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Helictite

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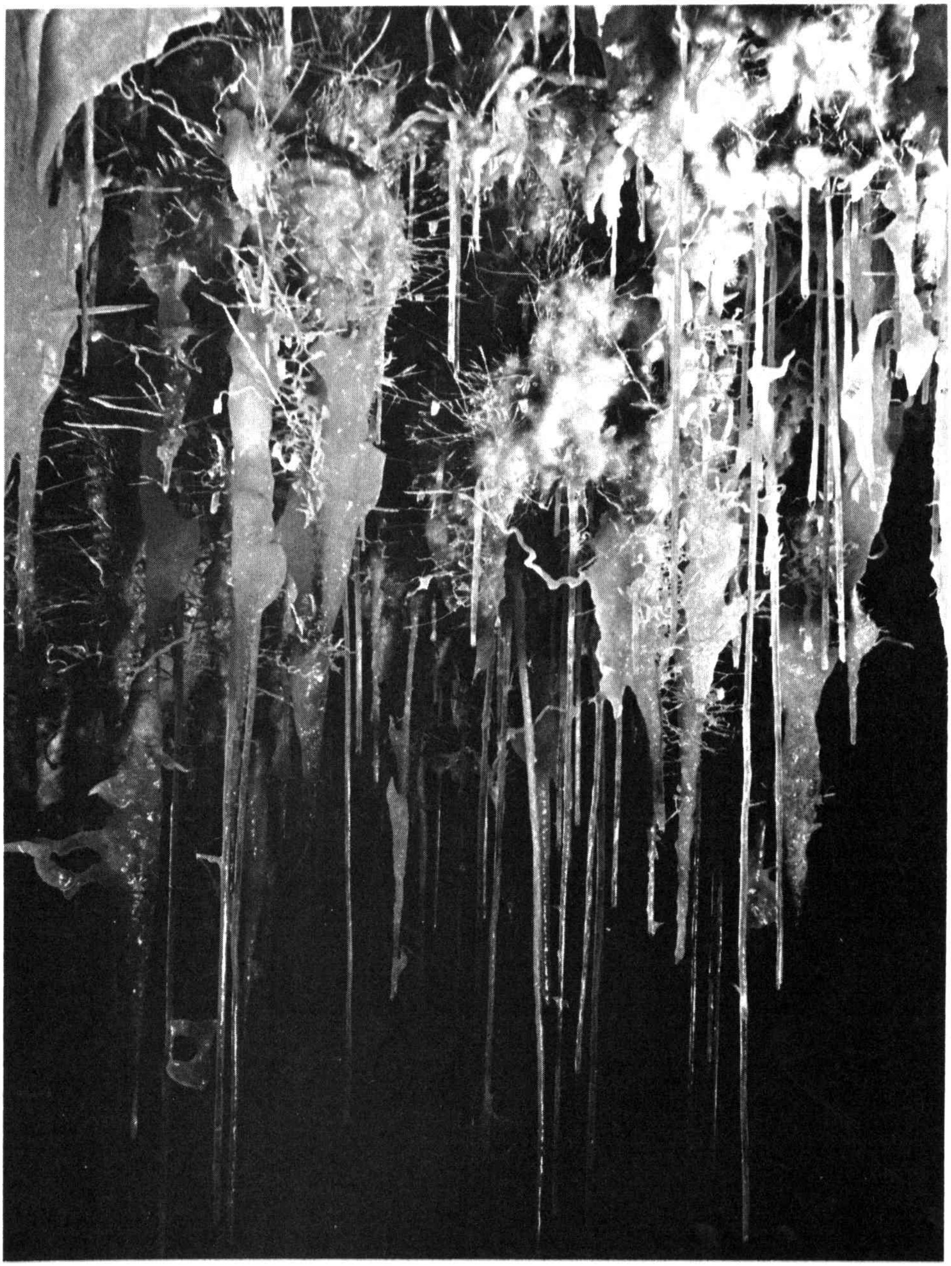

Helictites and straw stalactites, Easter Cave, near Augusta, Western Australia.
Photo by D. C. Lowry.

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ABSTRACTS AND REVIEWS

SOUTH-WESTERN AUSTRALIAN OCCURRENCES OF *STHENURUS* (MARSUPIALIA, MACROPODIDAE), INCLUDING *STHENURUS BROWNEI* sp. nov. By D. Merrilees. *J. Roy. Soc. W. Aust.*, *50*, 1967 : 65 - 79.

Specimens of *Sthenurus* from Mammoth Cave in the southwest of Western Australia have been re-examined and shown to fall into two groups, one with lower permanent premolars exceeding 16 mm in length, the other with lower permanent premolars less than 16 mm long. These two groups are interpreted as distinct species rather than as sexual morphs. One of the species is *Sthenurus occidentalis* Glauert 1910, and a revised concept of this species is presented. The other species is newly described as *Sthenurus brownei* Merrilees. The horizontal ramus of the mandible in *S. brownei* is much deeper behind M4 than below the P4-M1 interspace, in contrast with any other described species of *Sthenurus* in which mandibular form is known. Both *S. occidentalis* and *S. brownei* occur in Strong's Cave, near Mammoth Cave, and *S. brownei* also occurs in a limestone quarry at Wanneroo, near Perth.- A.M.R.

AGE OF COASTAL LIMESTONE, WESTERN AUSTRALIA. By C. Teichert. *Aust. J. Sci.*, *30* (2), 1967 : 71.

A compilation by Veeh (*J. Geophys. Research*, *71*, 1966 : 3379) of Th230/U238 and U234/U238 ages of corals taken from emerged reefs includes a sample collected by Teichert from Rottnest Island in 1963. Teichert states that the age of 100,000 ± 20,000 years confirms, and gives precision to, conclusions published by him in 1950 on the same reef and based on general geological considerations. It is now possible to conclude by extrapolation that the similarly situated fossil coral reefs of the mainland coast may be expected to be of the same general age. - E.A.L.

