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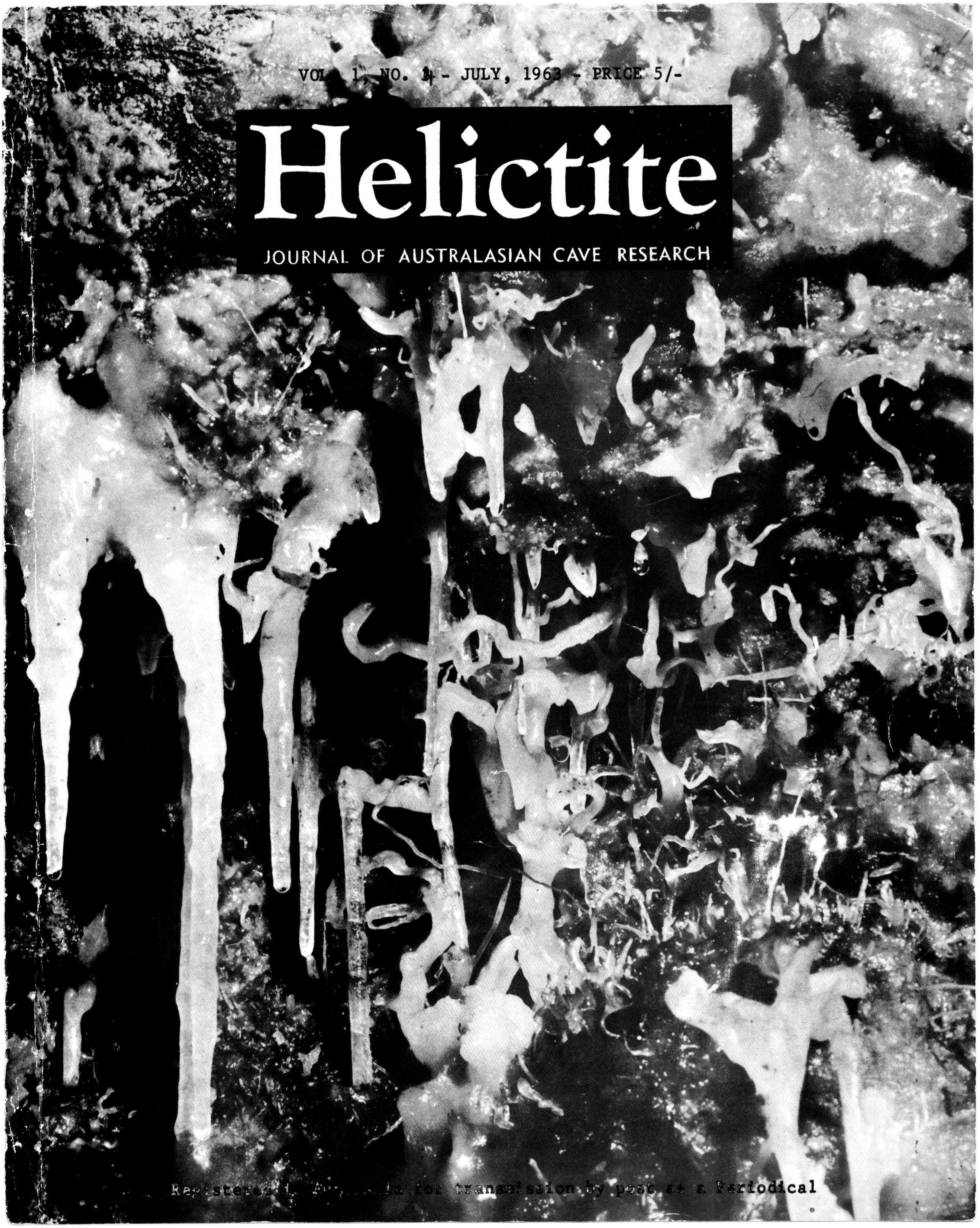

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CONTENTS

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ABSTRACT

THE FOSSIL VERTEBRATE FAUNA OF STRONGS' CAVE, BORANUP, WESTERN AUSTRALIA. By D.L. Cook. W. Aust. Nat. 8 (7), 1963 : 153-162.

This paper reports the occurrence of teeth and bone fragments from Strongs' Cave, Boranup, Western Australia, and compares it with a similar fauna recorded by L. Glauert in 1910, 1912 and 1914 from the Mammoth Cave in the Margaret River area. The material consists of shark's teeth, a lizard jaw, and teeth and bones of 15 species of mammals. Three orders of mammals are represented - Chiroptera, Rodentia and Marsupialia. In the latter, 13 species are listed belonging to six families.

The specimens were collected from the bed of a stream, downstream from a mound of talus, which partly fills the entrance chamber of the cave. The bone is fragmentary, and consequently difficult to identify. The mammalian and reptilian material had been washed from the talus mound and transported along the bed of the stream. It is thought that originally the animals fell through the cave opening onto the talus mound beneath. Eventually the roof collapsed, sealing off entry to all but the smallest mammals. The shark's teeth came from a beach deposit in the downstream section of the cave.

The material from the talus is divided into four groups: 1. Species which are extinct today. (i.e. *Nototherium mitchelli*). 2. Species which occurred in historic times, but are now almost certainly absent from the area. (i.e. *Setonix brachyurus*). 3. Species which have existed in historic times in Tasmania. (i.e. *Thylacinus cynocephalus*). 4. Species known to occur in the area at the present time. (i.e. *Trachysaurus rugosus*, *Macropus ocydromus*).

Cook concludes that the extinct forms are characteristic of Pleistocene deposits in many parts of Australia. Climatic conditions then are considered to have been more humid than at present. To support this, *Setonix brachyurus* (the quokka) is now confined to small isolated pockets in swamps on the coastal plain of Western Australia and on two islands, while *Sarcophilus harrisii* and *Thylacinus cynocephalus* occur today only in Tasmania, an area of high humidity, which suggests that this is a necessary factor for their survival. The age of the deposit has not been determined, as insufficient skeletal material has been collected. Also, because the material has not been found *in situ* contemporary charcoal cannot be used for a C-14 dating.

The fauna in the nearby Mammoth Cave has been dated at greater than 37,000 B.P. and is therefore at least as old as Upper Pleistocene. Six of the nine extinct forms from Mammoth Cave have not yet been found in Strongs' Cave. Comparison of the cave faunas and recent faunas, together with palaeoclimatic considerations, suggests the deposit is Pleistocene in age, but later than the Mammoth fauna, and extends into Recent or sub-modern times. -(A.M.R.)

MORPHOLOGY OF NEW ZEALAND LIMESTONE CAVES

By M. G. Laird, M.Sc.

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Abstract

Limestone caves in New Zealand can be divided into two distinct groups: those developed in the nearly flat-lying limestones of Oligocene age, and those formed in the strongly folded Mt. Arthur Marble of Upper Ordovician age. Caves formed in Oligocene limestone are typically horizontal in development, often having passages at several levels, and are frequently of considerable length. Those formed in Mt. Arthur Marble have mainly vertical development, some reaching a depth of several hundred feet. Previous research into the formation and geological history of New Zealand cave systems is discussed briefly, and the need for further work is emphasized.

