CAVES OF THE NULLARBOR – A REVIEW OF THEIR TYPES AND ORIGINS

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INTRODUCTION

There seems to be a basic human urge to classify the natural world into discrete and easily recognisable entities, i.e. pigeonholes. These entities are often seen to be significant in terms of the relationships of one entity to another and are delineated by quantitative boundaries which may not have any valid existence in the continuum of natural phenomena.

Thomson (1949) classified the Nullarbor caves into two groups based on depth; this classification has coloured the perceptions of many more recent visitors to the Plains. We believe that this perception has hindered the study of the Nullarbor caves. It appears almost certain that depth has little to do with modes of cave formation or of cave type and to some extent has focused attention on the deep caves, whereas there may be a great deal to be learnt from caves of intermediate depth in relation to both 'shallow' and 'deep' caves.

This paper discusses the evolution of the classifications proposed for the Nullarbor caves by various authors and presents a view that depth is not an attribute by which Nullarbor caves should be classified as it hides similarities and invites unrealistic pigeonholing. To achieve this, we follow through the evidence available in the literature and re-examine a series of caves of intermediate depth both on Mundrabilla Station and elsewhere. Several broad–scale, short–term visits to a wide range of caves has strengthened our view that there is a spectrum of caves rather than the two or three distinct types recognised in the past.

Discussion is restricted to the karst developed on the Sunda Plateau; the two or three caves known on the Roe Plain are excluded by virtue of their topographic position which has resulted in their development in the Roe Calcarenite and Abrakurrie Limestone only (Lowry and Jennings, 1974). The intense perforation of the near–surface zone, found right across the Bunda Plateau (Jennings, 1961,1970), is absent from the Roe Plain caves and they show more evidence of joint control than do the caves developed in the Nullarbor, Abrakurrie and Wilson Bluff Limestone sequence found on the Plateau (Lowry and Jennings, 1974).

BACKGROUND — THE PHYSICAL SETTING

The geology of the Nullarbor Plains has been extensively described by Lowry (1970) and by Lowry and Jennings (1974). A general stratigraphic sequence is shown in Table 1. The almost horizontally–bedded limestones are of high porosity and have been weathered and indurated as a kankar layer at the surface. The kankar overlies either a patchily indurated limestone or variably weathered limestone with cavities; these pass through into the more uniform, chalky Wilson Bluff Limestone.

The present climate is warm and semi-arid near the coast, grading north to hot desert. Most of the area receives less than 250mm of rainfall per annum with a pronounced winter maximum. Mean daily temperatures vary from minima around 4^oC in July to maxima about 18^oC in January. Evaporation rates are high, around 1500mm per annum. There is a pronounced climatic gradient northwards from the coast which is reflected in vegetation patterns; the wetter coastal areas have a low woodland or forest (Specht 1970), which grades northward to a treeless chenopod shrubland (the Nullarbor proper, Delisser, 1867). Pollen studies by Martin (1973) have shown that climatic variation has occurred over the last 20,000 years in this area. On this relatively flat terrain distance from the coast determines rainfall and the changes in coastline position over the last 20,000 years in concordance with world eustatic adjustments are important. Between 18,000 and 15,000 years before present the sea level was at its lowest, with the coastline at least 160 km south of its present position (Wright, 1971). The treeless plain then extended south to at least Eucla (Martin, 1978). Despite such variations there is little evidence to suggest that the Nullarbor experienced a significantly wetter climate than the present at any time since the Tertiary. It has never been more humid since its emergence from a Miocene sea (Jennings, 1967). However some fluctuations in effective wetness are needed to produce the dripstones found in caves on Mundrabilla Station and elsewhere, which are composed of halite, gypsum and calcite minerals with their substantially different mobilities. The higher sea level proposed by Lowry (1970), which cut the Hampton Range around one million years ago, may have increased rainfall and pushed the treeline northwards in the Madura to Eucla region. This may account for the increased mobilisation of the cave minerals.

