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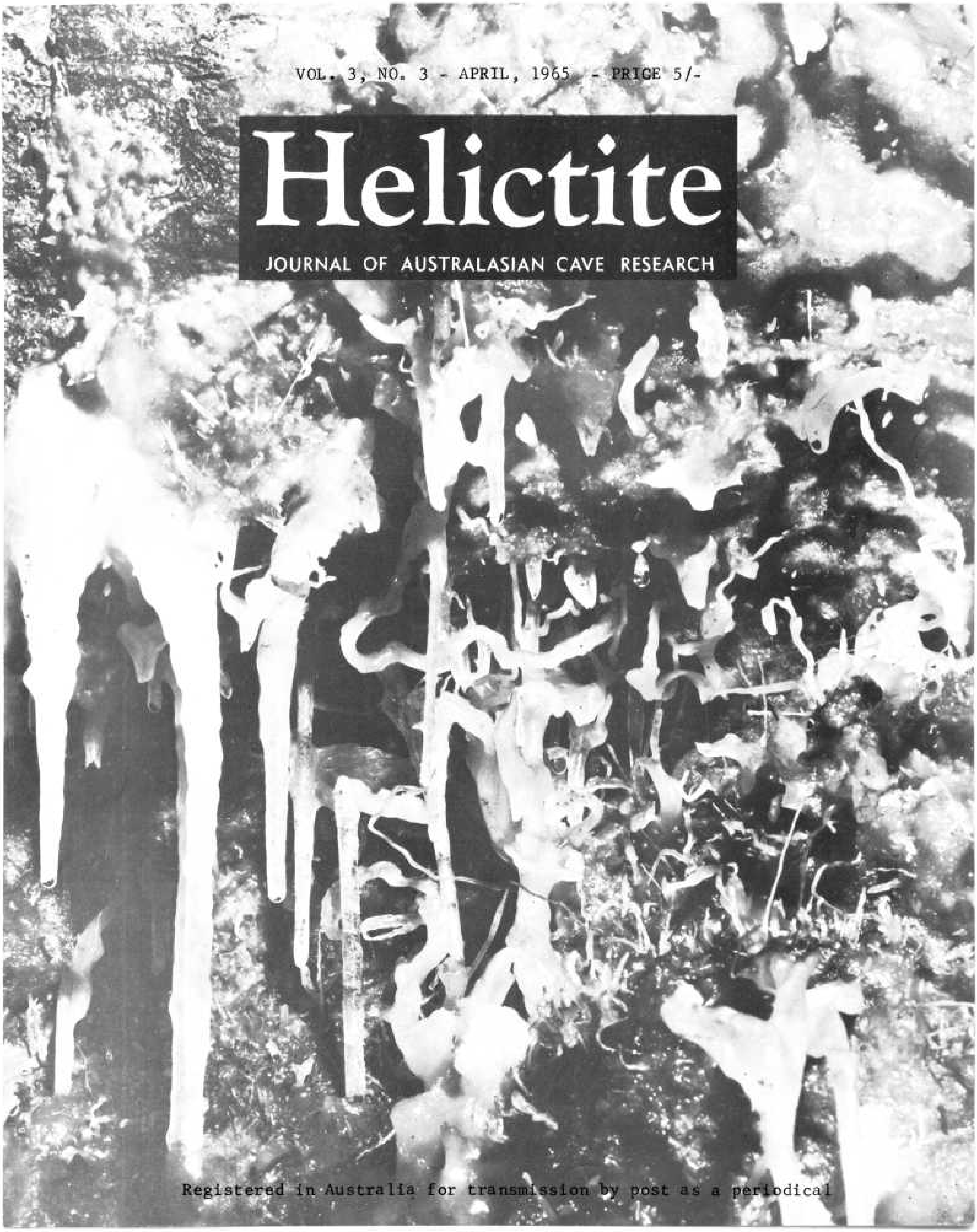

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" H E L I C T I T E "

Journal of Australasian Cave Research

Edited by Edward A. Lane and Aola M. Richards

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FIRST RECORD OF CRICKETS (ORTHOPTERA : GRYLLOIDEA) FROM AUSTRALIAN CAVES

When one mentions crickets occurring in caves, the reference is usually to "cave crickets", members of the family Rhaphidophoridae, which are found in caves throughout most of the world. These insects, with their long legs and antennae, and lack of wings, are a familiar sight to most speleologists.

True crickets, or Gryllids, are also found in caves in tropical regions throughout the world. They have been recorded from tropical Africa, Madagascar, Malaya and Indo-Malaya, Central America, Jamaica and Uruguay. Cave Gryllids belong to the family Phalangopsidae. About 20 different species are known belonging to 11 different genera. Most of them are troglophiles. They are rather large in size, their body colouration is pale, the eyes reduced, the wings reduced or absent, and the elytra short or sometimes absent. The female is apterous, but the male may retain the power of stridulation. To date only two genera of Phalangopsidae are known from the Australian fauna - Endotaria Chopard, a monotypic genus, and Endacusta Brunner which contains ten species. There is no record that any of these species are cavernicolous.

Through the examination of cave Orthoptera from the Western Australian Museum, the author (Richards, 1965) has identified Endacusta australis Sauss. as occurring in a number of "breakaway caves" on Mount Kenneth, 28° 48' S, 114° 59' E, near Geraldton in temperate Western Australia. The area consists of a laterite cap overlying a deposit of interbedded clay and sandstone in which the caves occur. "Breakaway" is a Western Australian term applied to the steep cliffs connecting old and new plateaus. The size of the caves is not known to the author, but they are probably not much more than rock shelters. The crickets were extremely numerous in these caves, 180 specimens being collected from one cave alone. They were not confined to the caves, but were also common in recesses on "breakaways" and gorges. This is the first record of cavernicolous Gryllids occurring in Australia.

A further cavernicolous species of Endacusta has recently been discovered by the author in the Australian Museum collections. This new species was collected from Walli Cave in the Belubula limestone belt 14 miles east of Canowindra, New South Wales. More specimens of this species are required before it can be described. It is considerably smaller and more strongly pigmented than the Western Australian material. This specimen from Walli Cave is the first cavernicolous Gryllid recorded from limestone caves in Australia, and its occurrence in a temperate rather than a tropical region is worth noting.- Aola M. Richards, University of N.S.W.

Reference

RICHARDS, Aola M. 1965 : Cavernicolous Grylloidea (Orthoptera) from Australia. J. ent. Soc. Qld., 4 : 67 - 68.

CAVES OF THE COASTAL AREAS OF SOUTH AUSTRALIA

By R. T. Sexton, B.Tech.*

Introduction

The majority of South Australian caves occur in the Tertiary and Quaternary limestones of the coastal areas. Their distribution is discussed here on a geological rather than a geographical basis. The most significant caves are briefly described and illustrated to indicate different types and related developments in the coastal limestones. The most notable feature of the limestones is their soft, porous nature. Caves also occur in South Australia in hard, massively bedded Cambrian and Pre-Cambrian limestones and dolomites. These are not discussed in the present paper.

To facilitate recording, South Australia has been divided into six zones as shown in Figure 1, and the caves numbered in order of discovery in each area. In general, both the name and the number of the cave have been given, but unnamed caves are specified by number only. The cave maps have been chosen to give as wide a coverage as possible of the various types, or to illustrate points of particular interest. The arrows on the section lines show the direction of viewing, and the sections are numbered to relate them to the plans. Where a cross-section and longitudinal section intersect, the common line has been drawn to relate the sections. The same scale has been used throughout for ease of comparison.

History

The first reference to coastal caves appeared about 120 years ago when Burr (1845) described sinkholes near Mount Schank. He said that bones of "kangaroo, opossum, wambat and dog", larger than those now living in the area, had been recovered from a cave. E.P.S. Sturt (1853) was the first to record the discovery of limestone caves in the Naracoorte district. Woods (1860) discussed the occurrence of caves in the Tertiary limestones of the south-eastern district of South Australia, particularly those at Naracoorte and near Mount Gambier. Later, in his book "Geological Observations in South Australia" (1862), he considered many aspects of the geology of the area, devoting several chapters to the caves. In 1908, W. Reddan, who was in charge of the development of the Naracoorte tourist caves, wrote to the South Australian Museum concerning the discovery by a workman of marsupial bones in the caves. These included bones of the extinct marsupial lion Thylacoleo carnifex Owen. Daily (1960) discussed further discoveries of T. carnifex at Naracoorte and elsewhere.

