages are superimposed on an earlier low energy phreatic system. Complete capture of the creek has not occurred as collapsed sections of the cave have restricted water flow through the system. On Viator Hill there are two moderately large caves and a number of smaller 'potholes'. These are dominantly low energy phreatic systems. Once formed, the two larger caves show a history of initial sedimentation and speleothem formation, followed by erosion and then further sedimentation and speleothem growth. The depositional periods are thought to relate to deteriorating climates and aggradation of the surface stream channel, while the intervening erosional period relates to a stable climate and stream incision. The Viator Hill cave sediments are mainly silty clays with locally abundant clay aggregates derived from surface soils. Some old guano deposits are incorporated. The sediments of the Glenlyon System are stream deposited silts and fine sand, with minor gravel.

Surface karst forms include a diversity of well-developed karren forms, as well as dolines, karst windows, and a natural arch resulting from collapse in the Glenlyon System.

The Texas Caves is a general term for the group of caves found adjacent to Pike Creek, a few kilometres upstream from the Glenlyon damsite and about 30 km east of the town of Texas, in the Border Rivers District of southeast Queensland. With the exception of one cave at Riverton, 10 km to the south, the Texas Caves are the only known limestone caves in southeast Queensland. The caves have been flooded by the Glenlyon Dam. This report will record the features of the caves area together with an interpretation of their development.

Main Viator Cave and the caves and dolines of the Glenlyon System have been known for a considerable time (Robinson 1978). In Main Viator Cave signatures have been seen dating back as far as 1892. The area has been visited regularly by the University of Queensland Speleological Society (UQSS) since its inception early in the 1960's and the society was the main body behind the unsuccessful campaign to prevent the flooding of the caves (UQSS 1973). The society discovered and explored Russenden Cave as well as most of the smaller caves on Viator Hill, and has explored the Glenlyon System in detail. Most of the caves in the area are covered by published and unpublished maps prepared by the UQSS (see Appendix 1) and these provided the basis for the author's field work. The maps accompanying this report are generally based on the UQSS surveys with some additional details added by the author. Although brief descriptions and information on aspects of the caves have been given from time to time in the UQSS newsletter *Down Under,* and brief summaries of the caves appear in the Australian Speleo Handbook (Matthews 1968, and in prep.), few detailed descriptions have been published (e.g. Shannon 1975, Grimes 1975, Grimes and Brown 1976). Interim reports on the studies carried out by the Geological Survey of Queensland (GSQ) are on file at that office (Tweedale 1970, Grimes 1973).

Field work involved general mapping and observations on the geology and geomorphology of the area. A brief preliminary survey was made in 1970 by G. Twidale, A. Graham, and E. Howe (Twidale 1970). The author worked in the area between 1973 and 1975 and in addition visited the area a number of times with UQSS parties. Most, but not all, of the caves were entered and information on the remainder was provided by UQSS members. Several levelling traverses were made on the surface to allow comparison of the cave levels with the stream terraces, and to provide information for the contour map of the Glenlyon System. The traverses were tied into previous surveys by the UQSS and to Water Conservation and Irrigation Commission (WCIC) survey marks which provided absolute elvations. Fossils were collected from the limestones at a number of localities and some of these are described by P. J. G. Fleming in Appendix 2. Several auger holes were drilled in Main Viator and Russenden Caves in order to study the cave sediments. Archer (1978) examined the bone deposits.

Laboratory tests on the cave sediments included mechanical analysis, spot tests for carbonate and phosphate, pH testing (using the CSIRO soil testing kit) and X-ray analysis of clay minerals. Detailed results are listed in Grimes (1977) and summarised in this report Attempts to extract pollen and spores from the sediments proved unsuccessful (H. Hekel and C. Bell, pers. comms.). Sediment colours are based on the revised Standard Soil Colour Charts of Oyama and Takehara (1967). Thin sections were cut from a number of limestone samples.

A grid has been used on the surface maps and the maps of the larger caves to facilitate references to localities. This grid is oriented to magnetic north (1975) and based on the WCIC bench mark 78 A which has been given the arbitrary co-ordinates of 2 000 m east and 3 000 m north. Grid references to the small scale Map 10 are to the nearest ten metres and use the first three significant figures while references to the larger scale Map 9 and the cave maps are to the nearest metre and use the last three significant figures.

The cave surveys are not all to the same standard and the accuracy has been indicated by use of the Cave Research Group of Great Britain (CRG) grading system which uses instruments and surveying techniques as a guide to accuracy (Sexton *in* Matthews 1968).

The terminology of cave features used here is basically that of Monroe (1970) and Jennings (1971). Some modifications and additional terms have been used and are briefly discussed here.

In Australia the term 'shawl' has often been applied in a general sense for all types of flowstone sheets hanging from roofs and projecting from walls. Here the term *curtain* is used for an undulating sheet, while *shawl* is restricted to Monroe's usage for a triangular sheet hanging from a ceiling. The term *ribbon* (Halliday 1974) is used here for a narrow, unconvolated sheet on a wall or sloping roof (Plate 3d).

The descriptive term *wall solution undercuts* is used for features illustrated in Plate 5a, that are attributed to prior water levels. They have no floor. Where more or less horizontal channels have been cut into a wall, and therefore have a narrow floor, the term *stream channel incut* is used and these are taken to indicate an old stream level at a time when the floor of the cave was higher.

Etch grooves are narrow, but relatively deep grooves often forming a network. They probably derive from solutional etching by water percolating through small joints in the rock. They are illustrated in Plate 4c and discussed in the section on the Dustbath (GL-6).

The term *blind shaft* is used here in preference to 'aven' in its English usage. When the hight is not more than twice the width, and it has a curved, bell-shaped form the term *bell-hole* is used (Plate 6a).

The two water filled shafts at the upstream end of the Glenlyon system have been called 'cenotes'. This is not a strictly correct usage of the term, which normally applies to much larger features, but it is retained here for conveniences of identification.

Red earth breccia is a term used here for consolidated cave deposits composed of limestone fragments and often bone material in a matrix of red earth; the whole commonly being cemented by calcite. The matrix is often more abundant than the limestone or bone fragments and there is a variation which consists of red earth fragments in a brown calcite 'tufa' cement.

REGIONAL GEOLOGY

The regional geology of the area is shown in the inset to Map 10. The geology has been discussed by Lucas (1960), Olgers and Flood (1970), Olgers *et al.* (1974) and Senior (1973). A structural interpretation has been presented by Butler (1974). The Cainozoic history can be compared with that presented by Browne (1969) for northern New South Wales. The limestone resources of the area have been delineated by Siemon (1973). The following discussion is based largely on these reports.

The caves occur in limestone lenses within the Texas Beds. These beds probably range in age from Devonian to Late Carboniferous, though the limestones containing the caves have Early Carboniferous (Visean) corals (Olgers *et al.* 1974;

and Appendix 2). The Texas Beds form part of the Wooloomin-Texas Block of the New England Fold Belt. They are a thick sequence of regularly bedded lithic sandstone and mudstone with minor chert, jasper, intraformational conglomerate, intermediate volcanics, and limestone lenses. Olgers *et al.* (1974) suggest that the sediments were probably all laid down in shallow water, but below wave base, and that thin submarine andesitic volcanics, up to 60 m thick, provided shallow 'banks' on which the coral reefs could be built. On the other hand Butler (1974) interprets the sediments as deep flysch deposits, and considers that the limestones are allochthonous blocks derived from the shelf to the south-west.

The Texas Beds were intensely deformed during a Carboniferous orogeny; dips are often steep to vertical and the beds are overturned in places. Butler (1974) interprets the structures as being due to a series of north-easterly moving nappes.

Permian sediments occur in fault blocks within the Texas Beds. Permian volcanics are found further east. The Beds have been intruded by Permian and Triassic granitic rocks of the New England Batholith.

The Jurassic and younger sediments of the Surat Basin overlie the Texas Beds to the north-west.

No detailed studies of the Cainozoic history of the region have been made and it is necessary to rely on general accounts in order to date the local features.

Basalt was extruded in parts of the region in late Oligocene and early Miocene times (Webb *et al.* 1967; Wellman and McDougall 1974). Senior (1973) indicates that these cover an early Tertiary lateritic surface.

A planation surface can be recognised in the area from summit conformities and occasional small plateau remnants at elevations at or above 600 m. This would appear to be the 'upper erosion surface' of Watkins (1967), which postdates early Miocene basalts. It may also correlate with the Miocene duricrusted peneplain postulated by Browne (1969) in northern NSW. Dissection of this surface would have been initiated by later uplift, the age of which is uncertain, though Browne (1969) suggests two phases: the late Miocene Macleay Epoch, and the late Pliocene and early Pleistocene Kosucisko Epoch.

The present stream valleys are the culmination of this erosion and the terraces and flood plains which occur in them are probably of late Pleistocene or Holocene age.

GEOLOGY OF THE CAVES AREA (Map 10)

THE TEXAS BEDS: The Texas Beds in the caves area are composed mainly of dark grey to black massive mudstones which are strongly jointed. A few chert beds occur and also some outcrops of rhythmically interbedded mudstones and labile sandstones; dip measurements are only possible in these outcrops. The strike of the steeply inclined beds is to the northwest. Facing is not known. A tightly folded synform occurs at 258367 (Map 10) with nearly vertical dips on either side.

Most of the limestone is contained in large lenses up to 400 m wide and 1000 m long, though there are smaller lenses grading down to beds only a few metres across. The three main lenses, which contain the caves, are those of the Glenlyon System, Viator Hill, and the Whale Rock area (Map 10). The first two are probably continuous beneath the alluvium of Pike Creek. The Whale Rock lens may have been offset by faulting, though there is no field evidence for this. The limestones are dominantly medium to dark grey, fine-grained, partly recrystallised biomicrites, with crinoid plates, corals, calcareous algae, bryozoa, pelecypod and gastropod fragments, and foraminifera as the main fossil components. Oolites and pellets are locally abundant. In some places there are irregular bodies of limestone breccias, which have a matrix of calcite, chert, or dark lutite. These may be depositional breccias. Nodular chert replacements occur in several places and there has also been some local ferruginisation.

The limestones are generally massive and bedding can only be seen in a few localities (e.g. at 216335, where there are thin interbeds of mudstone). Calcite veins are very common and generally form an irregular network, though occasionally a dominant orientation can be discerned. Joints are common with dominant strikes to the northeast and the northwest (parallel to the regional strike). Joint roses are presented in Fig. 1. Most joints are nearly vertical, though locally there are some well developed subhorizontal and inclined sets.

A description of the coral species is given in Appendix 2; they indicate an early Carboniferous (Visean) age. In addition to the GSQ collection, fossils from the area are held at the University of Queensland, the Queensland Museum, and the Kedron Park Teachers College. A rather dispersed conodont fauna has also been extracted and is held at the University of Queensland, but has not been studied in detail (G. L. Forster, pers. comm.).

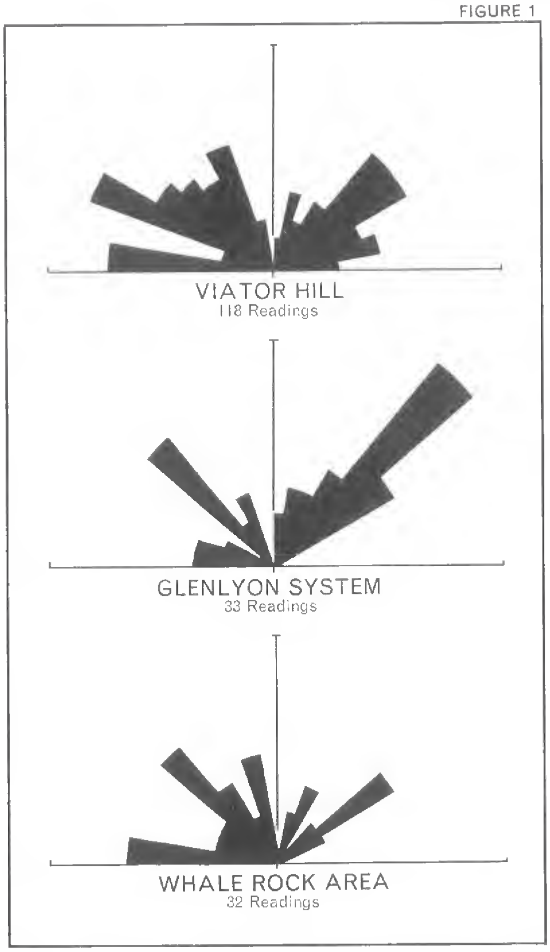

FIG. 1: Joint roses of Viator Hill, Glenlyon System and Whale Rock area.

THE CAINOZOIC SEQUENCE: A summit concordance at about 650 m in the hills above the valley may be related to the Miocene surface of Watkins (1967) and Browne (1969). The present deep valley of Pike Creek is the result of later erosion which is continuing at present. The caves, which lie in the lower part of this valley, were probably initiated in late Pleistocene times.

Alluvial terraces and high level gravels indicate several alternating stages of aggradation and incision of Pike Creek in the final stages of valley formation. These stages are contemporaneous with the evolution of the caves (see section on Cave development, and Table 1). Unfortunately no detailed studies of the terraces and their chronology has yet been attempted in the Border Rivers region.

The oldest alluvial deposits are scattered cobbles and pebbles which lie 10–15 m above the present stream bed. These are shown as Qpa on Map 10. The main alluvial terrace (Qa_2) is composed of clayey silt and fine sand and lies between six and eight metres above the present stream bed. Auger hole TA-1 (220315, Map 10) penetrated 4.4 m into this unit and revealed a soil of the Red-brown Earth type (in the usage of Stephens 1962). A detailed log is given in Grimes (1977). Below the Qa_2 terrace there is a less well-defined and less extensive level of Qa_1 deposits: clay, silt, sand, and travel with minimal soil development. This lies from two to six metres above the stream bed. The Qa_2 and Qa_1 terraces can both be seen in Plate 11a of this volume. The present stream bed (Qha) is made up of loose cobbles and pebbles, derived from Texas Beds lithologies, and minor sand and silt. Some higher banks of Qha cobbles are transitional with the lower part of the Qa_1 terrace. The depth of the alluvial deposits is not known, though at the damsite, downstream from the caves, drilling has indicated bedrock within a few metres of the present floor of the creek (WCIC 1973).

In addition to the terrace deposits there are colluvial deposits on the lower valley slopes which are sufficiently deep to mask the underlying geology. These have been mapped as Qc. An undifferentiated alluvial unit, Qa, has been mapped in some side valleys where the terrace levels cannot be distinguished.

The sequence of terraces could be due to eustatic changes of sea level, intermittent tectonic uplift, climatic variations, or a combination of these. Eustatic effects would probably not be great in view of the long distance between these inland draining streams and the oceanic base level at the mouth of the Murray River. Tectonic effects are possible; valley-in-valley forms are recorded in the New England District and are thought to indicate intermittent uplift in late Pliocene and early Pleistocene times (Browne 1969), so earth movements could have continued into more recent times. Unfortunately there have been no studies on the magnitude or timing of such movements and their effects on the stream terraces must remain hypothetical. The most likely factor is climatic control. Butler (1959, 1967) and other workers have suggested climatic changes to explain alternation between unstable phases of slope erosion and stream aggradation on the one hand and stable phases with soil formation and stream incision on the other. Butler (1967) suggests that the unstable phase is due to reduction in vegetation cover during a deterioration of the climate towards either drier or colder conditions, or both. In stable climates the vegetation can maintain its cover and slope erosion is reduced. Unfortunately there is not full agreement with this theory (see below).

The terraces in the area can be compared with similar terraces that have been studied elsewhere: in the Macleay valley by Walker (1970) and further south (e.g. Butler 1967). On the basis of relative position and soils the Qa_1 terrace at the caves would belong to the K_1 cycle and the Qa_2 terrace would correspond to K_2. The high level Qpa gravels may be remnants of an earlier K_3 cycle. Several authors have warned of the dangers of using K cycles for precise time correlations (e.g. Bowler 1967, and Young 1976). None the less, it is probably safe to make the general statement that the Qa_2 terrace (K_2) is of late Pleistocene or early Holocene age, while the Qa_1 terrace (K_1) is of Holocene age. Correlations between the terraces and the cave deposits are suggested later in this paper.

GEOMORPHOLOGY

Pike Creek is a tributary of the Dumaresq River and a part of the western drainage of the Border Rivers District which in turn is part of the Murray-Darling River system. The climate, though within the warm temperate (Cfa) class of the Koppen system is verging on the semi-arid (BSh) class. Mean annual temperature is 18.5°C, with a mean July temperature of 11°C and a mean January temperature of 24.6°C. The mean annual rainfall is 644 mm and 64% of this falls in the summer half of the year (based on data for the Texas post office; Bureau of Meteorology, 1975). The climate would appear to have fluctuated from more humid to more arid than the present during the development of the caves.

The area has a mature topography with strong relief: elevations range from 370 m A.S.L. in the valley floor up to 650 m on the crests of the main divides. Steep rocky slopes are common. The vegetation is generally open eucalypt forest.

The drainage has a moderately dense dendritic pattern. The valley of Pike Creek is generally less than a kilometre wide at its bottom and the greatest width is in the caves area, presumably because of the lesser resistance to erosion of the limestone lenses. Pike Creek tends to meander in the wider parts of its valley. The creek does not flow perennially but there are many permanent waterholes. Braided channels sometimes occur within the loose shingle deposits of its bed.

The limestone areas crop out much better than the other lithologies of the Texas Beds which are only exposed in stream cliffs and gullies. The karst morphologies of the limestones are the main interest of this report; the surface karst forms will be described first, and then the caves.

SURFACE KARST FORMS

The limestones show a wide range of surface karst forms. The most important features are the dolines or 'sinkholes', the most spectacular of which are the large collapse dolines of the Glenlyon system. The small scale solution sculpturing of the rocks shows a diversity of well-developed forms derived from both subaerial and subsoil solution.

THE DOLINES

THE GLENLYON AREA: There are about fifteen dolines in this area, ranging in size from small solutional forms to large collapse dolines up to 100 metres long and 8 metres deep, (see Maps 9 & 10). The collapse dolines were formed by the caving in of the roofs of underground chambers and their distribution indicates that the cave system was probably much more extensive at an earlier time. The two largest dolines, The Camp and Central Dolines (Map 9), act as karst windows exposing the underground stream which meanders across their floor, passing between them via a natural arch, and disappearing underground again before re-emerging on the banks of Pike Creek (see Map 9). The upstream end of the Glenlyon system, where the water from Pike Creek goes underground, is a collapsed stream cliff with large rotated blocks. The 'Briar Patch' (Map 9) is a shallow depression next to this collapsed cliff. It is regularly flooded by Pike Creek and has been largely filled with flood debris. The two 'cenotes' to the southwest of the Briar Patch are vertical collapse shafts containing water. They lie on a southwesterly continuation of the collapsed cliff. The collapse dolines sometimes coalesce to form composite forms; Crater Doline is the best example and has an irregular floor with three main depressions and a number of smaller ones (Map 9).

VIATOR HILL: Most of the dolines of Viator Hill are small solutional forms (Map 10) which have formed from the enlargement of several parallel or intersecting grikes. Sometimes there are vertical cave entrances or 'pot holes' within them. The size of the solution dolines varies from 2 to 10 metres across and up to 3 metres deep (excluding the depth of any caves or potholes). On the southeastern side of the hill there are several larger dolines of combined solutional and subsidence origin. The Main Cave entrance doline is a collapse feature at its western end, but the form of its eastern end is due more to subsidence and soil creep. Extending to the southeast from this doline are a line of three broad but very shallow subsidence dolines which extend across an area of colluvial cover (Map 10). They probably reflect the presence of an extension of Main Viator Cave along a subterranean drainage line leading towards Pike Creek.

THE WHALE ROCK AREA: This area contains only a few solutional and subsidence dolines (Map 10).

SMALL SCALE SOLUTION SCULPTURING

A great variety of small scale solution sculptures have been found in the area. The general term *karren* was applied to these features by Bogli (1960) who also described a number of specific types. English descriptive terms are applied here in accordance with the usage of Jennings (1971). The European equivalents are indicated in italics. Karren structures can be divided into two groups: the surface structures which develop from the solution of the bare rock outcrops by the action of rain water, and the subsoil structures which form from the solution of the rock beneath the surface by soil water.

THE SURFACE STRUCTURES: The most obvious of these are the grike fields *(kluftkarren)* and intervening clints which extend over much of the limestone outcrop area. These are solution trenches, which develop along joints or steeply dipping bedding planes. Where well-developed they can be over a metre wide and deep, and extend for up to 10 metres in length. They are separated by ridges of solid limestone of equal, but positive relief. The larger grikes often have an earth or rubble floor. Rain falling onto the grike fields is rapidly channelled underground and runoff from these areas is therefore negligible. Coalescing grikes can form small solution dolines and the concentrations of water inflow at these points would be a factor in localising cave development. Also common are solution flutes *(rillenkarren)*, which are narrow parallel grooves, separated by sharp edges, which run down sloping rock surfaces. At the top of an outcrop they can combine to form a sharp serrated crest. On more gently sloping rock surfaces solution pans *(kamenitsa)*, solution pipes, runnels *(rinnenkarren* and *maanderkarren)*, and some areas of rain pits are the usual forms. On vertical faces there are vertical rain solution runnels *(regenrinnenkarren)* and sometimes horizontal solution ripples. These last two features are also found in the vertical shaft entrances of some caves, together with small hemispherical pits which appear to be due to inflowing rainwater and may be analogous with current scallops. Current scallops are seen on the lower stream cliffs at Whale Rock, and would be due to solution by fast flowing flood waters.

THE SUB-SOIL SOLUTION STRUCTURES: These are generally less often seen in karst areas because they are soil-covered. However, in several places at the Texas Caves they have been exposed by stripping of the soil. They are characteristically smooth and rounded as distinct from the sharp-edged types formed at the surface. They include rounded depressions and networks of irregular holes in the rock) *(bodenkarren)* and rounded runnels separated by equally rounded ridges *(rundkarren)*. The best collection is seen in the Glenlyon area where they have been exposed by rotation of blocks adjacent to collapse areas, and subsidience of soil into dolines (Plate 3a). In the Whale Rock area the soil surface has been denuded by up to 40 cm in places and this has exposed a series of shallow horizontal notches which are probably related to solution by the acidic humus layer of successive levels of the topsoil.

THE CAVES

Although minor surface karst forms such as *rillenkarren* are found on most of the limestone outcrops in the region, major karst features, in particular caves, are only known in this area and at Riverton, about 10 kilometres to the south. This restricted distribution may be due to the larger than average size of these areas and their proximity to a large surface stream in each case: Pike Creek in the case of the Texas Caves, and the Dumaresq River (which may have been closer in the past) in the case of Riverton Cave.

Riverton Cave has not been included in this study. Its main importance is as a bat maternity colony for the region (Dwyer and Hamilton-Smith 1965; Dwyer 1966) and because it will become the sole remaining limestone cave in southeastern Queensland once the Texas Caves have been flooded. The cave has been mapped by the UQSS and a summary description has been compiled by Gillieson (in prep.).

The caves of the Glenlyon System are different in form and genesis from those of Viator Hill, and the two areas will therefore be described separately.

THE GLENLYON SYSTEM (Map 9)

This system has formed as a subterranean cutoff of a meander spur of Pike Creek. The spur is 300 m across at this place but the underground stream follows an irregular route and is longer than this (see Maps 9 and 10).

The downstream half of the Glenlyon System has been largely destroyed by collapse which has formed the two large dolines at 080350 and 010340 (Map 9). Swallow Arch (040350) and The Dustbath (020370) are remnants of the old system isolated between the two dolines. Cloister Cave (120360), Efflux Cave (135345) and Cliff Pit (100334) are remnants on the downstream side of the collapse area.

To the west of the Central Doline the downstream part of the Glenlyon Stream Cave has also been modified by collapse. This has formed the large Crater Doline (950360) and a number of smaller dolines. The present southerly diversion of the underground stream may be due to blocking of a previous more direct route by the collapse of the Crater Doline.

The upstream entrance to the Glenlyon System has been blocked by the collapse of the cliff adjacent to Pike Creek (880440). This blockage has altered the hydrology of the system by restricting the inflow of water. The present underground stream is 'underfit' and the stream passages contain a considerable amount of silty sediment.

The system shows fairly strong joint control in the orientation of the cave passages (c.f. Fig. 1 and Map 8a). The main stream passages are now dominantly stream flow features: current scallops are common features and stream channel incuts and nitches can be seen on the walls in places. The side passages on the other hand retain some of their initial low energy phreatic characteristics: irregular networks, smoothly hollowed walls, bedrock blades, and flat roofs from the final shallow phreatic stage (Plate 4a, b). Some stream flow modification also occurs in these passages. Modification by breakdown has occurred adjacent to the dolines. Speleothem deposits are uncommon and are generally limited to the higher parts of the system where saturated waters are seeping into the cave and where the deposits are not reached by flood waters.

Studies of current scallops by Goodchild and Ford (1971) showed that the size of individual scallops decreases with increasing stream velocities. As velocity is related to the cross sectional area of the stream one would therefore expect smaller scallops in constricted parts of the cave stream passage. However, this relationship was not borne out by measurements in the upper part of the Sewer (919395) and in the Downstream Section (970341). Perhaps the scallops predate the entrance collapse and consequent siltation, and therefore are not in equilibrium with the present hydrological system. The presence of speleothems covering scallops in parts of the cave supports this view (Plate 3c).

The hydrology of the system will be discussed after the descriptions of the component caves.

GLENLYON STREAM CAVE (Maps 8a, b)

This is the major cave of the system. It comprises a main stream passage and a number of smaller side passages. The total passage length is about 1000 m. There are numerous entrances to the cave and the major ones have been numbered on the map. Most entrances are at the margins of collapse areas but a few vertical solution shafts form additional entrances in the Dry Crawlways and the Flattener. The stream normally enters the cave by one or more impassable routes from Pike Creek and leaves from the horizontal entrance GL-1E in the Central Doline.

The northernmost part of the cave is a maze of numerous small passages and chambers which occur between a jumble of large collapsed limestone blocks which form the stream cliffs. Only the lowermost passages (The Wet Section, 887435) and a major high level bypass route at 898440 have been shown on the map.

The Wet Section has a broad shallow pool of water generally 20–30 cm deep and with a silty to gravelly bed. A few mounds of sediment rise above the water in side passages. The rock walls and low ceilings generally show current scalloping. There are no speleothems.

The high level passages are all in rockpile, with smooth fractured surfaces and no current scallops. There is some flood debris near the lower entrances which provide inflow points during large floods.

The Dry Crawlways (860400) form a major offshoot to the west of the main Upstream Section of the cave. They are a network of low passages formed under phreatic conditions with joint control modified by stream flow. The roof is frequently flat and smooth with some scalloped areas and represents solution at an old water level. The walls are scalloped adjacent to the stream channels and sometimes show stream incuts. Elsewhere smoothly curved walls and cavities, together with limestone roof pendants testify to the dominantly phreatic origins. Blind shafts are common in the ceilings and generally contain abundant speleothem deposits. Several entrances in the southwest (e.g. GL-15E) have formed where shafts such as these have intersected the surface. Speleothem deposits are rare away from these blind shafts. Those few which are seen have been partly eroded.

There has been some collapse in the area between GL-14E and the pool at 854416. The north wall has subsided here. The pool connects via a water trap with the northern 'cenote' (C.H.C. Shannon, pers. comm.). and there appear to be water-filled connections between the two 'cenotes' and between them and the Wet Section to the northeast.

The Dry Crawlways contain a considerable amount of sediment; in places this forms mounds reaching to the roof (e.g. section 22 of Map 8b). The intermittent streams flowing through the passages have incised channels into the sediment. The deposits are mainly grey fine–sandy silts (Grimes, in prep.) but the beds of the stream channels also contain some sand and gravel, particularly in the upper parts. The chamber at 855411 has some rounded cobbles up to 20 cm in diameter. These must have been washed in at a time when there was easier access from Pike Creek.

The Upstream Section of the cave lies between 890430 and 920400. The northern part is commonly referred to as the Bat Chamber. Water from the Wet Section enters the Bat Chamber from a low horizontal slot beneath a large subsided block which forms the steeply sloping north wall of the chamber. The fissure above this block opens to the surface to form several daylight holes, including entrance GL-2E. This fissure also extends to the southwest where it provides access to the Dry Crawlways and to the northeast where it joins to the irregular high level section.

The main stream passage in the Upstream Section is about 10 m wide and 2 m high. The roof is a flat solution plane in some places (e.g. section 4, Map 8b) but is generally arched (section 5 and Plate 3b). There are a few blind shafts with minor speleothem development. A few hanging rock projections occur at the downstream end of the passage. The rock surfaces have a finely pitted surface (hemispherical pits about 1–2 mm across) with a network of narrow etch grooves (1–2 mm wide and up to 5 mm deep). These grooves may be due to etching of veins or small factures. In some places beads of water are seen along the grooves which could indicate the existence of water seeping along fine cracks and becoming aggressive on exposure to the cave air.

The walls of the main passage are generally not well-exposed as they are hidden by mounds of sediment which reach nearly to the roof (Plate 3b). Stream incuts, meander niches, and scallops are seen where the gently meandering stream comes up against the walls.

Two narrow side passages extend off the northeast and are developed along vertical joints. The eastern passage terminates in a talus choke which is located beneath a small surface doline at 920435.

Throughout the cave the sediments are typically interlaminated dull yellowish brown (10 YR-5/4) fine sand and brownish black (10 YR-2/3) silt and mud. The laminae vary from 1 mm to 5 mm thickness and tend to lens in and out. They dip parallel to the present surfaces of the mounds.

The stream passage bifurcates at the downstream end of this section (919397). A small low-level passage, The Sewer, takes the present stream. To the north is the Flattener, which must originally have been the continuation of the main passage but is now almost entirely silted up.

The Sewer (924380) has the form of a pressure tube with smoothly curved walls and scalloped surfaces. Its diameter is much smaller than that of the main stream passages of the cave. A number of bell-holes rise above the general ceiling level. These are unscalloped and contain some speleothems. Plate 3c shows a view of the Sewer with small ribbons descending from a bell-hole and covering the scallops of the wall. The stream flows over soft silt with some gravel present at depth. The sediment apparently contains organic materials, as bubbles of an inflammable gas were released when the desposit was probed with a metal rod.

The Flattener (935395) is characterised by a gently inclined ceiling which has a more or less flat surface at the same level as the upstream section and an earth floor which lies generally less than half a metre beneath it. At its eastern end a vertical solution shaft in the ceiling reaches to the surface (944385) and a second but blind shaft is found in the same area (see Profile P-3, Map 8b). The Flattener is terminated at this end by a vertical fissure and a rockpile wall adjacent to the Crater Doline. A narrow passage adjacent to the rockpile is all that remains of the connection to the downstream end of the Sewer. There is an entrance (GL-16E) and several small daylight holes in the rockpile. The original form of The

Flattener was probably similar to the stream passage above and below this section, but it became filled with sediment after partial blockage by the collapse of the Crater Doline which allowed The Sewer to capture the main stream flow.

The Middle Section (915350) is similar in form to the Upstream Section. The main differences is that for the northern part of the section the eastern wall is composed of rockpile adjacent to the Crater Doline. GL-17E is the largest of several entrances through this rockpile. In this part the stream runs adjacent to the solid western wall and has formed scallops and some deep incuts in the wall (section 10, Map 8b). Further along this passage the stream meanders between sloping banks of sediment. The Middle Stream terminates in rockpile at its downstream end, with a large entrance (GL-18E) leading in from a doline at 920327.

The Rockpile Section (930325) consists of an irregular network of small passages and cavities between collapsed blocks. This part of the cave is consequently ill-defined and the mapped boundaries are only approximate. The stream water appears as occasional pools in the lower parts of the rockpile. Many of the lower blocks show current scalloping. In places smaller boulders and cobbles are held together by a dark grey clay matrix.

The Downstream Section (960330) is composed in its upper (southern) part of a series of interconnected, low, wide passages with many bedrock blades projecting from roof and walls, rock pillars, portholes, and solutionally enlarged joint fissures. Current scalloping is common, except in the higher parts where there are small etch grooves of the type described from the Upstream Section. There are a number of fallen blocks on the floor. This section would appear to have been a phreatic network now largely disrupted and modified by stream action.

Further downstream (north), past a collapsed section with the entrance GL-19E (963316), the stream flows into a wide chamber. At the southern end of this chamber the ceiling is a smooth and flat solution surface or has broad rounded concavities (30–50 cm wide and 5–10 cm deep). There are a number of blind shafts 1–2·5 m wide and up to 1·5 m high. The largest of these has a honeycomb form. Further north the roof is largely made up of fracture surfaces resulting from collapse. The walls of the chamber are scalloped up to two metres above the stream level. There are some small stalactites and ribbons.

The stream meanders across the floor and undercuts the wall at the northern end of the chamber (971337). The silty to fine sandy sediment forms mounds reaching nearly to the ceiling.

A high level extension at 965317 is in rockpile beneath the surface doline. Some small extensions from the main chamber at 973330 have phreatic features and show joint control.

Downstream from the large chamber is a narrow, arched stream passage with several large bell-holes. Walls and ceiling are strongly scalloped. This passage leads to the downstream entrance (GL-1E, at 980345) which is at the end of a small daylight chamber. There are collapsed blocks on the northern side of this chamber but a solid limestone wall forms the southern side and is marked by scallops and has several stream meander niches.

Two entrances in the Crater Doline (GL-20E and GL-21E) lead to a group of interconnected passages and small chambers which finally connect with the main stream passage. The largest chamber (966355) has a high roof extending into a small daylight hole. The other two chambers (964350 and 970349) have several blind shafts which contain flowstones, cave coral, and ribbons. The walls in the lower parts of this section have scallops. Elsewhere they are often marked by phreatic pockets (Plate 4a).

NETTLE MOAT CAVES (GL-10 and GL-11; 990320 and 995300, Map 9)

Though originally described as a single cave (Toop, in prep.) the Nettle Moat is actually two caves connected by the deep collapse doline at 985308. Mapping of the Nettle Moat Caves by UQSS was still in progress at the time of writing. The outline shown in Map 9 is reduced from a preliminary field compilation.

The northern cave (GL-10) is entered horizontally from the base of the doline. An eastern collapsed section, which lies beneath the edge of the Central Doline, is made up of several rockpile chambers with occasional daylight holes. The western part of the cave is composed of a number of small, joint controlled passages and chambers. There are a number of high blind shafts with speleothems. The sediment floor is irregular and there are steeply sloping mud floored passages which become impenetrable at their lower ends. A small, normally dry, stream channel indicates flow through this section and out of the entrance into the doline where it terminates in a small depression. The water feeding this channel appears to come from the Glenlyon Stream Cave during floods. It probably enters through one or more of the sloping passages. The rock walls are scalloped in some places; elsewhere they are smooth or fractured. There is some intricate phreatic sculpturing: blades, portholes, and small tubes being the most common forms.

The southern cave (GL-11) has a horizontal entrance in a small overhang in the side of the doline. This cave is basically a low, wide passage which enlarges into a small chamber in one part. There are several daylight shafts and much of the cave is in semi-daylight. Ceilings and walls have many fracture surfaces but solutional surfaces are equally common. Speleothems are moderately abundant: cave coral, short conical stalactites, some short straws, smooth flowstone coatings and ribbons. The flat floor is of earth and rubble.

The Dustbath (GL-6; 020370 Map 9)

A detailed description and map of this cave has been published elsewhere (Grimes and Brown 1976).

The Dustbath is a remnant of stream passage isolated by collapse of the Central and Camp Dolines. There are horizontal entrances (GL-6E and GL-22E) below cliffs at either end of the old stream passage. A third vertical shaft entrance (GL-23E), to the north, has formed above a higher level rockpile chamber.

The rockpile chamber connects to a smaller bedrock chamber, which has some small, but well-formed ribbons and to a low, flat-roofed passage (Plate 4b) which leads down to the old stream passage.

The stream passage is almost completely filled with silty sediments and in this way is similar to The Flattener Section of the Glenlyon Stream Cave. The roof is more or less flat and current scallops are common both on it and on visible parts of the walls (Plate 4b). Blind shafts and joint controlled fissures rise above the general level of the roof. These often contain speleothem deposits.

Cave coral is found in places throughout the cave, as are etch grooves of the type recorded from the Glenlyon Stream Cave. In one place (Plate 4c) these etch grooves show a progression in development from isolated narrow grooves (1–2 mm wide and several mm deep) through larger but still discrete grooves (up to 1 cm wide and several mm deep) and finally to a coalescing hackly surface with only a few raised remnants of the original smooth surface (Grimes and Brown 1976). The cause of this progression seems to have been a slight case-hardening of the surface so that solution was most active on the walls of the grooves, which therefore retreated across the surface.

Swallow Arch (GL-3A; 035345, Map 9)

The arch is a low, wide remnant of a stream passage which passes beneath a narrow wall of limestone separating the Central and Camp Dolines. The cave stream flows through the arch. Swallow Arch has a span of about 13 metres but it rises only 2 m above the water at its highest. The limestone cliffs rise 9 m above the stream and the wall is only 3 m wide in places at its top. The stream flows diagonally beneath the arch, between sloping banks of grey silty sediment. The walls and roof are strongly scalloped. Several blind shafts rise into the roof and contain cave coral and large rounded masses of moss covered speleothem material which could be old eroded stalactites. There is an isolated horizontal tube above the main level on the southern side of the arch. This is about 1 m in diameter and strongly scalloped. A map of the arch is held by the UQSS (see Appendix 2).

Cliff Pit (GL-9; 100335, Map 9)

A vertical shaft entrance leads to a joint controlled fissure-like passage. There is a low-roofed horizontal extension to the south and the roof of the fissure passage to the north becomes lower until it ends in a muddy crawlway which often contains water. There appears to be a hydrological connection with Cloister Cave. The lower parts of the fissure passageway have slightly weathered scallops. Narrow tubes and pockets in the wall and ceiling appear to be phreatic forms. Speleothems are absent except for some smooth wall coatings. Near the top of the entrance shaft there are some narrow horizontal solution ripples which would be due to rainwater inflow. A detailed map is held by the UQSS (see Appendix 2).

Cloister Cave (GL-7; 120360, Map 9)

This stream cave originally known as 'The Downstream Section', (e.g. Shannon 1968), is basically a deep undercut of the cliff above it with the outside walls formed by large subsided blocks. The stream flows in a horizontal entrance

(GL-7E) at the southwestern end, and a pool follows the inner wall around to the eastern end of the cave, where the water passes through a submerged passage and emerges in a pool in the adjoining part of the Efflux Cave (Brown 1970b). Brown (op. cit.) reports an air pocket within this section which contained a gas composed of Nitrogen (89.6%), Methane (7.3%), Oxygen (plus Argon) (2.0%), and Carbon Dioxide (1.1%). This mixture is probably derived from the decay of organic material in the sediments. The composition of the gas in the sediments of the Sewer (see above) may well be similar.

There are several inclined entrances through the rockpile on the western side and from a small subsidiary doline to the north (GL-25E). As a consequence much of the cave is in semi-daylight. The pool occupies much of the floor; the remainder is a steeply sloping bank of silty sediment and flood debris. The walls and ceiling are strongly scalloped. Some calcite (?) veins have been etched out in positive relief above the upstream entrance and now stand out 2–3 cm from the surface. A detailed map is held by the UQSS (see Appendix 1).

Efflux Cave (GL-8; 135345, Map 9)

A low, wide, horizontal entrance in the base of a cliff is the edge of a broad but low semi-daylight chamber which represents the bulk of the cave. The roof is generally 1 m or less above the floor. The roof and walls are scalloped and there are some tubes, blades and small bridges in the ceiling; all are scalloped and sharp edged. There is some V-section enlargement of irregular joints in the ceiling. The floor is gently sloping and silty with minor gravel and some heaps of flood debris. At its northeastern end the floor slopes steeply where flood waters are eroding an earth bank.

The stream enters the cave via a submerged passage from Cloister Cave (Brown 1970b) and rises in a pool at the back of the chamber. From there it flows along the southern wall and out of the entrance. It follows a narrow channel to a permanent waterhole in Pike Creek about 15 m away but goes underground briefly at two points before reaching the creek. The first of these is where the stream flows beneath a large subsided limestone block and the second is where it used to be bridged by an earth mound (C. H. C. Shannon, pers. comm.). This bridge has now collapsed and blocks the stream channel so that the present flow must be through cavities in the earth bank of Pike Creek. A detailed map of the cave and the stream course is held by the UQSS (see Appendix 1).

The 'Cenotes' (GL-26 and GL-27; 849420 and 845417 respectively, Map 9)

These are two vertical shafts in rockpile with shallow pools at their bases. There is hydrological connection with the Dry Crawlways and also with Pike Creek (possibly via the wet section of the Glenlyon Stream Cave). They have not been mapped at the time of writing.

Hydrology of the Glenlyon System

The Glenlyon System is an excellent example of a subterranean cutoff of a meander loop; a feature of karst areas which has been discussed in some detail by Thornbury (1954). It appears to be the only Queensland example of this form of subterranean drainage.

Complete capture of the surface stream has not occurred. This is probably due to successive collapses of various sections of the cave which restricted the through-flow of water so that downcutting by the surface stream could keep pace with cave development.

At normal stream flow levels the inflow point for the cave stream is not obvious. Gillieson (pers. comm.) reported an inflow of water into a small fissure in the bank of Pike Creek (910471, Map 9) which became visible at a time of low water. A small passage was seen beyond this fissure but has not been explored. Within the cave the water cannot be followed upstream beyond 888438 in the Wet Section where it emerges from beneath subsided blocks. In places around the edge of the Briar Patch (880440) small pools of water can be seen through openings in the rockpile of the cliffs, and it is likely the water from the influx fissure reaches the cave by flowing through small cavities between the subsided blocks. A hypothetical route is shown on Map 9. Some water may also reach the cave by percolation through the sediment banks of Pike Creek.

Standing water is also found in the two 'cenotes' and in the pool at 854416. An underwater connection is known between the pool and the 'cenotes' and presumably water reaches them by flowing either through rockpile from the Briar Patch area, or by direct percolation from the creek.

The shallow depression of the Briar Patch is filled with water during major floods and this water then enters the cave directly through passages in the rockpile of the cliffs.

Within the Glenlyon System there is a semi-permanent stream which follows the underground route shown on Map 9. In dry seasons the lower end of this stream dries up and on occasions the channel has been dry all the way up to the pools of the wet section.

An additional stream channel, which only carries water during floods, starts at the pool at 854416 and passes through the Dry Crawlways and into the Upstream Section. A tributary branch starts in an inaccessible extension at the southwestern end of the Dry Crawlways. This tributary may merely be the result of draining of back waters after a flood, whereas the main branch is fed by water welling up from the pool.

At the downstream end of the Stream Cave an overflow channel carries flood waters into and through the northern Nettle Moat Cave.

The normal stream flow rate through the Glenlyon System is between 10 and 20 litres per second (l/s). Flood debris within the cave shows that the passages fill completely during major floods. During small floods the cave stream shows only a small response to changes in flow rates in Pike Creek. In February 1975 the author observed a small flood in which the flow in Pike Creek rose from less than 1000 l/s to a peak in excess of 25 000 l/s. At the same time there was only a slight increase in the underground stream flow: from 14 l/s to 26 l/s. Shannon (1964) reports similar observations for a larger flood of 40 000 l/s in Pike Creek, with less than 60 l/s in the cave stream. At the peak of the 1964 flood a small flow occurred in the upper part of the Dry Crawlways channel, and there was water in the Briar Patch. Water had started to enter the cave through the rockpile entrances in the base of the cliff, and the underground stream flow rates could be expected to increase more rapidly for flood levels higher than this. The cave stream has a larger flow after floods, and then diminishes. This is probably due to flushing of the system during the flood, followed by accumulation of debris in the inflow area.

The gravels beneath the present stream bed, and the cobbles and gravel at the upstream end of the system probably remain from an earlier period of stronger flow which existed prior to the collapse of the upstream cliffs. The current scallops on the passage walls may also date from that earlier regime.

The Larger Caves of Viator Hill

Viator Hill has two large caves (Russenden Cave (VR-2) with about 500 m of passages, and Main Viator Cave (VR-1) with 200 m of passages), 14 smaller named caves and potholes, and a number of small unnamed pots (vertical shafts with minimal development at the base). The larger caves have horizontal development on one or more levels related to old water levels.

Main Viator Cave (VR-1; 251293 on Map 10)

Maps 1a and 1b provide detailed plan and sections of the cave. This cave has also been known as 'Cathedral Cave' and 'Old Cave' (e.g. Shannon 1968). It has been visited regularly since late in the late century (see Robinson 1978). During the February 1976 flooding in the region water backed up from the nearly completed dam and the cave was submerged for several days. When the water drained from the cave several new extensions were opened up. These have been mapped and described by the UQSS (Shannon 1976a, b), whose plans of the new sections are incorporated in Map 1a.

Cave Morphology: A horizontal entrance (VR-1E – Map 1) leads in from a doline at the base of Viator Hill. There are four daylight shafts which open into the roof of the cave (VR-12E, -13E, -19E, and -22E). From the main entrance a sizable passage leads to a large chamber about 50 m long and averaging five metres in height. This chamber forms the bulk of the cave. A lower side passage extends off to the northwest and a newly discovered passage extends to the northeast. The walls show horizontal solution undercuts at several levels related to old standing water levels (Plate 5a). The three best developed levels are at about 384·0 m, 382·4 m and 381·4 m A.S.L. (a, b, c on Map 1b).

The main entrance (VR-1E) has a low roof composed of horizontal flowstone, reddish and coarse grained, overlain by a massive red earth breccia with some bone fragments.

Beyond the entrance the passage opens up into an antechamber about 11 m long and 5 m high with an inclined shaft from the ceiling leading up to a daylight hole (VR-19E). The walls and ceiling are of limestone with minor red earth breccias. The floor is mainly made up of rubble and large fallen limestone blocks. Some subsidence occurred here after the February 1976 flooding. At the western end of the chamber there is a finely crystalline white flowstone with microgoured surface. Flowstones of this type are found throughout the cave and will be designated as the 'younger flowstones' as they are better preserved and in places overlie the reddish coarse-grained flowstones (such as the one already mentioned at the entrance); these latter will be designated as the 'older flowstones'.

A low roofed section of the cave extends to the south from the antechamber (540915, Map 1). The roof here is flat and is related to the lowest solution level of 381·4 m. The floor here is a dusty brown earth. A normally dry stream channel leads from the main entrance and meanders across this floor to a shallow depression.

Beyond the antechamber is a second low-roofed section at 534928. The low roof here is mainly composed of red earth breccia with interbedded 'older' red flowstones. The breccia consists of angular fragments of soft red-brown clay in a matrix of light brown moderately hard calcite tufa. The limestone walls here are pitted with hollows 1–2 cm wide and 1 cm deep. The floor is covered by large fallen limestone slabs.

This low section leads to a high-roofed offshoot from the main chamber at 526932. A daylight hole (VR-22E) opens into the roof. A large 'old' red flowstone, about two metres thick occurs high up on the north wall and continues into the main chamber at 526937. Solution undercuts of the 381·4 m and 382·4 m levels occur on the south wall. A small dry stream channel starts here, formed by rain water entering the daylight hole, and leads into the main chamber where it ends in a pit at 514934.

The main chamber is elongated along a 060° striking fault and joint line. The roof is arched and varies from five to eight metres in height. The walls and roof are of solid limestone with irregular areas of a brecciated limestone with a hard grey lutite matrix occurring between the fragments. This lutite breccia is also found in the surface outcrops (see above), and predates the formation of the cave; it probably dates from an earlier tectonic episode. The floor of the chamber is covered by rock debris at its southwestern end but elsewhere is composed of compact grey-brown earth (see later discussion of sediments). The floor has an irregular surface with several shallow pits which may be relicts of old guano mining activities.

At its northeast end the chamber narrows to a sharp angle developed along a fault zone in lutite breccia. There is evidence from drag effects that the northern (solid limestone) block has moved up relative to the southern (lutite breccia) block. West of here the north wall has two well-developed solution undercuts: the 381·4 and 382·4 m levels (Plate 5a). These two levels are not as well-developed on the south wall, although a higher (384 m) level can be seen on that side.

The high dome in the centre of the main chamber (505927) has a daylight hole (VR-12E) on its northern side. Below this hole is an 'older' weathered red flowstone which is overlain by a 'younger' white flowstone that forms a large compound canopy and a large (2 m) stalactite. The floor below has some large fallen blocks and a few squat 'younger' white stalagmites.

In the southern wall near this dome there is a low alcove behind a corroded old flowstone projection at 503920. Inside the alcove there is a 'younger' white flowstone with some well-developed gours on the floor and a coating of white crystalline cave coral on the back wall.

At the southwestern end of the large chamber there is another daylight shaft (VR-13E) and this also has a massive development of both 'older' coarsely crystalline flowstone and 'younger' finely crystalline flowstone. The old flowstone has individual calcite crystals up to 5 cm long and 3 cm wide. It does not occur below a level of 384·7 m (1·5 m above the present floor) in this area, and has a horizontal 'bedding' in its lower parts. This suggests that it formed above an old floor level, since removed, which predated the 'younger' flowstones and the present floor deposits. The horizontal 'older' flowstones in the entrance areas of the cave are probably also related to old floor levels, although they are lower (382·3 m) than at the western end of the cave.

The walls of the main chamber are irregular in form but generally smoothly surfaced with a powdery weathering film. They are sculptured by elongated V-notches up to 10–15 cm deep and 10 cm wide which are developed along joints. There are also large irregular hollows and the undercut levels mentioned earlier. Fine sculpturing effects include areas of pitting (with hemispherical pits 0·5 to 2 cm across) and small etch grooves (0·5 to 1·0 cm wide). One example of indefinite, shallow, vertical runnels was seen on an overhanging wall.

The largest new section disclosed by the February 1976 flooding starts from a subsidence pit which formed in the floor of the main chamber at 514937. From the bottom of this pit a low passage extends to the northeast beneath a bedrock roof. There was a small pool at the lowest point which has since risen in response to the rise in Pike Creek. From there the passage rises and becomes larger until it opens into a chamber at 535954. The sloping passage has solution undercuts on its wall which slope at the same angle as the passage, which suggests pressure flow in a water filled tube at the time of its formation.

Hollows in the walls up to 30 cm across could be the remnants of large scallops.

The chamber at 535954 has a flat roof at an elevation of 384·3 m and 5 m of head room at its western end. The earth floor rises to the east so that it is only 1·2 m below the roof at the far end of the chamber. Tree roots and carrot shaped stalactites hang in several rows from the ceiling and there are some stalagmites and small areas of flowstone on the earth floor. The chamber ends in a fissure that is largely filled by collapsed rubble. A few short passages can be followed into this rockpile.

The entrance to the main side passage (495940) which runs to the northwest from the main chamber, is not well-defined because the roof drops in several steps and the walls converge gradually. Further in, the roof is only 2–3 m above the floor and in places is a flat surface related to the 381·4 m level. Elongated blind shafts rise up to 3 m into the ceiling, and are developed along the joint which controls the passage direction. At its far end the passage becomes low and narrow and terminates in an earth filled squeeze. The earth floor of the side passage is much damper than the main chamber and there are many drip points in the roof.