CAVE CLASSIFICATIONS

As Jennings (1961, 1975) and Lowry and Jennings (1974) point out there are very few caves (250) known to be developed within the approximately 200,000km^2 Nullarbor karst, although Lowry (1968) estimates that there are 104–105 blowholes in 52,000 km^2 of the Western Australian portion of the Eucla Basin (two thirds of the Basin is in W.A.). However, the great differences in size, shape, depth, speleothem development, presence or absence of lakes and draughts amongst other characteristics led to the very early recognition of blowholes and caverns as two cave types extant on the Nullarbor. Tate (1879) considered that the blowholes were the precursors of caverns and noted the upward stoping domes. These were considered by Lowry (1968) to be the forerunners of blowholes. Bolam (1926) again recognised the two forms but felt that the domes were blocked blowholes which in turn developed from rockholes. Undoubtedly Lowry is correct in many, if not most, instances but the increasing numbers of domes observed to be choked with red 'sandy' fills with angular clasts deserve further consideration. More exploration makes the division between caves and blowholes increasingly indistinct.

Thomson (1949) and King (1949) were the first to formally discuss the two distinct ends of the spectrum — 'shallow' and 'deep'. The shallow caves were further divided into four classes according to entrance type (Table 2). King felt that the shallow caves were of vadose origin and cites the presence of dripstone as evidence of vadose action. He considered these caves were developed in a period of higher rainfall, possibly in the Pleistocene. The deep caves were considered to have been produced by phreatic activity just below the watertable which was presumed to be falling slowly. King argues that the change from "the pluvial Pleistocene to the arid present" would be sufficient to produce

a much lower watertable today. Given the porosity and permeability of the limestones the level of increased pluviality required to raise the watertable would seem extreme.
Jennings (1958) reaffirmed Thomson's classification but refuted the importance of vadose action in the shallow caves, instead emphasising the importance of a zone of 'intense small scale phreatic preparation' lying below the kankar layer of the Nullarbor Limestone. The zone can extend deeper than the 20–30m implied by Lowry and Jennings (1974) as can be seen in the entrance to Winbirra Cave (N–45). This zone of phreatic preparation carries with it an assumption of a watertable some 60–90 m higher than today. Evidence, other than the preparation, is lacking. Considering the low gradient and chemical uniformity of the present aquifer (Lockhart Jack, 1930, Spate and Ward, this vol.) the raising of the watertable by this amount by increased pluvial activity is hard to conceive.
Jennings (1961) continues the bipartite classification although he points out that there may be caves at intermediate levels and cites the eastern gallery of Weebubbie (N–2) as a possibility. Jennings at that time presented an entrance classification of five types although he points out that the entrance type does not necessarily reflect the cave type below. He also indicates that the evidence of vadose activity in Nullarbor caves is limited to constructional forms such as water–lain silt and sand floors. Thampanna Cave (N–206), and Mottled Cave (N–27) amongst others now provide spectacular examples of destructional vadose features such as channels cut in bedrock floors.
Anderson (1964) provides a refreshing new classification of Nullarbor caves under three heads:

1. those previously visited and mapped by speleological expeditions;
2. those visited but not seriously studied;
3. those not previously visited.

This classification was only possible because of the availability of a thorough examination of aerial photographs carried out by J.N. Jennings and made available to the 1963–64 expedition; a number of new and highly significant discoveries resulted. Unfortunately, and to the shame of Australian speleology, many of the features listed by Jennings were not visited until 1982; these features are largely on the South Australian part of the Nullarbor.
Many of these recently–explored features further blur the distinction between deep and shallow caves as there are many 'deep' caves which do not reach to the watertable but have characteristics previously reserved for 'shallow' caves. Anderson discusses some of the deep caves in detail and mentions intermediate levels in some of them (e.g. Firestick Cave, N–70). Little mention is made of the shallower caves, reflecting the preoccupation of Nullarbor cavers with the larger and perhaps more spectacular (on a size basis, at least) deep caves at the expense of the unifying intermediate caves.
In an unpublished note Jennings (1965) reviews his earlier publications and the discoveries of the 1963–64 expedition. His review further discounts the importance of entrance type, especially of the deep caves, believing them to be adventitious, and a result from or as an adjunct to cave formation. We do not know of a blowhole–type entrance (pavement surrounding a near circular hole less than two metres diameter) leading to a deep cave (reaching to or near the watertable) although Tommy Grahams (N56) is a small fissure

entrance leading to collapse, but not related to the collapse doline. We are confident that such an entrance might exist or might have existed.
Lowry and Jennings (1974) describe three types of caves as follows:

1. blowholes and near–surface caves of the Bunda Plateau;
2. Roe Plain caves; and
3. deeper caves of the Bunda Plateau.