LITTER SIZE AND MATERNITY SITES IN AUSTRALIAN BATS (CHIROPTERA). By J.L. McKean and E. Hamilton-Smith. *Vict. Nat.*, *84*, 1967 : 203 - 206.

A summary of literature on bats shows that litter size is known for 33 of some 55 species of Australian bats. Although single births are the rule, twin births may occur. Maternity sites such as trees, mines, caves and tunnels are listed. - A.M.R.

CAVERNS HAMPER DRILLING OF PHILLIPS' GULF WELL. *Aust. Fncl. Review*, Sydney, February 29, 1968.

Report by Phillips Australian Oil Co. on its Uramu No. 1 well in the Gulf of Papua. Drilling at 7,742 ft in limestone, operation was handicapped by lost circulation created by the presence of caverns in the reef limestone formation draining off drilling mud at a very high rate. Does this report record the deepest limestone cavern discovered? - E.A.L.

PARIETAL ART IN KOONALDA CAVE, NULLARBOR PLAIN, SOUTH AUSTRALIA

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Summary

This paper gives a first description of the engravings discovered on the walls of Koonalda Cave (N4), Nullarbor Plain, South Australia. It gives a typologic assessment with reference to known parietal art in the caves of Europe, and to cave engravings discovered in the Katherine area of the Northern Territory, Australia. It establishes the possibility of great antiquity and deals briefly with interpretation.

This announcement lays no claim to conclusiveness in the argumentation offered as the facts relating to Australian Paleolithic Man and his environment are as yet insufficiently known.

Discovery of Markings

The significance of the wall decorations in Koonalda Cave (N4) was first realised in 1957 by Adrian Hunt, a member of the contingent from the University of Sydney, during an expedition to the Nullarbor Plain by the Australian Speleological Federation. Prior to Hunt's discovery only "tourists" had visited the cave and some had left their names on the walls. Hunt described his discovery in a letter to the author dated January 28, 1958, enclosing copies of the first photographs. The first published reference to the drawings is G. Pretty (1960).

A brief description of Koonalda Cave, together with a location map and a plan of the cave, is given in Jennings (1961).

Description

Most markings have been made by gently pressing the fingers into the soft surface of the limestone thus producing closely set undulating marks which cover the wall in a tight maze. Many lines begin with the fingers spread slightly, but soon closing tighter so that clawlike, more or less diagonal marks at the beginning become much narrower bands undulating downwards. (Figure 1). To the left of the middle of the maze shown in Figure 1, there is apparently a figure with two big eyes which is difficult to discern in the reproduction. The "claw" over the "head" does not belong to this "figure" as it is clearly drawn over it, with its own undulating band.

Sometimes a big bunch of lines converges towards a tapering base. (See Figure 1, to the extreme right). A second group of markings can be described as deep cuts in the soft surface of the rock, made by a stick or other implement, and not by finger-printing (See left side of Figure 1).

A third group contains much finer and sharper cuts which are applied where the surface of the rock appears harder. These cuts can be compared with markings discovered in the Northern Territory, as far as the technique of incisions and scratchings is concerned, but not as to their pattern. However, comparison can be made with the first group as will be seen later.

The group of incised drawings and markings in Koonalda includes:

a. Roughly parallel diagonal incisions. (Figure 2).
b. Chessboard pattern. (Figure 3).
c. Oblong fishlike patterns. (Top of Figure 3 over the chessboard pattern, and also under the chessboard pattern, but less easily discernible).
d. Concentric circles. (Figure 4, faintly visible in the middle).

Typology

As regards typology, the only possible parallels to these highly abstract projections on the Koonalda Cave wall are the crudely but conveniently termed "macaronis" of the early parietal art of European caves.

These abstract expressions are the earliest form of parietal art in European caves and are either finger drawings or incised lines (as in Koonalda). The finger drawings predominate. The drawings are mainly on the ceilings of the caves and less frequently on the walls.

A large proportion of these European cave drawings can be related to Koonalda only by the technique of their execution but not strictly in their motifs. Those not offering parallels to Koonalda are rough meanders, and snake-like lines which form loops. Most are single drawings completely lacking the dense tangle of the drawings in Koonalda. The best handbook available is H. Breuil (1952). At Altamira (Breuil, 1952, Fig. 22, p. 67), a modest maze of finger-tracings in the clay of the ceiling, made of undulating and meandering lines, contains the head of a bull executed in the same finger-tracing technique. Fig. 23, p. 68, shows primitive meanders traced in clay with a toothed implement. Also in Breuil, Fig. 25, p. 68, Aurignacian drawings appear superimposed on finger-drawings in clay. A complete analogy, however, is to be found in a cave of the Garonne River Area, France. Fig. 268, p. 248, shows interlaced and densely set finger-tracings in the clay of the roof of the fourth hall of the cave. Breuil terms these "indecipherable". The same cave offers a very large meander, traced in clay, with an emerging bovine head at its right end (Fig. 270, p. 249); a maze of finger-tracings possibly containing a head (Fig. 271, p. 250); and elongated meanders (Figs. 283-285, pp. 254-255). The cave contains a Mousterian and two Aurignacian levels. A maze of finger-tracings in clay, on the ceiling of Pech-Merle in France, should also be mentioned (Fig. 305, p. 273).

In Hornes de la Peña (Spain), there are meandering drawings in clay made by a comblike instrument. However, none of the examples cited is as close an analogy as that mentioned from Garonne.