Two large white finely crystalline columns and associated 'younger' flowstones occur at 487950 in association with a high, steeply inclined, fissure at 491949. Some 'older' coarse flowstone remnants occur on the wall behind the columns. A cone of red earth descending from the fissure contrasts with the chocolate-grey earth of the floor elsewhere. The fissure is choked at the top by red earth. Its hanging wall has symmetrical scallops 1–3 cm in diameter and 1 cm deep with sharp edges. Similar features have been seen in the entrance shafts of some of the pots and they are presumably due to solution by water trickling down the surface. One side of the fissure is plugged by a soft white to pale brown sintery deposit.

The flat roof in the vicinity of section 8 is related to the solution level of 381·4 m. In general the roof and walls of this side passage are much more irregular than the main chamber, due to numerous large hollows (up to 30 cm wide and of similar depth) which give a honeycombed appearance in places. Fine texture superimposed on these features includes sharp edged shallow to hemispherical pits 1–3 cm across and up to 1 cm deep with micro-pits 2 mm or less developed on top of them. Brown surface stains are common and probably indicate bat roosts. The surfaces are clean, sharp edged and often damp, in contrast with the main chamber which has rounded powdery surfaces. There are numerous drips in this section but little dripstone apart from the large columns which are related to the fissure. This suggests that the waters are undersaturated and therefore aggressive which would explain the honeycombing effects. By contrast the large columns would have been deposited from saturated waters entering via the fissure.

The February 1976 flooding also opened up a new extension that is a continuation of the side passage from 482959. A small tunnel with a muddy floor slopes down from the floor of the side passage and leads to a pair of small low chambers with sloping floors and a final flat section which eventually becomes too tight to penetrate. The walls and ceiling are generally irregularly pocketed but there are flat ceilings in places which could indicate old water levels. There is a clump of helictites up to 5 cm long above a small alcove with a flowstone floor at 475968. The form of the earth floor suggested a strong outward flowing current (Shannon 1976b).

A line of shallow depressions extends to the southeast from the entrance doline of the cave. These could be shallow subsidence dolines above an unpenetrated and possibly earth filled extension of the cave system leading towards Pike Creek.

THE SEDIMENTS OF MAIN VIATOR CAVE: Sediments described here were exposed in a shallow UQSS excavation at 512927, and noted in six auger holes (MA-1–6) drilled by the GSQ and the UQSS. Detailed logs, and physical and chemical properties are tabulated in Grimes (1977) and summarised below. Localities are shown on Map 1 and a section in Fig. 2.

The sediments which form the floor of the cave have a considerable depth, exceeding 6·5 m in MA-6, and occupy more than half the original volume of the cave. The red earth breccias have been described already; they lie above the general floor level and are different in character to the floor deposits. They would appear to have formed and later been eroded prior to the formation of the present floor deposits. They are contemporaneous with the 'older' flowstones.

Mechanical analysis suggests that the floor sediments are dominantly very poorly-sorted silts. The poor sorting is due mainly to the common occurrence of clay aggregates of granule to small pebble size in the coarse fraction, and of a substantial percentage of non-aggregated clay in the fine fraction. Other components of the coarse fraction are small angular fragments of limestone and of grey lutite (both presumably derived from the walls of the cave) and small calcareous nodules and cemented particles which may be diagenetic. There is an overall trend from coarser mean grain sizes in the upper parts to finer means at depth. This trend may be partly of wholly due to progressive destruction by compaction of the clay aggregates in the deeper levels, or destruction of the aggregates during augering because the lower sediments were generally wet and plastic, and sometimes quite sloppy.

The acidity of the samples was tested with the CSIRO Soil pH Kit which uses a colour indicator and comparison with standard colour chips at pH intervals of 0·5. There was a general trend from strongly acidic near the surface (pH values as low as 3·0) to mildly alkaline at depth (pH up to 8·5). Details are given in Grimes (1977). The acidity near the surface may be due to decaying organic material together with bat droppings and urine deposited on the surface, the downward seeping acids being neutralised by carbonate waters at depth.

Phosphate and carbonate contents of the sediments were estimated by spot tests using an acid solution of ammonium molybdate. Phosphate was estimated by the presence and intensity of the yellow colour, and carbonate at the same time by the degree of effervescence. Details of these subjective estimates are listed in Grimes (1977). The only strong phosphate reaction was from the unit 5 material immediately above a presumed speleothem deposit at the base of MA-4; similar material at the base of MA-5 gave a moderate reaction. Weak to moderate phosphate reactions were obtained from units 1 and 2, but unit 3 was mostly negative. In all over one third of the samples tested were negative.

Carbonate was detected in only a quarter of the samples tested and most of these gave only weak reactions. The strongest reactions were from the deposits immediately above the presumed speleothems at the bottoms of MA-4 and MA-5, and from unit 1 in MA-6.

The sediments are mostly massive but show variations in colour and in the amounts and types of clay aggregate present. Often changes are difficult to correlate between holes but three main units and two subsidiary units can be recognised (Fig. 2).

Unit 1 is the surface deposit and varies from 30 cm up to possibly 1·7 m in thickness. It is a medium to dark grey and chocolate earth (5YR2/2 to 4/4) with varying proportions of clay aggregates. Small sand sized chips of limestone, lutite, and charcoal (?) are sometimes present.

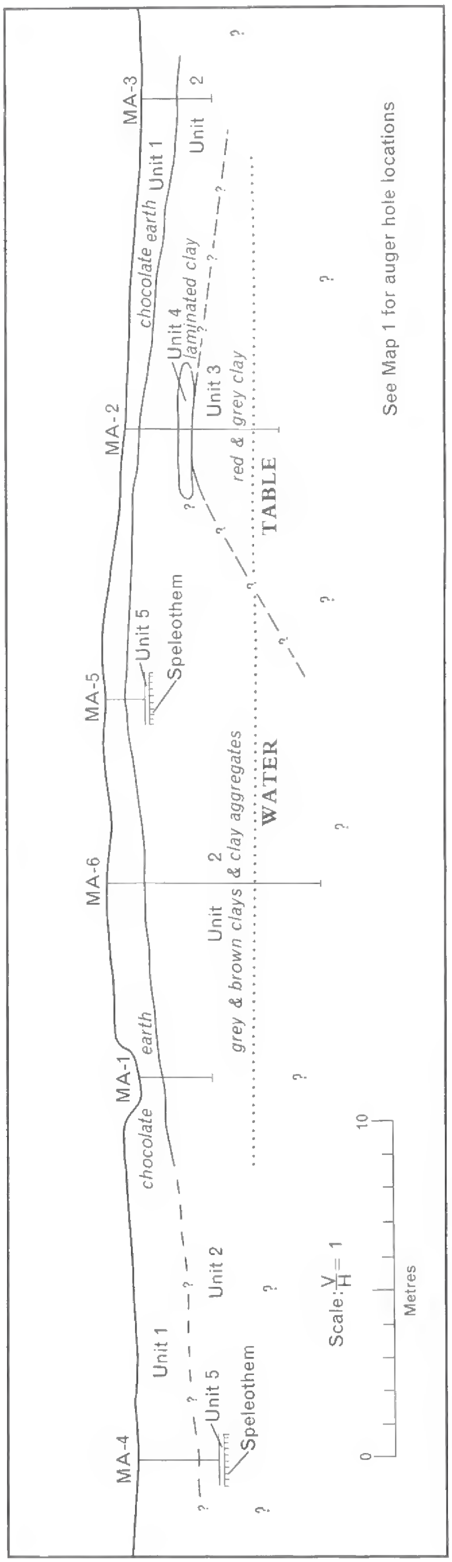

FIG. 2: Distribution of sediments in Main Viator cave.

The top decimetre or so has been compacted by visitors feet but below this it has a massive earthy structure. Median grain size averages 4·8 ϕ, in the coarse silt range. The material is extremely poorly sorted. The pH varies from 3·5 to 6·0, averaging 4·7.

Unit 2 is the thickest unit. It is quite variable in character with several recognisable subunits which however, cannot be correlated between holes. The thickness varies from 1·3 m to greater than 5·5 m. The texture varies from a loose earth to a compact clay. The clay aggregate content varies from a mere trace up to nearly 100%. Detailed lithologies are given in Grimes (1977). Brief descriptions of the major subunits follow:

The upper part of the unit seen in the UQSS Pit, and in MA-1, MA-2 and MA-5 is generally a medium to light grey clay or earth (5 & 10YR 3/3–4/2–6/1–7/2) with white flecks, dark spots of charcoal (?) and varying amounts of pale-grey, yellow-brown, and occasionally orange-brown clay aggregates ranging from granule size up to 4 cm. Interbeds of darker chocolate earth occur. In MA-3 the unit is a dark grey clay with aggregates. The lithology in MA-6 is of a richer brown colour (10YR 5/5–5/4–4/2), has a lesser proportion of clay aggregates, and reaches a much greater depth (6·45 m).

In MA-4 unit 2 is represented by an earthy deposit with an overall dull reddish-brown colour (5YR 4/3) which is composed almost entirely of multicoloured clay aggregates ranging from granule size up to 3 cm. The aggregates vary in colour; dark grey, yellow-brown, red-brown, light grey and chocolate coloured particles being present. The average size of the aggregates decreases with depth and the overall colour becomes lighter (5YR 6/4). The unit is phosphatic.

A similar multicoloured aggregate deposit is found between 1·1 and 1·5 m depth in MA-2. The overall colour is more yellowish (10YR 5/2–7/4).

A mottled yellow-brown (10YR 5/5) and light olive grey (5YR 6/1) clay subunit with no aggregates occurs as a bed between 2·4 and 3·0 m in MA-6.

Unit 3 is found only below 2·0 m in MA-2, though it could underlie MA-3 which was only a shallow hole. In its upper parts it is a mottled and streaky red-brown (10YR 4/4) and pale grey (5YR 8/1) pure plastic clay with occasional hard chips of red-brown claystone (the latter possibly derived from thin consolidated beds). At depth the colour becomes more uniform. There is a zone of grey-brown clay (5YR 4/5) between 2·9 and 3·5 m depth. The streaky patterns in this unit may be due to distorted clay aggregates in the plastic clay. The unit continues to the bottom of MA-2 (depth 4·55 m) but is absent from the deeper hole MA-6 to the southeast. It may be equivalent to the red earth of the cone beneath the fissure at 491949. The appearance of the unit is similar to that of unit F in RA-2 in Russenden Cave. An X-ray analysis of the unit's clays indicate the presence of both kaolin and illite.

Unit 4 is a localised but distinctive lithology found between units 2 and 3 at 1·6–2·0 m in MA-2. It is a hard, finely laminated medium to dark yellow-brown (7·5 Y 7/4) siltstone and claystone. The laminae are straight and even, and vary between 0·1 and 1·0 mm thickness. The thicker laminae appear to be graded. This unit apparently was deposited in calm water under fluctuating source conditions.

Unit 5 is a local facies found at the base of MA-4 and MA-5. Thin beds of powdery, spotty, white, black and brown clay and tufa-like material overlie hard rock which is thought to be speleothem material as a few calcite cleavage fragments were recovered. Whether the (presumed) speleothems overlie bedrock or further sediments cannot be determined, though the latter would seem likely in the case of MA-5 which lies between the two deep holes, MA-2 and MA-6.

RUSSENDEN CAVE (VR-2; 225301 on Map 10)

This cave (see Map 7 for details) was discovered by the UQSS in 1967 after excavation in a shallow doline (Bourke 1975). Its two entrances (VR-2 and VR-14) are on the western side of Viator Hill and only 70 m from the old stream cliffs and Qa_2 terrace on the edge of the hill (Map 10).

CAVE MORPHOLOGY: The cave has developed two main levels; the upper level contains considerable speleothem deposits, including some excellent canopies, columns, flowstones and shawls. The lower level is less extensive and contains foul air in late summer (see gas analysis in Brown 1970a). The chambers in both levels are floored by a considerable thickness of sediments. Bone beds have been excavated in the upper level (see Archer 1978).

The main entrance (VR-2E), 252011 on Map 7, is a tight opening in rockpile at the top of a steeply sloping passage in solid rock which leads down to the Main Chamber. A talus cone has been built up in the main chamber below the entrance.

Main Chamber (260017 – Map 7, Plate 5c): This chamber is about 25 m long, 10 m wide and 3 m high, with two large passages and a smaller one leading from it. The ceiling is horizontal at a level of 390·8 m (Profile P-2, Map 7), though in detail its surface is quite irregular with many small pockets (from 5 to 50 cm across and half as deep) and fissures rising above the general level (Plate 5c). The roof of the entrance passage continues as an inclined fissure in the main chamber ceiling (Profile P-2). There are massive flowstone canopies on the foot-wall of this fissure and these spill into the chamber below as a line of large stalactites.

The walls here and throughout much of the upper level of the cave are smoothly curved to irregular with V-notches along joints and many shallow hollows and pockets. The surfaces are smooth to roughly textured and have a white powdery film. Fossils in the limestone are sometimes etched out in slight positive relief.

There are several low alcoves and small subsidiary chambers about the sides of the Main Chamber. One in the western wall (248017) has its entrance partly blocked by two vertical bedrock blades which are joined by a flowstone mass. An impressive row of stalactites, stalagmites and large columns follow the western wall north from this grotto.

The floor of the main chamber is horizontal and composed of a dark red-brown earth, with some rocks in and near the entrance talus cone. Augering has indicated depths in excess of 5·5 m, so more than half of the original chamber has been filled by sediment. A large natural pit 1·8 m deep in the floor at 252027 is due to subsidence. This may open either into an open cavity at depth or be due to continuing solution of the bedrock beneath the sediment. Shannon (1972) considers that these pits may be due to simple compaction of the cave sediments over buried shafts in the bedrock floor.

At the eastern end of the main chamber the floor has been eroded as much as two metres by water running down into the passage which leads to the lower Foul Air Chambers. Here there is an old guano pile (271017) with a thin cemented capping (see discussion in sediments section).

A short side passage to the north of the main chamber is basically a continuation of that chamber. There is a high blind shaft in the roof above the auger site RA-4. A short low-roofed side passage leads to the Red Earth Section (241030).

The Red Earth Section is a large, joint controlled vertical fissure passage 20 m long, 2-3 m wide and up to 6 m high. A low roofed extension continues on from the southern end. The ceiling is arched with many large stalactites, shawls and curtains. The walls are vertical with many thin ribbons and curtains. A massive compound canopy together with gours and other speleothem deposits occurs at the northern end. Flowstones related to this group overlie, and therefore postdate, the red-brown earth floor. There are several subsidence pits. Horizontal cemented bands within the sediment have been left protruding from the bedrock walls next to these pits (Plate 5b). The solutions producing the speleothems entered the chamber through a master joint along its length together with several cross joints.

At the southern end of the main chamber (260008) there is a broad and rising flowstone floor which extends into the *Squeezes Section*. There are also large flowstone canopies and columns here, and the roof is richly decorated with stalactites. Further in, where the flowstone floor flattens, there are some dry gours up to 10 cm deep.

The flowstone forms a false floor and there is a second low crawlway below it (section 13, Map 7). The roof of this low section is the underside of the flowstone, with red earth breccia, limestone fragments and bones adhering to it, and some small younger stalactites. The walls are of cemented red-earth breccia alternating with old flowstone beds. The floor is of loose red-earth and gravel.

At 262005 there is a pit in the main chamber floor which also extends under the flowstone floor. The features seen here are similar to the low-level crawlway, but in addition there is a deposit of nodules of soft dark brown earth cemented in a light brown cement and beneath the cemented breccia there is a second, younger, flowstone floor which incorporates collapsed fragments of older flowstones and stalactites. There is some cave coral on the eastern, limestone, wall of this pit.

Further into the Squeezes Section, the first squeeze is through a flowstone constriction of the narrow walled passage. The second squeeze is between the low roof and a flowstone false floor. Beyond this is the Bone Chamber (238996); a low chamber about 5 m across with a very low, inaccessible continuation to the north. The roof is flat with shallow hollows up to 60 cm across. The loose red earth floor contained bone material and has been excavated by the Queensland Museum. The flowstone false floor of the second squeeze overlies cemented red earth with soft nodules and some bones. These deposits and their fossil faunas have been described and illustrated by Archer (1978).

The third, and final, squeeze is in loose earth below a low ceiling and ends in a small chamber beneath the rear entrance passage. It was in this area (about 241991) that a partial skull of *Protemnodon roechus* was found by D. Gillieson lying loose on the surface. This specimen is held in the Queensland Museum collection, F6132.

The rear entrance (VR-14E) is a near-vertical shaft which opens into the roof of an inclined passage that in turn opens into the small chamber at the squeeze. There is a flowstone canopy beneath the entrance shaft.

Beyond the rear entrance a low wide passage leads to the *Shawl Section* (240980). The roof of this passage is flat, with a few small blind avens, and is at the same level as the main chamber; the floor level here is higher than in the main chamber, and could therefore have a considerable thickness of sediment. That at the surface is a soft, dry, dusty dark-brown silt. Margot's Shawl was a prized feature of this section until it was broken early in 1974. The shawl occurred together with a large cluster of stalactites in a broad bell-hole at 240977. Some gours on the floor behind the shawl contain small crystalline calcite 'flowers.'

The low chamber beyond the shawl has lines of squat, and sometimes knobbly, stalactites hanging from joints along the roof. These are milky white and very coarsely cyrstalline; some have crystalline continuity throughout much of their body. There is a flowstone false floor at the far end of this chamber, about 30 cm above the present earth floor.

From the eastern end of the Main Chamber (271018) a gently descending passage leads down to the lower level of the cave: the *Foul Air Section*. The passage becomes smaller as it descends. Marks on the walls indicate that the sediment floor has been eroded by up to two metres in its upper part, but not at all at the lower end.

The Foul Air Section consists of a series of low passages with a few larger, and higher-roofed chambers, the largest (at 290038) is about 10 m long and 4 m at its highest point (section 7). The ceilings are flat or domed, and there are a number of bell-holes (Plate 6a). The walls and ceilings have a much more regular surface than the upper levels; the numerous small hollows and cavities are not present and instead there are broad curves. Joints tend to form lines of conical pits rather than the V-sections seen elsewhere. In detail the surfaces are powdery and smooth to finely fretted or granular in texture. Rounded pits (1 cm across and 0·5 cm deep) occur in places. Fossils are etched out in relief. Well-developed solution undercuts are seen on the walls at several levels (see sections) and indicate old water levels. The flat roofs also indicate old water levels at a time when the section was completely filled with water. Blades of limestone project from the walls and roof in the largest chamber (Plate 6b) but are not common elsewhere. The sloping fissure of section 8 is due to solutional enlargement of an inclined joint.

Speleothems are not common; the most abundant deposits being in the large blind shaft in the furthest chamber (275041). This has many stalactites and a large column with a nodular, somewhat eroded, surface which has been fractured and the lower part subsided about 20 cm. The broken surface has been covered by younger speleothems. A low passage to the west of this area has a flowstone floor with a few gours. Some conical stalactites in this area have small helictites up to 1·5 cm long extending from their sides.

Radiating bunches of calcite crystals are seen growing from joints in two places in the Foul Air Section (294025 and 305030). A broad flowstone false floor occurs at 287031 (section 7) about 10-20 cm above the present floor level. In a small chamber at 305031 the walls originally had a brown speleothem coating about 1 mm thick which has now largely flaked off.

The floor of the Foul Air Section is generally flat and composed of a dark brown to reddish earth. There are several small subsidence pits and a low mound in the large chamber. The sediments are at least 4·5 m deep in auger hole RA-2. Shannon (pers. comm.) reports that when the cave was first discovered fresh looking current markings could be seen on the floor. These indicated flow from the short branch at 294014 northeastwards to 315038. Earth mounds at the ends of these two chambers were suggestive of current formed deposits. Further observations on flow markings left by the February 1976 flooding are given in Shannon (1976a).

THE SEDIMENTS OF RUSSENDEN CAVE: Augering has shown that there is more than 5 metres of sediment in the Main Chamber of the upper level, and more than 4·5 m in the lower Foul Air Section.

The red earth breccias of the Squeezes Section have been described by Archer (1968), who assigns a Pleistocene age to their fauna. Their relationship to the earth and clayey deposits of the main chamber is not certain but they are thought to be older; the flowstone of the false-floor, which overlies and cements the breccia, may be contemporaneous with the columns at 250024 which extend at least 50 cm below the surface sediments and therefore are either older than or contemporaneous with the earthy sediments.

The main body of younger sediments are composed of clays and silts with a coarser admixture made up of clay aggregates together with small nodules and fragments of cemented material. There are many similarities with the sediments of Main Viator Cave, but also some significant differences: (a) clay aggregates, though present, are much less widespread; (b) with the exception of the active guano pile at 271017 (which has no correlate in Main Cave), the deposits are neutral to mildly alkaline (pH ranges between 7 and 7·75), and pH does not vary with depth; (c) the sediments are nearly all phosphatic, sometimes strongly so; (d) those of the upper level are generally calcareous, particularly in the upper parts where bands of calcareous cement are common. Detailed descriptions of the auger samples, together with sections in the subsidence pits and the old guano pile are given in Grimes (1977). The distribution in the Main Chamber is illustrated in Fig. 3 and the main features are summarised below.

The main surface deposit, unit A (Fig. 3), of the upper level of the cave was sampled in RA-1 and RA-4 and also examined in the natural pits in both the Main Chamber and the Red Earth Section. The unit consists of up to 2·8 m of reddish-brown earth (10R 4/4–5/4) with thin hard cemented bands and granule-sized nodules of cemented, honeycombed earth. Median grain size varies from the fine sand to medium silt range. In the main chamber pit there were patches of very dark brown to black, hard, sand-sized particles which might be manganese oxides. A few small bones and a fragment of a speleothem were also present in this pit. The unit extends into the Red Earth Section where it contains some bands of cemented white nodules. In RA-1 unit A includes a thin bed between 0·8 and 1·3 m depth which is a very soft, 'fluffy', greyish yellow-brown (10YR 5/2) sandy earth with a few thin cemented bands. It is phosphatic and calcareous. It could represent a thin bed of guano material.

Below the red-brown earth unit in the Main Chamber is a second unit, unit B, which was penetrated by RA-1 (below 2·8 m) and RA-4 (below 1·4 m) and which is also exposed in lowest part of the pit between the two holes. This is a dull to bright reddish-brown (2·5 YR 5/4–5YR 2/4) and greyish yellow-brown (10YR 5/2) compact clay and silt, with a few lighter coloured clay aggregates. There is a darker brown (5YR 2/4) bed between 3·75 and 4·2 m in RA-4. In the pit the unit contains pebbles and cobbles of limestone and speleothem material and some bone fragments. It is calcareous and moderately phosphatic.

At the bottom of RA-1 (4·3–4·43 m) a black and white (salt-and-pepper pattern) gritty clay overlies hard rock. This is similar to unit 5 of Main Viator Cave, which overlies speleothem material. It is not possible to tell the nature of the underlying rock in this case as no chips were recovered.

The talus cone, unit C, below the main entrance is a typical entrance facies containing a mixture of dark brown surface soil and rock fragments up to 1 m across. The maximum slope angle is 30°. On the northern side of the cone probing with a metal rod indicated the presence of rocks beneath the floor deposits. The entrance facies must therefore be older than or contemporaneous with the upper sediments of the Main Chamber (see Fig. 3). The talus cone also overlies a cemented floor level in the vicinity of RA-3.

Auger hole RA-3 was spudded in about half a metre below the level of the cemented floor under the talus cone and penetrated Unit D. This shallow hole first went through 0·75 m of pale yellow-grey (10YR 7/2) powdery and gritty earth with chips of light grey clay and cemented material. This section is strongly phosphatic and may include some guano material, though its pH (7·5) is higher than the main old guano pile. Beneath this is a reddish-brown (5YR 5/7–4/6–5/4) and pale yellow-brown (10YR 6/2) earth with some white specks and hard chips. The hole bottomed on a hard rock at 1·45 m depth; in view of its position this rock is probably part of a buried rockpile or talus cone. The sequence in this part of the cave would therefore be (from bottom up): older entrance facies (talus); pale earth and guano; flowstone cemented floor; younger entrance facies (present talus) (Fig. 3).

Unit E, the old guano pile at 271017, also has a cemented surface. This pile contains a number of unusual minerals which were identified by P. J. Bridge. A measured section here consisted of (from the top): 10 cm of hard nodular cemented material containing gypsum and ardealite; 10 cm of soft white powdery gypsum; about 60 cm of dark brown (7·5YR 3/3–4/4) earth with some almost black bands. This unit contains whitlockite, taranakite, and apatite in guano dust. Below this was a basal unit more than 75 cm thick which extends into the nearby subsidence pit. This was composed of hard white material containing taranakite, with minor leucophosphite, quartz, and apatite. A more detailed section is given in Grimes (1977). The pH values range from 6·5 to 3·0 and the sequence gave phosphatic reactions throughout.

In the Foul Air Section RA-2 initially penetrated 0·5 m of phosphatic greyish-brown to dull orange (5YR 6/2–6/4) friable earth with white flecks and cemented bands.5%8s mah o equivalent to unit A. A 10 cm cavity below a cemented band was followed at 0·6 m depth by Unit F: red earth and clay (10R 4/6) with beds of dull yellow-orange clay (10YR 7/4–7/3). The

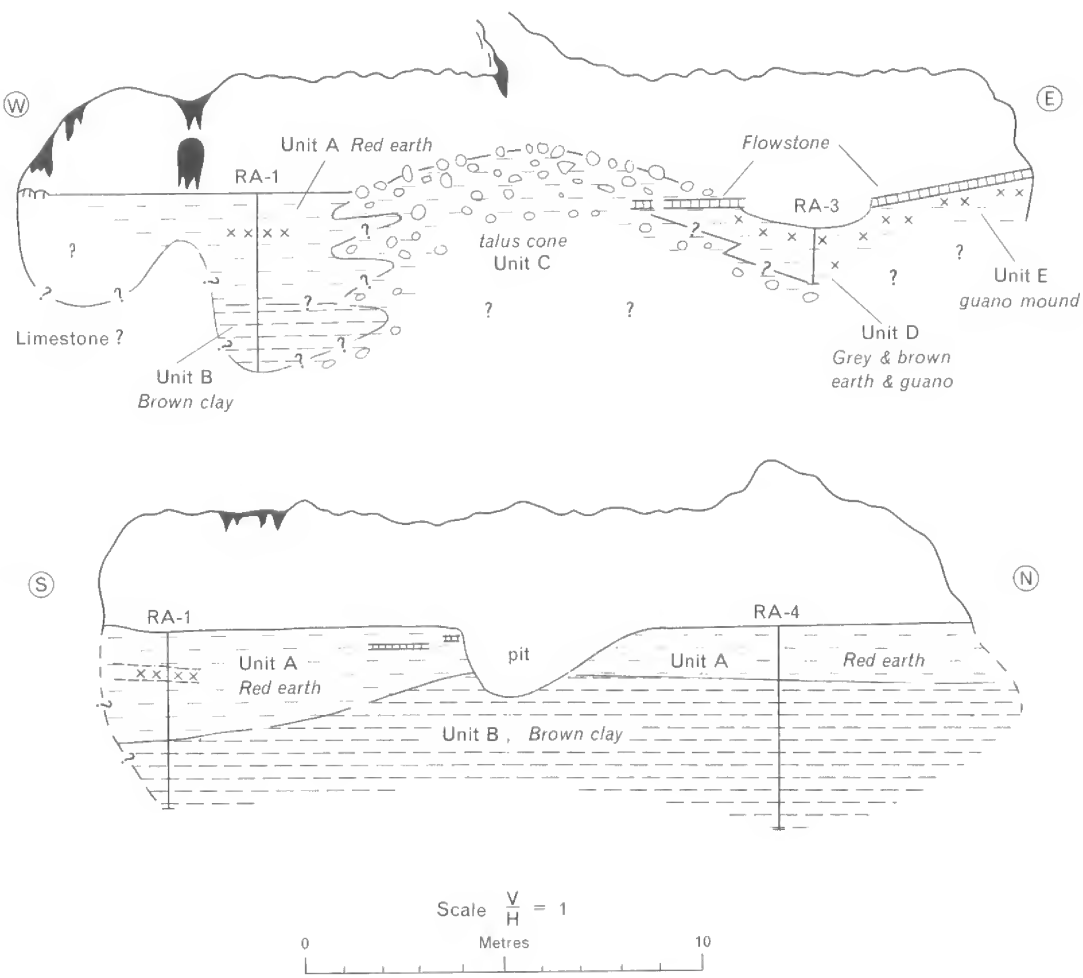

FIG. 3: Distribution of sediment in the Main Chamber of Russenden Cave.

latter became dominant below 2·3 m and contained granule and pebble-sized aggregates of red, light brown, and orange clay. This material continued to the bottom of the hole at 4·5 m. Unit F was only weakly phosphatic and poorly calcareous. X-ray analysis of clay minerals from this hole showed the presence of both Illite and Kaolinite; the former being dominant in the upper levels and the latter at depth (Grimes 1977).

The Smaller Caves of Viator Hill

There are fifteen small named caves on Viator Hill and a number of small unnamed potholes (see Map 10). The small caves exhibit a variety of forms which are divided into four main groups in this discussion, though there are some transitional types. These groups are: (a) The simple pots; (b) simple joint controlled fissure caves; (c) a dominantly horizontal system; and (d) pot or fissure entrances with horizontal extensions from the base. The last group is the most complex.

The Simple Pots

Simple pots are more or less vertical, cylindrical to elliptical shafts with minimal enlargement at the base (e.g. VR-17, Map 5). The simplest (unnamed) forms consist purely of a shaft which terminates in a rubble or earth floor. The most complex forms are transitional with group d.

Tumbleweed Pot (VR-7): This cave has a tight inclined entrance passage which leads to a vertical, somewhat elliptical fissure about 5 m deep. The fissure widens towards the base to form a small chamber with a sloping floor of loose earth and rubble. There is some cave coral on the walls. Information is from UQSS members. No map has been compiled at the time of writing.

Cruiscin Pot (VR-8): There is a small entrance leading down to a single vertical chamber 8 m deep and 5 m long at the base. The walls have many hollows and pockets of phreatic form, together with some good examples of limestone blades and small windows in the walls. There is a rubble floor below the entrance. The walls have been undercut close to the floor level by a solution level which shows a gentle dip to the south. Beneath this undercut the floor is of flowstone and there are some stalactites. The chamber walls have cave coral and flowstone cover in places. A map of the cave has been published by the UQSS (see Appendix 1).

Ironwood Pot (VR-9): This cave consists basically of two, one metre diameter, shafts, 5·5 m deep and separated by a solid rock partition with several large windows which connect the shafts. The shafts are smooth curved cylinders and could probably be considered to be rainwater inflow features superimposed on a phreatic origin. Information supplied by UQSS (see Appendix 1).

Saddle Pot (VR-17; see Map 5): There is a short inclined shaft which connects via a narrow slit to a small vertical fissure with an earth and rubble floor. The total depth is 7 metres. The walls of the fissure are sculptured by vertical runnels. At its base there are several low rounded cavities in the walls. These, together with the presence of some blades and windows between the cavities suggest a phreatic origin for the lower part of the cave. The upper parts can be classed as rainwater inflow shafts.

U-Tube Pot (VR-18): J. Toop (pers. comm.) describes this as about 5 m deep and consisting of an inclined shaft leading to a small chamber which connects to a second narrow vertical shaft from the surface. It has not been mapped at the time of writing.

Side-saddle Pot (VR-21): A narrow, 4 m deep vertical shaft leads to a small, low rubble floored chamber. A nearby surface fissure has been excavated and leads to the same chamber. The main shaft has some deep sharp-edged scallops on the vertical walls (0·5–1·5 cm diameter) due to solution by inflowing rainwater. The cave has not been mapped at the time of writing.

Fissure Caves

Fissure caves develop as vertical or steeply inclined fissures reaching to the surface to form one or more entrances. They are solution enlarged joints.

The Joint (VR-5; see Map 4): This cave has a small entrance fissure which connects with a second long narrow fissure with an earth or rubble floor and a roof blocked at varying heights by red earth or by botryoidal white speleothems (see Archer 1978, pl. 10). The red earths are also plastered to the walls in places, they contain bone material which has been studied by Archer (1978).

Below the entrance the rock surface is fresh limestone with deep scallop-like pits and runnels (10–20 cm wide and 5–10 cm deep) due to inflowing rainwater. The walls of the two fissures have intersected several vertical, cylinderical shafts which now remain as truncated wall and floor cavities (see plan, Map 4). These shafts appear to be old rainwater inflow routes and may have provided the entrances through which the red earth and its bone material entered the cave. The upper parts of the shafts are now plugged by red earth and speleothems (see Archer 1978, pl. 10D). Their walls are covered by reddish flowstone deposits, as are parts of the main fissure. The connection between the two fissures is through a narrow key-hole window in the side of a small vertical cylindrical shaft. At the far end of the main fissure a horizontal flowstone forms a false floor about a metre above the present floor. Foul air is commonly present in this cave.

MIKES POT (VR-6): There is a 12 m deep entrance shaft which is elongated at first but becomes cylindrical at the base, with rainwater scallops and runnels on the walls. Part way down this shaft a window opens into a second shaft which is plugged above by reddish stalactites and flowstones. The base of this second shaft opens into an elongate fissure about 0·5 m wide and 17 m long and with a roof up to 4 m high. There are abundant roof decorations and some flowstones on the walls. The floor and roof of the fissure drop in several steps until finally it becomes completely filled by sediment at a depth of 19 m below the entrance. A map has been published by the UQSS (see Appendix 1).

MUDSLIDE POT (VR-15): This is a small cave consisting of an open fissure partly blocked above by rockpile. A second sloping fissure connects to the first at its base and is separated from it by a large hanging wedge of rock. The cave has been surveyed by UQSS but the map has not yet been plotted.

DEAD SHEEP HOLE (VR-16; see Map 5): This is a simple, small fissure cave, about 5 m deep and 9 m long with several daylight holes between large blocks which close off the top of the fissure. The floor is of brown earth and rubble. There are some small flowstones on the walls and the ceiling.

HORIZONTAL SYSTEMS

CRYSTAL CAVE (VR-3; Map 2): This cave is the only one of its type on Viator Hill. The cave has also been known as 'The Grotto' or 'Crystal Grotto' (Shannon 1968). A short inclined entrance leads down 3 metres to a small chamber. From the base of the chamber the cave continues as a wide, low-roofed passage, extremely well-decorated with numerous white, coarsely-crystalline, conical stalactites and columns which often obscure the walls and obstruct the passage in many places. Some flowstones also occur on the walls and floor. Elsewhere the floor is earthy with some rubble. Where not obscured by stalactites, the ceiling is smoothly undulating with a powdery weathering surface. A small chamber at the rear of the cave is 2 m high with a domed ceiling.

POT OR FISSURE ENTRANCES WITH HORIZONTAL DEVELOPMENTS AT THE BASE

These caves have either more-or-less cylindrical rainwater inflow shafts similar to the simple pots or fissure entrance sections. They are distinguished from the simple caves by having a significant amount of horizontal development at their base.

BEVANS POT (VR-4; see Map 3): This cave has a 7 m entrance shaft, partly of solutional origin and partly formed between subsided blocks. At its base this shaft connects with two sloping fissure passages which open into the main chamber. The chamber has a U-shaped plan due to the presence of a large central block with, in places, only a few decimetres of space between it and the ceiling (see plan and section 4; Map 3). The floor is of rubble near the entrance but further in it is of brown earth with a westerly slope. The walls have smoothly rounded pockets separated by bluntly pointed blades; the ceiling has similar features and a dominantly phreatic origin is suggested. The rock surfaces are powdery. There are deposits of red earth, with some bone material, in the walls at several places. Flat bedded 'older' red flowstones are associated with these red earths and a correlation with the red-earth breccias of the nearby Main Viator Cave is suspected. The cave is well decorated with stalactites, shawls, curtains and ribbons, stalagmites, and flowstones. Speleothems are particularly abundant in dome shaped bell-holes in the roof.

DROP-IN POT (VR-10): A tight entrance squeeze leads to the top of an elliptical fissure about 8·5 m deep and 4 m long. The walls of the fissure are covered by cave coral and some flowstone. From the fissure a small passage leads to a small chamber, about 4 m across, with a flat roof and solution undercuts. The walls have a smooth powdery surface. The floor is of rubble beneath the entrance and elsewhere is a loose red earth. A dry stream channel crosses the floor from the entrance to the far side of the chamber. Information is from UQSS members; a map has been published by the UQSS (see Appendix 1).

CUNDOWIE CAVE (VR-11): A small, excavated hole leads to a vertical fissure, about 10 m deep, with muddy rock walls. At the base of the fissure there is a heavy growth of cave coral. Holes in the floor and at the northern end of the fissure lead to a low chamber, about 10 m long, with a rubble, earth and flowstone floor and a horizontal ceiling partly covered by cave coral. A low, flat roofed, passage leads to the west, past a large subsided block with a flowstone coating. Several short, low, tight passages lead off from this passage and from the main chamber. The flat ceiling appears to be a solution plane marking an old water level. A map has been published by the UQSS but has some major errors of scale and direction (Appendix 1).

RABSCUTTLE HOLE (VR-20; Map 6): This is a 10 m deep cave with two levels of horizontal development. An entrance shaft with rainwater inflow runnels and small scallops leads to an elongated fissure which has a horizontal solution plane crossing its lower part (The middle level – Map 6). A small passage with phreatic forms extends from this level and has flowstone and earth floor. The walls and roof of the fissure have an abundance of flowstones, cave coral, and stalactites, which block the extremities and partly cover the floor.

A continuation of the entrance shaft down through the floor of this middle level leads down to the lower level. This has a small chamber with several small bell-avens. Low, flat-roofed passages lead off from this chamber and appear to have developed at an old water level. Shannon (1975) considers that features on the walls of these passages are current scallops. This, as well as the flat ceiling, leads him to conclude that the passages are stream passages.

In the main chamber of the lower level the walls have smoothly surfaced pockets and a small window allows a view of a similar pocket to the northwest. These are phreatic features and predate the draining of the cave to the level of the flat roofed passages. The floor is of a loose red-brown earth with some small bones on the surface. Some older red-earths with bone material also occur at the middle level. More detailed descriptions of the cave have been given by Shannon (1975) and Grimes (1975).

The February 1976 flooding of this cave opened up a new passage which extended from the chamber for about 5 m back beneath the middle level (Shannon 1976b). This is not shown on Map 6.

THE WHALE ROCK AREA
(250220; Map 10)

There is only one small true cave in this area: Sagging Gut Cave. Other cave-like forms are an overhanging cliff above Pike Creek which forms a water filled rock shelter, and Whale Rock itself, which is a small rock in the middle of the waterhole that has a horizontal tube of water level which goes in about 2 m and then rises vertically to a hole, 'the spout', in the top of the rock.

SAGGING GUT CAVE (BRK-1): This cave has been described by Bourke (1970). It has two horizontal levels close to the ground surface and a final tight vertical squeeze which may lead to a third level. There is some cave coral and floor is of rubble and mud. The wall features suggest a phreatic origin which must predate the downcutting of Pike Creek adjacent to the cave. The cave had only been partly mapped at the time of writing.

HISTORY OF CAVE DEVELOPMENT

A relative chronology can be established for many of the erosional and depositional features within each of the major caves, and in some cases correlation is possible between the individual caves, and between events in the caves and the erosional and depositional history of Pike Creek. An absolute chronology is more difficult to obtain; The faunas of the cave deposits give some time control (Archer 1978), and approximate ages can be obtained from comparisons of the stream terraces with dated terraces and K-cycles further south (see geological section). The deduced sequence of events is listed in Table 1.

The caves were all initiated by phreatic solution when the bed of Pike Creek, and hence the 'water table', was above its present level. In the case of the Glenlyon System a stage of underground stream development has followed as a result of capture of part of the flow of Pike Creek. On the other hand the caves of Viator Hill show no strong evidence for the existence of rapidly moving streams and these caves appear to have followed a variation of the non-fluvial development pattern outlined by Frank (1972). C. H. C. Shannon (pers. comm.) disagrees with this viewpoint and postulates a previous diversion of water from Pike Creek through Viator Hill as a necessary stage in the dcvelopment of its caves.

Development of the Viator Hill Caves

The caves of Viator Hill all show evidence of having grown mainly under slow moving phreatic conditions, i.e. nothophreatic in the terminology of Jennings (1976). This is evidenced by the irregular form of their passages and chambers on the large scale, and on a smaller scale by the presence of many solution hollows, pockets, blades, and other features in the walls and ceilings (Plate 6b).

In the larger caves horizontal ceilings (Plate 5c) and undercuts in the walls (Plate 5a) are evidence of solution occurring below a succession of levels as the caves were drained. Flat ceilings have been quoted by many authors as evidence for old water levels (e.g. Jennings 1971; Frank 1972; and literature cited therein), often with connotations of fluctuating levels between the flat ceiling (or top of the wall undercut) and the maximum extent of the wall beneath it. In addition rapid stream flow is often assumed. This latter assumption is generally not justified in the case of the Viator Hill caves where there are no scallops to suggest

TABLE 1: Development of the Texas Caves

Tentative Ages and Climates[1]			Glenlyon System		Pike Creek[2]
HOLOCENE	1000 BP?	dry?	Silt mounds in stream passage Collapse of upstream entrance Vadose scallops and nitches Siltation?	Speieothems; Doline collapse sequence	(Qha gravels, modern stream cliffs,) (soil stripping near cliffs and dolines) Qa$_1$ terraces (383–4 m)
		wet?	(Incision of terraces and) (stream passage sediments)		Erosion of Qa$_2$ terrace
	4000 BP?	dry?	(385–6 m terrace in camp doline,) (siltation within caves)		Aggradation, Qa$_2$ terrace (388–9 m)
-?-		wet?	Vadose incision of cave floor?		Incision of creek bed (380–?)
LATE PLEISTOCENE		dry?			Possible aggradation?
		wet?	(Partial capture of Pike Creek and) (enlargement of main stream passages)	Phreatic formation	Incision of creek bed (–?–)
	30 000 BP?	dry?			Aggradation, Qpa gravels (390–395 m) Stream at 400–410 m?
		wet?			Stream above 411 m

(1) Climates and ages of terraces are based on the K-cycle theory, and correlations with dated terraces elsewhere in Australia.
(2) Elevations of Pike Creek and its terraces refer to the area between the Glenlyon System and Viator Hill.

strong currents, nor are there long linear passages of the type found in most stream caves (c.f. the Glenlyon System). Further there are often no apparent entrances or exits for through flowing streams at the levels of these features. Instead the flat ceilings of the chambers are generally surrounded by walls on all sides, and some of the higher wall undercuts make a full circuit of the chambers above the level of connecting passages. Some chambers with these features have only a single entrance and therefore could not have contained a through flowing stream. The situation therefore appears to have been one of partly drained phreatic chambers with standing pools of slowly circulating water.

Since draining, the main history has been one of deposition and erosion of sediments and speleothems, with some solution continuing at depth (Table 1).

The Viator Hill caves have not all developed at the same time. The highest caves would probably have developed first and progressively lower caves would have formed as Pike Creek cut down beside the hill and lowered the water level. Thus The Joint (VR-5) near the top of the hill would have been the first cave to form, and also the first to be drained and opened to the surface. It is not surprising therefore that the bone deposits in The Joint contain the oldest fauna in the hill (Archer 1978).

TABLE 1: CONTINUED

RUSSENDEN CAVE	MAIN VIATOR CAVE	THE JOINT
Speleothems Subsidence pits, Entrance closed Red earth (unit A) Brown earth/clay (unit B) guano mound guano entrance cone eroded younger bone beds Red and brown clay (unit F)	'Younger' speleothems Breakdown rubble Chocolate earth (unit 1) red earth cone unit 2 unit 4 Red and brown clay (unit 3)	Speleothems Minor sediments?
Younger sedimentation begins	Younger sedimentation begins	
Wall undercuts in Foul Air Section? (Erosion of speleothems and breccias, solutional enlargement of lower levels) cave stream?	Lower wall undercuts? (Erosion of 'older' speleothems and breccias, solutional enlargement of lower levels) cave stream?	(Erosion of bone breccias)
Speleothems (Red earth breccias and older bone beds)	'Older' speleothems (Red earth breccias and bone beds)	
Opening of entrances Draining of upper level	Opening of entrances Draining of upper level	?
390.8 m solutional level Phreatic formation of upper level	384 m solutional level Water at 385–7 m Phreatic formation of upper level	Speleothems
		(Deposition of bone breccia) (Draining, opening of entrances) Phreatic formation

For the smaller caves on the hill the history of development approximates to the model of Frank (1972): (1) Phreatic solution of the cavities and possibly deposition of some residual clays; (2) Drainage of the cavities as Pike Creek lowered its bed, with some breakdown and development of entrances; (3) Accumulation of entrance facies sediments, rubble and surface soils with bone material in some cases, and development of speleothems; (4) Blockage of some or all entrances leading to a cessation or reduction of sedimentation so that speleothem development becomes dominant. In some cases (e.g. The Joint, Bevans Pot, and Rabscuttle Hole) two stages of deposition of sediment can be recognised. The earlier stage consists of partly cemented red earths, with or without bone breccias, and has now been largely removed by erosion or subsidence into deeper cavities. The later stage is made up of unconsolidated red and red-brown earths. These two stages are seen in more detail in the larger caves.

The two large caves: Main Viator and Russenden have the most complete record of development. These also follow Frank's (1972) non-fluvial model, though with some important variations. The main level of development of Main Viator Cave is about 5 metres below that of Russenden Cave and it may therefore have been initiated slightly later. However the difference is probably not significant in view of the likely variations in the 'water table' across the hill. The sequences within the two caves are very similar and are assumed to be contemporaneous (see Table 1).

The main level in both caves developed chiefly from solution by slow moving phreatic waters below a water level which must have been higher than 387 m in Main Cave and 391 m in Russenden Cave. The bed of Pike Creek was presumably at comparable levels on the respective sides of the hill. There are remnant gravels (Qpa) on the surface at these elevations which are probably contemporaneous. Some residual clays might have accumulated in the bottoms of these phreatic chambers, but such deposits have not been recognised.

As Pike Creek lowered its channel and approached its present course, the water levels in the caves would have dropped. Flat ceilings and horizontal solution undercuts in the walls indicate still-stands as the caves were drained. The ceiling level of 390·8 m in the Main Chamber of the Russenden Cave (Plate 5c), and the wall undercut at 384 m in Main Viator Cave are two which could have formed at this time. The lower levels might have formed then or might be due to later floodings when water levels rose again.

The removal of hydrostatic support within the caves would have resulted in some collapse of the ceilings and this, coupled with surface denudation which truncated high level blind shafts and fissures, would have resulted in the opening of entrances. Rubble and soil material from the surface could then be washed in to form the red earth breccias. Speleothem deposits also formed and were interbedded with the red earth breccias and often cemented them. These are the 'older' coarse grained flowstones of Main Viator Cave. In Russenden Cave there is not such a marked difference in crystal form or colour between speleothems of different ages but 'older' speleothems can be identified in the squeezes area from their stratigraphic relationships. The erosion of surface soils suggests surface instability, possibly due to a change towards an arid or colder climate, although the coarsely crystalline nature of the flowstones suggests that these were constantly wet so conditions cannot have been too dry. Alternatively the flowstones could have indicated short returns to a humid climate within a dominantly arid period. Surface instability should also result in aggradation of the surface stream (Butler 1959) but no stream terraces occur which can be assigned to this time: possibly any that formed were obliterated by younger deposits.

The red earth breccias appear to have been mainly transported by mass movements and are generally close to present or previous entrances. Associated bone deposits in Russenden Cave have been studied by Archer (1978) who suggests a late Pleistocene age. Some bones also occur in the breccias of Main Cave but have not been studied in detail.

A line of shallow depressions extends southeast from the Main Cave entrance (Map 10) and could indicate the existence of a lower and more extensive level of earth filled passages extending from the cave. This may be related to the low level development of the Foul Air Section of Russenden Cave.

The low level development and the erosion of the breccias and speleothem deposits in the higher levels are thought to be contemporaneous and to be due to a return to a wetter and possibly warmer climate. This climatic change would have produced a number of effects (deduced from the K-cycle model of Butler 1959, and others). Stream incision may already have commenced with the return to stability and the 'water table' would have been lowered as a consequence. However the rate of groundwater circulation would now have been increased by the wetter climate, and these waters would have been more aggressive in view of the thicker vegetation cover. The overall result would be active phreatic solution below the lowered 'water table' and the formation of the low level sections of the caves. The deposits in the upper levels would have subsided or been washed into these lower levels.

Shannon (pers. comm.) goes one step further and postulates that this low level development was in the form of a stream diverting waters from Pike Creek beneath Viator Hill. The stream incision and concurrent cutting of the stream cliffs on the northwestern side of Viator Hill (220310 on Map 10) may well have intersected some caves. The rapidity with which the caves drained after the January 1976 flooding, together with the way in which the water level in the newly formed pit in Main Viator Cave has since risen in step with the rise in the Glenlyon Dam, suggests a fairly permeable connection at present. Thus some movement of water from Pike Creek doubtless occurred.

However no definite stream formed passages can be seen at present, and the circulation may have been of a more diffuse form. From time to time UQSS members have reported 'stream passages' in the small caves of Viator Hill. These references are generally based on the presence of flat ceilings or wall undercuts which, as discussed earlier, do not in themselves imply strongly flowing streams.

Any stream entrances and exits would now be buried beneath the alluvial terraces of Pike Creek and the only part of the lower levels which has not been filled by later sediments is the Foul Air Section of Russenden Cave. Here we see only the uppermost part of the level and this has an overall morphology which suggests dominantly phreatic and epiphreatic solution. There are solution levels related to old water tables but there is no evidence of strong stream flows. No stream deposits have been identified in any of the caves on Viator Hill.

The line of depressions southeast of Main Cave have a linear and vaguely meandering form and this could indicate a concentrated stream passage draining water away from Viator Hill and much of the eroded cave sediment may have been removed in this manner, but this need not be part of a through flow cave.

The next stage in the development of the area was the aggradation of the bed of Pike Creek to form the Qa_2 terrace deposits. The water tables would have risen in consequence and some of the solution undercuts in the lower parts of the caves may have formed at this time if they do not date from the earlier drop in the water table. The 382·4 and 381·4 m levels in Main Cave may date from this time as no red earth breccias or older speleothems are found below this level.

Deposition of the younger sediments in the caves may be contemporaneous with the Qa_1 and Qa_2 terraces of Pike Creek and both effects could be due to a further stage of surface instability related to reduced vegetation and a change towards an arid or cold climate. The Qa_2 terrace has been tentatively correlated with K_2 cycle terraces elsewhere which are of late Pleistocene and early Holocene ages (see geological section). The possibility of vegetation changes caused by aboriginal man cannot be discounted as an alternative source of instability.

Deposition in the caves appears to have continued until quite recent times, though there might be a disconformity releated to the break in surface deposition between the Qa_2 and Qa_1 terraces. The sedimentary units found in Russenden Cave are generally different from those in Main Cave and there are also variations within each cave. These result from differences in source materials and conditions in the two caves. The presence of clay aggregates, particularly in the Main Cave deposits, suggests that the main source was from surface soils and their preservation implies transportation and deposition by mass movement with only minor water transport.