Introduction

Speleologists in New Zealand are extremely fortunate in the high proportion of cave-containing calcareous rocks cropping out in their country. The rocks include Paleozoic marbles and limestones, and sediments of Upper Cretaceous to Upper Pliocene age ranging in composition from highly calcareous sandstones to pure calcarenites.

Although these calcareous rocks have a wide distribution in time and space in New Zealand, most cave exploration has been carried out in limestones of the Te Kuiti Group (or their correlatives elsewhere) of Lower to Mid Oligocene age, and in Mt. Arthur Marble, of Upper Ordovician age. Because the caves developed in the horizontal or gently-dipping Oligocene limestones are markedly different from those formed in the strongly-folded Mt. Arthur Marble, caves in the two rock types will be treated separately.

Caves in Oligocene Limestone

Limestones of the Te Kuiti Group crop out over hundreds of square miles in the south-western portion of Auckland Province, perhaps having their best development in the vacinity of Te Kuiti. Although large areas of limestone of similar age, lithology, and structural setting also occur along the north-west coast of the South Island, and to a lesser extent in Southland, the best studied area is south-west Auckland. The stratigraphic thickness varies from tens of feet to several hundreds. The limestones are characteristically strongly jointed, flaggy and well-bedded, the interval between bedding planes generally being one foot or less. Because of the low dip (usually less than ten degrees), there is a strong tendency towards the development of horizontal cave systems.

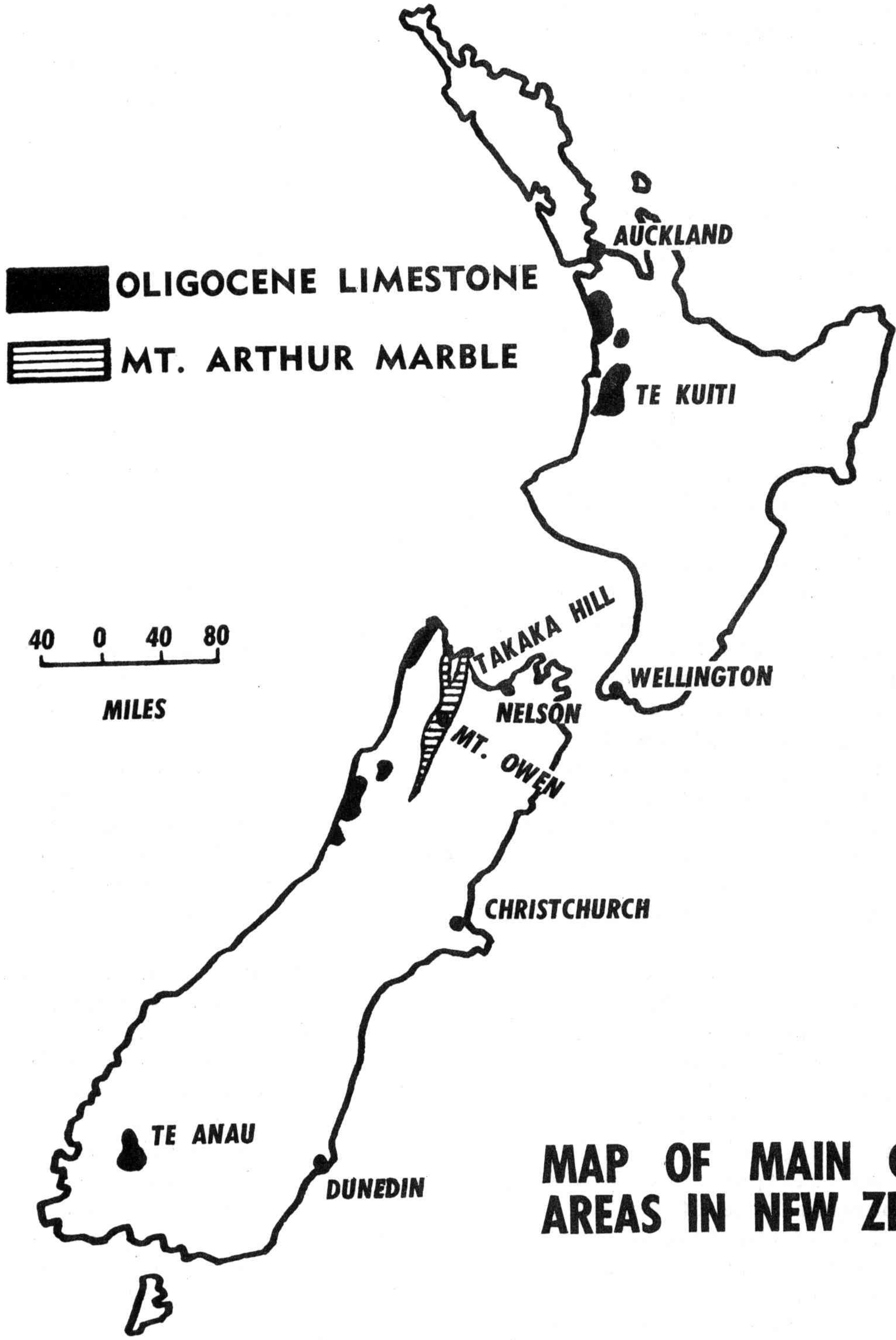
Although no systematic study of the topic has yet been undertaken, passage formation in this type of cave appears to be controlled largely by joint patterns, and to a lesser extent by faults. In a few cases it has been suggested that tectonic control has played an important role, and Barrett (1960, 1963) discusses two instances where development of the main cave passage probably has occurred along the axis of a gentle synclinal warp. It is probable that further research will reveal more examples of such control.

Almost all caves developed in the Oligocene limestones still contain the stream that formed them or helped in their development. In some cases the cave system consists of passages at several levels, the stream being found in the lowest and most recently formed level. Yet others have had a complex history, where the present active system has only an accidental relationship to the earlier formed and now abandoned upper level passages. One instance is recorded (Laird et al, 1959) of a stream abandoning its original underground route after forming a new entrance half a mile upstream from the old one. This later-formed cave then fortuitously intersected the abandoned system near the original resurgence.

Several of these complex systems attain considerable length. The longest cave at present known in New Zealand is "Gardner's Gut" (Te Kuiti district), whose surveyed length is four and a quarter miles (May, 1961). Exploration is still continuing in this cave and this figure cannot be considered final. The stream passages of the cave had been explored as long ago as 1955, but it was not until 1959 that hitherto unsuspected upper-level passages were discovered, at an average height of about 30 feet above stream level. This discovery almost doubled the explored length of the system. Several other caves, most of them in the Te Kuiti district, have a total length of more than two miles.

Flowstone and dripstone formations often form a glittering array in the dry upper levels of these complex systems. The Waitomo Tourist Caves, also situated in the Te Kuiti district, are known widely for their display of such speleothems. A few caves are also known for their deposits of gypsum, which occur sometimes in the form of crystals of selenite, and in other cases as delicate gypsum flowers.