An isolated clawlike painting in the Italian cave Grotte de la Basua at Toirano, Ligurie, Northern Italy, is also of great interest as it resembles two isolated clawlike patterns from Koonalda (Figure 5. These figures are just above the maze photographed in Figure 1). The pattern in the Italian cave is executed in soot (trace fuligineuse laissée par une main) on the wall of the cave (Leonardi, 1958). No industry has been recovered in the cave, but the traces appear dated by footprints which have been attributed to Neanderthal man. I would also like to draw attention here to another more naturalistic isolated "claw" which appears in our Figure 1, top left of centre line.

The incised lines and scratchings should be compared with those discovered in the Katherine area, Northern Territory, Australia (Walsh, 1964). Incised lines are currently reported from many caves in Europe, but in general do not get much attention. They often appear around and in conjunction with the more spectacular animal pictures. A perusal of Laming (1959) or Célébonovic and Grigson (1957) will make that sufficiently clear. Groups of short incised lines have been interpreted, according to Vértes (Vértes, 1965, at present is the only reference available to me on this topic), as imitations of cave bear scratchings in connection with a cave bear cult. Vértes publishes the sole example available in Hungary and ascribes the scratchings to the Würm I/II interstadial. Though an interpretation of these patterns as imitations of cave bear claw marks does not sound very convincing (why should a bear scratch a cross made from two parallel lines, or cross four parallel lines with one single line?), still the lines are evidence of abstract expression in Paleolithic design.

The incisions from the Northern Territory quoted above, might be seen as diminished versions of the Koonalda "claws with extension". (See Walsh, 1964, Plate 9, lower picture). But notwithstanding Walsh's efforts to exclude natural or biological agencies (e.g. owls), this question is still unexplained.

Further, I would like to draw attention (without however committing myself beyond the simple registering of typological similarities) to the often mentioned chessboard patterns of "lattices" in Magdalenian art which have been interpreted in different ways, sometimes as traps. A survey of interpretations is given by Laming and an interpretation of Figure 3 in this paper as a net is possible in view of the presence of the fishlike forms over and under it.

Age

Pending further investigations it is impossible to define the age of the art even approximately. Arguments which can be considered may be grouped as follows:

1. Typology. The "macaroni" are first observed in the Aurignacian and are at the beginnings of representational art. The first animal figures appear entangled in them, or growing out of them, and are drawn in the same technique. They are always earlier than all the other drawings and engravings. (Breuil, 1952, p. 39). The short clawlike painting in soot from Northern Italy seems the earliest instance so far known. The associated footmarks are claimed to be those of Mousterian man. The lattices in European caves date from the Magdalenian period. In Koonalda, by analogy, they likewise could be regarded as representing a later period than the macaronis.

2. Structure of the cave and location of the drawings. I deliberately refrain here from giving the exact location of the drawings within Koonalda Cave. The problem of adequately safeguarding the relics has not yet been solved. The drawings have already suffered (though not extensively) from tourist interference and growing publicity would only worsen the position.

According to Jennings (1961), the section of the cave containing the drawings (and they occur only in the one part of the cave) must be regarded as belonging to the earlier phase of the cave's formation, predating the development of the main passages.

On the occasion of my 1965-66 excavations, Richard Wright (pers. comm.) observed that although all the drawings are at the same level on the wall, some are now far out of reach from the present floor level. This could mean that what may have been the oldest passage of the cave has already been destroyed, the bottom of the higher passage having collapsed into lower regions.

In other parts of the passage in which the drawings occur, substantial rockfalls have covered them over. Large fallen blocks rest against the wall and drawings continue down behind them.

3. Stratigraphy. In Trench III, at the bottom of the "plastic white" layer, approximately half a yard under a fireplace dated by C 14 as 31,000 + or - 1,650 BP (29,050 B.C.), V-82, we found a small hexagonal slab of limestone, lying in the centre of rough or half-made tools and refuse.

Figure 1. First group of markings. Drawn with fingers in soft clay.
Photo, Richard Wright.

Figure 2. Second group of markings. Incisions and scratchings.
Photo, Bronwyn Roberts.

Figure 3. Second group of markings. Patterned incisions. Photo, Richard Wright.

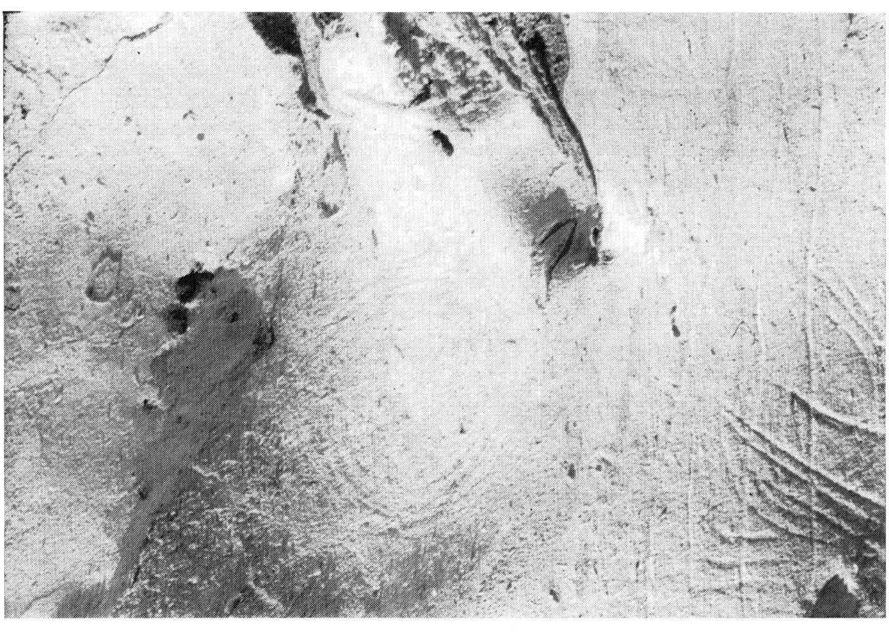

Figure 4. Second group of markings. Patterned incisions. Photo, Bronwyn Roberts.