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*Adelaide, South Australia.

Two other papers of importance on caves of the Murray Basin appeared in the 1930's. Tindale (1933) described the Tantanoola Caves and their deposits and noted that the present caves were partly excavated from indurated material choking old sea caves. Punyelroo Cave, near Swan Reach on the River Murray, was the subject of a paper by Parkin (1938) based on the results of an expedition made by University of Adelaide students.

The written record of Kangaroo Island caves is scanty. Bell's booklet (No Date) on the exploration in 1926 of the Kelly Hill and Mount Taylor Caves is of interest. Ward (1926) explains their origin by comparison with cave systems elsewhere in Australia and overseas.

Thomson began investigation of the Nullarbor Plain caves in 1933 and later described several caves (1950). In the same Journal, King (1950) discussed their origin. More recently, Jennings (1961, 1962, 1963) has studied the geomorphology of the Plain and its caves.

Geological Context

About three-quarters of the 160 or so caves and allied features discussed here occur in the flat-bedded Tertiary limestones of the Eucla and Murray Basins, the latter being divisible into the Murray Basin proper and the Gambier Sunklands. Beyond a coastal scrub belt, the flat treeless surface of the Eucla Basin forms the Nullarbor Plain. Shallow caves are formed in the Lower Miocene Nullarbor Limestone, but deep caves penetrate into the underlying Upper Eocene Wilsons Bluff Limestone, in most cases reaching the watertable at a depth of about 300 ft. A spectacular cliff line bounds the Eucla Basin. In contrast, the Murray Basin rises gradually from a low coastline and the watertable is rarely more than 100 ft below the surface, restricting the depth of accessible caves. Groundwater recharge in both basins is chiefly a function of local rainfall percolating directly underground. Drainage channels are few and a lesser source of percolation. The only caves known in the Murray Basin proper are the series developed in the Miocene cliffs along the River Murray. Similar caves have developed along the Glenelg River in both South Australia and Victoria. The Oligocene bryozoal limestones of the Gambier Sunklands are generally covered with younger deposits, often of considerable thickness, but they outcrop east of the Naracoorte scarp and in the coastal area near Mount Gambier. Both areas are rich in caves. Extensive volcanic activity has occurred in the Mount Gambier district, particularly around the Mount Burr Highlands, Mount Gambier and Mount Schank. With the exception of the Nullarbor Limestone, which is hard, fine grained and well jointed, all these rocks have high primary porosity, yet the effects of jointing may often be seen in the broad outline of the caves. It should be noted that the Naracoorte Caves are aligned along the Kanawinka Fault Scarp.

Quaternary aeolianite deposits (more precisely aeolian calcarenite, i.e. consolidated windblown lime-rich sands) are found along much of the coast-

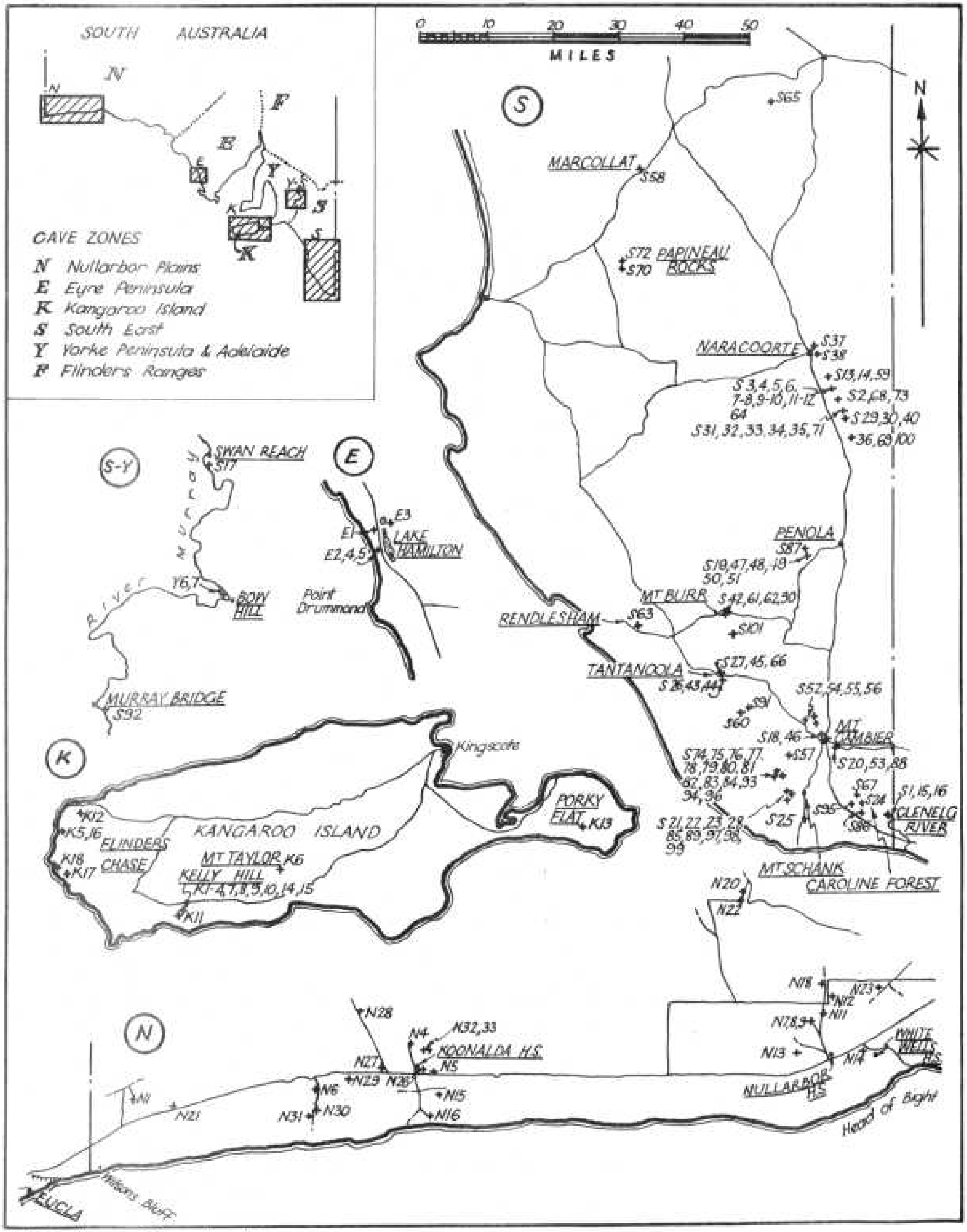

Fig 1. Cave locations

line. Caves occur in these deposits in a localised area on Eyre Peninsula, along the south and west coasts of Kangaroo Island, and in the south-eastern area of the State (the "South East") where calcareous dunes form long and low parallel ranges marking Pleistocene high shore lines.

Other areas with good potential for caves require further investigation. On Lower Yorke Peninsula there is an extensive kunkar plain which is drained by shallow dolines (c.f. Lake Hamilton). Although generally rock choked, one such hole, 18 in. diameter, drops six ft into a flat floored chamber 12 ft across. Sinkholes are also reported in kunkar near Maggea in the Murray Basin; others near Wymarka are known to have been filled in.

Rainfall varies from eight in. a year on the Nullarbor Plain to 36 in. at Mount Gambier. Summer air temperatures may reach 100°F and cave temperatures are around 60°F. An outline of the geology of South Australia may be found in the series of papers edited by Glaessner and Parkin (1958).

MARINE TERTIARY LIMESTONES

EUCLA BASIN (See part maps N1, N4, N7, N20, and map N33)

Less than half of the estimated 100 or so caves occurring on the Nullarbor Plain (Jennings, 1963) have been visited by the Cave Exploration Group (South Australia). However, it seems likely that the caves discussed here are representative of those on the South Australian portion of the Plain.