Closely spaced sinkholes and shafts, for which the local Maori term "tomo" is often used, are a common feature of the landscape developed on the Oligocene limestones. Most are dry, but others carry a certain amount of local drainage. Sometimes this drainage forms the main stream of a cave system, while in other instances it finds its way from the bottom of a sinkhole via narrow, joint-controlled cracks to a larger underground stream. A solution, rather than a collapse, origin for these sinkholes



MAP OF MAIN CAVING AREAS IN NEW ZEALAND

must be accepted. However, for other shafts which intersect an underground system at some point along its course, a collapse origin seems more likely. The largest and best known of these tomos of collapse origin is the "Lost World", near Te Kuiti. At the bottom of this great 300 ft shaft, the Mangapu Stream flows through about an acre of surprisingly prolific vegetation, which draws sustenance from a meagre soil, and dim daylight from the hole above.

Collapse has also played an important role in the enlargement of some already formed cave systems. The best known example of this is in "Hollow Hill" cave, Te Kuiti district, where roof and wall collapse, followed by stream removal of the debris, has caused a cavern 790 ft long, 200 ft wide and 100 ft high.

Caves in Mt. Arthur Marble

Mt. Arthur Marble is found only in the South Island in Nelson Province, where it is exposed in a chain of mountains stretching for 100 miles south-south-west from Takaka Hill. (See map, page 65). So far, speleological activity has been limited mainly to Takaka Hill (3,000 ft) and Mt. Owen (6,155 ft). The marble forms lenses, locally reaching a thickness of 3,000 ft, in argillite, and ranges in colour from blue-black to pure white. It is characteristically massive or with poorly defined, widely separated bedding planes, and is strongly folded with few joints. The massive nature and lack of much jointing has tended to inhibit the easy flow of ground water, and accounts for the less frequent occurrence of sinkholes, and the comparative rarity of speleothems in these caves. Because of the strong folding, extensive horizontal cave systems have not been developed. However, small horizontal caves are found occasionally in the eroded axes of tight folds, or developed for a short distance along joints or small faults. The major cave systems are usually vertical in their upper part, and thus contrast strongly with those occurring in the Oligocene limestones. Development of these vertical systems is by solution down the steeply-dipping limbs of folds in the marble, down joints, or, commonly, down fault planes.

Some of these vertical cave systems achieve considerable depths, three known caves in marble descending more than 800 ft. The deepest system so far explored is "Harwood Hole", Takaka Hill, which has a total depth of just under 1,300 ft (Lambert and May, 1959; Pybus, 1960). This is probably the deepest cave outside Europe; certainly it is the deepest known in the Southern Hemisphere. Although a small, blind, dry valley leads to the entrance, this chasm, 200 ft by 100 ft at the top, appears to have been formed mainly by collapse into an already active cave system, as is evidenced by an enormous pile of rubble at the bottom of the 600 ft deep entrance shaft. Beyond the base of the pile of collapse debris the passages are unmistakably waterworn, although now nearly dry, and 300 yards from the foot of the shaft the active system, with its stream, is encountered. The major passages appear to be strike controlled.

Several cave systems in marble at a height of about 4,500 ft on Mt. Owen have also been discovered recently and studied. Nearly all originate in shafts, many of them formed along fault planes.

Age of New Zealand Limestone Caves

Very little research has been done on the problem of the age of limestone caves in New Zealand, detailed work having been carried out on only one cave system. Barrett (1963) provides microfloral evidence to show that infilling of passages in Kairimu Cave (south-west Auckland) occurred during a high sea level in Upper Pliocene or Lower Pleistocene times. In the same paper he also suggests that development of the oldest passages began in the Upper Miocene. Some of Barrett's conclusions may be contested, but at least the paper represents the first attempt to carry out research in a previously untouched field.

From the writer's own observations, it appears that the formation of at least one of the caves in marble at Mt. Owen pre-dates the present cycle of erosion. The entrance shafts to most of these caves carry, or show signs of having recently carried, surface drainage. An exception is the major hole, "Giant's Stairway", which reaches a depth of 850 ft below the surface. The entrance, a vertical shaft 106 ft deep, is situated on the flank of a hill. It is an active system with a small stream 350 ft down, and although the entrance shaft and the ones immediately below it are now free of running water, they are unmistakably waterworn, and not collapse features. No evidence of a former surface water-course remains. The region has, however, been heavily glaciated in the Pleistocene Period, and it is probable that the formation of this cave system pre-dates the last ice advance, which began approximately 15,000 years ago, and which moulded the present landscape in the area.

Up to the present time very little research into the development and geological history of cave systems in New Zealand has been attempted, and consequently the above can only be regarded as a very generalised account. It is hoped that this paper will act as a stimulus to other New Zealand speleologists and geologists to carry out more detailed studies on cave development and morphology. With the increasing interest in speleology in this country, and with the large number of caves now explored and surveyed, it is expected that there will be a stronger tendency towards research into these factors in the future.

Acknowledgements

The author wishes to thank Messrs. P.J. Barrett and V.R. MacGregor of Auckland University, and Mr. D.J. Young of the New Zealand Geological Survey, for useful suggestions and criticism during the preparation of this paper.

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A SECOND REPORT ON BAT-BANDING IN AUSTRALIA. By D. Purchase. C.S.I.R.O. Wildl. Res. Tech. Paper 2 : 1-16, 1962.

During the period August, 1957, to June 30, 1961, 10,704 bats of ten species were banded. The bent-winged bat, *Miniopterus schreibersi* (Kuhl), accounts for 10,191 of this total, and recoveries of this species indicate a seasonal dispersal from the breeding areas. To date, these are Willi Willi Bat Cave, Kempsey, N.S.W.; Church Cave, Wee Jasper, N.S.W.; Guano Cave, Lake Gillear, Victoria; and Bat Cave, Naracoorte, South Australia. The distances covered during seasonal dispersal of these bats suggest that the total population within its Australian range may be served by relatively few breeding sites.

Full data for 27 selected recoveries and comments on their general significance are given. A list of 80 localities in which bats have been banded is given. On July 1, 1960, bat-banding in Australia was placed on a national footing with the formation of a bat-banding scheme under the auspices of the Australian Bird Banding Scheme, and 12 banders have been enrolled. Present studies on *M. schreibersi* are listed as follows:-

1. Population structure and turnover. P.D. Dwyer, Kempsey, N.S.W.
2. Ecology of a colony. E. Hamilton-Smith and J.B. Hood, Naracoorte, South Australia.
3. Dispersal and distribution. D. Purchase, Wee Jasper, N.S.W.-(A.M.R.)

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THE LAVA CAVES OF VICTORIA

By C. D. Ollier, M.Sc.

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Introduction

Many lava tunnels are found in the Western District of Victoria, associated with volcanic eruptions of Pleistocene to Recent age, and some are probably only a few thousand years old. All Australian volcanoes are now extinct, but the most recently active were probably erupting up to 5,000 years ago, that is after the arrival of the Australian aboriginal. The newness of the Victorian caves results in original features being preserved in fine detail. All known lava caves have now been surveyed, mainly by members of the Victorian Cave Exploration Society.