Figure 5. First group of markings. Isolated "claws" appearing over the maze shown in Figure 1. Photo, Adrian Hunt.

Figure 6. Marks made by tourist disfiguring the art gallery. Photo, Bronwyn Roberts.

According to its position in soft ground, it must have been used as a solid surface for toolmaking. When raised, its lower surface revealed fine cuttings, comparable with the fine lines on the walls of the cave described as the "second group of markings."

None of these observations contradicts the possibility of an age approximating the chronological position of identical or similar drawings in European caves.

Interpretation

Several suggestions relating to interpretation have been put forward in hitherto private discussions, for example:

1. Natural. This is the classical suggestion of sceptical minds. At a certain level in the Nullarbor limestone, the rock is densely perforated by small water channels which, when broken longitudinally, show shallow grooves . Jennings (1961, p. 28) described these channels as "solution tubes," and said they most probably indicated a former watertable.

I rule out the possibility that the finger tracings in Koonalda Cave are spurious and actually represent solution tubes broken longitudinally into half-tubes. Cross sections through this kind of channelled rock invariably show broken channel openings, which run into the rock. No such openings are present on the walls where the drawings occur; besides, the level of the drawings does not approximate with the general level of the solution tubes in the Nullarbor limestone. Nevertheless, there is some tubework in the vicinity.

Limestone surfaces subjected to rainfall often show parallel, shallow flutings and grooves. Thus it could be argued that the maze of grooves is the result of water slowly finding its way down the walls. This can be ruled out because, where the cave walls bend inwards, the maze still covers the surface. No water can percolate that way down the walls. Nor are the forms at all like those of minor solutional sculpture.

Consequently, human agency seems to be the most likely origin.

2. Tourists. This origin can be dismissed as some drawings occur at places which today are completely inaccessible. The drawings also are weathered to such a degree that it is hard to envisage any white man having produced them.

3. Sharpening grooves. As most of the macaroni were done in the soft surface of the limestone wall, which today is still impressionable to a high degree where the drawings occur, no sharpening or polishing of bone tools could be carried out satisfactorily on these surfaces. Concerning the sharp, cut lines in the more resistant rock, only partial explanation

can be provided by the sharpening hypothesis, and no explanation of this type could explain the more complicated patterns of these incisions.

4. Art. If we understand by art the representation and projection onto the cave wall of psychic experiences, this would be a likely avenue to explore.

It might be suggested that the dark interior of the cave was a strange and uncanny environment, which invited projection. According to Jung whenever man faces the unknown, such a background is peopled with formations of the projective activity of the subconscious mind (Jung, 1953). In the abstract maze covering the walls of the cave, we might see the representation of emotional states and stresses of early man, who released psychic tensions in this way. But what tensions? We have no way of knowing.

There is, however, a further manifestation of human psychic activity which must be considered, and which I personally prefer.

5. Communication. It is evident that the signs on the cave walls belong to an associative complex, and these manifestations are the equivalent of statements about an important subject. They might be interpreted as the predicate of a sentence, which cannot be rendered easily by naturalistic signs. In other words, the lines convey a message relating to an activity, telling what to do. One important activity occurred in the cave in past times - the mining of chalcedony. My recent excavation in the cave facing the section where the deep incised lines occur, brought to light deep mining pits, and seams of chalcedony in the cave walls which were mined. The incised lines seem to me to lead to these occurrences of chalcedony and to point out the location of the mining pits and seams. Lines which are cross-hatched seem to indicate exhaustion of the mine. I located a mining pit by interpreting deep, incised lines on the wall in this way. This, however, is only a partial solution as the meaning of the dense maze of finger drawings might have to be found on another level of human interest. Nevertheless, it points out a possible avenue to be explored by painstaking cataloguing of facts, analysis, and further excavations. This work is now under way.

Assuming the association with mining, however, we can infer that if mining occurred in the cave between certain dates, the markings also belong to that period.

Preservation

As the cave wall is still soft in most places it is easily impressed, and recent visitors have already written their names across the prehistoric drawings. But a still graver barbarism has occurred. The photograph (Figure 5) was taken in 1958. In 1966 the same section of the wall was re-photographed. As can be seen from Figure 6, someone has replicated the "claw" beside the original. The sharper outlines of the modern drawing can clearly be discerned, in contrast to the more weathered appearance of the prehistoric one. This incident should be a spur for Government action to find a quick solution for the preservation of the relics. The cave could easily be closed with iron grills, at a modest expenditure, as the entrance is not too large.

Acknowledgment

I wish to thank Mr. and Mrs. C. Gurney, graziers, of Koonalda Station, whose friendship and unflagging helpfulness made the seasons spent in exploratory work on the Nullarbor an agreeable and successful endeavour.

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RECENT AUSTRALIAN CONTRIBUTIONS ON PIPES, FOIBE, AND CLIMATIC HISTORY FROM SPELEOLOGICAL EVIDENCE

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Signs of increasing maturity in Australian speleology have been evident of late, one being the widening range of scientific serials in which contributions are appearing. There is consequently more need for reviews in this journal to enable cavers to keep in touch with the advances being made.

The Geological Survey of Western Australia has sent D.C. Lowry to the Nullarbor for several long seasons of field work, primarily for regional geology and stratigraphy, but it is encouraging to see the Survey interested enough in his speleological findings to publish some of them itself (Lowry, 1967). In this instance they are making available a novel hypothesis of considerable interest relating to the formation of pipes and foibe. The pipes, known locally as "blowholes", are vertical shafts 1-6 feet in diameter and 5-35 feet in depth, blocked at the bottom or leading to shallow caves. Previously they have been interpreted as forming from above by solutional and corrasional deepening of rockholes, possibly aided by joint intersections. Lowry proposes another mode of formation - upward growth of foibe as a result of salt-wedging or exsudation to puncture the surface from below. He documents frequent close association of pipes or shafts open to the surface with blind vertical pipes ending near the surface in hemispheres, 6 inches to 6 feet in diameter. Though one may object to his own term "roof-dome" for these features because of prior use of "dome" for very large roof features of this form in the Nullarbor deep caves, the evidence presented does seem to substantiate the idea that upward extension of foibe produces many open pipes in the Nullarbor.

