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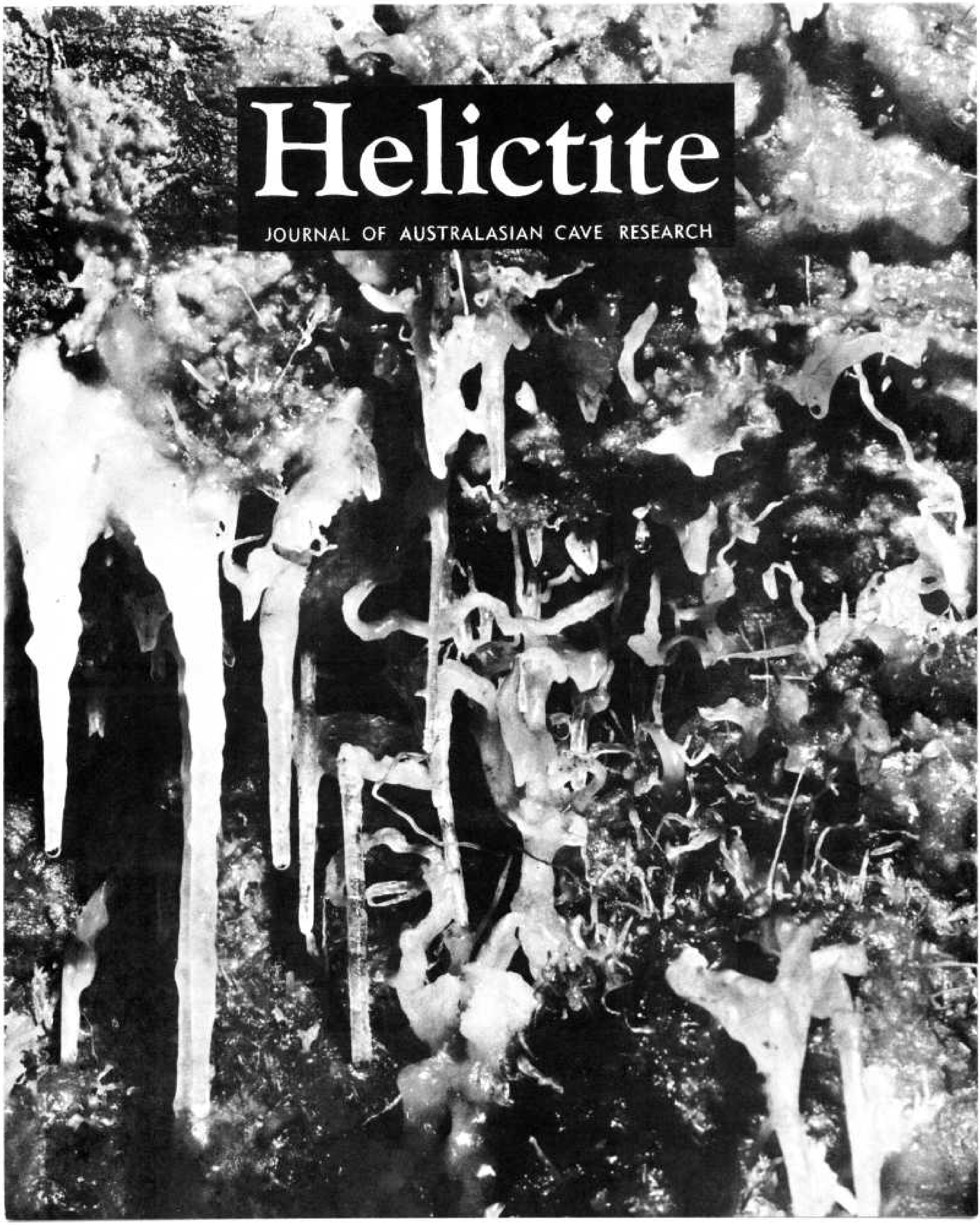

"H E L I C T I T E"

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UNEXPLAINED MARKINGS IN KINTORE AND CUTTA CUTTA CAVES, NORTHERN TERRITORY, AUSTRALIA

By W. P. Walsh

Department of Anthropology, Australian National University, Canberra

Introduction

During April 1963, a survey party of Darwin Speleological Group members discovered a series of incised lines on a rock face 600 ft. beyond daylight in the Cutta Cutta Cave near Katherine, Northern Territory. A search revealed three more groups of lines in the same area, between 500 and 700 ft. beyond daylight. In August the same year, lines were found up to 1,000 ft. from daylight and further search could reveal more groups at this distance within the cave.

Similar markings were subsequently located in the Kintore Cave, about 31 miles from Cutta Cutta. In Kintore Cave the lines exist both in the cave entrance in daylight, and well into the cave proper.

Cutta Cutta Cave

This cave is reached by driving 16 miles south along the Stuart Highway from Katherine, and then following a bush track south of the Highway for a little over half a mile. The entrance is in a low limestone outcrop on the edge of a wide, dry valley. A large collapse runs back into the outcrop from the dry valley, with the cave entrance at the inner end.

Although the cave must have been known to the aboriginal inhabitants of the area (evidenced by the fact that the cave is known to the aborigines as "Cutta Cutta"), they did not bring it to the attention of the first white settlers. The European discovery of the cave is attributed to a stockman named Smith, who came across it whilst lost. As a result, the cave was known for many years as Smith's Cave.

This was the first of several popular names given to the cave. During the 1939-45 War it was frequently visited by servicemen from the nearby Venn and Tindall Airstrips. Due to its position near the town of Katherine, the cave was known to servicemen as the Sixteen Mile Cave, a name which still persists in the area. The Djowan name of Cutta Cutta was discovered recently and seems a more fitting and less confusing title.

The cave is developed in a Middle Cambrian limestone of the Daly River Group. This Tindall Limestone Unit consists of a massive well-jointed crystalline limestone. It is usually of a cream or honey colour, but the exposed surfaces weather black. The outcrop in which the entrance is situated is a particularly pure limestone with almost no insoluble material. True dip and strike is hard to establish, but the horizontal component of the jointing is either horizontal or exhibits slight dips.

From the collapse doline the cave descends a steep talus slope to a depth of about 60 ft. From this point the cave assumes the pattern of a predominantly straight tunnel, lying horizontally, and running for three-quarters of a mile, or more, in a north-westerly direction. This main axis tube is rather higher than wide for the first quarter of a mile, but then becomes more and more circular in cross section. A considerable number of side passages exist at this -60 ft. level and several discontinuous sub-level developments exist from -60 ft. to the water table at -157 ft. All the incised markings seem to be restricted to the -60 ft. level and to the anterior part of the cave.

