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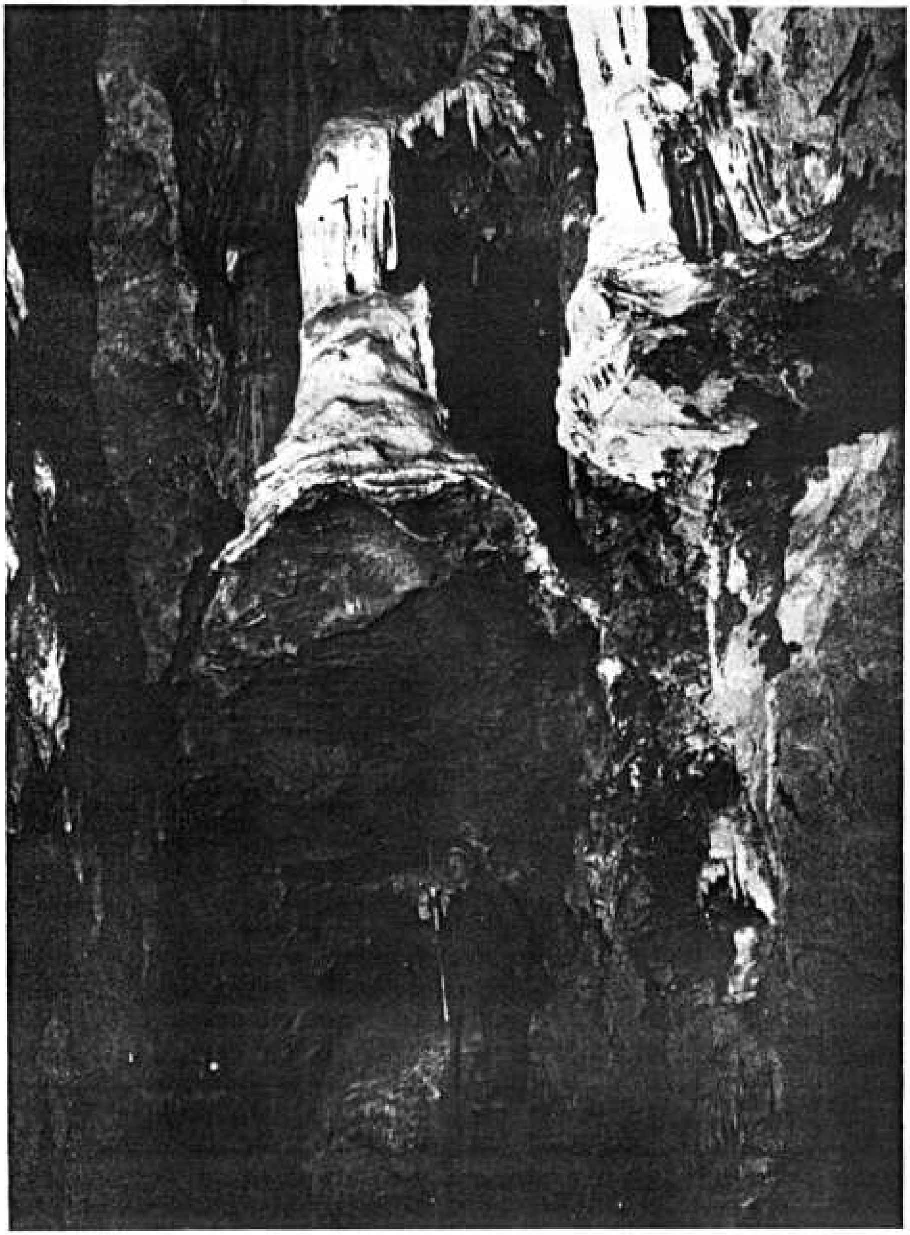

Flowstone floor with column, Piano Cave, Walli, NSW. Subsequent fluvial action has removed the former supporting fill.

"H E L I C T I T E"

Journal of Australasian Cave Research

Editors

E. A. Lane, Aola M. Richards, J. N. Jennings

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## ABSTRACTS AND REVIEWS

GUANO MINERALS FROM MURRA-EL-ELEVYN CAVE, WESTERN AUSTRALIA. By P.J. Bridge. Mineralogical Magazine, 39, 467 - 469, 1973.

Colonies of Chalinolobus morio Gray have formed a large guano pile in Murra-el-elevyn Cave, Western Australia, and have coated much of the porous limestone rubble floors and boulder piles of the bat chambers with a buff to dark brown-black, massive to crystalline crust scattered with insect remains, bat droppings, dead bats and skeletal material. Analysed crystalline coatings from the walls and floor of one chamber contained biphosphammite, ammonian $KH_2PO_4$, syngenite, aphthitalite, monetite, hannayite, whitlockite, apatite and minor gypsum, taylorite, brushite, mirabilite, guanine, and unidentified compounds. The minerals are derived from the interaction of bat urine, droppings, and limestone. Analyses for CaO, MgO, $Na_2O$, $K_2O$, $SO_3$, $P_2O_5$, $CO_2$, $NH_3$, $H_2O^-$, total N, and ignition loss are given. High $K_2O$ and low total N figures are characteristic of the analyses. Crusts of similar appearance have been collected also from other caves on the Nullarbor Plain. All appear to be leached with the exception of that from a cave near Madura which contains biphosphammite. - E.A.L.

GUANINE AND URICITE, TWO NEW ORGANIC MINERALS FROM PERU AND WESTERN AUSTRALIA. By P.J. Bridge. Mineralogical Magazine, 39, 889 - 890, 1974.

Guanine and uric acid were first described from Peruvian guanos in the early 19th Century but have been omitted from compilations of mineral lists. To correct this oversight, the minerals and names were submitted to and accepted by the Commission on New Minerals and Mineral Names, I.M.A., in late 1973, to give recognition to the original discoverers. The occurrence of these minerals in guanos from Western Australia substantiates the Peruvian occurrences. In Western Australia, uricite has been identified with other minerals in a bird-guano in Dingo Donga Cave. Guanine has been found in the phosphatic crusts in Murra-el-elevyn Cave and described by Bridge in the 1973 paper referred to above. - E.A.L.

HUMAN OCCUPATION OF DEVIL'S LAIR, WESTERN AUSTRALIA, DURING THE PLEISTOCENE. By C.E. Dortch and D. Merrilees. Arch. & Phys. Anth. Oceania, 8, 89 - 115, 1973.

Further excavations in Devil's Lair in 1972 were in materials similar to those reported before but with less rubble. Some 3 m were dated between 12,000 and 25,000 B.P., with more sediment below unexcavated. A hearth and two pits of unknown purpose demonstrated actual human occupation of the cave. More stone and bone implements were recovered. It is suggested that an older entrance became blocked in late Pleistocene or early Recent time which put a stop to human occupation. The present entrance is new and Aboriginal occupation was not renewed through it. An average rate of sediment accumulation of much less than 1 mm a year is thought to conceal short bursts of sedimentation, perhaps during heavy rainfalls, separated by long periods without accumulation. However, the dates obtained do not give proof of this. - J.N.J.

# SEDIMENTARY DEVELOPMENT OF THE WALLI CAVES, NEW SOUTH WALES

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Abstract

The sedimentary history of the Walli Caves began with the deposition of finely laminated clay during the latter part of bedrock development in the phreatic zone. After aeration and entrance development, entrance facies accumulated, and this was followed by the deposition of large amounts of fluvial and lacustrine deposits. Episodic fluvial erosion of these deposits then took place, and flowstone was formed extensively during periods between each active erosion phase to produce a striking sequence of suspended flowstone sheets.

## INTRODUCTION

The Walli Caves are just north of the small community of Walli and about 27 km northeast of the town of Cowra. They were entered at least as early as 1876 (M'Cartie, 1882; Wilkinson, 1894) and M'Cartie in 1876 referred to them as being "newly discovered". They may have been known earlier, however, since the limestone in the area was discovered in 1815 (Oxley, 1820). In the older literature they are referred to as the Belubula Caves. Wilkinson (1894) collected vertebrate fossils from the caves during his visit in 1876 and reports that the specimens included *Macropus* sp., *Phascolomys* sp., *Halmaturus* sp., and *Protemnodon* sp. Additional collections of bone have been made recently by members of the Sydney Speleological Society and among these are *Thylacinus* sp., *Thylacoleo carnifex*, and *Phascolomys* sp.

### General Geology

Highly folded Ordovician sediments and volcanic rocks crop out in the vicinity of the Walli Caves (Stevens, 1952). The basal formation, the Walli Andesite, is composed mainly of porphyritic andesites with lesser amounts of basalts, spilites, tuffs, and breccias. It is probably about 1,200 m thick (Smith, 1966) and covers the area immediately to the south and to the east of the caves. The next youngest formation is the Cliefden Caves Limestone which overlies the Walli Andesite conformably. It will be described in the following section.

The Malongulli Formation conformably overlies the Cliefden Caves Limestone. It consists "...mainly of impure siliceous limestone with some tuffs, shales and limestone breccia." (Stevens, 1952, p.116). It crops out to the west of the caves.

There is very little alluvium exposed in the vicinity of the caves and no ironstone or other laterite-derived material.

## The Limestone

The Cliefden Caves Limestone (named after the caves which occur about 5 km northeast of the Walli Caves) is shaly in the lower part and grades into more massive beds in the upper part. In the immediate vicinity of the caves there is only one prominent shale bed indicating that the outcrop in which the caves occur is in the upper part of the formation. Stevens (1952) estimates the total thickness at about 750 m. The exposure in which the caves occur is about 2.5 km long and 1 km wide. The limestone strikes in a northerly direction and dips westerly from a few degrees to about $70^{\circ}$.

A fair amount of nodular and vermicular chert is included in the limestone. Two partial chemical analyses of the limestone given by Carne and Jones (1919) list $CaCO_3$ content as 95.28 and 95.75 per cent, $MgCO_3$ as 1.24 and 2.31 per cent, $MnCO_3$ as 0.03 and 0.01 per cent, and $FE_2O_3$ and $Al_2O_3$ as 0.36 and 0.10 per cent. The insoluble residue of five samples analysed in this investigation ranged from 1.12 to 3.40 per cent with a mean of 1.75 per cent. It contained a large amount of combustible material. The clays in the insoluble residue consist of illite and chlorite in that order of abundance.

## Physiography

The Walli Caves are in an area of moderate relief at an altitude of 400 to 530 m (Fig.1). The hill slopes are generally convex and do not usually exceed about $30^{\circ}$ though cliffing is developed locally along the main stream.

The area is drained by the nearly perennial Licking Hole Creek. It heads about 5 km south of the caves area and joins Liscombe Pools Creek about another 3 km below the caves area. The latter joins the Belubula River about 4 km farther north. Licking Hole Creek is cutting down at present and bedrock is exposed in many places along its channel. It flows between interlocking spurs for part of its course through the limestone. There are no alluvial terraces along the stream in the caves area but there is a break in slope on some of the spurs which is suggestive of bedrock terraces. The stream is probably perennial along its entire course on the volcanic rocks, since it is fed by at least one spring. However, total sinking on the limestone within the caves area was observed on three occasions during the summer months between December 1967 and December 1968 and there were probably other times when total sinking occurred but was not observed.