The process proposed for their upward growth is more startling than the direction of growth itself although related evidence for substantial roof and wall sculpture of the Nullarbor deep caves by salt weathering has been gathering recently and cannot now be disputed (Lowry, 1964; Wigley and Hill, 1966; Jennings, 1967). In the deep caves the clasts frittered from the roof remain to testify to the process; in the shallow caves they are dispersed, according to Lowry, by occasional vadose flow. He also gives evidence of a satisfactory nature for appropriate air movements and relative humidities to promote evaporation and so crystallisation of cyclic salts brought into the caves in solution. It has long been known that there are salts in quantity moving about beneath the Nullarbor Plain. The chief difficulty remaining rests in the great difference between the long tubes in the roofs of the shallow caves and the forms found in the deep caves. The latter resemble the tafoni of surface weathering, in crystalline rocks chiefly, and similarly attributed to the force of salt crystallisation whereas the former belong in type to forms found in caves in humid climates where there is no possibility of this dry condition process operating at all. One suggestion Lowry makes to explain the elongation of the forms he is discussing compared with the much shallower cavernous weathering of the deep caves is that air trapped in roof hollows is warmer than elsewhere and promotes more evaporation there. This in turn causes greater local crystallisation to extend them upwards in tube form. However, the differences in temperature between a roof hollow and the main chamber of Lynch Cave recorded by Lowry seem scarcely great enough to localise weathering in this way and the author himself seems doubtful whether such differences are general in any case. A second suggestion is localised seepage from the surface "confined to a small duct or zone"; this is a double-edged weapon because it is water movement of such a kind which previous workers have called in to explain the open Nullarbor pipes by solution working downwards and by other workers elsewhere to explain foibe by solution working upwards. Much of Lowry's argument against rockholes developing into open pipes is weakened if such ducted seepage is accepted.

To sum up, Lowry's case for many open pipes being developed from below is a good one, though the older notion of rockholes becoming open pipes may have wider application than he thinks. On the other hand the exsudation mechanism for upward development appears to require further examination and defence even though it is a process which should operate in this semi-arid climate if anywhere.

Lowry also considers the age of the foibe. Fresh breaching of clay covers by foibe and truncation of calcite decorations by them are cited as indicating active formation today. Middle Pleistocene is given as the start of their formation but this is much less convincing since it rests on Middle Pleistocene dating of wind deflation of calcareous clay from the Nullarbor by Jessup (1961). Jessup's dating, like much Quaternary chronology in Australia, perforce rests on a most tenuous basis. Similarly, Lowry's dating inference from the absence of any but historically known animal skeletons in caves with solely open pipe entrances, is sound enough in principle, but of strictly limited value because of our present quite inadequate knowledge of the Quaternary history of Australian mammals.

Less rigorous in approach and claiming much more for itself than Lowry's contribution is A.G. Link's paper in the main international journal of geomorphology (Link, 1967). Link's generalisations, some of them rather sweeping, rest on the study of a single cave, McEachern Cave, in western Victoria. This cave has already been discussed by Ollier (1964). The close resemblance between the cave surveys in the two papers suggests either phenomenal accuracy in independent surveys or some failure in acknowledgment by the later author.

McEachern Cave is a short, dry, horizontal cave entered by a circular shaft 4 feet across and 50 feet deep. Roof collapse in vertically jointed, horizontal Oligocene limestone dominates its nature. Both Ollier and Link describe the cave as youthful because of this collapse though generally speleologists have tended to regard cave breakdown as a later, degenerative process in cave history. Moreover, both authors make evident that little solution is going on now, a condition hard to regard as youthful. Roof collapse in the horizontal beds of the cave results in a characteristic stepped cross-section, which Link erroneously refers to as a "Gothic arch". The "Gothic arch" is a pointed arch, whereas the similarity is to the corbel arch, though both are Assyrian in origin.

There are also small foibe in the ceiling with eucalyptus tap roots in them. Link's views on them make an interesting comparison with Lowry's ideas. He also thinks that open pipes develop from foibe reaching the surface, though they may later be modified by rainwash and surface streams entering them. The mechanism envisaged relates to a humid climate and forest vegetation, however. Tap roots are thought to crush the crystalline structure of the rock immediately surrounding them and spalling occurs where the root emerges into the cave below. Seepage water coming down the taproot dissolves the crushed rock and helps to bring about upward extension of foibe. In surface outcrops, root splitting of rocks is well-known but no-one has demonstrated the small-scale crushing postulated by Link. Chemical action by root exudates seems likely to be more effective than mechanical action in the confined circumstance of deep root growth down a joint intersection in bedrock. Nevertheless, this mechanism for upward foibe extension is worthy of elaboration and testing.

In a different category is Link's explanation of sets of scratch marks on ceilings and walls as the result of "small marsupials running swiftly upside down over the roofs of caves". One scarcely sees the need for further pursuit of this unlikely process and turns with relief to the suggestion by Wakefield (1967) that they are wombat scratchings when the floor was nearer the roof than now through the presence of fill since transported elsewhere. Wakefield's interpretation could usefully be considered in relation to the roof markings described by Walsh (1964) from Northern Territory caves.

The main part of Link's paper is the "exhaustive examination" of thick, stratified deposits in the cave, yielding, it is claimed, the "best evidence to date of the late Pleistocene-Early Holocene 'arid period' in southern Australia", which may have been accompanied by low temperatures according to the author.