Description of the Caves

It is intended to publish complete descriptions of the individual cave systems elsewhere, and in this paper is a descriptive summary with emphasis on geological features.

The absolute size of the caves varies greatly but, on the whole, they seem to be generally larger than those described in the literature. The caves range in size from small tubes a few inches across, which are mere tributaries to the main caves, up to large caves hundreds of feet long. The main chamber at Skipton Cave is 200 ft long, has a maximum width of 70 ft, and is 15 ft high. Church Cave, Byaduk, contains a chamber roughly 170 ft long and 25 ft high. Mount Hamilton Cave has no great chambers but has a total length of passages amounting to 3,162 ft. (See Figure 1). In general, the tubes are about the size and shape of a railway tunnel. Mt. Hamilton is about 110 miles west of Melbourne; Byaduk is about 160 miles west of Melbourne.

Shape of the Caves

Plan. In plan the caves are usually conspicuously elongated. Simple, straight tubes give nearly linear plans, as at Porndon. The tube may show swellings and constrictions as in Sausage Cave, Mount Hamilton. (See Figure 2). Tunnels may branch in an upstream direction (Panmure) and some may branch and anastomose, giving a braided pattern (Mount Hamilton). The elongation is dominantly in the direction of flow of the lava, that is, parallel to the valley walls in a valley flow, or in the direction of maximum slope on the sides of volcanoes. Mount Hamilton Cave indicates a radial drainage pattern, with tubes radiating from the volcanic centre.

Small tributary and linking tunnels may be up to 90 degrees to the main trend. Parwan Cave has an irregular plan, indicating a somewhat different mode of formation to the other caves. Some tubes show a bulbous ending to the tunnels, at either the upstream or downstream end.

Longitudinal section. The direction of slope in longitudinal section, particularly that of the roof, is down away from the magma source and close to that of the surface of the flow. Just occasionally, as at the entrance to Turk Cave, Byaduk, the slope is in the opposite direction to the main lava flow direction. There may be enlargements and constrictions along the length of the tunnel, as in Sausage Cave, Mount Hamilton.

Termination of the caves may be of several types, including those due to collapse of the roof as well as the original ones. Downslope terminations commonly occur where the roof slopes gently down to meet a very flat floor. In another type, usually upslope, an otherwise flat floor bends sharply up to meet the roof. Another common type of termination, occurring both upslope and downslope, is an abrupt one in which the cylindrical tunnel suddenly becomes bulbous making a dome or bubble-shaped chamber. Harman 1 Cave, Byaduk, provides an example. (See Figure 2). In some instances the floor is flat, but in others the floor matches the roof in curvature so that the cave is shaped like an inverted spoon, sloping down at the end and the sides at a narrow angle. There is no systematic change in tunnel size along the length of the caves, and large chambers can occur at either end or anywhere in the middle.

Cross section. In cross section there is usually a well-defined floor which may be quite flat. Above this the cross section is typically arcuate. We have not found any completely circular cross sections, though these have been reported from overseas. (Walker, 1959;Stearns and Macdonald, 1946).

A notable departure from a circular cross section is the aptly named Church Cave, Byaduk, where there are definite, almost vertical walls. Minor tributary caves may have irregular cross sections, which are original shapes. Other irregular cross sections are due to collapse. The cross section of a cave may be approximately constant for distances up to about eight times the width of the cave.

The junction of the wall or roof with the floor is of some interest. In some cases the floor becomes convex at the junction, so a trench or angular fissure marks the junction. In others there is a continuous concave curve joining the wall and the floor. Yet others have benches or tidemarks at the junction, but these will be described later.

Some cross sections are compound in origin - that is, after formation of a first cave with simple cross section, lava flow beneath the cave floor has led to further complexities. The simplest complication is when

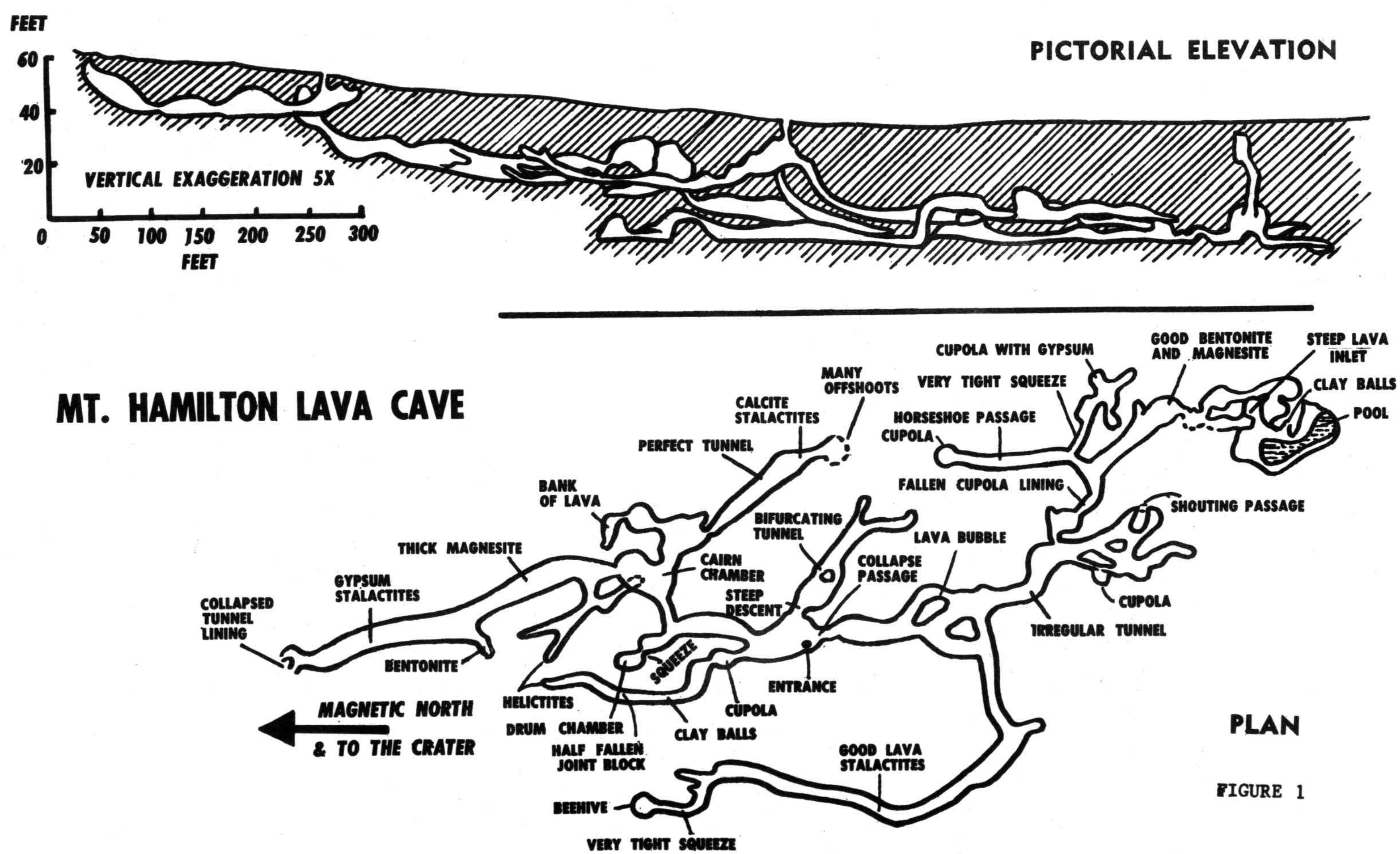
PICTORIAL ELEVATION
FEET
60
40
20
0
VERTICAL EXAGGERATION 5X
50
100
150
200
250
300
FEET
MT. HAMILTON LAVA CAVE
PLAN
COLLAPSED TUNNEL LINING
GYPSUM STALACTITES
BENTONITE
THICK MAGNESITE
BANK OF LAVA
PERFECT TUNNEL
CALCITE STALACTITES
MANY OFFSHOOTS
CAIRN CHAMBER
STEEP DESCENT
BIFURCATING TUNNEL
COLLAPSE PASSAGE
LAVA BUBBLE
HORSESHOE PASSAGE
CUPOLA
VERY TIGHT SQUEEZE
CUPOLA WITH GYPSUM
GOOD BENTONITE AND MAGNESITE
STEEP LAVA INLET
CLAY BALLS
POOL
FALLEN CUPOLA LINING
SHOUTING PASSAGE
CUPOLA
IRREGULAR TUNNEL
SQUEEZE
ENTRANCE
CUPOLA
CLAY BALLS
HELICTITES
DRUM CHAMBER
HALF FALLEN JOINT BLOCK
GOOD LAVA STALACTITES
BEEHIVE
VERY TIGHT SQUEEZE
MAGNETIC NORTH & TO THE CRATER