# FIGURE 1 WALLI CAVES AREA

LOCATIONS OF CAVES IN 1b FROM UNPUBLISHED PACE AND COMPASS SURVEY BY 1st CRONULLA SEA SCOUTS, OCTOBER 1963.
GEOLOGY PARTLY AFTER PACKHAM (1963)

Form line interval = 20 m datum - sea level

Palaeozoic sediments

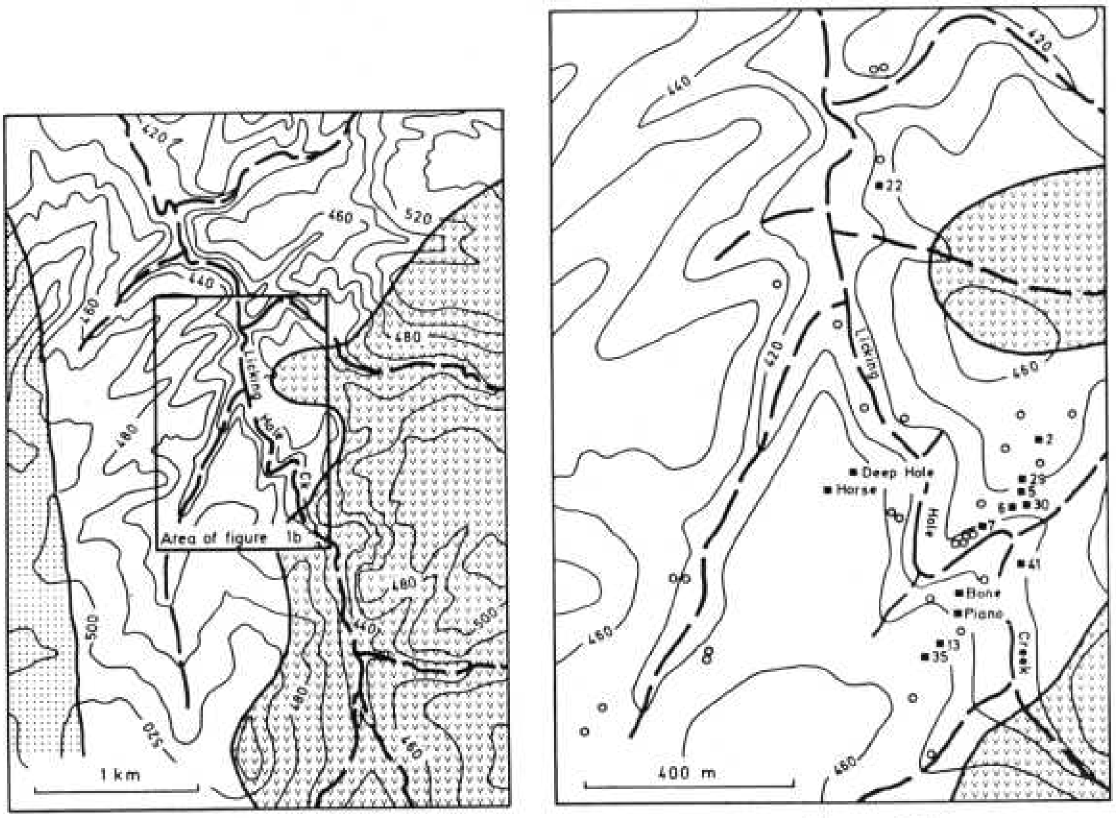
Cliefden Caves limestone (Palaeozoic)

Palaeozoic volcanics

N

■ Entrance to cave described in text

○ Other cave entrance




1a 1b

Limestone bedrock is exposed over about half of the surface in the caves area and is especially prominent on the steeper slopes. Well-developed solution flutes as well as rounded solution runnels, solution bevels, solution pans, bedding grikes, rainpits, and other, undefined solutional forms are present on these limestone exposures.

## THE CAVES

There are over 40 recorded cave entrances, potholes, and dolines in the Walli area. They are concentrated in the upstream end of the limestone outcrop within about 1 $km^2$ (Fig. 1). Members of the Sydney Speleological Society and other caving groups have carried out extensive surface and underground excavations in the area which have resulted in access to previously sealed caves and to connections between existing caves. Most of the openings have been numbered and these numbers will be used to designate the caves which do not have names.

### Piano Cave

Piano Cave (Figs.2, 3) is a series of interconnecting passages developed essentially on a single level whose walls and ceilings are mostly bedrock. Clay and mud are the dominant floor materials with some breakdown especially in the southeastern part. Flowstone floors are also present and, as in the other caves, the clay and mud has been washed out from between successive flowstone layers so that the flowstone sheets may separate a passage into two or three levels, a characteristic repeated in other caves. The ceilings are mostly irregular and in some places Deckenkarren are prominent. Most of the floor of the cave is near the level of the nearby Licking Hole Creek, yet there are no permanent pools and only the lowest parts are wet and muddy.

The entrance to Piano Cave is a small solution doline and appears to be formed in a bedding grike. There is a drop of about 1 m to the top of a breakdown pile. A narrow passage with an irregular ceiling slopes downwards for about 18 m and opens into a small, low room floored with flowstone. Flowstone sheets separate the next 15 m of irregularly shaped passage into three levels. At the lower end of this part (955079, Fig.2), and at a total depth of about 14.5 m below the entrance, the main level of the cave is reached. A passage leading off to the right, along profile P-P9, is separated into two levels by a flowstone sheet for about 9 m. It opens into a small room with a breakdown and sediment floor which slopes upward toward the back of the room where it meets the ceiling. Remnants of additional, higher flowstone sheets in varying stages of collapse are suspended from the walls and ceiling of this room. There is also some vertebrate fossil material within the sediment. A small passage, divided into two levels by a flowstone sheet, leads off to the left of this room (profile P-P4) and joins with the northwest passage complex. Farther along profile P-P1 the main passage continues for about 30 m where it opens into the largest room of the cave, the Big Room. This 30 m of passage is partly separated into two levels by a flowstone sheet, and there are at least two additional flowstone sheets visible in the ceiling. At 050070, Figure 2, there is a broken piece of stalactite, 1 m in diameter, embedded in the lower flowstone sheet. At 044062, Figure 2, a large blade reaches from floor to ceiling except where it is parted along a bedding plane near the middle.

The Big Room is floored with breakdown and has an irregular ceiling with large Deckenkarren. Numerous passages lead off from the western side of the room. Those to the northwest are fairly regular in plan but their ceilings are mostly highly irregular except for three short sections along profiles P-P3 and P-P7 where there are flat ceilings with ceiling half-tubes. Blades and spongework occur along profile P-P5. Near this area there are tufts of gypsum growing from freshly spalled walls. Bedded chert crops out in these passages also, and flowstone sheets separate the passages into two levels at many places.

The passage along profile P-P1 to the southwest of the Big Room is up to 15 m high with a very irregular ceiling with well-developed Deckenkarren. At 027042, Figure 2, there is a blade, 3 m high. This passage also is partly divided into two levels by a flowstone sheet. Near the end of this passage is the lowest point in the cave, 22 m below the entrance and about 3 m below the stream bed of Licking Hole Creek at its nearest downstream point. The other passage leading from the southwest corner of the Big Room (profile P-P2) is similar in form and content to the northwest passages except that it has no outcrops of chert.

The floor of the Big Room slopes up toward the east (along profile P-P3) and meets the base of a breakdown cone. This breakdown cone and the ceiling above it continue to slope upwards for about 20 m until the breakdown finally blocks farther access. Access along the top of this breakdown cone is possible only because many of the breakdown blocks are too large to fill in the Deckenkarren on the ceiling.

## Cave No.13

Cave No.13 (Fig.4) is actually part of the Piano Cave, but breakdown has sealed the connection between them. The first part of the cave is a $60^{\circ}$ slope downward over breakdown with a ceiling, or hanging wall of bedrock limestone. This breakdown floor and bedrock ceiling are just another part of the large breakdown cone and Deckenkarren ceiling that occur in the southeast part of Piano Cave. The lower part of the cave has a floor of red sediment and contains two prominent flowstone sheets which partly separate the passage into two levels. The deepest part of the cave is some 21 m below the entrance and about 5 m above the stream bed of Licking Hole Creek at its nearest downstream point.

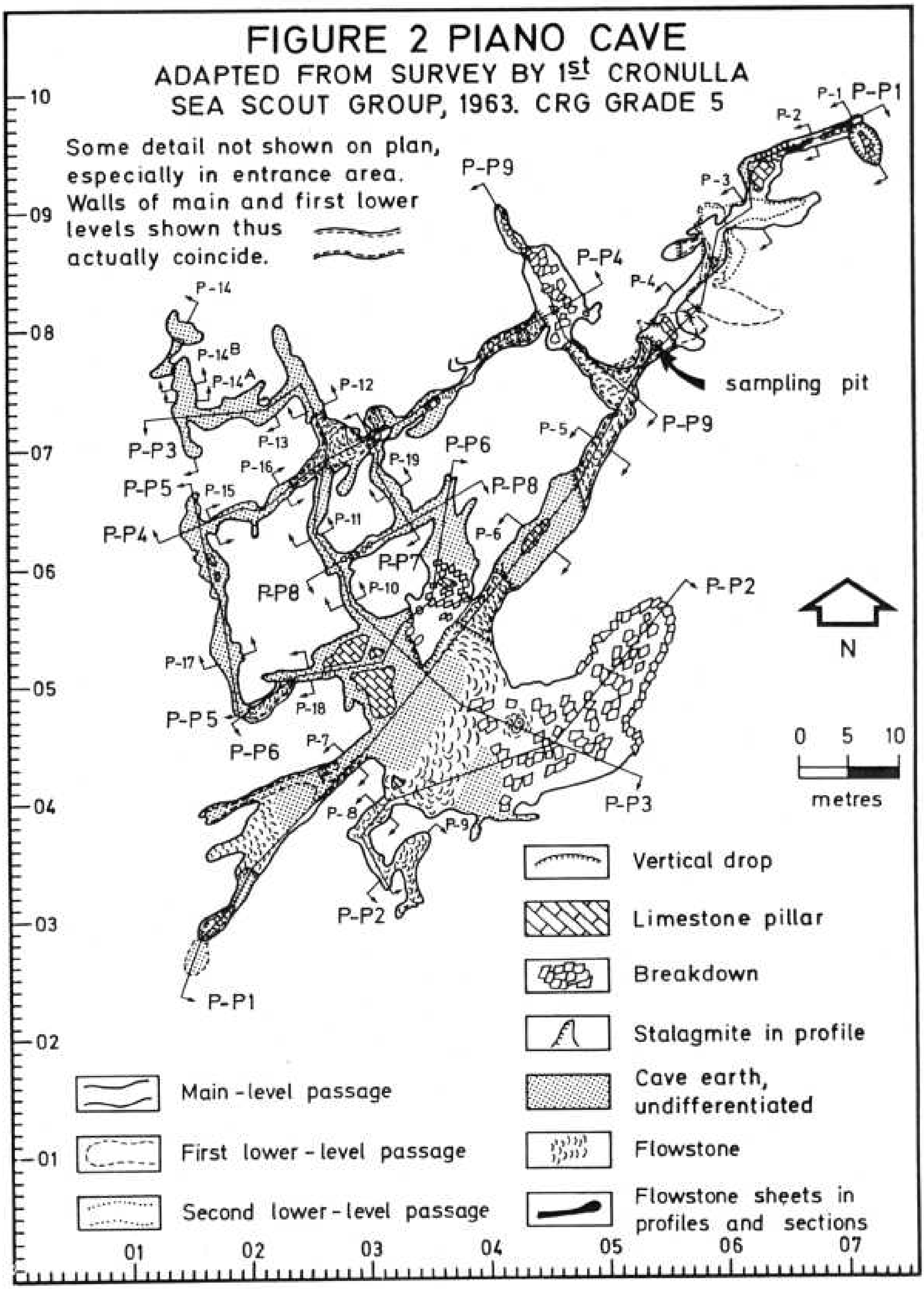
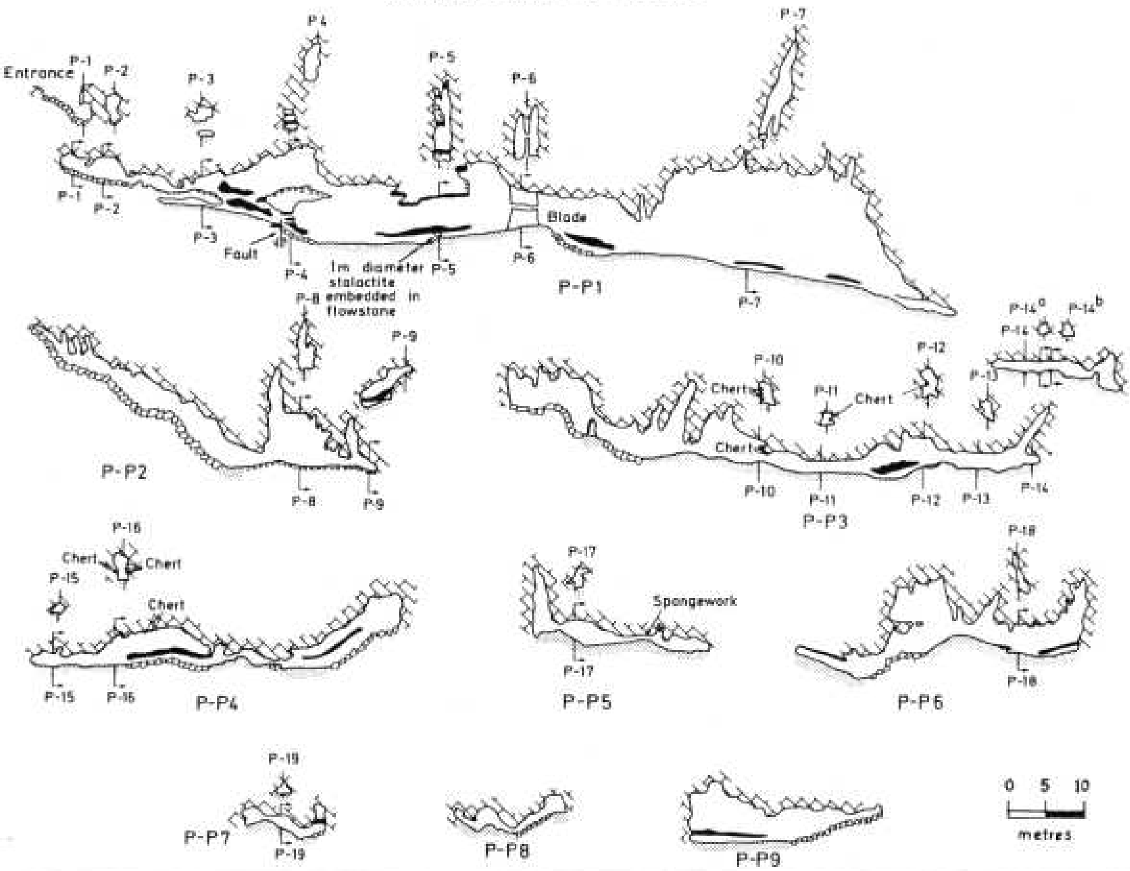