At the bottom, overlying angular limestone blocks, are red quartz sands containing extinct and Tasmanian animal bones, often well-weathered. They are considered to have been washed in from Quaternary beach sands on the surface near the cave and to belong to a humid climatic phase of the Late Pleistocene on the basis of a C 14 date of 15,200 BP near their top (incorrectly reported by Link as 14,300 BP according to Wakefield, 1967). The humid climate is inferred from the giant kangaroo Sthenurus sp., in the layer, although no evidence is given that the ecology of the species sustains the argument. The largest living kangaroo, the red, is a dry country animal.

Above the red sands is a finely laminated calcrete. It consists of angular calcite grains and some etched quartz grains derived from the bedrock. The calcite grains are thought to have two sources, the one is frost-breccia and the other is aeolian erosion of Quaternary strandline calcareous sand of the area. On this basis this layer is thought to belong to an arid, possibly cold phase of the Late Pleistocene-Early Holocene.

The frost-breccia concept must be rejected since even Tricart's "microgelivation" fails to produce fragments of the minute size concerned here. With it goes the cold climate. Aridity depends on interpreting the increased proportion of calcareous compared with quartz sand as a result of reduced runoff. But why should not quartz sand be blown into the cave as well as calcareous sand? The calcareous grains cannot have formed as crystalline films on a pool ("calcite flottante") according to the author because this is thought to require a sea level rise of 20-30 feet to cause cave flooding and because the walls lack coatings of secondary carbonate. However, sea level rise is not the only possible cause of temporary cave pools and Ollier (1964) reports flaky calcite on the floors of other caves in the area to which he ascribes such an origin.

Red quartz sands overlie the thin calcrete and these contain only living animals. A humid climate is thought to have returned to cause the renewed washing in of quartz sand and a date of 8,000 B.C. is given for the beginning of this final period, on what basis is not apparent.

It is hard to regard Link's climatic history as well established and it is regrettable that it is his paper which has been published in the widest reaching journal rather than the much better based account from the same sequence of deposits by Wakefield (1967), which might with much more justice claim to furnish the best attested Late Pleistocene-Holocene climatic sequence from southern Australia. Because of its importance, Wakefield's fuller sequence of deposits and events is set out in tabular form herewith (Table 1). In support of this, Wakefield furnishes full details of the stratigraphy and of a wide variety of analyses - size, chemical, X-ray, heavy mineral, palaeontological.

The mammalian evidence is particularly impressive. Indeed, one thinks that here is the most convincing case of the deriving of climatic history from mammalian data yet published in Australia. Quite large assemblages of species are listed and the succession of wet sclerophyll forest fauna →

mallee scrub fauna → dry sclerophyll forest fauna seems well based. The end of the first phase yielded the C 14 date of 15,300 BP mentioned above. It is also encouraging to see that Wakefield discusses effective precipitation for the first of these phases instead of jumping to increased absolute precipitation as has so often been done by previous workers.

On the other hand the interpretation of the stratigraphical and sedimentological data is not so sure. Most critical is the interpretation of the calcareous silt and fine sand layer (Link's calcrete) as of aeolian origin to initiate the semi-arid phase substantiated higher in the column by the mallee fauna. This interpretation rests essentially on the fact that the bryozoal fragments and forams found in this layer are smaller and more abraded than those to be found in the bedrock limestone. This seems slender support when other data are borne in mind. The author himself recognises wet conditions in the cave between the deposition of the calcareous layer and the recent reddish quartz sands containing the mallee fauna. These are required by the partial cementation of the middle horizon of the calcareous layer, by the subsequent stream erosion, and by the solution which caused floor collapse about this time also. Moreover, no explanation is given for the supposed aeolian phase involving the erosion of more distant calcareous dunes instead of the deflation of nearer quartz sands. Quartz sands were supplied to the cave both before and after the calcareous deposition, the later deposits during the dry mallee fauna phase so that these also may have been aeolian. There are discrepancies here which require closer examination.

The suggestion made earlier in this article of an origin for this layer as "calcite flottante" seems worthy of consideration. Such an origin would fall into sequence between palaeontological indications of immediately previous wet surface conditions and stratigraphical evidence for immediately subsequent wet cave conditions. Wakefield's threefold climatic sequence would not be disturbed by this modified interpretation of the stratigraphy; there would simply be a restriction of the semi-arid climate to the phase of deposition of the red quartz sand layer.

Be this criticism valid or not, the further results promised by Wakefield from McEachern Cave will be eagerly anticipated by Australian speleologists. Those already made available should stimulate others to similar efforts where cave sediments of like promise are to be found.