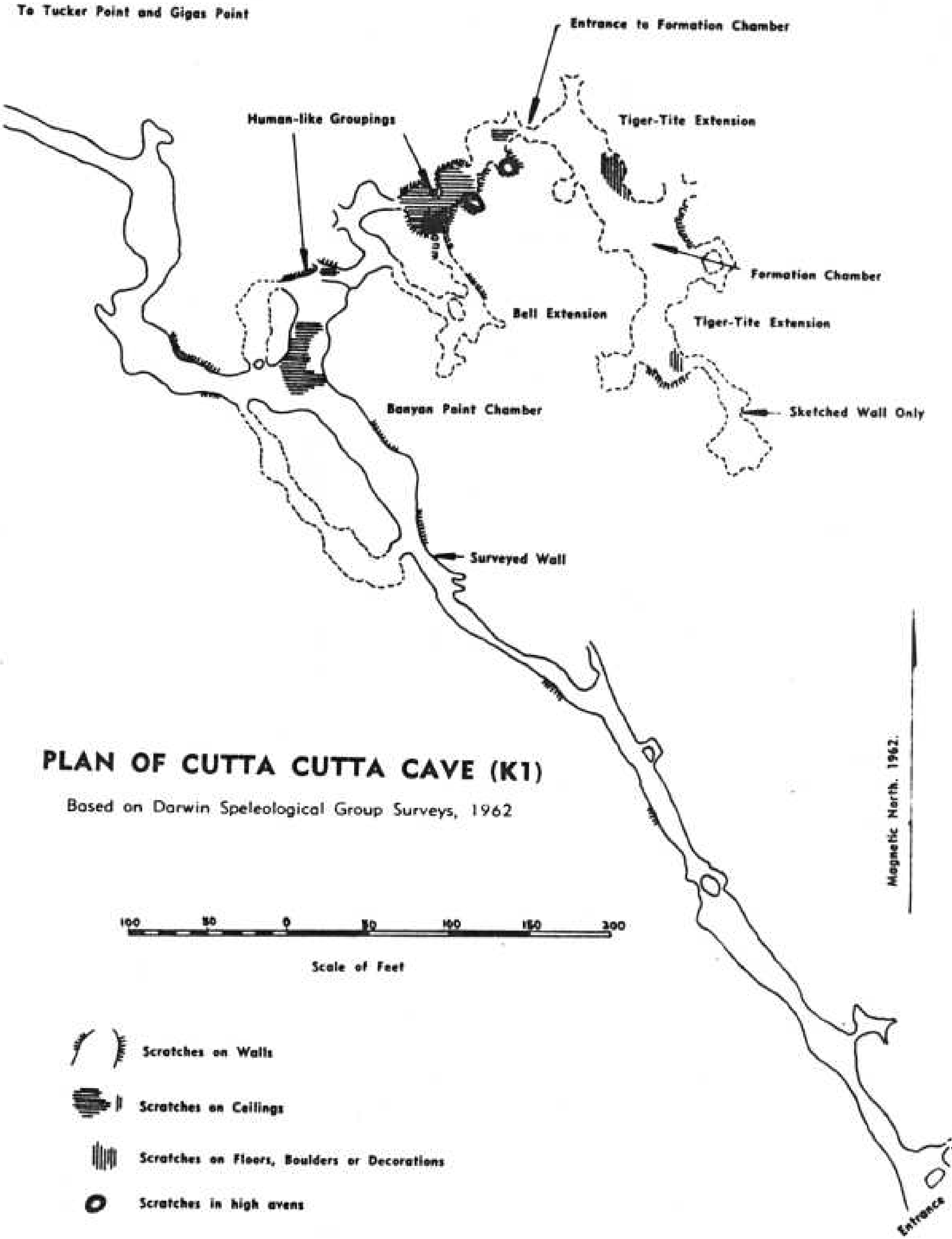
Kintore Cave

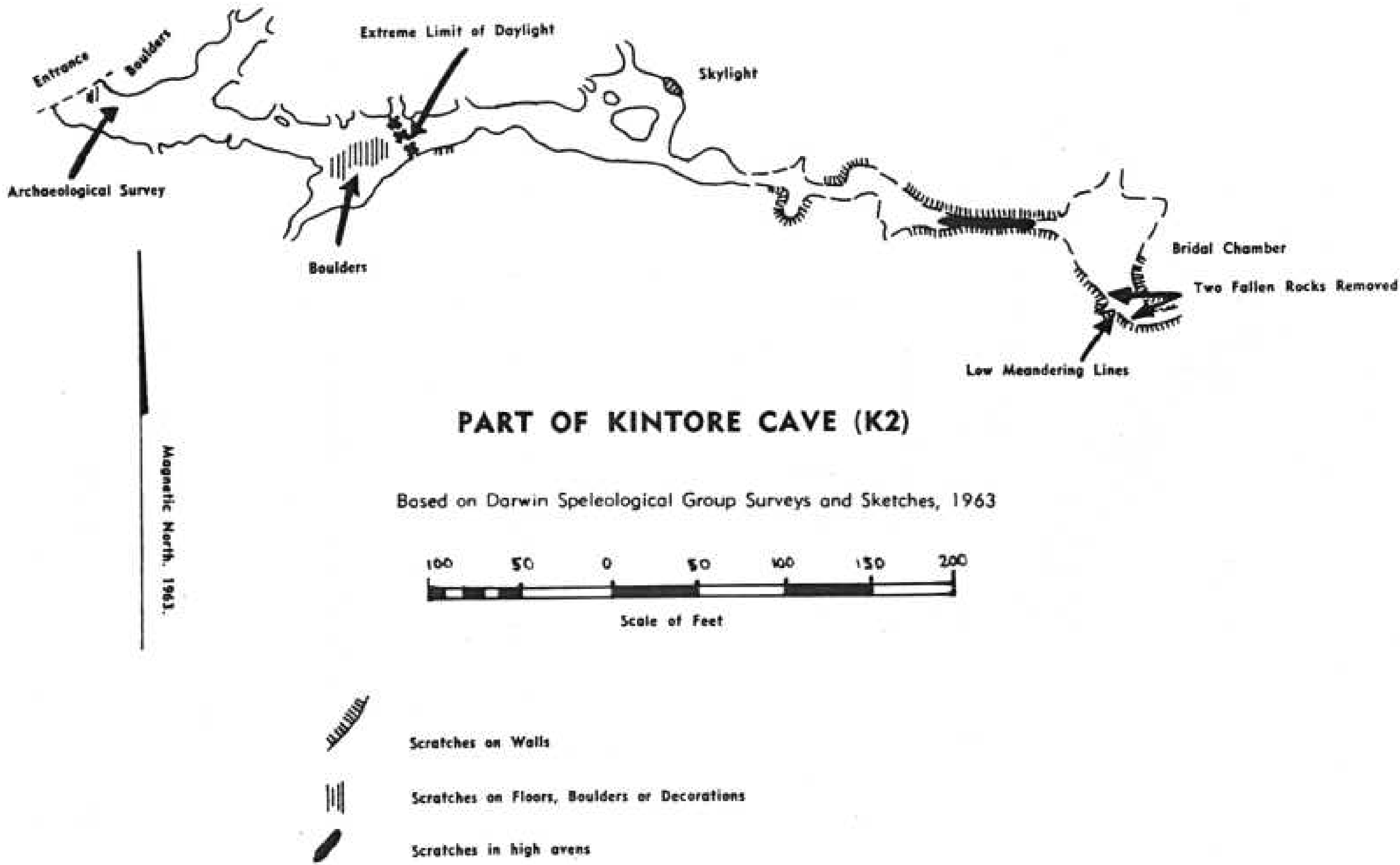
The Kintore Cave is reached by driving north along the Stuart Highway from Katherine for 15 miles and then travelling south of the Highway for about four miles along the internal tracks of the Northern Territory Administration Experimental Farm. The main cave entrance is situated at the foot of a cliff fringing a low limestone ridge.