Two of the deeper type of cave are in South Australia - Koonalda N4 and Warbla N1. Koonalda, with 4000 ft of large scale passages is one of the largest caves on the Nullarbor. Its 220 by 140 ft collapse doline entrance lies in a hollow countersunk in a broad, shallow depression in the Plain. From the floor of the sink, roughly 60 ft below the overhanging rim, there is a sharp descent for 250 ft from the entry to a major junction. The Northwest Passage continues for 600 ft over a large rockfall, with the Main Passage branching off and extending for 2400 ft in a northerly direction. The West Passage branches off the Main Passage 600 ft from the first junction and connects with the Northwest Passage as shown on the map. A series of lakes at -240 ft then follow. A low island divides the first two shallow muddy lakes, but the third is cut off by a huge rockfall rising 110 ft above the water. This final lake is 40 ft deep and may continue beyond the final narrow flooded passage.

Warbla Cave has a 130 ft diameter collapse doline entrance set in a low rise facing a wide plain. An irregularly horizontal passage 800 ft long at -180 ft terminates in a huge domed chamber. The talus mound in the centre all but chokes the edges of this chamber, but a small break leads down to small pools 300 ft below the ground surface level.

Contrasting with the bold spacious passages of the deep caves, the shallow caves are comparatively cramped and reach a maximum depth of 70 to 80 ft. A number of these caves are several hundred ft long, with flat sand or silt floors and fairly level ceilings up to 12 ft high. Jimmies Cave N23, N15, and Koomooloobooka N6 have multiple entrances which are either solution pipes or small collapse windows up to 8 ft across and 15 ft deep. There are minor debris piles on the floor, but in such cases as Murrawijinie Cave N7, the unsupported roof has collapsed to form a considerable mound below a wide entrance window. The name of this cave means "handmarks" and refers to aboriginal hand paintings on some of the walls. Collapse has continued further into N8 where there are daylight chambers on either side of a massive rockfall below the entrance. Knowles Cave N22 is an elongated doline 600 ft long. A saddle slightly below plain level separates the shallow southern section, surrounded by low rockfaces, from the northern section which finally terminates in a 70 ft deep cave beneath an overhanging wall. Clay Dam N16 is a 70 ft deep by 70 ft diameter sinkhole with little cave development leading off. Some rockfall caves have only small entrances. Bunabie Blowhole N21 is entered through a three ft diameter by 15 ft deep roofhole. Beyond the first roomy chamber, small passages and chambers continue between rockfall and roof for several hundred ft reaching an estimated depth of 30 ft. White Wells Cave N14 is somewhat similar, but the passages follow the domed roof through tangled rockfall to a depth of 90 ft. The entrance of the Catacombs N20 is a small opening in the side of a shallow sinkhole leading directly onto the crest of a huge rockpile. Gaps between fallen blocks descend to the level of the silt floor shown on the map at the southern end. Potholes are also found on the Plain and may reach a depth of 80 ft. N33 is typical of those increasing in diameter at a depth of 30 ft or so - Thomson's "bottleneck" caves.

MURRAY BASIN

River Murray (See part map S17)

Punyelroo Cave S17 has more than 3000 ft of joint-controlled main passages, generally four to ten ft high and six to 20 ft wide. The entrance, enlarged to 40 ft high and 15 ft wide, soon reduces to the level passage system 25 ft above the lagoon, yet floods have carried a log 600 ft into the cave. The pebble and sand floor, interrupted in places by massive rockfalls, has a slight fall away from the entrance. The cave is devoid of decoration and the rock is perforated with small solution holes and boxwork.

There are two caves at Bow Hill with entrances eight ft above water level which show evidence of frequent flooding. Y6 is 150 to 200 ft long and two to three ft high. Y7 is 120 ft long and enlarges to standing height in places. Floor holes reach water. S92 at Murray Bridge is a massive rockfall subsequently exposed by quarrying. After a descent beyond large fallen blocks, small pools may be seen at approximately river level.

GAMBIER SUNKLANDS

Naracoorte (See maps of part S5, S11 - 12, part S14, part S29, S59, S64)

From S37, a mile north of the town of Naracoorte, the 28 known caves extend in a straight line for 15 miles at a bearing of 160°. The caves have many features in common, but vary widely in size and detail. They are developed horizontally and generally follow a strong NW - SE trend with some development at right angles. Typically the passages are 20 to 40 ft wide and five to 15 ft high. The floors are formed of broken rock probably resulting from roof breakdown into underlying cavities. These cavities may still be seen in many places as low passages and chambers developed laterally at the base of the collapse material. Apparently these were formed by solution at a period of higher watertable. Few of the caves reach the present waterlevel. The rockpile may be penetrated sometimes through the interstices between fallen blocks, or more commonly between blocks and the side of the domed roof. Entrances may form where upward breakdown reaches the surface, however many of the caves are entered through solution tubes two to five ft diameter and from four to 50 ft deep.

The maps illustrate a number of these points. The broken-rock floored entrance chamber of the Lost Cave S59 leads to the largest pools in the area, whereas a domed rockpile S38 leading down from the floor of James Quarry has the watertable merely exposed around its perimeter. The 800 ft long Big Cave S5 has three roof collapse entrances, two of which are shown. The Bat Cave S3 and S68 have similar entrances up to 30 ft diameter in the roof of long rockfall passages. The small soil-choked passages at the south end of the Big Cave were excavated in the search for new caves. Soil filled passages are also found in the Cathedral Cave S11 - 12, contrasting with the huge entrance chamber giving the cave its name. The Sand Cave S29, the largest cave in the South East, consists mainly of large rockfall passages. Some low level passages are choked with sand, but others, including those shown on the map, are mud floored and appear to have been inundated for considerable periods. The entrance is a 50 ft deep solution pipe entering the roof of the final chamber. An adjacent calcite encrusted tube appears to be blind, but a number of sand spills entering the cave indicate that others do reach the surface. The beautiful Alexandra Cave S4, open to tourists, was discovered when a depression was excavated and found to lead to such a sand pipe. On the other hand, the Specimen Cave S64 has a very short solution entrance. There are a number of gaps in the rockfall in this cave, but all choke off at the silt level seen around its margins. S13 and the Beekeepers Cave S14 have 50 ft and 33 ft pipe entrances respectively. The latter has a small passage at the base of adjacent rockfalls (see map) that separates the 800 ft entrance section from a further 1200 ft of cave. The Robertson Cave S30 has one huge chamber with a rockfall reaching roof window entrances, yet a second chamber has a spacious domed cavity.

The Bat Cave is the breeding place for a massive colony of the bat

Miniopterus schreibersi. The Big Cave once contained the mummified body of an aboriginal, long since removed. Many of the caves have yielded bones of extinct marsupials, and a series of small solution passages in James Quarry held the first almost-complete skeleton of Thylacoleo carnifex ever found (Daily, 1960).

Lower Southeast

Mount Burr (See map S42). Four caves are grouped near Mount Burr. Gran Gran Cave S90 and Quarry Cave S42 have low narrow joint solution passages containing water. Roof holes in a chamber formed by collapse give access to S90, whereas S42 is entered through a hole exposed in a quarry. The rock extending four to five ft above the present watertable is riddled with small solution holes. Of the two 18 in. diameter avens in the roof of the main chamber of S90, one is blind but the other has just reached the surface and is still unmodified by weathering. S61 and S62, nearby, are entered through 15 ft deep potholes. S61 reaches the watertable like the others, but S62 is merely a talus floored chamber.

Five miles south of Gran Gran, Mount Burr Cave S101, first described by Woods (1862), has just been rediscovered. A gully running down the side of Mount Burr terminates at a small swamp. Overflow waters pass into a wide cave developed in the side of the limestone outcrops surrounding the swamp. The ceiling is five to six ft high and irregularly scalloped fins of rock have been left projecting from floor and roof.