FIGURE 2 PIANO CAVE
ADAPTED FROM SURVEY BY 1st CRONULLA SEA SCOUT GROUP, 1963. CRG GRADE 5

FIGURE 3 PROFILES AND CROSS-SECTIONS OF PIANO CAVE, WALLI

SYMBOLS SAME AS FIGURE 2



Cave No.35

The cave is unsurveyed and, like No.13, is an extension of the Piano Cave. It lies immediately south of the Piano Cave and there was a physical connection, now blocked artificially, between the two. The present entrance, opened in 1965 by the Sydney Speleological Society (P. Wellings, oral communication, 1968), is a nearly vertical drop of about 25 m to the floor of an essentially single level passage complex with about 100 m of passageway. The main passage is similar to the joint passage in Piano Cave (profile P-P1). Like the other caves, No.35 contains flowstone sheets partly separating the passages into two levels. There is also a moderate amount of vertebrate fossil material exposed in sediment on the floor and adhering to the walls of the cave.

Deep Hole

Deep Hole (Figs.5, 6) is about 350 m northwest of Piano Cave. It is similar to Piano Cave in that it is developed mostly on a single level; it contains a good deal of Deckenkarren; and numerous flowstone sheets separate some of its passages into two, three, or even four levels. Desiccation-crack moulds, composed of calcite, occur on the underside of many of these flowstone sheets. It probably contains more passage than any of the other caves in the area. The 613.6 m that were surveyed do not represent all of the cave; there is a good deal of unsurveyed passage in the southeast part. Its total depth below the entrance is about 32 m which is about 1 m below the bed of Licking Hole Creek at its nearest downstream point.

The entrance to Deep Hole is a nearly vertical drop of about 21 m to the top of a small breakdown cone. From here passages lead off to the west, north, and southeast. The west passage (along profile DH-P1) has a high ceiling for the first 30 m. A shale bed occurs at this point, and the passage continues to the right and joins a cross passage, 9 m high, which ends against the same shale bed. The walls of these joint passages are irregular, reflecting the thin bedding of the limestone. The floor consists of red earth and small amounts of breakdown.

The passage to the north of the breakdown cone at the bottom of the entrance along profile DH-P2 has an irregular floor of flowstone and breakdown and an equally irregular ceiling of bedrock limestone. It ends in a small room which contains angular breakdown with a fresh appearance. The rest of the passage complex to the north consists of a number of levels partly separated by flowstone sheets and partly by limestone. Along profile DH-P4 blades and Deckenkarren with up to 4 m of relief form a highly irregular ceiling for the first 25 m. At this point holes in the flowstone floor lead down to the lower levels. Continuing along DH-P4 the passage rises over a steep flowstone sheet and ends in a small room containing two blades. The walls and ceilings of the irregularly

FIGURE 4 WALLI № 13 CAVE

ADAPTED FROM SURVEY BY 1st CRONULLA SEA SCOUT GROUP, 1963. C R G GRADE 5

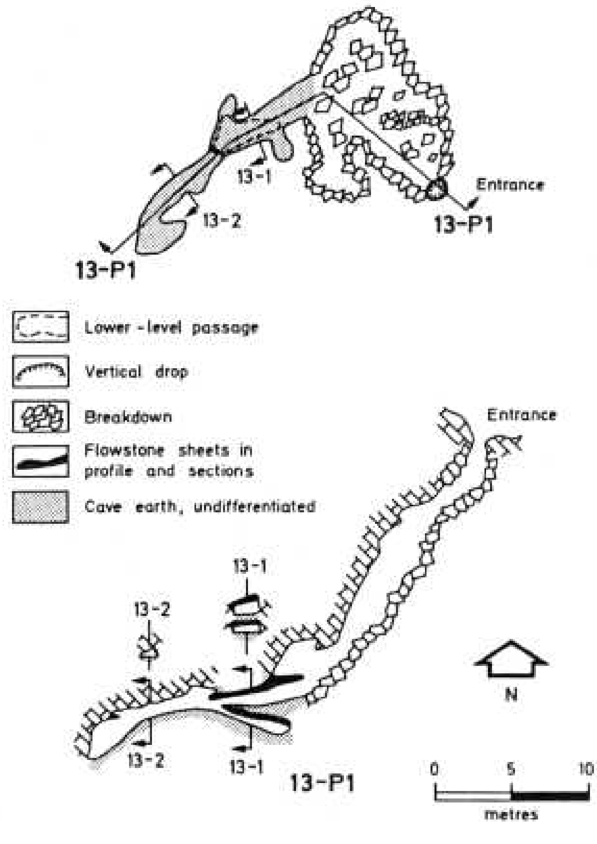


FIGURE 5 WALLI DEEP HOLE

SURVEYED BY R. FRANK AND K. FITCHETT AUGUST, 1968. CRG GRADE 6sD

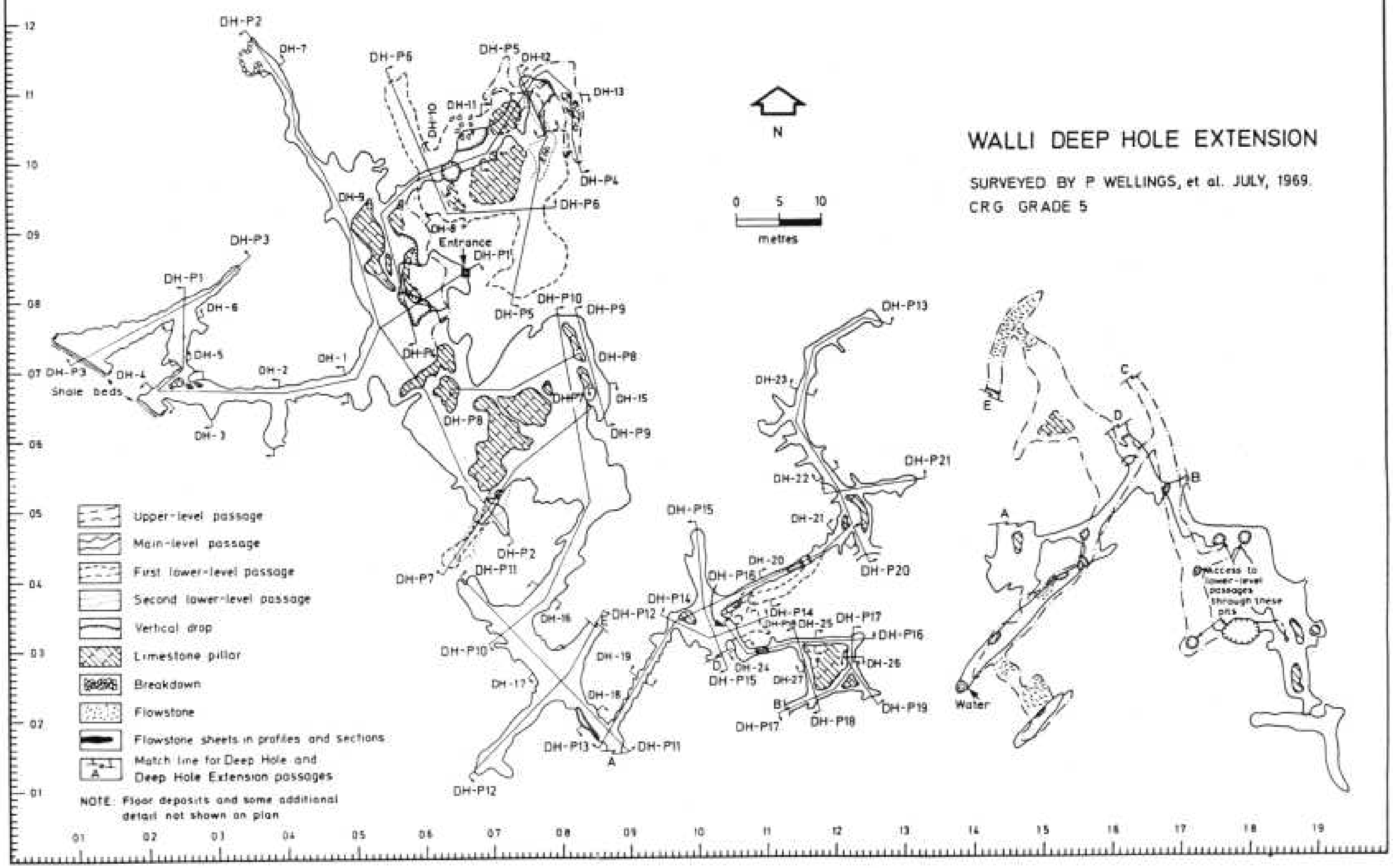
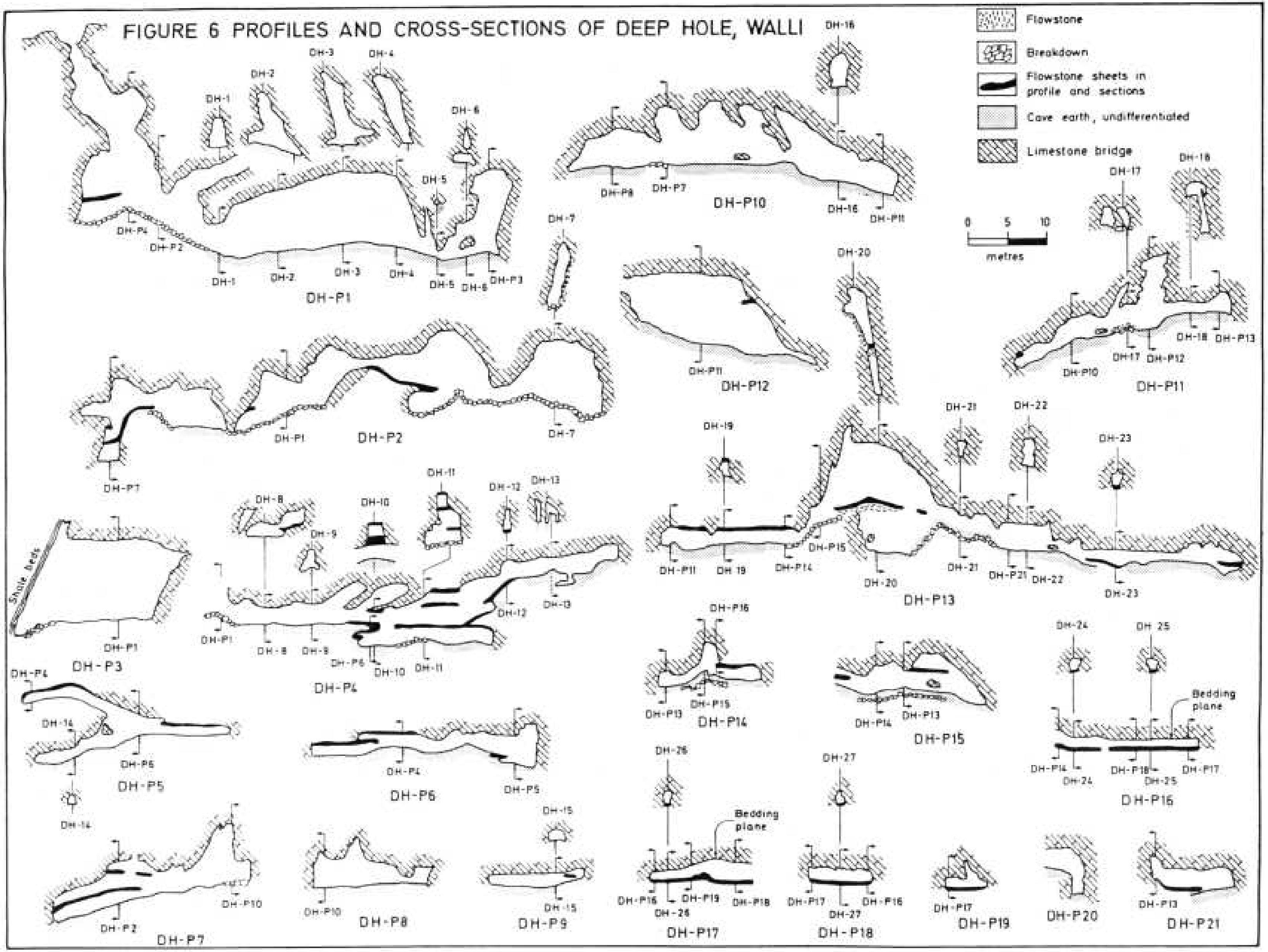


FIGURE 6 PROFILES AND CROSS-SECTIONS OF DEEP HOLE, WALLI



shaped lower levels are partly made up of speleothems and sediment but sufficient limestone is present to indicate that the bedrock passages are truly irregular. Clay and mud with varying amounts of moisture cover the floors. At 073093, Figure 5, there are graded beds of cave pearls. The lowest point in the cave is the lower passage along profile DH-P5.