As with the Cutta Cutta Cave, the Kintore Cave must have been known to the aborigines. The twilight zone of this cave was recently excavated for its aboriginal archaeological content.

The cave was a popular picnic spot with white settlers during the latter part of the 19th. Century and the early part of this century. It was mainly due to the visits of various South Australian political figures (including Messrs. Kintore and Playford) that references to the cave appeared in the literature of the time. After this short period of popularity, the location of the cave was forgotten, and no search was made for it until the 1950's. This search was initiated by the Assistant Administrator of the Territory, Mr. Marsh, and successfully carried out by the Northern Territory Speleological Society.

Kintore Cave is also developed in Middle Cambrian limestone of the Daly River Group, but it is uncertain whether it lies in the Tindall or Manbulloo Unit of the Group. The limestone is predominantly a calcrudite, but it may be partially organic or chemical in origin. In appearance it is light grey with frequent, rounded limestone pebbles occurring either at random or in beds. These pebbles suggest that the deposit is extensively cross bedded. The horizontal component of the jointing is, however, very flat-lying.


To Tucker Point and Gigas Point
Entrance to Formation Chamber
Human-like Groupings
Tiger-Tite Extension
Formation Chamber
Bell Extension
Tiger-Tite Extension
Banyan Point Chamber
Sketched Wall Only
Surveyed Wall
PLAN OF CUTTA CUTTA CAVE (K1)
Based on Darwin Speleological Group Surveys, 1962
Magnetic North. 1962.
100 50 0 50 100 150 200
Scale of Feet
Scratches on Walls
Scratches on Ceilings
Scratches on Floors, Boulders or Decorations
Scratches in high avens
Entrance


Entrance
Boulders
Archaeological Survey
Extreme Limit of Daylight
Boulders
Skylight
Bridal Chamber
Two Fallen Rocks Removed
Low Meandering Lines
PART OF KINTORE CAVE (K2)
Based on Darwin Speleological Group Surveys and Sketches, 1963
100 50 0 50 100 150 200
Scale of Feet
Magnetic North. 1963.
Scratches on Walls
Scratches on Floors, Boulders or Decorations
Scratches in high avens

In plan, the cave shows an extensive reticulation of joint-controlled passages developed on one level only. In section, these passages are seen to lie very close to the level of the surrounding plain, and consequently are very close to the surface of the ridge. As a result the cave has many entrances where roof collapse has broken through to the surface. Most of the passages are wider than high, and display the morphological effects of roof collapse and those of a small, intermittent stream which still occupies the cave.

THE INCISED MARKINGS

The incised lines are found on soft rock surfaces or scratched into soft mud coatings on the cave wall. Some very faint scratches are found on hard rock faces or on secondary calcite. On the softer rocks or mud, the lines attain a depth of up to 2 mm. When they occur on hard rock surfaces or on the soft surface layers of rock or clay which have scaled away from the wall, only fine scratches about 0.2 mm deep exist.

The great majority of the lines occur in a characteristic grouping of from three to five sub-parallel lines spanning a width of about 3.5 to 5 cm, and continuing for from a few centimetres to metres in length. These sets of incisions often occur in great profusion, so that it is almost impossible to separate one set from the next. In areas where the sets are not so complex two parallel sets of similar length exist 15 to 23 cm apart.

Some of the sets of both the clay-filled and clay-free types are arranged in such a way that they bear a strong resemblance to human figures. However, such groupings are very rare and any attempt to read a deeper meaning into them than coincidence alone would be statistically undesirable. At the moment, these human-shaped groupings appear to be restricted to the Cutta Cutta Cave. Further search might show them to be present in the Kintore, and perhaps to be more abundant in both caves than present investigations suggest.

Superimposition and Relative Antiquity

The vast majority of the lines are covered by a film of clay which makes them inconspicuous and difficult to photograph. This clay film is, in places, overlaid by vegetable debris deposited at a clear and undisturbed high-water mark. In the Cutta Cutta Cave this high-water mark is at about 100 ft. above the present water table, and recent flooding of the incised areas seems unlikely. As both the clay and the high-water mark are deposited over the incised lines, it would appear that these pre-date flooding.

Occasional groups, or individual sets, are not clay-filled and these reveal the colour of the rock underlying the clay. Sets of this type exist in both the Kintore and Cutta Cutta Caves and may reasonably be considered more recent than the clay-filled sets. In both the clay-filled, and more occasionally the clay-free sets, extensive superimposition occurs.

Distribution of Types

Cutta Cutta Cave

Old or clay-filled sets exist on the walls and ceilings between the Banyan Point Chamber (500 ft. from daylight) and the entrance to the Formation Chamber in the Tiger-Tite Extension (750 ft. from daylight). Profusely scored sections are confined to vertical walls and small avens and pockets in the ceiling. Some sections of these old lines are covered with later sets. It is common for both the older and newer sets to lead into crevices in the wall or ceiling which are too narrow for the insertion of a hand.