Tantanoola (See maps S26, S27, S43). Two important caves occur in the dolomites of "Up and Down Rocks" - the Tourist Cave S26 in the face of the Rocks, and the Lake or North Cave S43 on flat ground above this scarp. The former is a single solution chamber that has been excavated through an earlier horizontally developed sea cave, subsequently filled completely with a now cemented sequence of marine and shore deposits. The small entrance of the Lake or North Cave is at the top of a comparatively roomy chamber, part of a long rockfall passage forming most of the cave. The low crawlway to the spectacular Lake Chamber represents the air space above a vast rockfall that has dropped almost intact into a still accessible passage underneath. Three Sisters Cave S27 is another large underground chamber. However, the watertable is merely exposed in small pools around the margins of the central rockpile. The chamber is reached directly through three short solution pipes in the roof. Among other caves in the area are S66, a 250 ft long open collapse doline in bryozoal limestone with a 50 ft high rockface in the northeast quadrant only, and the 600 ft long Morgans Cave S60, typical of joint caves in the lower southeast that reach the watertable.

Mount Gambier. Caves a few miles northwest of Mount Gambier include S52, reputedly four miles long; S55, where a shallow well has broken into a collapse doline; Drop Drop S54, a steep sloping passage descending from the base of a large depression; and S56, the largest of the group, consisting of a series of large collapse domes. In the City area and to the east, are a number of large sinkholes all of which reach water at a depth of about 90 ft. Engelbrechts Cave S46 has been filled with rubbish, but a 20 ft wide water-filled passage at its base can still be reached. The Town Cave S18 is a similar sinkhole which reduces to a minimum cross-section of 50 ft by 80 ft about 30 ft below ground level. It opens out underneath with the greatest lateral development of 70 ft terminating in a small pool. Umpherstons Cave S20, 150 ft diameter with overhanging walls, has an edge lake around a rockfall, and the adjacent 200 ft square S53 has a shallow central pool. These two occur in solution perforated bryozoal limestone capped with five to 12 ft of dune material. S88, further east, is a group of three dry sinkholes up to 100 ft by 80 ft and 35 ft deep.

Kongorong - Mount Schank (See maps S22, S77, S78, S79). Most prominent of the features in this area are the cenotes, or water-filled sinkholes. They range in size from the 220 ft by 180 ft Devils Punchbowl S79 to the 80 ft diameter Gouldens Hole S22, with the water 28 ft and 45 ft below plain level respectively. These two illustrate the type of sinkhole whose perimeter is flush with the surrounding plain, and those whose rim has been countersunk by weathering. Other cenotes are S23, Wurwurlooloo (Teatree place) S21, Ela Elap (= Lap Lap or small fish?) S28, S75, Double Well S76, S80, and the recently filled-in Allendale Sinkhole S25. The water may be up to 150 ft deep and the sinkholes evidently widen out below water level. Ramps cut in the side of a number of them give access for watering of stock. Although the sides of the sinkholes may be pocked with solution cavities six to 12 in. high and one to three ft wide, the sections observed in the ramps suggest that solution has proceeded back six to ten ft from the sinks themselves before giving way to solid rock. An exception is the 70 ft long passage seen in S22. In this sinkhole, bands of cherts in the sides of the ramp are seen to extend around the sink as lines of resistance to sculpturing. In some, e.g. S74, S75 and S80, the ramps have taken advantage of natural steps in the bedding. S81 and S82 have reed and shrub covered floors 30 ft and 25 ft below plain level respectively, but while the former has pools around its perimeter, the other is dry at present. S82 and S83 are large dry sinkholes with rounded outlines where silting has proceeded so far that even swamp floor conditions do not occur. The two lakes of Double Well S76 lie against the ends of a 30 ft deep sinkhole with a ten ft high and 60 ft wide ridge of rock separating them.

As in the Tantanoola area, there are caves which suggest that these sinkholes are due to the complete collapse of the overlying rock into solution cavities below the present watertable. Judging from the crystal clear water and clean bottom in Kilsby's Hole S78, the roof window entrance has only recently fallen in, yet the Rubbish Cave S77 has a silt floor around the central rockfall. Benara Sinkhole S57 is entered through a small roofhole in the top of a 70 ft high domed chamber,the floor of which is completely occupied by an 80 ft diameter lake.

Woods (1862) reported pipes descending to the watertable which he attributed to direct solution by surface waters, but a number of joint plane caves occur which seem to have been modified at most by such waters.

Slit Cave S89 is a joint plane cave two to three ft wide and 250 ft long with deep pools 20 ft below the ground surface along its entire length. S93 is similar but is 600 ft long and has a number of roof hole entries. S94, however, occupies two parallel joints 20 ft apart with a series of small cross passages.

Caroline Forest. Hells Hole S67 is the deepest of the cenotes, 90 ft from the lowest part of the rim to the water. The slightly overhanging walls reduce to an oval hole 140 ft across, 55 ft above the water. The bryozoal limestones underlie a softer thin-bedded limestone which has rock-shelters up to 20 ft deep weathered into it. Divers report that underwater the walls bell out immediately, with a central flat-topped rockfall ten to 25 ft below the surface. The water is 90 ft deep and at -65 ft a 15 ft diameter passage at least 100 ft long has been observed. The Caroline Sinkhole S24 has rockfall covering much of the floor and the lake is only 14 ft deep. Notching of the same soft material noted in Hells Hole has been used by aboriginals as a camping place. S95 is another open sinkhole 100 ft across and 75 ft deep. Although covered with deep water, boulders are visible just below the surface in the centre. S86 is a completely dry basin 300 ft long and 75 ft deep, covered with talus and soil.

Glenelg River (See map S1). Only one of the group of caves found in the 100 ft high cliffs along the banks of the Glenelg River lies in South Australia. This is S15, and in common with the others, including the Princess Margaret Rose tourist cave, is a 320° joint enlargement about 20 ft above river level. About 100 ft long and 25 ft high, the end is blocked by a cone of sand filtering in from the surface through a roofhole. Flooded caves are developing at present at the water's edge. Several caves occur in the banks of Dry Creek, a silted up tributary of the Glenelg. S16 is a small passage just below the scarp. Snowflake Cave S1 is basically a level solution passage 15 ft below and 250 ft away from the existing bed of the creek. A roof collapse reaches the surface giving access to the solution area. The cave name is derived from the thick deposits of lublinite, a variety of calcium carbonate, on the roof.

The Nelson Fault, running at 300° from the mouth of the river, is marked by a series of swamp floored sinkholes of the order of 100 ft diameter and 20 ft deep. There are only minor solution cavities in the surrounding rock exposures. Several miles to the south, the Piccininny Blue Lake has been dived to a depth of 200 ft and a rising passage into a further chamber has been discovered.

DUNE LIMESTONES

KANGAROO ISLAND

Kelly Hill (See part map K1 - 4, K14, K11). The Kelly Hill caves occur in the back of a five mile wide belt of scrub covered coastal ridges. The main system is one of the biggest and best decorated in the State of South Australia, consisting of a series of elongated 100 ft high collapse domes covering an area of 650 ft by 550 ft. The aeolianite is remarkably homogeneous except for a bed of soft sand that can be seen in several localities in the cave; this may represent an old beach. The plains behind the dunes are drained by the South West River, but an overflow stream disappears into the foot of the hill. The cave descends to areas of irregularly dissolved limestone at plain level. It contains chambers ten ft in height, and ranges down to cavities a foot or less high with fins of rock preventing access.

Where the domes approach the surface, large chambers may result, e.g. the "Trogs Joy" or "Tourist" sections where roof heights reach ten to 20 ft. The twin six ft diameter solution pipes, K1, reach the top of another such chamber. Elsewhere the domes have cut the surface forming the K2, 3, 4 and 14 entrances or the completely choked collapse area further north of the cave. Cracking of the heavy flowstone cementing the rockfalls shows that settlement is continuing, and difficulty in penetrating to the limit of these falls is reflected in the vagueness of map outlines. Other collapse dome caves in the vicinity are not known to connect with the main system.

The Frosted Floor Cave K11, a quarter of a mile SSW of K1, is in aeolian calcarenite showing the more usual complex cross-bedding. In fact, the roofline shown in section 15 follows curved dune bedding. The entrance chamber has roof holes similar to K1. Traces of now vanished pools can be seen in deep deposits of calcite flakes giving the cave its name.

Mount Taylor. Mount Taylor is a large isolated dune. K6 consists of a group of interconnecting domes, one of which breaks the surface. Decoration includes a large stalagmite leaning at 70^{o}, emphasising the instability of the rockfall floor.