A short distance southeast of the bottom of the entrance is the largest room in the cave. Deckenkarren with relief up to 6 m are the dominant features in the room. The floor is composed of red earth and small amounts of breakdown. Of the remaining passages to the southeast the following dominant features may be noted. Along profile DH-P11 (076029, Fig.5) there are small blades and limestone partitions. The high ceiling near this point shows the dip of the limestone is only $10^{\circ}$, a drastic change from the $65^{\circ}$ dip of the shale bed in the west passage. The joint passage at the south end of profile DH-P13 has walls similar to those in the west passages reflecting the thin bedding of the limestone. The ceiling of this passage is a flowstone sheet except for one small part where some Deckenkarren are exposed. Near the north end of this same profile there is a flat ceiling which may be, in part, a bedding plane. The passage along profiles DH-P16 and DH-P17 have flat, bedding plane ceilings. Here the limestone also dips about $10^{\circ}$. The ceiling of the passage along profile DH-P18 is a reflection of the thin bedding dipping at a slight angle. High-relief Deckenkarren are prominent in the area near the intersection of profiles DH-P13 and DH-P15. Flowstone sheets divide the passages into levels throughout most of this southeast passage complex.

Gypsum occurs as tufts on freshly spalled walls especially in the vicinity of 1205, Figure 5. Gypsum crystals up to 5 cm long also grow from the clay floor near 072108, Figure 5. X-ray diffraction of some speleothems on the wall at 105036, Figure 5, showed them to be aragonite.

## Horse Cave

Horse Cave (Fig.7) is about 60 m southwest of the Deep Hole. It is much simpler than either Piano Cave or Deep Hole but contains the same major features as the other two; namely, a single level, red clay and mud floor, prominent flowstone sheets, and Deckenkarren. Its total depth is about 40 m, and its lowest point is about 1 m above the bed of Licking Hole Creek at its nearest downstream point.

Access is through a nearly vertical, bedding-plane fissure which drops about 21 m to the top of a large breakdown pile. The breakdown floor slopes down and to the right into a large room completely floored with the breakdown. A short solution tube with a floor of red mud and clay leads off to the northeast, and the wall near this tube contains spongework. At the far end of the room a passage floored with mud and

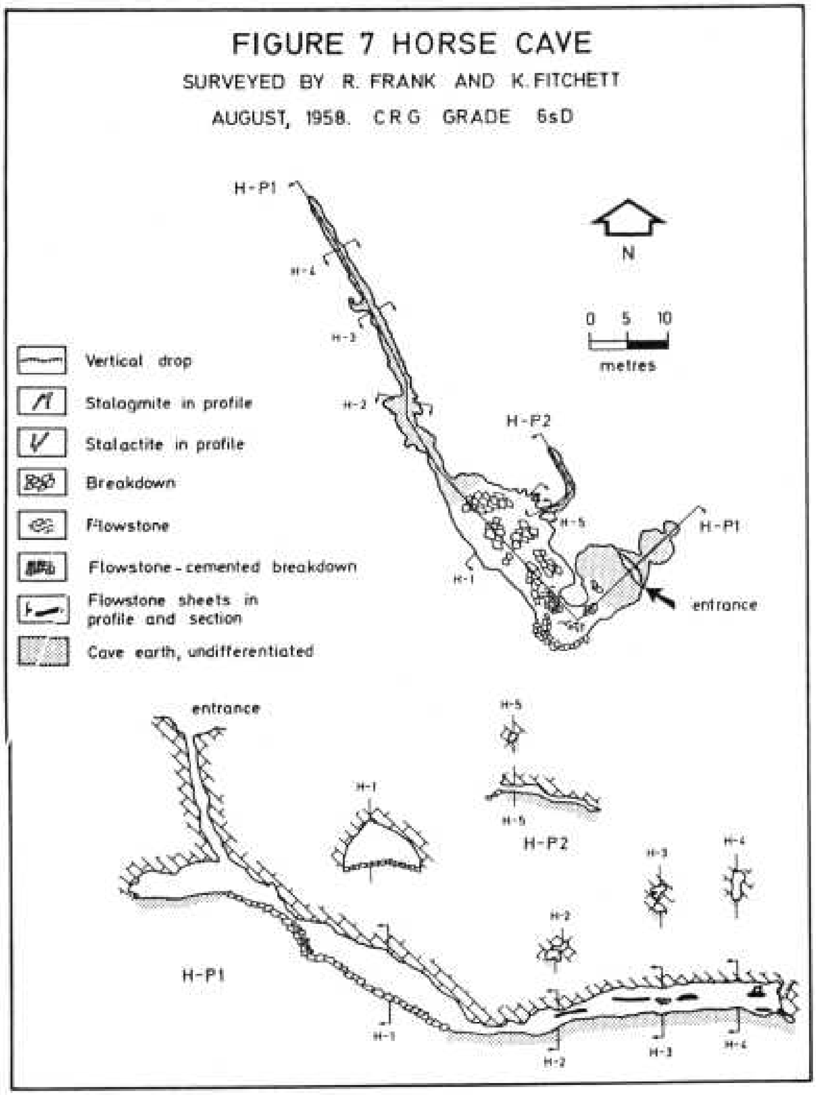


FIGURE 7 HORSE CAVE
SURVEYED BY R. FRANK AND K. FITCHETT
AUGUST, 1958. CRG GRADE 6sD
H-P1
N
0 5 10
metres
Vertical drop
Stalagmite in profile
Stalactite in profile
Breakdown
Flowstone
Flowstone-cemented breakdown
Flowstone sheets in profile and section
Cave earth, undifferentiated
H-P2
H-P1
entrance
entrance
H-1
H-5
H-P2
H-3
H-4
H-2
H-P1
H-1
H-2
H-3
H-4

clay contains a number of flowstone sheets stretching across it. It continues in a fairly straight course for about 42 m where it is finally plugged with speleothems.

Oolite, Stovepipe and Box Cave System

Underground excavations in caves with different names and separate entrances have resulted in connections between these caves. The system (Fig.8) is on the opposite side of Licking Hole Creek from the previously described caves, and about 300 m north of Piano Cave. The total depth below the highest entrance (No.2) is about 40 m.

The southern part consists of bedrock passages partly or wholly filled with breakdown and soil-derived sediment and passages through partly cemented breakdown and soil-derived sediment. A single, large breakdown cone has obviously contributed most of the material in the southwest area and in the south part of the large room. The breakdown and soil-derived sediment in the passages south and east of entrance No.5 may also be the result of this same breakdown cone. The absence of bedrock floors in this area makes this indecisive. In some of the bedrock passages large Deckenkarren, blades, and limestone partitions are present. At least two of these passages also contain flat ceilings which are not due to bedding planes (profiles OSB-P2 and OSB-P3). There are also flowstone sheets which divide the passages into two or three levels as along profile OSB-P1.

The big room has a floor of breakdown which slopes to the north. It is partly covered with flowstone and red clay and mud. The mud floor near 042048, Figure 8, contains large desiccation cracks and white; powdery gypsum (shown by X-ray diffraction) has been precipitated on the surface of the mud near the desiccation cracks. The ceiling is irregular and contains prominent Deckenkarren.

In the vicinity of 042044, Figure 8, a fault is exposed with steeply dipping, thin beds on the east side and low-dipping thick beds on the west. The geometrical aspect of the fault is not clear and a brief examination on the surface above the cave showed no sign of it, so it may be a penecontemporaneous structure. The passage to the west of the large room near 040054, Figure 8, contains tufts of gypsum growing from a freshly spalled wall. At the north end of the large room an irregularly shaped passage, 30 m long, ends abruptly in flowstone. An excavated, body-sized crawl, 15 m long, with one small intervening room connects this passage with the dissimilar part of the cave known as the Stovepipe. This section of the cave is a bedding-plane fissure, 12 to 18 m high, that dips $60^{\circ}$ to $70^{\circ}$. Its total length is about 60 m, and it averages 1 to 2 m wide. A side passage, developed along a joint, extends from near the bottom of a nearby vertical surface entrance (No.2) for about 15 m where it joins a small room developed along another bedding plane which is comparable to the main passage. The straightness and regularity

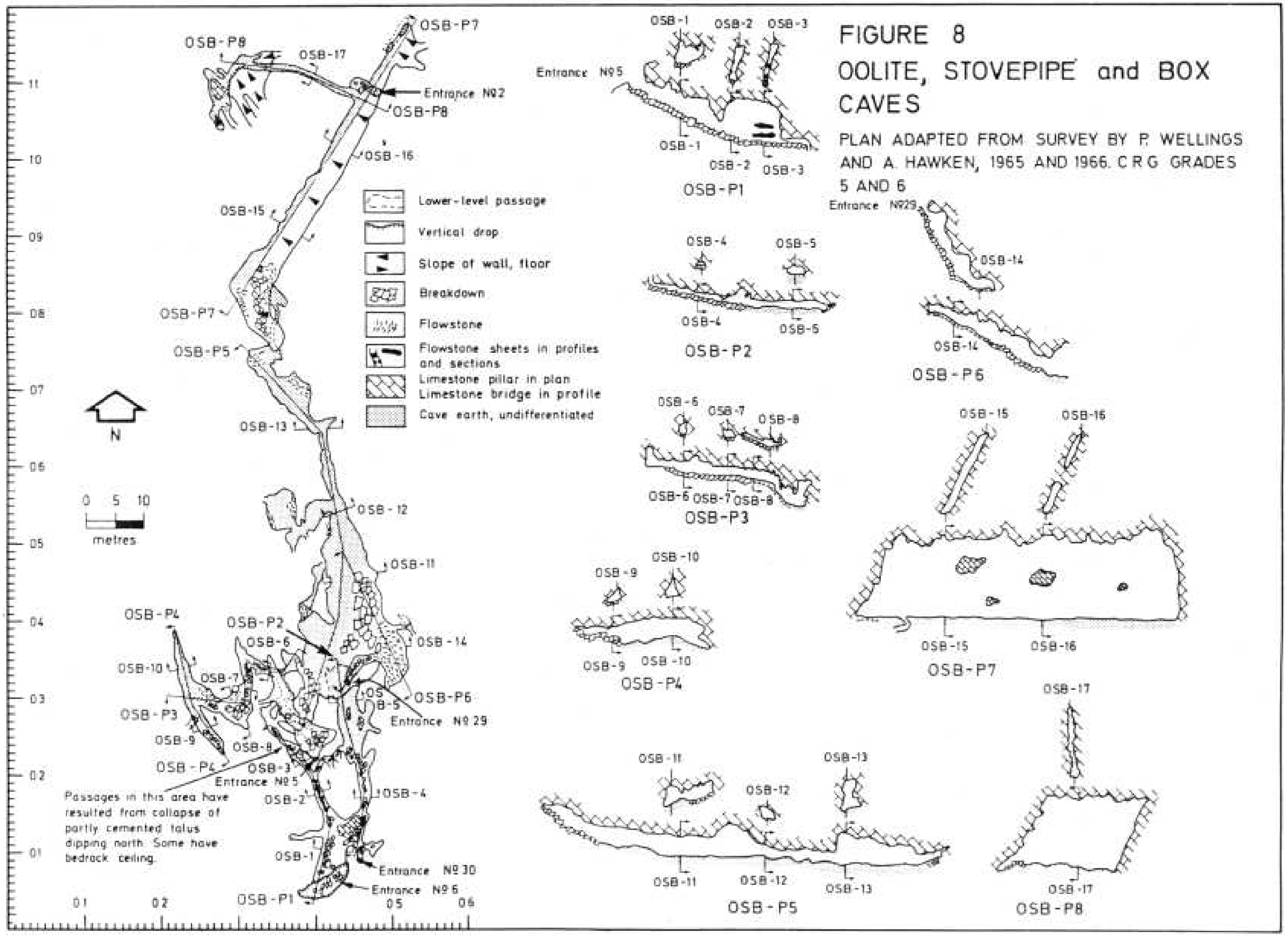



FIGURE 8
OOLITE, STOVEPIPE and BOX CAVES
PLAN ADAPTED FROM SURVEY BY P. WELLINGS AND A. HAWKEN, 1965 AND 1966. C R G GRADES 5 AND 6

of the passage outlines and the absence of flowstone sheets as horizontal partitions in the Stovepipe area contrast markedly with the other parts of the cave. There are also no Deckenkarren in the Stovepipe area. Chert outcrops on the walls especially in the joint passage along profile OSB-P8, and enlarged anastomosis tubes are present in the terminal room.