Clay-free sets occur in the Banyan Point Chamber and at the extreme end of the Tiger-Tite Extension (1,000 ft. from daylight). With these are found a large number of fine scratches occurring on hard limestone and on calcite decorations. These fine scratches may belong to either the earlier or later period as the rocks on which they are found are not coated with mud.

No scratches exist in the Tucker Point-Gigas Point area (1,400 ft. from daylight) where sub-fossil bone material of the false vampire bat (*Macroderma gigas* Dobson) suggests a past roosting site of this species.

Kintore Cave

A boulder in the immediate entrance of the cave is closely covered with sets of lines, all clay-filled. Another large group of lined boulders occurs at the limit of daylight where the lines are concentrated along angles of the boulders, so that the sets present a pattern of V's with the apex downward. As with the first group, all lines are clay-filled.

Very few sets exist from the limit of daylight to a point some 200 ft. further into the cave. From this point onward, however, there is a great profusion of lines, and the majority are clay-filled. It is in this section that the lines are found in the most inaccessible positions. In one instance, sets attain a length of about two metres and cover one wall of a narrow passage from floor to ceiling, reaching a height of 4.5 metres.

Some rock faces in the inner sections of the Kintore are covered in hard secondary limonite, which occasionally preserves numbers of very fine scratches, but generally forms a border to the engraved areas. Those sections not covered by limonite or clay consist of a soft friable coating of calcareous material over a chalky limestone. A number of unusual lines occur on this surface. These consist of sets of two or three, or individual meandering lines.

Close examination of two loose rocks taken from deep within the Kintore has revealed a vast number of small lines of irregular arrangement occurring in conjunction with the distinct sets. Although a field check has not been possible, these tiny lines may be found to accompany the larger sets in all locations.

Possible Origins

Although it has not been possible to determine definitely the correct origin of these incised markings, there are a number of possible explanations for them, and these are now considered.

1. Geological. Solutional etching or any similar geological process may be discounted on the grounds that the lines correspond to no known or suspected structural features. Not only do they not correspond to bedding, jointing or cleavage, but in some cases the lines have quite clearly been incised into the rock with considerable force, so that the surrounding wall material is splintered or has been spalled away. A geological origin would therefore seem to be impossible.

2. Animal. The arrangement of the marks in sets of four or five, and the arrangement of the sets in groups of two, strongly suggests an animal origin. Any animal which is to cause these lines must possess claws and be of about the right size to space the individual lines of a set correctly, and also to account for the spacing between the sets of a group. Since the caves are level and without any major obstacles, almost any animal could obtain access to the marked sections.

The following animals are known or suspected of entering the caves:-

At the present time the Kintore Cave is inhabited by two species of bats, the bent-winged (*Miniopterus schreibersi* Kuhl) and the sheath-tailed (*Taphozous georgianus* Thomas). The Cutta Cutta Cave is inhabited by the bent-winged bat and the orange horseshoe bat (*Rhinonicteris aurantius* Gray). All these are too small to cause the markings arranged in the observed pattern.

The Cutta Cutta Cave has been inhabited until recently by the false vampire bat (*Macroderma gigas* Dobson), and may still be on occasions. This bat would provide sets of lines of the correct size, and would suit the distance between sets moderately well. However, it is hard to explain how a bat could produce lines horizontally across ceilings, or be responsible for the large number of very low lines in the Kintore Cave. Also no indications exist to suggest that *M. gigas* has ever lived in the Kintore Cave, or that it ever roosted in the marked sections of the Cutta Cutta Cave. No scratch marks, however, occur either in the section of the Cutta Cutta Cave where skeletal material of *M. gigas* is abundant, or in two other known roosts of the species.

Therefore, despite the convenient size of *M. gigas*, it seems extremely improbable that it is responsible for the marks. The lack of any marks appropriate in size to the numerically large present-day bat populations in both caves indicates that bats do not cause any scratch marks of note, or at least not in these caves.

Goannas (*Varanus* sp.) are quite common in the caves at distances of up to a quarter of a mile from daylight. These animals, although approximately the right size, would be incapable of climbing up to and scratching overhanging walls or flat ceilings.

The dingo (*Canis antarticus* Kerr) ventures a long way into the dark zone, but does not provide any explanation for the higher markings.

The Little Northern Native Cat (*Satanellus hallucatus* Gould) is known from the Cutta Cutta Cave. This and related species are widely known as dwellers of the twilight zone. They may venture into these caves as far as the furthest scratchings, but could not be responsible for the marks found on flat ceilings.

The echidna (*Tachyglossus aculeatus* Shaw and Nodder) appears to be a permanent inhabitant of the Kintore Cave. This animal, too, is precluded by the existance of the higher marks.

Bandicoots and possums may occur in the caves, but again, could not make the higher markings. On the other hand, the marks could have resulted from a variety of animals - bats marking the ceilings, for example, echidnas the lower walls, and goannas scratching boulders.

Such a theory of composite origin does not seem reasonable as all the marks are remarkably similar. Indeed, only the few very low meandering single sets of one, two or three lines in the Bridal Chamber of the Kintore Cave deviate from the common pattern. These markings are so outstandingly different that they may well have another origin.

3. Human Agency. The markings are very numerous. When such factors as the mud coatings are taken into account, it does not seem possible for them to be some form of recent and elaborate accident or hoax.

This does not rule out the possibility that the lines were made by aboriginal inhabitants of former years. Indeed, it seems that man alone could be responsible for marks occurring on flat sections of the roof. It is more difficult to see how man could have been responsible for one or two groups in high avens and chimneys. In at least one case in the Kintore, a site could be reached by climbing, but such a climb would partially obliterate the probably pre-existing groups of scratchings.

Groups which lead into very narrow crevices would also be hard to ex-

[Plate 9]

plain in terms of human activity. Lastly, there is the motive and the fact that almost all the groups seem to be totally non-representational. The latter, of course, is an assumption and should not necessarily rule out human agency.

Conclusions

At the moment no satisfactory explanation of these abundant cave markings seems possible. Similar, if not identical groups, exist in at least one cave near the border of Victoria and South Australia (these were brought to my notice by Dr. A.M. Richards who recently visited the Princess Margaret Rose Cave). However, no direct comparisons have yet been made. It seems possible that these markings are widely distributed, perhaps occurring throughout the Continent.