Articles Reviewed

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HISTORY OF McEACHERN CAVE, VICTORIA, ACCORDING TO WAKEFIELD, 1967

DEPOSITS	CAVE EVENTS	MAMMALIAN REMAINS	CLIMATE AND DATING
RECENT SEDIMENTS (2-8 feet) (c) Black quartz sand, some organic content, slightly cohesive.		Modern fauna of dry sclerophyll woodland.	Slightly wetter than at present.
(b) Reddish quartz sand, slightly cohesive.	Sand brought through entrance shaft and other pipes. Rapid deposition of (a)	Includes Mallee spp. Absence of wet sclerophyll spp.	
(a) White quartz sand, loose, some $CaCO_3$ concretions.		Few bones	
NEWER ROOF FALL	Floor collapse and minor faulting } Through solution below Cave breakdown		
STREAM BED BONE RUBBLE	Stream erodes older sediments	Bones derived from older beds	Mid-Holocene warm-arid period. Rainfall 15-20 inches less than present; mean annual temperature 2-3^{o}C higher than present.
CALCARENITE SEDIMENTS (1-2 inches) (c) Grey laminated calcareous sand, some clay, small % quartz sand, many ostracod valves. (b) Orange-red calcareous silt-fine sand, small % quartz sand, half area cemented. (a) Grey laminated calcareous silt, small % quartz sand.	Strong air currents blow in particles from calcareous sand dunes. Second entrance implied. Secondary cementation of part of (b) due to water percolating down, accompanied by high cave humidity due to open water elsewhere in the cave.	Few bones	
PLEISTOCENE SEDIMENTS (30 inches) (b) Brown, slightly organic quartz sand. Less compact, unstratfied. (a) Grey quartz sand, compacted and stratified. Coarser sediments on one side.	Quick accumulation of sand from surface quartz sand dunes via entrance shaft. Early stream action in part of cave.	Presence of wet sclerophyll forest spp. Absence of certain dry sclerophyll forest spp. Presence of 6 extinct spp.	C 14 date 15,200 $\pm$ 320 BP. Last Pleistocene cold period. Mean annual temp. 5^{o}C lower. Reduced evaporation makes same rainfall as present equivalent to 40-50 inches.
OLDER ROOF FALL	Cave breakdown		

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ABSTRACTS AND REVIEWS

KARST REGIONS IN INDONESIA. By D. Balázs. Karszt-és Barlangkutatás, 5 - 1963-1967. Hungarian Speleological Society, Budapest, 1968 : 3 - 61, plus 26 figures, 3 tables.

The East-Indian Archipelago of more than 20,000 islands stretches between South-East Asia and Australia. Modern workers believe that the present-day distribution of the islands is the result of quite young - Tertiary and even Quaternary - tectonic movement. The archipelago is one of the most seismic areas on earth; nearly 1,000 recent volcanoes occur in the region, of which 177 can be considered as still active.

In this paper, karst regions are discussed against the general physiographical background. Most of Indonesia's karst areas have developed in Tertiary calcareous marine deposits with the most outstanding karst landforms in the Sulawesi Karst Area (Celebes). The largest and best-known karst areas of the archipelago have been formed on limestone plateaus of Upper Tertiary Age (mainly Miocene) - in South Java and West Irian, for example. These areas are mainly reef-limestones which form, despite their young age, comparatively hard, compact sequences providing good stratigraphic conditions for the development of typical karstic surface and subsurface features. The Miocene reef-limestones, which make up more than 50 percent of the present-day karst areas, have been little affected by folding. Their emergent fault-blocks are horizontally stratified or only slightly tilted.

The elevation of the Indonesian karst regions varies, in general, between 200 and 600 m. Single blocks soaring to 1,000 m are rare and high karst plateaus are known only in the central mountain range of West Irian (West New Guinea). The karst regions form a number of sub-types within the group of tropical landforms, the most significant are conical karst (Kegelkarst) and pinnacled karst (Turmkarst).

The author believes that no analysis of paleoclimate is necessary as there has probably been little variation, and that karst features evolved continuously under tropical climatic conditions, i.e., warm, humid and moist. The mean annual temperature is 26^{o}C throughout the archipelago and most of the land areas are of an island nature. The difference between the mean temperatures of the warmest and coldest months of the year is only 1 or 2^{o}C.

The prevailing winds are the monsoons and rainfall distribution is characterised in the individual areas by a very sharp seasonality due to the monsoon effect. Tables are given of monthly and annual mean rainfall at 18 stations. The average value for these stations is 2,462 mm. The number of rainy days of the wet season average 15 to 20 a month; in the dry season the figure is not higher than one or two. The annual precipitation for most of the archipelago's karst areas is said to exceed 1,200 to 1,500 mm.

From the point of view of the intensity of karstification, the amount of rain falling during 24 hours is important. The record cloudburst was at Ambon meteorological station on an August day in 1933 - 702 mm. The effect of precipitation of this magnitude on a karsted surface can only be imagined.

Although the rate of evaporation is markedly higher than in the temperate zone, the ratio of runoff is higher. As a result of torrential rain-showers of random distribution in time, the springs connected with free sink-holes are characterised by very unsteady yields. Comparatively large amounts of waste are carried by water through the open sink-holes during showers, plugging or filling underground passages. The physico-chemical characteristics of the Indonesian karst are discussed briefly. The average carbonate content of 37 karst springs combined was found to be higher than the figures for other tropical karst areas.

Most of the karst plateau areas are covered with primary forest vegetation, although the specific composition is rather varied, a feature of tropical forests. In areas where the topography consists of steep limestone walls, there is an impenetrably thick vegetation cover and the roots of trees penetrate as deep as 20 to 30 m down the fissures. Masses of lianes crawl in all directions producing a green carpet even on vertical precipices. On the plateaus, the dense foliage markedly reduces the penetration of sunshine. The karst also offers good protection for animals, such as the tiger, leopard, many races of monkey, wild-hog, and a great number of species of snakes, lizards and birds. In the caverns are hosts of bats.

Schematical descriptions follow of some of the major karst areas, based partly on the author's own observations and partly on the rather scant literature. Scores of areas are completely unexplored geomorphologically and are blanks on geological maps. Areas discussed here are in Sumatra, Java, Little Sunda Islands, Kalimantan (Indonesian Borneo), Sulawesi (Celebes), Maluku Islands (Halmaheras), and Irian-Barat (West New Guinea). A review of the regions is tabulated at the end of the section to aid comparison. Many maps are included.

In Sumatra, caves and underground drainage are apparently very extensive in the central highlands. The middle stretch of mountains is called Gunung Ngalan Saribu which can be translated as "Mountains of Thousand Caves." These karst regions take up to 2,000-3,000 mm of high-intensity rainfall a year. Deep ravines have been carved out leading to depressions drained by fast-growing cave systems. The growth of the open underground spaces is largely promoted by the abrasive, mainly granitic material carried by the underground rivers. In the higher-sited inactive caverns, large-scale stalactite formation is occurring. The active caves are predominated by erosion and corrosion-made features of the bedrock. The caves are populated by bats, fish, crayfish, etc., on which little or nothing has been published.