## Bone Cave

This cave (Fig.9) is a small portion of a large filled doline about 45 m north of the entrance to Piano Cave. All the floor, most of the walls, and part of the ceiling are composed of cemented breakdown and soil-derived sediment. This fill contains a fair number of vertebrate fossils. Limestone bedrock is exposed in the ceiling, or hanging wall, in places.

## Cave No.22

Cave No.22 (Fig.10) is a small cave about 880 m northwest of Piano Cave and on the opposite side of Licking Hole Creek. Its total depth is 21 m which puts the deepest part about 3 m below the bed of the creek at its nearest downstream point. Nearly vertical joints and a dip on the limestone of only about $10^{\circ}$ in this area have produced highly regular and predictable passage shapes similar in form to the Stovepipe Cave, but much smaller.

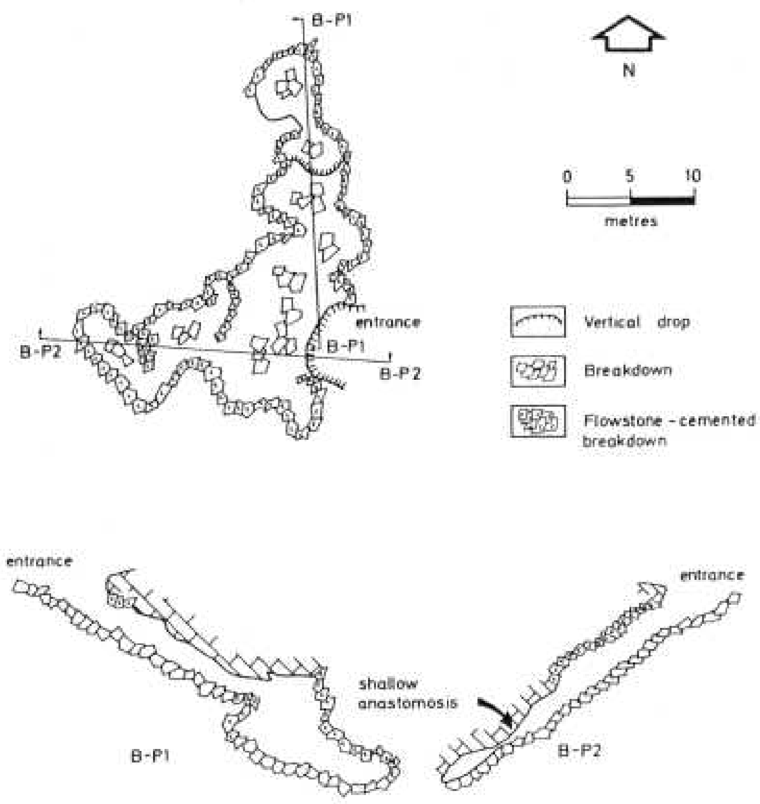
Access is through two vertical fissures which join shortly beneath the surface and drop 11.5 m to the floor of a small room. A short crawl over flowstone and breakdown to the west of the entrance room leads to a low room developed along a bedding plane. The passages to the north of the entrance room are narrow fissures developed along joints which are occasionally intersected by low rooms developed along bedding planes. Cross-section 22-6 shows a typical example of one of these joint passages with an intersecting bedding-plane room. In this same area there are two well-developed ceiling half-tubes intersecting nearly at right angles. Chert crops out in abundance throughout the northern part of the cave.

## Cave No.41

The entrance to Cave No.41 is about 150 m northeast of Piano Cave. The cave is unsurveyed. It contains about 50 m of joint-controlled passage similar to that of Cave No.22. Its total depth is about 7 m making its lowest point about 2.5 m above the channel of Licking Hole Creek at the nearest downstream point. Tufts of gypsum (shown by X-ray diffraction) grow on freshly spalled walls throughout the cave and are especially prominent along the main joint passage where they are producing crystal-wedged flakes of limestone.

FIGURE 9 BONE CAVE

PLAN ADAPTED FROM SURVEY BY 1st CRONULLA SEA SCOUTS, 1963. C R G GRADE 5



Cave No.7

Cave No.7 is a small cave with an entrance along a narrow vertical fissure about 180 m north of Piano Cave. Morphologically it resembles Cave No.22. It contains red clay and mud with a moderate amount of vertebrate fossil material.

The remaining holes in the area are either filled dolines, solution pipes, cliff-foot caves, or remnants of caves with characteristics similar to the Piano Cave or to Cave No.22.

## THE SEDIMENTS

The most distinctive feature of the deposits in the Walli Caves is the alternation of beds of mud and clay with relatively pure flowstone (Pl.1 and front cover).

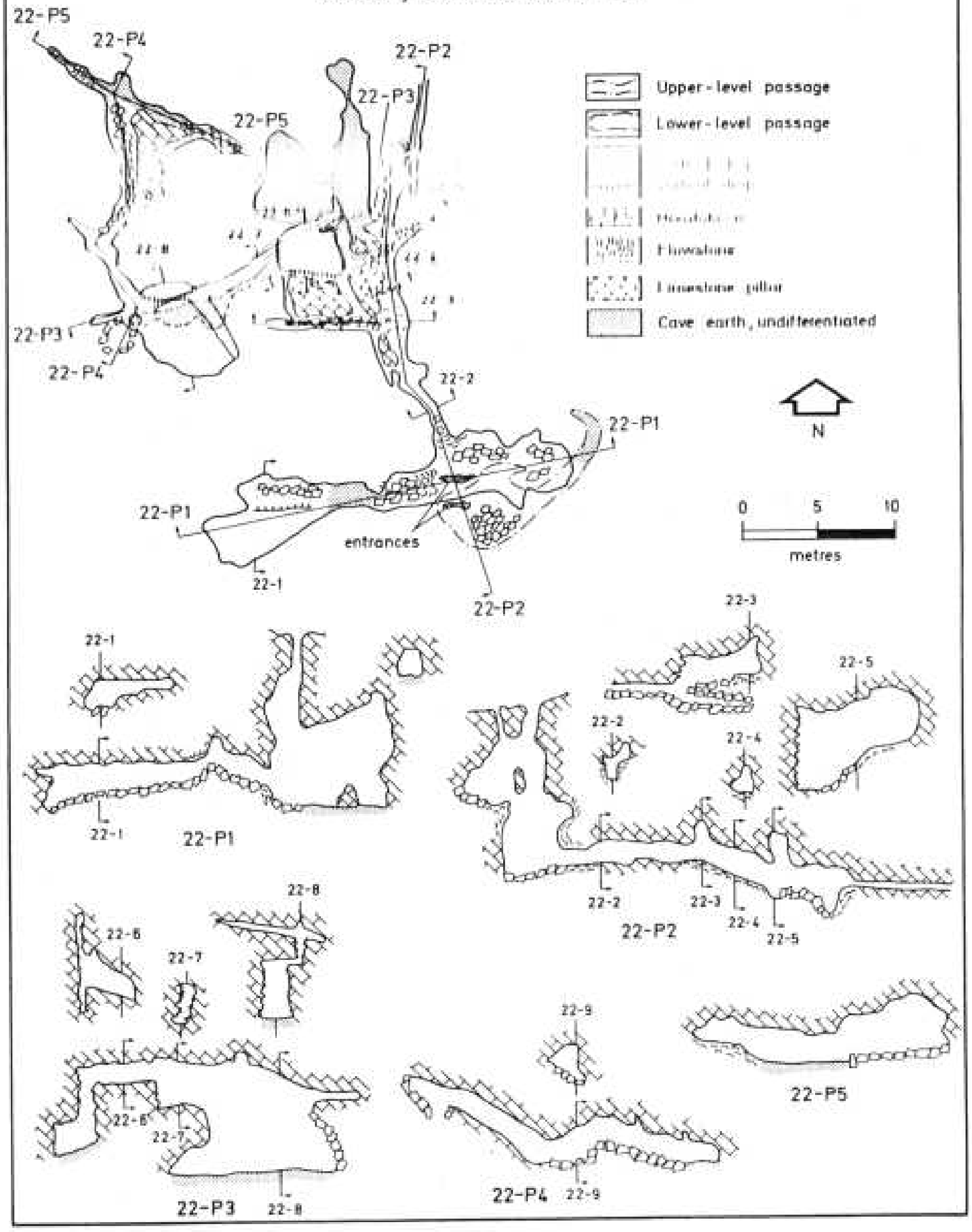
The most impressive sequence of flowstone sheets and associated clastic sediments occurs in the Deep Hole (0610, Fig.5) where four successive flowstone sheets are present. They vary in thickness from 15 cm to about 40 cm and the total height from the base of the lower one to the top of the upper one is about 16.5 m. Generally, the thickness of the flowstone sheets varies from a few centimetres to over a metre. Their upper surfaces may be quite irregular with stalagmites, columns, and other speleothemic forms developed on them. Curtains and draperies with various shapes form canopies over the edges of the sheets in places where the sheets have been broken off and small stalactites a few centimetres long grow on the underside of the upper sheets in some places. The undersides of the flowstone sheets may be pure crystalline calcite or there may be detrital mud and clay with or without calcite cement adhering to the sheet. Where there is little or no mud or clay on the underside, vertebrate remains or broken stalactites may be exposed (Pls.2, 3). Desiccation-crack fills of calcite are also impressively displayed on the underside of the flowstone sheets in numerous places (Pl.4). The polygons formed by these desiccation-crack fills vary from a centimetre or so to about 60 cm across and from a few millimetres to about 30 cm deep.

The clastic sediments between flowstones are mostly clay or mud but particle-size is generally larger between the lower flowstone sheets where significant amounts of sand and gravel may be present (for example, in the Piano Cave at 0507, Fig.2; in the Deep Hole at 062097, Fig.5). Stratification in the finer material is usually well-developed as thin laminae which are grossly horizontal but wavy in detail. Some graded bedding occurs in the larger sized deposits. Other sedimentary structures - invertebrate burrows, desiccation cracks, and argillans - are almost always present in the finer materials. Some microscopic faulting occurs in the clay deposits.

FIGURE 10 CAVE Nº 22

SURVEYED BY R. FRANK, P. POTTER AND K. FITCHETT

AUGUST, 1968. CRG GRADE 6sD



Non-clay detritals in these deposits include quartz, chert, bone fragments, and speleothem fragments as well as cave pearls and fragments of reworked clastic cave sediments in local abundance. Minor amounts of volcanic rock fragments and minerals associated with these rocks also occur.

Cement is almost all calcite and is usually restricted to desiccation-crack fills though it is more evenly distributed in the coarser material. Traces of manganese minerals are present in many of the finer sediments. Some occur on planar surfaces and have the dendritic pattern characteristics of pyrolusite. Others fill invertebrate burrows as botryoidal and pelletal coprolites. One coarse sample from the Piano Cave contains patchily distributed collophane.

Aside from the fluvio-lacustrine and fluvial sediments occurring between the flowstone sheets there are several entrance-facies deposits in the Walli Caves. The largest and most impressive of these are the one of the Bone Cave, Cave No.13, and the southern part of the Oolite, Stovepipe and Box Cave system. The lower parts of the former two are also exposed in the Piano Cave in the room at 045085, Figure 2, and in the eastern part of the Big Room, respectively. Several smaller entrance-facies deposits occur in the other caves.

On the whole, these entrance-facies deposits are typical in their texture and clastic content, consisting of breakdown, bone fragments, and soil-derived material and having a large range in particle-size, polymodally distributed. Calcite cement occurs in sufficient quantities locally to support parts of the material as walls and ceilings of passageways.