If a thorough search is conducted for the marks in Australian caves and their circumstances are carefully investigated, an explanation or explanations should appear, on evaluation.

Perhaps the most conclusive evidence would be provided by searching for bone material in all the known sites and attempting to locate the relevent common faunal element.

Acknowledgements

I wish to take this opportunity to thank all those who have helped me in the course of this study. In particular, I should like to thank Mr. J. Golson of the Department of Anthropology, and Mr. J.N. Jennings of the Department of Geography, both of the Australian National University, Canberra, for helpful discussions and criticism of this manuscript. I should also like to thank Mr. D. Maggs for permission to use his photographs, and members of the Darwin Speleological Group for their assistance in the caves.

Captions to Plate 9 Opposite Page 90

Top picture: Characteristic scratch marks on a boulder on the floor of the Cutta Cutta Cave.

Bottom picture: A group of scratch marks on a wall of Cutta Cutta Cave. The reproductions are from colour slides taken by Mr. D. Maggs.

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ABSTRACTS

NEW CAVERNICOLOUS CARABIDAE (COLEOPTERA) FROM MAINLAND AUSTRALIA. By B.P. Moore. J. ent. Soc. Qd., 3, 1964 : 69 - 74.

The following new cavernicolous Carabidae are described: the new genus Speotarus Moore, with the species S. lucifugus Moore (type) from Naracoorte, South Australia, and S. princeps Moore from Ashford, N.S.W.; Notospeophonus jasperensis Moore from Wee Jasper, N.S.W., and the subspecies N. jasperensis vicinus Moore from Bungonia, N.S.W.; N. pallidus Moore from Myponga, South Australia; and the subspecies N. castaneus consobrinus Moore from Buchan, Victoria. The species of Speotarus provide the first recorded occurrence of the subfamily Lebiinae in caves, and are thus of exceptional interest. All the new forms appear to be recently evolved cavernicoles.- A.M.R.

NEW RECORDS OF CAVE AND MINE-DWELLING PSOCOPTERA IN AUSTRALIA. By C.N. Smithers. J. ent. Soc. Qd., 3, 1964 : 85.

This paper is the first record of Psocoptera (book lice) from Australian caves. Two species are mentioned - Lepinotus reticulatus Enderlein and Psyllipsocus ramburi Selys-Longchamp. Both are common in dwellings in many parts of the world. P. ramburi is known from caves and is a polymorphic species occurring in a number of forms which have various degrees of pigmentation, eye, ocellus and wing development. Material was obtained from Naracoorte, South Australia; Buchan, Victoria; Wee Jasper, Wombeyan and Charbon, N.S.W.- A.M.R.

SOME GEOMORPHOLOGICAL PROBLEMS OF THE NULLARBOR PLAIN. By J.N. Jennings. Trans. Roy. Soc. S. Aust., 87, 1963 : 41 - 62.

A rediscussion of geomorphological problems presented in previous papers by Jennings (1958, 1961) on the basis of further data provided by recent exploration by speleological parties. Considerable interest centres on the underground morphology of the Nullarbor Plain, one of the world's largest karst regions. Jennings says that present knowledge pointed to a poverty of caves in the Nullarbor, known caves probably not exceeding 100 in the 65,000 square miles of limestone. The underground as well as the surface morphology is indicative of a retarded, immature karst. This is thought to indicate that Pleistocene pluvials did not cause the climate to depart very much or for very long from its present semi-arid to arid range. Jennings supports the view that cave destruction is in progress today rather than formation. The extremely flat surface of the Plain is regarded as an almost unmodified emerged sedimentary surface of Miocene age. The shallow caves are considered to be primarily of vadose origin, while the few deep caves are believed to have developed along the lines of "master caves", and their coastal distribution thought to be climatic in origin rather than structural.- E.A.L.

A NEW SPECIES OF ECHINODILLO (ISOPODA, ONISCOIDEA, ARMADILLIDAE) FROM FLINDERS ISLAND, TASMANIA. By Alison J.A. Green. Proc. Roy. Soc. Tasmania, 97, 1963 : 77 - 80.

A new species of isopod, Echinodillo cavaticus Green, is described from a limestone cave near Whitemark, Flinders Island (Furneaux Group, Bass Strait). It is considered to show striking similarities to E. montanum Jackson found on Marquesas Island. No mention is made of any modifications or adaptations to cave life. The species is described from 10 males and 13 females.- A.M.R.

THE DEVELOPMENT OF KAIRIMU CAVE, MARAKOPA DISTRICT, SOUTH-WEST AUCKLAND. WITH AN APPENDIX ON SPORES AND POLLEN GRAINS BY W.F. HARRIS. By P.J. Barrett. N.Z. J. Geol. Geophys., 6, 1963 : 288 - 298.

Kairimu Cave is five miles east of Marakopa, a township on the west coast of the North Island of New Zealand, at South Latitude approximately 38°20'. The cave was formed in a 30 ft. thick band of Lower Oligocene limestone and its drainage system determined mainly by a shallow syncline in the limestone. Barrett says that development of the oldest passages was initiated under phreatic conditions after uplift in Late Miocene. However, the main period of cave development was controlled by vadose conditions. During Late Pliocene and Early Pleistocene, a time of high sea-level regimes, the cave was flooded and filled with silt and clay. This conclusion was suggested by the height of the cave entrance above sea level (350 ft.) and has been confirmed by microfloral age determinations of the clay fill. Diagrams include a plan of 8400 ft. of surveyed passage in Kairimu Cave, all of which lies within a mile of the single negotiable entrance - where its stream emerges from the hillside.- E.A.L.

A REVIEW OF THE GEKKONID LIZARD GENUS HETERONOTA GRAY, WITH A DESCRIPTION OF A NEW SPECIES FROM WESTERN AUSTRALIA. By Arnold G. Kluge. J. Roy. Soc. W. Aust., 46 (2), 1963 : 63 - 67.

In this paper a new species of Heteronota is described from the North-West Natural Region of Western Australia. This new species, Heteronota spelea Kluge, appears to be restricted to subterranean cavities. Its known geographic range is less than 160 miles wide at its extremes. This limited range and peculiar habitat suggest that it is a geographical relict.- A.M.R.

BAT BANDING. By P.D. Dwyer. Aust. Nat. Hist., XIV (6), 1963 : 198 - 200.