FIGURE 1

the floor is buckled up into an arch, which usually cracks in the middle to make a rift or chasm along the ridge. If the lower lava then withdraws it might form a new tunnel below the old one, which can be entered through the rift. The process might be repeated more than once, and a most complex cross section can result, as at Church Cave, Byaduk.

Two of the caves, the inner Turk Cave and the Mount Eccles Gothic Cave, have cross sections and structures strongly suggesting plastic deformation of original outlines. The small Turk Cave has a bulbous termination, but the cross section is markedly asymmetrical, so that the southern wall meets the floor at an angle greater than 90 degrees and the northern wall meets the floor at an acute angle of about 50 degrees. The impression is gained of an original cave with a flat floor and a symmetrical rounded roof which has been pushed sideways while still in a somewhat plastic state.

In Gothic Cave the roof, instead of being rounded as in most caves, rises to a sharp angle. Flow layers exposed in the roof are partly truncated and deformed. These features indicate lateral movement of the surrounding basalt towards the cave, pinching in the roof and folding the flow structures.

Setting of the Caves

No generalisations can be made about the type of flow in which caves may be expected, or of the position of caves within a flow. Some Victorian lava caves occur on the flanks of cones (Skipton, Mount Hamilton), some occur in valley flows (Byaduk), some on wide lava plains (Parwan), and some on smaller lava plains associated with early eruption of nearby volcanoes (Panmure, Porndon).

Relationship Between Caves and the Enclosing Lava

The lava flows around the caves are divided into layers of basalt, a few feet or inches in thickness, and parallel to the surface. There may be partings between the layers, often lined with lava stalactites and stalagmites. In some of the smaller openings the upper and lower surfaces are connected by vertical threads of basalt apparently stretched out when the layers were parted, like treacle between two pieces of bread.

The upper portions of the caves cut across the layering, and the layers reach the cave walls without being noticeably deflected. Concealing these layers, in many instances, is a lining or skin of basalt, plastered on to roof and walls. This lining is usually a few inches thick, but in some caves there is a thicker, rather complicated lining.

Unfortunately, the internal structure of the basalt at the bulbous terminations of some of the caves nowhere is clearly seen. There is a

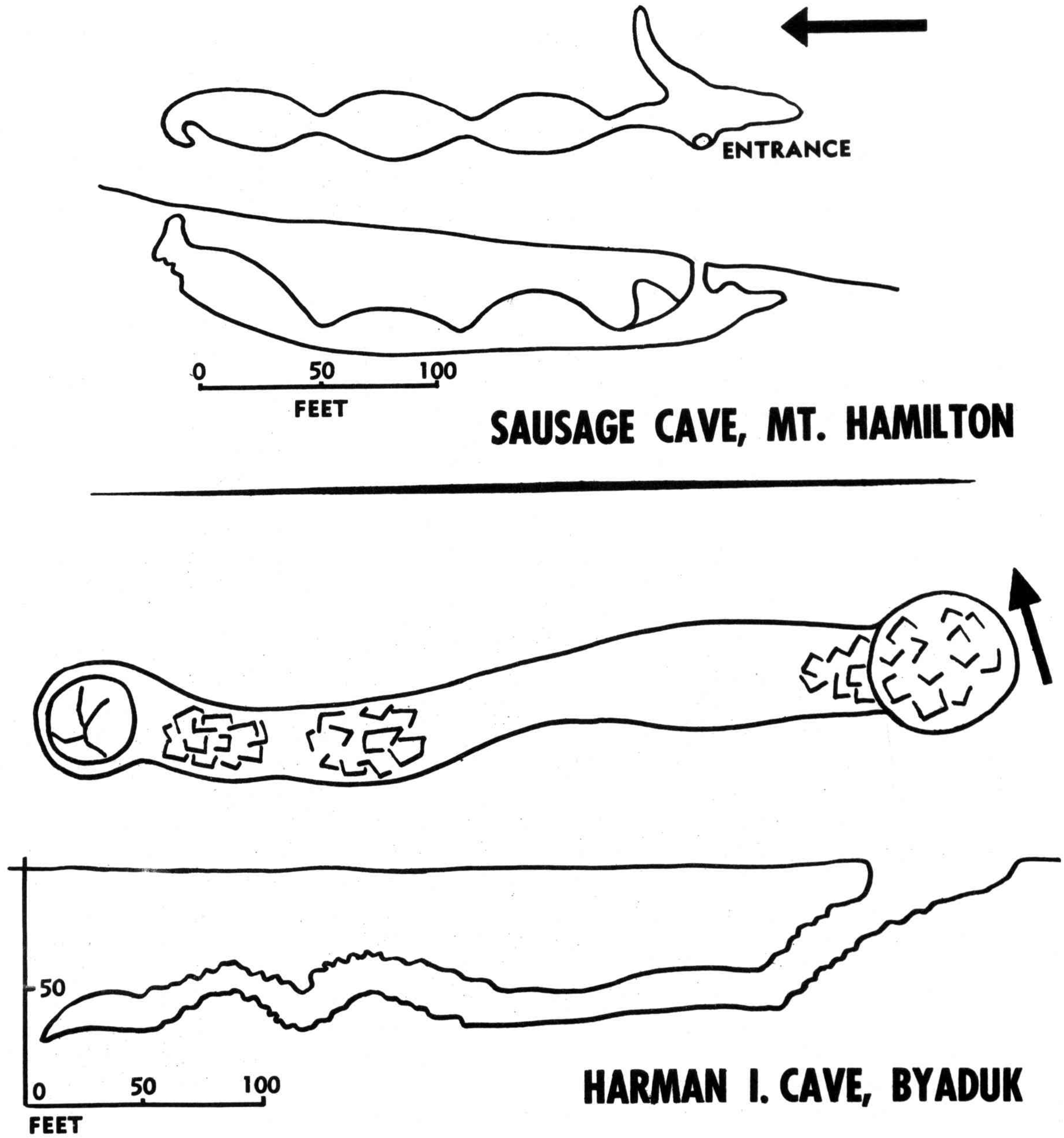
ENTRANCE
0
50
100
FEET
SAUSAGE CAVE, MT. HAMILTON
50
0
50
100
FEET
HARMAN I. CAVE, BYADUK

FIGURE 2

suggestion that the flow layers here are sub-parallel to the inner surface of the cave.