Thin beds of flowstone and of fine clastic material also occur in these entrance-facies deposits - the former resulting from a decreased rate of clastic sedimentation and the latter due to brief flushes of water.

One other type of clastic deposit - breakdown produced by crystal wedging of the limestone by gypsum - is worth mentioning here since it exhibits a process which has received little attention in the speleological literature and may be quantitatively important in the production of breakdown. It is currently being produced in fair quantity in Deep Hole, Piano Cave, and Cave No.41. It is best displayed in Cave No.41 as slivers and flakes of extremely sharp-angled limestone a millimetre or so thick and a centimetre or more in diameter (Pls.5, 6).

Crystal wedging of limestone by gypsum has been observed in Grotte de Riusec in southern France (Trombe, 1961) and in the Nullarbor Plain caves of Australia (Wigley and Hill, 1966: Lowry, 1967: Frank, 1971a. 1971b) and Lowry has proposed it as a mechanism for producing domes in the shallow caves there. Gypsum is relatively abundant in the Walli

PLATE 1. Two lower flowstone sheets in Deep Hole.

PLATE 2. Vertebrate skeleton embedded in underside of flowstone sheet in Deep Hole.

PLATE 3. Broken stalactites embedded in underside of flowstone sheet in Deep Hole. Light spot is about 8 cm in diameter.

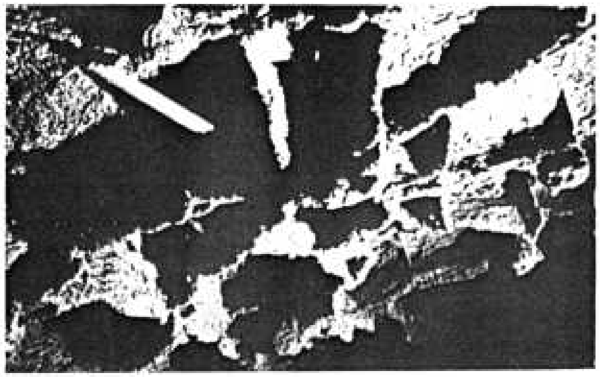


PLATE 4. Calcite desiccation-crack fills on underside of lowest flowstone sheet in Deep Hole. Scale is 30 cm long.

PLATE 5. Limestone wall in Cave No. 41 showing crystal wedging by gypsum. Darker areas have undergone recent spalling. Arrow indicates flash bulb for scale.

PLATE 6. Detail of wall in Plate 5. Arrows indicate flakes of limestone recently wedged off by nodular gypsum. Match stick for scale.

Caves as wall crusts, needles growing from clay, and powdery precipitates on desiccation-cracked mud floors, and these conditions suggest that it is currently being precipitated. The source for the sulphur is more likely to be the nearby volcanic rocks than the neritic limestone.

In addition to the previously described sediments, recent breakdown and entrance-facies deposits are accumulating at the present entrances to the caves.

## AGE OF THE DEPOSITS AND CORRELATION AMONG CAVES

Unfortunately, datable organic material in good stratigraphic context is sparse in the Walli Caves' deposits. There are probably sufficient amounts of bone in the Bone Cave and in Cave No.7 for $^{14}C$ analysis but the deposits in these two caves cannot be directly correlated with the main depositional sequences in the other caves.

A $^{14}C$ analysis of charcoal from 15 to 25 cm below the top of a sampling pit in the Piano Cave gave an age of 1,100 ± 90 BP (GaK-2204). Sedimentologically this deposit appears to be younger than the sediments between flowstones and the deposits in the small room at 045085, Figure 2, and so probably it is younger than all deposits in the caves except for the most recent entrance accumulations. The date therefore gives a minimum age for the majority of cave sediments.

The lack of age control makes it necessary to correlate between caves on sedimentological criteria and so precise contemporaneity of the various cave deposits is not established. If a common cause is assumed for the deposition of the sediments, the times of deposition will probably not depart very much from one another.

## DEPOSITIONAL HISTORY OF THE CAVES

The deposits and their arrangement into alternating beds of clay and mud with flowstone sheets is not unusual. Similar sequences have been reported from many caves and Pengelly (1864) describes comparable deposits in Windmill Hill Cavern, Brixham, England, where most of the detrital material between flowstone sheets has been removed. A more recent example is given by Méroc (1961). The extent and prominence of these deposits in the Walli Caves, however, makes them more impressive than most deposits of this kind.

Pengelly interpreted the flowstone sheets in Windmill Hill Cavern as being in inverted superposition, that is, the higher one was the older one. He also postulated that a third flowstone sheet, highest and oldest, had previously existed but had been destroyed except for fragments embedded in the underside of the higher one which still persisted.

Though he is not explicit, these embedded flowstone fragments must have been his prime evidence for considering the existing flowstone sheets to be superpositionally inverted.

In the case of the four main flowstone sheets in Deep Hole there are 24 possible chronological sequences but the evidence detailed below suggests that these, as well as those in the Piano Cave, are in a regularly inverted superpositional sequence, that is, they are successively older towards the top. Figure 11 represents diagrammatically their sequence of formation.

Parallel-bedded flowstone fragments of stalactites are embedded in the underside of the flowstone sheet in Piano Cave near 050070, Figure 2, and stalactite fragments are also embedded in the underside of the second highest flowstone sheet in Deep Hole near 060097, Figure 5. These fragments could have been derived only from an older deposit and, considering the horizontal bedding of the enclosing flowstone sheets, probably were derived from a stratigraphically higher deposit. Calcite desiccation-crack fills are present on the underside of the two lower flowstone sheets in Deep Hole near 062096, Figure 5, but absent from the two upper ones and these are larger and more extensively developed beneath the lowest flowstone sheet than beneath the second lowest. This, together with the fact that the amount of remnant mud and clay decreases upwards (it was difficult to find any to sample beneath the second highest flowstone sheet and there is none beneath the highest one) suggests that the clastic sediments were removed from the top downward. Stalagmites and canopies are larger and more extensively developed on the upper flowstone sheets than on the lower ones suggesting that the upper ones have been in existence longer. The lower flowstone sheets are more extensive than the upper ones suggesting that they have not been subject to as much erosion and could be younger. The upper flowstone sheets show signs of corrosion on their undersides suggesting that they have been exposed longer and are therefore older. The texture of the clastic sediments varies considerably both within each cave and among the different caves but there is some indication that the water-deposited material is generally coarser near the bottom. The cemented bed of cave pearls showing excellent grading occurs near the lowest flowstone sheet in Deep Hole. The sediments beneath the lowest flowstone sheet in Piano Cave have an upper particle-size of 6 mm and a median of about 0.5 mm. The higher clastic water-deposited sediments are much finer and some have upper particle-size limits of $>2\mu m$.

Aside from the fluvio-lacustrine clastic sediments between flowstones there are also considerable deposits of entrance-facies material in the Walli Caves. It is necessary to account for these in the general framework of the caves' history and to relate them chronologically to the fluvio-lacustrine deposits. This can best be done by reference to the Piano Cave since it is there that both types of deposits are found in proximity to one another.

In the sediments at the bottom of the sampling pit (055079, Fig.2) there are detrital lumps of clay with characteristic undulatory laminae which show them to have been derived from clay similar to that from 025074, Figure 2. Other reworked lumps of this clay type occur in the sediment adhering to the underside of the lower flowstone sheet at 0507, Figure 2, and in the sediment making up part of the entrance-facies deposits at 045085, Figure 2. This indicates that the clay predates both the water-deposited sediment beneath the lower flowstone, and hence all sediment that existed above it also, and the entrance-facies deposit. Reworked lumps of previously cemented sediment, some of which contain lumps of the clay, are also present in the sediment beneath the lowest flowstone sheet. In addition, there are void argillans of well-oriented clay up to 1 mm thick in the sediment of the upper part of the entrance-facies deposits at 045085, Figure 2.

The chronology that suggests itself, then, is as follows. The clay with undulatory laminae was deposited in the cave from ponded water, during the late stages of the formation of the cave while it was still in the phreatic zone. The cave was then air-filled and entrance-facies sediments, consisting of soil-derived material, limestone rock fragments, and bone, were deposited mainly by gravity with occasional flushes of water and consequent flowstone formation and partial cementation. Some fragments of the previously deposited phreatic clay were included in these entrance-facies deposits. The cave then received large quantities of detritus both from the surface and reworked from the entrance-facies sediments and the phreatic clay. This was deposited by streams at first and later in nearly stagnant ponds. At the same time, some clay was redistributed as plane or channel argillans within the existing entrance-facies deposits.

This last phase of sedimentation corresponded with the main sedimentation of the clastic ponded sediment in the Deep Hole and in parts of Horse Cave and the Oolite, Stovepipe and Box Cave system. After the caves were nearly filled with these ponded sediments, deposition ceased and flowstone formed on top. Subsequent flood water entered the caves and eroded the sediments from beneath the flowstone sheet. These flood waters also concentrated fallen stalactites and flowstone fragments and contributed to the stalactite and flowstone breakage. The erosion of the clastic sediments proceeded in stages which alternated with periods when there was little or no ponded or stream water in the caves. During these relatively dry periods desiccation cracks formed on the surface of the remaining sediments and flowstone sheets formed over the top. There were at least four of these erosion phases and three periods of subsequent flowstone formation in the Deep Hole. There is evidence for at least three erosion phases in the Piano Cave.

# FIGURE 11 DIAGRAMMATIC CROSS-SECTIONS ILLUSTRATING THE SEQUENCE OF FORMATION OF FLOWSTONE SHEETS IN THE WALLI CAVES

A, Formation of highest flowstone sheet on top of fluvial and fluvio-lacustrine clastic sediments.

B, Fluvial erosion of some of the clastic sediments. Contemporaneous stalactite formation on underside of flowstone sheet. Some of these stalactites broken off during fluvial erosion.

C, Recession of water and formation of desiccation cracks in clastic sediments.

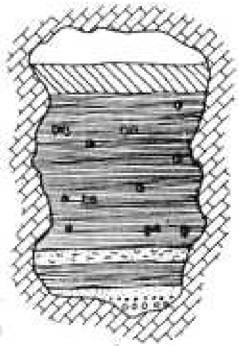
D, Formation of second highest flowstone sheet. Beginnings of collapse of suspended flowstone sheet and formation of stalactites and stalagmites.

E, Repetition of phases B to D with formation of third highest flowstone sheet. Further collapse of upper flowstone sheets and continuing development of stalactites and stalagmites.

F, Repetition of phases B to D with formation of fourth highest flowstone sheet. Other development as in E.

G, Further fluvial erosion, flowstone collapse, and stalactite and stalagmite formation to produce present-day condition.

Flowstone | Stalactites and Stalagmites | Clastic sediments with bone fragments and invertebrate burrows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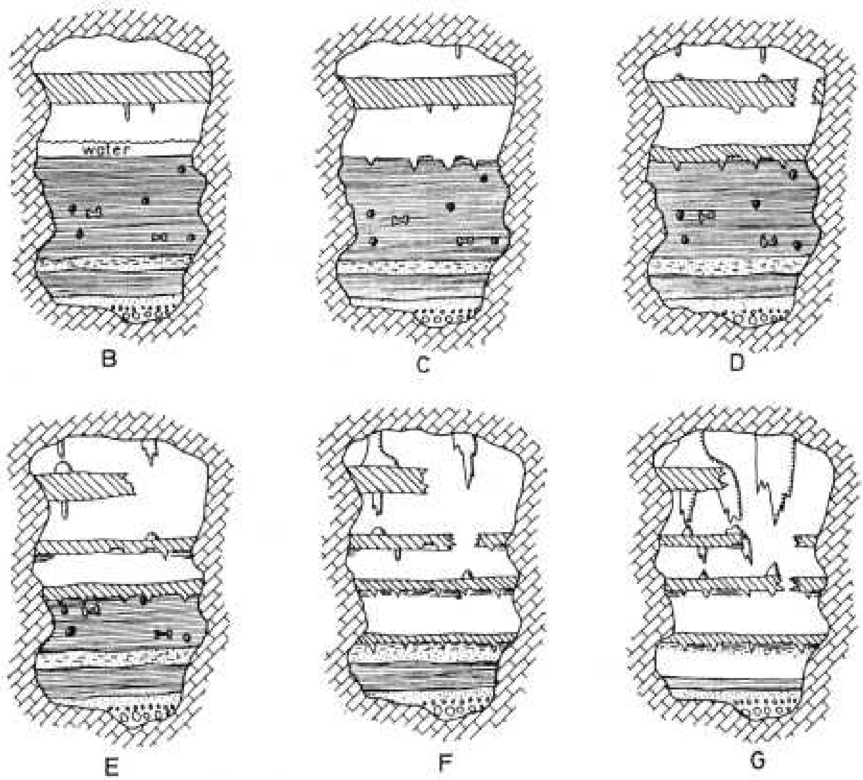

## Relationship Between Phases of Cave-Sediment Erosion and Surface Denudation

Hillsides along Licking Hole Creek valley increase in slope as they approach the stream, which is in bedrock for much of its length through the caves area. Tiny, discontinuous strips of flood-plain alluvium a few metres wide at most and up to a metre high are the only stream deposits in the valley. Incision appears to have been unbroken by halts, and variations in stream load cannot have been great so that there are neither alluvial terraces nor bedrock erosional features to which it might be possible to relate the erosion phases of the cave sediment.