Earlier Lowry (1970) erected a classification of four types; two of these were very general (shallow = 'Thylacine', deep = 'Cocklebiddy'), although fairly rigid criteria were used to define the types, as shown in Table 3. The two other types are very specific; 'Nurina' and 'Gecko' caves are restricted to the Roe and Mardabilla Plains respectively and have specific lithologic associations. However, the similarities of Gecko types to caves all over the Bunda Plateau recently led one of the present authors (APS) into the error of using Gecko as a type for a morphologically similar cave at the opposite end of the basin — emphasising the danger of using mixed specific and general criteria.
The Thylacine type caves were seen as deeper than the lithologically defined Gecko type shallow caves but not as deep as the Cocklebiddy type (Table 3). The Thylacine type caves have generated considerable interest in the last few years, chiefly because of their abundant speleothems of various mineralogies. The caves have a wide variety of entrance types ranging from the largest (and quite deep) collapse dolines to blowholes to fissures to holes in pavements. Collapse type entrances are also common in pavements and there are a number of blowholes without pavements. The Thylacine caves tend to possess the following characteristics:

- lack of lithological control and restricted distribution
- stable collapse with evidence of fracture parallel to bedding planes
- abundant 'normal' speleothems, often of black calcite
- abundant black calcite infill of anastomoses and other cavities
- large–scale destruction of calcite speleothems and bedrock by halite wedging
- abundant halite (and to a lesser extent gypsum) speleothems

These caves seem to be largely found in the eastern half of the Eucla Basin.

DISCUSSION

We feel that the categories used to categorise Nullarbor caves in the past are inadequate to describe caves such as Kelly (N–165) and Webbs (N–132) on Mundrabilla Station and a large number of others, chiefly on Koonalda and Nullarbor Stations and to the north of the latter property. These caves are not as deep as the Cocklebiddy type but are obviously stable elements in the environment. The dripstones provide evidence of a complex or longer history than we might have suspected in the past. Creating another category for these caves merely avoids the issues of genesis and the possible relationships between caves.

The restricted distribution of Thylacine caves and the absence of Cocklebiddy type in the same area, with some overlap in the central part of the Basin, leads us to the hypothesis that these caves may be proto-deep caves which have not developed fully. This may be because insufficient time has elapsed for the slow processes of solution to operate fully at or below the watertable, or that the cave systems are related to the establishment of conduit drainage for the Basin. Jennings has discussed from his earliest publications the possible role of higher sea levels in the development of cave systems on the Nullarbor. His zone of 'intense phreatic preparation' which preceded the caves requires a sea level about 75m higher than the present day or, alternatively, much wetter conditions for this development. The occurrence of more effective rainfall intervals since the Miocene regression seems unlikely (Martin, 1978); the abundant calcite speleothem development of the Thylacine type caves may in fact have required a very small increase in infiltration. Analysis of drips during and following rainfall events might well resolve the issue.

There is no evidence of sea levels as high as 75 m above present levels since the Miocene regression, but Lowry (1970) believes that the Roe Plains and Hampton Range developed during a Pleistocene sea level about 40m above present. Of course evidence of higher sea levels may well have been destroyed in cliff retreat, since the Pleistocene removed earlier wave–cut features; this is quite likely. We believe that the 40m higher level may have been responsible for the initiation of phreatic passages that were the precursors of Cocklebiddy type caves. The subsequent fall in sea level would have led to a series of relatively rapid collapses as hydrostatic support was withdrawn. A rapid fall in sea level may also have contributed to the development of a series of conduits rather than dispersed phreatic circulation. Phreatic preparation below the present watertable has been reported by Lewis (pers. comm.) from most of the dived caves and abandoned upper level phreatic passages exist at approximately the right altitudes for the higher sea levels of Lowry in a number of deep caves (e.g. Koonalda (N–4), Mullamullang (N–37), Firestick (N–70)). We would suggest that caves such as Old Homestead (N–83), Knowles (N–22), N–215 and N–182 amongst others are caves further developed from the Thylacine type toward the Cocklebiddy type in the middle of a shallow to deep cave spectrum.