In Main Viator Cave the oldest sediments of this series appear to be the red and brown clays of unit 3 (see cave descriptions, and Fig. 2). This unit might be a facies equivalent of unit 2 or may predate it. It is similar to the unit F in Russenden Cave.

Unit 2 is the main deposit in Main Cave. The numerous and varied clay aggregates within it suggest a source from a variety of surface soils, and possibly some re-working of the old red earth breccias. Lateral variations within the unit probably reflect variations in the source materials from different entrances. Introduction of organic material (e.g. guano and plant debris) locally may also have contributed to the variation, though the generally low phosphate contents suggest that guano was not abundant. The laminated clay (unit 4) indicates the presence of a small semi-permanent pool in that area and might be due to a slightly wetter but seasonally fluctuating climate at that time. Speleothems developed within unit 2 in several places during its deposition. These could indicate a reduction in sedimentation, either due to temporary entrance blockages or to brief wetter climates with greater surface stability.

The chocolate brown surface earths (unit 1) are the final stage in deposition in Main Cave and these may still be forming in some parts of the cave. In other parts of the cave the sediments have been buried by rockfalls from the ceiling. 'Younger' stalagmites and flowstones have built up over the sediment floor in a few places and are active at present.

In Russenden Cave the earth floors of the Shawl Section, the Main Chamber and Red Earth Section, and the Foul Air Section are all at different levels although each is more or less horizontal (see sections on Map 7). This suggests that deposition occurred independently in each section and that they were separated by barriers. The Squeezes would doubtless be the barrier between the Shawl Section and the Main Chamber but the barrier between the latter and the Foul Air Section is less obvious; there may have been a rock barrier at depth but the most likely feature is the old guano pile which was being built up at the same time as the sediments. This could have been quite an effective barrier if mass movement was the main process and there were only small intermittent streams.

The oldest deposits in Russenden Cave appear to be the red and brown clays (unit F) found at depth in the Foul Air Section. These are not as phosphatic as the rest of the Russenden sediments and could therefore predate the old guano mound. There may have been a time break between the formation of this unit and the remainder of the deposits related to the break in surface aggradation between formation of the Qa_2 and Qa_1 terraces. Unit F is similar to Unit 3 in Main Cave.

In the Main Chamber of Russenden Cave the earliest deposits are the brown earths and clays of unit B (see Fig. 3). This unit could interfinger with the rubble of the entrance cone and may also be contemporaneous with the earliest guano deposits as it is phosphatic. The red earth unit A overlies unit B and forms the surface deposit. This unit has thin interbedded flowstones and cemented bands and occasional guano beds. It is interbedded with the entrance rubble cone (unit C) and is a lateral equivalent of the guano deposits (units D and E).

When the floor of the Main Chamber had built up to the same level as the old guano mound the intermittent streams from the entrance would have been able to flow down the far side of the mound and erode the present channel which leads down to the Foul Air Section.

Deposition in Russenden Cave was terminated by the blockage of the entrances which may be a recent event. Since then the main developments have been continuing speleothem development, subsidence of the natural pits in the floors, and probably some further erosion of the guano mound.

Development of the Glenlyon System

The present Glenlyon System is a stream cave modified by collapse and by blockage of its influx area. However, many of the side passages of the system show features which are inherited from an earlier phreatic stage. The history of development deduced for the system is not as complex as is the case for the Viator Hill caves, mainly because the Glenlyon System lacks a complex sequence of sediments and speleothem deposits (see Table 1).

As with the Viator Hill caves the initial low energy phreatic stage must have occurred when the 'water table', and hence the bed of Pike Creek, was higher than at present, but it may have commenced a lttle later than in Russenden and Main Viator Caves as the main levels of the Glenlyon System are at lower elevations, i.e. below 385 m. The flat roofs in several passages in the upstream parts of the system attest to a water level standing between 384 and 385 m. Pike Creek must have adopted a course close to its present form by this time and subterranean capture of part, at least, of its flow may then have occurred. Since capture an epiphreatic stream has enlarged the main stream passages to their present linear form with more-or-less elliptical cross sections. As Pike Creek continued to incise its course down to, and possibly below, the 380 m level, these passages would have been drained and a vadose system would have been established with possible incision of the passage floors at the lowest stage.

Draining of the system, together with surface denudation, would have initiated collapse of the larger chambers. The present form of the resulting dolines suggests that some have suffered a longer period of surface weathering and soil development than others. A possible sequence of collapse is as follows: (1) The conical doline at 040295 (Map 9) and the shallow doline to its east were first to collapse and destroyed a hypothetical southeasterly extension of the system from either the Nettle Moat caves or from the Central Doline area; (2) Collapse of the Camp Doline appears to have been next in the sequence and abandonment of the Dustbath stream passage in favour of the Swallow Arch route may have been a result of this collapse, or could have been consequent on the later collapse of the Central Doline; (3) The Central Doline collapsed; (4) Terrace deposits formed in Camp Doline, and to a lesser extent in the Central Doline (see below); (5) The Crater Doline and the group of small dolines to its south appear to have collapsed fairly recently, this collapse being responsible for the blockage of the Flattener and diversion of the underground stream to the Sewer; (6) The most recent collapse was that of the upstream cliffs which blocked the entrance to the system. This continuing history of collapse probably prevented the cave system from ever capturing the full flow of Pike Creek, which was therefore capable of maintaining its surface channel.

The terraces in the Camp Doline are at a height of 385–6 m and may be contemporaneous with the Qa_2 terrace which has a level of 388–9 m on the far side of Pike Creek, the lower elevation within the doline could be due to the lesser supply of sediment. Alluvial deposits in the Central Doline show only a poorly-developed terrace form but may be contemporaneous. Deposition within the caves would also have occurred at this time.

Later incision of Pike Creek and erosion of the Qa_2 terrace would have been accompanied by erosion of the sediments in the stream passages of the cave system, though the deposits in the side passages may have remained relatively undisturbed. Further deposition, contemporaneous with the Qa_1 terrace, may have been responsible for the gravels below the present stream bed.

The recent collapse of the upstream entrance would have reduced the stream flow through the cave. The current scallops in the stream passages appear to predate this collapse and their excellent preservation, together with the preservation of subsoil karren forms on the rotated blocks of the cliff, suggest that only a short time has passed since the collapse of this section.

Since the collapse the main developments in the system have been the growth of speleothems and possibly the formation of the sediment mounds in the stream passages as a result of the reduced energy of the system. Major floods still fill the system but currents would be much slower than before.

Cave Development and Climatic Change

The development of the caves has been in stages which can be related to the history of Pike Creek: erosional and depositional phases within the caves appear to correspond to periods of incision and aggradation of the creek bed. Both the cave and surface stages may be related to climatic fluctuations. These cycles are superimposed on the long term incision of the valley of Pike Creek as a result of post-Miocene uplift.

Debate concerning the relationship between climates on the one hand and stable and unstable surface conditions on the other has not yet been resolved. The ideas of Butler (1967) are followed here in proposing the relationship between climates, surface processes, and cave development. In humid climates the vegetation cover stabilises the valley slopes and surface erosion is mainly restricted to incision of the stream beds (Butler 1967). Stream incision would lower the water tables adjacent to the stream and drain any previously waterfilled cavities in that area. The higher rainfall will however mean a greater circulation of ground waters at the lowered level, and the thick vegetation cover will make these waters more corrosive as a result of the humic acids present. Solution will therefore be active at depth and will produce a series of low-level cavities. Any earlier, or contemporary, sediments in the upper levels will subside or be washed down into these lower levels. If there is sufficient connection with the surface streams the resulting throughflow may remove much of the material from the system.

With a change to aridity, or to a colder climate, or both, the vegetation cover is reduced and soil erosion occurs. The stream beds will be built up because of the greater sediment load and terraces will be formed (Butler 1959). In the caves near the streams, the water table will tend to rise but overall circulation will be reduced and the waters become less aggressive. Where entrances are present the eroded surface soils will be washed or subside into the caves and, if the arid phase continues for long enough, they will eventually fill most of the cavities and block the entrances. As the vegetation adapts to a new climate, surface stability will return. The stream will start to incise its channel again and the water table will be lowered accordingly. The reduced precipitation will inhibit cave development and consequently there will be little record of this period in the cave history.

A return to a higher rainfall will trigger further cave development at depth and destroy much of the earlier sediments.

This concept of climatic control and the relationships between surface and subsurface development is the basis of the interpretation presented in Table 1.

ACKNOWLEDGMENTS

Acknowledgment is due to the UQSS for assistance in the field, for providing access to its maps and records, and for the useful discussions I have had with society members, in particular with C. H. C. Shannon and A. L. Brown who also commented on early drafts of this report. A preliminary draft of this paper was critically read by Professor J. N. Jennings who made a number of helpful suggestions. P. J. Bridge identified phosphate minerals. Additional field assistance was provided by A. Noon, G. Webb, and A. Glasscock of the GSQ, and by members of the UQSS, Kelvin Grove College of Advanced Education, and the Queensland Museum.

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APPENDIX 1: LIST OF CAVE AND SURFACE MAPS FOR THE TEXAS CAVES

Most cave and surface maps of the area are listed here. The only omissions are some early maps which have been superceded by more recent surveys. In addition to the maps listed here the 1:250 000 Goondiwindi geological sheet (Senior 1973) and the 1:100 000 Texas topographic sheet provide regional information.

ASF Map No.	Coverage	CRG grade	Scale	Views[1]	Authorship	Date	Publication[2]
BORDER RIVERS KARST REGION (Texas Caves area):							
4 BRK. UQS 125	Surface map: Glenlyon, Viator Hill, and part Whale Rock. Showing topography, vegetation, and cave entrances.	–	about 1:6 000	P	K. G. Grimes	1973	
4 BRK. GEN 3	Limestone Deposits, Limevale – Riverton area.	–	1:100 000	P	J. E. Siemon	1973	*Geol. Surv. Qd Rep.* **80**: fig 5
4 BRK. GEN 20	Limestone deposits, Reedy Creek – Texas Caves – Riverton and Cragie areas.	–	1:48 000	P	J. E. Siemon	1973	*Geol. Surv. Qd Rep.* **80** : fig 22
4 BRK. GEN 21	Geology and Geomorphology, Texas Caves area.	–	1:10 000	P	K. G. Grimes	1975	This paper : Map 10
4 BRK1. UQS –	Sagging Gut Cave (Whale Rock area)		Surveyed in part by J. Toop, UQSS, but not drawn up.				
GLENLYON AREA:							
4 GL UQS 124	Surface features, upstream part of the Glenlyon system.	6	1:120	P	C. H. C. Shannon	?	—
4 GL. UQS 38	Downstream part of the Glenlyon system. includes 4 GL-7, -8, -9.	5	1:120	PLX	A. L. Brown	1972	—
4 GL. UQS 109	as above, at reduced scale	5	1:240	PLX	A. L. Brown	1972	
4 GL. GEN 1	Surface and subsurface karst forms, Glenlyon system.	4–7	1:1 000	P	K. G. Grimes, *et al.*	1975	This paper: Map 9.
4 GL1. UQS 122	Glenlyon Stream Cave	5	1:240	P	C. H. C. Shannon *et al.*	1968–70	—
4 GL1. UQS 49	as above, at reduced scale	5	1:480	P	C. H. C. Shannon *et al.*	1968–70	—
4 GL1. UQS 123	as above, at reduced scale and lacking much detail	5	1:960	P	C. H. C. Shannon *et al.*	1972	*Down Under,* **11** : 132
4 GL1. GEN 2	Glenlyon Stream Cave	3–5	1:500	PLX	C. H. C. Shannon *et al.*	1968-75	This paper: Maps 8a, b
4 GL3. UQS 108	Swallow Arch	6	1:120	P	C. H. C. Shannon	?	This paper: Map 9
4 GL6. UQS 120	The Dustbath	5	1:120	PLX	A. L. Brown *et al.*	1972–75	This paper: Map 9
4 GL6. UQS 119	as above, at reduced scale	5	1:250	PLX	A. L. Brown *et al.*	1975	*Down Under,* **15** : 7
4 GL7. UQS 109	Cloister Cave	5	1:240	PX	A. L. Brown	1972	This paper: Map 9
4 GL8. UQS 121	Efflux Cave	6	1:120	P	C. H. C. Shannon	?	This paper: Map 9
4 GL8. UQS 109	Efflux Cave	5	1:240	PX	A. L. Brown	1972	This paper: Map 9
4 GL9. UQS 109	Cliff Pit	5	1:240	PLX	A. L. Brown	1972	This paper: Map 9
4 GL10. UQS –	Nettle Moat (north)	4	Surveyed by C. H. C. Shannon, UQSS, but not yet drawn up				
4 GL11. UQS –	Nettle Moat (south)	4	Surveyed by C. H. C. Shannon, UQSS, but not yet drawn up				
RIVERTON AREA:							
4 RN1. GEN 1	Riverton Cave	3?	1:600	P	P. D. Dwyer	1965	Helictite. **4** : 7
4 RN1. UQS 39	Riverton Cave	5	1:240	PX	D. S. Gillieson *et al.*	1973	*Down Under.* **12** : 56–7

ASF Map No.	Coverage	CRG grade	Scale	Views[1]	Authorship	Date	Publication[2]
VIATOR HILL AREA:							
4 VR. UQS 43	Surface traverse : Viator Hill; relates VR-1, VR-2, VR-5, VR-6, VR-7, VR-8, VR-10, VR-11, VR-12E, VR-13E, VR-19E.	7	1:480	P	A. Sprent	1968	—
4 VR. UQS 133	Surface map and cave outlines; Viator Hill.	3–7	1:1 000	P	K. G. Grimes, A. Sprent,	1976	—
4 VR1. UQS 48	Main Viator Cave	5	1:240	PLX	C. H. C. Shannon, A. R. K. Watt, *et al.*	1970	—
4 VR1. UQS 50	As above, at reduced scale	5	1:480	PLX	C. H. C. Shannon, A. R. K. Watt, *et al.*	1973	*Down Under*. **12** 9–10
4 VR1. GEN 1	Main Viator Cave	5	1:500	PLX	C. H. C. Shannon, *et al.*	1976	*This paper:* Map 1a, b
4 VR2. UQS 47	Russenden Cave	4	about 1:400	P	C. H. C. Shannon	1968	*Down Under*. **8**:15, **9**:17
4 VR2. UQS 57	Russenden Cave	4	about 1:400	PX	C. H. C. Shannon	1969	—
4 VR2. GEN 1	Russenden Cave	4	1:500	PLX	C. H. C. Shannon & K. G. Grimes	1968–75	This Paper: Map 7
4 VR3. UQS 60	Crystal Cave	5	1:120	PX	D. S. Gillieson	1970	*Down Under*. **10**: 62
4 VR3. GEN 1	Crystal Cave	5	1:150	PLX	D. S. Gillieson & K. G. Grimes	1970–75	This paper: Map 2
4 VR4. UQS 61	Bevans Pot	5	1:60	PL	A. W. Graham	1971	*Down Under*. **10**: 107–8
4 VR4. GEN 1	Bevans Pot	5	1:150	PX	A. W. Graham, & K. G. Grimes	1971–75	This paper: Map 3
4 VR5. UQS 52	The Joint	4	1:120	PL	M. J. Graham	1964	*Down Under*. **3**:5, **12**:8
4 VR5. GEN 1	The Joint	4	1:150	PLX	M. J. Graham, & K. G. Grimes	1964–75	This paper: Map 4
4 VR6. UQS 53	Mikes Pot	4	1:120	PL	M. J. Graham	1964	*Down Under*. **3**:6 & **11**:133
4 VR7. UQS –	Tumbleweed Pot		Surveyed by K. Williamson, UQSS, but not yet drawn up				
4 VR8. UQS 46	Cruiscin Pot	5	1:60	PL	D. S. Gillieson, *et al.*	1973	*Down Under*. **12**:52
4 VR9. UQS 45	Ironwood Pot	5	1:60	PL	D. S. Gillieson, *et al.*	1973	*Down Under*. **12**:53
4 VR10. UQS 44	Drop-in Pot	5	1:60	PX	D. S. Gillieson, *et al.*	1973	*Down Under*. **12**:53–4
4 VR11. UQS 59	Cundowie Pot	5	1:120?	PX	D. S. Gillieson, *et al.*	1971	*Down Under*. **10**:61
4 VR15. –	Mudslide Pot		Surveyed by J. Toop, UQSS, but not yet drawn up.				
4 VR16. GEN 1	Dead Sheep Hole	3	1:150	PLX	K. G. Grimes	1975	This paper: Map 5
4 VR17. GEN 1	Saddle Pot	3	1:150	PL	K. G. Grimes	1975	This paper: Map 5
4 VR20. UQS 110	Rabscuttle Hole	2–3	1:100	PL	K. G. Grimes	1975	*Down Under*. **14**:53
4 VR20. GEN 1	as above, at reduced scale	2–3	1:150	PL	K. G. Grimes	1975	This paper: Map 6

1. Views; P=Plan, L=longitudinal profile, X=cross section. 2. Unpublished maps are held in the UQSS map collection.

APPENDIX 2

REPORT ON COLLECTIONS OF CARBONIFEROUS CORALS FROM THE TEXAS CAVES AREA

P. J. G. FLEMING
Geological Survey of Queensland

Coral specimens collected by K. Grimes, March 1975, assigned Geological Survey of Queensland Locality numbers L.1671, L.1672, L.1673, and L.1675, have been determined as follows (see Map 10 for localities): L.1671, *Aphrophyllum?* sp., Rugosa indet., *Syringopora* sp.; L.1672, *Aphrophyllum* sp. c.f. *A. hallense* Smith, *Neozaphrentis* sp., *Syringopora* sp.; L.1673, *Aulina?* sp.; *Neozaphrentis* sp., *Syringopora* sp.; L.1675, *Neozaphrentis australis* Pickett, *Merlewoodia?* sp. or *Symplectophyllum?* sp.

DISCUSSION

Although some of the material on weathered surfaces appears to be well-preserved, recrystallization and other processes have rendered most of the corals unsuitable for detailed study. The generic compositions of the faunas from each of the localities indicates an early Carboniferous age, although only one species can be clearly identified. *N. australis* Pickett occurs in the early Carboniferous Rangari Limestone in New South Wales (Pickett 1966). *Aphrophyllum hallense* Smith is a cerioid colonial coral, but the specimens from L.1672, although apparently fasciculate, appear to be most closely comparable to *A. hallense* in their internal organization. *Aulina?* sp. from L.1673 is a small form with large lonsdaleoid dissepiments and short major and minor septa not reaching the axis. The small amount of material does not indicate identity with *A. simplex* Hill. *Neozaphrentis* forms are quite common in L.1672 and L.1673 collections. They normally have 22 major and 22 minor septa whose free lengths vary considerably, depending on the very variable width of the stereozone. The major septa reach only about half way to the axis, and the minor septa are almost covered by stereome in some specimens. A specimen from L.1675 is not determined, but resembles both *?Merlewoodia* sp. and *Symplectophyllum naoticum* of Pickett (1966; respectively pl. 10, fig. 6 and pl. 12, fig. 6). *Syringopora,* as in other early Carboniferous limestones, is usually present in small quanitities.

Taken as a whole, all of the corals present in these localities suggest a Visean age.

LITERATURE CITED

PICKETT, J., 1966. Lower Carboniferous coral faunas from the New England district of New South Wales. *Mem. Geol. Surv. N.S.W., Palaeont.* **15:**

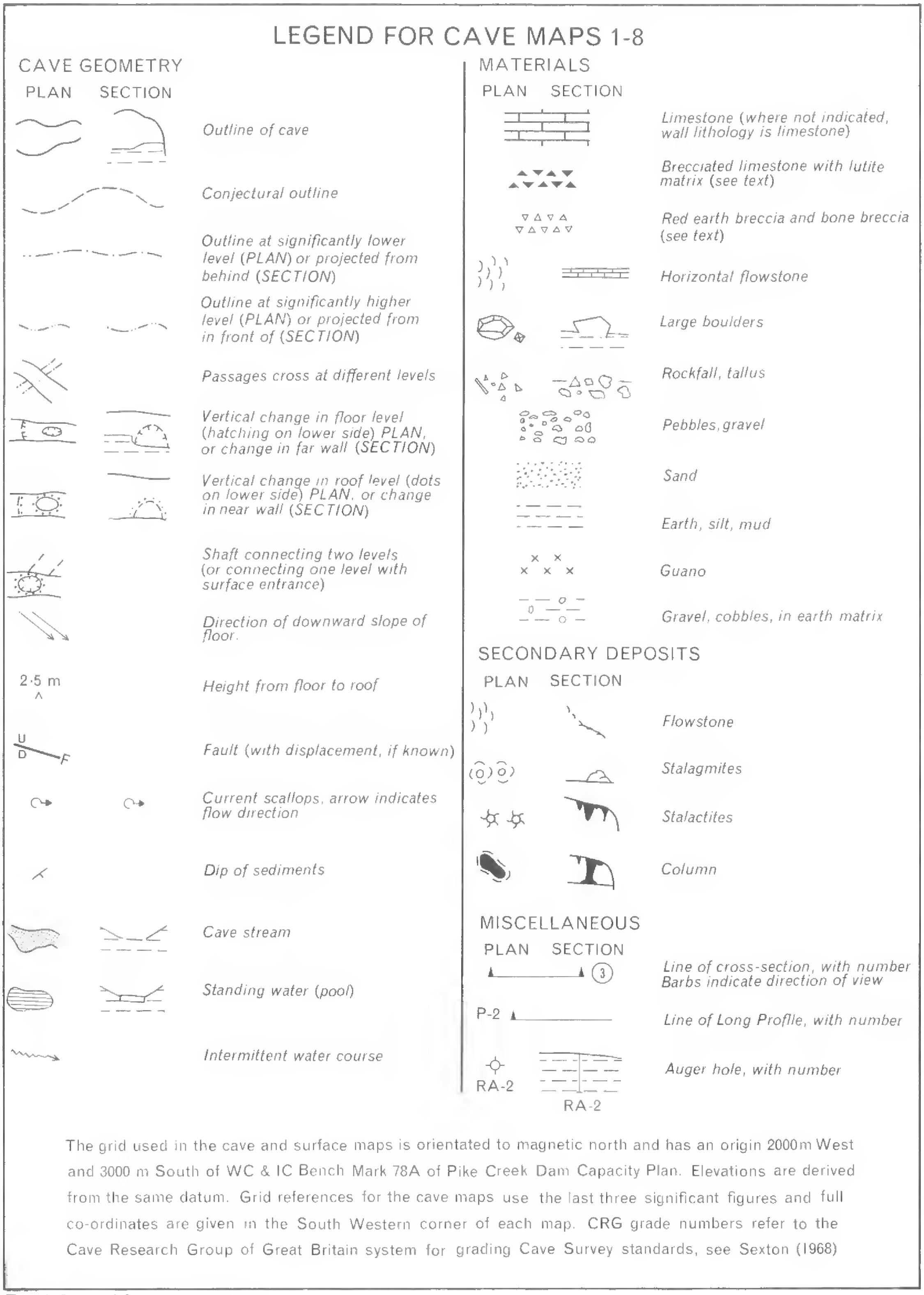
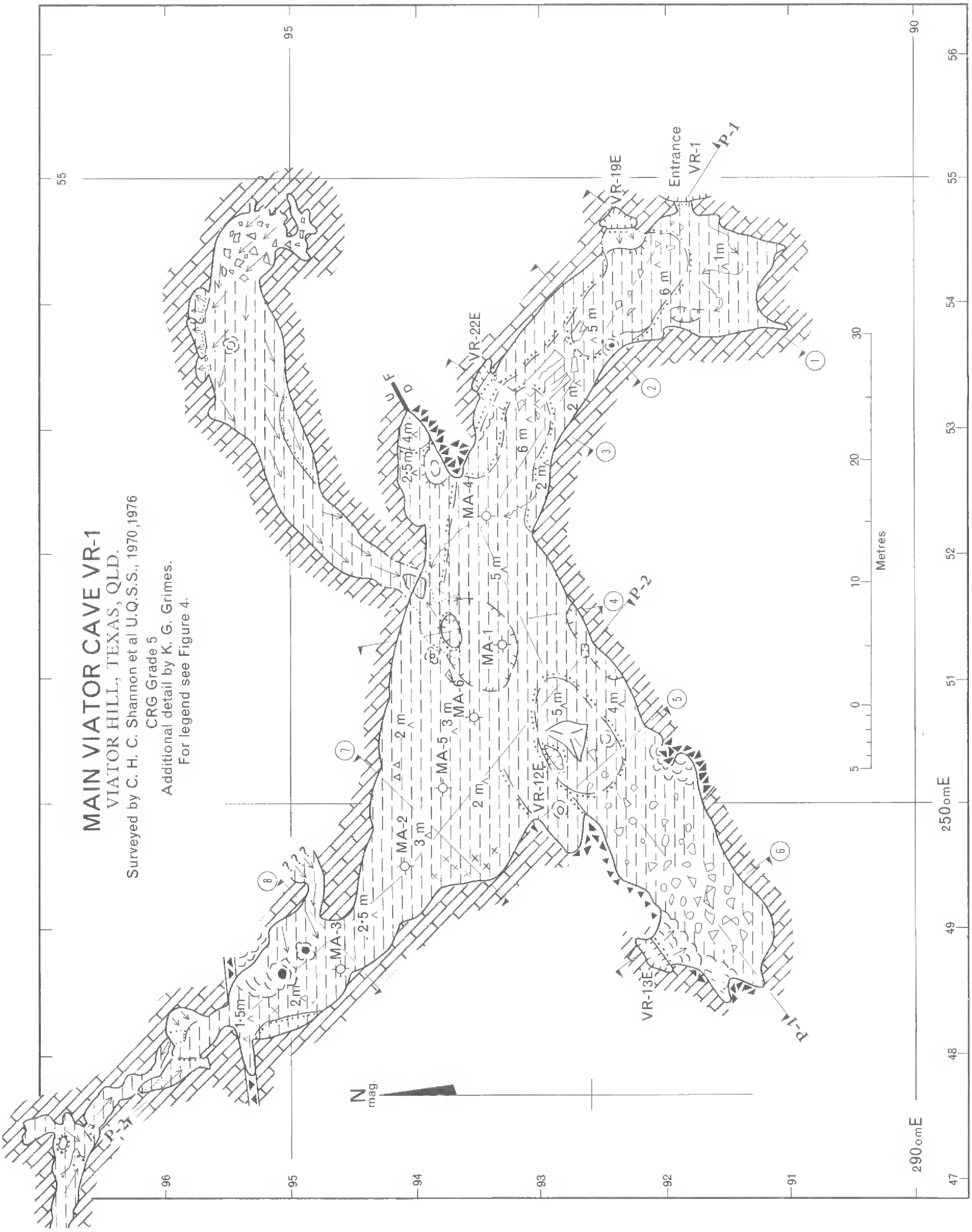
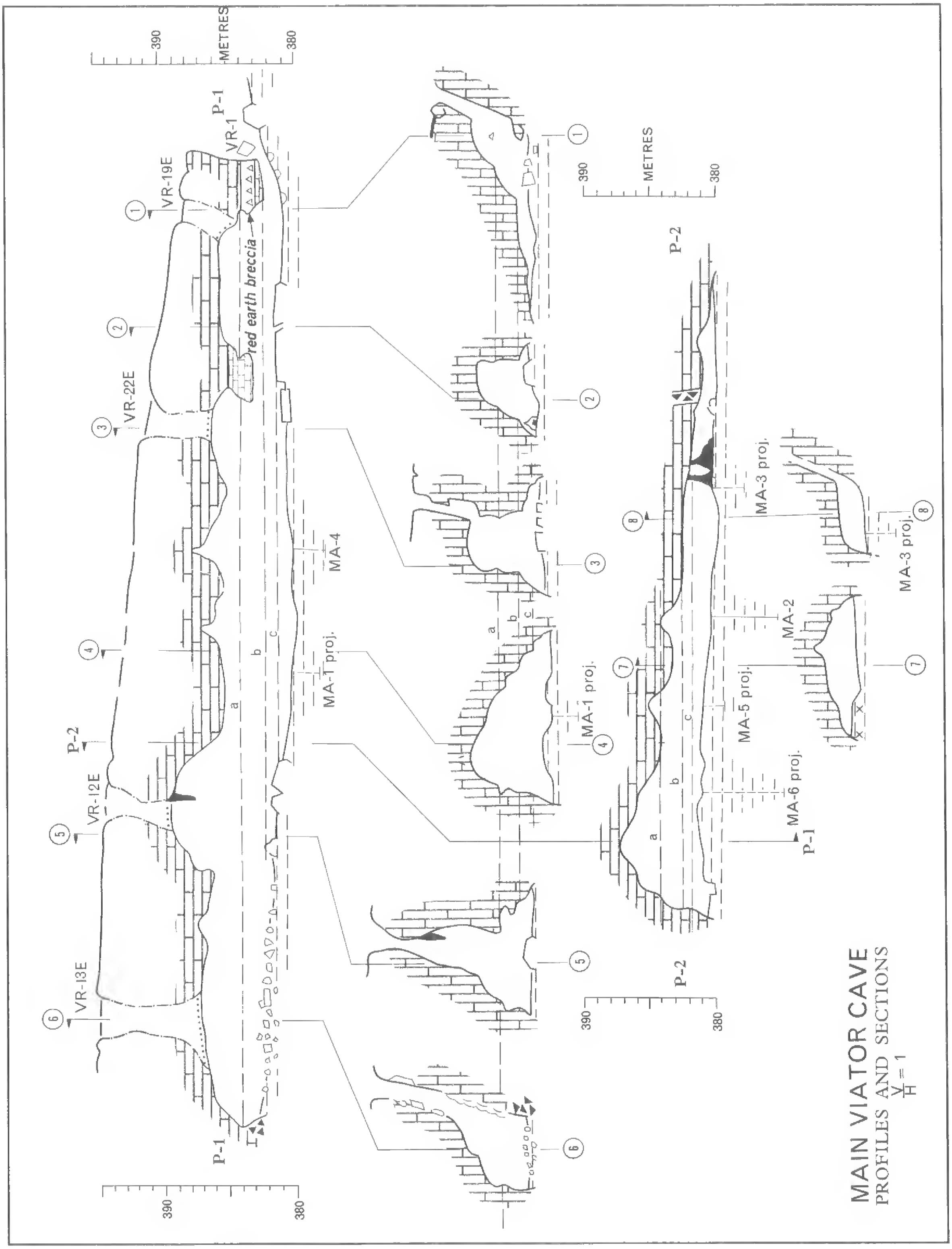
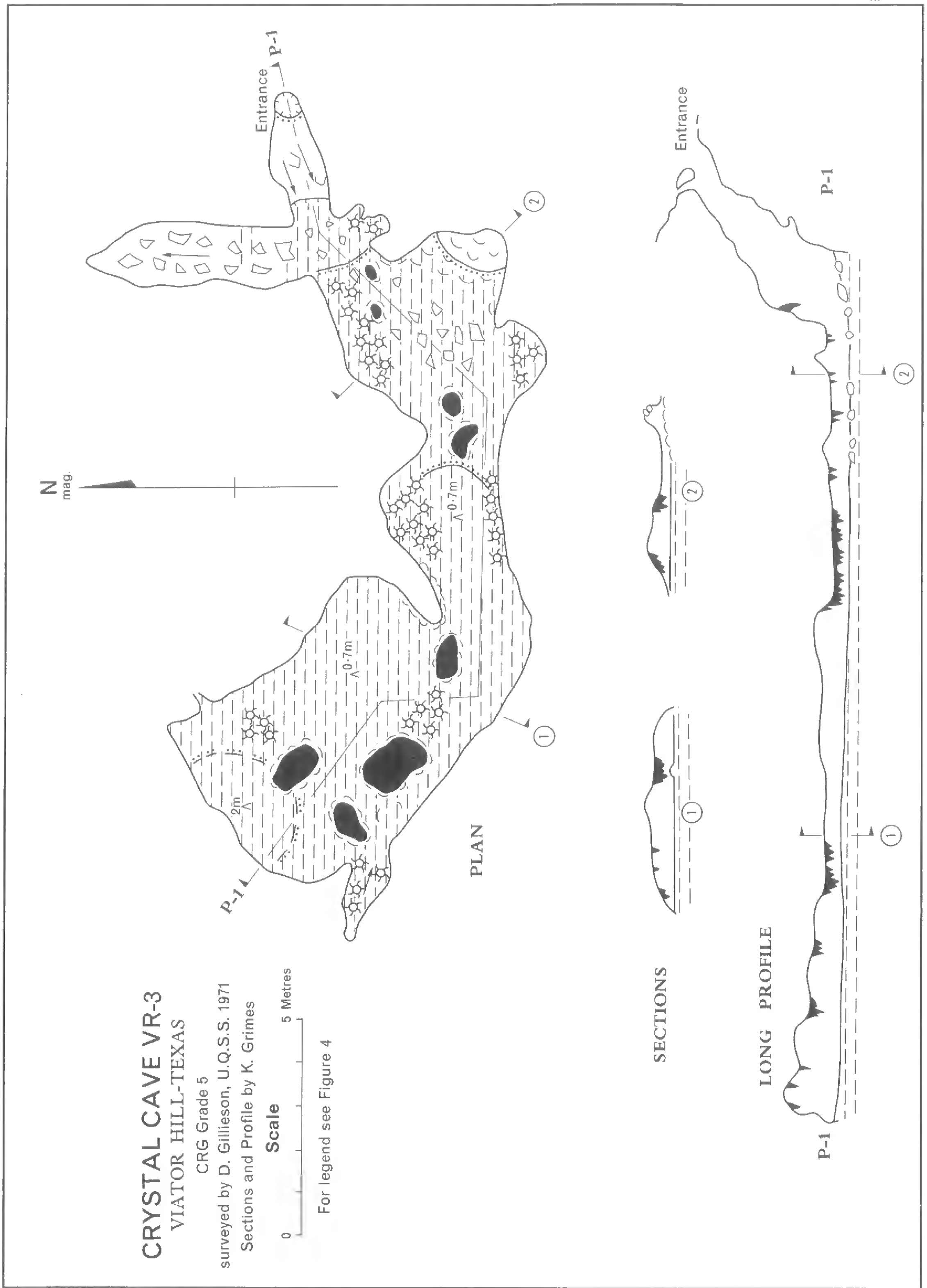
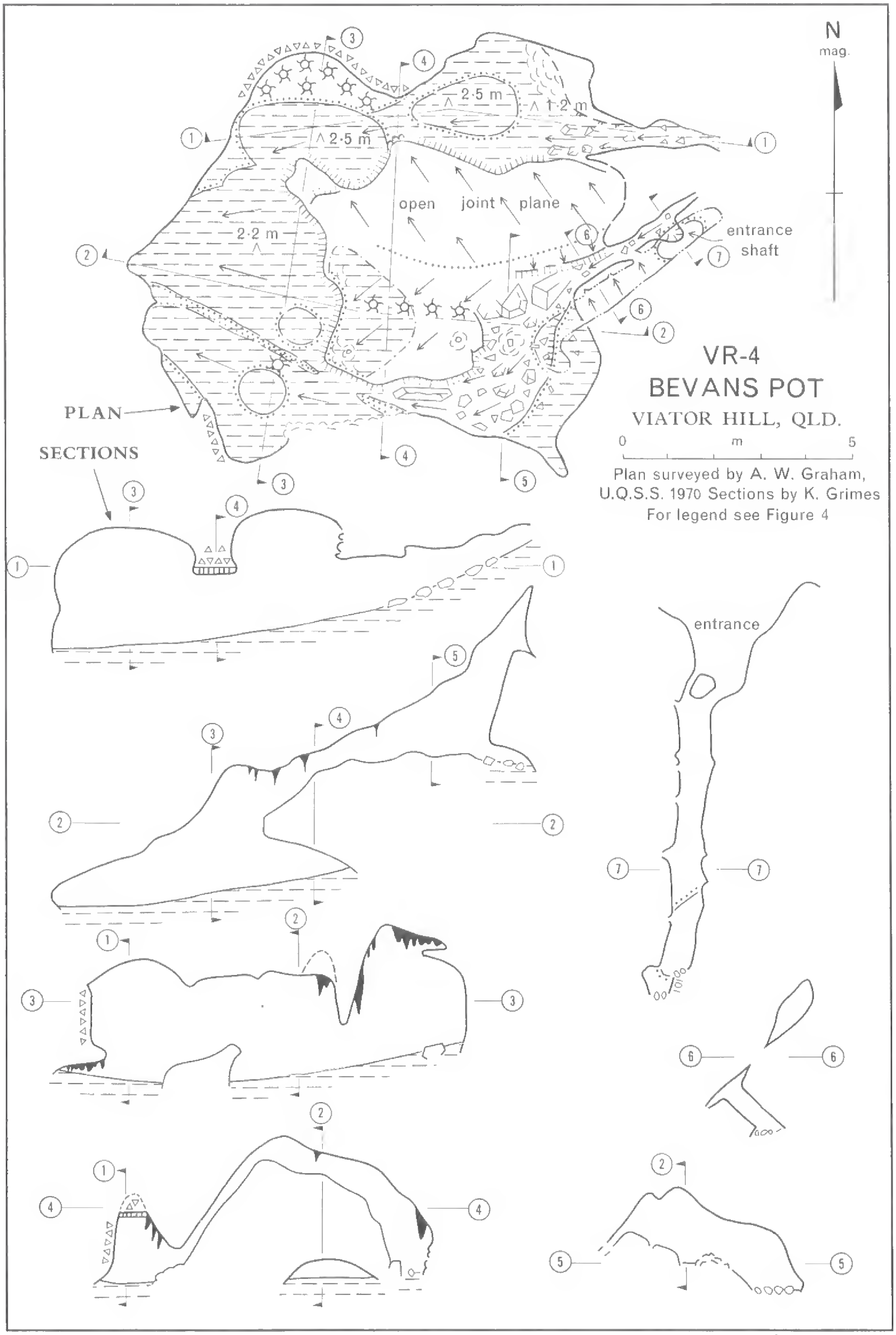


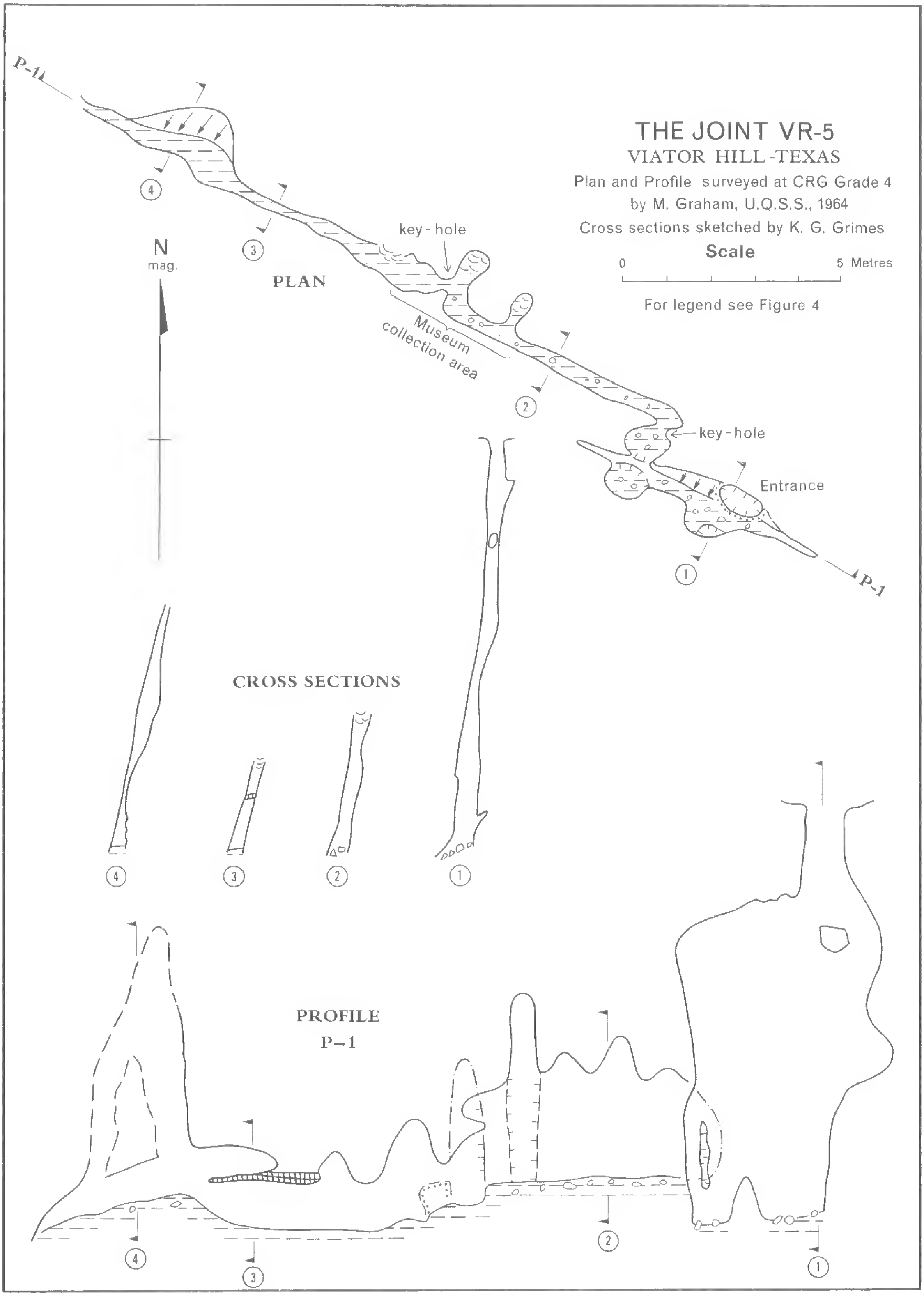
FIG. 4: Legend for cave maps 1–8.

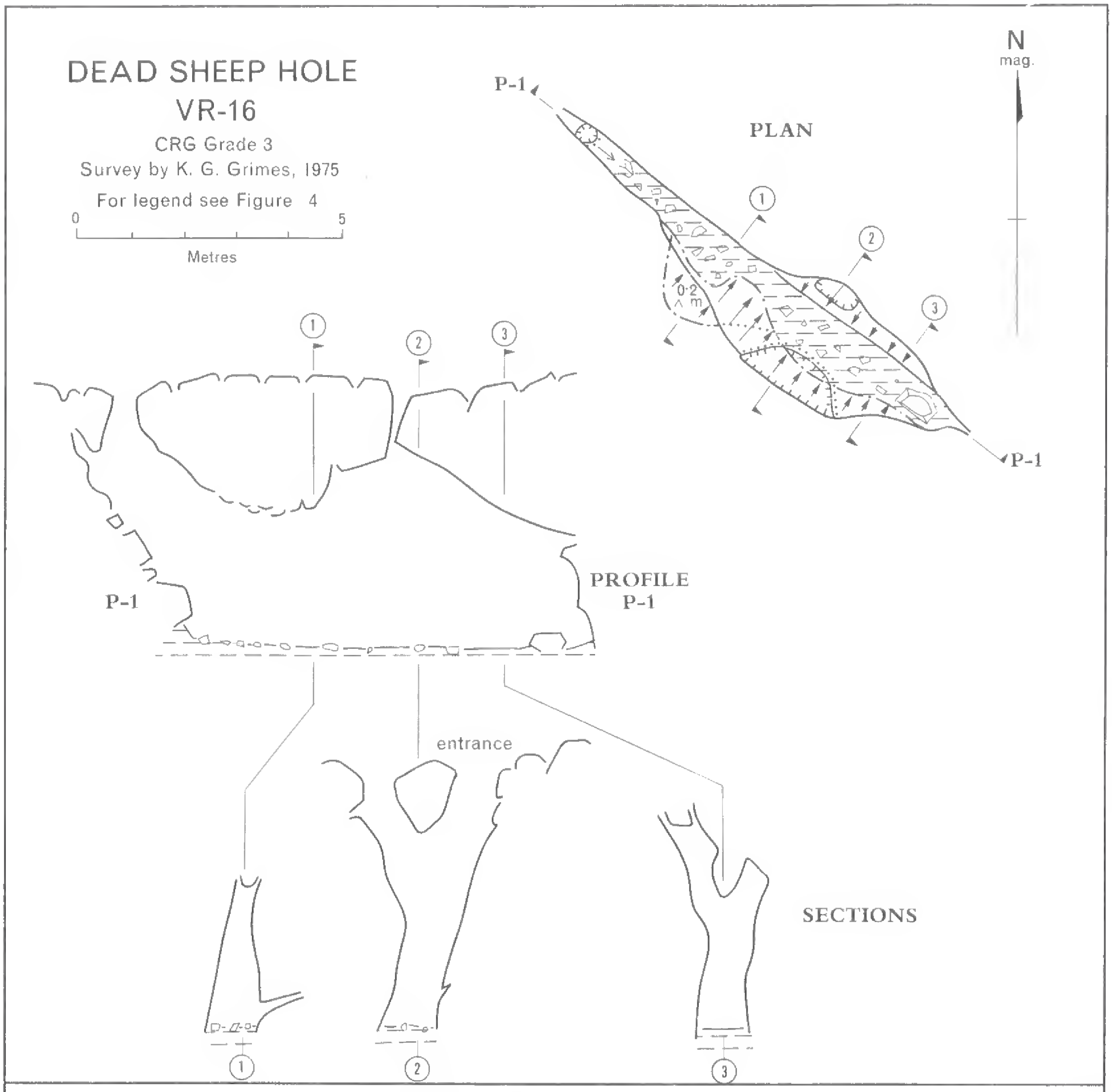

MAIN VIATOR CAVE VR-1
VIATOR HILL, TEXAS, QLD.
Surveyed by C. H. C. Shannon et al U.Q.S.S., 1970,1976
CRG Grade 5
Additional detail by K. G. Grimes.
For legend see Figure 4.
Entrance
VR-1
VR-19E
VR-22E
VR-12E
VR-13E
MA-1
MA-2
MA-3
MA-4
MA-5
MA-6
P-1
P-2
Metres
N mag.
250omE
290omE

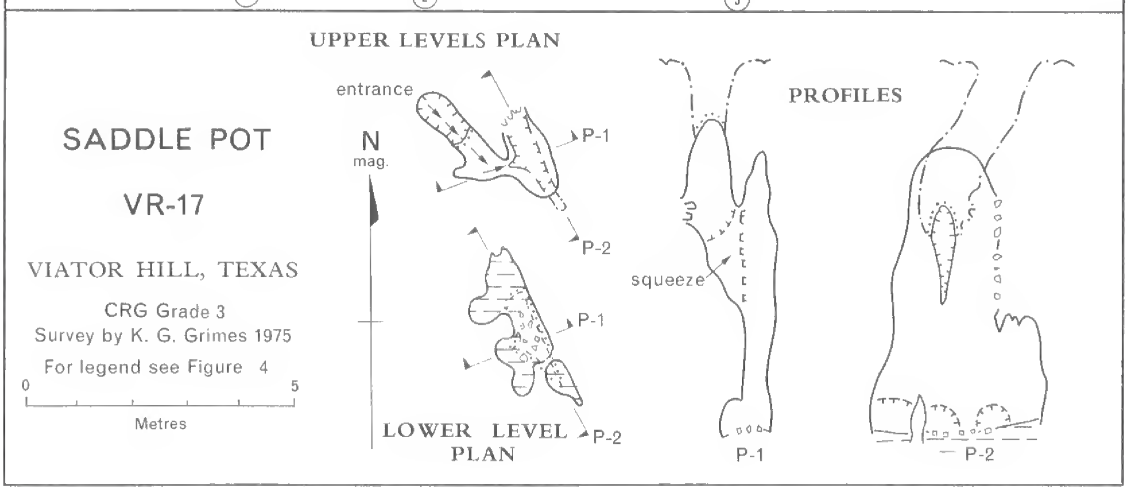

MAIN VIATOR CAVE
PROFILES AND SECTIONS
V/H = 1
METRES
390
380
P-1
P-2
VR-1
VR-19E
VR-22E
VR-12E
VR-13E
red earth breccia
MA-4
MA-1 proj.
MA-2
MA-3 proj.
MA-5 proj.
MA-6 proj.
a
b
c
1
2
3
4
5
6
7
8

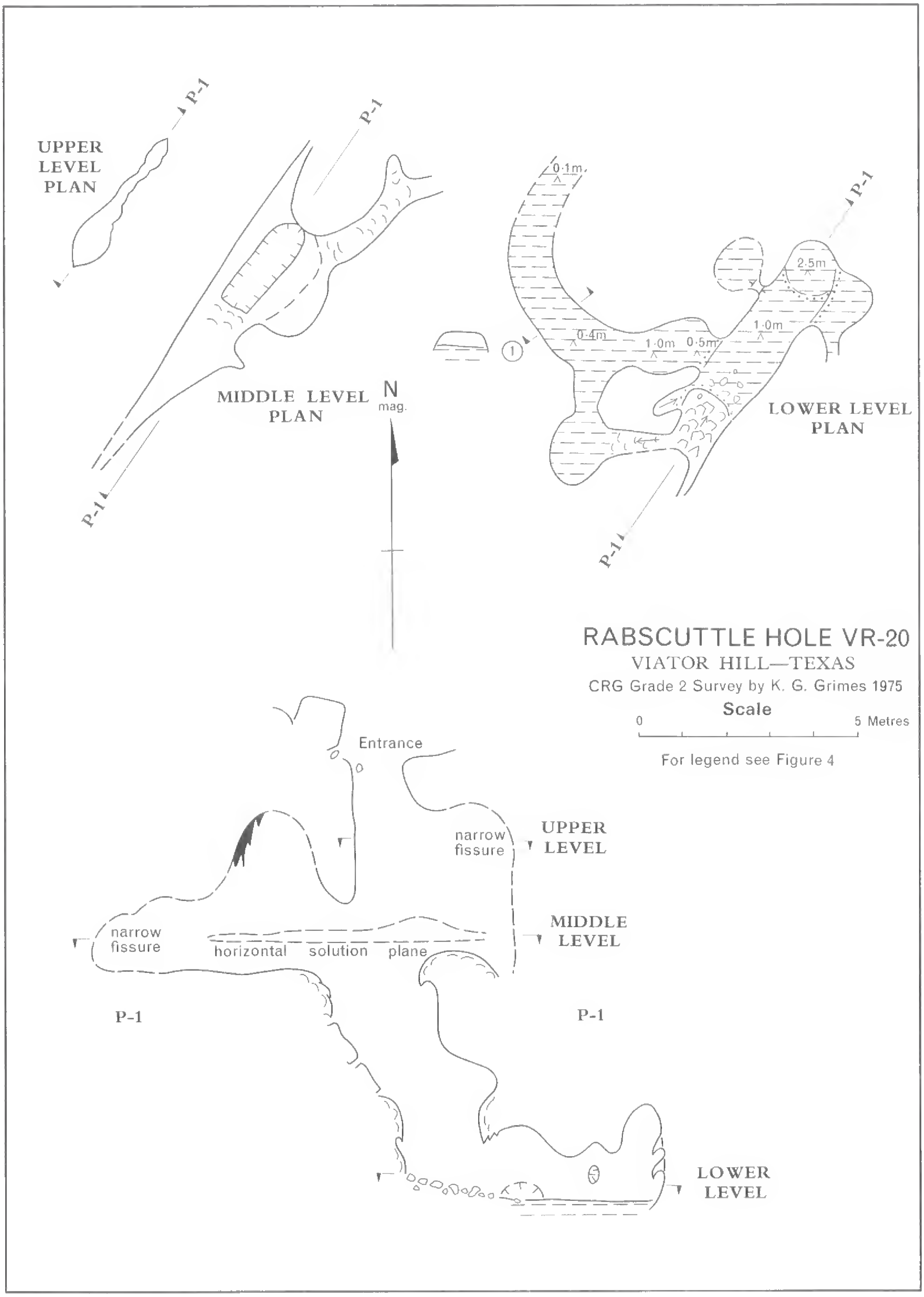

CRYSTAL CAVE VR-3
VIATOR HILL-TEXAS
CRG Grade 5
surveyed by D. Gillieson, U.Q.S.S. 1971
Sections and Profile by K. Grimes
Scale
0
5 Metres
For legend see Figure 4
N
mag.
Entrance
P-1
0·7m
2m
PLAN
SECTIONS
LONG PROFILE