In Australia there are 45 species of small bats, the Microchiroptera. So far just over 10,000 individuals of nine species have been banded. Recoveries of marked bats now number 1,425. These have included only four of the nine species banded. More than 1,000 of them have been recoveries of the Bent-winged Bat. Although most bats recovered have been retaken only once, a number have been taken two or more times, and a few on six different occasions. Most have been taken in the cave or mine where they were banded, but over 400 have been retaken after moving from one locality to another. To date it is only for the Bent-winged Bat that a reliable picture is emerging. Distances travelled by banded individuals have varied from less than 100 yards between two caves up to 220 miles. The ability to "home" is well developed. Most individuals undertake seasonal movements between summer and winter roosting places. Breeding females make annual journeys in spring and summer to and from special caves where maternity colonies are established. - A.M.R.

TWO NEW SPECIES OF ACARINA FROM BAT GUANO FROM AUSTRALIAN CAVES. By H. Womersley. Trans. Roy. Soc. S. Aust., 86, 1963 : 147 - 154.

Two new species of Acarina found associated with the guano of bat caves in New South Wales and South Australia are described. The first, Coproglyphus dewae Womersley (fam. Tyroglyphidae, subfam. Carpoglyphinae), is entirely coprophilous in all stages of development. It is recorded from Fig Tree Cave and Basin Cave, Wombeyan, N.S.W.; a railway tunnel, North Sydney, N.S.W.; and from Naracoorte, South Australia. The other, Neotrombidium gracilare Womersley (fam. Leeuwenhoekiidae), has been found in the guano only as adults, and is probably coprophilous in that stage. The larvae, when known, may be found parasitic on Streblidae or other ectoparasites of bats. It is recorded from Fig Tree Cave, Wombeyan, N.S.W.; Murder Cave, Cliefden, N.S.W.; and Punchbowl Cave, Wee Jasper, N.S.W. The known species of Neotrombidium, whether known as adults or larvae, are discussed and their possible hosts considered.- A.M.R.

THE SKIPTON LAVA CAVES. By C.D. Ollier. Vict. Nat., 80, 1963 : 181 - 183.

A description and the first published plan of Skipton Lava Cave, near Ballarat, Victoria. The cave was formed inside a lava flow erupted from the now-extinct volcano, Mt. Widderin. Although the cave has suffered extensive collapse, it contains the two largest chambers in the volcanic caves of Victoria. It also contains a small, permanent lake, despite the fact that the cave is formed in permeable volcanic rock. Many years ago a large bat colony inhabited the cave. The presence of undisturbed guano in association with basalt has led to the growth of some extremely rare minerals in the main chamber.- E.A.L.

NEW ZEALAND CAVE FAUNA - 1. THE LARVA OF DUVALIOMIMUS MAYAE BRITTON 1958 (COLEOPTERA; CARABIDAE: TRECHINAE). By Brenda M. May. Trans. Roy. Soc. N.Z., 3 (14), 1963 : 147 - 150.

This paper describes a trechine larva trapped in association with adults of Duvaliomimus mayae Britton in a cave near Waitomo, New Zealand. It is presumed to be the same species as the adults. Comparison with the larvae of four allied European and Japanese cavernicolous species reveals the similarity of D. mayae to the Japanese species Trechiama pluto Uéno.- A.M.R.

CARBONATE MINERALOGY IN CAVES

By C. D. Ollier, M.Sc.

Department of Geology, University of Melbourne

In his introduction to the Symposium on Cave Mineralogy held by the National Speleological Society in the U.S.A. (1962), W.B. White writes: "A cave forms an ideal natural laboratory for studying low temperature reactions since underground the temperature and pressures remain constant for long periods of time." But surely if a laboratory is a place to do experiments, caves are rather poor labs, because we cannot control the variables. In cave mineralogy we are usually working backwards - the experiment (crystal growth) is over and we are trying to work out what went on from the final product. To do this is not easy for there are many variables in a cave environment which may or may not be relevant, and to a degree unknown. Nor is it easy to apply laboratory findings to cave mineralogy, and attempts to apply experimental data directly may lead to ludicrous results. As R.C. Curl points out, it is not even enough to find out what factors are concerned with crystal growth of a particular mineral, and laboratory data of the "factors concerned" type is largely useless. Only a knowledge of the actual mechanism of crystal growth will reveal how the factors operate. Of course, this knowledge is ultimately derived from laboratory experiments, but there will always be a good deal of inference in matters of cave mineralogy. Because of the lack of control in "cave experiments", application of knowledge gained from the study of cave mineralogy is very limited, but we can hope, with W.B. White, that the study will prove rewarding and that the results may find application in wider fields such as the chemistry of weathering or chemical oceanography.

However, we do not need any justification for studying cave mineralogy. We study minerals in caves simply because they are there, and we wonder why they are there, and why they have the particular form, abundance and distribution that they do.

There are several groups of cave minerals; the minerals of the enclosing rock, the minerals derived from this rock by erosion or as insoluble residues, stray minerals that may be washed into a cave, and finally the secondary minerals that form in the cave environment. The last group includes odd rarities, like the complex phosphates formed in guano, but mainly concerns the carbonates deposited in limestone caves. The N.S.S. Symposium was almost entirely devoted to anhydrous carbonates of secondary deposition, although other topics are briefly discussed in the introduction.

Cave mineralogy is concerned with all the minerals in caves, their shape, chemistry, crystallography, distribution, mode of formation, age - in fact, all conceivable aspects of mineralogy. The basic work of recording mineralogical information from caves is still terribly inadequate and there is much scope for amateurs to do valuable work in this field. (This does not mean collection of stalactites!) On the other hand, professional scientists have applied elaborate techniques such as radiocarbon dating, X-ray diffraction, and petrofabrics. The situation at present is that we have a fair idea of how cave minerals originate, and have a good idea of where the problems lie.

The mineralogy of caves has been described adequately before, perhaps the best summary being by Warwick in "British Caving". The present article is a brief review of those aspects of carbonate mineralogy which were discussed at the N.S.S. Symposium, with a few personal remarks added.

Growth of Stalactites

G.W. Moore gives an account of the growth of stalactites. Drips of water have a limiting size of about 5 mm and are liable to deposit small rings of calcite of this diameter. Successive drips may eventually build a straw stalactite, which continues to secrete at the tip as long as saturated water flows down the hollow of the straw. Later filling and overgrowth may convert the straw into a massive stalactite, but growing stalactites will always have a flat bottom, where drips are active, and are not perfectly pointed. The drip mechanism also imposes a lower limit to the size of stalactites.