Porky Flat. K13, just south of Porky Flat, is an 18 in. high flattener entered through a two ft diameter by 12 ft deep pipe. Its interest lies in its isolated position.

Flinders Chase (See map K5). The caves of Flinders Chase, a large flora and fauna reserve, are of considerable interest. The several square miles of West Bay Hollow drain to a short blind gully incised in the coastal aeolianite. A low passage K17 carries the stream towards the sea for a further 500 ft until it is lost in a large cemented rockfall that reaches the surface. At the Ravine des Casoars, there are a number of sea caves in the sides of the cliff facing the beach. K16 is 400 ft long, 40 ft wide and up to ten ft high. There have been no roof falls and decoration includes gours and long stalactites. The 50 ft wide entrance chamber of K5, adjacent to K16, soon leads to a massive rockfall. Contrasting with the penguin rookeries in the entrance, the inner part of the cave, with fine decoration and flowstone, has the appearance of many of the other caves formed in this rock. Near Cape Borda, a single wide dome K12 descends 50 ft to a silt floor at the level of an adjacent swamp pan.

SOUTHEAST

Marcollat (See part map S58). Marcollat Cave S58 is situated in Stewarts Range. The five entrances are 100 ft from a large swamp, and although rounded by weathering, are the result of rock breakdown reaching the surface. The main passage has a rockfall along most of its length but mud floored solution chambers at approximately swamp level can be reached in a number of places. Running water has been observed in the cave in winter and the inflows can be seen around the perimeter of the swamp basin. Overall vertical development is about 20 ft and roof thickness can only be several ft in places. Sloping bedding of the dune material controls the shape of the main passage as shown on the map.

Penola. The Monbulla Cave S19 is the largest of a group of caves adjacent to the Grey - Monbulla Drain in the Cave Range. A number of inaccessible crevices in the banks of the drain, which seem to utilise a natural watercourse in this section, lead into a wide flat system which extends 500 ft into a low hill. Generally two to three ft roof heights increase to ten to 15 ft further away from the drain. Silt floors and vegetable debris indicate frequent flooding. Roof collapse has occurred forming new entrances in places, and in others low rock-floored chambers in which fine decoration has developed. Several of the entrances appear to be solution pipes descending to such chambers. S47 and S49 are caves several hundred ft long similar to the Monbulla Cave to which access is gained through small roof collapse windows. In several other minor caves in the district, it has not been possible to penetrate the rockfall to such solution zones.

Papineau Rocks. The swamp south of Papineau Rocks has an overflow creek running west towards a ten ft high saddle in the Ardune Range. The stream disappears under a six ft rockface 100 ft from the swamp and reappears through similar crevices 300 ft away. Undercutting of the dune is apparently widespread as S70, 170 ft off the stream line, consists of several 20 ft high domes reaching the solution zone. Thin rock cover results in high air temperatures. Numerous other reports of caves in the Ardune and Avenue Ranges have yet to be investigated.

Rendlesham. Rendlesham Cave S63 is in the landward side of the Woakwine Dune, the most recent of the cave-bearing ranges. A number of entrances two to six ft in diameter drop 15 ft to a rockfall chamber. A further descent of 20 ft reaches an 18 in. high silt floored flattener.

EYRE PENINSULA

Lake Hamilton (See map E1). This eight mile by two mile lake is cut off from the sea by aeolianite deposits which rise sharply to form precipitous 300 ft high sea cliffs. There is a small plain northeast of the lake dotted with small dolines, collectively E3, which dispose of surface water. Generally two to three ft diameter and five to six ft deep, the deepest reaches 20 ft. Most important in this area are the caves which owe their origin to lake water percolating seawards through the aeolianite. Two minor caves are simple domes collapsed into underlying solution areas. E4 has a solution pipe dropping several ft onto the crest of a flowstone cemented rockfall, but the larger dome forming E5 has cut the surface allowing soil to enter and choke the perimeter. In the two major caves, the solution areas may be entered via later collapses. The Honeycomb Cave E2 has several such domes which intersect, one cutting the surface giving access to the system, and the other opening at its base into a labyrinth of solution cavities. These spread out in a zone extending four to five ft above the present watertable, which can be observed in floor holes. The entrance dome of the Homestead Cave E1 descends to a silt level in two places. The widest mud chamber is littered with minor roof falls, but the shallow lake at one end leads to a substantial roof-fall. The air space above the lakes is one to two ft and the maximum water depth ten ft. Considerable solutional activity has occurred at water level, giving deep but generally inaccessible holes around the perimeter of the lakes. Calcite flakes form on the water surface and both caves are noted for fine decoration.

DISCUSSION

Parent Rock

The Tertiary marine limestones and Quaternary dune limestones in which the caves are found often bear superficial similarities and often occur in association, so that it is not always clear in which rock the cave occurs. The geological map shows that Hells Hole S67 is in Pleistocene aeolianite overlying Tertiary limestone. The thin, flat bedded limestones in which the notching occurs may perhaps be later marine sediments.

Cave Origin

With the exception of the sea caves at the Ravine des Casoars, Kangaroo Island, the caves occurring in dune limestones owe their origin to the fact that all cavernous deposits form a barrier to drainage. They are formed only where runoff waters have undercut the deposits by solution and mechanical corrasion in escaping through them. These waters generally enter at observable inflows, either at the end of surface channels or around the perimeter of swamps, and move through the cave as a fast moving stream. However, water movement in E1, Mount Hamilton, is imperceptible and only in the case of West Bay Hollow has the concentration of water resulted in a negotiable passage at the point of water entry.

The origin of caves in the Tertiary marine basins is not so clear cut. Jennings (1961), discussing the shallow caves of the Nullarbor Plain, has noted the high degree of phreatic preparation of the zone 15 to 80 ft below the surface of the Nullarbor Limestone, probably during a period of higher watertable caused by a Pleistocene high sea level. This perforation can be seen in some caves of the Gambier Sunklands, e.g., Gran Gran S90, where pools of water are still present, and in Punyelroo S17, in the Murray Basin, now 25 ft above river level. Jennings considers that the present caves may have been scoured out by vadose waters, aided by the collapse of the weakened rock. Parkin (1938) pointed out that flood waters have certainly helped to enlarge Punyelroo. Jennings suggested that even where there was a regional watertable, evidence pointed to localised currents along joint systems. He concluded that the deep Nullarbor Plain caves were the result of such streams at the watertable or in the zone of oscillating water level, followed by collapse. The Naracoorte caves seem to be a further example of this, although the watertable is not seen in many of the caves due to a general lowering which apparently occurred even before the effects of changing land use and artificial drainage were felt. The caves and cenotes of the plains south of Mount Gambier could well have been inundated instead of drained as in the caves previously discussed. The flooded Homestead Cave E1, although in aeolianite, may well be at the active stage of such cave development, but suggests that water movement need not be rapid.

Cave Development

The terms "dome" and "rockfall" are used extensively in this paper, but in soft, weak rocks such as these, collapse plays a most important part in the development of caves rendering repetition inevitable. Roof breakdown may be minor, or domed collapse chambers with only small gaps between mound and roof may comprise the whole of the accessible cave. Rockfall mounds range in size from three to five ft high in the dunes of the Southeast to more than 100 ft high at Kelly Hill. Continued solution of the base of the material evidently compensates for bulking of the broken rock. In the Lake Cave S43, a cavity 80 ft high containing a 35 ft deep lake has been excavated. The shape of roof falls reflects the bedding of the parent rock; asymmetrical rockpiles often result from breakdown of steeply cross-bedded aeolianites, whereas domes in flat-bedded massive Tertiary limestones may have a level ceiling marking a bedding plane. Where roof collapse reaches the ground surface, entrance may be gained to caves otherwise inaccessible. Solution pipes also give access to many caves in both aeolian calcarenite and marine limestones.

Future Investigations

Knowledge of South Australian caves is still very incomplete. Caves known to exist in many areas, notably the Nullarbor Plain, Kangaroo Island and the dune ranges of the Southeast, have not even been visited yet. Many more surveys will have to be carried out. The relationship between caves, watertable and general topography requires much more study before a complete picture can be obtained. Comparison with details of caves developed in similar rocks in other parts of Australia and overseas will be of importance. In the Yucatan, Mexico, caves similar in many respects to those of South Australian Tertiary limestones have developed in a flat Pliocene limestone plateau rising gradually from the sea. It is felt that the parallel is sufficiently close to justify the use of the Mayan-Spanish term "cenote" here.