N
mag.
2·5 m
1·2 m
2·5 m
open joint plane
entrance shaft
2·2 m
VR-4
BEVANS POT
VIATOR HILL, QLD.
0 m 5
Plan surveyed by A. W. Graham, U.Q.S.S. 1970 Sections by K. Grimes
For legend see Figure 4
PLAN
SECTIONS
entrance

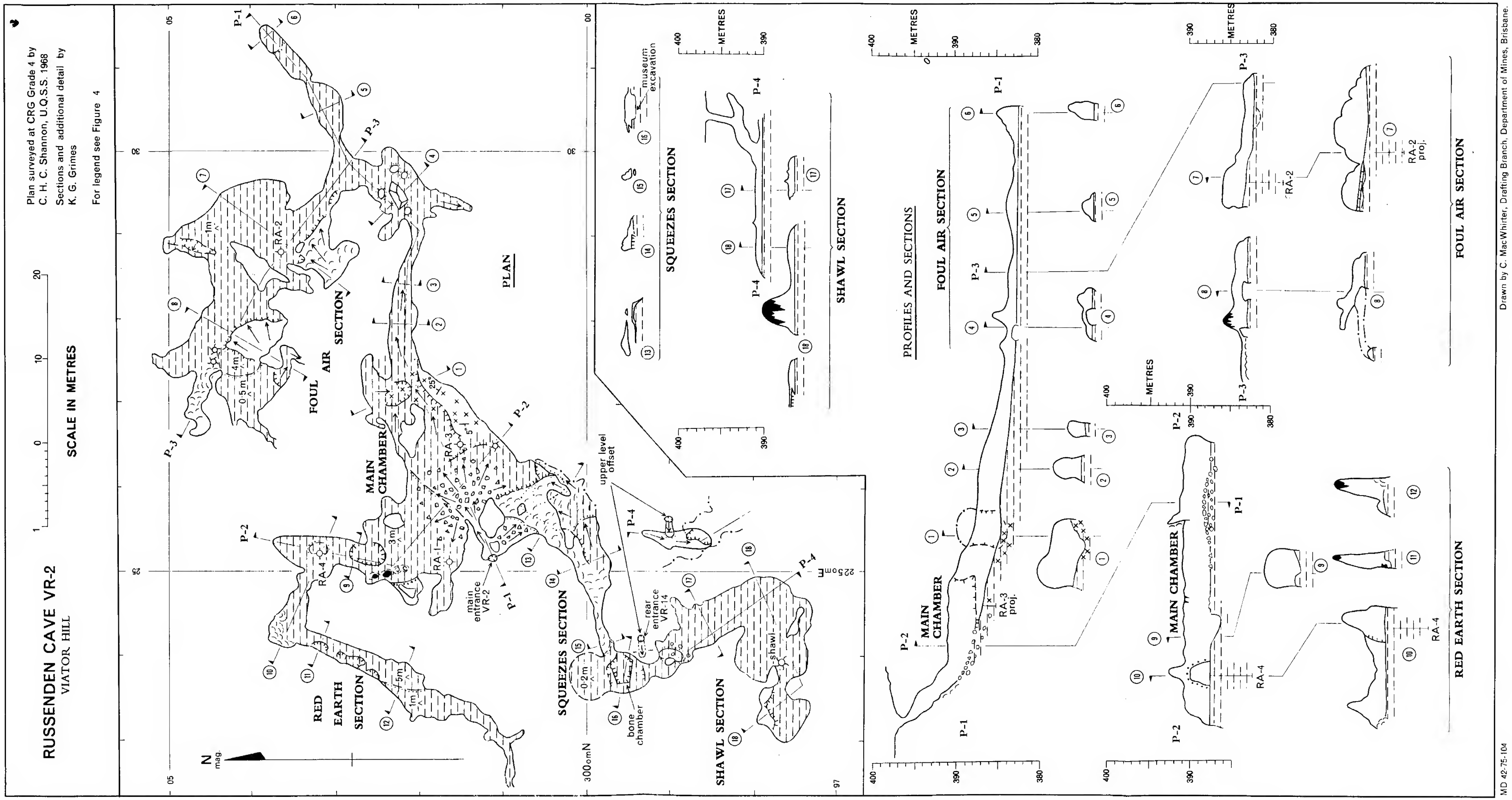

THE JOINT VR-5
VIATOR HILL-TEXAS
Plan and Profile surveyed at CRG Grade 4
by M. Graham, U.Q.S.S., 1964
Cross sections sketched by K. G. Grimes
Scale
0
5 Metres
For legend see Figure 4
PLAN
N
mag.
key-hole
Museum collection area
key-hole
Entrance
P-1
P-1
CROSS SECTIONS
PROFILE
P-1
1
2
3
4

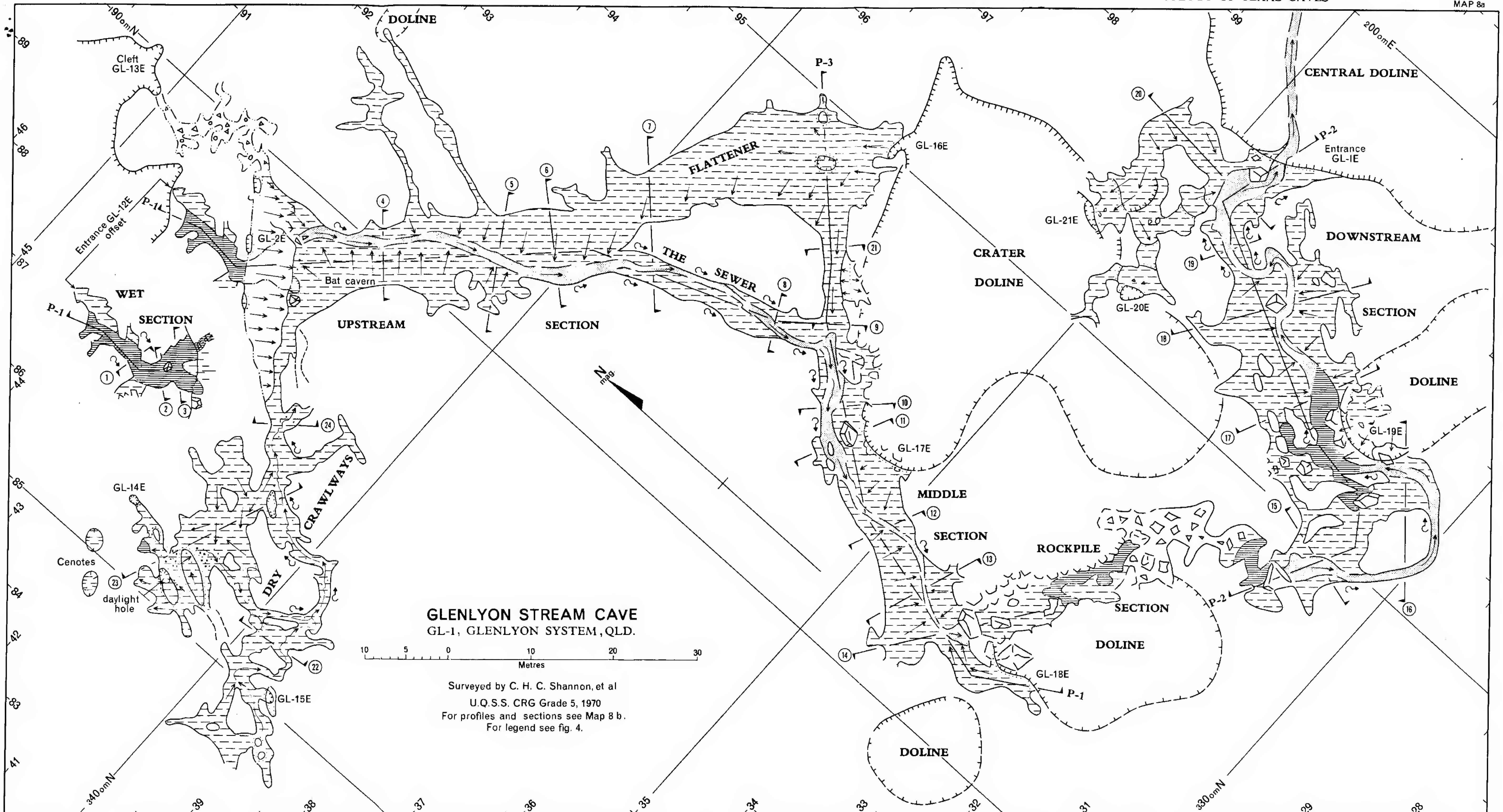

DEAD SHEEP HOLE
VR-16
CRG Grade 3
Survey by K. G. Grimes, 1975
For legend see Figure 4
0
5
Metres
N
mag.
PLAN
P-1
P-1
1
2
3
0·2
m
PROFILE
P-1
P-1
entrance
SECTIONS
1
2
3


SADDLE POT
VR-17
VIATOR HILL, TEXAS
CRG Grade 3
Survey by K. G. Grimes 1975
For legend see Figure 4
0
5
Metres
N
mag.
UPPER LEVELS PLAN
entrance
P-1
P-2
P-1
P-2
LOWER LEVEL
PLAN
PROFILES
squeeze
P-1
P-2

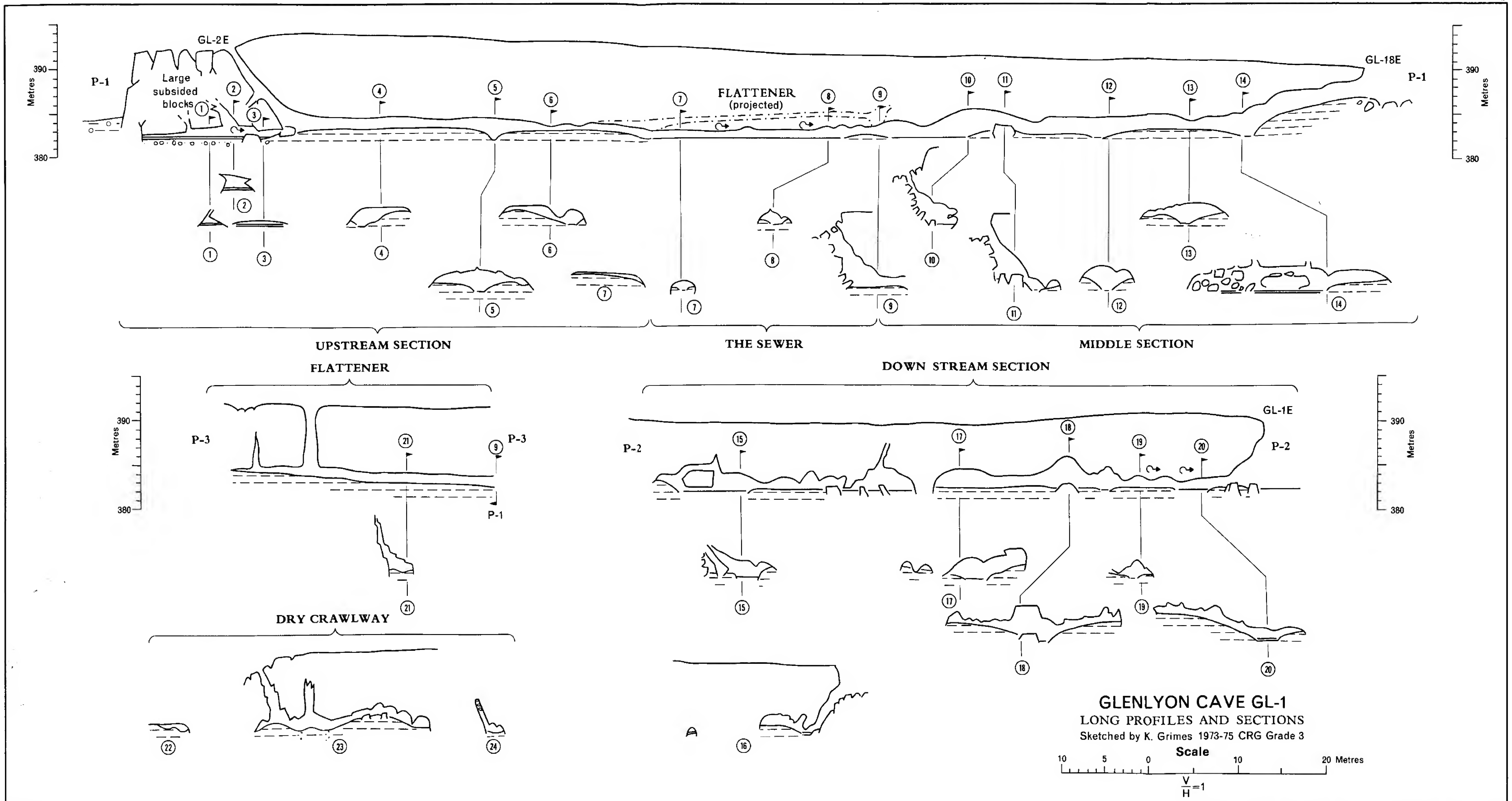


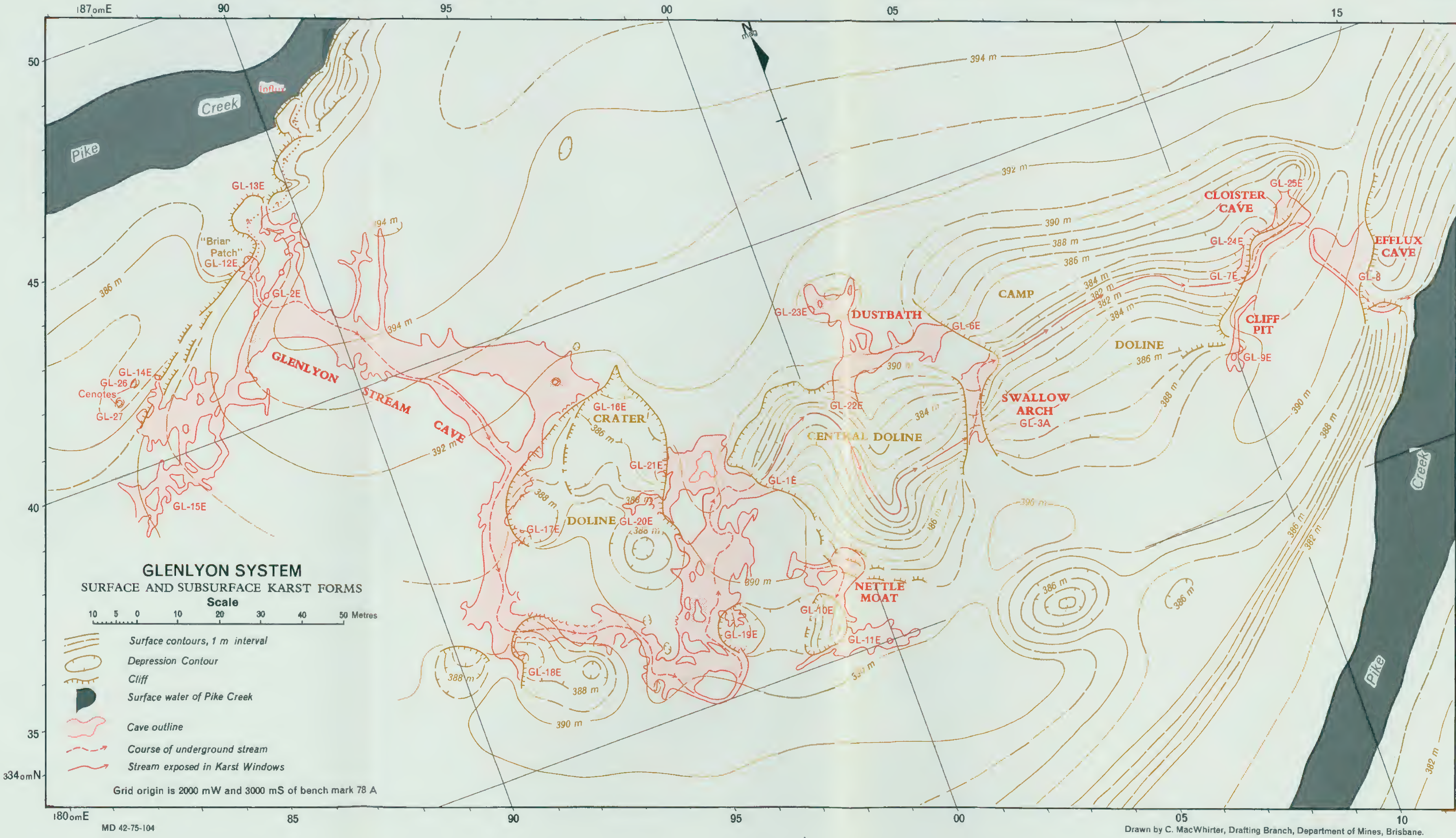
P-1
UPPER LEVEL PLAN
MIDDLE LEVEL PLAN
N mag.
0·1m
2·5m
0·4m
1·0m
0·5m
1·0m
1
LOWER LEVEL PLAN
RABSCUTTLE HOLE VR-20
VIATOR HILL—TEXAS
CRG Grade 2 Survey by K. G. Grimes 1975
Scale
0
5 Metres
For legend see Figure 4
Entrance
narrow fissure
UPPER LEVEL
narrow fissure
horizontal solution plane
MIDDLE LEVEL
P-1
P-1
LOWER LEVEL


RUSSENDEN CAVE VR-2
VIATOR HILL
Plan surveyed at CRG Grade 4 by C. H. C. Shannon, U.Q.S.S. 1968
Sections and additional detail by K. G. Grimes
For legend see Figure 4
SCALE IN METRES
PLAN
MAIN CHAMBER
FOUL AIR SECTION
RED EARTH SECTION
SQUEEZES SECTION
SHAWL SECTION
main entrance VR-2
rear entrance VR-14
bone chamber
upper level offset
museum excavation
shawl
300₀mN
225₀mE
PROFILES AND SECTIONS
METRES
Drawn by C. MacWhirter, Drafting Branch, Department of Mines, Brisbane.
MD 42-75-104



Drawn by C. MacWhirter, Drafting Branch, Department of Mines, Brisbane.


GL-2E
GL-18E
GL-1E
P-1
P-2
P-3
Large subsided blocks
FLATTENER (projected)
UPSTREAM SECTION
THE SEWER
MIDDLE SECTION
FLATTENER
DOWN STREAM SECTION
DRY CRAWLWAY
Metres
390
380
GLENLYON CAVE GL-1
LONG PROFILES AND SECTIONS
Sketched by K. Grimes 1973-75 CRG Grade 3
Scale
10 5 0 10 20 Metres
V/H=1


GLENLYON SYSTEM
SURFACE AND SUBSURFACE KARST FORMS
Scale
10 5 0 10 20 30 40 50 Metres
Surface contours, 1 m interval
Depression Contour
Cliff
Surface water of Pike Creek
Cave outline
Course of underground stream
Stream exposed in Karst Windows
Grid origin is 2000 mW and 3000 mS of bench mark 78 A
Pike
Creek
Influx
GL-13E
"Briar Patch"
GL-12E
GL-2E
GL-14E
GL-26
Cenotes
GL-27
GL-15E
GLENLYON STREAM CAVE
GL-16E
CRATER
GL-21E
GL-17E
DOLINE
GL-20E
GL-18E
GL-19E
GL-10E
NETTLE MOAT
GL-11E
GL-1E
CENTRAL DOLINE
GL-22E
GL-23E
DUSTBATH
GL-6E
CAMP
DOLINE
SWALLOW ARCH
GL-3A
CLOISTER CAVE
GL-25E
GL-24E
GL-7E
CLIFF PIT
GL-9E
EFFLUX CAVE
GL-8
394 m
392 m
390 m
388 m
386 m
384 m
382 m
187omE
180omE
334omN
322o mN
Drawn by C. MacWhirter, Drafting Branch, Department of Mines, Brisbane.
MD 42-75-104

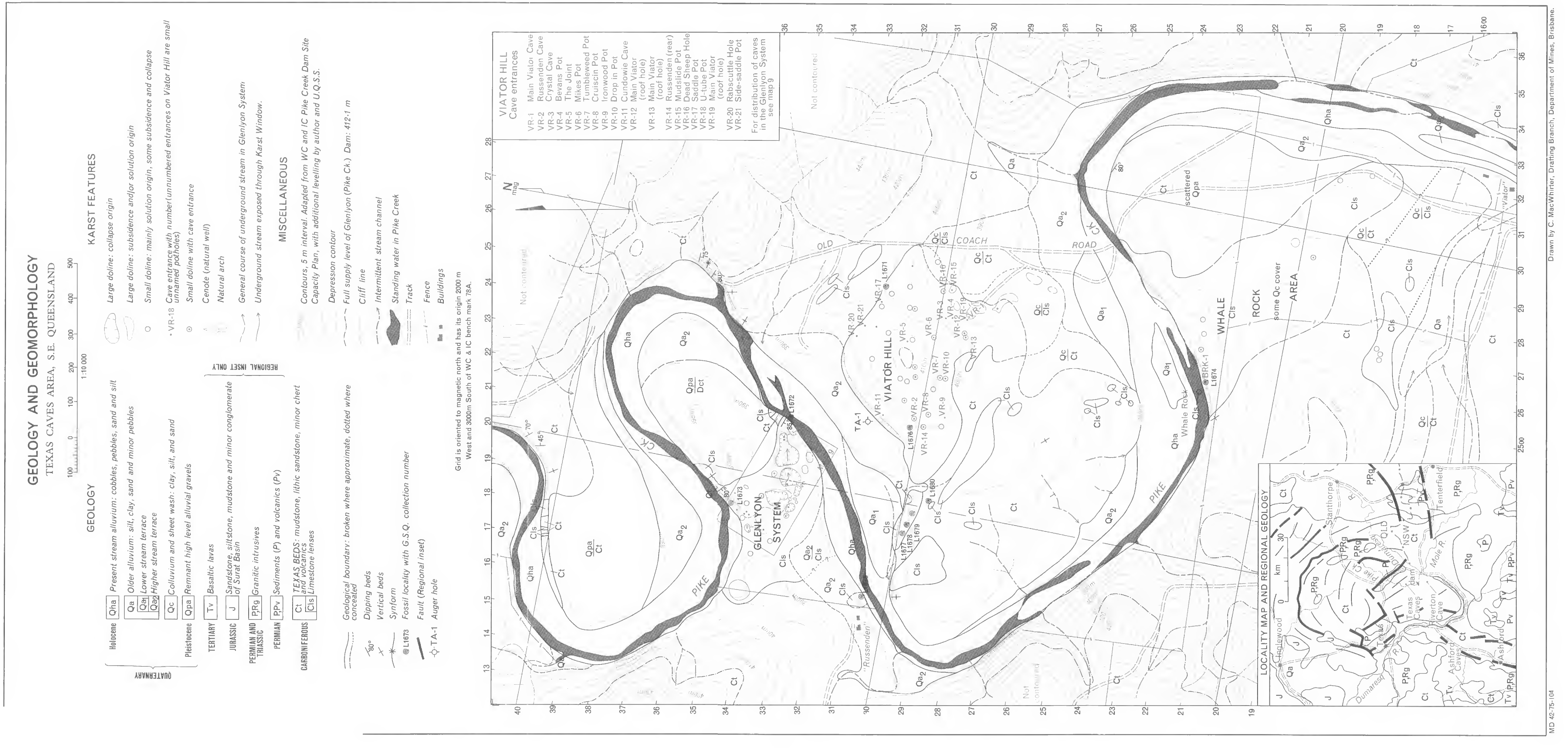

GEOLOGY AND GEOMORPHOLOGY
TEXAS CAVES AREA, S.E. QUEENSLAND
1:10 000
GEOLOGY
QUATERNARY
Holocene
Qha Present stream alluvium: cobbles, pebbles, sand and silt
Qa Older alluvium: silt, clay, sand and minor pebbles
Qa1 Lower stream terrace
Qa2 Higher stream terrace
Qc Colluvium and sheet wash: clay, silt, and sand
Pleistocene
Qpa Remnant high level alluvial gravels
TERTIARY
Tv Basaltic lavas
JURASSIC
J Sandstone, siltstone, mudstone and minor conglomerate of Surat Basin
PERMIAN AND TRIASSIC
PRg Granitic intrusives
PERMIAN
PPv Sediments (P) and volcanics (Pv)
REGIONAL INSET ONLY
CARBONIFEROUS
Ct TEXAS BEDS: mudstone, lithic sandstone, minor chert and volcanics
Cls Limestone lenses
Geological boundary: broken where approximate, dotted where concealed
Dipping beds
Vertical beds
Synform
Fossil locality with G.S.Q. collection number
Fault (Regional inset)
Auger hole
KARST FEATURES
Large doline: collapse origin
Large doline: subsidence and/or solution origin
Small doline: mainly solution origin, some subsidence and collapse
Cave entrance with number (unnumbered entrances on Viator Hill are small unnamed potholes)
Small doline with cave entrance
Cenote (natural well)
Natural arch
General course of underground stream in Glenlyon System
Underground stream exposed through Karst Window.
MISCELLANEOUS
Contours, 5 m interval. Adapted from WC and IC Pike Creek Dam Site Capacity Plan, with additional levelling by author and U.Q.S.S.
Depression contour
Full supply level of Glenlyon (Pike Ck.) Dam: 412·1 m
Cliff line
Intermittent stream channel
Standing water in Pike Creek
Track
Fence
Buildings
Grid is oriented to magnetic north and has its origin 2000 m West and 3000m South of WC & IC bench mark 78A.
VIATOR HILL
Cave entrances
VR-1 Main Viator Cave
VR-2 Russenden Cave
VR-3 Crystal Cave
VR-4 Bevans Pot
VR-5 The Joint
VR-6 Mikes Pot
VR-7 Tumbleweed Pot
VR-8 Cruiscin Pot
VR-9 Ironwood Pot
VR-10 Drop in Pot
VR-11 Cundowie Cave
VR-12 Main Viator (roof hole)
VR-13 Main Viator (roof hole)
VR-14 Russenden (rear)
VR-15 Mudslide Pot
VR-16 Dead Sheep Hole
VR-17 Saddle Pot
VR-18 U-tube Pot
VR-19 Main Viator (roof hole)
VR-20 Rabscuttle Hole
VR-21 Side-saddle Pot
For distribution of caves in the Glenlyon System see map 9
VIATOR HILL
GLENLYON SYSTEM
WHALE ROCK AREA
Whale Rock
some Qc cover
scattered Qpa
OLD COACH ROAD
PIKE CK
"Russenden"
"Viator"
Not contoured
TA-1
L1671
L1672
L1673
L1674
L1676
L1678
L1679
L1680
BRK-1
LOCALITY MAP AND REGIONAL GEOLOGY
Inglewood
Stanthorpe
Tenterfield
Texas
Texas Caves
Riverton Cave
Ashford Caves
Ashford
Dumaresq R.
Mole R.
QLD
NSW
Glenlyon Dam
km
Drawn by C. MacWhirter, Drafting Branch, Department of Mines, Brisbane.
MD 42-75-104

PLATE 3

FIG. a; Subsoil karren forms exposed by stripping of the soil from a tilted block in the cliffs at the upstream end of the Glenlyon System.

FIG. b; The stream passage in the upstream section of the Glenlyon Stream Cave. Note sediment mounds and arched ceiling.

FIG. c; Looking into the upstream end of The Sewer, Glenlyon System. Note scalloped walls, bell holes in ceiling, and depositional ribbons which appear to postdate the scalloping.

FIG. d; Serrated ribbons on the wall of The Dustbath, Glenlyon System.

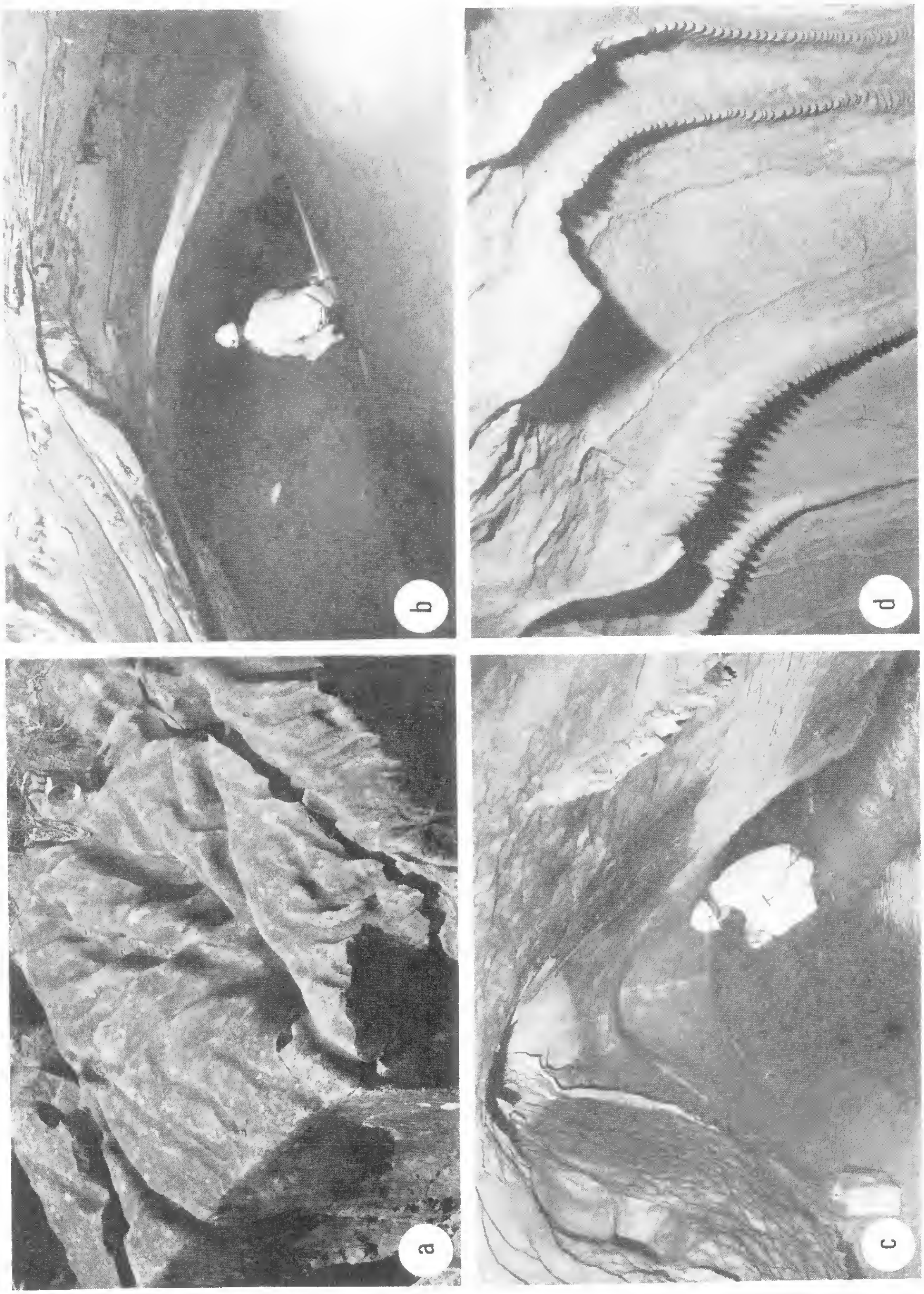

b
d
a
c

PLATE 4

FIG. a: Stereopair, phreatic spongework in a side passage of the downstream section of the Glenlyon Stream Cave. 30 cm scale.

FIG. b: In The Dustbath, Glenlyon System. Note the flat roof with large scallops. The floor is of a stream deposited silt which has largely choked this abandoned part of the system.

FIG. c: Etch grooves on a wall in The Dustbath. Note graduation in form from left to right. Tape is graduated in centimetres.

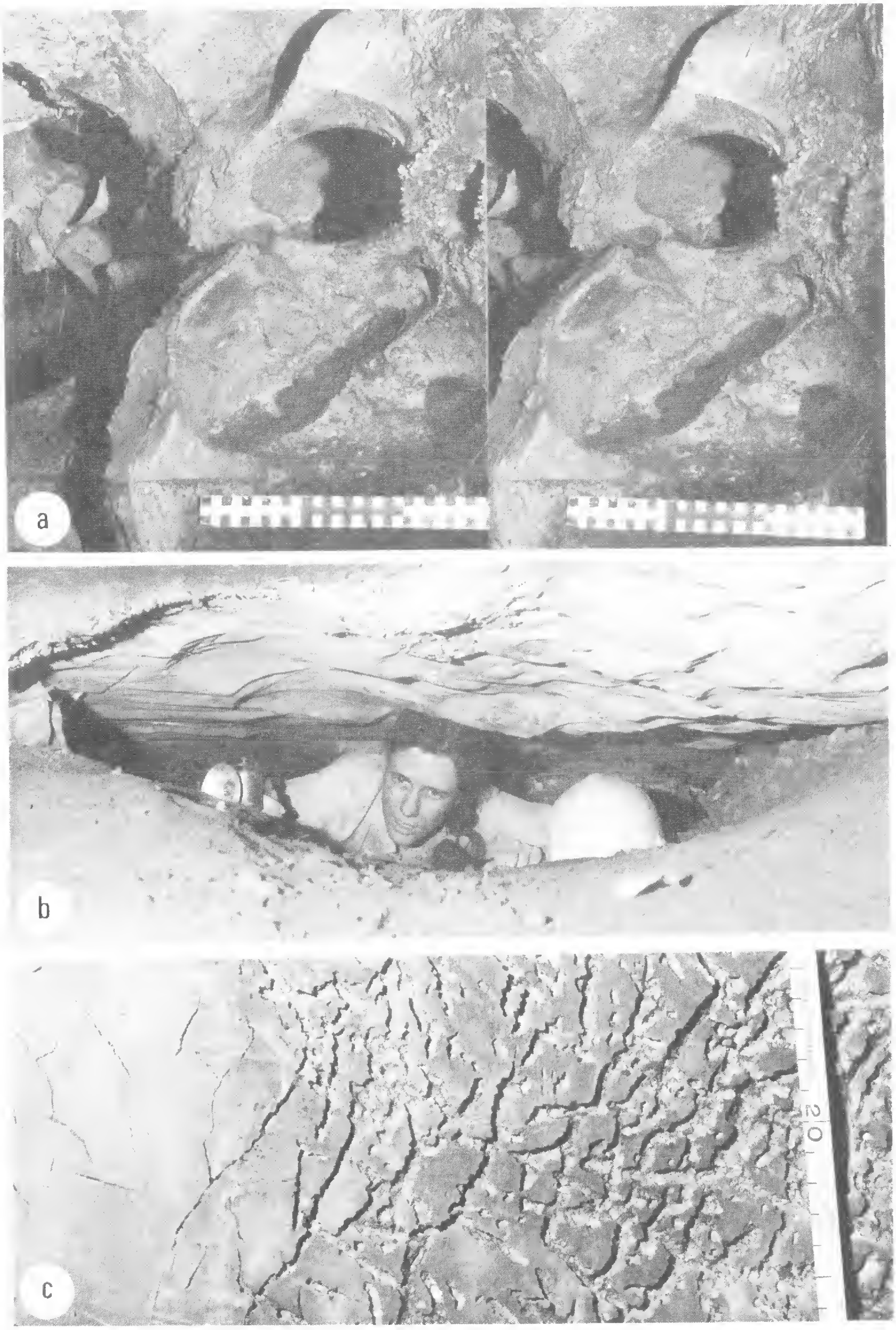

a
b
c

PLATE 5

FIG. a: Two solution undercuts (the 382·4 m and 381·4 m levels) in the north wall of the main chamber of Main Viator Cave. 30 cm scale.

FIG. b: Subsidence pit about 1·5 m deep in the floor of the Red Earth Section of Russenden Cave. Note cemented bands adhering to the limestone wall on the left.

FIG. c: Main Chamber of Russenden Cave, looking southeast. Note entrance talus slope on right with roof fissure and speleothems above; the pocketed, but horizontal roof (the 390·8 m solution level) and a part of the old guano mound against the far wall.

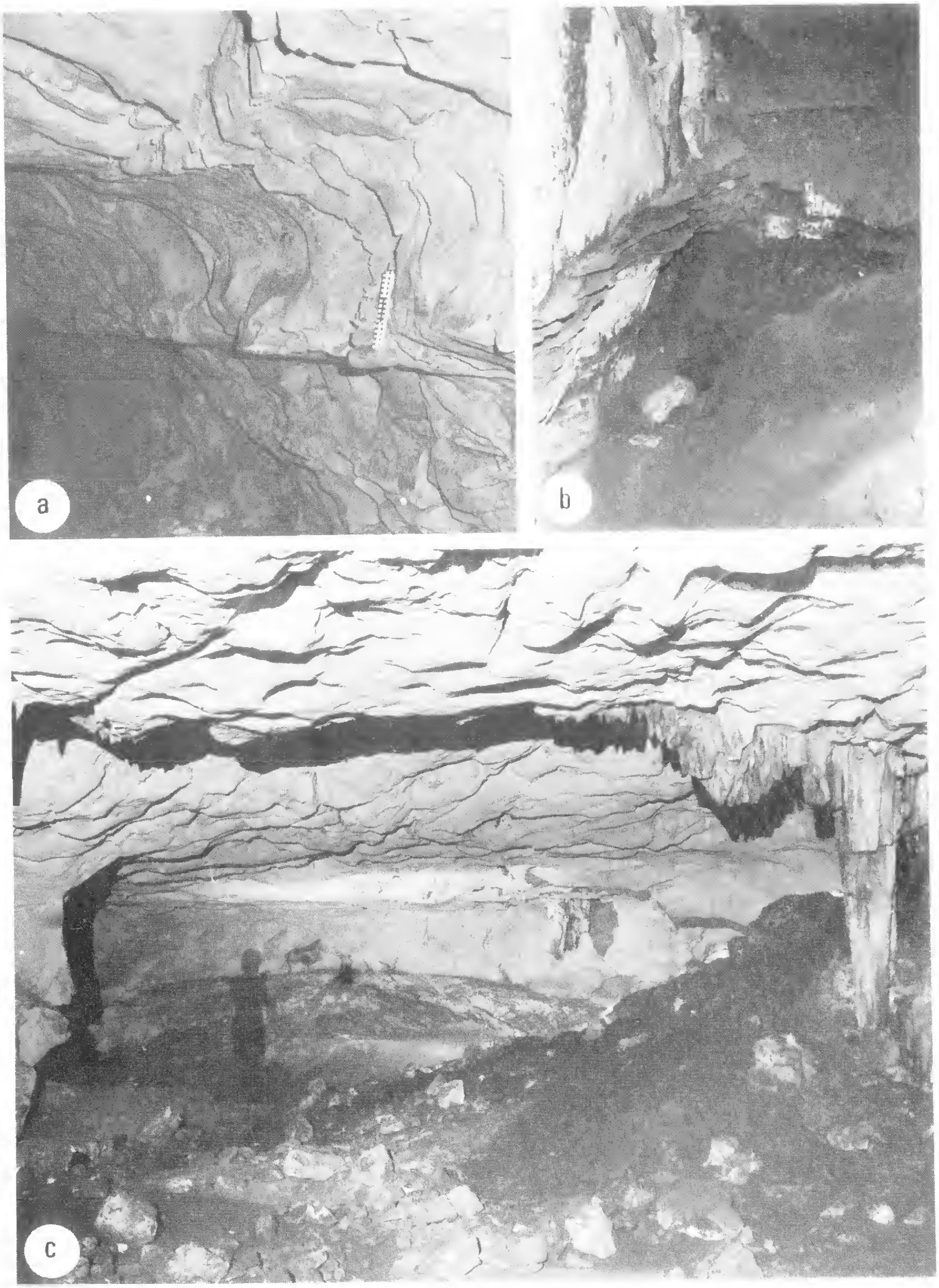
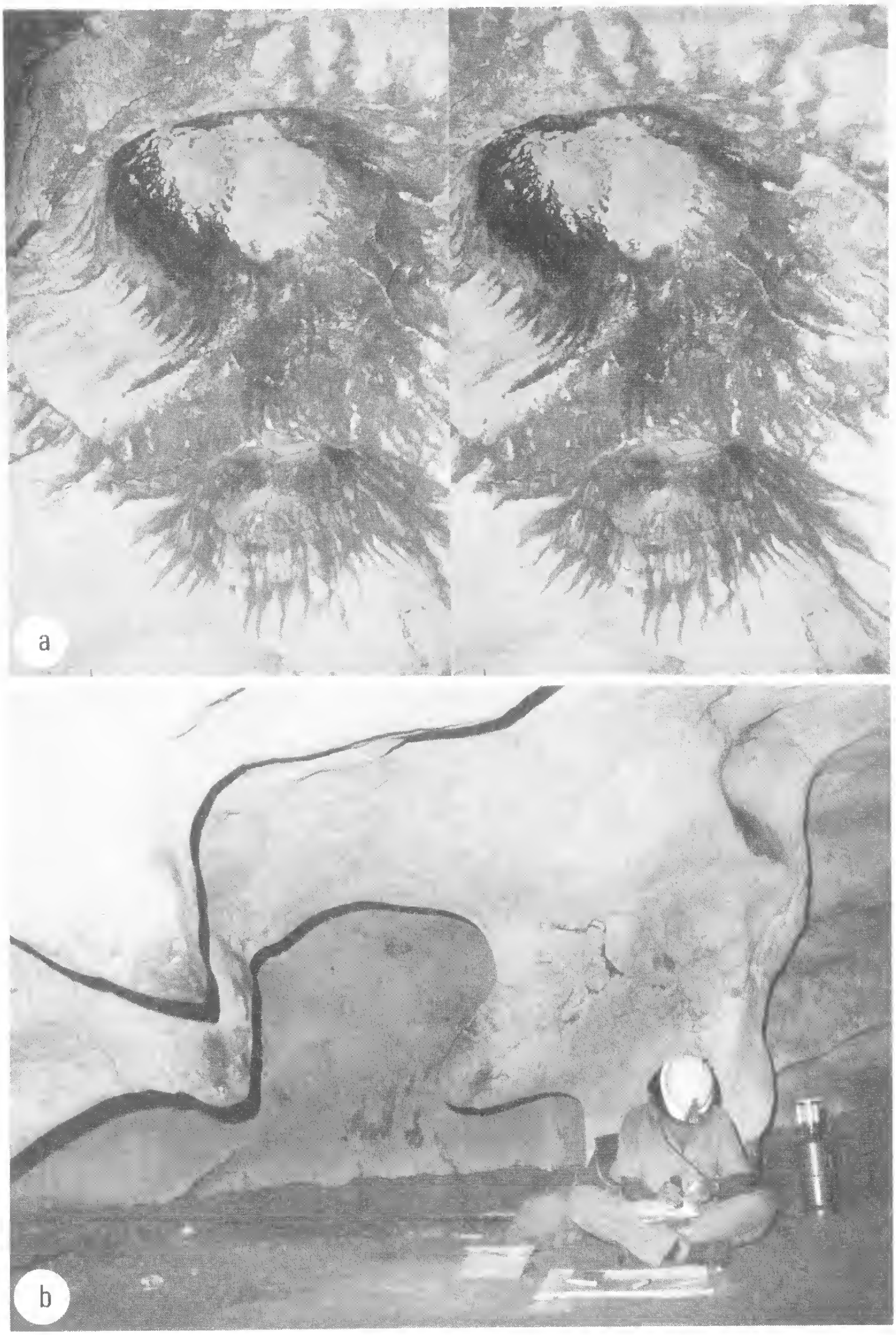

a
b
c

PLATE 6

FIG. a: Stereopair, two bell holes in the ceiling of the Foul Air Section of Russenden Cave, approximate diameter is 50 cm. The staining may be due to bat roosting.

FIG. b: In the Foul Air Section of Russenden Cave, near auger site RA-2, showing phreatic sculpturing with the formation of bedrock blades and partitions.


a
b

Mem. Qd Mus. **19**(1); xxx-61–109-xx, pls. 7–10. [1978]

QUATERNARY VERTEBRATE FAUNAS FROM THE TEXAS CAVES OF SOUTHEASTERN QUEENSLAND

MICHAEL ARCHER
Queensland Museum

ABSTRACT

Results of excavation in Pleistocene deposits of two of the Texas Caves on Viator Hill, southeastern Queensland, are reported. The history of the deposits is interpreted on the basis of lithology and fauna. The fossiliferous sediments of The Joint (VR-5) consist of a limestone breccia fissure-fill. The sediments in Russenden (rear) Cave (VR-14) are mainly detrital accumulations from solution pipes, but appear to have had a more complex history than the sediments of The Joint.

The Joint fauna, including twenty-four kinds of mammals, contains a greater proportion of extinct marsupials, than that of Russenden (rear) Cave. It also contains a sebecosuchian crocodile, a type of crocodile previously unknown in Australia, and thought to have become extinct throughout the world during the Tertiary, as well as a new species of *Procoptodon*, *P. texasensis* sp. nov., that may also be represented in the geographically close Pleistocene Cement Mills fauna.

The Russenden (rear) Cave fauna, with thirty-eight kinds of mammals, is more diverse than The Joint fauna, and probably better representative of the mammal fauna living around the Texas Caves during late Pleistocene times.

Considered together, the following mammal taxa from the Texas Caves faunas are of particular interest: 1) now entirely extinct: *Zygomaturus* sp., cf. *Z. trilobus;* three *Sthenurus* spp., cf. *oreas*, cf. *atlas*, and aff. *occidentalis; Procoptodon texasensis* n. sp.; *Protemnodon brehus; P. roechus; Macropus agilis* subsp., aff. *M. a. siva; M.* sp., cf. *M. thor; M.* sp., aff. *M. altus; M. titan; Conilurus albipes; Thylacinus cynocephalus, Sarcophilus laniarius*, and possibly a species of *Antechinus;* 2) now regionally extinct from southeastern Queensland: *Dasyurus viverrinus, Isoodon obesulus, Pseudomys desertor*, and *P. novaehollandiae* (the latter two were not previously recorded from Queensland); 3) and those not presently known in southeastern Queensland to occur in the contemporary habitats present on Viator Hill: *Cercartetus nanus, Perameles nasuta, Thylogale* sp., and *Rattus lutreolus*. The remaining nineteen species would be expected to survive in the area today, although in fact only two types of kangaroo and four bats have been collected from the area despite two mammal surveys.

The faunas as a whole most closely resemble the Cement Mills fauna of southeastern Queensland. Differences between the Texas faunas and other Pleistocene Queensland faunas, such as the eastern Darling Downs, in large part apparently reflect regionally different palaeoenvironments. The Texas faunas suggest the presence of sclerophyll forest on Viator Hill, with grasslands and possibly pockets of rainforest or wet sclerophyll forest in adjacent areas.

Entrance into the most conspicuous of the Texas caves on Viator Hill, Main Cave (VR-1), is via a passage formed in part of bone breccia. For this reason, the occurrence of fossil bones in the Texas caves has probably been known by Europeans since at least 1845, when the caves were encountered by Roderick McLeod (Robinson 1978).

From then until 1973 various incidental surface collections of fossil bones were made. In February 1973, and March and October 1975, following the decision to dam Pike Creek, Queensland Museum staff undertook three expeditions to excavate and recover as much of the fossil material as possible before the caves were submerged. With the cooperation of personnel from the Geological Survey of Queensland, the Kelvin Grove College of Advanced Education, the Department of Irrigation and Water Supply, and numerous volunteers, major excavations were undertaken in what appeared to be the two palaeontologically most important caves in the area: The Joint (VR-5) and Russenden (rear) Cave (VR-14). The results of these excavations, and a review of surface collections from other caves in the area, are presented here.

Modern mammal names, unless otherwise indicated, are used in the sense of Kirsch and Calaby 1977, or Ride 1970. Fossil species names are those used by the authors of the most recent revisions of the groups concerned. Modern mammal registration number prefixes J and JM indicate Queensland Museum collections. Fossil vertebrate numbers of the Queensland Museum are prefixed by F. Fossil vertebrates of the Australian Museum are also prefixed by F and, in order to distinguish them here, are given as F(AM). Marsupial tooth number follows Archer (1978). Accordingly, the maximum (as in some peramelids) upper dental formula is: I1, I2, I3, I4, I5, C1, P1, P2, P3 (unerupted in juveniles), M1 (an ephemeral tooth absent in the adult dentition, and the same tooth regarded as dP4 by Thomas 1888, and dP3 by Stirton 1955), M2, M3, M4, M5. Crown terminology follows Archer (1976). The way in which dental measurements have been made is shown in figures in the text. The general geology, morphology and long-term geological history of the Texas Caves are reviewed by Grimes (1978), and reference to cave names, numbers and geological features follows this work.

THE JOINT (VR-5)

GENERAL CONSIDERATIONS: The Joint is a long (about twenty-two metres), narrow (less than one metre) and tall (up to ten metres) limestone fissure in the Palaeozoic Texas Beds of the New England Fold Belt. Details of the morphology of this cave (VR-5) have been given most recently by Grimes (1978). In his Map 4 he indicates the area from which the bone breccia was collected by the Queensland Museum (see also Plate 10 of the present paper) during 1975. The exact area of earlier collections has not been recorded.

Breccia has partly filled the upper parts of the southeastern end of The Joint. This reddish variably indurated sediment contained the fossil bones collected by the Queensland Museum. In the collection area it had completely blocked The Joint and progress beyond this point was effected by wriggling through a key-hole passage formed in the breccia itself. It was the breccia surrounding this particular key-hole (another key-hole near the entrance is through massive limestone) that was removed for study. In all, about 1·8 cubic metres were removed. Despite extensive examination, no trace of sedimentary levels was distinguished. All of the visible breccia appeared to be an amorphous mass wedged between the walls of The Joint without evidence for discrete episodes of accumulation. At the time of excavation it was noted that all bones were broken, incomplete, and showed no apparent preferred orientation. Further, after processing the breccia in the laboratory, it was evident that many large animals such as diprotodontids, crocodiles, and giant kangaroos were represented by only small fragments, despite the fact that almost two cubic metres of breccia were removed, an amount which appeared to represent about half of the bone-bearing breccia visible in the area at the time of collection. These observations suggest the following interpretation. Animals may have fallen into The Joint when it was an open fissure, smaller animals falling farther than larger animals, before coming to rest as carcases at the bottom. Some rodents evidently survived the fall because a few bones have clearly been gnawed. However, none of the bones show evidence of carnivore activity and it is extremely unlikely the cave was used as a lair. The narrow width of The Joint's massive limestone walls would not have permitted an animal the size of a diprotodontid (*Zygomaturus* is represented) to fall completely into the fissure, and large animals such as this probably wedged themselves near the surface. After either rotting or being pulled apart by carnivores, some of their bones would have fallen further down into the fissure, while others might have been pulled back to the surface. This process of selective accumulation continued until such time as the fissure filled to the surface with earth, bones and limestone fragments. Before or after it became indurated, most of this fissure fill was removed by erosion from beneath and only remnants of it now remain. The only large masses left are in the southeastern end, and even here, except at the key-hole, it does not extend to the floor of the fissure. While we worked in The Joint during February, 1975, it began to rain, and from the cataract of water that came down the walls it was easy to see how erosion could have dissolved much of the breccia fill originally cemented to these walls.