Skeats and James (1937) interpreted the layering in basalts as formed by successive flows. However, the surface of a flow has quite distinct features which are not present in the sub-surface layers associated with the caves, and it is now thought that the layers are formed by differential movement within one thick lava flow.

The thickness of the flows is not known, and so the relative position of the cave in the flows can only be guessed. The position relative to the surface has been measured, but it is quite variable. However, as a very rough generalisation, we might say that most cave roofs are about 20 feet below the flow surface.

Ornament on Cave Walls and Floors

Many of the lava tunnels are lined with a skin of lava which displays flow marks, wrinkles and drip marks testifying to its original liquid state. The lining is usually a single sheet, but in Gothic Cave, Mount Eccles, there is a complex cave wall with several linings and vesicular basalt between them. Occasionally the lining has fallen away from the cave wall revealing the layered basalt behind, with its partings, buckles and vesicle trains. Some walls have no trace of a lining, and in a few places the lining has solidified as it peeled off, forming a lip or festoon. In Mount Hamilton Cave the lining in one place apparently has been broken by gas pressure, and a burst bubble of lava hangs from the roof. The lining is sometimes divided into polygonal slabs by a pattern of cracks. On floors or steep walls the skin may be wrinkled into ropy lava.

The lining is usually decorated with small stalactites of basalt. These are commonly about 1½ inches long, about ½ inch in diameter and have rounded ends, hanging like bunches of grapes. They have smooth and shiny outer surfaces, but internally they are vesicular and crystalline. Mineralogically there is a considerable development of secondary magnetite, epidote, and acicular amphibole indicating pneumatolitic alteration of the original basalt minerals. The larger ones are more regular, conical or pyramidal in shape, and up to eight inches long.

The floors and lower parts of the walls sometimes have lava stalagmites, but these are comparatively rare. Small, thin and sometimes branching stalagmites about one inch long and 1/4 inch diameter are the commonest type. Larger, lumpy masses about four inches across and eight inches high are also present.

Some stalactites occur in groups or "hands", apparently formed where a jet of lava has squirted into the cave at a late stage of formation. On a larger scale there are "lava cascades" (entrance to Turk Cave) and lava "fountains" (end of Sausage Cave, Mount Hamilton).

The floors show a variety of structures. The simplest type is a very flat floor with a smooth glossy surface, but more commonly there are complexities, and some floors are quite irregular, like a choppy sea. Revealing relationships are displayed in Shepards Cave, Byaduk, where there are several chambers separated by narrow constrictions. The centre of the floor in the chambers is flat and smooth with few joints. Around the edges, and especially near the entrance to the next chamber, the surface becomes jointed and wrinkled into a flow pattern indicating flow towards the opening. Within the constriction the surface slopes down sharply and becomes very contorted, and this then merges with the flat surface of a lower chamber. The innermost chamber terminates where a flow-wrinkled surface rises to meet the roof.

Cave floors are frequently broken into polygonal slabs by a pattern of cracks or joints. In some instances, such as parts of Church Cave, the floor is broken further into a jumbled mass of tabular blocks. Arched-up floors are breached usually by a large, open joint or chasm, as in Porndon Rubbish Cave. In Turk Cave the floor slabs have turned-up edges, like water-lily leaves, indicating that for a while they were plastic and banging into each other as they floated on an unstable floor.

At the junction of the walls and the floors there may be benches, which appear to be of two main types. Those associated with a flat floor are generally step-like in cross section, as at Porndon Arch Cave, where both sides of the cave along much of its length have a simple step-like bench about 18 inches above the floor. The small, irregular Staircase Cave, Byaduk, has a remarkable series of parallel benches on one wall which form a near-perfect stairway with flat "treads" about ten inches wide covered with stalagmites, and near-vertical "risers" varying from a few inches to 18 inches high. Multiple benches occur on the walls of the central Church Cave and also on the walls of Gothic Cave, Mount Eccles, where they have been subsequently covered by a six inch thick layer of basalt. These benches appear to be tidemarks, left at successive levels as the lava surface inside the cave subsided. Another type of bench is associated with domed and arched floors as at the termination of Harman 1, Byaduk. These are sheets of basalt about four inches thick which slope upwards from the junction of wall and floor and then curve downwards, and may even curl around so that a hollow space is almost completely enclosed underneath.

Some floors have small cracked domes, which are miniature lava blisters. Harman 1, Byaduk, terminates with a large blister, encircled by a curled bench.

Modifications Due to Cave Collapse

Collapse structures can be divided into two types: those that happened when the lava was hot, and those that happened after cooling.

It is often apparent that an original, smooth, rounded roof and walls have collapsed while the rocks surrounding them were in a plastic state. The fallen blocks are deformed and in some cases welded to each other, and the lining and layered lava sag down into the cave, leaving gaps above with lava stalactites and stalagmites. These features are particularly well developed in parts of the Mount Hamilton Cave and in Skipton Cave.

More commonly collapses have taken place while the rocks were obviously quite solid so that the outlines of the roof and of the fallen blocks are quite angular. In some cases this collapse has not continued through to the surface, so that a cave is still intact, but with altered outlines. The collapse may be more or less uniform over the whole roof, as in the Main Turk Cave, Byaduk, or it may form a series of isolated heaps of broken blocks below corresponding domes, as in Harman 1 Cave, Byaduk. (See Figure 2). In other cases the collapse has continued to the surface. Some, such as the Flower Pot Cave, Byaduk, are nearly circular in plan with overhanging walls. The upper part of the roof seems to have collapsed as a single unit and is preserved as a thick pancake of rock at the bottom. Elsewhere, elliptical depressions are formed and sometimes, as between Turk and Tunnel Caves, Byaduk, a long section of cave has collapsed to give a sinuous, steep-walled depression.

The general lack of surface collapse over many of the caves is rather remarkable. Over the complex anastomosing system of the Mount Hamilton Cave, with its more than 3,000 feet of tunnels, the surface is quite smooth and gently inclined away from the volcano, and the only entrance is by a small, joint-bounded hole just large enough for human entry.

Origin of the Caves

It is intended to publish elsewhere a complete discussion of the mode of origin of the caves (Ollier and Brown, 1963) but a brief account can be given here.