Acknowledgments

Thanks must go to Dr. B. Daily of the University of Adelaide, and to Mr. J.N. Jennings of the Australian National University, Canberra, for reading the manuscript. The paper is based on ten year's work by members of the Cave Exploration Group (South Australia) in exploring and recording South Australian caves.

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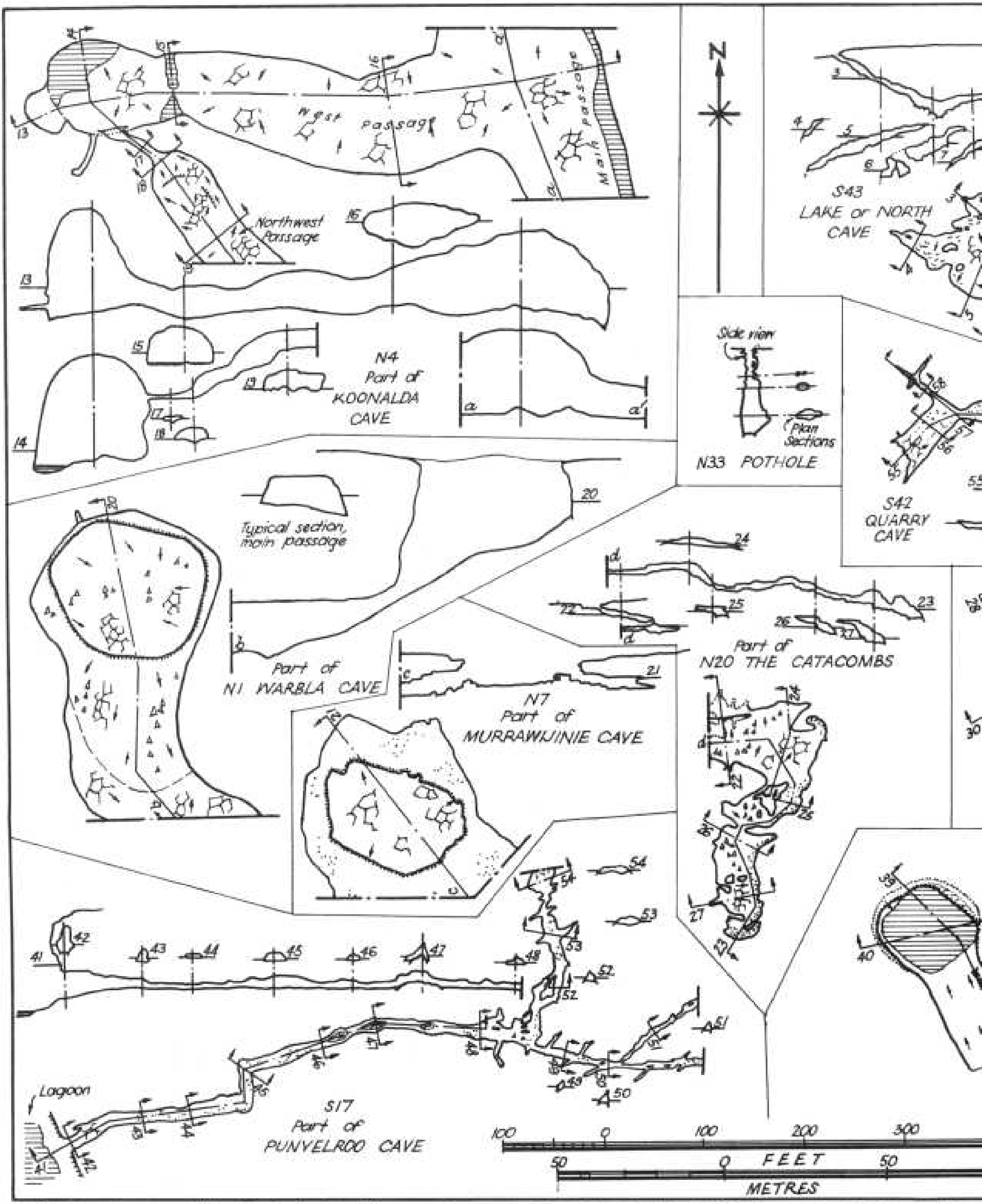
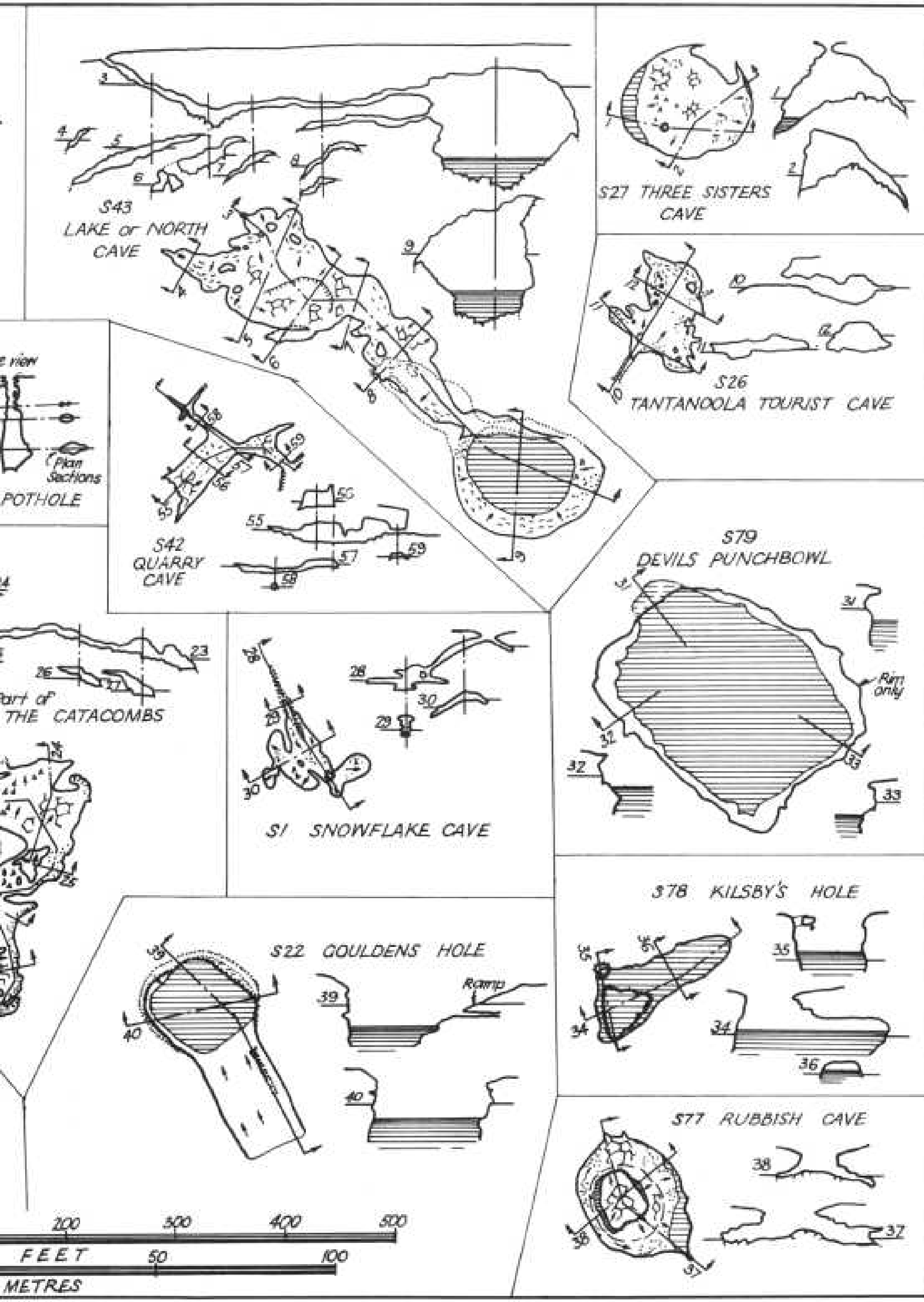