The breccia at the key-hole is not uniformly indurated. In some places it is merely a light brown poorly-cemented sediment with bones and 5–10 cm limestone cobbles. Often only 10 cm away, it is completely indurated, crystalline, and only just softer than the limestone cobbles themselves. Some of the overhanging breccia surface is covered by a mamilary surface of soft, crystalline carbonate.

Some bones were noted on the very narrow soil floor near the breccia key-hole. From their colour and preservation, most do not appear to be erosional remnants from the overhanging breccia. The only specimen of *Sarcophilus* from The Joint (F8883, collected prior to 1973) probably came from this situation. It lacks any adherring breccia or carbonate cement, and is not of the same pale colour as the bones from the breccia.

The breccia was processed in Brisbane by breaking it into progressively smaller and smaller pieces, checking each time for signs of teeth. All of the postcranial fragments obtained were submitted to Gakashuan University for radiocarbon dating, but neither the collagen nor apatite fractions of the sample proved datable (Kigoshi, pers. comm.). The reasons for this failure to obtain a date are not clear, and it was not stated that the sample was beyond the range of radiocarbon dating, although this may in fact have been the case.

THE FAUNA FROM THE JOINT: Details of the vertebrate systematics are presented later in conjunction with the fauna from Russenden Cave. A summary only of the fauna is presented here.

Reptilia

?Sebecosuchian crocodile (F7898, Hecht and Archer 1977)

Lizard (indet.) (F8475, clearly not part of breccia, presumably younger)

Mammalia: Marsupialia

Sarcophilus laniarius (e.g. F8883, although it may be part of a younger faunal assemblage, see above)
Thylacinus cynocephalus (e.g. F8871)
Perameles nasuta (e.g. F8493)
Isoodon sp., cf. *I. obesulus* (e.g. F8382)
?*Vombatus* sp. (e.g. F8853)
?*Zygomaturus* sp. (F8240)
Aepyprymnus rufescens (F8479)
Sthenurus sp., aff. *S. occidentalis* (F8529)
S. sp., cf. *S. atlas* (e.g. F8380)
S. sp., cf. *S. oreas* (e.g. F7900)
Prodoptodon texasensis n. sp. (F7894)
Protemnodon roechus (e.g. F8238)
P. brehus (e.g. F7916)
Thylogale sp. (e.g. F7923)
Petrogale sp. (e.g. F8873)
Macropus (Prionotemnus) dorsalis (e.g. F7901)
M. (P.) sp., cf. *M. (P.) thor* (e.g. F8859)
M. (P.) sp., aff. *M. (P.) agilis siva* (F9444)
M. (Macropus) titan (e.g. F8862)
M. (Osphranter) sp., cf. *M. (O.) altus* (e.g. F8532)

Placentalia

Conilurus albipes (e.g. F8491)
Pseudomys sp. (e.g. F7989, isolated molars)
Pseudomys sp. (*P. gracilicaudatus* or *P. desertor*, F8830, clearly not part of older breccia)
Rattus sp., cf. *R. fuscipes* (e.g. F8879, probably not from older breccia)

RUSSENDEN CAVE (VR-14)

GENERAL CONSIDERATIONS: Russenden Cave (VR-2 and VR-14) was opened by members of the University of Queensland Speleological Society only as recently as 1967 (Bourke 1975). Details of its morphology have been given by Grimes (1978). Prior to 1973 incidental surface collections had been made by various people from the main chamber, entered directly by VR-2, as well as from the rear entrance chamber, entered directly by VR-14. In 1973 and 1975, the Queensland Museum concentrated attention on a small area known now (e.g. Grimes 1978, Map 7) as the Bone Chamber. It could be entered by crawling from either the main chamber or more directly by crawling from the rear entrance tunnel (VR-14). A detailed sketch map of the Bone Chamber is shown in Fig. 1.

In 1973 and March 1975 lumps of bone-bearing breccia were collected from the eastern edge of the Bone Chamber. In March 1975, two test samples of the soft sediments near the east wall were taken, from 0–20 cm, and 20–40 cm. In October 1975, the March test excavation was expanded in the eastern half of the Bone Chamber and level samples were taken as recognizable stratigraphic units. The October excavation was preceded by removal of collapsed material, called CU (Clean Up), from the excavation pit, and involved units between 0 and 20 cm from the surface. This CU sample, because it also included the UB (Upper Bone-rich) unit contained a large amount of the faunal remains recovered from the Bone Chamber. Other units (Fig. 2) were less rich in bone material and as a result are now less well-represented taxonomically than the CU (0–20 cm) interval.

STRATIGRAPHIC UNITS RECOGNIZED IN THE EXCAVATION: Figure 2 illustrates the stratigraphy of the Bone Chamber excavation. The south and west wall sections reveal the most complex stratification. Considered from the base of the excavation, the following units and samples were recognised.

Lower Red unit (LR): A compacted light brown (5YR 5/6) completely friable sediment composed

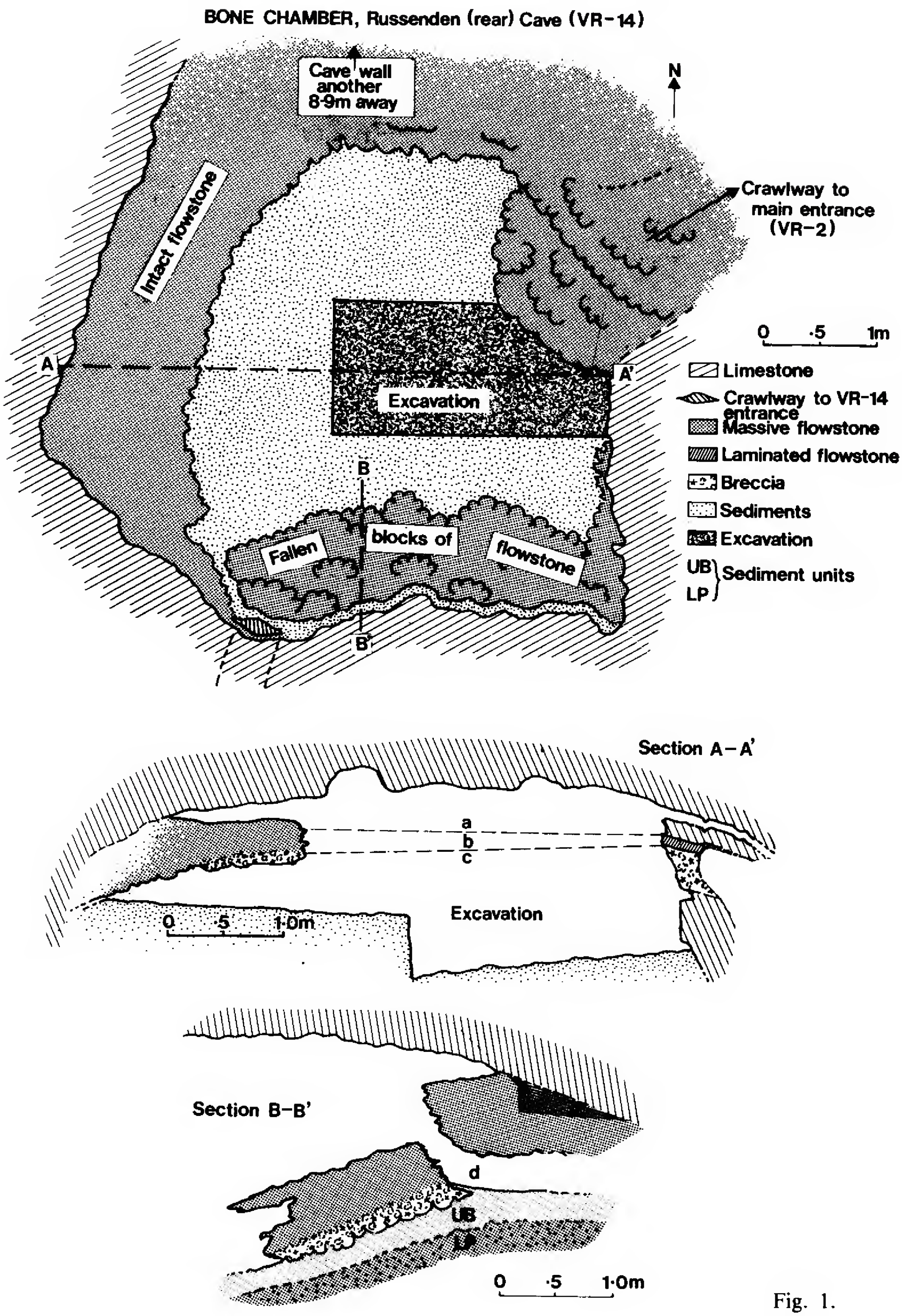

BONE CHAMBER, Russenden (rear) Cave (VR-14)
Cave wall another 8·9m away
N
Crawlway to main entrance (VR-2)
Intact flowstone
0 ·5 1m
A
A'
Excavation
Limestone
Crawlway to VR-14 entrance
Massive flowstone
Laminated flowstone
Breccia
Sediments
Excavation
UB
LP
Sediment units
B
Fallen
blocks of
flowstone
B'
Section A–A'
a
b
c
Excavation
0 ·5 1·0m
Section B–B'
d
UB
LP
0 ·5 1·0m

Fig. 1.

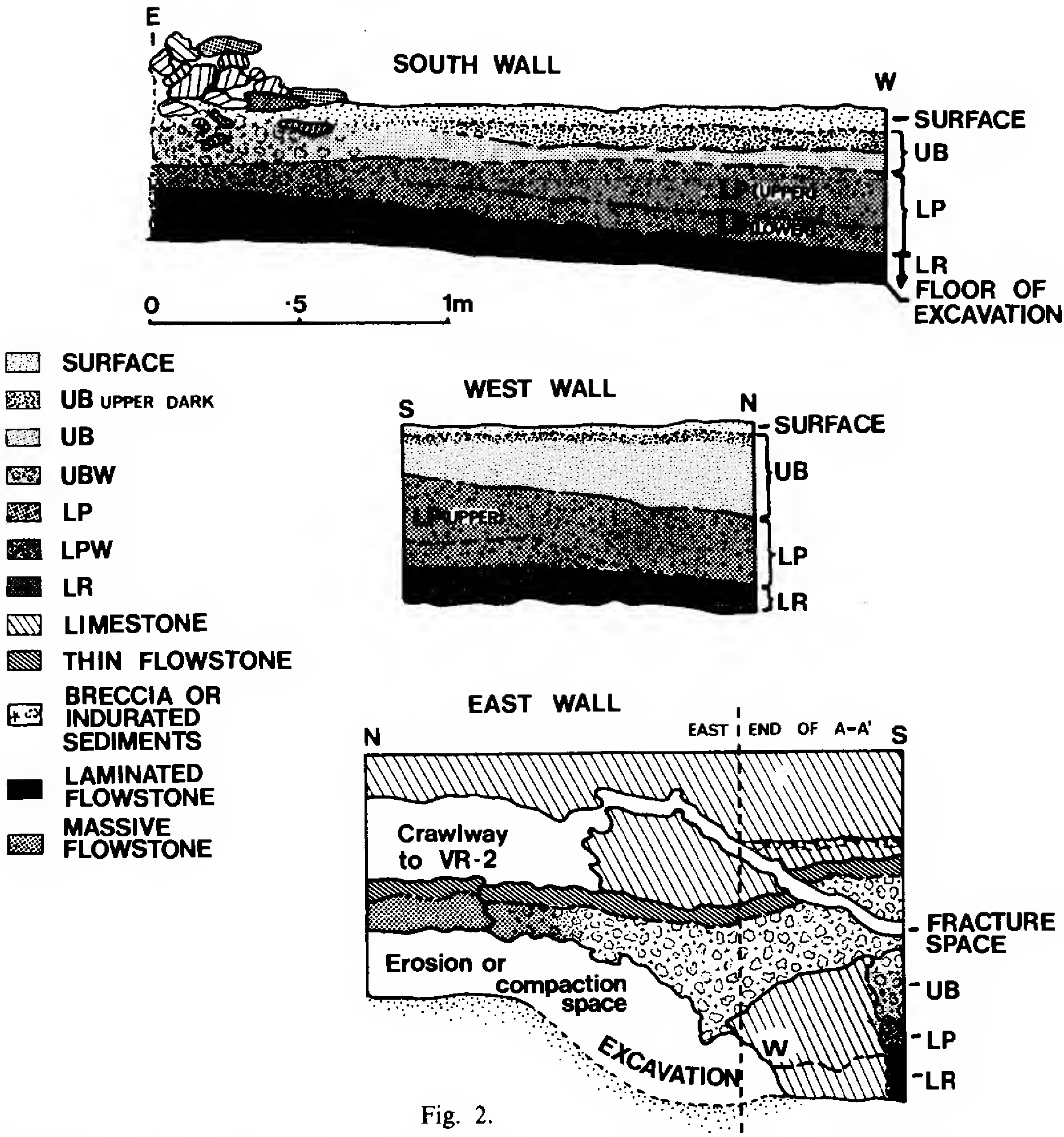


Fig. 2.

FIG. 2: South, west and east walls of the excavation in the Bone Chamber, Russenden (rear) Cave (VR-14). W indicates remnant of original tunnel wall. The vertical dashed line shown on the east wall represents the position of the east end of section A–A' of Fig. 1.

of subrounded silt to pebble-sized clay and carbonate nodules and other possibly autochthonous detritus. The carbonate nodules appear as white pebbles of irregular size. No bone was observed and there is nothing in this unit to suggest a contribution from outside the cave. The surface of this unit dips to the northwest. As far as could be determined, this unit underlies the whole of the excavation area. Its surface is not obviously eroded although the contact between it and the overlying sediments, in terms of texture and colour, is abruptly distinct. The excavation floor occurs within this unit so its thickness is unknown.

FIG. 1: Plan and sections of the Bone Chamber, Russenden (rear) Cave (from tape and compass survey, Archer and Kohout, 16 October 1975). Abbreviations not included in legend: a, interpreted former surface of flowstone across chamber; b, flowstone across chamber; c, surface of underlying sediments prior to compaction or erosion; d, fracture space adjacent to crawlway to rear entrance (VR-14).

Lower Pebbly unit (LP): A friable moderate brown (LP 5YR 3–4/4) sediment composed of angular clayrich silt to pebble-sized detritus and whitish carbonate lumps. Bone is uncommon but present in local concentrations throughout this unit. Two subunits are recognizable: a thin (maximum thickness, 10 cm) lower part (5YR 3–4/4), characterized by more angular detritus and abundant carbonate nodules, and which lenses out in a northerly direction; and a much thicker (maximum thickness, 25 cm) upper part (5YR 4/4) characterised by smaller-sized particles and few carbonate fragments. The Lower Pebbly unit thickens to the west and wedges out to the east. Its base dips to the northwest, but its top dips only to the north. Maximum thickness of the unit is 35 cm. Bone samples from the Lower Pebbly unit were not separated into upper and lower subunits at the time of collection.

Near the east end of the excavation, where the sediments abut against the cave wall, stratigraphic levels are very difficult to discern. For this reason two divisions of excavated material were made: LP, as noted above; and LPW (Lower Pebbly Wall) including only material collected within 60 cm of the cave wall and over a vertical distance equivalent to that of the LP level farther west where the position of the upper and lower boundaries are clear. The upper contact, between the Lower Pebbly unit and the Upper Bone-rich unit is gradational and recognisable mainly by a textural change, the Upper Bone-rich unit being composed of less angular particles.

A bone sample from the LP unit (not including the LPW division) was submitted from radiocarbon dating, but neither collagen nor apatite fractions were adequate (Kigoshi, pers. comm.). The reasons for this inadequacy are not clear.

Upper Bone-rich unit (UB): A friable to semi-indurated (in the southeastern corner) moderate to light brown (5YR 4–5/6) sediment composed of silt to pebble-sized particles as well as numerous small bones. The top of this unit is marked by a 1 cm thick dark band of possibly carbon-enriched sediment. The character of the Upper Bone-rich unit changes vertically from a moderate to light brown (5YR 4/6), finer, more acid-reactant, better-sorted sediment above to a light brown (5YR 5/6) coarser, less well-sorted sediment below. This change is completely gradational. The whole unit dips and thickens to the north. It is up to 25 cm thick in the northwest corner of the excavation, but as thin as 7 cm in the southwest corner. The lower contact with the Lower Pebbly unit is gradational, and based on textural change (see above).

As was the case for the Lower Pebbly unit, the eastern 60 cm of this unit was collected separately (UBW) from the remainder and for the same reasons. Also collected as separate samples (UBP and UBPW) were bone-rich sediments filling pockets or cavities developed within the UB layer in the southeastern half of the excavation. These pockets appeared to be water erosion channels developed through the more compacted south-eastern sediments, in which bones and darker more organic-rich sediment had come to rest.

A bone sample was submitted from the UB unit (not including bone from UBW) but as for all other samples submitted from the Texas Caves, neither collagen nor apatite dates could be obtained.

The surface layer: The entire Bone Chamber is covered by a variably thick (average 2 cm) layer of very fine brown silt-sized sediment which may represent dust accumulation in the gently concave surface of the chamber floor. No bone or other large detritus was collected from this layer. Contact with the underlying UB layer was not observed to be gradational.

THE BRECCIA: adjacent and cemented to the eastern wall of the Bone Chamber, is a brown carbonate cemented breccia containing some bones. It also occurs as patches cemented beneath the flowstones around the circumference of the Bone Chamber. Its relationship to the UB unit is prolematical. The eastern end of the UB unit (sample UBW) appears to be gradationally continuous with the breccia. However, in the southern and northeastern part of the excavation, where the UB unit is completely friable, this unit contains rare clasts of what appear to be the same breccia. The problem is discussed below.

INTERPRETED HISTORY: In the course of excavating the Bone Chamber, the eastern boundary wall revealed several features which enabled the older episodes of development to be interpreted. The massive limestones of the ceiling were found to curve gently down the eastern wall,, forming what appears to be the very top of a broadly arched tunnel, against whose southeastern wall the excavation is developed. Tunnels of this kind are characteristic of Russenden Cave (see Grimes 1978). It seems highly probable that the Bone Chamber represents a corner in a tunnel linking the main chamber of Russenden Cave with the now detritus-filled chamber containing Margot's Shawl.

Not considering for the moment the breccia in the bone chamber, the oldest observed sediment filling this tunnel is the Lower Red (LR) unit. It appears to contain no bone or other allochthonous detritus, and either represents a purely autochthonous cave sediment or else a highly sorted inorganic fraction of an externally derived sediment, possibly with its source in the main chamber of Russenden Cave.

The next oldest sediment is the Lower Pebbly (LP) unit. Its bones and the dip to the northwest suggest a solution pipe had broken through to the southeast admitting allochthonous materials and perhaps providing owl roosts. Most of the bones in this and the Upper Bone-rich (UB) units are of small mammals and this suggests accumulation perhaps from owl pellets. Alternatively, the entrance may have only been large enough to admit small mammals. Whatever, the present rear entrance solution pipe (VR-14) is in a highly suitable position to be the one that allowed entry of the allochthonous materials in the LP unit. The northwestern edge of the rubble pile below this solution pipe slopes off towards the Bone Chamber, and is only about two to three metres away from the excavation site.

Change from Lower Pebbly (LP) to Upper Bone-rich (UB) unit deposition was gradational. The surface of the detritus fill in the Bone Chamber was becoming horizontal but still retained a gentle northern dip, suggesting continued accumulation from the southeastern rear entrance solution pipe. Bones in the UB unit are commonly encrusted with calcium carbonate, but otherwise free in the sediments. This is true mainly in the areas of the excavation west of the eastern end. This generalization is complicated by the observation that (as noted above) the sediments of the UB unit become gradually more indurated as they approach the wall, and ultimately are difficult to distinguish from the breccia adherring to the cave wall. There are at least two possible interpretations: 1) The bones (all or some) in the UB unit were in fact derived by decalcification of an older overlying breccia, thus accounting for their encrustation. Although this is possible, it is unlikely that the hypothesized older breccia could be equivalent to the presently visible breccia in the bone chamber because this appears to be laterally equivalent to the UB unit; 2) Not all of the bones in the UB unit are encrusted and this lack appeared at the time of excavation to be a function of the distance from the edge of the Bone Chamber. This suggests that the induration, formation of the breccia now visible, and attendant encrustation may have been a peripheral phenomenon that affected the previously rather than subsequently deposited UB unit. Therefore the age of the bones in the UB unit and the breccia would be the same. Although this interpreatation seems reasonable, it is difficult to understand how bones isolated in the otherwise non-indurated parts of the UB unit could develop encrustations, unless they somehow acted as centres of precipitation of calcium carbonate. I had hoped that radiometric dates on bones from the breccia and other levels would contribute to an understanding of the relative ages of the various units, but as noted above, no dates could be obtained.

Some time following deposition of the UB unit, and the possibly contemporaneous sediments of the breccia, the Bone Chamber was evidently covered, at least peripherally, by laminated flowstones about 5 cm thick near the east wall, and much thicker (possibly up to 40 cm) in the northern and western parts of the Bone Chamber. These flowstones have various irregular local dips, but in general appear to dip to the southwest. Approximately two metres to the northeast of the Bone Chamber, along the squeeze passageway leading to the main chamber of Russenden Cave, is a massive flowstone cone, presumably the centre of calcium-carbonate-enriched waters responsible for flowstone deposition in the Bone Chamber. In some areas of this flowstone, notably the east wall, the base contains clayballs suggesting an erosion interval contemporaneous with the first stages of flowstone deposition. There are no interbedded detrital sediments in the flowstone squence and this, combined with a lack of bones observed in the flowstone, may indicate that the rear entrance solution pipe was blocked.

This period of flowstone deposition may have been contemporaneous with the actual carbonate induration of the breccia and some of the encrustation on bones in the UB unit noted above.

Flowstone deposition was followed by compaction or erosion of the underlying sediments. Evidence for this is twofold: There is at present a widespread space, at least about 25 cm high, under the whole of the Bone Chamber flowstones, as well as under the flowstones in the connecting tunnel leading to the main chamber of the cave; further, in the east wall of the Bone Chamber, there is a continuous five centimetre gap between the actual ceiling of the Bone Chamber and a portion of the arched roof of the original tunnel. This gap represents a subsidence of part of the tunnel wall onto or with the accumulated sediments below. Breccia adherring to the wall is fractured and displaced across this gap. It seems probable that this wall collapse could not have occurred if all the soft sediments had remained *in situ* against the wall. However, it could have occurred contemporaneously with compaction of the sediments.

Following compaction or erosion of the underlying softer sediments, much of the then unsupported flowstone collapsed in the southern side of the Bone Chamber, bringing down with it remnants of underlying breccia. Collapse also occurred in the southeastern corner, adjacent to the excavation, contributing to the confusion of interpretation of the breccia's age by introducing lumps of the breccia into the now exposed and non-indurated top of the UB unit.

A remnant thin rim of calcium carbonate on the east wall, about 5 cm above the massive flowstone, suggests a period of ponding of calcium carbonate enriched water, perhaps as rock pools on the surface of the flowstone.

Events of unknown age in this sequence include the development of the pockets or tunnels (UBP, and UBPW samples) in the UB unit suggestive of solution tunnels. Solution tunnels (if that is what they are) of this kind must have been formed by undersaturated waters and therefore must either have predated or postdated the period of flowstone deposition rather than been a contemporaneous development. Bones in these tunnels need not be of the same age as the tunnels themselves. Some of these bones have a less leached and mineralized appearance than bones from the UB or LP units, and are interpreted to be younger than bones from these two units. Others, however, including an M^1 clearly representing the Pleistocene *Macropus titan*, are preserved in a manner identical to bones from the UB unit, and may represent a lag deposit following the erosion of the pockets in the UB unit.

We know that when the rear entrance (VR-14) was discovered in 1967 or 1968, the solution pipe was blocked by debris. We don't know how long ago this blockage occurred. The few bones recovered in 1973 from the surface of the large chamber below the rear entrance, adjacent to the Bone Chamber, included rabbits, but it is not inconceivable that these had accumulated since 1967–8. In view of the lack of much surface bone below this rear entrance, and its probably rather recent origins, it is concluded here that the rear entrance has been blocked since at least late Pleistocene time.

The final events presently recorded in the Bone Chamber include our excavation, in a very complicated deposit, and the entrance of the major flood waters which have entered the cave, slumped the excavation walls, and inundated all of the Russenden Cave chambers (Shannon 1977).

FAUNAS FROM THE BONE CHAMBER, RUSSENDEN CAVE: Details of the taxa enumerated here are given in the systematic section below. The lists given here are summaries of each of the samples noted above.

Lower Pebbly Unit (LP)

Marsupialia
Smithopsis murina (e.g. F8424)
Phascogale tapoatafa (F8534)
Dasyurus viverrinus (e.g. F8519)
Perameles nasuta (e.g. F8418)
Petaurus norfolcensis (F8537)
Macropus (Macropus) sp. cf. *M.* (*M.*) *giganteus* or *M.* (*M.*) sp. cf. *M. titan* (e.g. F8514)
M. (Osphranter) sp., cf. *M. (O.) altus* (F8512)
?*Petrogale* sp. (F8417)
Petrogale sp. (F8415)
?*Macropus dorsalis* (F8419)

Placentalia
Conilurus albipes (F9456)
Pseudomys sp., cf. *P. novaehollandiae* (e.g. F8421)

Lower Pebbly Wall (LPW)

Marsupialia
Antechinus sp., aff. *A. flavipes* (F8466)
Perameles nasuta (e.g. F8468)
Pseudocheirus peregrinus (e.g. F8413)
Aepyprymnus rufescens (e.g. F8407)

Placentalia
Conilurus albipes (e.g. F9445)
Pseudomys sp., cf. *P. novaehollandiae* (e.g. F8421)
P. gracilicaudatus or *P. desertor* (F8464)
Rattus sp., cf. *R. fuscipes* (F9446)

Upper Bone-rich Unit (UB)

Marsupialia
Petrogale sp. (e.g. F8323)
?*Sthenurus* sp. (F8317)

Placentalia
Conilurus albipes (F9457)
Pseudomys sp., cf. *P. oralis* (F9458)
Rattus sp. (F8327)

Upper Bone-rich Wall (UBW)

Amphibia
Unidentified frog (F8265)

Reptilia
Unidentified snake (F8363)
Geckonid, indet. (F8267)
?*Amphibolurus* sp. (F8342)

Mammalia: Marsupialia
Sminthopsis murina (F8344)
Antechinus sp., aff. *A. flavipes* (e.g. F8343)
Dasyurus viverrinus (e.g. F8341)
Perameles nasuta (e.g. F9447)
Acrobates pygmaeus (F8206)
?*Vombatus* sp. (e.g. F8368)
Unidentified genus (F8362)
Petrogale sp. (F8353)
Unidentified genus (F9448)
Macropus (Prionotemnus) sp., cf. *M. (P.) agilis siva* (F9449)

Placentalia
Rhinolophus megaphyllus (e.g. F8268)
?*Miniopterus schreibersii* (F9450)

Upper Bone-rich Pocket (UBP)

Marsupialia
Aepyprymnus rufescens (F8940)
?*Petrogale* sp. (F9451)

Placentalia
Rhinolophus megaphyllus (F8939)
?*Pseudomys* sp. (F8540)
Conilurus albipes (F8938)

Upper Bone-rich Pocket Wall (UBPW)

Reptilia
Unidentified ?lizard (F8432)

Marsupialia
Aepyprymnus rufescens (F8434)
Petrogale sp. (e.g. F8429)

Placentalia
Rhinolophus megaphyllus (F8433)
Conilurus albipes (e.g. F9452)
Pseudomys sp., ?*P. desertor* (F9453)

0–20 cm (also includes here CU sample, both of which are mixed samples containing mainly UB but also a small amount of LP)

Reptilia
Unidentified geckonid (e.g. F8937)
?Agamid (F8230)

Aves
Columbid (e.g. F8197)
cf. *Aegotheles* (e.g. F8311)
Alcedinid (e.g. F8200)
Turnix sp. (e.g. F8198)
Coturnix sp. (e.g. with F8311)
Passeriform, small
Passeriform, large

Mammalia: Marsupialia
Sminthopsis murina (e.g. F8220)
Antechinus sp., aff. *A. flavipes* (e.g. F8032)
Antechinus sp. (F8445)
Phascogale tapoatafa (e.g. F8285)
Dasyurus viverrinus (e.g. F8042)
Perameles nasuta (e.g. F8310)
Isoodon obesulus (e.g. F8280)
Petaurus breviceps (e.g. F8205)
P. norfolcensis (e.g. F8202)
Pseudocheirus peregimus (e.g. F8208)
Trichosurus sp., cf. *T. vulpecula* (F8898)
Cercartetus nanus (e.g. F8207)
?*Vombatus* sp., cf. *ursinus* (e.g. F8234)
Aepyprymnus rufescens (e.g. F8331)
Sthenurus sp., cf. *oreas* (F8307)
Protemnodon sp., cf. *P. brehus* (F8154)
?*Thylogale* sp. (e.g. F8172)
Petrogale sp. (e.g. F8196)
Macropus (Prionotemnus) sp., cf. *M. (P.) agilis siva* (e.g. F8293)
M. (Osphranter) sp., cf. *M. (O.) robustus* (e.g. F8161)
M. (Macropus) sp., cf. *M. (M.) titan* (F8899)
M. (M.) sp., cf. *M. (M.) giganteus* (F8304)

Placentalia
Nyctophilus timoriensis (F8141)
Rhinolophus megaphyllus (e.g. F8145)
Miniopteris schreibersii (e.g. F8152)
Conilurus albipes (e.g. F8528)
Pseudomys sp., cf. *P. oralis* (e.g. F8507)
P. sp., cf. *P. desertor* (e.g. F8120)
Rattus sp., cf. *R. lutreolus* (F8854)

OTHER TEXAS DEPOSITS

The foregoing lists of faunas are the result of systematic excavation. The following sites and specimens were obtained as incidental collections made by various people since 1969.

RUSSENDEN CAVE: A partial skull of *Protemnodon roechus* (F6132, Plate 9, A–B, collected D. Gillieson, 1969) was collected from the entrance rubble pile below the rear entrance (VR-14) solution pipe. This area contains flowstones and cemented rubble, and is the probable point of accumulation for most of the bones found in the Bone Chamber.

The large chamber leading off directly from the solution pipe from VR-14 has a horizontal earth floor. Bones were rare on the surface of this chamber but included the following taxa (collected by J. Covacevich, 1970, and M. and E. Archer, 1973): *Oryctolagus cuniculus,* F8449; ?*Petrogale,* F8451; a lizard, F8454; and *Rattus,* cf. *R. rattus,* F9454.

A narrow by-pass dig leading from the rear entrance (VR-14) rubble pile towards the Bone

Chamber produced an isolated lower canine of *Sarcophilus harrisii* (F9455, collected D. Gillieson, 1969).

The main entrance (VR-2) of Russenden Cave leads to a large chamber from which some bone material was collected (J. Covacevich, 1970; H. Godthelp, 1975): *Petrogale* sp. (e.g. F8895); *Aepyprymnus rufescens* (F8909); a rodent (F8902); *Rhinolophus megaphyllus* (F8906); and a frog (F8905). The frog, *Rhinolophus* and one of the *Petrogale* (F8903) specimens appear to be 'modern' and unlike the preservation of older bones from the Bone Chamber. The *Petrogale* specimen F8895 was cemented into flowstones in the southwestern corner of the main chamber, at the entrance to the tunnel that leads to the Bone Chamber.

RABSCUTTLE HOLE (VR-20): Specimens from the surface of Rabscuttle Hole (collected A. Burrows, 1975) include the following: *Pseudomys gracilicaudatus* (e.g. F8926); *Rattus* sp. (e.g. F9459); *Petrogale* sp. (F8924); *Trichosurus vulpecula* (e.g. F8914); *Oryctolagus cuniculus* (e.g. F8931); an elapid snake (e.g. F8927); and lizards (e.g. F8932) have a modern appearance and lack any carbonate encrustation. However, specimens referable to *?Pseudomys* sp. (e.g. F8855), and *Petrogale* sp. (e.g. F8929) have a carbonate encrustation and may be older.

MAIN VIATOR CAVE (VR-1): One specimen (F8500) was collected and this appears to represent a small *Petrogale*-sized kangaroo.

BEVANS POT (VR-4): Forty specimens (e.g. F8893) of *Petrogale* sp. were collected from the surface of this cave. Their preservation is consistent with interpretation of their age as modern. They were probably accumulated within historic times.

CRYSTAL CAVE (VR-3): Specimens (collected by P. Jell and J. Covacevich, 1970) collected from the surface of this cave include the following: *Petrogale* sp. (e.g. F9460); *Oryctolagus cuniculus* (F9461); and *Ovis aries*. All have a modern appearance.

SYSTEMATICS

CLASS AMPHIBIA

F8265, from the UBW sample of the Russenden Bone Chamber, contains various unidentified frog bones. There are many frogs living in the area today (Czechura, in Archer 1978), including some which are known to frequent various Texas caves such as *Litoria lesueuri*.

CLASS REPTILIA
ORDER CROCODILIA
SUBORDER SEBECOSUCHIA

F7898, a left maxillary of a crocodilian from The Joint breccia, appears to represent a sebecosuchian crocodile (Hecht and Archer 1977), and as such is one of the most important specimens recovered from this deposit. An isolated tooth (F8383), not noted by Hecht and Archer (1977), may be also referable to this taxon. Previously, except for a tentative reference of isolated teeth from the Pliocene Awe fauna from New Guinea (Plane 1967), this group of crocodiles was thought to have become extinct throughout the world during middle Tertiary time. It also is important in representing in Australia yet another group with a Gondwanaland distribution.

The question of how it came to be in the cave is equally interesting. Grimes (1978) has indicated that the flood plain of Pike Creek was formerly higher than it is now, and probably extended higher up the flank of Viator Hill. The Joint is near the top of this hill, and may have been more easily accessible to a crocodile living in the ancestral Pike Creek than it would be today.

Hecht and Archer (1977) note other previously undocumented Australian Tertitiary specimens evidently referable to the Sebecosuchia, some from Pliocene deposits of northeastern South Australia (the Palankarinna fauna). These records combined with The Joint specimens, suggest that the group was widespread on the Australian continent. However, its apparent absence from other Pleistocene deposits in Australia suggests either that they were very rare crocodiles, or that they in fact only survived this late in the Texas area of southeastern Queensland. At the moment I favour the former interpretation, particularly in view of the fact that the Pleistocene record of northern Australia is very poorly known.

ORDER SQUAMATA
SUBORDER OPHIDIA

Snakes are represented by isolated vertebrae (e.g. F8363, in the UBW sample of the Bone Chamber) but have not yet been identified. None appear to be referable to large boids such as have been reported from several Pleistocene cave deposits (e.g. Smith 1976, Archer 1972).

SUBORDER LACERTILIA

None of the numerous lizard fossils have been identified, mainly because of the awesome incompleteness of modern comparative skeletal collections. However, it is clear that at least several families are represented, including gekonids, agamids, and probably varanids. The modern lizard fauna of the Texas Caves area is very diverse (Czechura, in Archer 1978), and many live in and around the limestone cave entrances.

CLASS AVES

The fossil birds from the Texas Caves faunas are under study by P. Rich. Provisional identifications based on tarsometatarsi and humeri are noted above for birds in the CU sample. Two of the genera represented *(Turnix* and *Coturnix,* Button Quails and Quails respectively) have not been recorded for the modern bird fauna of the area (Archer 1978c), but this omission from the modern fauna is likely to be based merely on oversight (G. Ingram, pers. comm.).

CLASS MAMMALIA
SUBCLASS MARSUPIALIA
FAMILY DASYURIDAE

Sminthopsis murina (Waterhouse)
(Plate 7A)

This small dunnart was reasonably abundant from the top to the bottom of the excavation in the Bone Chamber. I cannot find any features in which these Russenden specimens differ from those of modern *Sminthopsis murina,* the systematics and characters of which have been reviewed most recently by Archer (in press). It has been identified here by the transverse orientation of the metacristids and hypocristids, the small to absent entoconids, closely spaced premolars, and size. A statistical summary of the measurements of all Bone Chamber specimens is given in Table 1. Methods of taking these measurements on small dasyurids have been described elsewhere (e.g. Archer 1976).

It is not known if *Sminthopsis murina* occurs in this area today although it is known from Mt. Tamborine. The habitats recorded for this species vary from swamps to dry woodlands, habitats still present around Viator Hill.

TABLE 1: MEASUREMENTS OF *Sminthopsis murina* FROM THE RUSSENDEN (REAR) CAVE DEPOSITS

Parameter	I_1–M_5	C_1–M_5	M_2–M_4	M_2–M_5	M^2–M^4	M^2–M^5
$\bar{x}$	10·4	10·4	4·4	5·8	4·8	5·4
N.	5	1	10	9	1	1
O.R.	10·0–10·9	10·4 —	4·1–4·7	5·3–6·3	4·8 —	5·4 —
S	0·34	—	0·18	0·30	—	—
C.V.	3·30	—	4·13	5·07	—	—

TABLE 2: MEASUREMENTS OF LOWER TEETH OF MODERN MALE *Antechinus flavipes* FROM NORTHEASTERN AND SOUTHEASTERN QUEENSLAND, AND THE FOSSIL *Antechinus* SPECIMENS (LEFT DENTARIES ONLY). L = LENGTH; W = WIDTH (SEE FIG. 3).

Parameter		P_2L	P_2W	M_2L	M_2W	M_3L	M_3W	M_4L	M_4W	M_5L	M_5W	M_2–M_4
Modern southeastern Queensland males	$\bar{x}$	0·14	0·09	0·18	0·11	0·22	0·14	0·23	0·14	0·21	0·13	0·61
	N.	11	11	11	11	11	11	11	11	11	11	11
	O.R.	0·13–0·15	0·08–0·10	0·17–0·21	0·10–0·12	0·21–0·24	0·13–0·14	0·21–0·24	0·14–0·15	0·18–0·22	0·12–0·13	0·56–0·64
	S	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·02
	C.V.	5·73	7·41	6·11	4·94	4·16	4·94	4·08	3·27	5·84	3·16	4·04
Modern northeastern Queensland males	$\bar{x}$	0·13	0·09	0·18	0·11	0·23	0·14	0·23	0·15	0·20	0·12	0·62
	N.	8	8	9	9	9	9	9	9	9	9	9
	O.R.	0·12–0·15	0·08–0·10	0·17–0·20	0·10–0·12	0·21–0·23	0·13–0·15	0·22–0·24	0·13–0·16	0·19–0·22	0·11–0·14	0·58–0·67
	S	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·03
	C.V.	6·69	10·29	5·50	4·55	3·42	7·05	2·60	7·77	6·12	8·11	5·36
Fossil Bone Chamber (less F8445)	$\bar{x}$	0·14	0·09	0·19	0·12	0·24	0·15	0·23	0·15	0·21	0·13	0·62
	N.	2	2	5	5	6	6	6	6	6	6	4
	O.R.	0·14–	0·09–0·10	0·18–0·21	0·12–0·13	0·23–0·27	0·14–0·15	0·20–0·26	0·18–0·20	0·24–0·25	0·13–	0·60–0·68
	S	0·00	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·00	0·02
	C.V.	0·00	0·01	6·79	4·42	3·56	3·78	6·45	3·37	2·50	0·00	2·74
F8445		0·14	0·10	0·21	0·13	0·27	0·17	0·26	0·17	0·21	0·13	0·68

Antechinus sp., aff. **A. flavipes** (Waterhouse)
(Plate 7B)

Specimens referred here to *Antechinus flavipes* have come only from the sediments of the Bone Chamber. Reference of all specimens to *A. flavipes* has been made with considerable reservation. Identification has been based on the crowded P_3, short and wide premolars, two-rooted but reduced P_3, small entoconids, low but distinct paraconid on M_2, and size. Although some specimens (e.g. F8343) are in most respects indistinguishable from modern *A. flavipes*, others are strikingly unlike any modern specimens. In particular, F8445, from the CU sample, is outside the range of any modern *A. flavipes* specimens measured, in many dental features (combined length of M_{2-4}; length and width of M_4; length and width of M_3; and width of M_2). In addition, it is outstanding in its proportionately short premolar row and bulbous crown bases, features which seem to be extraordinary developments of normal *A. flavipes* tendencies.

Apart from F8445, (Plate 7C-C'), the entire Bone Chamber *Antechinus* sample also seems to be on the average larger in some dental features than modern *A. flavipes* from southeastern Queensland. Seen in this context, it could be suggested that F8445 represents the extreme in large size in an overall larger-sized population. Table 2 is a comparison of the Bone Chamber specimens (using only left dentaries, measurements as shown in Fig. 3) with modern male specimens of *A. flavipes* from southeastern and northeastern Queensland. The sexes of the Bone Chamber specimens are of course unknown but using all male modern specimens for comparison means that the relatively large size of the Bone Chamber individuals cannot be due simply to a predominance in that sample of males. It may be noted that on the average, north Queensland *A. flavipes* are larger than those from southeastern Queensland, and in this respect, more closely approximate the size of all of the Bone Chamber individuals except F8445, which is still outside the range of modern variation in the characters noted above.

I have compared F8445 with all known species of *Antechinus*, as well as related genera such as *Phascogale* (*P. calura* is very *Antechinus*-like in dental morphology) and am satisfied that it cannot be referred to any known species, unless to *A. flavipes*. More detailed systematic work on this thin-tailed group of Antechinuses is required, however, before the Bone Chamber specimens, and F8445, in particular, can be confidently allocated to or separated from *A. flavipes*.

There is no evidence for believing *Antechinus flavipes* occurred within the Texas Caves area in Recent times, although it does occur as far west in southwestern Queensland as Chinchilla on the western edge of the Darling Downs, and as close as Wallangarra. It lives in a variety of habitats from swamps to dry sclerophyll woodland, a habitat which is still present today on Viator Hill.

Phascogale tapoatafa (Meyer)
(Plate 7D)

Only four very fragmentary Bone Chamber specimens represent this distinctive dasyurid. The only specimen measured (F8534) is as follows: LM^2 (in a maxillary fragment with P^{2-3}) buccal length, 3·8; maximum width from the outside

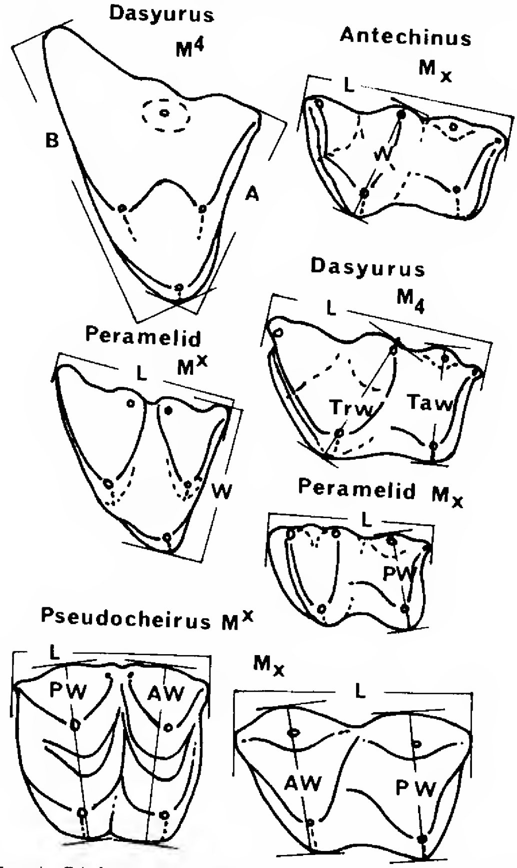


FIG. 3: Right upper and left lower molars of *Dasyurus, Antechinus*, a peramelid, and *Pseudocheirus* to show positions from which measurements were obtained (for these taxa only). Terminology of widths is that used in the Tables and relevant sections of the text. Figures are not drawn to the same scale.

flanks of the protocone to the metastylar corner of the tooth, 4·0. The size of the Bone Chamber specimens is consistant with that of modern southeastern Queensland specimens (e.g. J4695).

Living *Phascogale tapoatafa* are always uncommon. For this reason, their relative rarity in the Bone Chamber deposits is not surprising. The preferred habitat in southeastern Queensland appears to be wet or dry sclerophyll forest, and pockets of the latter still occur on Viator Hill. Specimens of living animals have come from as close as Woodenbong.

Dasyurus viverrinus (Shaw)
(Plate 7E)

Native cats are represented by very fragmentary specimens from the Bone Chamber. There is some doubt about the specific identity of this material. At present three living species of *Dasyurus* have been recorded from Queensland: *D. maculatus,* which is still living around the Texas area; *D. hallucatus* which once occurred as far south as Gympie (Ride 1970); and *D. geoffroii* which evidently occurred in the arid southwestern areas of the State. In addition, Bartholomai (1971) has described an extinct Pliocene species, *D. dunmalli* from the Chinchilla Sand, southeastern Queensland, and simultaneously referred (but without detailed analysis) specimens from the Pleistocene eastern Darling Downs deposits to *D. viverrinus,* and from the Pleistocene Cement Mills fauna (Bartholomai 1977) to *D.* aff. *D. viverrinus.* Distinguishing *D. maculatus* and *D. hallucatus* from other species and the Bone Chamber specimens on the basis of size and molar morphology is not difficult. Similarly, *D. dunmalli* is unique in having a single-rooted P_3, and unlike the Bone Chamber specimens (F8341, F8443, F8409 and F8283) in which the $P^2 - M_2$ region is preserved. This leaves *D. geoffroii* and *D. viverrinus,* which in terms of molar morphology and size are very similar.

Smith (1972) suggests that the upper fourth molars (=M^3 of Smith) of these species may be distinguished by a ratio of protocone-parastyle to protocone-metastyle lengths. Table 3 is a comparison of Queensland Museum specimens of *Dasyurus geoffroii* and *D. viverrinus* for these characters (see Fig. 3) and they clearly support Smith's suggestion. On this basis, the only M^4 from the Bone Chamber, F8042, is referable to *D. viverrinus.*

Marshall (1973) regards the M_4 (= M_3 of Marshall) of *Dasyurus geoffroii* to differ from

TABLE 3: M^4 IN *Dasyurus geoffroii, D. viverrinus,* AND THE TEXAS SPECIMEN F8042.

Species	*D. geoffroii* (W.A.)			*D. viverrinus* (?Tas.)			F8042		
Parameter	A (Pr. to past. M^4)	B (Pr. to metast. M^4)	A/B	A	B	A/B	A	B	A/B
$\bar{x}$	4·9	6·6	0·75	4·3	6·5	0·67	4·0	6·6	0·66
N.	2	2	2	9	9	9	1	1	1
O.R.	4·7–5·1	6·4–6·7	0·73–0·76	3·8–4·7	6·1–6·8	0·59–0·74	—	—	—
S	0·28	0·21	0·02	0·35	0·24	0·05	—	—	—
C.V.	5·77	3·24	2·55	8·08	3·69	8·26	—	—	—

TABLE: M_4 IN *Dasyurus geoffroii, D. viverrinus* AND THE TEXAS CAVES SPECIMENS (TRW = TRIGONID WIDTH: TAW = TALONID WIDTH)

Species	*D. geoffroii* (W.A.)				*D. viverrinus* (?Tas.)				Texas specimens			
Parameter	A (M_4L)	B (M_4 TrW)	C (M_4 TaW)	B/A	A	B	C	B/A	A	B	C	B/A
$\bar{x}$	5·6	3·4	3·0	0·61	5·3	3·3	3·0	3·0	5·4	3·1	2·8	0·57
N.	9	9	9	9	8	8	8	8	2	2	2	3
O.R.	5·1–6·0	3·0–3·7	2·6–3·3	0·56–0·67	5·0–5·6	2·9–3·5	2·6–3·2	0·57–0·65	5·3–5·5	3·1–3·2	2·8–	0·57–0·58
S	0·35	0·27	0·24	0·04	0·23	0·19	0·20	0·03	—	—	—	—
C.V.	6·27	7·83	8·08	6·05	4·39	6·02	6·78	4·68	—	—	—	—

that tooth in *D. viverrinus* in being relatively narrower (compared to the tooth's length), in having the talonid narrower than the trigonid (it is supposedly as wide as the trigonid in *D. viverrinus*), and in having the protoconid in a slightly more anterior position relative to the metaconid. The last character is not accessible in isolated teeth because it depends on orientation of the crown. In any case, P. Crabb (pers. comm.), having more extensively examined Marshall's material, suggests this character is subject to variation. Table 4 compares the other two characters for Queensland Museum specimens of both species, as well as cave surface specimens of *D. geoffroii* from southwestern Western Australia. It is clear that although the M_4 trigonids of *D. geoffroii* are on the average slightly larger than those of *D. viverrinus*, the trigonids of the latter are consistantly wider than the talonids, supposedly a condition lacking in *D. viverrinus*. Similarly, the ratio of M_4 crown length to trigonid width clearly does not distinguish the two species based on at least the present sample. For these reasons, Marshall's (1973) characters have not been found useful in determining the specific identity of the Bone Chamber specimens.

Confirmation of Smith's (1972) diagnostic characters with the Queensland Museum's modern specimens have been the basis for determining F8042 as *Dasyurus viverrinus*. There is at present no reason for believing any of the other Bone Chamber specimens are referable to *D. geoffroii*, and all are accordingly tentatively referred to *D. viverrinus*.