When lava flows, the surface in contact with the air cools quicker than the inside, and therefore solidifies quicker. Most geologists agree that caverns are formed in basalts by draining out of liquid from below a solidified upper surface of a flow. Victorian lava caves are of this type, but clearly the simple explanation above does not account for all the observed shapes and structural features of the caves or the surrounding flows, and a more involved explanation is required.

Mention must be made of a different theory of origin. Skeats and James (1937) believed that some lava caves, such as Harman 1 Cave, Byaduk, were formed as gas cupolas very close to the surface, like a blister full of gas just below the lava skin. These blisters were then subsequently buried by later flows. They interpreted the layered lava as a succession of separate flows. This explanation now seems to be completely unacceptable.

The suggested theory of Ollier and Brown (1963) is briefly this:- Lava is erupted, flows under gravity, and a crust is formed on the surface by cooling. Movement of the lava in general is by laminar flow, and a layering is produced by partial congealing of the lava. Where lava tunnels are present the flow layers invariably accompany them.

Liquid lava is concentrated between the laminae, at first, but later becomes further segregated, and comes to occupy tubes running through the layered-lava. Eventually the mobile liquid lava is concentrated into a few major channels. These are a continuing source of heat, and the hot liquid contents may even erode or melt some of the earlier layered-lava. However, all these processes are contemporaneous; solidification and remelting, flow and hydrostatic pressure, are all working together. The end result is cylinders of liquid lava flowing through tubes cut in virtually solid layered-lava.

Sometimes, due to a breach in the toe of the flow and/or cessation of supply from the volcanic source, the liquid lava will escape from the confining tubes, and the space left behind will be a cave. If this happens in an early stage the cave may be of irregular shape, like Parwan Cave, where some liquid has been drained from between crude joint blocks in the layered-lava. If it takes place at an advanced stage a perfect tube with nearly cylindrical shape will form.

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THE SUBTERRANEAN FRESHWATER FAUNA OF NORTH WEST CAPE, WESTERN AUSTRALIA

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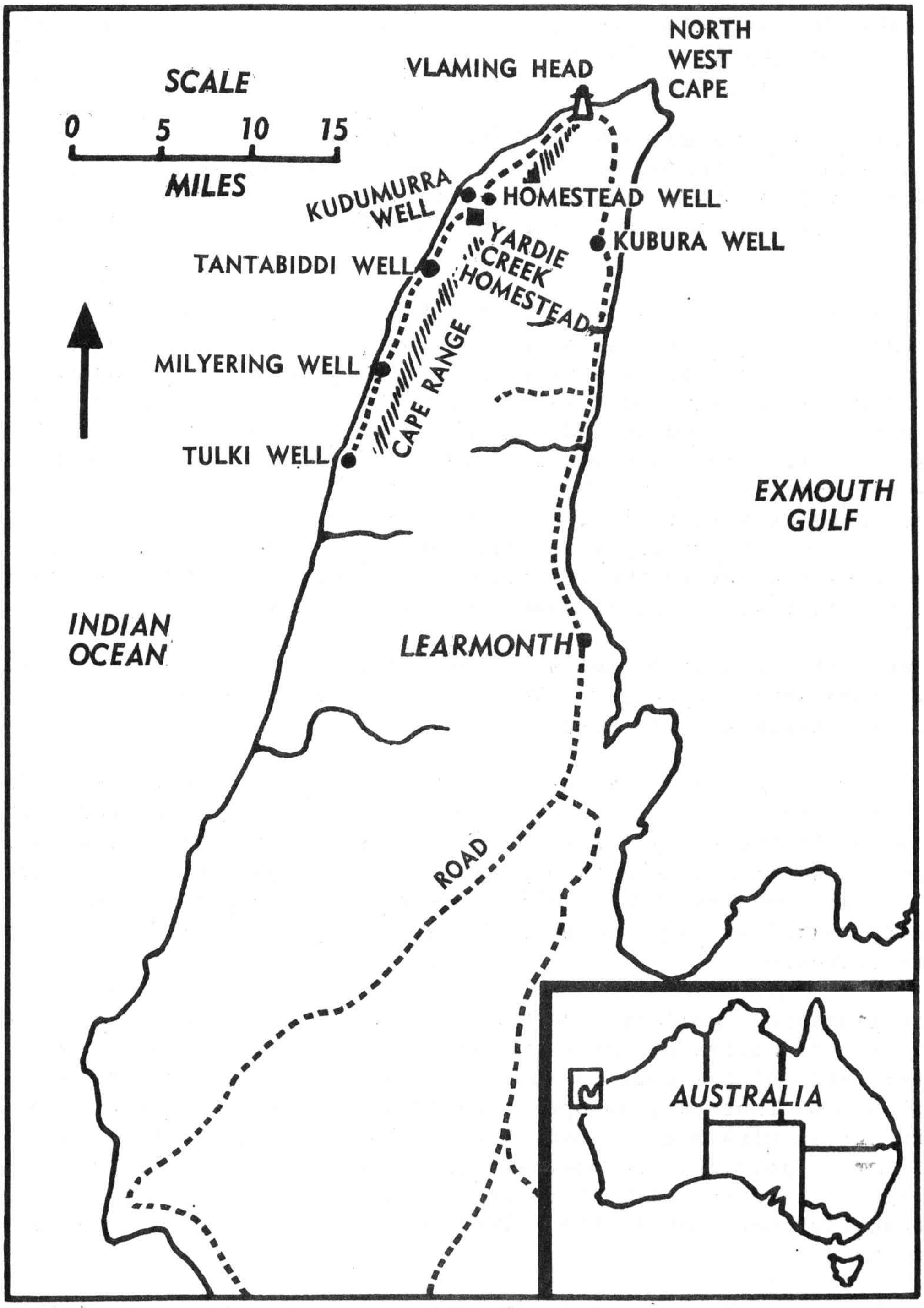
In Western Australia the occurrence of a specialised subterranean freshwater fauna in the western coastal plain of North West Cape has been known since 1944. This area consists of a very flat, stony platform which contains many small, shallow sink holes as well as artificial wells. It consists of almost pure coral rock and fossils. The surface is about two metres above the water level. Within the coral rock is an extensive subterranean network of waterways, which forms the home of the cave fauna. The platform extends along the western margin of the peninsula to a length of at least 15 miles and from one to two miles wide. The Cape Range lies immediately to the east of the platform.

When Mr. G.P. Whitley, of The Australian Museum, Sydney, visited Yardie Creek Station in 1944, he obtained a specimen of a blind fish from the Milyering Well on the station. At the time of his visit the fish had been known for at least 16 years, and up to a dozen specimens could be observed at any one time. The fish, a goby, was yellowish-white when alive and without any pigment. The brain was visible through the upper surface of the head as a more or less triangular dark patch. The eyes were absent, and the scales were reduced in number and entirely absent from the head.