An alluvial sequence exposed by an erosion gully just upstream from Cave No.22 has a buried A horizon and a soil profile developed on its surface. This is a record of change in slope stability and may correspond with one of the phases of erosion and flowstone deposition in the caves.

However, one correlation between the surface stream and erosion of the cave sediments is suggested by Figure 12. As has been noted there are no bedrock floors exposed in any of the caves. The deepest points in Deep Hole, Horse Cave, and the Oolite, Stovepipe and Box Cave system are floored with wet mud. In addition, there are no flowstone sheets on the floor of any of the caves represented in Figure 12 nor does any appear to be currently forming. These facts suggest that the caves are currently undergoing erosion of the detrital sediments by periodic flood waters. Figure 12 also suggests that the deepest points of the caves are approximately graded to the level of Licking Hole Creek and that the stream acts as the local base level for cave sediment erosion.

## ACKNOWLEDGMENTS

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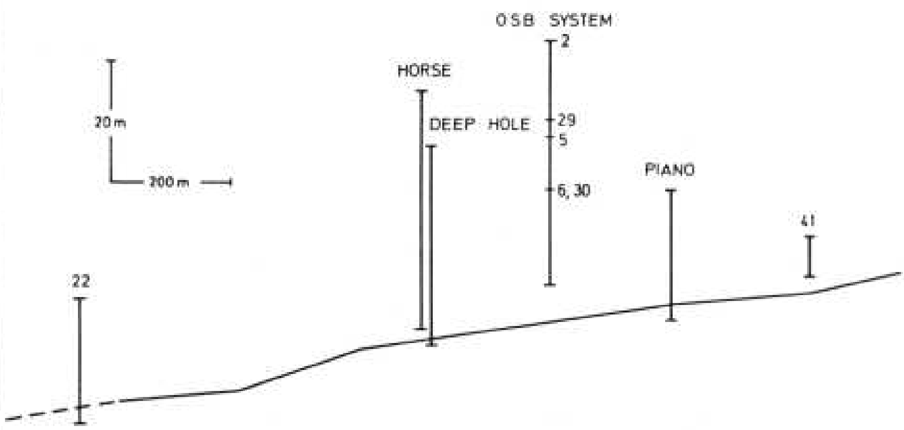
Mr P. Wellings of the Sydney Speleological Society supplied unpublished maps of the Piano Cave, the Oolite, Stovepipe and Box Cave system, the Bone Cave, and part of the Deep Hole as well as a surface map containing cave locations. I am indebted to him for allowing me the use of these maps which saved many days of survey work. I also appreciate the untiring efforts of Mr K. Fitchett, Department of Biogeography and Geomorphology, ANU, during surveying and sampling work. The figures were drawn by Mr S. Hale, Department of Geography, University of Reading, U.K., and Mr E. Quenet, Department of Geography, University of Newcastle upon Tyne, U.K.

Mr W. Rowlands and Mr A. Young, owner and past manager, respectively, of Greylands, permitted access to the caves. The Australian National University provided financial support.

FIGURE 12 Thalweg of Licking Hole Creek with height range of principal caves plotted at nearest downstream point on the creek



## REFERENCES

CARNE, J.E. and JONES, L.J. 1919 : The Limestone Deposits of New South Wales. Mineral Resour. N.S.W. No.25.

FRANK, R. 1971a : Cave Sediments as Palaeoenvironmental Indicators, and the Sedimentary Sequence in Koonalda Cave, pp.94-104, in D.J. Mulvaney and J. Golson (eds.) Aboriginal Man and Environment in Australia, A.N.U. Press, Canberra.

FRANK, R. 1971b : The Sediments, pp.31-44, in R.V.S. Wright (ed.) Archaeology of the Gallus Site, Koonalda Cave, Australian Aboriginal Studies No.26.

LOWRY, D.C. 1967 : The Origin of Blow-Holes and Development of Domes by Exsudation in Caves of the Nullarbor Plain. Rec. Geol. Surv. West. Aust. No.1967/12.

M'CARTIE, D. 1882 : Report of Police on Caves near Canowindra. Votes Proc. N.S.W. Legis. Assembl., 5 : 567.

MÉROC, L. 1961 : Le Remplissage de Cavernas des Pyrénées. Rass. Speleol. Ital. Memorie 5, 2 : 244-258.

OXLEY, J. 1820 : Journals of Two Expeditions into the Interior of New South Wales. London.

PACKHAM, G.H. (ed.) 1969 : The Geology of New South Wales. J. Geol. Soc. Aust., 16 (1).

PENGELLY, W. 1864 : Introduction to Cavern Accumulations. Rep. Trans. Devon. Ass. Advmt Sci., Part 3 : 31-41

SMITH, R.E. 1966 : The Geology of Mandurama-Panuara. J. Proc. R. Soc. N.S.W., 98 : 239-262.

STEVENS, N.C. 1952 : Ordovician Stratigraphy at Cliefden Caves, near Mandurama, N.S.W. Proc. Linn. Soc. N.S.W., 77 : 114-120.

TROMBE, F. 1961 : Sediments d'origine Chimique dans les Grottes. Rass. Speleol. Ital. Memorie 5, 1 : 11-49.

WIGLEY, T.M.L. and HILL, A.L. 1966 : Cave Decoration, pp.37-39, in A.L. Hill (ed.) Mullamullang Cave Expeditions 1966. Occ. Pap. Cave Explor.Grp S. Aust. No.4.

WILKINSON, C.S. 1894 : Description of the Belubula Caves, Parish of Malongulli, Co. Bathurst. Rec. geol. Surv. N.S.W., 3 : 1-5.

# DR. ROBERT BROOM, TARALGA

By

Glenn S. Hunt

The Australian Museum

Almost forty years ago, Robert Broom achieved a measure of world-wide recognition through his discoveries of Australopithecines (Fossil "ape-men") in the limestone caves at Sterkfontein, Swartkrans and other sites in South Africa. Had he made his discoveries today, he would surely have been ranked in the public mind alongside Louis and Richard Leakey.

Broom made his first discovery at Sterkfontein in his seventieth year and continued a spate of discoveries, writing and lectures until his death, 15 years later, in 1951.

Broom's palaeontological studies, however, did not begin in the caves at Sterkfontein, nor with his prolific work, spanning 50 years, on the fossil reptiles of the arid Karroo Plateau. They began 9,000 miles away at Wombeyan Caves, New South Wales, late in 1894. Broom was then 28 and had started a modest medical practice at the nearby township of Taralga, in the Goulburn district. His short stay at Taralga was to have a profound effect on his life.

This article has been prompted by the discovery of some of Broom's correspondence with The Australian Museum, Sydney, which he wrote while living at Taralga. This, with other material, allows us to explore with additional insight an important though previously obscure phase of Broom's life.

The story of Broom's life was written by Professor G.H. Findlay and recently published in South Africa (Findlay, 1972) (1). He, like Broom's other biographers (2), knew the man personally and his book contains interesting, often anecdotal detail not available from Australian sources. Any quotations not otherwise acknowledged have been taken from it.

This short history traces Broom's four years in Australia. It is not restricted to matters of speleological interest, but is written in the belief that "the story of his confident and dangerous career may still interest those who never met him".

## A Constant Desire to See New Things and Places

Robert Broom, the second son of John and Agnes Broom, was born on 30 November 1866, in Paisley, Scotland. Shortly after his birth, the family left Paisley and its collapsed textile industry and settled in Glasgow, where Broom's father did reasonably well as a travelling salesman dealing in soaps and candles. John Broom found enough spare time to become interested in "botanizing" and to take his family on frequent visits to the countryside, often accompanied by fellow members of the Glasgow Natural History Society.

It is not surprising that Broom developed an early interest in natural history which later, while studying science and medicine at Glasgow University, matured into a passion for comparative anatomy. He quickly demonstrated a keen grasp of the subject. Richard Owen, the great nineteenth century palaeontologist, wrote to Broom in 1890 saying "I cannot help forseeing that you will leave - life and health being spared - a lasting name in the promotion of our common science."

For Broom, a medical degree represented freedom of movement and an assured income, enough to live on while he pursued his greater interest in comparative anatomy. There was little to be gained by staying in Britain. The trickle of interesting natural history specimens from the New World, Africa and Australia was quickly mopped up by the elderly, established "experts" in the field. Much better to go to the source of material. "Perhaps it might be called wanderlust - a constant desire to see new things and places ... I might just as well have gone to South Africa or Colorado, but was extremely fortunate that I went to Australia".

## The First Two Years: Chillagoe, Cudal and Hillgrove

The "Gulf of Siam" docked at Sydney on 28 May 1892. On board the 2,000 ton cargo steamer were the captain, two passengers, a crew of 43, and the ship's surgeon, Robert Broom (3). The choice of a cargo vessel may have been deliberate. Broom had earlier sailed on two voyages to America as doctor on a passenger ship - "Oh! the scenes in the steerage - smell, sawdust, tiers of beds; some too sick to rise; wives and weans...".

Broom's elder brother, William, had preceded him to Australia and was working as a mine assayer at Herberton, inland from Cairns in northern Queensland. On docking in Sydney, Broom signed off and quickly boarded the "Peregrine" bound for Townsville and there transferred to the "Quitaing" for the remaining journey to Cairns. At William's instigation, Broom smuggled two miniature rifles and ammunition into Queensland. "I fear a little smuggling never troubled my conscience ... Why should I pay a few pound's duty on rifles that were to be used for pleasure and science?". This was not just Scottish parsimony - he would later find it easy to reconcile his conscience with "the needs of science". Broom did not stay at Herberton, but in early June, 1892, took up a post as medical officer at the nearby Chillagoe District Hospital which mainly served the small silver mining population at Muldiva.

The demands of medical work were small and Broom spent much time searching for fossils and collecting plants and animals. "The great frilled lizard is not common ... one day while riding in the bush I observed a fine specimen run up a tall slender tree; dismounting I followed thinking I could not but catch it. When near the top, and I within a couple of feet of it, seeing no escape down the tree, it took a flying leap of 30 feet or so, and long before I was down, was up a second tree, where I left it undisturbed." (Broom, 1898). He retained many specimens, especially of reptiles and mammals, for later identification and study and sent others to his teachers and friends. Plants were sent to Baron von Mueller at the Botanical Gardens in Melbourne.

Broom's collecting activities took him to the limestone country near Chillagoe (Broom, 1898) and perhaps he entered some caves. Had he found the fossil bone deposits they contain, he would undoubtedly have stayed longer in the area.

During his eleven months in northern Queensland, Broom developed a strong respect for the Australian Aborigines and compiled a glossary of their words referring to the world of nature. He was later to write (4): "He may have no calves to his legs and his brain may be small, but the Australian aboriginal has a peculiar kind of ability. He is an expert naturalist ... It is said he builds no houses, but why should he ... The whole land is his estate, and he does not believe in living in only one part of it ... I would go much further to see an exhibition of boomerang-throwing than to see an exhibition of engines". And he added, "By the whites the black is looked upon in the same way as the Bushman has been despised in South Africa. The race, however, is doomed. The wretched white people are crowding in and taking the natives' land. They bring their vices and diseases; their virtues they leave at home. Fifty years will see the last of them. Their places will be taken by the whites for a few years, and who knows but they will in their turn perish before the Mongols. If 'the meek shall inherit the earth', the present race of whites are not likely to be the last occupiers of Australian soil".

Broom finally left Queensland in May, 1893, his departure long delayed by typhoid which left him delirious for two months and took him close to death. In Scotland, his fiancée, Mary Baillie, was preparing to join him in Australia.

Broom decided to settle in Cudal on the Central Western Slopes, New South Wales, 20 miles or so west of the town of Orange. His decision to settle here may have been influenced by his knowledge of Richard Owen's work on the marsupial bone deposits at the nearby Wellington Caves (5).