Dasyurus viverrinus could almost certainly survive in the dry sclerophyll forest of the Viator

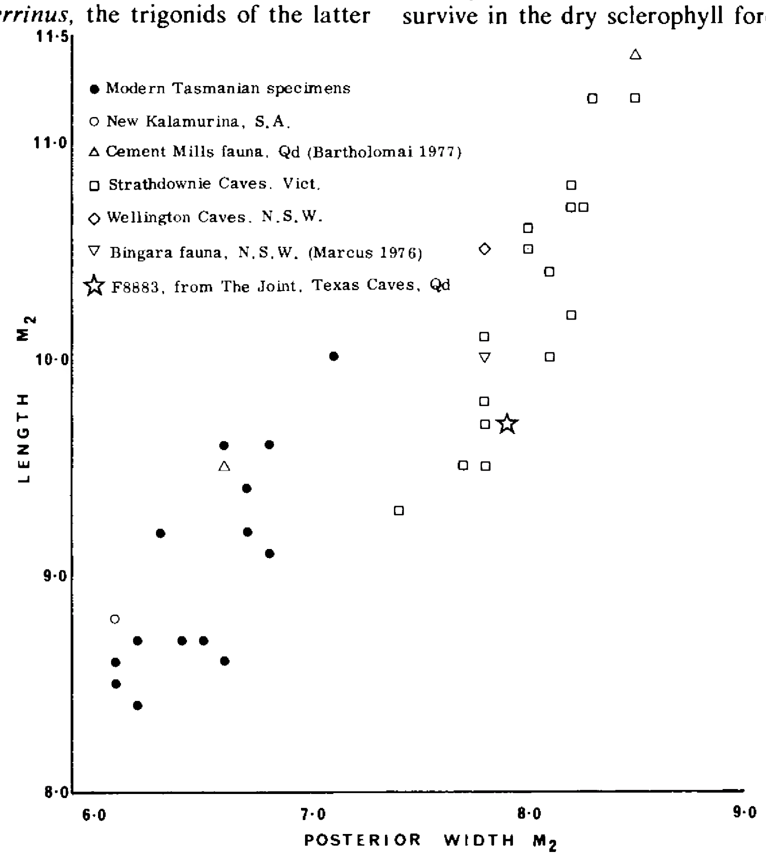


FIG. 4: Comparison of the M_2 (length vs maximum transverse talonid width) of modern Tasmanian and various fossil samples of *Sarcophilus*. The larger cluster includes material from Wellington Caves, the type locality of *laniarius*. The smaller cluster includes modern *S. harrisii*. Of particular note are the Cement Mills specimens, one of which is decidedly part of the larger *laniarius*-cluster, while the other falls into the *harrisii*-cluster. The Texas specimen (F8883) falls into the lower range of the *laniarius*-cluster and as a result has been referred here to *S. laniarius*.

Hill area today and the reasons for its apparent extinction from southeastern Queensland are not understood. It has similarly become extinct in South Australia (Smith 1972). Troughton (1967) suggests the species was decimated by some form of epidemic disease in 1901–3 at which time it suffered an extensive reduction of range.

Sarcophilus laniarius (Owen)
(Plate 7F)

Two specimens, F8883 from The Joint, and F9455 from the by-pass dig between the entrance chamber and the Bone Chamber of Russenden (rear) Cave (VR-14), appear to represent this large dasyurid. The Joint specimen, collected by A. Bartholomai, a left dentary fragment preserving M_2 and alveoli for I_{1-3}, C_1, P_1, M_3, and roots of P_2, is not preserved in the manner of other bones collected from the breccia, and it may represent a younger fauna than that of The Joint breccia. The Russenden specimen, collected by D. Gillieson in 1969, is preserved in a fashion comparable with bones from the UB and LP samples. The size of the M_2 of F8883 is as follows: M_2L, 9·7; M_2 trigonid width, 6·6; M_2 talonid width, 7·9.

Measurements of F8883 were plotted (Fig. 4) with those of other M_2s of fossil *Sarcophilis* from Strathdownie (National Museum of Victoria), Wellington Caves, Gore (Cement Mills fauna), Bingara, and New Kalamurina, and modern *Sarcophilus* from Tasmania. Two clusters are apparent, one including F8883, the Strathdownie, Wellington, and Bingara specimens, and the other including specimens from New Kalamurina and modern Tasmania. The type specimens of *laniarius* come from Wellington Caves, and if the larger cluster in Fig. 4 is to receive taxonomic distinction (and this question is entirely unsettled), *laniarius* is the available name. The smaller cluster includes all measured modern *Sarcophilus* from Tasmania and would be called *harrisii*. The Gore specimens present an interesting problem. Bartholomai (1977), in the description of the Cement Mills fauna, refers these to *S. laniarius*, but this examination suggests that two distinctive populations are included in the sample: one, including only F3734 and F3725, is very large and may be referable to *laniarius;* the other is comparable to modern *harrisii* in dental size and includes all of the other specimens. This supports the previous suggestion by Bartholomai (1977) on the basis of such evidence as the presence in the sample of both *Palorchestes parvus* and *P. azael*, that the Gore sample may represent a mixture of different aged faunas.

The Russenden canine (F9455) has not been allocated to either the *harrisii* or *laniarius* group of specimens, because it has not yet been demonstrated that lower canines of *Sarcophilus* fall into two groups comparably distinct as those for the lower M_2. Tentatively it has been referred to *S. laniarius*.

The living species *Sarcophilus harrisii* once occurred throughout much of Australia (Archer 1978a) and has been recorded from the Australian mainland in deposits dated as recently as 430 ± 160 years BP (Archer and Baynes 1972). Specimens referred to *laniarius* have come from many Pleistocene deposits in Australia, but most of these are inadequately dated. Marshall (1973) records *S. laniarius* from the late Pleistocene Frenchman's Creek and late Pleistocene-Holocene Lake Victoria faunas, New South Wales. P. Crabb (pers. comm.) is presently studying material from the early Pleistocene Lake Victoria region that appears to be referable to *Sarcophilus*, but possibly a species ancestral to the *laniarius-harrisii* group. This would suggest that *laniarius* may only range from early to late Pleistocene in age.

FAMILY THYLACINIDAE

Thylacinus cynocephalus (Harris)
(Plate 7G)

A single isolated left M_3 from The Joint represents this modern species. The measurements of the tooth are as follows: length, 12·8; trigonid width, 6·2; talonid width, 6·8. They are consistant with interpretation of the tooth as *Thylacinus cynocephalus* (e.g. see Ride 1964). All features of the tooth compare well with modern specimens, such as J13681, except for the tooth's slightly better-developed posterobuccal cingulum.

Elsewhere (Archer 1974, and more recently Milham and Thompson 1976), a case has been made for the extinction of the Thylacine on the Australian mainland following the appearance of the Dingo. The absence of Dingo remains from both The Joint breccia and all of the Russenden Bone Chamber samples suggests that both deposits probably predate the appearance of the Dingo, possibly about 4000 years BP. The oldest reliably dated Dingo remains (Milham and Thompson 1976) are from a Nullarbor cave deposit dated at 3,450 ± 95 years BP.

The distribution of the Thylacine included all states of Australia, and Papua New Guinea, and its presence in The Joint breccia is by no means unexpected.

Family Peramelidae

Differentiation of peramelid species using fragmentary dental remains only is frought with uncertainty, and conclusions reached now about recognition of distinctive dental features very likely will be found inadequate once a comprehensive continental wide analysis is made of all species. The Texas peramelid specimens have been compared with all known genera, but not all species of *Isoodon* or *Perameles*. Two genera have been recognized, *Perameles* and *Isoodon*, on the basis of: 1) angle of recline of the ascending ramus (much lower in *Perameles*); 2) height of the anterior cingulum of the lower molars and distance between its anterolingual end and the paraconid tip (generally cingulum lower and more distant in *Perameles*); 3) development of the hypocone (smaller in *Perameles*); 4) length of the postmetacrista (longer in *Perameles*, particularly on M^4); 5) shape of the protocone root alveolus (simple, smaller, and oval in *Perameles*, dumb-bell or bilobed outline in *Isoodon*); and 6) length of the maxillary vacuities (longer in *Perameles*). Some of these features (1, 3) are noted by Merrilees (1967) and others (1, 2, 3, 5) by Smith (1972). Methods of taking measurements are shown in Fig. 3.

Perameles nasuta Geoffroy
(Plate 7H)

At least twenty-four specimens appear to represent *Perameles nasuta*. They have been referred to this species because they cannot obviously be distinguished from this species and they lack the characters of *P. bougainville*, *P. gunnii*, and *P. eremiana* reviewed by Smith (1972). *P. nasuta* is also biogeographically the closest species of living *Perameles* to the Texas Caves area. Specimens are known from Cunningham's Gap.

The Joint specimens representing *P. nasuta* include only four isolated teeth as follows: F8493, M^4L, 4·0; M^4W, 3·5; F7914, M_2L, 3·9; M_2PW, 2·5; F8530, broken left lower molar; and F7985, trigonid of an M_2.

The Bone Chamber specimens are more numerous, but few included measurable cheek-teeth. The following measurements are based on various different teeth (details are on data sheets lodged in the Queensland Museum library): M_{2-4}, 12·0; M_2L, 3·3; M_2PW, 2·2; M_5L, 4·7; P^3L, 3·6; P^3W, 2·3; M^2L, 4·5 and 4·4; M^2W. 3·5; M^3L, 4·5 and 4·3; M^3W, 4·1.

Perameles nasuta today commonly occupies rainforest and wet sclerophyll forest in south-eastern Queensland, but also extends into drier habitats. For this reason, it is evidently not a good palaeoenvironmental indicator.

Isoodon obesulus (Shaw)
(Plate 7I)

The Joint and Bone Chamber deposits contain a poorly-represented small species of *Isoodon*, which in terms of size, is distinguishable from the larger *I. macrourus*. Confusion could possibly occur with *I. auratus* but in the Texas specimens in which the ascending ramus is preserved, the angle of ascension is consistant with specimens of *I. obesulus* and not *I. auratus* (G. Gordon, pers. comm.).

Measurements (all Bone Chamber specimens) are as follows: F8284, M_2L, 3·5; M_3L, 3·8; M_4L, 4·0; M_5L, 4·1; F8280, M_3L, 3·9; F8081–2 (one specimen), M_2L, 3·2; M_3L, 3·6; M_4L, 3·5, C_1–M_4, 21·6; M_{2-4}, 10·0; F8086 M^2L, 3·3; M^2W, 2·7; M^3L, 3·5; M^3W, 3·0; M^4L, 3·3; M^4W, 3·2; M^{2-4}, 9·3.

Living *Isoodon obesulus* has not been recorded from coastal southeastern Queensland, where the common peramelid is *I. macrourus*. *I. obesulus* has also been identified (Archer, Van Dyke and Beaton, in preparation) from archaeological shelter sites in the Carnarvon Ranges of southeastern central Queensland. Bartholomai (1977) reports *Isoodon* sp. from the Pleistocene Cement Mills fauna of southeastern Queensland, regarding it to be smaller than any Queensland Museum specimens, and, on the basis of its small size, possibly distinct from known species. Modern comparative specimens from southeastern Queensland, previously identified as *I. obesulus* in the mammal collections of the Queensland Museum, all evidently represent the larger species *I. macrourus* (G. Lyne and G. Gordon, pers. comms.). The Cement Mills specimens are clearly smaller than these, but not significantly different in size from Texas fossil specimens or modern Western Australian specimens of *I. obesulus*. The Cement Mills and Texas faunas are evidently the only ones in Queensland in which occur both *I. obesulus* and *P. nasuta*.

Isoodon obesulus in other states of Australia appears to favour woodland and sclerophyll forest habitats, both of which still occur on Viator Hill.

VOMBATIDAE

Vombatus sp., cf. **V. ursinus** (Shaw)

Wombat remains from The Joint and Russenden (rear) Cave deposits represent a species of *Vombatus* (E. Wilkinson, pers. comm.), based on the combination of grooved upper premolars and V-shaped inter-lobe valleys of the molars. Most specimens however consist only of fragments of isolated molars, and are at present unidentifiable. The more complete specimens (e.g. F8531) are under study by E. Wilkinson. He suggests (pers. comm.) that they probably represent *hirsutus (hirsutus* being at least a race of *ursinus;* it was included within that species by Ride 1970).

Vombatus ursinus occurs today as close to Texas as Stanthorpe, southeastern Queensland, in dry sclerophyll forest.

DIPROTODONTIDAE

?Zygomaturus sp., cf. **Z. trilobus** Owen (Plate 7P)

F8240, a fragment of a very large molar, is indistinguishable from the lingual half of the hypoloph of M^3 of *Zygomaturus trilobus.* The enamel is smooth, without the common punctate appearance of *Diprotodon,* and the part of the loph preserved is uncurved, the curved condition being normal for *Nototherium.* Because of the very fragmentary nature of this specimen, this identification can only be regarded as tentative.

Zygomaturus trilobus occurs in Pleistocene deposits across the continent. Recently collected specimens even demonstrate it was present in northern Australia. There seems little reason to doubt that it was a large terrestrial browsing marsupial and thus probably could not have survived in rainforest.

Its size would also make movement in dense forest of any kind difficult. The probable habitat would be open woodland with an understorey of shrubs.

BURRAMYIDAE

Cercartetus nanus (Desmarest) (Plate 7J)

Three dentaries, from the 0–20 cm sample of the Bone Chamber, represent this pigmy possum. Two of the specimens, F8207 and F8209 are virtually identical to J13580 from the forests of the Lamington Plateau, southeastern Queensland, and in dental characters, conform only to *C. nanus* (e.g. see Turnbull and Schram 1973). The third, F9462, has a somewhat larger dentary, but lacking teeth, the possibility that it might be different cannot be checked. Tentatively all three specimens are assumed to represent *Cercartetus nanus.*

Measurements are as follows: F8207, $P_1 - M_4$ (alveolar distance), 6·3; M_{2-4} (alveolar distance), 4·3; M_2L, 1·6; M_2W, 1·1; M_3L, 1·4; M_3W, 1·1; F8209, M_{2-4} (alveolar distance), 4·3; M_2L, 1·5; M_2W, 1·0; F9462, P_1–M_4 (alveolar distance), 6·2; and M_{2-4} (alveolar distance), 3·4.

Cercartetus nanus is very rare in Queensland's modern fauna, being only known from the Lamington Plateua of southeastern Queensland. It occurs in dry and wet sclerophyll forests of the southern states and it could probably still survive on Viator Hill.

Acrobates pygmaeus (Shaw) (Plate 7K)

One specimen, F8206, represents this distinctive Feather-tailed Glider, from the Bone Chamber.

Measurements are as follows: condyle of dentary to posterior edge of I_1 alveolus 12·3; posterior edge of I_1 alveolus to posterior edge of M_4 alveolus, 5·7; P_3L, 0·9; P_3W, 0·6; alveolar distance (inclusive) M_{2-4}, 3·2.

Acrobates pygmaeus is common in sclerophyll forests of southeastern Queensland, being known from a specimen as close as Wallangarra, and it is not surprising to find it in the Texas fauna. What is unusual, however, is its relative rarity compared with *Cercartetus nanus.*

PETAURIDAE

Pseudocheirus peregrinus (Boddaert) (Plate 7L)

All of the specimens representing this Common Ringtail Possum are isolated teeth or tooth fragments, and were recovered from the LPW and 0–20 cm samples from the Bone Chamber. They have been distinguished from teeth of the otherwise very similar *Schoinobates volans* by the lack of an entostylid on the lower molars, and a lack of lingual buttresses on the flanks of the paracone and metacone of the upper molars. In addition, in all the fine details of the complex structure of M_2, the Texas specimens match *Pseudocheirus peregrinus* and not *S. volans.*

Measurements (see Fig. 3) are as follows: F8208, M_3L, 3·9; M_3AW, 2·1; M_3PW, 2·2; F8413, M_4L, 3·8; M_4AW, 2·3; M_4PW, 2·1; F9463, M_4AW, 1·9; F8201; M^3 or ^{4}L, 3·8; M^3 or ^{4}AW, 3·4; M^3 or ^{4}PW, 3·3.

Pseudocheirus peregrinus in southeastern Queensland lives in a wide variety of habitats from open woodland to rainforest, and hence is a poor indicator of palaeoenvironments. It is known from living individuals as close as Wallangarra.

Petaurus Shaw

There are three species of *Petaurus* living in southeastern Queensland: *P. breviceps, P. norfolcensis* and *P. australis*. The first and last are uncommon compared with *P. norfolcensis. P. australis* is easily distinguished on the basis of size from the other two species. Separation of the two smaller species is complicated by two factors. First, as Fleay (1947) notes, the two hydridize in captivity and there must remain at least some small doubt about the reality of two species. Second, identification of new or fossil material based on existing Museum samples is complicated by a long history of confusion about the identification of these two species. Tentatively, I have assumed that *P. norfolcensis* may be differentiated from *P. breviceps* by its larger size, proportionately longer rostrum, and wider, fluffier tail base. Only the first character is useful for identifying the Texas fossils. I could find no morphological feature of the cheekteeth that consistently differentiates these two species.

Because of their overall marked similarity, I find it difficult to envisage how they could coexist in the same area. However, the Bone Chamber specimens are neatly divisible into two groups: one resembles *Petaurus breviceps* and the other *P. norfolcensis*.

Petaurus breviceps Waterhouse (Plate 7M)

Two specimens from the 0–20 cm sample of the Bone Chamber appear to represent this very small species of *Petaurus*. F8413 is not clearly identical to modern *P. breviceps*. Although it closely resembles J11596, an undoubted *P. breviceps* from Eukey, nr. Stanthorpe, it differs in that its molars are slightly wider, the M_2 is slightly longer, and the dentary is deeper. F8205, however, is smaller than J11596.

Measurements are as follows: F8413, posterior edge of alveolus of I_1 to posterior side of posterior root M_5, 10·6; M_{2-5}, 7·7; M_{2-4}, 5·6; M_2L, 2·4; M_2PW, 1·6; M_3L, 2·0; M_3PW, 1·6; M_4L, 1·8; M_4PW, 1·3; depth of dentary body below trigonid M_4, 5·0; F8205, P^2L, 1·0; P^2W, 0·5; P^3L, 1·9; P^3W, 1·2; alveolar length (inclusive) M_{2-4}, 5·0.

Petaurus breviceps living in Queensland inhabits sclerophyll forest, and woodlands of the more interior regions. Compared with the apparent habitat preference of *P. norfolcensis* for the wetter coastal forests, the occurrence of *P. breviceps* rather than *P. norfolcensis* on Viator Hill would not have been surprising. Living individuals of *P. breviceps* have been collected from as close as Stanthorpe.

Petaurus norfolcensis (Kerr) (Plate 7N)

Four specimens represent this larger glider in the samples removed from the Bone Chamber. F8202–3 very closely resemble J12287, an undoubted *Petaurus norfolcensis* from Kallangur, southeastern Queensland. F8204 is an isolated premaxillary which is similarly indistinguishable from *P. norfolcensis*.

Measurements are as follows: F8202, P_3–M_5, 9·6; M_{2-5}, 8·8; M_{2-4}, 6·8; M_2L, 2·7; M_2PW, 2·0; M_3L, 2·5; M_4L, 2·0; M_4PW, 1·6; M_5L, 1·7; M_5PW, 1·3; F8203, ant. tip I_1 crown to rear of M_5 alveolus, 20·3; alveolar length (inclusive) P_1–M_5, 12·9, alv. length (inclusive) M_{2-5}, 8·9; alv. length (inclusive) M_{2-4}, 6·5; M_3L, 2·3; M_3PW, 1·8; M_4L, 2·1; M_4PW, 1·6; F8204, alv. length (inclusive) I^{1-3}, 4·7; height of unworn I^1 crown, 2·3; F8537, posterior edge I_1 alveolus to posterior edge of M_5 alveolus, 12·5; alveolar length (inclusive) M_{2-4}, 6·9; dentary depth below trigonid M_4, 5·3.

Petaurus norfolcensis normally occupies the wetter coastal sclerophyll forests of Queensland. Its interpreted presence in the Texas Caves suggests either a broader habitat tolerance for this species than could be determined by modern distributions, or else a climatic deterioration in the Texas area since the late Pleistocene.

PHALANGERIDAE

Trichosurus, cf. **T. vulpecula** (Kerr) (Plate 7O)

An isolated lower incisor, F8898, appears to represent this Brush-tailed Possum. Unfortunately, the tooth is very worn and identification can only be regarded as tentative. There is no reliable way to eliminate the remote possibility that the tooth could represent *Trichosurus caninus* or even *T. arnhemensis,* and it is largely because of the southwestern Queensland location of Texas (*T. arnhemensis* is only known from northern Australia), and the observation that no other species in the Russenden (rear) fauna is known to require a rainforest habitat (*T. caninus* does, at least in Queensland), that the tooth is assumed to represent *T. vulpecula.*

The very wide habitat tolerance (except rainforest) of *Trichosurus vulpecula* makes it useless as a tool for interpreting the palaeoenvironment. It is curious that this normally very abundant possum is very rare in the Russenden (rear) faunas. It is absent in the Cement Mills fauna (Bartholomai 1977). The rarity to absence of this possum in these late Pleistocene faunas may have a common cause. Live animals have been observed around Viator Hill (Archer 1978c).

?POTOROIDAE

Genus indet.
(Plate 7R)

F8362 (Fig. 5 for measurements) from the Bone Chamber, is not clearly referable to any known marsupial taxon. It appears to represent a left M^1 from which the protocone has been lost. The posterior half of the tooth has a well-developed transverse loph, but there was evidently no anterior loph. The interpreted buccally situated paracone has short longitudinal crests extending anteriorly and posteriorly from its apex, but there is no remnant of a transverse crest extending lingually towards the now missing protocone. There is a posterior cingular basin. The tooth is unlike the otherwise similar M_2 of petaurids in having the high and complete posterior transverse loph. For this reason it is concluded here to represent a potoroid tooth, but of uncertain generic affinities. It is possible that it could be an abnormal M^1 of *Aepyprymnus.*

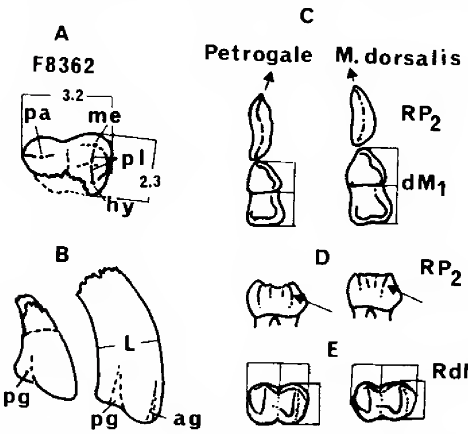


FIG. 5: A, F8362, gen. indet., but possibly a potoroid LM^1. Anterolingual (lower left) dashed line indicates position of missing protocone. Abbreviations: *hy,* hypocone; *me,* metacone; *pa,* paracone; *pl,* posterior transverse loph. B, RI^1(F8495) and RI^2(F9464) of *Protemnodon brehus.* The position of maximum buccal transverse length is indicated by L. Abbreviations as follows: *ag,* anterior groove; *pg,* posterior groove. C–D, characters in addition to size used to separate anterior juvenile cheekteeth of *Petrogale* sp. and *Macropus dorsalis.* C, indicating that in P_2, the anterior end of the occlusal crest is generally directed relatively more lingually in *M. dorsalis;* the trigonid of M_1 in *M. dorsalis* is relatively longer. D, the anterolingual "vertical" crest (indicated by arrow) of P_2 in *M. dorsalis* normally is relatively less vertical than it is in *Petrogale* sp. Figures are not to the same scale.

POTOROIDAE

Aepyprymnus rufescens (Gray)
(Plate 7Q)

One tooth, F8479, represents this taxon in the Joint fauna, but eleven specimens were recovered from the Bone Chamber. It was identified on the basis of details of molar morphology, and the posteriorly increasing molar gradient from M_2 to M_4, a feature confined to *Aepyprymnus* among potoroid genera.

Measurements on Bone Chamber specimens are as follows: F8331, P^3L, 9·2; P^3PW, 3·4; F8332, M_5L, 6·6; AW 4·8; F8407, M_{2-4}, 18·1; M_2L, 5·2; M_3L, 6·3; M_4L, 7·0; F8243, M^5L, 6·8; F8241, M^5L, 7·3; F8242, P_2L, 6·5; M_1L, 4·9; M_1PW, 3·6. These measurements are comparable to those of modern specimens and specimens from the Cement Mills fauna of southeastern Queensland (Bartholomai 1977).

Aepyprymnus rufescens normally inhabits savannah woodlands and sclerophyll forests, habitats still present on Viator Hill. The nearest living population known is at Stanthorpe.

MACROPODIDAE

STHENURINAE

Procoptodon texasensis n. sp.
(Plate 8A, C, E Fig. 6)

HOLOTYPE: Queensland Museum F7894, RM^1 (damaged) and excavated entire RP^3; collected H. Godthelp, P. Rainbird, and M. Archer, 25 February 1975, as part of a breccia lump. From breccia (at the breccia keyhole) in The Joint (VR-5), Texas Caves (Long. 151°27′E, Lat. 28°56′S), Viator Hill, along Pike Creek, southeastern Queensland.

DIAGNOSIS: Differs from *Procoptodon pusio* in having a P^3 that is markedly larger; has a well-developed posterobuccal crest that is almost half the length of the crown; a completely cuspose buccal longitudinal crest; a lingually convex occlusal edge on the lingual longitudinal crest; a more complexly crenulated longitudinal basin; and a lingual crest that continues to the anterior edge of the tooth.

Differs from *P. goliah* in having a P^3 with a much better-developed posterobuccal crest; a completely cuspose buccal longitudinal crest; a lingually convex occlusal edge on the lingual longitudinal crest; a wider longitudinal basin between the lingual and buccal crests; less well-developed transverse crenulations in the longitudinal basin between the well-developed main anterior and posterior transverse crests; a much more brachyodont crown; and a more oval than subquadrate occlusal crown outline.

Differs from *P. rapha* to which it is otherwise most similar, in having a shorter-crowned P^3 (antero-posterior length) which has a smoothly convex lingual crest; a buccal crest composed of four discrete cusps ununited into a crest for almost half of their height above the base of the longitudinal basin; much less well-developed crenulations in the longitudinal basin between the similarly less well-developed but distinct anterior and posterior transverse crests; much more brachyodont crown; less well-developed crenulations connecting the large posterobuccal crest to the main longitudinal buccal crest; and a more oval, less triangular outline.

DESCRIPTION: The M^1 is thoroughly broken, but was *in situ* in a small fragment of bone, immediately below the unerupted P^3. Its roots had

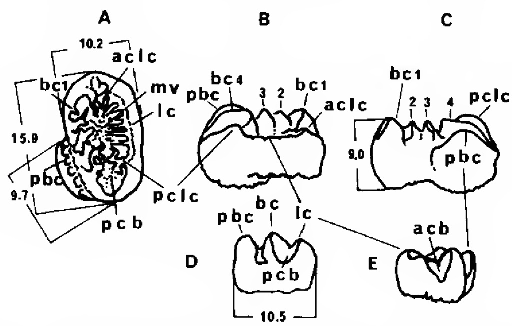


FIG. 6: Terminology, and measurements (mm) of the Rp^3 of F7894, the holotype of *Procoptodon texasensis* n. sp. A, occlusal view; B, lingual view; C, buccal view; D, posterior view, and E, anterior view. Abbreviations as follows: *aclc*, anterior cusp of the lingual crest; *acb*, anterior cingular basin; *bc*, buccal crest; *bc1–4*, cusps 1 to 4 on buccal crest; *lc*, lingual crest; *mv*, median longitudinal valley; *pbc*, posterobuccal crest; *pcb*, posterior cingular basin; and *pclc*, posterior cusp of the lingual crests.

begun to resorb, and the top of the crypt for P^3 was well down, at the level of the M^1 crown-root junction, suggesting the P^3 was close to erupting at the time of death. Although no roots were preserved on P^3, the base of the crown was flush with the surface of the breccia fragment, and any roots would have been removed by erosion or abrasion. I excavated the P^3 from the bone fragment, leaving part of the root of the crypt intact above the base of the M^1 crown.

The M^1 fragment includes the base and posterior face of the metaloph, and the outline of the remainder of the crown, which is broken off below the enamel. The metaloph has a smooth posterior surface and no remnant of a posterior cingulum or pocket. The occlusal edge of the metaloph fragment is abruptly recurved posteriorly and strongly suggests that it is close to the actual occlusal margin of the crown. If this is the case, the tooth was very low-crowned compared with *Procoptodon rapha* (see Plate B). The basal crown outline suggests the buccal length of the tooth was longer than the lingual length. The lingual vertical face of the hypocone reclines buccally.

The P^3 crown outline is essentially oval, but wider posteriorly than anteriorly because of the large posterobuccal crest. The crown height is low compared with *Procoptodon rapha*. There are three longitudinal crests; a long lingual and buccal crest and a shorter posterobuccal crest. The lingual crest also forms the curving, convex lingual edge of the occlusal edge of the crown and extends from the extreme anterior to posterior edges of the tooth. Its occlusal edge is complete. Along its length, two poorly-defined cusps can be recognized: a minor anterolingual cusp defined only by the positions of a small transverse ridge that extends buccally towards the buccal crest; and a somewhat larger posterolingual cusp similarly defined by the position of a posterior transverse ridge that extends buccally to the base of the buccal crest. The buccal crest actually consists of four blade-like cusps arranged in a row and joined near the base of the crown's occlusal surface. This crest terminates anteriorly with a large anterobuccal cusp that has a small vertical crest extending to the anterior edge of the crown, and posteriorly with a long blade-like cusp whose occlusal edge ascends posterodorsally to the posterior edge of the crown. At both the anterior and posterior ends of the crown, the lingual and buccal crests converge medially and unite near the base of the crown. The four cusps forming the buccal crest are complexly oriented. The large anterobuccal cusp has a semi-circular occlusal edge whose anterior end swings lingually to contact a smaller ridge extending buccally from the main lingual longitudinal crest. The two enclose the anterior end of the median longitudinal basin of the crown. The posterior end of the occlusal edge of the anterobuccal cusp of the buccal crest bifurcates and the main limb ascends the anterobuccal wall of the tooth forming a prominant near-vertical buccal ridge. The lesser limb swings posteriorly and contacts the base of the second cusp of the buccal crest. This has a smaller and linear occlusal edge oriented anterolingually. Its anterior end abuts against the flank of the anterior cusp, and its posterior end merges into the base of the buccal crest. The third cusp is oriented transversely, the lingual edge ascending towards the longitudinal median basin, and the buccal edge ascending to contact the valley between the buccal and posterobuccal crests. The fourth and largest cusp is oriented longitudinally, its posterior edge being the posterior edge of the buccal crest, and its anterior edge turning sharply lingually just before contacting the third cusp. At this point it bifurcates and the two resulting ridgelets ascend towards the base of the longitudinal median basin. The posterior of these two ridgelets then swings posterolingually and contacts a prominant buccal ridge from the posterior cusp on the lingual longitudinal crest. They thus form the posterior end of the median longitudinal basin of the crown. The two transverse links between the lingual and buccal longitudinal crests, besides enclosing the median longitudinal basin, define a steep wedge-shaped anterior basin whose apex is the anterior edge of the tooth, and a broader posterior basin or pocket. The posterobuccal crest, like the lingual crest, has an entire occlusal edge. Its anterior end originates about midway along the buccal margin of the crown, and about half way down its side. From this point it descends to a height just below that of the posterior cusp of the buccal crest, and then ascends again posterolingually, to contact the buccal crest half way up the buccal face of the posterior cusp of the buccal crest. There are no enlarged transverse ridges linking the occlusal edge of the posterobuccal crest to the flank of the buccal crest. All three major crests have numerous associated low-relief flanking ridgelets, although the cusps of the buccal crest have less than the median flanks of the other two. All three major longitudinal crests are about subequal in height, and compared to *P. rapha*, very low.

DISCUSSION: It is first necessary to consider why F7894 has in fact been referred here to *Procoptodon* rather than *Sthenurus*. Stirton and Marcus (1966) and Tedford (1966) regard that the P^3 of species of *Procoptodon* is more bulbous at its base, with a broader more massive crown. The only possible overlap with other genera noted by Stirton and Marcus (1966) is *Sthenurus occidentalis*. Bartholomai (1970), in reviewing Queensland *Procoptodon* specimens then known, concludes that the concept of the genus as defined by Stirton and Marcus (1966) is applicable to Queensland specimens. I have compared F7894 with all species of *Sthenurus* and *Procoptodon* for which upper premolars are known, including some species of *Sthenurus* such as *S. orientalis* for which upper premolars were previously unknown. Comparison has also been made with the excellent review by Marcus (1966) of the extensive Bingara *Procoptodon* samples, as well as with the Bingara specimens in the collections of the Australian Museum. F7894 has the bulbous P^3 crown that is interpreted to be characteristic of *Procoptodon*. But as Stirton and Marcus (1966) point out, this feature is also present in some specimens of *Sthenurus occidentalis* (e.g., Western Australian Museum no. 63.2.143). The P^3 of *S. occidentalis* differs from this tooth in species of *Procoptodon* and specifically F7894, as follows: it has an anteriorly more narrowed crown; a lack of well-formed transverse anterior and posterior links between the lingual and buccal crests; a less well-developed posterobuccal crest than *P. rapha* (and F7894); and a more complete, less dentate occlusal edge on the buccal crest. Tedford (1966) figures a P^3 of *Sthenurus atlas* which has a large posterobuccal crest otherwise characteristic of *P. rapha* (and F7894). However, it also differs from that tooth in species of *Procoptodon* in the same ways as does *S. occidentalis* except for the larger size of its posterobuccal cusp.

Compared with the P^3 of species of *Procoptodon*, F7894 is unlike *P. rapha* in enough features to preclude need for additional comment. It resembles the P^3 of *P. goliah* in absolute crown length, but clearly differs from this species in the development of the posterobuccal crest, as well as by other features noted in the diagnosis. Samples of *P. rapha* P^3s described by Marcus (1976) are outside the size range of F7894 and similarly differ in other features noted in the diagnosis. The massive development of the posterobuccal crest in F7894 is approached in *P. rapha* and for this reason, it has been concluded here that *P. texasensis* is most closely related to *P. rapha*.

Bartholomai (1977) notes a dentary of *Procoptodon*, F4548, from the Pleistocene Cement Mills fauna of southeastern Queensland, that he regards to be similar to *P. rapha*. It differs from specimens of *P. rapha* in having less ornamentation on the only two intact teeth, M_4 and M_5. He concludes that it may represent extreme intraspecific variation, but without structurally intermediate specimens, it cannot be assigned to *P. rapha* with certainty. The similarities of this *Procoptodon* specimen to *P. rapha*, the general similarities of the Cement Mills fauna (see below and Table 10) to the Texas Caves faunas, and the close geographic position of the two areas, suggest the possibility that the Cement Mills *Procoptodon* specimen may be conspecific with *P. texasensis*. The less well-developed crenulations of the Cement Mills specimen are features one would expect for molars of *P. texasensis*. As noted above, the crenulation of P^3 of *P. texasensis* is certainly less well-developed than P^3s of *P. rapha*.

ORIGIN OF SPECIFIC NAME: The specific name is given in dual reference to the Texas Caves, of which The Joint (the type locality) is one, and the Texas Beds to which the limestone belongs. The Texas Beds is evidently the same formation in which the cave deposits at Gore were formed (Siemon 1973), and from which were obtained specimens including F4548, the only other specimen possibly referable to *Procoptodon texasensis*, which form the basis of the Cement Mills fauna (Bartholomai 1977).

Sthenurus Owen

All of the remains of *Sthenurus* from the Texas caves are fragmentary and too incomplete to allow confident identification. Nevertheless, there are a few specimens which can be tentatively referred to known species. Material representing all known species of *Sthenurus* was examined during this study, although several species are poorly-known.

Sthenurus sp., cf. **S. atlas** (Owen)
(Plate 7U)

Two specimens from The Joint, F8380 and F7895, with simple unornamented enamel, are very similar to specimens of *Sthenurus atlas*. F7895, a left P_3, is worn in a manner suggesting it might even be part of F8380, a left dentary fragment with M_{2-4}. These specimens have the characters of *S. atlas* as outlined by Tedford (1966). F8380 is also similar to *S. andersoni* but smaller. The P_3, F7895, is longer than the molars, which is a character of *S. atlas* and not *S. andersoni*.

Measurements are as follows: F7895, P_3L, 16·1; P_3AW, 6·5; P_3PW, 8·1; F8380, M_{2-4}L, 38·4; M_2L, 10·2; M_2AW, 9·0; M_2PW, 9·7; M_3L, 12·9; M_3AW, 10·0; M_3PW, 10·4; M_4L, 14·7; M_4AW, 11·4; M_4PW, 11·7.

Sthenurus atlas has been recorded from three other Pleistocene sites in eastern Australia: Lake Menindee, Wellington Caves (Tedford 1966), and Lake Victoria (Marshall 1973). This Texas specimen represents its first possible occurence in Queensland.

Sthenurus sp., cf. **S. oreas** De Vis
(Plate 7T)

At least two isolated lower molars from The Joint and one from the Bone Chamber, are very similar to this species. There are no diagnostic characters that would enable positive reference of isolated lower molars to this species, but they are similarly ornamented and comparable in size to the materials referred to this species by Bartholomai (1966). They also show similarities to the Pliocene *S. antiquus*.

F8239, an isolated upper molar, is also similar to *Sthenurus oreas*, but this similarity depends on the doubtful interpretation of the tooth as an M^1. If in fact it is an M^2, in size and morphology it would more closely resemble F2926, an unallocated specimen from the Chinchilla Sand (Bartholomai 1966), or *S. occidentalis* from which it differs only in that the premetacrista is fractionally better-developed in the Texas specimen.

Measurements are as follows: F7900 (Joint), $M_{3?}$AW, 11·4; $M_{3?}$PW, 11·5; F8307 (Bone Chamber), ML, 12·2; F8239, ?M^1L, 11·7; ?M^1AW, 10·8; ?M^1PW, 10·8;

Sthenurus oreas has been recorded from the Cement Mills, Wellington Caves, Bingara, and eastern Darling Downs Pleistocene faunas (Bartholomai 1966, Tedford 1966, and Marcus 1976).

Sthenurus sp., aff. **S. occidentalis** Glauert
(Plate 7S)

F8529 from The Joint, is a right maxillary fragment with M^1, and damaged P^2 in place. Regretably few species of *Sthenurus* are known from P^2, thus making comparison difficult. P^2 of this specimen has a pronounced posterobuccal cingular pocket, a structure so far known to occur only in *S. occidentalis*. The M^1 of F8529 is also similar in morphology to that tooth in *S. occidentalis*, with comparably developed longitudinal cusp crests. However both teeth are smaller than the corresponding teeth in *S. occidentalis* (e.g. see Merrilees 1968). In size they are closer to *S. brownei* but P^2 in this species appears to lack the posterobuccal pocket.

Measurements are as follows: F8529, P^2–M^1, 20·3; P^2L, 8·9; M^1L, 11·0; M^1AW, 9·9.

Sthenurus occidentalis has been recorded from Mammoth Cave in Western Australia, Brothers Island in South Australia, King Island and Scotchtown Cave, Tasmania.

Macropodinae

Protemnodon roechus Owen
(Plate 8A, B)

A partial skull (F6132) from the side of the entrance rubble cone of Russenden (rear) Cave is the only Texas caves specimen that undoubtedly represents this very large extinct kangaroo. It has the depressed anterolingual cingular pockets and markedly curved longitundinal crest of P^3 which are characteristic of *Protemnodon roechus* (Bartholomai 1973). This particular individual has a bone swelling along the buccal alveolar rim of the maxillary between P^3 and M^3, suggesting disease.

Measurements as follows: P^3–M^5, 80·9; M^{2-5}, 63·4; M^{2-4}, 45·8; P^3L, 19·6; P^3AW, 10·3; P^3PW, 10·6; M^2L, 12·5; M^2AW, 12·6; M^2PW, 12·7; M^3L, 16·1; M^3AW, 13·9; M^3PW, 16·6; M^4L, 17·3; M^4AW, 14·8; M^4PW, 14·3; M^5L, 17·8; M^5AW, 14·1; M^5PW, 13·2.

Protemnodon roechus has been recorded from the eastern Darling Downs, Gore, Bingara, Wellington Caves (Bartholomai 1973, 1977).

Protemnodon brehus (Owen)
(Plate 8H, J)

Some specimens of *Protemnodon* from the Joint, and possibly one from the Bone Chamber of Russenden (rear) Cave, represent this species. The Joint specimens are all fragmentary but include an isolated P^3 (F8238) and M_2(F7916) which demonstrate features regarded by Bartholomai (1973) to be indicative of *P. brehus*, rather than the other large species, *P. roechus*.

Two isolated large upper incisors, evidently I^1 and I^2 clearly do not represent *P. anak* or *P. roechus*, based on specimens illustrated by Bartholomai (1973), and F(AM)38785 which preserves the upper incisors and the anterior end of a P^3 identifiable as *P. roechus*. For this reason they are interpreted here to represent *P. brehus*. The I^1 is almost unworn and hence probably not the same individual as the I^2. The I^2 (F9464) differs from that of *P. roechus* (present in F(AM)38785) and *P. anak* (e.g. F3672) in having a pronounced posterior groove on the buccal surface of the crown, and differs from *P. roechus* in having the crown proportionately shorter (anteroposteriorly) near the base. The only known I^1s of *P. roechus* (F5053, F(AM)38785) are both very worn thereby obliterating details of distal crown morphology. F8495 is however markedly shorter (anteroposteriorly)-crowned (see Fig. 5) having a maximum buccal transverse (anteroposteriorly) length of 11·4 as opposed to 16·3 (F5053) and 15·7 (F(AM)38785) for *P. roechus*. This I^1 length in *P. anak* (F651, F3672) is shorter, being 9·1 in F651, and 10·3 in F3672. The distal end of the crown has a broad buccal posterior vertical groove and a smaller anterior groove. There are no traces of these grooves in the *P. roechus* specimens. There were probably similar grooves in at least some *P. anak* (e.g. F3672).

F7916 is a large right lower molar (length, 17·0; AW, 11·1; PW, 11·4) interpreted here to represent *Protemnodon brehus* because it lacks an anterolingual notch in the anterior cingulum and has a posterior cingulum, features which are normally present in *P. roechus* (Bartholomai 1973).

F8154 (Plate H1), an isolated premolar fragment from the Bone Chamber, may represent this species. It resembles the P^3 of F4947 but differs in evidently having been broken from a considerably taller crown; in that the anterior crest from the anterior cusp is shorter than that structure in F4947; and in that the buccal face of the crown fragment is planar rather than curved. The tooth was unerupted.

Protemnodon brehus has been reported from many eastern Australian Pleistocene faunas including the Cement Mills, eastern Darling Downs, Wellington Caves, Bingara, Lake Victoria, Lake Menindee, and Lake Tandau faunas, and from several isolated localities such as Coreena and Planet Downs, in central and northwestern Queensland respectively, the Warburton River, South Australia, and Mammoth Cave, Western Australia (Bartholomai 1973, 1977, Marcus 1976, Tedford 1967, Merrilees 1973, and Marshall 1973).

Thylogale sp.
(Plate 7V, W)

Two upper third incisors from The Joint, F7923 and F7947, are notched all along their occlusal length, a feature present in the I^3 of *Thylogale stigmatica* and *T. thetis*. In the same sample are a fragmentary dentary, F8524, and an isolated upper first molar, F7095. The last two specimens represent a very small macropodid with a dental morphology similar to that of *Thylogale* species.

Small isolated macropodid teeth from the Bone Chamber may also represent a species of *Thylogale*, but none of the specimens from this deposit have confidently been referred to a species of this genus. They include F8172, F8173 and F8186, isolated upper molars which are similar in morphology to those of Queensland species of *Thylogale*.

Measurements are as follows: (Joint) F8524, P_3 – M_3, 18·3; M_2PW, 3·4; P_3L, 4·2; F7093, M^1PW, 4·7; (Bone Chamber, Russenden (rear) Cave), F8172, M^xL, 5·0; M^xAW, 3·6; M^xPW, 3·6; F8173, M^1L, 5·3; ?M^1AW, 4·0; ?M^1PW, 4·2.

The I^3 morphology suggests *Thylogale billardieri* is not represented, and it is therefore probable that The Joint specimens represent either *T. stigmatica* or *T. thetis*, which in terms of dental morphology alone, are very similar species. Thylogales living today in southeastern Queensland seem to prefer rainforests or adjacent wet sclerophyll forests. The presence in the Texas cave deposits of Thylogales is thus surprising. Nothing else in the deposits requires interpretation of such a well-watered palaeoenvironment. It can only be concluded that they were either occupying habitat uncharacteristic of the modern species in southeastern Queensland, or that there was in fact a residual pocket of wet sclerophyll forest or rainforest in the vicinity of Viator Hill. Live animals are known from as close as Killarney.

Petrogale sp.
(Plate 7Y)

Specimens referable to Rock-wallabies were common in The Joint but less common in the Russenden (rear) Cave deposits, as well as on the surface of other Texas Caves such as Bevans Pot. They have been identified on the basis of size, premolar and molar morphology. The only taxa with which they could have been confused are species of *Thylogale* (which are smaller, have shorter premolars, and markedly different upper molar morphology), and *Macropus (Prionotemnus) dorsalis* (which differs in being larger, and in details of the M^1 and P^2 morphology (Fig. 5).

TABLE 5: MEASUREMENTS OF *PETROGALE* SP., FROM BEVANS POT, THE JOINT, RUSSENDEN (REAR) CAVE (BONE CHAMBER SEDIMENTS), AND MODERN SOUTH-EASTERN QUEENSLAND

Parameter		P^2–M^3	P^3–M^4	M^2PW	P^2L	P^3L	P_2–M_3	P_3–M_4	M_2PW	P_2L	P_3L
The Joint	$\bar{x}$	25·1	—	6·15	5·77	7·20	19·50	—	3·80	4·86	6·47
	N.	1		2	7	2	2		3	7	3
	O.R.	25·1	—	6·1–6·2	5·5–6·0	7·0–7·4	18·3–20·7	—	3·4–4·4	4·3–5·5	6·2–6·7
	S	—	—	0·07	0·19	0·28	1·70	—	0·53	0·36	0·25
	C.V.	—	—	1·15	3·27	3·93	8·70	—	13·93	7·41	3·89
Russenden	$\bar{x}$	—	—	—	—	—	—	—	4·13	—	—
	N.								3		
	O.R.	—	—	—	—	—	—	—	4·0–4·3	—	—
	S	—	—	—	—	—	—	—	0·15	—	—
	C.V.	—	—	—	—	—	—	—	3·70	—	—
Bevans Pot	$\bar{x}$	22·93	25·43	5·34	5·65	6·93	21·53	23·21	4·25	5·02	6·07
	N.	8	4	14	8	4	3	7	11	5	6
	O.R.	21·5–24·3	24·1–26·7	5·1–5·5	5·4–6·0	6·9–7·0	20·7–22·2	21·8–24·7	4·0–4·6	5·0–5·1	5·9–6·3
	S	1·05	1·12	0·13	0·21	0·05	0·76	0·85	0·21	0·04	0·16
	C.V.	4·57	4·42	2·50	3·66	0·72	3·55	3·67	4·97	0·89	2·69
Modern SE.Q.	$\bar{x}$	—	25·16	5·21	—	7·10	—	22·54	4·16	—	6·14
	N.		9	10		9		8	8		8
	O.R.	—	23·8–26·9	4·9–5·5	—	7·0–7·3	—	19·4–24·5	3·9–4·4	—	5·9–6·5
	S	—	1·01	0·19	—	0·10	—	1·75	0·17	—	0·18
	C.V.	—	4·01	3·56	—	1·41	—	7·78	4·06	—	3·01

The taxonomy of Petrogales is currently undergoing revision (G.B. Sharman, pers. comm.) and no attempt has been made here to identify the species present in the Texas Caves. In general, they cannot be differentiated, on the basis of morphological dental features, from specimens in the Queensland Museum, from areas near Texas (e.g. Stanthorpe, Warwick) previously regarded as *Petrogale penicillata*.

Measurements are given in Table 5.

Among the specimens from The Joint were some illustrating dental anomolies or features not noticed among modern specimens. F8405, A left P^2, may be abnormal in completely lacking any posterior cingular pocket, and having instead an isolated cingular shelf. F8882, a left upper molar, has a small cusp on the posterior flank of the paracone, a feature also present in some specimens from Bevans Pot.

Modern species of *Petrogale* inhabit rocky areas in almost all habitats throughout Australia. Their presence on Viator Hill is therefore not surprising. The abundance of unmineralized and intact skulls on the surfaces of many of the Texas Caves suggests these animals were living on Viator Hill within historic times. However, no sightings were made by us during several trips to the Texas Caves area.

?**Petrogale** sp.
(Plate 7X)

F8417, a right dentary from the Bone Chamber with M_{2-4}, M_5 in the crypt, and alveoli for $I_1 - P_3$, is not clearly referable to *Petrogale*. The alveoli for P_3 indicate that it was a very large tooth, larger than that tooth in any *Petrogale* examined during this study. The molars are also relatively longer. The large size of these teeth however is still smaller than those of specimens referred below to *Macropus (Prionotemnus)*, aff. *M. (P.) agilis siva*.

Measurements are as follows: $P_3 - M_4$, 25·8; P_3 (alveolar length), 6·3; M_1PW, 4·5.

Macropus (Prionotemnus) dorsalis (Gray)
(Plate 7Z)

Numerous specimens from The Joint and one from the Bone Chamber of Russenden (rear) Cave appear to represent this medium-sized Black-striped Wallaby. It has been differentiated from *Petrogale* spp. and *Macropus* cf. *M. (Prionotemnus) agilis siva* by the following features: absolute size larger than *Petrogale* but smaller than *Macropus* cf. *M. (Prionotemnus) agilis siva;* long blade-like premolars similar to those of *Petrogale* but differing as shown in Fig. 5; trigonid of M_1 relatively longer anteroposteriorly, with a wider anterior cingulum than specimens of *Petrogale;* M^1 slightly longer than that tooth in *Petrogale;* and a relatively narrower anterior cingulum and a lower forelink on molars posterior to M^1.

Measurements are given in Table 6, and clearly indicate the close similarity between The Joint and modern specimens.

Macropus (Prionotemnus) dorsalis has also been reported from the Pleistocene Cement Mills fauna by Bartholomai (1977). The nearest record of live *M. dorsalis* to Texas is probably Mt. Lindsay, southeastern Queensland. Individuals have been found in savannah woodlands, as well as rainforest and brigalow. The presence of this species in the Texas caves is therefore not unexpected.

TABLE 6: MEASUREMENTS OF FOSSIL *Macropus dorsalis* FROM THE JOINT, AND MODERN SOUTHEASTERN QUEENSLAND SPECIMENS.

Parameter		P^2–M^3	M^2W	P^2L	P_2–M_3	M_2PW	P_2L
The Joint	$\bar{x}$	—	6·15	5·68	—	—	4·83
	N.	0	2	5			4
	O.R.	—	6·1–6·2	5·5–5·8	—	—	4·7–5·0
	S	—	0·07	0·13	—	—	0·13
	C.V.	—	1·15	2·30	—	—	2·61
Modern SE.Q.	$\bar{x}$	25·60	5·73	5·70	22·97	4·52	5·12
	N.	6	6	6	6	6	6
	O.R.	24·9–26·7	5·1–6·4	5·4–6·0	21·5–24·3	4·2–4·8	4·9–5·6
	S	0·66	0·52	0·24	1·07	0·22	0·26
	C.V.	2·59	9·01	4·15	4·64	4·93	5·16

Macropus (Prionotemnus) sp., aff. **M. (P.) agilis siva** (De Vis)
(Plate 7CC, DD)

There are numerous isolated teeth from the Bone Chamber of Russenden (rear) Cave, and one maxillary fragment (F9444) from the Joint breccia, which are clearly referrable to the subgenus *Prionotemnus* in the sense of Bartholomai (1975). They have high-crowned macropodine type molars, well-developed parastylar crests on the upper molars, no forelinks, and long trenchant premolars. F9444, is a right maxillary fragment with P^2, M^1 and M^2. P^3 has been excavated from the crypt below P^2 and M^1. It most closely resembles specimens of *Macropus (Prionotemnus) agilis siva,* but differs in that in the M^2 of F9444, the preparacrista and forelink are better-developed, and the M^1 and M^2 are anteriorly narrowed. Compared with modern specimens of *M. (P.) a. jardinei,* F9444 is larger overall; has a better-developed preparacrista on M^2; M^1 and M^2 are narrowed anteriorly, although one of the modern specimens examined, J14605, has slightly narrowed anterior ends; P^3 of F9444 has a less well-developed anterolingual cingulum such that the crown is roughly triangular in outline as in species of *Troposodon,* although again one modern specimen observed, J14565, resembles F9444 in this feature; the base of the M^2 and M^1 hypocones in F9444 are swollen and extend anterolingually such that the lingual medial intersection with the base of the protocone forms a straight-sided V-shape, rather than the U-shape of modern specimens; and the forelinks in F9444, although poorly-developed, are still generally better-developed than those structures in modern specimens.