A comparatively long section on Java discusses subsurface rivers, particularly those draining the Gunung Sewu and other areas near Jogjakarta. The region is notable for several hundred doline lakes and ponds. The surface of this mountainous karst area is also known for its concial hills, estimated to number 40,000. Senile and youthful caves are scattered throughout the karst mountains. In the northern part, rivers plunge through deep canyons into high, broad-entranced caves. These huge systems are largely unexplored. Collapse sinks and karst pits are frequent.

Caves are mentioned on Bali, at Bukit Badung, and Sumba Island (both in the Little Sunda Islands). The caves have river systems which carry the abundant water of the rainy season quickly to the sea and emerge in coastal or submarine springs.

Kalimantan (Indonesian Borneo) is poor in limestone in the west, south and central parts, but the east zone has vast, largely unexplored karst regions. The largest karst area lies at the eastern tip of Mangkalihat Peninsula. Several other areas are mentioned. The author says it is very difficult to visit these karst areas because of the lack of roads or even paths. The available maps, however, show depressions in the karst and rivers plunging underground. Rainfall is in the 2,000 to 3,000 mm range.

Limestone is extensive in Sulawesi (Celebes) with karsted elevations up to about 2,600 m. In the southwest, large underground channels have developed in the karst block and emerge as huge Vauclusian springs. One of the largest is near Bantimurong with a yield of between 80 and 150 cubic m per minute. The hydrology of the catchment and springs has not been determined. Annual precipitation averages 3,000 to 3,500 mm. In the Maros area, high limestone walls have been markedly undercut by combined chemical and physical erosion and running-off surface waters; overhangs have stalactites several metres long and tufa draperies. In areas near the sea, the accumulation of marine lamellibranches at the foot of rock walls and in cave entrances suggests that the sea came right to the karst edges in Quaternary time. In steep rock precipices, one-time drainage channels (cave passageways) are often exposed. Many cave labyrinths, several kilometres long, are almost completely unexplored. Masses of dripstone in the earlier caverns handicap access. Cave-hollowed inselbergs occur north of Pangkadjene, a region resembling the inselberg-studded karst regions of South China and North Vietnam.

In Irian-Barat (West New Guinea), karst areas are very widespread, but geological information is often non-existant and thousands of square kilometres of karsted surface may be undiscovered. Little information is available, for example, on the karsted mountains and plateaus of the Central Mountain Range which lie at 4,000 to 5,000 m and are difficult to approach. Precipitation ranges between 4,000 and 8,000 mm a year. Some areas are under permanent snow and ice.

Near-Irian islands, such as Misool, also have large karst areas. On Misool whole rivers reach the sea through unexplored cave systems.

This paper is filled with fascinating information and the author's contention that the area could be a vast natural laboratory for karst research is justified. Although the promise of these Indonesian karst regions is great, the difficulties confronting the explorer, the speleologist and the scientist are more than formidable. - E.A.L.

DEVONIAN REEF COMPLEXES OF THE CANNING BASIN, WESTERN AUSTRALIA. By P.E. Playford and D.C. Lowry. Geol. Surv. of W. Aust., Bull. 118, 1966 : 150 pp., plus 48 figures, and 7 plates in a separate atlas.

A detailed study of the series of Middle and Upper Devonian reef complexes exposed along the northern margin of the Canning Basin, Kimberley Division, Western Australia - near Broome and Derby. The authors mapped the complexes which occur as well exposed, rough limestone ranges (e.g., Napier Range, Oscar Range, Geikie Range) extending over a length of about 180 miles. The descriptions include lithology, structure, stratigraphy and fossils. Four basic facies are recognised in the reef complexes - the reef, back-reef, fore-reef and inter-reef. The reef and back-reef together make up limestone platforms with areas ranging from a few acres to hundreds of square miles. The maximum thickness of the reef complexes may exceed 3,000 ft.

The reef facies is named the Windjana Limestone and is composed of massive limestone, dolomitic limestone and dolomite. The back-reef is named the Pillara Limestone and was deposited in the shelf lagoon behind the reef rim of each platform. It consists predominantly of well-bedded limestone. The deposits were laid down essentially horizontally. The fore-reef consists of talus deposits derived from the reef rim and from the shelf lagoons. The dip is commonly 30-35 degrees, flattening gradually down the slope. The inter-reef facies were deposited almost horizontally on the floor of the inter-reef basins between the platforms, and now occupy the valleys between the limestone ranges where exposures are generally poor. Large masses of conglomerate, composed of granite and metamorphic clasts up to boulder size, are associated with the reef complexes in a number of areas. It is suggested that they were shed from fault scarps which were active in Devonian times. There has been mild folding and tilting and some faulting, but for large areas, the beds are almost undisturbed.

The geomorphology of the Limestone Ranges is described and many excellent photographs illustrate the text showing the rugged nature of the terrain, karst and other features. The geomorphology was described by Jennings and Sweeting in 1963. The present authors differ from Jennings and Sweeting in their suggested origin of the pediment surfaces which usually mark the edges of the ranges. Other features mentioned in the paper include cliff faces up to 300 ft high and six miles long, together with water and wind gaps cutting the ranges (e.g., Windjana Gorge, Geikie Gorge). The gorges are believed to be superimposed on the ranges.

Caves are mentioned briefly, such as Tunnel Creek and Cave Spring, and cliff face caves in Windjana Gorge which apparently belong to an older cycle of erosion. These latter caves are commonly decorated with aboriginal paintings, marked by representations of mythological beings. The cave systems, however, are developed only on a minor scale in most of the areas under discussion.- E.A.L.

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