Since then numerous other specimens have been collected from both Milyering and Kudumurra Wells; but the fish were much scarcer in Kudumurra Well, usually only one or two specimens being present whenever the well was inspected. Examination of about 50 specimens has shown a range in length of from 30 mm to 42 mm. In 1945, Whitley described the fish as *Milyeringa veritas* Whitley, erecting the new genus *Milyeringa* Whitley for it. In 1962, Mees placed *Milyeringa* in the family Eleotridae because of its close affinities with several genera in that family.

It was not until 1958, when Mr. A. Snell visited Yardie Creek Station, that additional information was obtained about the cave fauna in the area. Snell obtained further specimens of *M. veritas*, and amongst them he discovered some shrimps. These were sent later to Dr. L.B. Holthuis, of the Leiden Museum, by The Australian Museum (Lane and Nurse, 1959). In 1959, further shrimps were obtained by Dr. G.F. Mees, of the Western Australian Museum. The shrimps were obtained from two wells - Milyering and Kudumurra. The two wells are about ten miles apart. The shrimps were common in the Kudumurra Well, but scarce in the Milyering Well. Altogether, 162 specimens


SCALE
0 5 10 15
MILES
VLAMING HEAD
NORTH WEST CAPE
KUDUMURRA WELL
HOMESTEAD WELL
YARDIE CREEK HOMESTEAD
KUBURA WELL
TANTABIDDI WELL
MILYERING WELL
CAPE RANGE
TULKI WELL
EXMOUTH GULF
INDIAN OCEAN
LEARMONTH
ROAD
AUSTRALIA

of shrimps were sent to Holthuis, and the large number proved to be very valuable, as it made it possible to show that two species were present, both of which had unusually variable characters that in most shrimps are of specific or even generic importance. These two species he placed in the new genus Stygiocaris Holthuis as S. lancifera Holthuis and S. stylifera Holthuis (Holthuis, 1960).

S. lancifera proved to be much the commoner of the two, 147 specimens being present as compared with 15 specimens of S. stylifera. The shrimps were about half an inch long, transparent, without pigment and no sign of any eyes. They are the first troglobic shrimps to be recorded from Australia.

During Mees' visit in 1959, he obtained a specimen of an eel from Tantabiddi Well. The eel was 37 cm in length, a pure white colour while still alive, and without any eyes. Dispersed pigment in the skin "was irregularly but more or less evenly distributed over the whole body." A further specimen was collected from the same well in 1960, but, although the eel has also been observed in Milyering Well, it would appear to be far less plentiful than the blind goby and shrimps. The eel, a new species, was described by Mees in 1962 as Anommatophasma candidum Mees, and placed in the new genus Anommatophasma Mees. No other cave fauna was found associated with the eel in the Tantabiddi Well. The goby, shrimps and eel appear to comprise the total cave fauna in the area.

There are a number of wells on the Yardie Creek Station, and Mees climbed down into all of them. Only in three was cave fauna found, i.e. Milyering, Tantabiddi and Kudumurra Wells.

The Milyering Well is hacked out of coral stone, the water surface is about two metres down and the water in the well about 50 cm deep. It was constructed in the early 1920s. In the walls on, and just below, the water surface are water channels through which the gobies can enter or leave the well. In 1959 and 1960 (Mees, 1962) the water was about 27°C (80½°F). It was "very tasteless partly due to the high temperature and partly to fairly high salinity."

The Tantabiddi Well is a natural cavity. It is a little pool with several square metres of water surface which is partly covered over. The greatest depth of the pool is about half a metre, and the bottom is covered with mud. There are no open connecting channels. Those that do exist are filled with mud, through which eels are able to move, but not the free swimming goby and shrimps, and consequently they do not occur in this well. The water temperature in 1959 was 24°C (75°F). The water was less brackish than that in the Milyering Well due to the greater opening in the roof.

The Kudumurra Well is entirely cemented. The water level is at about

1.75 metres down and depth is not more than 50 cm. As in the Milyering Well there are numerous connecting channels. The well was constructed in 1913. The water temperature varied from 28.3°C (83°F) in May, 1960, to 29-30°C (84-86°F) in August, 1959. Water samples were not taken from this well.

Various types of animal life were found trapped in the wells. Both Whitley (1945) and Mees (1962) consider that the rich organic matter in the wells creates favourable conditions and, as a result, the concentration of fish and shrimps in the wells is greater than it is elsewhere in the area. All three wells show tidal movements, the water moving up and down about 15 cm each day.

In August, 1962, Kubura Well, ten miles south of Vlaming Head lighthouse, was explored by Mr. P. Cawthorn and Mr. P. Symons of the Speleological Group of the Western Australian Naturalists Club (Cawthorn, 1963). All three types of subterranean freshwater fauna were discovered, but of the shrimps only *Stygiocaris stylifera* was taken and not *S. lancifera*. It is of interest to note that in the earlier material obtained from Milyering Well and Kudumurra Well, *S. lancifera* was by far the commoner of the two species. Holthuis considers that this new material shows some differences from the type material.

The geological structure of the North West Cape Peninsula has been studied by Condon, Johnstone and Perry (1953), who claim that the Cape Range is mainly of Tertiary age and that the coastal platform is Recent. Mees (1962) quotes Dr. B.W. Logan, of the Agricultural and Mechanical College of Texas, as saying that the area along the foot of the Cape Range was inundated by the sea in sub-Recent times. He considers it is an aeolian limestone formed by terrestrial agencies, and that it dates from Pleistocene to Recent. Some of the platform, he considers, may also be cut in Pliocene or Miocene limestones which occur on the sides of the Cape Range. Thus the coastal platform is not more than about 5,000 years old.

As it is inconceivable that morphological changes of the magnitude present in the cave fauna could have taken place in such a short period, Mees has postulated that the fauna may have developed in late Tertiary or in Pleistocene times in the Cape Range. With the emergence of the coastal platform and the decrease in salinity of the water, the cave fauna was then able to colonise the platform from the cave systems in the Range.

In 1962, members of the Speleological Group of the Western Australian Naturalists Club explored 29 caves and solution pipes in the Cape Range (Cawthorn, 1963; Cook, 1963). Of these, only one contained water, and no cave fauna was observed. Cawthorn suggests that the variable characters present in the shrimps indicate that the fauna in the Cape Range and that of the platform are not now connected, but have developed independently in the last 5,000 years since their migration to the coastal platform.

Thus it would seem the origin of this very interesting fauna is still in doubt. Further exploration, examination and collecting from the wells on the eastern coastal plain and at Vlaming Head are necessary, as well as geological examination of wells on both the eastern and western coastal plains.

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SUB-FOSSILS FROM MOUNT HAMILTON, VICTORIA. By N.A. Wakefield. Vict. Nat. 79 (11), 1963 : 323-330.

This paper records the finding in the main lava cave at Mount Hamilton, Victoria, of sub-fossil bones of about 290 native mammals, representing 26 species. Of these species, three were prehistoric, two are known as recent only from Tasmania, and another ten species are today no longer present in Victoria. Some of the species represented have not been recorded previously for Victoria and provide valuable data on past distribution of native mammals. It is claimed the species indicate that climatic and vegetational changes have occurred in the locality during the period of deposition of the bones. -(A.M.R.)

(END OF VOLUME ONE)