Fig. 2 Caves of the Eucla Basin, Murray Basin, & Gambier Sunklands (Tantanoola, Mt Schank-Kong



ntanoola, Mt Schank-Kongorong, Glenelg River, Mt Burr)

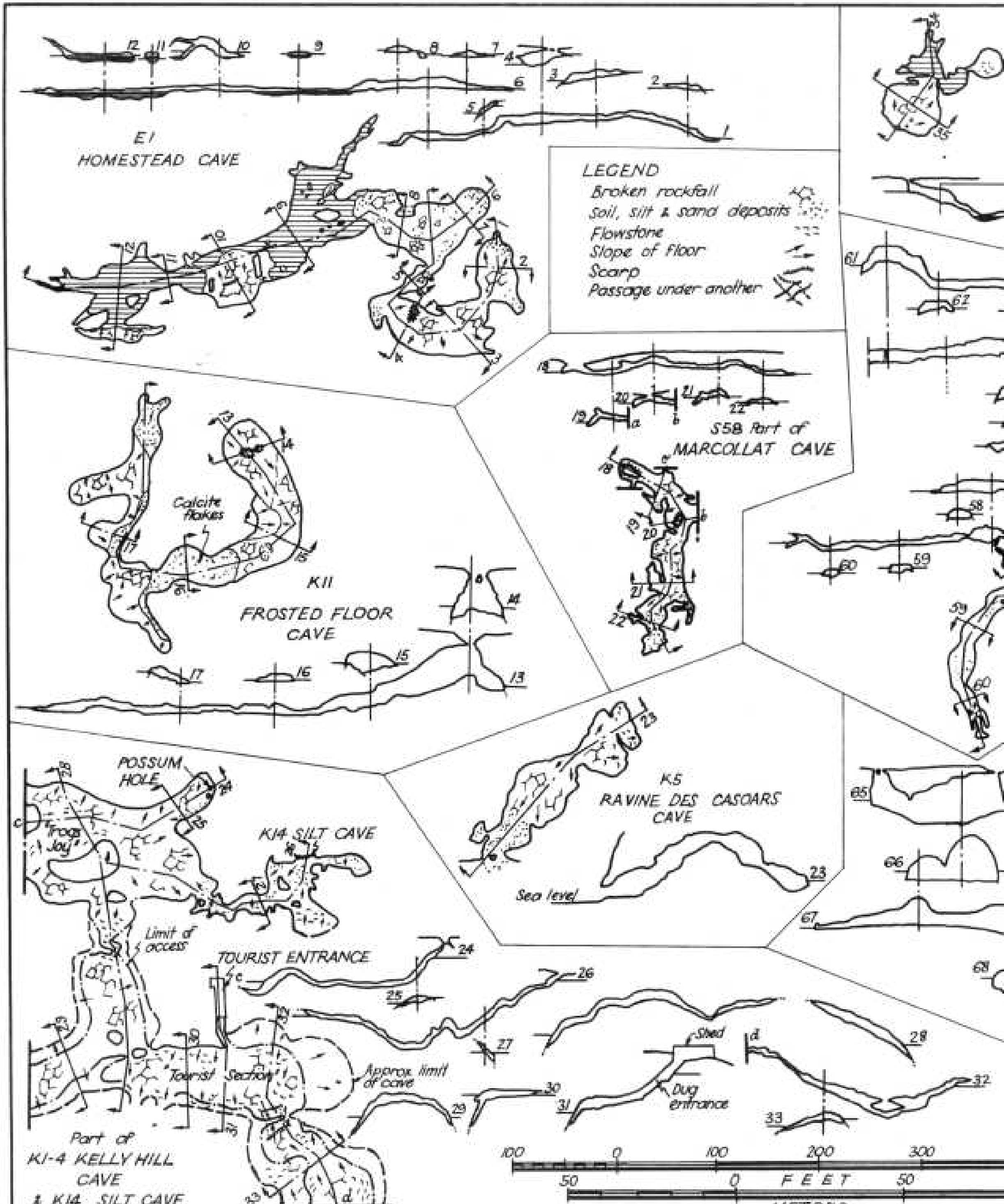
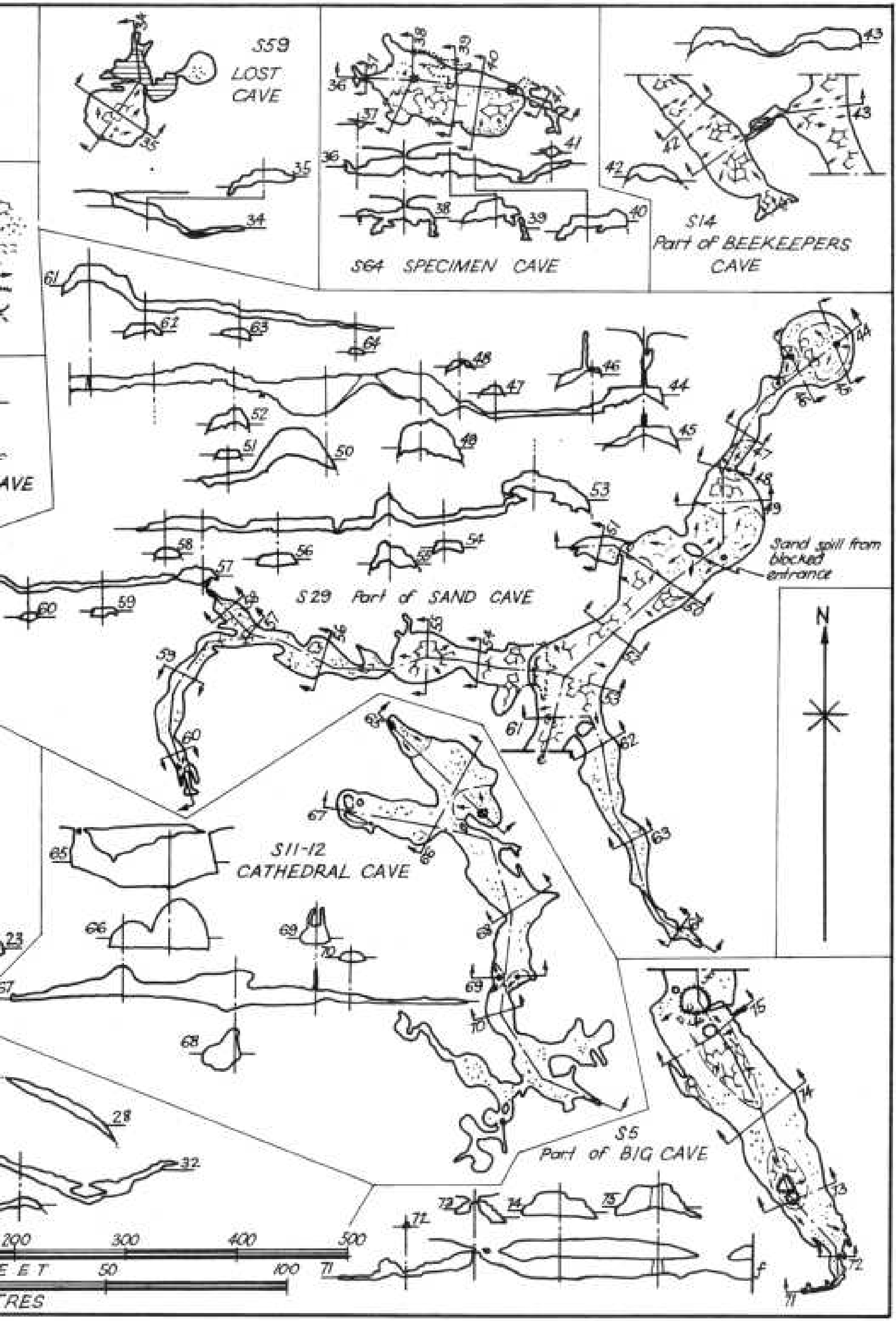


Fig 3 Caves of the Gambier Sunklands (Naracoorte) and dune limestones


S59
LOST CAVE
S64 SPECIMEN CAVE
S14
Part of BEEKEEPERS CAVE
S29 Part of SAND CAVE
Sand spill from blocked entrance
N
S11-12
CATHEDRAL CAVE
S5
Part of BIG CAVE
200
300
400
500
E E T
50
100
TRES

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ABSTRACTS AND REVIEWS

THE RHAPHIDOPHORIDAE (ORTHOPTERA) OF AUSTRALIA. PART 2. A NEW GENUS. By Aola M. Richards. Proc. Linn. Soc. N.S.W., LXXXIX, 1965 : 373 - 379.