Some specimens from the Bone Chamber in Russenden (rear) Cave are probably also referable to *Macropus (Prionotemnus)* sp., cf. *M. (P.) agilis siva.* For example, F3231, an LM^1, and F8181, an LP_2, are almost certainly referable to this taxon. Other isolated teeth from the Bone Chamber, although referable to the subgenus *Prionotemnus* are less clearly referable to the same taxon as F9444. These include F8293, an RM^1 that has a very large parastylar crest and even a post-paracone crest that is so well-developed it resembles a stylar cusp. A slight depression separates this post-paracone crest from the paracone. Possibly it is an abnormal tooth. F8293, an RM^1, also has a very prominent parastylar crest, post-paracone crest, and even a very slight forelink. F8195, an RM_1 has an enclosed anterior trigonid basin, an uncommon structure present in some *siva* specimens (e.g. F3598), but also some *M. dryas* specimens. F8187, a lower right molar, also has an enclosed anterior trigonid basin, but one which is closed by the presence of two discrete anterior cingular cusps.

Measurements are as follows: F9444, P^2L, 8·4; P^3PW, 5·0; M^1L, 8·3; M^1AW, 5·6; M^1PW, 6·1; M^2L, 9·5; M^2AW, 7·2; M^2PW, 7·8; P^3L, 10·2; P^3PW, 5·0; F8181, P_2L, 7·2; P_2PW, 3·6; F8231, M^1L, 8·7; M^1PW, 4·7; F8195, M_1L, 8·1; M_1AW, 4·7; M_1PW, 5·3; F8187, M_xL; 9·6; M_xAW, 5·1; M_xPW, 6·3; F8293, M^1L, 8·6, M^1AW, 6·1; M^1PW, 6·4.

Macropus (Prionotemnus) agilis siva has been recorded from the Queensland Pleistocene Cement Mills and eastern Darling Downs faunas, as well as from Monto, central Queensland (Bartholomai 1975). Modern *M. agilis* is restricted to northern Australia and New Guinea, but at least one population of *M. a. jardinei* still survives on Stradbroke Island in southeastern Queensland. Modern animals appear to favour savannah woodlands or open forest areas, habitats abundantly present today on and around Viator Hill.

Macropus (Prionotemnus) sp., cf. **M. (P.) thor** (De Vis)
(Plate 7AA)

Two specimens from The Joint, F8473 and F8859, may represent this uncommon Pleistocene species. The lower molars have only a slight vertical posterior hypolophid groove. P_3 is relatively small and unlike the large P_3 of some of the other species of this subgenus such as *Marcopus (Prionotemnus) agilis.* Reference of these fragmentary Joint specimens to this taxon is very tenuous, and it is only suggested here in preference to leaving them unreferred to any known species, because they reveal an overall resemblance to the eastern Darling Downs specimens referred by Bartholomai (1975) to *M. thor.*

Measurements are as follows: F8859, M_5L, 13·1; M_5AW, 8·3; M_5PW, 8·3; F8473, P_3L (worn), 7·1; P_3AW, 3·2; P_3PW, 3·4; M_3L, 11·5; M_3AW, 7·7; M_3PW, 8·2; M_4L, 13·4; M_3AW, 9·2; M_3PW, 8·4.

Macropus (Prionotemnus) thor has only been recorded from the Pleistocene deposits of the eastern Darling Downs (Bartholomai 1975).

Macropus (Osphranter) sp., cf. **M. (O.) altus** (Owen)
(Plate 8K)

Several specimens from both The Joint and Russenden (rear) Cave are morphologically similar to specimens of modern *Macropus (Osphranter) robustus* as well as to fossil *M. (O.) altus.* They are very large, lack forelinks and have poorly-developed parastylar crests on the upper molars, poorly-developed posterior vertical grooves on the lower molars, and wide well-developed premolars. One isolated I^3 has a single vertical groove near its anterior end.

Figure 7 is a comparison of the means of cheektooth dimensions for P^2 to M^4 of various *Macropus (Osphranter)* samples based on Table 7: a modern sample from southeastern Queensland (mainly localities near Warwick); a modern sample from mid- and northeastern Queensland (not including any *M. (O.) antilopinus);* Texas Caves specimens; eastern Darling Downs *M. (O.) altus* (after Bartholomai 1975); and the single known upper cheektooth row of *M. (O.) stirtoni* (after Marcus 1976). It is clear that the two modern *robustus* samples differ from each other to a greater extent than the eastern Darling Downs *altus* sample differs from the single known upper tooth row of *stirtoni.* It is also apparent that the northeastern sample of *robustus* is more similar in size to the *altus* sample than is the southeastern *robustus* sample. This is particularly evident in the dimensions of P^3 and M^4 which are about intermediate between those of the southeastern *robustus* and *altus* specimens. The *altus* sample is clearly different from both *robustus* samples in the dimensions of P^2 and M^1. The Texas specimens do not clearly ally with either the modern *robustus* or *altus* samples. In the size of P^3, (inferred from a section of the tooth visible in F7896), and M^1, the Texas specimens closely approach the *altus* sample. However, the M^2 is intermediate between northeastern *robustus* and the *altus-stirtoni* specimens, and the M^3 broadly overlaps with that tooth in northeastern *robustus* and is clearly smaller than the *altus-stirtoni* specimens M^{4-5} have not been clearly identified among the isolated Texas molars.

On the basis of the known *Macropus (Osphranter)* populations, it could only be concluded that the Texas specimens, albeit few in number, suggest an animal intermediate between modern northeastern Queensland *robustus* and *altus-stirtoni* in size, and therefore, not clearly referable to one or the other. I have tentatively referred it here to *altus* on the basis of the premolar and M^1 size. No clear morphological characters have been noted other than size which enable separation of *robustus-antilopinus* from *altus* samples (Bartholomai 1975).

This points out the very unsatisfactory state of *Osphranter* taxonomy. Owen (1874) describes *cooperi* on the basis of a very poorly-preserved dentary. Bartholomai (1975) describes the holotype's distortions, and concludes that *cooperi* is a synonym of *altus* Owen, 1874, the latter name being preferred as the senior synonym. Marshall (1973) concludes (but without a detailed analysis) the same synonmy, and in addition suggests *birdselli* Tedford, 1967 is yet another synonym of this species (he regards the senior synonym to be *cooperi*). Marcus (1976) describes *Osphranter stirtoni* having made comparisons with the cast of the holotype of *cooperi* as well as specimens of modern *Macropus giganteus* and 'Pan-Australian' samples of modern *robustus.* He evidently did not have Bartholomai's (1975) revision of the group containing the amplified description of *altus.* As a result, Marcus's (1976) diagnosis does not serve to distinguish *stirtoni* from *altus,* although the two may be distinct. In fact, none of the diagnoses in any of the works cited enable the species established or revised to be satisfactorily diagnosed from all of the other species. Bartholomai (1975) admits the sample of *altus* is too small to compare statistically with all of those of modern *robustus* and *antilopinus,* and measurements given indicate that these would probably overlap in some absolute dimensions. The diagnosis of Marcus (1976) does not mention *altus* (or its synonyms as recognised by Bartholomai and Marshall), or *antilopinus.* In the discussion, Marcus (1976) makes comparisons with specimens referred by Marshall (1973) and De Vis (1895) to *cooperi* and suggests there is probably overlap between De Vis's sample (included in Bartholomai's work as *altus*) and *stirtoni.* Further, Marcus (1976) has clearly shown that modern *Osphranter* is sexually very dimorphic in absolute size, and it is not inconceivable that a preponderance of one sex only in any of the very small fossil samples could significantly affect the mean measurements of the whole sample.

All of this indicates the folly of attempting here to positively identify the fragmentary Texas *Osphranter* specimens. It seems entirely possible that the *altus* populations could represent a larger Pleistocene population of *robustus,* in the same kind of relationship as that which exists between *Macropus (M.) titan* and *M. (M.) giganteus.* The intermediate size of the Texas specimens might then be seen as part of the continuous variation between *altus* and *robustus*.

Modern *Macropus (Osphranter)* species prefer rocky hillsides in a wide range of vegetation habitats. *M. (Osphranter) robutus* is living today on Viator Hill (e.g. JM2247).

Macropus (Macropus) titan
(Plate 8M)

As in the case of the larger *Macropus (Osphranter)* species, there are problems involved in identifying fragmentary remains of the larger *M. (Macropus)* species. Most of the Texas Caves material appears to fall within the size and character range of *M. (M.) titan*, and compares well with specimens from the *titan* sample of the eastern Darling Downs. Bartholomai (1975) indicates that there is overlap in many features between *M. titan* and *M. giganteus*, but the extent of this overlap is reasonably well-documented by large samples, unlike the case of the *M. (Osphranter) altus-robustus* problem noted above. On the basis of this documentation (Bartholomai 1975), most of the Texas specimens noted below would fall outside the range of modern *M. giganteus*, but not all of them. A few are noted below as *M. (M.)* sp., cf. *M. (M.) giganteus*.

F8431, a LP^2 from the Bone Chamber of Russenden (rear) Cave, is probably the best single reason for recognising *Macropus (Macropus) titan* in the Texas Caves material. It compares very well with *M. titan* specimens (e.g. F4274, F4235, F4552, and F4252) from the eastern Darling Downs in size and morphology, even to the extent of possessing a small posterobuccal cusp on the flank of the crown. It only differs in that the posterior width (7·5) is slightly wider than other specimens measured (6·4 – 7·2).

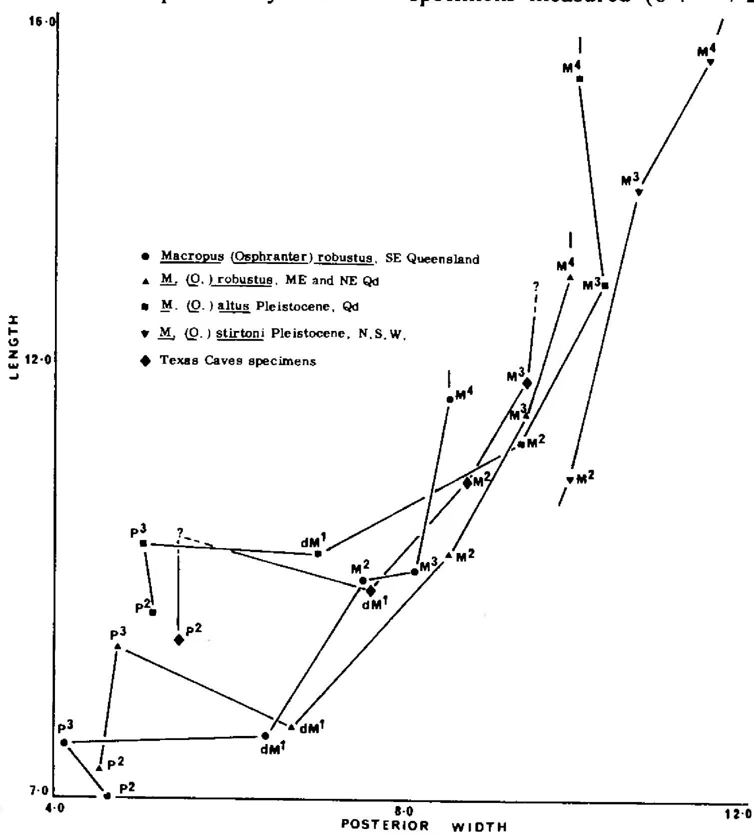


FIG. 7: Comparison of the mean lengths and widths (mm) of P^2 to M^4 in various eastern Australian modern and fossil populations of *Macropus (Osphranter)* species, based on data summarized in Table 7. The fossil samples are small (*altus*, 1–3; *stirtoni*, 1; and Texas, 1–3 individuals). The Texas specimens have been tentatively referred to *M. (O.)* sp., cf. *M. (O.) altus* on the basis of the similarity of the anterior region of the cheektooth row (see text).

TABLE 7: CROWN DIMENSIONS OF P^2–M^4 IN TWO MODERN AND THREE FOSSIL SAMPLES OF *Macropus (Osphranter)* FROM EASTERN QUEENSLAND AND NEW SOUTH WALES.

Parameter		P^2L	P^2AW	P^2PW	P^3L	P^3PW	dM^1L	dM^1AW	dM^1PW	M^2L	M^2AW	M^2PW	M^3L	M^3AW	M^3PW	M^4L	M^4AW	M^4PW
M. (O.) robustus southeastern Queensland	$\bar{x}$	7·0	3·7	4·6	7·6	4·1	7·7	6·0	6·4	9·4	7·2	7·5	9·6	8·0	8·1	11·6	8·7	8·5
	N.	11	11	11	10	10	11	11	11	11	10	10	10	10	10	10	10	9
	O.R.	6·2–7·9	3·3–4·0	4·3–4·9	7·0–8·2	3·8–4·3	6·8–8·3	5·7–6·4	5·9–6·9	8·8–10·2	6·7–7·9	6·9–8·4	9·2–10·1	7·5–8·6	7·4–8·8	11·1–12·3	8·3–9·2	7·8–9·3
	S.	0·45	0·21	0·18	0·45	0·18	0·37	0·22	0·29	0·34	0·36	0·50	0·33	0·37	0·41	0·44	0·36	0·58
	C.V.	6·33	5·64	3·89	5·96	4·36	4·86	3·64	4·56	3·63	4·92	6·68	3·43	4·70	5·03	3·80	4·07	6·75
M. (O.) robustus mideastern Queensland	$\bar{x}$	7·3	4·0	4·5	8·7	4·7	7·8	6·1	6·7	9·8	8·0	8·5	11·4	9·2	9·4	13·0	10·2	9·9
	N.	3	1	2	15	13	2	2	2	8	8	8	13	13	13	15	15	13
	O.R.	7·1–7·6	4·0	4·3–4·6	7·8–9·5	4·1–5·2	7·5–8·0	6·0–6·2	6·6–6·7	9·4–10·4	7·2–8·9	7·9–9·5	10·5–12·5	8·3–9·5	8·7–10·2	11·7–14·6	9·5–10·7	9·0–10·6
	S	0·28	—	0·21	0·49	0·29	0·35	0·07	0·07	0·40	0·54	0·47	0·57	0·34	0·43	0·87	0·42	0·45
	C.V.	3·87	—	4·77	5·59	6·14	4·56	1·15	1·06	4·10	6·76	5·51	5·01	3·65	4·62	6·72	4·10	4·51
Texas Caves specimens	$\bar{x}$	8·8	—	5·4	—	—	9·4	7·1	7·6	10·7	8·1	8·7	11·8	9·3	9·4	12·9	—	—
	N.	3		3			1	1	1	1	1	1	1	1	1	1		
	O.R.	8·4–9·2	—	4·9–5·8	—	—	9·4–	7·1–	7·6–	10·7–	8·1–	8·7–	11·8–	9·3–	9·4–	12·9–	—	—
M. (O.) altus (Bartholomai 1975)	$\bar{x}$	9·1	—	5·1	9·9	5·0	9·8	—	7·0	11·1	—	9·3	12·9	—	10·3	15·3	—	10·0
	N.	1		1	2	1	1		1	3		3	3		2	1		1
	O.R.	9·1	—	5·1	9·8–10·0	5·0	9·8	—	7·0	10·7–11·4	—	9·2–9·4	12·6–13·3	—	10·0–10·5	15·3	—	10·0
M. (O.) stirtoni (Marcus 1976)		—	—	—	—	—	—	—	—	10·7	—	9·9	14·0	10·3	10·7	15·5	11·2	11·5

Two of the dentary specimens (e.g. F8899 and F8412), referred here to *Macropus (M.) titan* are difficult to distinguish confidently from *Macropus (Osphranter)* species, such as *M. (O.) ferragus*. Bartholomai (1975) notes in the diagnosis of the subgenera only one feature which enables separation of dentaries of *M. (Macropus)* and *M. (Osphranter)*, but no dental features. The single feature is the narrower more excavated width of the dentary immediately below the anterior end of the cheektooth row. In practice, this is a difficult character to use, and there is overlap. Additional features used here to separate lower cheekteeth of *M. (M.) titan* and *M. (M.) giganteus* from *M. (Osphranter) ferragus*, include the smaller size of *Macropus*, the relatively lower height of the anterior cingulum of the molars, and the better-developed pocket in the posterior face of the hypolophid. These characters are noted within the text of Bartholomai's (1975) revision.

Measurements are as follows: (Bone Chamber) F8899, M_{2-5}, 53·7; M_2L, 9·5; M_3L, 12·1; M_3AW, 9·0; M_3PW, 10·0; M_4L, 15·1; M_4AW, 9·8; M_4PW, 9·7; M_5L, 18·1; M_5AW, 10·7; M_5PW, 9·9; F8431, P^2L, 9·6; P^2AW, 5·6; P^2PW, 7·5; (The Joint) F8862, P_2 (alveoli) – M_2, 26·2; M_2L, 10·8; M_2AW, 6·6; M_1L, 10·0; M_1AW, 5·6; M_1PW, 6·8; P_3L, 6·8; P_3AW, 2·5; P_3PW, 4·4; F8412, M_{2-3}, 23·0; M_2L, 9·8; M_2AW, 7·2; M_2PW, 8·3; M_3L, 13·5; M_3AW, 8·8; M_3PW, 9·7; M_4AW, 9·3; M_5PW, 8·9; F8870, M_3L, 14·1; M_3AW, 9·0; M_3PW, 8·2. F8862 closely matches *M. titan* specimens F4193, and F4172 (Darling Downs). F8899 closely matches *M. titan* specimens F1651 and F5630 (Darling Downs).

Macropus (Macropus) titan is known from Pleistocene deposits of most Australian states except the Northern Territory and Western Australia. Its modern derivatives live in most habitats except the arid desert areas. *M. (M.) giganteus* is still living on Viator Hill (e.g. JM1862).

Macropus (Macropus) sp., c.f. **M. (M.) giganteus** Shaw
(Plate 8L)

Some specimens from the Bone Chamber, Russenden (rear) Cave, have the characters of *Macropus (Macropus)*, but are too small to be placed within *M. (M.) titan*. None appear to represent the Pleistocene *M. (M.) rama* on the basis of the diagnostic characters given by Bartholomai (1975). This leaves several modern species such as *M. (M.) rufogriseus*, *M. (M.) parryi* and *M. (M.) giganteus*, among Queensland species, and several additional large species known from other areas of Australia. No attempt has been made here to compare these non-*titan* Texas *M. (Macropus)* specimens with the smaller species of this subgenus simply because they are too large. They closely approximate *M. giganteus* in size and morphology but cannot be confidently referred to this species because they could also represent the morphologically very similar *M. (M.) fuliginosus*, which today although not known from Queensland, occurs as far east as western New South Wales.

Measurements are as follows: F8304, P_3L, 7·4; P_3PW, 3·8; F8514, M^3L, 13·5; M^3AW, 9·9; M^3PW, 9·8; F8514, $M^{\underline{x}}L$, 13·3; $M^{\underline{x}}AW$, 9·7; $M^{\underline{x}}PW$, 9·8.

Macropus (Macropus) giganteus is living today on Viator Hill (e.g. JM1862, and skull picked up on surface, JM1089).

Bartholomai (1975) regards *Macropus (Macropus) titan* and *M. (M.) giganteus* to be successional species of each other, anticipating that a better fossil record will make it increasingly difficult to recognize diagnostic characters that will separate the two. Marshall (1973) regards *M. giganteus* to be the result of late Pleistocene dwarfing of *M. titan* populations. The occurrence of *M. (M.)* sp. cf. *M. (M.) titan* and *giganteus* in the Russenden (rear) cave deposits (both in the LP layer) might raise some doubts about this interpretation. A similar situation occurs in the Cement Mills fauna (Bartholomai 1977). In both cases some doubt must first be raised about the actual contemporaneity of the two forms. In the case of the Cement Mills deposit, there is other evidence (the two extremes of *Sarcophilus* size, and the two species of *Palorchestes)* to suggest that more than one fauna is involved. In the case of the Pleistocene Bone Chamber specimens, evidence for significantly different faunas has not been recognized. However, as was noted in the discussion of the stratigraphy of the Bone Chamber, this area of the cave has had a complex history. It is possible that specimens in this deposit represent significantly different ages, although this would be the only evidence for such an interpretation. Alternatively, and perhaps more realistically, some of the specimens regarded here to be *M. (M.)* sp., cf. *M. (M.) giganteus* may in fact merely represent small individuals of *titan*. Whatever the true situation, I do not think the variables involved in the Texas Caves situation are well enough understood to use this as a test area for hypotheses relating to the relationships of those two taxa.

Placentalia

Chiroptera

Texas caves specimens identified here have only been compared with modern Queensland bats. In all cases, the specimens could be exactly matched in size and dental morphology with bats living in southeastern Queensland. For this reason, more extensive comparisons with non-Queensland bats were not made, and it is therefore possible, although improbable, that morphologically identical non-Queensland bats might be represented by some of the fossils.

Rhinolophidae

Rhinolophus megaphyllus Gray
(Plate 8N)

This species was the most common bat fossil in the Bone Chamber, as well as in adjacent caves. In the main chamber of Russenden Cave, three specimens were collected (F8906-8) that have a modern appearance, and the species has been collected live from caves on Viator Hill. It seems probable that this species has survived in the area since at least late Pleistocene times.

Measurements are as follows: F8258, M_{1-3}, 5·0; F8542, C_1 – M_3, 7·7; M_{1-3}, 5·0; F8268, C_1 – M_3, 8·3; M_{1-3}, 5·1; F8939, M_{1-3}, 4·9.

Vespertilionidae

Nyctophilus timoriensis (Geoffroy)
(Plate 8O)

Only one specimen, F8141, represents this bat from the sediments of the Bone Chamber. It has not been collected live from the Viator Hill area, although this area is well within its extensive modern range in Australia. At least one specimen is known from Stanthorpe, southeastern Queensland.

Measurements as follows: F8141, P_3 – M_2, 5·2; M_{1-2}, 3·6.

Miniopterus schreibersii (Kuhl)
(Plate 8P)

Eight specimens from the Bone Chamber of Russenden (rear) Cave represent this Bent-wing Bat. Main Viator Cave was evidently a maternity cave for this species and several modern specimens have been collected from the Texas Caves area. Evidently, as in the case of *Rhinolophus megaphyllus*, this species has survived in the area since at least the late Pleistocene.

Measurements are as follows: F8152, M_{1-3}, 4·3; F8143, M_{1-3}, 4·3; F8146, M_{1-3}, 4·4; F8153, M_{1-3}, 4·4; F8144, M_{1-3}, 4·4; F8150, M_{1-3}, 4·4.

Muridae

Rodent specimens were identified by J. Mahoney. Most species names used here have been listed as similar to (i.e., cf.) the modern species names. This reflects the uncertainties involved in identifying murids on the basis of the fragmentary fossil remains. However, in each case, the fossils could not be differentiated from more complete modern specimens of the species to which they were referred (J. Mahoney, pers. comm.).

Pseudomyinae

Conilurus albipes (Lichtenstein)
(Plate 9C)

Of all murid remains in the Texas Cave deposits, those of the White-footed Tree-rat are the most common. This is in direct contrast to their apparent rareity within historic times, with only two modern specimens in Australian museums and not many more in European museums. Gilbert obtained one specimen from an unspecified locality on the Darling Downs. Gould (1863) suggests it occurred widely throughout its inland range wherever there was tree-growth, the animals nesting in hollow limbs of large eucalypts. The abundance of this otherwise rare animal in the caves of Viator Hill prompted an extensive survey of the depauperate small mammal fauna of the area, but despite the opening of innumerable hollow logs and spouts of eucalypt trees destined to be flooded, no trace of any small mammal was found. Evidently here, as is generally assumed to be the case throughout Australia (e.g. Ride 1970), this rodent has become extinct.

Pseudomys sp., cf. **P. oralis** Thomas
(Plate 9F)

This species of *Pseudomys* is uncommon in the Texas cave deposits. It was collected live in 1969 from the ranges east of Warwick, southeastern Queensland, and is at present not known to be living elsewhere in Queensland (Covacevich 1974), although it occurs in a limited area of northeastern New South Wales. The recorded habitat is flood debris along creek beds in Eucalypt forest, with dense ground cover.

Pseudomys sp., cf. **P. desertor** Troughton
(Plate 9E)

This species was originally collected from sand dune and spinifex country in the Northern Territory, and subsequently from the more arid inland areas of Western Australia and northern South Australia, in the vicinity of the junction of the Murray and Darling Rivers. It has not previously been recorded from Queensland, although J. Mahoney (pers. comm.) notes that a modern specimen (J4214) was collected in 1925 from Lake Galilee in central western Queensland. Presence of this species in the Texas Caves deposit is unexpected, and either indicates that the habitat requirements of the species were wider than the previously known distribution suggests, or that there was formerly a relatively xeric habitat in the vicinity of Viator Hill. Against the latter alternative, is the absence in the Texas caves faunas of other arid-adapted mammals such as *Macrotis, Chaeropus, Dasycercus*, and so on.

Pseudomys sp., cf. **P. desertor** or **P. gracilicaudatus** (Gould)
(Plate 9D)

Specimens from the Bone Chamber listed under this category in Tables 8 and 9 are not clearly referable to *Pseudomys* sp., cf. *P. desertor* because they share characters with *P. gracilicaudatus*, but are similarly not clearly referable to *P. gracilicaudatus*. However, specimens from the surface of Rabscuttle Cave (e.g. F8926) are more certainly referrable to *P. gracilicaudatus*.

Mahoney and Posamentier (1975), Covacevich (1975), and Borsboom (1974) review information about this species. It is known to occur live in southeastern Queensland (T. Kirkpatrick, pers. comm.). Open forest is a recorded habitat for the species, and is present today on Viator Hill.

Pseudomys sp., cf. **P. novaehollandiae** (Waterhouse)
(Plate 8R)

This tiny murid was reasonably common in the LP unit of the Bone Chamber of Russenden (rear) Cave. It has not previously been recorded from Queensland, although it occurs today as far north as the north coast of New South Wales (Posamentier and Recher 1974).

Habitats recorded for the species include dry sclerophyll forest with a sclerophyllic understorey, a vegetation type still present on areas of Viator Hill.

At Port Stephens, N.S.W., Posamentier and Recher (1974) found this species in association with the native species *Rattus lutreolus, R. fuscipes*, and *Sminthopsis murina*, all of which are also present in the Texas caves deposits.

TABLE 8: MEASUREMENTS OF MOLAR ROW LENGTH AND M^2 WIDTH FOR TEXAS CAVES MURIDS (A = M^{1-3} LENGTH; B = M^2 WIDTH; C = M_{1-3} LENGTH; D = M_2 WIDTH).

Parameter	*Conilurus albipes* (Bone Chamber)				*Pseudomys* sp., cf. *P. oralis* (Bone Chamber)				*P.* sp., cf. *P. desertor* (Bone Chamber)			
	A	B	C	D	A	B	C	D	A	B	C	D
$\bar{x}$	9·8	2·8	9·8	2·9	7·3	2·2	7·0	2·1	5·8	1·9	5·4	1·7
N.	9	19	25	26	3	4	4	5	1	2	1	1
O.R.	9·4–10·4	2·6–3·0	9·0–10·6	2·7–3·1	7·2–7·4	1·9–2·3	6·8–7·2	2·0–2·1	5·8	1·8–1·9	5·4	1·7
S	0·33	0·13	0·45	0·17	0·12	0·19	0·17	0·05	0	0·76	0	0
C.V.	3·33	4·72	4·56	5·73	1·59	8·70	2·75	2·15	0	3·82	0	0
	P. sp., cf. *P. gracilicaudatus* (all)				*P.* sp., cf. *P. novaehollandiae* (Bone Chamber)				*Rattus* sp., cf. *R. lutreolus* (Bone Chamber)			
	A	B	C	D	A	B	C	D	A	B	C	D
$\bar{x}$	5·8	2·0	6·0	1·9	4·1	1·1	4·2	1·2	7·3	2·5	—	—
N.	1	1	2	2	1	1	5	6	2	3		
O.R.	5·8	2·0	6·0	1·9	4·1	1·1	4·0–4·6	1·1–1·3	7·0–7·5	2·3–2·6	—	—
S	0	0	0	0	0	0	0·24	0·08	0·04	0·02	—	—
C.V.	0	0	0	0	0	0	5·66	6·62	4·88	6·19	—	—

Rattus sp., cf. **R. lutreolus** (Gray)
(Plate 8Q)

This murid is uncommon in the Texas Caves deposits as are all species of *Rattus*. It is common in most of eastern Queensland (Covacevich 1974) in moist areas in closed and wet sclerophyll forests. It is possible that it may have maintained populations in the wet grassy areas adjacent to Pike Creek, a bend of which surrounds Viator Hill. Its rarity in the deposits suggests a suitable habitat may not have occurred actually on Viator Hill. Living individuals have been collected at Warwick.

Rattus sp., cf. **R. fuscipes** (Waterhouse)
(Plate 9G)

This species is also uncommon in the cave deposits, but a very common rat throughout eastern Australia, particularly in wet sclerophyll forests. As in the case of the *R.* sp., cf. *R. lutreolus* specimens, the rarity of specimens of this species in the Texas Caves deposits suggests that the habitat for this normally very common rat was not actually on Viator Hill, but rather closer to the moister margins of Pike Creek.

Rattus rattus (Linnaeus)

Rattus rattus (F9454) was collected from the surface of the main chamber of Russenden (rear) Cave. This widespread species has established populations throughout Australia, in a great variety of habitats. It is possible it reached the area at the time of European settlement in the middle of the nineteenth century.

DISCUSSION

Summary of Texas Caves Faunas

Table 9 is a list of the taxa reported above which were recovered from the Joint breccia, and the sediments of the Bone Chamber, Russenden (rear) Cave.

The Joint fauna clearly differs from that of Russenden (rear) Cave, mainly in being more impoverished. All of the reasons for this are not clear but certainly must include the different collecting techniques. The Joint fauna was obtained by hand-breaking lumps of breccia, whereas the Russenden (rear) Cave fauna was largely obtained by sieving, a more efficient technique for recovery of small mammals. The probably older age of the Joint fauna, as discussed below, would further account for some of the differences in species in the two deposits.

There is some, albeit meagre, evidence for faunal development within the Russenden (rear) Cave sequence. Comparing the LP with the UB samples and its lateral equivalent (not including UBP, which may be younger than UB, see above; or 0–20, which is clearly a mixed sample), some species appear to have delined up through the deposit (e.g. *Sminthopsis murina)* and others to have increased in abundance (e.g. two of the bat species). However, the minimum numbers of individuals in all samples, except the 0–20 cm sample, are too small to conclude anything meaningful about unit differences.

The diversity of the Russenden (rear) Cave fauna is probably reasonably representative of the mammal fauna actually living on and around Viator Hill at the time of its accumulation, interpreted below to be late Pleistocene. No group of expected mammals is unrepresented, and some are represented by more species than occur in southeastern Queensland modern faunas. Numerous mammalian taxa represented have either become completely extinct (e.g. *Sthenurus* sp., *Protemnodon roechus, Macropus agilis* aff. *M.a. siva, M. titan, Conilurus albipes, Sarcophilus laniarius,* and possibly *Antechinus* sp.), or regionally extinct from southeastern Queensland *(Dasyurus viverrinus, Isoodon obesulus, Pseudomys desertor,* and *P. novaehollandiae).* Others are extremely rare in southeastern Queensland *(Cercartetus nanus)* or not now known in southeastern Queensland to occur in habitats presently found on Viator Hill *(Perameles nasuta, Thylogale* sp., and *Rattus lutreolus).* The remainder include species which, on the basis of known habitat requirements, could be expected to have been found living on Viator Hill at the time of European settlement *(Sminthopsis murina, Antechinus flavipes, Phascogale tapoatafa, Vombatus* sp., *Acrobates pygmaeus, Petaurus* sp. (possibly only *P. breviceps,* see discussion above), *Pseudocheirus peregrinus, Trichosurus vulpecula, Aepyprymnus rufescens, Petrogale* sp., *Macropus dorsalis, Pseudomys oralis, Nyctophilus timoriensis,* and *R. fuscipes),* or which were encountered live on Viator Hill during these investigations (e.g. *Macropus giganteus, M. robustus, Rhinolophus megaphyllus,* and *Miniopterus schreibersii).*

Palaeoenvironments

The majority of species recorded from The Joint breccia are indicative of a dry to wet sclerophyll forest habitat. The possible exceptions are *Thylogale* sp. and *Perameles nasuta,* which

TABLE 9: MINIMUM NUMBER OF INDIVIDUALS OF MAMMALS IN THE JOINT AND RUSSENDEN (REAR) CAVE FAUNAS

Taxa	Joint fauna	Russenden (rear) Cave faunas							
		LP	LPW	UB	UBW	UBP	UBPW	0–20cm	total (R)
Sminthopsis murina	0	3	0	2	1	0	0	16	22
Antechinus sp., aff. *A. flavipes*	0	0	1	1	2	0	0	6	10
Antechinus sp.	0	0	0	0	0	0	0	1	1
Phascogale tapoatafa	0	1	0	0	0	0	0	1	2
Dasyurus viverrinus	0	1	0	0	2	0	0	3	6
Sarcophilus laniarius	1	0	0	0	0	0	0	0	1
Thylacinus cynocephalus	1	0	0	0	0	0	0	0	0
Perameles nasuta	1	1	1	0	1	0	0	2	5
Isoodon obesulus	1	0	0	0	0	0	0	1	1
Vombatus cf. *V. ursinus*	1	0	0	0	0	0	1	1	2
?Zygmaturus sp., cf. *Z. trilobus*	1	0	0	0	0	0	0	0	0
Cercartetus nanus	0	0	0	0	0	0	0	2	2
Acrobates pygmaeus	0	0	0	1	0	0	0	0	1
Pseudocheirus peregrinus	0	0	1	0	0	0	0	1	2
Petaurus breviceps	0	0	0	0	0	0	0	1	1
P. norfolcensis	0	1	0	0	0	0	0	2	3
?Trichosurus sp., cf. *T. vulpecula*	0	0	0	0	0	0	0	1	1
Aepyprymnus rufescens	1	0	1	1	0	1	1	2	6
Genus indet., F8362	0	0	0	0	1	0	0	0	1
Procoptodon texasensis n. sp.	1	0	0	0	0	0	0	0	0
Sthenurus sp., cf. *S. atlas*	1	0	0	0	0	0	0	0	0
S. sp., cf. *S. oreas*	1	0	0	?	0	0	0	1	?2
S. sp., aff. *S. occidentalis*	1	0	0	0	0	0	0	0	0
Protemnodon roechus	1	0	0	0	0	0	0	0	1
P. brehus	1	0	0	0	0	0	0	1	1
Thylogale sp.	2	0	0	0	0	0	0	?	?1
Petrogale sp.	4	1	0	1	4	1	2	1	10
?Petrogale, F8417	0	1	0	0	0	0	0	0	1
Macropus dorsalis	3	1	0	0	0	0	0	0	1
M. sp., aff. *M. agilis siva*	1	0	0	0	0	0	0	2	2
M. sp., cf. *M. thor*	2	0	0	0	0	0	0	0	0
M. sp., cf. *M. robustus*	2	1	0	0	0	0	0	1	2
M. titan	2	1	0	0	0	0	1	1	3
M. sp., cf. *M. giganteus*	0	1	0	0	0	0	0	1	2
Rhinolophus megaphyllus	0	0	0	0	2	1	1	3	7
Nyctophilus timoriensis	0	0	0	0	0	0	0	1	1
Miniopterus schreibersii	0	0	0	0	1	0	0	4	5
Conilurus albipes	1	4	4	1	0	1	3	25	38
Pseudomys sp., cf. *P. oralis*	0	0	1	1	0	?	0	2	?5
P. sp., cf. *P. desertor*	0	0	0	0	0	?	1	2	?4
P. sp., cf. *P. novaehollandiae*	0	5	0	0	0	0	0	0	5
P. sp.*	1	0	1	0	0	?	0	3	5
Rattus sp., cf. *R. lutreolus*	0	0	0	0	0	0	0	2	2
R. sp., cf. *R. fuscipes*	0	0	1	?	0	0	0	1	?3

**P.* sp. = *P. desertor* or *P. gracilicaudatus* although known from wet sclerophyll forests, are more commonly found in rainforests, at least in southeastern Queensland. Unfortunately, some of the more environmentally sensitive smaller species are unknown from The Joint, larger species being more common. The preferred habitat of the sebecosuchian crocodile might be assumed to be water, evidence supporting the reasonable probability that Pike Creek was then, as it is now, adjacent to Viator Hill.

The Bone Chamber faunas include many small species, most of which support the concept of a dry to wet sclerophyll forest habitat. Exceptions include *Pseudomys* sp., cf. *P. desertor* which is today indicative of dry, semi-arid to arid habitats, and *Perameles nasuta*, ?*Thylogale* sp., *Rattus* sp., cf. *R. lutreolus* and even *R.* sp., cf. *R. fuscipes* specimens, which on the contrary suggest a wet sclerophyll or possibly rainforest habitat. In each case, the aberrant species are very uncommon, and this could be interpreted in at least two ways: either the habitats of these animals were remote from the immediate area of Viator Hill; or these species were occupying non-preferred habitats and hence present in low numbers.

Comparisons of Pleistocene Queensland Faunas

Table 10 presents summary faunal lists for the four largest southeastern Queensland Pleistocene faunas: the Cement Mills fauna (Bartholomai 1977); the eastern Darling Downs (no general summary has previously been made, but the extensive revisionary works of Bartholomai on the kangaroos from these deposits consider the majority of known taxa); The Joint fauna; and the Russenden (rear) Cave faunas.

There are absences of whole groups from all of these faunas. Direct comparisons are limited by what are presumably problems of selective fossilization, such as the apparent absence of bats in the eastern Darling Downs, Cement Mills, and Joint faunas. There is also the probability that there were different habitats in the particular areas examined. For example, nothing in the eastern Darling Downs fauna suggests an arboreal habitat; on the contrary, the extraordinary abundance of grazing and browsing kangaroos suggests the Pleistocene Darling Downs was much as we see it today, a vast grassland habitat with patches of shrubs suitable for the browsers. The Cement Mills fauna also contains many grazing kangaroos, but it also possesses some forest species such as *Phascolarctos stirtoni*, *Perameles nasuta*, *Vombatus ursinus*, and *Potorous* sp., aff. *P. tridactylus*. In still greater contrast to the eastern Darling Downs, are The Joint and Russenden (rear) Cave faunas which have a high proportion of species indicating a forest habitat.

Despite these overall differences, these faunas are more similar to one another than any is to non-Queensland Pleistocene faunas, with the possible exception of the Wellington Caves and Bingara faunas of New South Wales. Many of the kangaroos, diprotodont and wombat species present in these New South Wales faunas also occur in the deposits of the eastern Darling Downs.

Notable Absences from or Rarities in the Fauna

Compared with other eastern Australian Pleistocene faunas in Australia, some absences in the combined Joint-Russenden species list (Table 9) are of interest. Only one wombat species appears to be represented, and of particular interest is the absence of *Phascolonus gigas* which is normally present in the better-known Pleistocene faunas. Possibly the forested limestone hillside habitat was unsuitable for species other than *Vombatus* sp., cf. *V. ursinus*, whose remains were not uncommon in the Russenden (rear) Cave.

Only *Zygomaturus* sp., cf. *Z. trilobus*, of four possible late Pleistocene diprotodontoids, is represented. Absence of the other three may reflect their unwillingness to walk across slopes with jagged limestone projections. Comparison can be made with the Wellington Caves, which contain at least two of the three non-Texas diprotodontoids and many of the wombats. The difference in character of the exposed limestone of the two areas is marked. At Wellington the limestone outcrops around the caves have rounded edges. On Viator Hill, the limestone weathers into sharp karst structures, with a vertical relief in some areas of as much as a metre. The intervening depressions are filled with tall grasses. Movement through this type of country would almost certainly have been avoided by the larger herbivores if they could bypass the hill on the adjacent riverine floodplain soils.

The apparent absence of *Thylacoleo carnifex* is not so easily understood, although it could be the result of a chance sampling error.

Trichosurus vulpecula, the common Brush-tailed Possum, was found on the surfaces of many of the Texas Caves, but only a single tooth appears to represent this species from the excavated deposits. This rarity in the older deposits is unexpected compared with the abundance of the species today in most areas of Australia. Perhaps

TABLE 10: COMPARISON OF MAMMALS PRESENT IN SOUTHEASTERN QUEENSLAND PLEISTOCENE FAUNAS

Cement Mills	Eastern Darling Downs	The Joint	Russenden (rear) Cave
—	—	—	*Sminthopsis murina*
—	—	—	*Antechinus flavipes*
—	—	—	*A.* sp.
—	—	—	*Phascogale tapoatafa*
Dasyurus aff. *D. viverrinus*	*D. viverrinus*	—	*D. viverrinus*
Sarcophilus sp.	—	—	—
(*S.* sp., large)	*S. laniarius*	*S. laniarius*	*S. laniarius*
Thylacinus cynocephalus	*T. cynocephalus*	*T. cynocephalus*	—
Perameles nasuta	—	*P. nasuta*	*P. nasuta*
Isoodon obesulus	—	*I. obesulus*	*I. obesulus*
Phascolarctos stirtoni	—	—	—
Vombatus ursinus	?	*V. ursinus (hirsutus)*	*V. ursinus (hirsutus)*
Phascolonus gigas	*P. gigas*	—	—
P. cf. *P. magnus*	*P. magnus*	—	—
—	*P. medius**	—	—
?Zygomaturine	*Zygomaturus trilobus*	*Z. trilobus*	—
Nototherium inerme	*N. inerme*	—	—
—	*Diprotodon optatum*	—	—
Palorchestes azael	*P. azael*	—	—
P. parvus	—	—	—
Thylacoleo carnifex	*T. carnifex*	—	—
—	—	—	*Cercartetus nanus*
—	—	—	*Acrobates pygmaeus*
—	—	—	*Trichosurus vulpecula*
—	—	—	*Petaurus norfolcensis*
—	—	—	*P. breviceps*
—	—	—	*Pseudocheirus peregrinus*
Potorous aff. *P. tridactylus*	—	—	—
Aepyprymnus rufescens	*A. rufescens*	*A. rufescens*	*A. rufescens*
Bettongia sp.	—	—	—
Sthenurus oreas	*S. oreas*	*S.* sp., cf. *S. oreas*	*S.* sp., cf. *S. oreas*
—	—	*S.* sp., cf. *S. atlas*	—
—	—	*S.* sp., aff. *S. occidentalis*	—
—	*S. andersoni*	—	—
—	*S. pales*	—	—
—	*S. orientalis*	—	—

TABLE 10 Continued: COMPARISON OF MAMMALS PRESENT IN SOUTHEASTERN QUEENSLAND PLEISTOCENE FAUNAS

Cement Mills	Eastern Darling Downs	The Joint	Russenden (rear) Cave
Procoptodon sp., cf. *P. texasensis*	—	*P. texasensis*	—
—	*P. rapha*	—	—
—	*P. goliah*	—	—
—	*P. pusio*	—	—
Protemnodon anak	*P. anak*	—	—
P. brehus	*P. brehus*	*P. brehus*	*P. brehus*
P. roechus	*P. roechus*	*P. roechus*	*P. roechus*
—	*Wallabia indra*	—	—
Thylogale sp.	—	*Thylogale* sp.	?*Thylogale* sp.
—	—	*Petrogale* sp.	*Petrogale* sp.
Macropus sp., cf. *M. agilis siva*	*M. agilis siva*	*M.* sp., cf. *M. agilis siva*	*M.* sp., cf. *M. agilis siva*
—	*M. piltonensis*	—	—
—	*M. gouldi*	—	—
M. dorsalis	—	*M. dorsalis*	*M. dorsalis*
—	*M. thor*	*M.* sp., cf. *M. thor*	—
M. parryi	—	—	—
—	—	*M.* sp., aff. *M. robustus*	*M.* sp., aff. *M. robustus*
—	*M. altus*	—	—
—	*M. ferragus*	—	—
M. titan	*M. titan*	*M. titan*	*M. titan*
M. giganteus	—	—	*M.* sp., cf. *M. giganteus*
—	*M. rama*	—	—
—	*Fissuridon pearsoni*	—	—
—	*Troposodon minor*	—	—
—	—	—	*Rhinolophus megaphyllus*
—	—	—	*Nyctophilus timoriensis*
—	—	—	*Miniopterus schreibersii*
—	—	*Conilurus albipes*	*C. albipes*
—	—	*Pseudomys* sp.*	*P.* sp.*
—	—	—	*Pseudomys* sp., cf. *P. oralis*
—	—	—	*P.* sp., cf. *P. desertor*
—	—	—	*P.* sp., cf. *P. novaehollandiae*
—	—	—	*Rattus* sp., cf. *R. lutreolus*
—	—	—	*R.* sp., cf. *R. fuscipes*
Rattus sp.	—	—	*Rattus* sp.
—	*Homo* sp.	—	—

it is possible that the activities of European man, in opening up forested areas, have benefited these opportunistic possums.

AGE OF THE TEXAS CAVES FAUNAS

As noted above, no radiometric dates could be obtained for bone samples from The Joint or Russenden (rear) Cave. For this reason, it is necessary to consider faunal composition in an attempt to understand the relative ages of these faunas.

The Joint contains a greater percentage of extinct taxa than the Russenden (rear) Cave deposits, despite the smaller number of species represented in The Joint. It also contains the sebecosuchian crocodile, a type of animal unknown anywhere else in the world from the Pleistocene. Although this single occurence in The Joint is certainly not an irrefutable reason for regarding them to be older than the Russenden deposits, it contributes to this general conclusion. Finally, as Grimes (1978) points out, The Joint is higher up on Viator Hill than Russenden and, on the assumption that the caves on this hill have been gradually exposed from top to bottom as the ancestral Pike Creek cut down towards its present bed level, The Joint would have been in a position to receive bones long before Russenden (rear) Cave.

The Joint fauna contains many of the same or closely related extinct species characteristic of Pleistocene mammal assemblages in New South Wales (e.g. Wellington, and Bingara). But comparisons of this sort do not yet enable us to place The Joint fauna within a specific part of the Pleistocene. The superpositional faunas from the Lake Victoria area of New South Wales do give some idea of faunal development within the Pleistocene of eastern Australia, although there are no radiometric dates associated with these faunas. Compared with these, most overlap in elements occurs with the late Pleistocene Frenchman's Creek and Lake Victoria faunas.

The Russenden (rear) Cave faunas, although presumably younger than the Joint fauna, are regarded here to be Pleistocene in age because of the presence of *Stenurus* sp., cf. *S. oreas*, two species of *Protemnodon*, *Macropus (Prionotemnus)* sp., cf. *M. (P.) agilis siva*, and *M. titan*. The association of these undoubted Pleistocene species with a mammal microfauna containing rodents, small dasyurids, bats, and small possums, makes this fauna more important as a basis for comparisons with the abundant but as yet largely undescribed Pleistocene small mammal faunas from caves in New South Wales.

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Many people helped with the actual recovery of sediments from the caves. Foremost among those whose arms weren't twisted were Mr H. Godthelp, K. Grimes, E. Archer, and R. McKay. A large percentage of the total work force in 1975 consisted of the students and staff including Messrs B. Cooke, N. MacIntyre, G. Cooke, and J. Marsh of the Kelvin Grove Teachers College. Queensland Museum staff who breathed more than their fair share of cave earth included Messrs D. Joffe and R. Kohout, and Ms P. Rainbird.

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PLATE 7

Mammals from The Joint (VR-5), and Russenden (rear) Cave (VR-14). A: F8344, *Sminthopsis murina*, LC_1–M_5, x2. B: F8286, *Antechinus* sp., aff. *A. flavipes*, LC_1–M_5, x2. C: F8445, *Antechinus* sp., x2. C': occlusal view of F8445, LP_2 and M_{2-5}, x2. D: F8285, *Phascogale tapoatafa*, RC^1, M^{2-3}, x2. E: F8042, *Dasyurus viverrinus*, LM^4, x3. F: F8883, *Sarcophilus laniarius*, LM_2 and roots of P_2, x1. G: F8871, *Thylacinus cynocephalus*, LM_3, x1. H: F8085, *Perameles nasuta*, RM^{2-3}, x2. I: F8086, *Isoodon obesulus*, RM^{2-4}, x2. J: F8027, *Cercartetus nanus*, LP_3–M_3, x2. K: F8206, *Acrobates pygmaeus*, LP_3, x2. L: F8201, *Pseudocheirus peregrinus*, RM^x, x2. M: F8413, *Petaurus breviceps*, RI_1–M_5, x1·5. N: F8203, *Petaurus norfolcensis*, LI_1 and M_{3-4}, x1·5. O: F8898, *Trichosurus* sp., cf. *T. vulpecula*, I_1, x1·5. P: F8240, ?*Zygomaturus* sp., cf. *Z. trilobus*, lingual half of LM^3 hypoloph, x1. Q: F8407, *Aepyprymnus rufescens*, RM_{2-5}, x1. R: F8362, genus indet., ?LM^1 (with protocone missing), ×3. S: F7894, *Sthenurus* sp., aff. *S. occidentalis*, RP^2–M^1, ×1. T: F8239, *Sthenurus* sp., cf. *S. oreas*, M^x, x1. U: F8380 (LM_{2-4}) and F7895 (LP_3), photographed but not actually found together, *Sthenurus* sp., cf. *S. atlas*, ×+1. V: F7947, *Thylogale* sp., RI^3, ×2·5. W: F8524, ?*Thylogale* sp., LP_2–M_3, x1. X: F8417, ?*Petrogale* sp., RM_{2-4}, x1. Y: F8526, *Petrogale* sp., RP_2–M_2, half of M_3, and M_4, x1. Z: F8860, *Macropus dorsalis*, RP_2–M_2, x1. AA: F8859, *Macropus* sp., cf. *M. thor*, LM_5, x1. BB: *Macropus* sp., aff. *M. agilis siva*, F9444, RP^2–M^2 (P^3 in crypt), ×1. CC: *M. a. siva*, F8923, RM^1, ×2. DD: as for CC, but buccal view showing occlusal view of excavated P^3, x1.