Calcite grows fastest in the c axis crystallographic direction, and straws are made of calcite with the c axis vertical. In large stalactites those crystals growing with the c axis perpendicular to the surface gradually eliminate those with other orientations, so the stalactite tends to have a radial crystallographic structure. Occasionally regular crystallography may be preserved right across a thick stalagmite. Sometimes the oriented overgrowth is associated with regular crystal form, and W.A. and A.M. Bassett describe a hexagonal stalactite from Rushmore Cave, South Dakota, with c axis vertical, so they postulate overgrowth onto a straw. W.B. White points out that although regular external form is rare, many stalactites break along clean cleavage lines, showing that the internal crystallographic structure is continuous even when the shape of the stalactite is irregular. (If a stalactite is submerged by flooding the horizontal crystals may enlarge regularly; the beautiful Jewel Casket in Yallingup Cave, Western Australia, seems to be a magnificent example of this type.)

(blurred lines above are in original publication)

Moore maintains that rate of growth of stalactites is very slow, and never exceeds several millimetres per year, perhaps a quarter of a millimetre being average, and very fast growth rates inferred from stalactites on concrete are not valid. (Some of the stalactites growing on wire netting from natural drips seems to indicate rather more rapid growth, as at Yarrangobilly, N.S.W.) Dating by radiocarbon has shown stalagmites thickening by only 0.06 mm per year. Growth in length of straws can obviously be much greater, and growth in length must not be confused with growth in bulk.

Why is calcium carbonate precipitated from solution in a cave? It is not likely to be due to evaporation, for air in caves with active formations is saturated. Loss of CO_2 to the atmosphere from a drip could cause precipitation of calcite. The CO_2 content of air is only 0.03%, so the contribution of atmospheric CO_2 to speleogenesis is negligible. Cave atmospheres normally have the same percentage of CO_2, but soil atmospheres have up to 0.65%, so CO_2 can be dissolved in the soil and diffused again when the low CO_2 partial pressure in the cave is reached, causing precipitation of calcite. (This mechanism seems to provide a simple explanation of why stalactites are absent in arctic regions but plentiful elsewhere - if there is no soil, there can be no high percentage of CO_2, and so the mechanism cannot work.) Stalactite growth is not necessarily related to rate of water flow, because the water may or may not be saturated with CO_2.

Carbon isotopes can be used to indicate more about the mechanism of stalactite formation. Limestone is so old that its radiocarbon is virtually finished, while living things have the highest proportion, so there is a "zero age" carbon in the soil and "infinite age" carbon in the limestone. Simple theory indicates that in the formation of a stalactite, 50% of the carbon should come from the air and 50% from the rock, but it turns out that stalactites have 90% of modern carbon. Moore believes this means that calcium bicarbonate remains in contact with the reservoir of carbon dioxide in the soil atmosphere long enough for the abundant radiocarbon-bearing soil bicarbonate to exchange with and nearly mask the small quantity of available bicarbonate from the limestone before the solution moves down through the rock to the cave. (It would seem that if solutions are in contact with rock for a long time there might be further exchange, increasing the proportion of "old" carbon. Perhaps in deep caves or those with sluggish movement of groundwater, the percentage of modern carbon would be lower.)

Calcite/Aragonite

R.L. Curl provides a very well documented account of the calcite/aragonite problem. These minerals are polymorphs of calcium carbonate, but since aragonite is 16 times more soluble than calcite it is very much rarer, although Curl presents some evidence to suggest that it is more common than is usually supposed. The problem is to know how aragonite comes to be present in caves, and how it manages to survive. It is evident that aragonite is in some sense "stable" in the presence of calcite, and Curl discusses and clarifies concepts of stability.

Many factors may be involved in the formation of one polymorph rather than another, and Curl reviews much work on chemical and physical factors in the formation of aragonite - a large task which is mainly unprofitable, for a great deal of the work cannot be evaluated. Curl points out that a knowledge of possible factors is not enough; what is required is a knowledge of actual mechanism of crystal formation, a knowledge of how the factors work. He goes on to a discussion of crystal growth, especially screw dislocation and growth layers, to show how very small amounts of impurities might have great effect on crystal growth rates. Unfortunately, little is known about the crystal growth of calcite or aragonite in particular. Nevertheless, it is thought that in understanding the relative abundance of aragonite and calcite, the competition during growth is of paramount importance. In this connection, J. Shlichta points out that the screw dislocation-growth step mechanism is unique for near equilibrium conditions in growth from a solution, and the process is not a reversible one, so a great deal of discrimination can go on during nucleation. He also mentions that the energy of hydration has to be overcome in getting from ions in solution to the solid crystal, another factor which may be discriminatory between calcite and aragonite in nucleation.

Curl points out later, in reply to a question, that the fact that aragonite is more soluble than calcite does not mean that aragonite necessarily dissolves more rapidly. The solubility is a matter of equilibrium but the rate is controlled by kinetics. This distinction is very often overlooked.

Secondary Minerals

W.B. White and G.H. Deike list the secondary minerals identified in Wind Cave, South Dakota, and discuss them according to their setting. Perhaps the most interesting are the boxworks, the blades of which are not simple veins or crack fillings but complicated mineral assemblages consisting of a core of calcite, sediment layers and clear outer calcite crystals. Where boxwork is traced into solid rock the fracture filling is usually paper thin, but it enlarges when it emerges without any change in colour or texture, and becomes the core of the blade, 1-2 mm thick. The authors also describe the mineralogy of geodes, dripstone, globulites and other types of deposition.

Great stress is put on the discovery of euhedral, apparently authigenic quartz crystals, and it is a pity the occurrence is not described in more detail. The authors believe it is definitely secondary, and conclude that the cave minerals were deposited from solutions at 150 to 200°C. They do not say whether any superheated water is available, and at first sight it appears that they have applied their physical chemistry rather naively. Even if the quartz is not a sample of insoluble residue, it is well-known that anomalous high temperature quartz can be found in sediments which have never suffered high temperatures, and some other explanation is required.

Again it is seen how difficult it is to apply laboratory knowledge to real minerals, and the authors say their explanation of the assemblages is only "highly tentative". Nevertheless, the paper is valuable as a factual record of cave mineralogy, and could well be used as a model for further investigations and reports.

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THE PENGELLY CAVE-RESEARCH CENTRE, U.K.