However, concrete evidence for such an hypothesis is limited and this paper shows that speleologists have much to learn about Nullarbor caves and their relationships to one another. There is still a great deal of observational data to be gathered and evaluated; evidence of higher sea levels and cave passages and on climatic change must be sought after. Clear thinking about the rates and processes of collapse and its removal is also required, as well as investigation of the zone of intense phreatic preparation.

The effects of hindsight are extremely noticeable in this paper. Since the trip that generated the initial concerns about classification, one of the authors has had the opportunity to re–examine some caves and to discover others — breaking down earlier ideas about restricted distributions. This is a reflection of the much greater ease of today's travel on the Nullarbor and the lifting of real or imagined restrictions on access. However, this re-examination has reinforced the need to regard the Eucla Basin karst systems as a complete entity.

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Table 1
Stratigraphy of the Eucla basin in the Madura area
(after Lowry, 1970)

Quaternary/Tertiary	kankar
Lower Miocene	Nullarbor limestone Mullamullang limestone member Abrakurrie limestone
Middle/Upper Eocene	Wilson Bluff limestone
Middle Eocene	Hampton sandstone
Cretaceous	Madura Formation Loongana sandstone
Proterozoic/Archaean	Granite

Table 2
Entrance types

According to Thomson (1949)

(a) *"Those having a narrow cleft or fissure–type opening. These are usually only as deep as the upper hard crust, 60 to 70 feet, and consist for the most part of various short passages, never more than a few feet wide. They nearly always contain some dead stalagmites and stalactites"*. (The caves Thomson cites in this category do not seem to fit well with his descriptors).

(b) *"Bottleneck Cave (blow–hole entrance) ..... found in stony outcrops ..... have several quandong trees around the entrance ..... in the interior is found a heap of mullock ..... never found at the base of normal blowholes. I have never found ..... caves to contain stalactites ..... They mostly consist of one chamber only and rarely have passages leading off but often have many small pipes a few inches in diameter leading into them at varying heights. They are generally about 40 feet deep"*.

(c) Omitted

(d) *"Small sink-hole entrances, i.e. with sink-holes 60 to 70 feet across and 10 to 30 feet deep, and generally having long passages leading down from the bottom of the sink-hole and usually deepening to between 50 to 60 feet".*

According to Jennings (1961)

(a) *"Vertical solution wells or shafts. ..... circular in cross-section, about 2-4 feet in diameter and up to 15-30 feet in depth before changing character....."*

(b) *"Narrow cleft or fissure-like openings".* (See Thomson above, none known to Jennings).

(c) *"Small oblique entries in the sides of dolines. These are usually in collapsed rock masses and do not show active solutional sculpturing".* (= Thomson (b)).

(d) *"Roof collapse windows. As chambers below enlarge, solution shafts may also be enlarged by collapse until their usual character is lost and angular, joint-controlled windows develop".* (tending towards Thomson (d)).

(e) *"Large lateral entries in collapse dolines. When roof fall has proceeded so far as to produce a walled collapse doline, wide entries at the foot of portions of the rim lead sideways into the remainder of the cave system".* (logical extension of Jennings' type (d)).

Table 3
Summary of Lowry's cave types (after Lowry 1970)

	COCKLEBIDDY TYPE	THYLACINE TYPE	NURINA TYPE	GECKO TYPE
Former classification	'deep'	'shallow'	...	...
Depth	100 to 380 feet	Mostly 10 to 90 feet	10 to 70 feet	10 to 20 feet
Length	Mostly several hundred to a few thousand feet	Mostly a few tens to a few hundred feet	The longer cave is more than 1000 feet long	A few tens of feet
Cross section	Usually spacious; 20 to 50 feet high and 50 to 100 feet wide	Usually less than 5 feet, sometimes laterally extensive	5 to 10 feet wide; up to 10 feet high	Less than 5 feet high and 5 feet wide
Abundance	Sixteen known in Western Australia	Probably several hundred	Only two known	Probably several tens
Type of entrance	Collapse doline; commonly large	Mostly a blow hole	Collapse doline	Collapse doline
Comments	Some reach below the water table	None known to reach the water table	Restricted to Roe Plains	Restricted to Mardabilla Plain
Stratigraphy	Kankar Nullarbor Lst. (Mullamullang Lst. member) (Abrakurrie Lst.) Wilson Bluff Lst.	Kankar Nullarbor Lst.	Roe Calcarenite Abrakurrie Lst.	Kankar Nullarbor Lst. Toolina Lst.

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