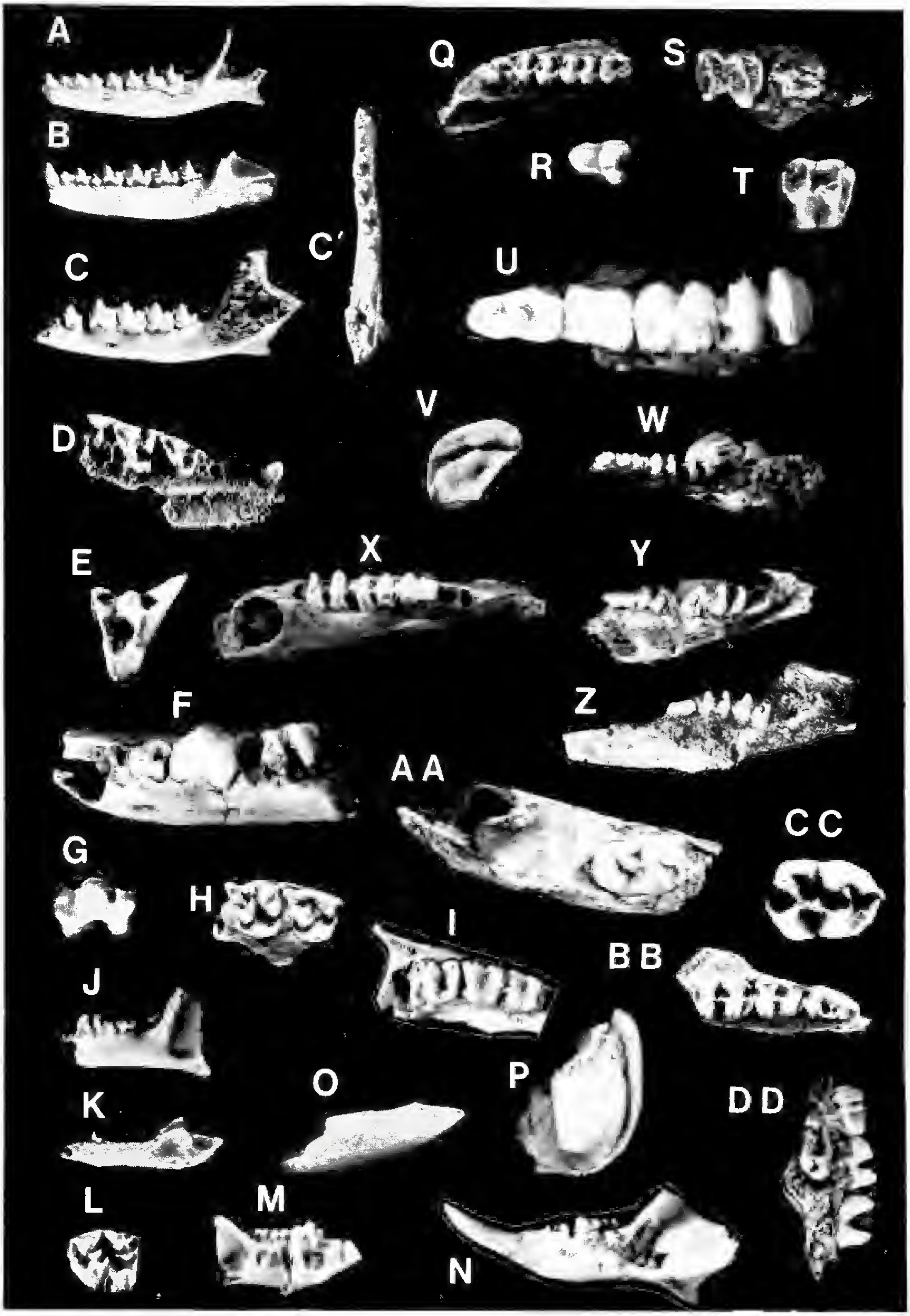
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PLATE 8

Mammals from The Joint (VR-5), Russenden (rear) Cave (VR-14), and a non-Queensland specimen of *Procoptodon rapha*. A–A': stereopair, F7894, *Procoptodon texasensis* n. sp., occlusal view of RP^3 (anterior is up), x2. B–B': stereopair, MF956 (Australian Museum), *P. rapha* from the Bingara fauna (Marcus 1976), RP^3, x2. C–C': stereopair F7894, *P. texasensis*, occlusal view of RM^1 (anterior is to the right), x2. D–D': stereopair F7894, *P. texasensis* lingual view RP^3 (anterior is up), x2. E–E': stereopair F7894, *P. texasensis*, RP^3, buccal view (anterior is up), x2. F–F': stereopair MF956, *P. rapha*, RP^3, lingual view (anterior is up), x2. G–G': stereopair MF956, *P. rapha*, RP^3, buccal view (anterior is up), x2. H: F8495 (I^1) and F9464 (I^2) (not found together but interpreted here to be conspecific, see text), *Protemnodon brehus*, buccal view of I^{1-2}, x1. I: F8154, *Protemnodon*, cf. *P. brehus*, P^3 fragment, x1. J: F8238, *P. brehus*, RP^3 (anterior is up), x1. K, F7896, *Macropus (Osphranter)* cf. *M. (O.) altus* R and LP^2–M^1, occlusal view (anterior is up), x1. L: F8304, *Macropus (Macropus)* sp., cf. *M. (M.) giganteus*, P_3, x2. M: F8431, *Macropus (M.) titan*, LP^2, x1. N: F8258, *Rhinolophus megaphyllus*, LP_3–M_s, x2. O: F8141, *Nyctophilus timoriensis*, LP_3–M_2, x2. P: *Minopterus schreibersii*, F8150, x2. Q: F8085, *Rattus lutreolus*, LM^{1-3}, x2. R: F8421, *Pseudomys novaehollandiae*, LM^{1-3}, x2.

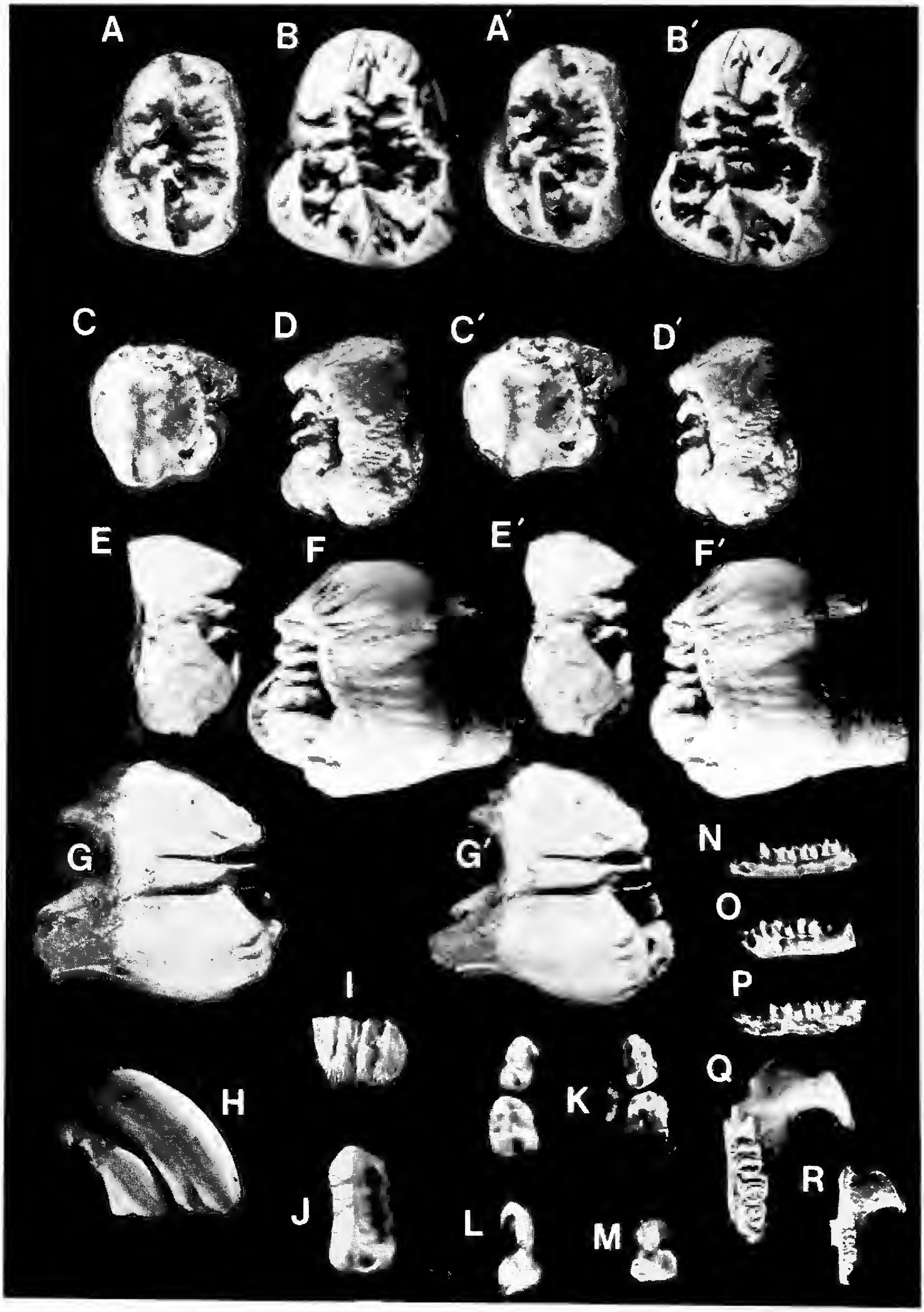
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PLATE 9

Mammals from Russenden (rear) Cave (VR-14). A–B: F6132, *Protemnodon roechus*, skull fragment with L and RP^3–M^5, x 0·5. C: F8528, *Conilurus albipes*, skull fragment with L and RM^{1-3}, x2. D: F8926, *Pseudomys* sp., cf. *P. gracilicaudatus* (from Rabscuttle Hole), RM^{1-3}, ×2. E: F9453, *Pseudomys* sp., cf. *P. desertor*, RI_1–M_3, ×2. F: F8411, *Pseudomys* sp., cf. *P. oralis*, RM_{1-3}, ×2. G: F9446, *Rattus* sp., cf. *R. fuscipes*, LI_1–M_3, x2.

Photograph in the Bone Chamber of Russenden (rear) Cave (VR-14) (see Figs. 1–2 for scale). This view is facing the east wall and is taken from within the excavation. Features are as follows: *a*, the crawl space that leads to the main chamber of Russenden Cave (VR-2); *b*, the massive limestone ceiling of the Bone Chamber; *c*, the fracture space between the ceiling and a dropped block of ceiling limestone; *d*, the dropped chunk of ceiling limestone; *e*, flowstone cone, centre of distribution for massive flowstones in Bone Chamber; *f*, massive flowstones capped by more finely laminated flowstones; *g*, blocks of flowstone falling into cavity below; *h*, breccia merging with lower parts of massive flowstone; *i*, less indurated sediments laterally equivalent to UB and LP units (see Fig. 2); *j*, space under flowstone produced either by erosion or compaction of sediments.

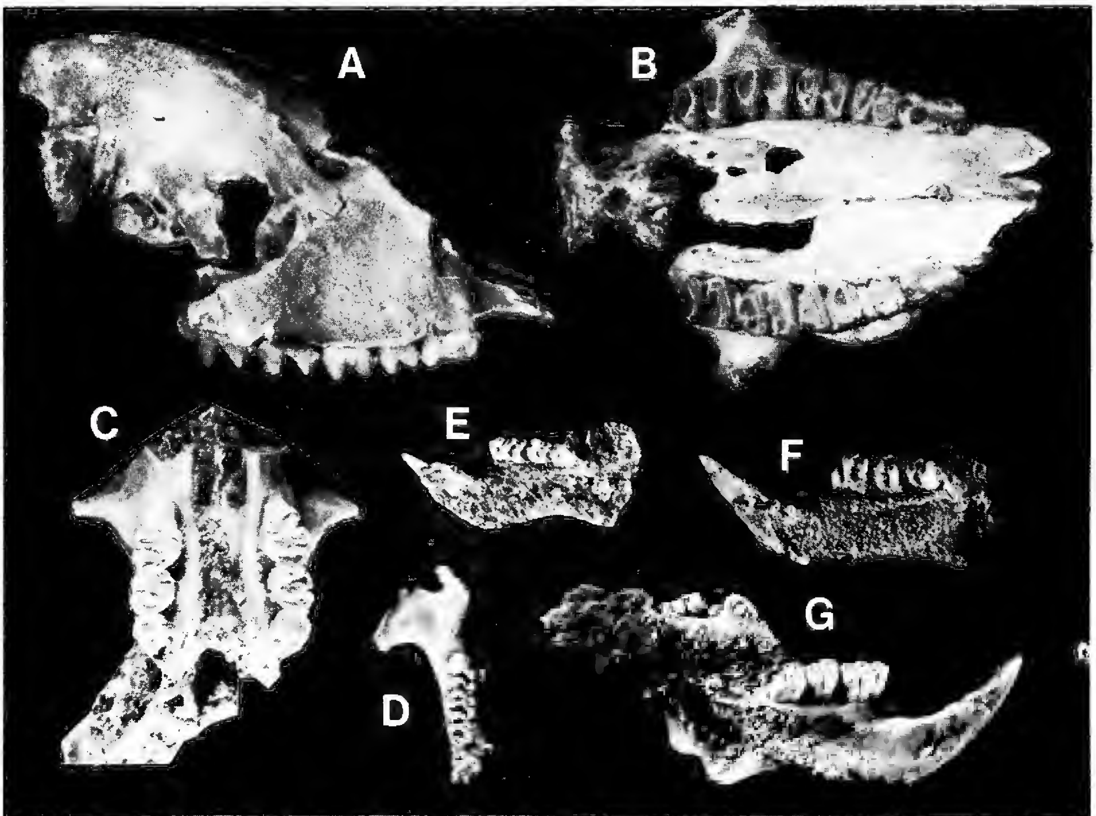
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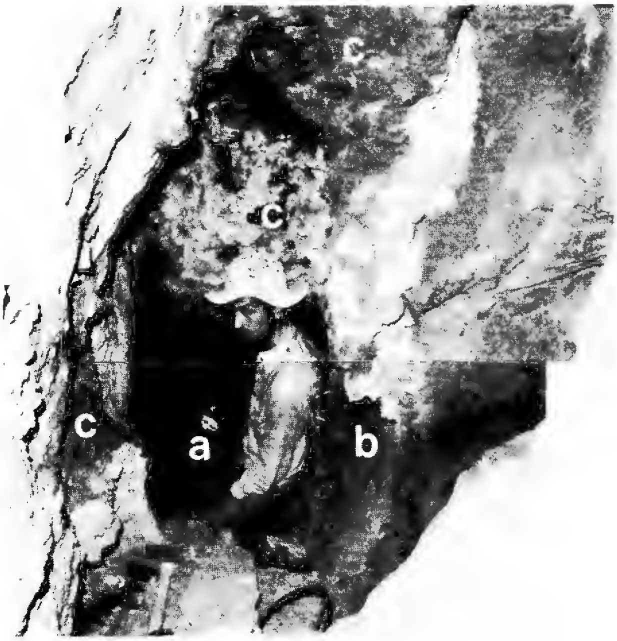
PLATE 10

The Joint (VR-5). A and B are views of the 'Breccia Keyhole' (see text) after removal of bone breccia from the walls. A is looking southeast; B is looking northwest; C is a horizontal view looking along The Joint itself. The walls are almost vertical. The soil floor (a) appears as the dark strip between the walls. A head (at d) indicates the position of the first keyhole in The Joint, formed in massive limestone. D is a view looking up towards the top of The Joint fissure, past remnant masses of bone breccia. Materials indicated are as follows: *a*, soil floor; *b*, massive limestone walls of The Joint; *c*, bone breccia; and *d*, position of limestone keyhole.



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Mem. Qd Mus. **19**(1): 111-19, pl. 11. [1978]

MODERN FAUNA AND FLORA OF THE TEXAS CAVES AREA, SOUTHEASTERN QUEENSLAND

MICHAEL ARCHER
Queensland Museum

ABSTRACT

Compilations of modern faunal and floral survey data by various researchers from the Texas Caves area are presented. Reptiles and birds are very diverse but the terrestrial native mammal fauna is depauperate. Introduced mammals and plants are abundant and they probably contributed to the apparent extinction in the area of what was once a very diverse mammal fauna.

In 1973 and 1975, in anticipation of the flooding of Pike Creek and the submergence of the Texas Caves, the Queensland Museum undertook to survey the fossils of the Texas Caves (Archer 1978), as well as aspects of the modern fauna of the Viator Hill area. Grimes (1978) has reviewed the geology and caves of the area. Smith and Shipp (1978) have described a nicoletiid (silverfish) from one of the Texas Caves. The following people have been responsible for particular surveys and the lists provided below: R. McKay (Queensland Museum), lycosid spiders, freshwater fish; G. Czechura (working in conjunction with Kelvin Grove College of Advanced Education), amphibians and reptiles; P. Dwyer and D. Joffe (Queensland University and Queensland Museum), birds; M. Archer and S. Van Dyck (Queensland Museum), mammals; J. Marsh (Kelvin Grove College of Advanced Education), plants; and E. Hamilton-Smith, cave invertebrates in general.

ARACHNIDA (LYCOSIDAE ONLY): R. McKay

Lycosa godeffroyi: claysoils on river banks, and clay alluvium.
L. semicincta: grasslands only.
L. palabunda: cracked clay soils with grass clumps.
L. speciosa: under riverine trees and bushes.
L. lapidosa: under stones on river banks.
Artoria, new species: under small pebbles on river banks.

MOLLUSCS

Numerous specimens of gastropods have been collected from the surface of Viator Hill and the surfaces of several cave floors by A. Burrows and K. Grimes in 1974, 5 and 6. These specimens are in the collections of the National Museum of Victoria or the private collection of F. W. Aslin. They are currently under study by F. W. Aslin.

PISCES: R. McKay

All fish were netted from the Pike Creek, adjacent to Viator Hill.
Retropinna semoni (e.g. I. 10360)
Tandanus tandanus (e.g. I. 10361)
Nematocentrus fluviatilis (e.g. I. 10362)
Craterocephalus fluviatilis (e.g. I. 10363)
Hypseleotris klunzingeri (e.g. I. 10364)
Gambusia affinis (introduced species, e.g. I. 10359)

AMPHIBIA: G. Czechura

Habitats in which animals were seen or collected have been abbreviated as follows: A, slopes of Viator Hill, limestone with variously thick vegetation; B, swamp near Pike Creek; C, caves area around Glen Lyon Cave, limestone but topographically lower and closer to Pike Creek, than A; D, *Callitris* forest on hill slopes, giving way to sclerophyll woodland on stoney areas around base of hills; and E, the 'camp' on the floodplain of Pike Creek, savannah woodland. Some specimens of amphibians have yet to be accessed into the collections of the Queensland Museum. An asterisk after a name indicates the species was observed but not collected.

Family Pelodryadidae

*Littoria caerulea**: common near water; some were found in caves; A–E.
L. peroni: found in buildings (abandoned homesteads) and in swampy areas; B, C.
L. rubella (e.g. J25926): common in swampy areas and along creeks; B–E.
L. latopalmata: found in grassy areas and along creeks; B–D.
L. lesueuri (e.g. J25928–33): some were found in caves, as well as in damp areas; C–D.
Ranidella parinsignifera: found calling from swampy areas; B–D.

Family Myobatrachidae

Uperoleia rugosa (e.g. J25922): found in swampy areas, and near a small creek, calling from moist grassy areas; B, D.
Lymnodynastes fletcheri (e.g. J25925): found in densly grassed areas near standing water; B–D.
L. terrareginiae (e.g. J25923): found breeding in swampy areas; B.
L. dumerilii: found in swampy areas and along creek margins; B, D.
L. ornatus (e.g. J25924): common near water, on dirt roads, and in caves; they were breeding; A–E.

REPTILIA: G. Czechura

Habitats surveyed are the same as those noted above for amphibians and are similarly abbreviated.

Order Squamata

Suborder Lacertilia
Family Gekkonidae

Heteronotia binoei (e.g. J25936): common amongst rocks; A, C–D.
Oedura robusta: found under bark on trees; D.
Gehyra australis (e.g. J25937): found under bark on trees; C.
Diplodactylus sp.*: observed in a stoney area adjacent to a road; E.

Family Scincidae

Morethia boulengeri: found under debris; C.
*M. taeniopleurus**: observed among rocks and leaf litter; A, C.
Lerista fragilis: found under wood in area of *Callitris* pine; D.
Cryptoblepharus boutonii virgatus: common on rocks and trees; A, C–E.
Ctenotus robustus (e.g. J25938–40): found among rocks; A, C.
Carlia burnetti: found among leaf litter in woodlands; D.
C. vivax (e.g. J25916–20): found among rocks and grassy areas; A, C–D.
Egernia striolata: found on tree trunks; C.
***E. cunninghami* (e.g. J26336): found widely on rocky outcrops; A, C.
*Sphenomorphus quoyii**: observed among rocks and in cool damp areas; C.

Family Pygopodidae

Lialis burtoni (e.g. J25934): common in rocky areas; A.
Delma plebia: found under a log in grassland; A.

Family Agamidae

*Amphibolurus barbatus**: found in woodlands; D.
A. nobbi: (no notes).
A. sp.: under fallen timber; C.

Family Varanidae

*Varanus tristis orientalis**: found under rocks; A.
*V. gouldii**: commonly sighed; A.
*V. varius**: commonly sighed; A.

Suborder Ophidia
Family Boidae

Liasis childreni (e.g. J26335): found near area of *Callitris;* D.
*Morelia spilotes variegata**: (observed, no notes).

Family Colubridae

*Dendrolaphis punctatus**: (observed, no notes).

Family Elapidae

Suta gouldii (= dwyeri): found near camp at night; D.
Pseudechis porphyriacus (e.g. J25941): found near caves, and along Pike Creek; A.
*Demansia psammophis**: commonly observed in area; C–E.

Order Chelonia

Family Chelyidae

Elseya latisternum: observed in large numbers by J. Covacevich (pers. comm.) in the still pools of Pike Creek.

AVES: P. Dwyer and D. Joffe

Species with an asterisk after the name are represented by specimens in the Queensland Museum. The remainder are sight identifications.
Hoary-headed Grebe *(Poliocephalus poliocephalus)*
Little Grebe *(Tachybaptus novaehollandiae)*

---

*Observed but not collected.
**The material referred here to *Egernia cunninghami* may be separable taxonomically from other southeastern Queensland populations of this species.

Australian Pelican *(Pelecanus conspicillatus)*
Pied Cormorant *(Phalacrocorax varius)*
Little Pied Cormorant *(P. melanoleucos)*
Black Cormorant *(P. carbo)*
White-necked Heron *(Ardea pacifica)*
White-faced Heron *(A. novaehollandiae)*
Nankeen Night-heron *(Nycticorax caledonicus)*
Straw-necked Ibis *(Threskiornis spinicollis)*
Black Duck *(Anas superciliosa)*
Crested Hawk *(Aviceda subcristata)*
Whistling Kite *(Haliastur sphenurus)*
Wedge-tailed Eagle *(Aquila audax)*
Brown Falcon *(Falco berigora)*
Nankeen Kestrel *(F. cenchroides)*
Dusky Moorhen *(Gallinula tenebrosa)*
Coot *(Fulica atra)*
Masked Plover *(Vanellus miles)*
Black-fronted Dotterel *(Charadrius melanops)*
Peaceful Dove *(Geopelia striata)**
Bar-shouldered Dove *(G. humeralis)*
Common Bronzewing *(Phaps chalcoptera)**
Crested Pigeon *(Ocyphaps lophotes)*
Galah *(Cacatua roseicapilla)*
Little Lorikeet *(Glossopsitta pusilla)*
King Parrot *(Alisterus scapularis)*
Red-winged Parrot *(Aprosmictus erythropterus)*
Eastern Rosella *(Platycercus eximius)**
Pale-headed Rosella *(Platycercus adscitus)*
Red-rumped Parrot *(Psephotus haematonotus)*
Turquoise Parrot *(Neophema pulchella)*
Pallid Cuckoo *(Cuculus pallidus)*
Spotted Owl *(Ninox novaeseelandiae)*
Barn Owl *(Tyto alba)*
Owlet-nightjar *(Aegotheles cristatus)*
Spine-tailed Swift *(Hirundapus caudacutus)*
Fork-tailed Swift *(Apus pacificus)*
Kookaburra *(Dacelo novaequineae)*
Red-backed Kingfisher *(Halcyon pyrrhopygia)*
Sacred Kingfisher *(H. sancta)*
Rainbow Bee-eater *(Merops ornatus)**
Dollarbird *(Eurystomus orientalis)*
White-backed Swallow *(Cheramoeca leucosternum)*
Welcome Swallow *(Hirundo neoxena)**
Fairy Martin *(Cecropis ariel)*
Richard's Pipit *(Anthus novaeseelandiae)*
Black-faced Cuckoo-shrike *(Coracina novaehollandiae)**
White-winged Triller *(Lalage suerii)**
Hooded Robin *(Melanodryas cucullata)*
Eastern Yellow Robin *(Eosaltria australis)*
Jacky Winter *(Microeca leucophaea)*
Rufous Whistler *(Pachycephala rufiventris)**
Grey Shrike-thrush *(Colluricincta harmonica)**
Restless Flycatcher *(Myiagra inquieta)*
Willie Wagtail *(Rhipidura leucophrys)**
Grey-crowned Babbler *(Pomatostomus temporalis)**
Rufous Songlark *(Cinclorhamphus mathewsi)**
Brown Songlark *(C. cruralis)*
Superb Blue Wren *(Malurus cyaneus)**
Speckled Warbler *(Sericornis sagittatus)**
White-throated Warbler *(Gerygone olivacea)*
Yellow-rumped Thornbill *(Acanthiza chrysorrhoa)**
Southern Whiteface *(Aphelocephala leucopsis)**
Varied Sittella *(Daphoenositta chrysoptera)*
Brown Treecreeper *(Climacteris picumnus)*
Spiny-cheeked Honeyeater *(Acanthagenys rufogularis)*
Striped Honeyeater *(Plectorhyncha lanceolata)*
Noisy Friarbird *(Philemon corniculatus)**
Little Friarbird *(P. citreogularis)**
Noisy Minor *(Manorima melanocephala)**
White-earred Honeyeater *(Lichenostomus leucotis)**
Fuscous Honeyeater *(L. fuscus)*
White-plumed Honeyeater *(L. penicillatus)*
Brown Honeyeater *(Lichmera indistincta)**
Mistletoebird *(Dicaeum hirundinaceum)**
Striated Pardalote *(Pardalotus striatus)*
House Sparrow *(Passer domesticus)*
Red-browed Firetail *(Emblema temporalis)*
Diamond Firetail *(E. guttata)*
Black-throated Finch *(Poephila cincta)*
Plum-headed Finch *(Aidemosyne modesta)**
Chestnut-breasted Finch *(Lonchura castaneothorax)*
Common Starling *(Sturnus vulgaris)*
White-winged Chough *(Corcorax melanorhamphos)*
Apostlebird *(Struthidea cinerea)*
Australian Magpie Lark *(Grallina cyanoleuca)*
White-breasted Woodswallow *(Artamus leucorhynchus)*
Masked Woodswallow *(A. personatus)*
White-browed Woodswallow *(A. superciliosus)**
Dusky Woodswallow *(A. cyanopterus)**
Grey Butcherbird *(Cracticus torquatus)*
Pied Butcherbird *(C. nigrogularis)**
Australian Magpie *(Gymnorhina tibicen)*
Pied Currawong *(Strepera graculina)**
Torresian Crow *(Corvus orru)*.

MAMMALIA: M. Archer and S. Van Dyck

Mammal surveys in the Texas Caves area were run once by Archer in February, 1975, in conjunction with the students and staff of Kelvin Grove College of Advanced Education; and again by Van Dyck in March, 1976. Traps used included wire live traps, Elliot live traps, postholes, breakback traps and mist-nets. Both surveys in cleared and uncleared country were disappointing and resulted in no native mammals except bats, Brush-tailed Possums, monotremes, water rats and two of the larger kangaroo species. Introduced mammals were common, and we can only conclude that the area is now depauperate in native mammals at least in part because of these introduced species. From the results of the palaeontological survey (Archer 1978), it is clear that the area once supported a very diverse fauna.

Endemic mammals:

Tachyglossidae

Tacyglossus aculeatus one individual found on grassed floodplain of Pike Creek

Ornithorhynchidae

Ornithorhynchus anatinus: individuals observed swimming in Pike Creek in early morning

Macropodidae

Macropus giganteus (e.g. JM1862): common on lower hillslopes

M. robustus (e.g. JM2247): common on Viator Hill

Phalangeridae

Trichosurus vulpecula: commonly observed along creeks, spotlighted at night

Vespertilionidae

Miniopterus schreibersii: colonies present in at least Main Cave of Viator Hill

Chalinolobus gouldii (e.g. JM1460): individuals netted over Pike Creek and adjacent tributaries

Eptesicus pumilus (e.g. JM995–6): collected from verandah of abandoned Russenden Station house

Nycticeius greyi (e.g. JM1465): individuals netted over Pike Creek and adjacent tributaries

Rhinolophidae

Rhinolophus megaphyllus: present in Texas Caves (P. Dwyer, pers. comm.)

Mollosidae

Tadarida loriae (e.g. JM1462): Individuals netted over Pike Creek and tributaries

Muridae

Hydromys chrysogaster: two individuals were observed, by J. Covacevich (pers. comm.), swimming in Pike Creek

Introduced mammals

Muridae

Rattus rattus: found around abandoned buildings, on the surface of some of the caves, and in the bush on and around Viator Hill

Mus musculus: trapped in same situations as *Rattus rattus*

Bovidae

Bos taurus: most common mammal in the area

Ovis aries: common

Equidae

Equus caballus: uncommon

Felidae

Felis cattus (many collected but none retained): commonly observed on Viator Hill

Leporidae

Oryctolagus cuniculus: commonly observed

Canidae

Vulpes vulpes: commonly observed

In addition, the surfaces of many of the caves have very fresh-appearing bones representing some of the above mammals as well as the following (murids were identified by J. Mahoney):

Macropodidae

Petrogale sp.: as noted elsewhere (Archer 1978), none were seen live, but the great abundance of fresh bones representing Rock Wallabies suggests they may still survive in adjacent areas.

Muridae

Rattus sp., cf. *R. fuscipes:* fresh-appearing dentaries were collected from an unnamed pothole by A. W. Graham, 22.1.1970.

Pseudomys gracilicaudatus: two dentaries and a maxilla of fresh appearance were collected by A. Burrows from the surface of Rabscuttle Cave, 18.7.1975.

CAVERNICOLOUS FAUNA: E. Hamilton-Smith

Smith and Shipp (1978) have described a new nicoletiid silverfish from Russenden Cave (VR-2) and note they were evidently common in other caves of the area.

The annotated list provided below is an amalgamation of collections made over several years.

Isopoda (indet.)

Mikes Pot (VR-6), R. M. Bourke, 1.3.69; Crystal Cave (VR-3), R. M. Bourke, 22.3.69; Main Viator Cave (VR-1), R. M. Bourke, 2.3.69; Hamilton-Smith, 8.2.64, 22.3.69; Russenden Cave (VR-2?), J. Toop, 26.11.72.

Diplopoda (indet.)

Glen Lyon Cave (GL-1), R. M. Bourke, 1.3.70; Main Viator Cave, Hamilton-Smith, 22.3.69.

Araneae (indet.)

The Joint (VR-5), R. M. Bourke, 22.3.69; Main Viator Cave, Hamilton-Smith, 22.3.69.

Thysanura

Nicoletiidae

Nicolotia russendenesis Smith and Shipp

Russenden Cave (and other caves), J. Toop, 26.11.72.

Orthoptera
Gryllidae
Endacusta sp.

Mike's Pot, R. M. Bourke, 2.3.70.

Dictyoptera
Blatellidae
Gislenia sp.

Crystal Cave, R. M. Bourke, 22.3.69; Russenden Cave, R. M. Bourke, 2.3.69, Hamilton-Smith, 22.3.69; J. Toop, 26.11.72; Glen Lyon Cave, R. M. Bourke, 1.3.70; Main Viator Cave, Hamilton-Smith, 8.2.64, 22.3.69.

This species is undescribed. Only immature specimens have been collected. It is closely related to, but distinct from *G. australis* (Saussure) (M. J. Mackerras, pers. comm.).

Psocoptera
Phyllipsocidae
Phyllipsocus ramburi Selys-Longchamps

Main Viator Cave, Hamilton-Smith, 22.3.69.

Coleoptera
Carabidae
Notospeophonus sp.

Main Viator Cave, Hamilton-Smith, 8.2.64.

The genus *Notospeophonus* appears to be virtually confined to caves in southern and eastern Australia. It consists of a number of closely related species. The Texas form is the most northerly representative of the genus. It is currently undescribed but appears to be conspecific with a species occurring in the Timor Caves near Murrurundi, N.S.W. (B.P. Moore, pers. comm.).

Cratogaster melas Carter

Mike's Pot, R. M. Bourke, 1.3.69; The Joint, Hamilton-Smith, 22.3.69.

Spp. indet.

Glen Lyon Cave, J. Toop, 3.3.71; Main Viator Cave, J. Toop, 3.3.71.

Anisotomidae
Pseudonemadus sp.

Main Viator Cave, Hamilton-Smith, 8.2.64.

This record was published (*J. Aust. ent. Soc.* **6**: 114) as *P. integer* (Portevin), but this determination must be re-assessed in the light of more recent taxonomic revision of the genus.

Diptera
Family indet.

Glen Lyon Cave, R. M. Bourke, 1.3.70; Russenden Cave, J. Toop, 26.11.72.

Streblidae
Brachytarsina amboinensis uniformis Maa

Main Viator Cave. (Maa 1971).

This specimen was taken from the bat *Eptesicus* sp. (cited by Maa under the name *Vespadelus pumilus*) but normally occurs on *Miniopterus* spp., which also occur in the cave.

Nycteribiidae
Basilia musgravei Theodor

This specimen is noted by Maa (1971). It was taken from *Eptesicus* sp. (*Vespadellus pumilus* in Maa) which is its normal host.

In general, although some of these specimens require further study, none appear to be troglobitic. Of the determined species, only *Nicoletia russendenensis* and *Notospeophonus* sp. appear from our present knowledge to be confined to caves. However, the former is probably endogenous rather than truly cavernicolous and the latter is a troglophile. With the exception of *Notospeophonus* sp., the assemblage is typical of that found in caves throughout the northern part of Australia.

PLANTS: J. Marsh (noted above), and E. Ross and N. Brynes (Queensland Herberium).

Plants were collected by J. Marsh in conjunction with students of Kelvin Grove College of Advanced Education. They were identified by E. Ross and N. Brynes. Common names are also listed if they are available.

Amaranthaceae

Nyssanthes diffusa (Barb-wire Weed)

Bignoniaceae

Pandorea pandorana (Wonga vine)

Boraginaceae

Heliotropium amplexicaule (Blue Heliotrope)

Cactaceae

Opuntia sp. (Prickly Pear)

Capparidaceae

Breynia oblongifolia (Coffee Bush)

Chenopodiaceae

Bassia birchii (Galvanized Burr)
Rhagodia nutans (one of the berry saltbushes)

Commelinaceae

Commelina cyanea (Wandering Jew)

Compositae

Calotis lappulacen (Daisy Burr)
Cassinia quiquefaria
Centaurea calciptrapa
Cirsium vulgare (Spear Thistle)
Eclipta platyglossa
Erigeron canadensis (a fleabane)
Glossogyne tenuifolia (Native Cobbler's Peg)
Lactuca saligna (Wild Lettuce)
Vittadinia triloba (Fuzz Weed)
Zinnia peruviana (Wild Zinnia)

Convolvulaceae

Convolvulus erubescens (Australian Bindweed)
Dichondra repens (Kidney Weed)

Cruciferae

Sisybrium officinale

Cupressaceae

Callitris sp. (a cyprus pine)

Cyperaceae

Fimbristylis dichotoma (a sedge)
Scirpus validus (a sedge)

Euphorbiaceae

Phyllanthus simplex

Geraniaceae

Geranium solanderi

Gramineae

Aristida sp.
Bothriochloa decipiens (Bitter or Pitted Blue Grass)
Chloris truncata (one of the windmill grasses)
Cymbopogon refractus (Barb-wire Grass)
Digitaria divaricatissima (Blow-away Grass)
Echinopogon intermedius (one of the rough bearded grasses)
E. nutans (one of the rough bearded grasses)
Enneapogon gracilis (one of the bottle washer grasses)
Eragrostis sp.
Panicum simile
Setaria geniculata (Slender Pigeon Grass)
Stipa ramosissma
Sporobolus creber (Hedge Mustard)
Vetiveria filipes

Labiatae

Ajuga australis (Australian Bugle)
Mentha saturejoides (Native Pennyroyal)
Salvia reflexa (Mintweed)

Leguminosae

Cassia barclayana (a native cassia)
Desmodium sp. (a tick trefoil)
Glycine tabacina (Glycine Pea)
G. tormentella (Woolly Glycine)

Malvaceae

Malvastrum spicatum (Malvastrum)
Pavonia hastata (Pavonia)
Sida corrugata (Corrugated Sida)
S. rhombifolia
S. subspicata

Menispermaceae

Stephania japonica var. *discolor* (Tape Vine)

Myrtaceae

Angophora floribunda
Eucalyptus melanophloia
Callistemon viminalis
Casuarina cunninghamii

Nyctaginaceae

Boerhavia diffusa (Jar Vine)

Oleaceae

Jasminum svavissimum (one of the native jasmines)
Notelaea mircocarpa (Native olive)

Oxalidaceae

Oxalis corniculata (Yellow Woodsquirrel or Creeping Oxalis)

Philesiaceae

Eustrephus latifolius (Wombat Berry)

Polygonaceae

Rumex brownii (Swamp Dock)

Portulacaceae

Portulaca oleracea (Pigweed)

Ranunculaceae

Clematis microphylla (Narrow-leaved Headache Vine)

Rosaceae

Rubus parvifolius (a raspberry)

Rubiaceae

Asperula conferta (Common Woodruff)
Canthium buxifolium
Wahlenburiga sp. (an Australian Bluebell)

Rutaceae

Geijera parviflora (Wilga)

Simaroubaceae

Ailanthus altissima (Tree-of-Heaven)

Sinopteridaceae

Cheilanthes distans

Solanaceae

Petunia hybrida (Common garden Petunia)

Sterculiaceae

Brachychiton diversifolium (Northern or Tropical Kurrajong)
B. populneum (Kurrajong)
B. rupestris (Coffee Bush)

Thymelaeceae

Pimelea curviflora (Tough-barked Rice Flower)
P. liniflora (Queen-of-the-Bush)

Umbelliferae

Apium leptophyllum (Slender celery)

Verbenaceae

Verbena officinalis (Common Verbena)

Vitidaceae

Cissus opaca

Xanthorrhoeaceae

Lomandra multiflora (a mat rush)

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People who gave useful advice and criticism of the lists include B. Campbell, G. Ingram, S. Van Dyck, D. Vernon, M. Grant, J. Covacevich, and E. Hamilton-Smith. Ms R. Ownes typed the manuscript. Mr A. Elliot took the photographs used in plate 11.

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PLATE 11

FIG. A: Habitats around Viator Hill, looking northeast toward the base camp at the foot of the cliffs of Viator Hill. The savannah is developed on the floodplain of Pike Creek. A dry meander channel forms a trough through the floodplain. Everything visible here is now under water except for the tall hills in the background.

FIG. B: Savannah woodland along the edge of Viator Hill. Birds, reptiles and amphibians were common in this area, but the native small mammal fauna was depauperate. Dam waters have now covered the area shown.

A

B

Mem. Qd Mus. **19**(1): 121-3, pl 12. [1977]

A NEW SPECIES OF CAVE-DWELLING NICOLETIID SILVERFISH (THYSANURA: INSECTA) FROM THE TEXAS CAVES, QUEENSLAND

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ABSTRACT

Nicoletia russendenensis n. sp. is described from specimens collected in Russenden Cave (VR-2), southeastern Queensland. It differs from other *Nicoletia* in the absence of styli on abdominal segment II and the presence of a pit on the vertex.

Specimens of a species of nicoletiid silverfish were collected by G. J. Toop on 26 November 1972, from Russenden Cave, Texas, Queensland. They were common here and in other caves in the area suggesting that they may be cavernicolous. The type locality is now under the waters of Glenlyon Dam.

Nicoletiids are narrow, parallel-sided insects, lacking eyes and often pigment or scales. They are phytophagous and usually subterranean or cavernicolous in habit. The genus *Nicoletia* Gerv. is characterised by a lack of scales and pigment, with styli on abdominal segments II–IX, and exertile vesicles on segments II–VII. The species described here is placed in the genus *Nicoletia* although it has lost the styli on segment II. However, work now in progress on other undescribed nicoletiids from Australia may create the need for a new subgenus to be erected.

Nicoletia russendenensis n. sp.
(Fig. 1; Plate 12A, B)

HOLOTYPE: T7514 (Queensland Museum), male, collected G. J. Toop, 26.xi.1972, Russenden Cave (VR-2), Viator Hill adjacent to Pike Creek, Glenlyon Station, southeastern Queensland.

OTHER MATERIAL: Three males, two females and one juvenile female, collected G. J. Toop, 26.xi.1972, Russenden Cave. Many others were seen in the caves prior to and especially during the flooding of the caves (Toop pers comm). A paratype has been lodged with the Australian National Insect Collection (unregistered). The remainder of the specimens have been returned to the South Australian Museum (Specimen lot BS 2249).

DIAGNOSIS: This species differs from all other known species of *Nicoletia* in the absence of styli on abdominal segment II, and the presence of a pit on the vertex.

DESCRIPTION: General colour is white. Length: males up to 5·8 mm, females slightly smaller, up to 5·7 mm. Antennae are very long, 6–7 mm in both sexes. Caudal appendages are of unknown length (damaged in all specimens) but greater than 2·3 mm. Eyes are absent. Mandibles (Fig. 1a) have five primary teeth, and two secondary teeth (one on the first primary, the other on the third). Maxillae (Fig. 1b-c) have 4-segmented palpi with an exertile papilla distally, and a row of stout curved setae on the inner surface of the lacinea. Labium (Fig. 1d) has 4-segmented palps with each apical segment globose. An obvious pit occurs on the vertex of the head (presumably sensory) (Fig. 1e, Plate 12A). Setae on the margins of the terga are shorter than the length of the segment. Legs (Fig. 1f, g) have 3 claws. Styli occur on segments III–IX and exertile vesicles occur on segments II–VII.

In males the abdomen (Fig. 1H; Plate 12B) has parameres extending only a short distance beyond the base of the styli of segment IX.

In females the ovipositor (Fig. 1i) has eight-segmented anterior gonopophyses with small hooks on tips, the posterior gonopophyses terminate in small globose segments; the total length of the ovipositor is 1 mm.

ACKNOWLEDGMENTS

We would like to thank Elery Hamilton-Smith of the South Australian Museum for access to the material, and Dr Guy Cox and Dianne Hughes for the preparation of the electron micrographs.

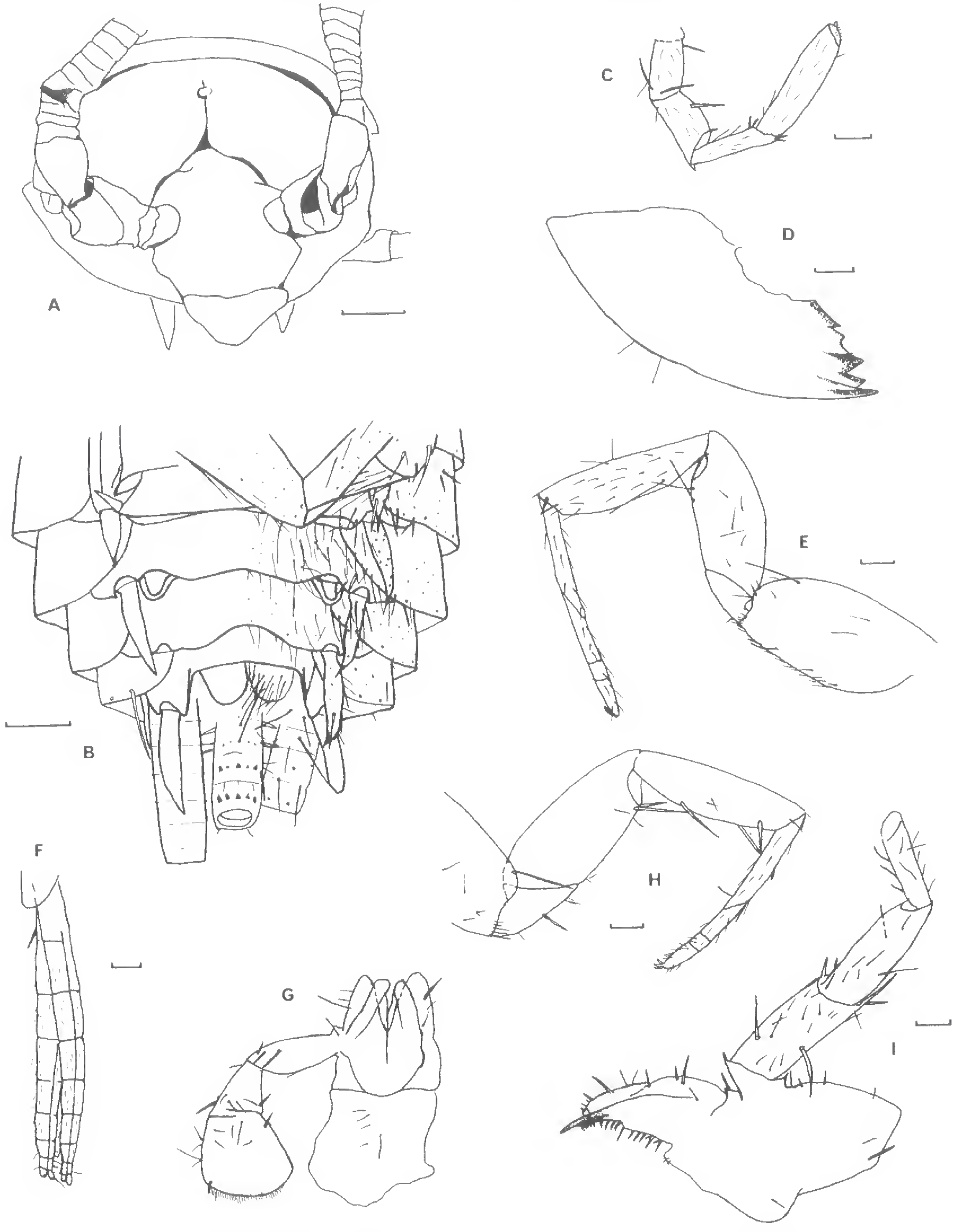
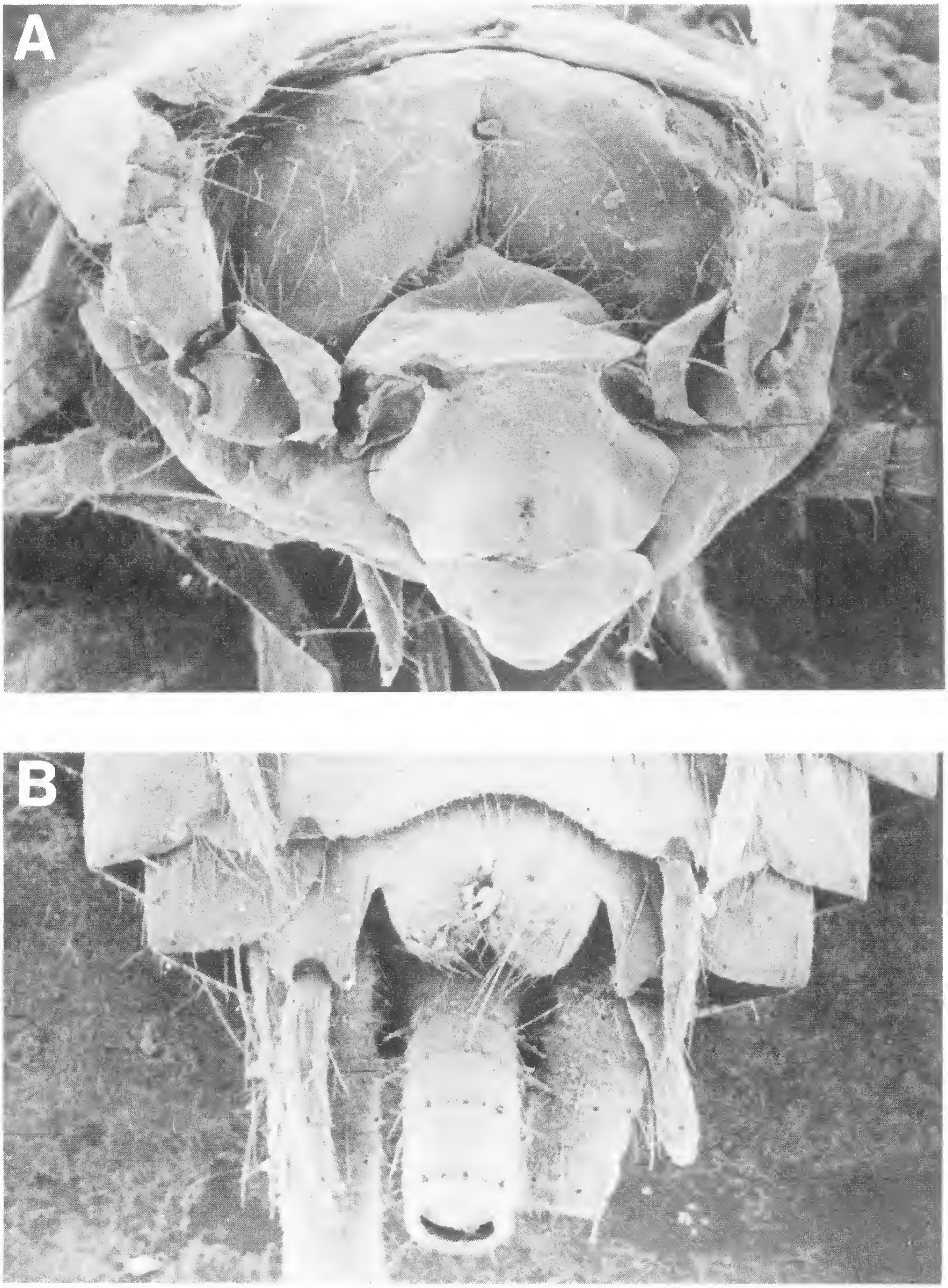


FIG. 1: *Nicoletia russendensis*. A, Cephalic view of male showing pit; B, Ventral abdomen (male), setae not drawn on right side of body; C, Complete maxillary palp (male); D, Mandible (male); E, Hind leg (female); F, Ovipositor, left lateroventral view; G, Labium, only one palp shown (male); H, Mid leg (female); I, Maxilla with apical segment of palp missing (male). Scale lines 0.1 mm.

FIG. A: Cephalic view of the head of a male, X200.
FIG. B: Ventral view of abdominal segments viii-ix of a male, X210.


A
B

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