The Pengelly Cave-Research Centre is situated at Higher Kiln Quarry, Buckfastleigh, Devon, England. It is named after William Pengelly, the nineteenth century excavator of Kent's Cavern, Torquay. The Centre was founded on March 31, 1962, at a joint meeting of the Society for the Promotion of Nature Reserves, the Devon Naturalists' Trust and the Devon Speleological Society. The land was purchased by the Society for the Promotion of Nature Reserves and is to be developed for the furtherance of cave research and conservation in Britain. Unlike other European cave laboratories, the Pengelly Centre is essentially an amateur project. Higher Kiln Quarry contains the entrances to five caves, each of which shows different features of scientific interest. Research facilities inside the caves will follow later.

The Association intends to publish annually a Journal containing articles on the various aspects of cave studies, including archaeology, biology, geology, hydrology, cave research centres, the teaching of speleology, conservation, etc. The first issue of the Journal should be ready about the middle of 1964.

ROYAL SOCIETY OF VICTORIA MEDAL

The 1963 award of the Royal Society of Victoria's Medal for Scientific Research has been made to Mr. D.J. Mulvaney, M.A., of the University of Melbourne, for his work in Australian archaeology. During 1963, Mr. Mulvaney carried out extensive excavations in the Kintore Cave, near Katherine in the Northern Territory of Australia.

BAT ECHOLOCATION - A REVIEW

By E. A. Lane

The Australian Atomic Energy Commission

The work of Griffin, Mohres, and many others, over the past few years has shown beyond all doubt that some bats use ultrasonic waves for locating objects in their vicinity, and it appears that few species rely on sight as a means of orientation. The superb flying skill of these animals indicates a very high degree of utilisation of the information contained in the received sound waves, and has raised many problems concerning the principles of echo-location, such as the avoidance of fine wires when receiving echoes against a background of noise considerably greater in intensity; and variation in forms of transmission between families. Many intensive studies have been made recently and the papers listed here are a selection.

In his paper on echo-location ecuity of bats, Kay (1962) studied the family Vespertilionidae in terms of its echo-location ability. He outlines a simple Frequency Modulation system and notes that at least two other forms of transmission are used by the bat. He adds that such a double-channel, pulsed F.M. system could account for the high degree of acuity of the animal's echo-location system. Such a system had not yet been tried by man to solve his echo-location problems in Asdic or Radar and might well prove to be an aid to blind people.

Griffin, McCue and Grinnell (1963) state that one of the critical factors in the survival of bats has been the ability to locate flying insects precisely and rapidly in darkness. Detection is sometimes based on sounds generated by the insect, but they are commonly intercepted by echo-location. Therefore, echoes from small insects must be detected despite the presence of louder echoes from other objects at about the same distance, such as twigs and larger insects. The echo-location can also be complicated by orientation sounds from other bats nearby. The problem is the recognition of meaningful signals in the presence of irrelevant noise. The paper discusses controlled experiments with cave-dwelling bats on the bats' obstacle avoidance reactions as a result of resistance to jamming noise of various frequencies and intensity.

Jamming was most effective at special frequencies. The difference in obstacle avoidance in the presence of coherent noise and non-coherent noise (four independent noise generators) was small and not consistant. Detection of wires in noise was similar to detection in quiet conditions. The bat's ears and brain apparently are capable of discriminating echoes from noise by means of differences in direction of incidence. When confronted with small wires in high intensities of broadband noise, the bat almost always approached the rows of wires sufficiently obliquely so that the echo and most of the noise reached it from directions differing by about 60 degrees.

Grinnell and McCue (1963) give a progress report of their neurophysiological investigations of the bat _Myotis lucifugus_ stimulated by F.M. acoustical pulses. They detail several experiments and state that their observations on overlapping pulses strongly suggest that if _Myotis_ measures distance by sensing time-interval between outgoing pulse and incoming echo, it can measure ranges at least as small as 5 cm.

Kay and Pickvance (1963) studied the ultrasonic emissions of Lesser Horseshoe bats. Two features were observed. The range of frequencies used by adult bats when congregated in a crowd of 60 or more does not exceed 3 Kc/s, even though their frequency of emission is of the order of 113 Kc/s. Baby bats can make sounds of echo-location type within three days of birth.

They report erratic variations in the emission frequencies used by young bats at first, and a rise in frequency as the bat grows older and the power of the laryngeal muscles develops until the muscles produce the high frequency vibrations characteristic of the adult. With well-developed but still juvenile bats, frequency wavers at the start of transmission up to a constant value - the bat apparently hunting for the required frequency.

Cahlander, McCue and Webster (1964) discuss work on the determination of distance by echo-locating bats. A bat could intercept an insect by sensing the direction of the insect and flying a collision course until its open mouth intercepted it. However, by means of a high-speed movie camera, the authors have shown that _Myotis_ does not use this method to catch flying insects. They found that the most common manoeuvre was the cupping of the interfemoral membrane to form a scoop. Alternatively, the bat may reach out with a wing and guide the insect into the cupped membrane. In either case, the bat transfers the insect from membrane to mouth while in flight. Since the spreading of the membrane, or reaching out with the wing, can only succeed at close range, the authors presume that the bat can sense the distance to the prey. Another example of probable distance-measuring is the landing of bats against a wall. This involves upward movement of the legs and gripping the wall as flight ceases.

They discuss two basic schemes for measuring range-time interval between transmission and reception of echo. They also discuss a method of sending out a continuous wave the frequency of which is a suitable function of time, and by beating, can detect the frequency difference between the echo and the signal being transmitted. (See Kay, 1961). The time delay method is used in conventional Radars and the beat-frequency method has been used in radio altimeters.

Films and synchronised tape recordings of a bat catching tossed meal-worms indoors, showed that the beat-note hypothesis was not applicable since there was no signal overlap even when the prey was so close that the bat could touch it with a wing-tip. This research suggests a working hypothesis that *Myotis* (and perhaps vespertilionids in general) sense range by means of "some internal clock" as Radar does. They suggest that the function of the F.M. is to allow for pulse compression to improve the discrimination of distance.

Another brief report is worth noting here. It is an account of work carried out by R.G. Beil, an acoustics engineer of California (Report, 1964). Beil experimented with blindfolded humans in a specially designed non-sound-reflecting (anechoic) chamber using electronic devices to generate high-frequency sound beams. Test subjects could hear echoes of sounds at much higher frequencies than the normal hearing range. They could locate and judge the size of small objects at a distance of ten feet, tell a closed fist from an open palm, could detect cylinders ranging from fence wire to water pipe, judge difference in sizes, and distances from 2½ to 10 ft.

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