A new genus Australotettix Richards is erected. So far it is confined to New South Wales and this is the first record of the family Rhaphidophoridae in the State. Two new species of cave cricket are described. Australotettix montanus Richards has been collected from several areas in the Blue Mountains, while A. carraiensis Richards occurs in limestone caves at Carrai and Windy Gap, about 28 miles due west of Kempsey. Both species share their habitats with large populations of glow-worms, Arachnocampa sp. Australotettix is the largest genus of Rhaphidophoridae so far recorded from Australia, an adult male of A. montanus reaching a length of up to 30 cm from the tip of its antennae to its hind tarsi.- A.M.R.

BAT MANDIBLE FROM MOUNT WIDDERIN CAVE, SKIPTON, VICTORIA. By K.G. Simpson and G.T. Smith. Vict. Nat., 81 (3), 1964 : 78 - 79.

This note records the finding of a bat mandible in guano collected from Mount Widderin Cave, a lava cave south of Skipton, Victoria. The mandible is identified as belonging to Miniopteris schreibersi (Kuhl) and is considered to be a Recent subfossil.- A.M.R.

GEOMORPHOLOGY OF THE STAR MOUNTAINS. By H. Th. Verstappen. Nova Guinea, Geology, 5, 1964 : 101 - 158.

KARST MORPHOLOGY OF THE STAR MOUNTAINS (CENTRAL NEW GUINEA) AND ITS RELATION TO LITHOLOGY AND CLIMATE. By H. Th. Verstappen. Zeitschrift für Geomorphologie, N.F. Bd. 8, 1964 : 40 - 49.

These two papers deal with the scientific results of the Netherlands New Guinea Expedition, 1959. While the Nova Guinea paper provides a comprehensive summary of the geomorphology of the Star Mountains area, the Zeitschrift für Geomorphologie article, which sets out the principal results of the investigations of karst phenomena, is an almost exact reprint of section five, "Karst development in relation to lithology and climate", of the larger work.

The following is an abstract. Limestones are the predominant rock type in the Star Mountains area. The limestone is the northeastern flank of an eroded anticline, presenting a steep scarp to the southwest ("the limestone barrier") and a dipslope to the northeast. The summit of the cuesta forms the main ridge of the Juliana Range and the Star Mountains. The limestone mass thus ranges in altitude from Mount Juliana (4,640 metres) to 500 metres above sea level. Such a range produces wide differences in local climate and thus in conditions for the denudation of limestone.

In the alpine zone, towards the summit of Mount Juliana, two types of karst phenomena occur; deep potholes and large caves, and finely eroded lapies (rillenkarren). The former large forms are related to glacial meltwaters from the Pleistocene glaciation. The lapies are forming at the present time as a result of the corrosive action of aggressive waters produced by the diurnal freeze and thaw typical of high mountains in tropical latitudes.

Below about 3,400 metres are found karst forms associated with temperate climates. In foraminiferal limestones, lapies developed under vegetation are less rugged than than those of higher altitudes. However, the coralline limestones show a conical karst development, a feature associated with the tropics which may be a relic of a past warmer climate, although no development of the characteristic sinkholes of temperate karst areas seems to have occurred.

The coralline limestone forms become an accentuated conical karst, termed "labyrinth" karst, at altitudes below 2,000 metres. In this area there is an irregular development of conical hills and deep pits dominated only by accentuated forms along major joints.

This apparent climatic zonation with altitude does not apply to all limestones. Examinations of the physical properties of the various rocks were made to see whether the diversity of forms in similar climatic and altitudinal areas were due to contrasts in lithology. However, no simple correlation between lithology and landforms is apparent. It is emphasised that any attempt to establish an age sequence of tropical or other karst forms is premature without an adequate understanding of the lithological as well as the climatic factors involved.

Part six of the Nova Guinea paper describes the Sibil River and the adjacent karst areas of the dip-slope of the Star Mountains. The Sibil River sinks into the limestone plateau after a course of 23 km and thence flows underground to a double vauclusian spring in the gorge of the East Digoel River some 13 km from the stream sink (ponor).This underground course was traced by fluorescein testing. A large cave, Umbuk Cave, partially collapsed near the entrance, is described in detail. A coloured morphological map at 1:50,000 illustrates many of the surface karst features of the area around the Sibil Valley.

In the concluding section of the major paper the evolution of the limestone landforms is tentatively correlated with other geomorphological features, particularly the Pleistocene glaciation.

Discussion

The landforms described here and the conclusions drawn from them are to be compared with those described by Jennings and Bik (1962) and abstracted in Helictite, 1 (2) : 18. A similar diversity of forms is reported from Australian New Guinea, and the conical karst typical of tropical climates is reported from altitudes whose climate is equivalent to that of temperate latitudes. Jennings and Bik, however, do not emphasise lithological contrasts as an explanation of contrasting karst forms under similar conditions to the same extent as Verstappen. In general, these two pioneer studies from New Guinea have produced ample evidence to demand a much closer examination of the theories of karst landform development in the tropics.

The papers on the Star Mountains are both illustrated by maps and photographs, although reproduction is better in Nova Guinea. The use of oblique air photos and stereo-pairs to illustrate the labyrinth karst is particularly effective. From the speleological viewpoint a sketch plan of the Umbuk Cave and better descriptions of cave localities would be desirable. The modern techniques of geomorphology have been used to summarise the evolution of the landforms of the Star Mountains, particularly the study of correlative sediments and air photographs. Some additional details on the stream flows may have helped to give a better picture of the karst processes operative today.- I. Douglas, Australian National University.

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LE SYSTÈME KARSTIQUE ET L'ÉVOLUTION DES GROTTES (Karst Systems and Cave Evolution). By A. Cavaillé. Speleunca (4th. Ser.) Mem., 2, 1962 : 9 - 28.

Based on French limestone plateaus, a generalised scheme of cave systems and their evolution is set out here. Most of the material is familiar enough and the virtue of the paper rests in the overall synthesis, which would require more space than is available even to be summarised here. Suffice it to note that substantial caves are thought to be the product of watertable and vadose stream action rather than of deep phreatic solution in the Davis-Bretz sense, or even of shallow phreatic activity of recent American workers. Another point of interest is that dry valleys, product of Pleistocene cold periods but now without streams, nevertheless have continued to concentrate infiltrating surface water and so produced cave systems along their length or roughly parallel to them. This recalls Ollier and Tratman's findings for part of County Clare, Ireland. A further aspect often overlooked is that springs may not always keep pace with river incision and may be left sitting high above the valley floor, where, however, they may continue to control cave development.

Most of the new material in the paper is found in a final section on terminology, stimulated by the variety of meanings attached to such commonly used terms as "active" and "fossil". For example, "active" has been used both for caves which are currently being fashioned by solution or corrasion and also for caves which are no longer being enlarged but are in process of blockage by active secondary precipitation forms ("concretions" in French, reminding us that in English we have no satisfactory general term to replace the confusing use of "formations" for them). Cavaillé has proposed and defined the following: embryonic, young, mature, old, dead, senile, fossil and complex. The distinctions rest chiefly on the relative importance of active erosion, development and decay of "concretions", cave breakdown and cave fill. This classification tends to overlook the facts that secondary calcite forms are often actively growing whilst erosion is still going on, e.g., much of Kubla Khan Cave, Tasmania, and that cave breakdown can play an important role in cave enlargement, e.g., in the aeolian calcarenite caves of the Southwest, Western Australia. The "dead" cave category - blocked off completely by concretions - seems not significantly different from "old" caves, though "fossil" cave is given the only meaning it should have. As with many like systems of terms for natural phenomena, it is suspected that most cases will fall into the complex category or be so transitional that they defy attribution to a particular category unless quantitative limits are introduced.-

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Australian National University.

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