Broom was soon riding among the limestone outcrops near Cudal. He collected a few specimens of fossil coral which he sent to The Australian Museum for identification (6), thus establishing a formal contact which would prove valuable during his later stay at Taralga.

After marrying Mary Baillie in Sydney on 19 November 1893, he returned to his lodgings at the rear of Landauer's chemist shop. Using Findlay's words: "Mary soon learned what it was to be married to this type of naturalist. One afternoon he took her out on some sort of hunt-ramble to explore a cave. Putting his arm down a hole, he told his wife that if he should be bitten in the hand by a snake in the hole she should forthwith cut his arm off with an axe. Fortunately nothing happened".

Although the New South Wales Medical Board registered him as a medical practitioner (Plate 1) on 13 December 1893 (7), Broom had no desire to settle down in practice. Cudal had proved disappointing from the fossil point of view. He left and took up an appointment at Hillgrove, a gold mining settlement east of Armidale on the edge of the New England Plateau. Surrounded by unrewarding igneous and metamorphic rocks, Broom decided to record his previously unpublished work and settled down sufficiently to write his first paper since reaching Australia. It described a deformed lamb's head he had exhibited several years previously to the Natural History Society of Glasgow (Broom, 1894). But a few months at Hillgrove were enough and the Brooms journeyed to Sydney for a short honeymoon. It was here that Broom noticed the following advertisement placed in the Sydney dailies. "Taralga Progress Association. To Medical men. - The Committee of the above invite Applications from Medical Gentlemen willing to settle in this town. Population of police district, 1975 persons. Nearest doctor, 26 miles distant. The Committee are prepared to grant a subsidy of £100 to suitable man, payable quarterly, for the first year only." (8).

## Taralga - Settling down for 18 months

It is one of the contradictions of Broom's life that the winner of the William Hunter Medal in Obstetrics and author of "Analysis of 100 consecutive cranial presentations" (9) should decide to practice medicine in tiny out-of-the-way places. However, the pattern of life he was establishing in Australia was to set the mould for most of the next 40 years.

Taralga, with a population of 450, was described by tourists of the day as "a dull but nevertheless pleasantly-situated town" and "unpleasant with wind and dust" (Plate 4, top). Broom accepted the appointment and arrived there in early October, 1894. "The Recent Medical Appointment. - The Secretary of the Medical Committee in existence here informs me that the recent appointment of Dr. Percival made by this body, for this district, has been declined by the person nominated. No reason is assigned for the refusal, so the Committee purpose offering the position to the gentleman who received the next highest number of votes, a Dr. Broome (sic), who I understand was in practice for some time at Hill-Grove." (10).

Broom evidently found he could achieve a satisfactory mix of medicine and science. "My first two years in Australia had been spent in getting acquainted with the general animal life, and in collecting skulls of mammals and lizards, but had little opportunity of doing any serious scientific work. Most of the time I lived in hotels or was boarding in private houses. At Taralga I was more or less settled and my medical practice only took up a small part of my time. Almost at once I started on a career of great scientific activity ... While at Taralga I hunted for Jacobson's Organ in every mammal and reptile that I could readily come across, and cut hundreds of microscopic sections ... One of the first results was the discovery that among mammals there are very different arrangements of the cartilages that support the organs, but among closely allied animals the arrangement of cartilages is remarkably constant. Work on this organ since my Taralga days has resulted in settling the affinities of many obscure mammals." (11). While still at Taralga, Broom was awarded a Doctorate of Medicine, Glasgow, for his thesis on this organ. He also wrote about 15 scientific papers on a range of subjects: medicine, comparative anatomy, embryology, palaeontology and natural history (12).

From the speleological point of view, however, his most important discovery was to occur on a picnic 20 miles away at Wombeyan Caves, barely a month after his arrival in Taralga.

## My Little Bone Deposit on the Hill above the Caves

"A number of our (Taralga) townspeople and many visitors spent the 9th and the following day at the Wombeyan Caves and had a really enjoyable trip, those who were of the party being delighted with their outing." (13).

Perhaps the townspeople thought a picnic provided an ideal occasion to entertain their new doctor, but Broom was also interested in the prospect of seeing bats, rock wallabies and other animals at the caves. Whilst pottering around on the hill near the Arch (see Figure 1), he quite unexpectedly came upon an inconspicuous bone breccia deposit packed with the remains of small marsupials. "This deposit ... is evidently the remains of the floor of a cave, the whole roof and sides have long since been weathered away. The stone is very hard and consists of a brownish lime deposit in which are embedded innumerable small bones, with the remains of a few stalactites and an occasional calcite rhomb. The bones are mostly those of small marsupials, though I have also found the remains of at least one species of rodent and the very perfect cranium of a small bird." (Broom, 1896a). The bone material is now thought to be derived from regurgitated owl pellets which fell to the floor of a Late Pleistocene cave and became encased in flowstone (Ride, 1960; Turnbull and Schram, 1970).

Broom was certainly "delighted with the outing". He had at last found a good fossil deposit and took as much of the breccia home as possible. After freeing the bones from the matrix, he soon concluded that "most of the marsupials belong either to extinct species or to species not now living in the district" (Broom, 1896a). However, difficulties were to arise.

Broom was back at Wombeyan as soon as possible. "... the Caretaker Mr. Chalker agreed that he (Broom) could come and take some light loads of breccia. After spending the night at the caretaker's home, he would ride back to Taralga next day with his haul on horseback. Chalker was a little afraid because of the area being a government reserve and advised Broom to write to the Minister of Mines for permission." The Department of Mines received Broom's letter on December 19 (14) and promptly refused permission to excavate the deposit.

Broom was furious, but not deterred. "So instead, he paid calls to Mr. Chalker of an afternoon with his buggy, spent the night with him, and loaded some heavier items next morning, 'while Chalker put the telescope to his blind eye'." Broom developed a warm respect for Mick Chalker. The Chalkers were a remarkable family - Charlie Chalker was an intrepid cave explorer at Wombeyan and "Old Ned" and "Old Dan" Chalker were stated to be respectively the heavy and light-weight champion pugilists of the "world".

Apparently Broom again sought permission of the Department of Mines and in February they reconsidered (15). From the events which followed, it seems likely that Broom believed the Department had tacitly (or explicitly) allowed him to excavate the deposit on the hill but had refused permission for him to dig <u>in</u> the caves themselves. Broom later maintained, however, that the Department never granted him permission and subsequently sent someone to Wombeyan to remove the breccia (16). Whatever happened, Broom believed that the colonial bureaucrats had treated him shabbily and he formulated his lifelong maxim: "Do what you want to do and get permission afterwards" (17). The experience hardened his attitude to government interference in science. Even at the age of 80 (Plate 2), he openly flouted a law which required him to apply for a permit to dig in the Australopithecine caves at Sterkfontein.

Broom continued to visit the site at Wombeyan and to prepare the breccia he collected. Some of the tiny jaws he laboriously freed from the matrix had, for their size, a huge grooved premolar tooth (Plate 3). He was fascinated and wrote to Robert Etheridge, Curator of The Australian Museum, asking if similar jaws had been found elsewhere (Plate 3). "I am afraid", Etheridge replied, "I can give you very little help towards elucidating your little marsupial jaw. The Museum possesses a lot of minute material, but it is all unworked and in the rough. In fact, hardly any investigations have been made in this direction by anyone."

Broom also asked if Etheridge might be able to communicate a paper which described this species to the Linnean Society of New South Wales (18). He did not mention his difficulties with the Mines Department. Broom's paper, "On a Fossil Mammal Allied to <u>Hypsiprymnus</u> but Resembling in Some Points the Plagiaulacidae", was read before the June 1895 meeting of the Society (19). He named the species <u>Burramys parvus</u>, "Burra" being the Aboriginal name for the Wombeyan district, and "mys" meaning mouse-like.


Plate 1. Robert Broom, registered medical practitioner No. 1856. Photograph of Broom , aged about 27, submitted to the New South Wales Medical Board in 1893.

(Archives Office of New South Wales.)

Plate 2. Broom studying new Australopithecine finds from Sterkfontein Caves, at the Transvaal Museum in 1949.

(Courtesy of Transvaal Museum.)

There is a sequel to this story. Broom, and all who took an interest in this "rare fossil", believed Burramys to be extinct. However, in 1966 and 15 years after Broom's death, a small rat-sized marsupial was found, alive, on Mt. Hotham, Victoria. It had huge grooved premolars. Dr. David Ride, an authority on marsupial evolution, was astounded to receive a telegram: BURRAMYS EXTANT STOP NOT REPEAT NOT EXTINCT STOP LIVE MALE CAPTURED MOUNT HOTHAM STOP AM TRYING FOR A FEMALE (Ride, 1970).

The irony of this discovery would have amused Broom, especially since he had described the species in his first of almost 400 palaeontological papers (20, 21). Today, several populations of the Mountain Pigmy Possum are known to exist in the high country of south east Australia.

After his paper had been read to the Linnean Society and his palaeontological bona fides established, Broom again sought permission to excavate in the Wombeyan Caves by asking Etheridge to make an approach on his behalf. He wrote as follows:

Taralga,
18 July 1895

Dear Mr. Etheridge,

There has recently been shot in this district a rather remarkable native dog - many who have seen hundreds of so called dingos have never seen one like this ... I thought perhaps you might be able to get it from Roberts (of the Stock Board, Goulburn) for the Australian Museum by writing him.

There is another thing I should like to refer to. The Department of Mines refused to give me permission to prospect for Fossil bones in the Wombeyan Caves on the plea that there is a Government Palaeontologist for this purpose. They would allow me to look for the bones, but I must send them at once to the Australian Museum for examination. I am perfectly willing to send them to the Australian Museum after examination which I recognise is the proper place for them, but I can hardly agree to spend time and money and not even have the credit for examining them. Of course I might do the thing surreptitiously but there would be the danger of getting the exceedingly kind and intelligent caretaker into trouble. I have good reason to believe that some good things may be got. From my little bone deposit on the hill above the caves (22) I have got at least three new genera and two new species of known genera - one new genus is only represented by a few teeth unfortunately but it is exceedingly interesting as it is neither reptile, Monotreme nor Marsupial and may either belong to the Edentata or to a new order altogether.

I trust you may be able to obtain permission for me to do a little prospecting - the result of which will I have no doubt be the means of enriching the Australian Museum and the Scientific World.

Ever yours sincerely,

R. Broom

Etheridge was unmoved and not helpful: "The whole of the Caves of N.S. Wales that are located on Crown Lands are in the care and under the supervision of the Dept. Mines & Agric., & the Australian Museum has nothing to do with the matter whatever. The depository of the Departmental collections is the "Mining & Geological Museum", Sydney ... if you have already addressed the Under-Secy. for Mines & Agric. without success, I am afraid that I am quite powerless in the matter." (23).

Broom doubtless did "do the thing surreptitiously" but failed to find any large deposits. He did make collections of bones lying in the Victoria Arch and collected bats from Fig Tree Cave for his own work on Jacobson's Organ (Broom, 1896 c) and for his friend Grafton Elliot Smith at The University of Sydney who was studying the structure of the brain.

Despite his earlier disclaimer, Etheridge did assume an interest in the deposit: "In about a fortnight's time (mid-February, 1896) an opportunity will occur for a visit to be made to the Wombeyan Caves in company with the Superintendent of Caves of the Department of Mines (W.S. Leigh). I am very anxious to see these caves as a new deposit of fossil bones has recently been discovered. I ... request permission to visit these caves officially. The time occupied will be one week and approximate cost £6.0.0." (24).

Mick Chalker led the two men up the hill and showed them Broom's deposit. In his report of the trip (25), Etheridge wrote: "I found the reported deposit of fossil bones to be much exaggerated, occupying a small depression on the surface of a limestone hill, and of no great extent. The bones are all small, and much comminuted, being those of small Marsupials, Rodents, & Bats".

Etheridge left the specimens of breccia, limestone and calcite he had collected for Chalker to send on to Sydney (26). With Leigh, he passed back through Taralga without meeting Broom and "after adventures with the Coach between Taralga and Goulburn ... did not reach the latter town until 11.30 p.m. on Friday night!" (27). Broom heard of the visit soon enough and concluded his letter to Etheridge on March 10 by saying: "I was sorry not to see you when in Taralga, I would have liked to have shown you over my Museum!".

Broom presumably believed that Leigh and Etheridge had secretly come to Wombeyan to investigate his activities and to "rob" him of some of the breccia. This would explain his bitterness when he later told Findlay of the episode (28).

Etheridge's visit, however, did not affect Broom's work. When Broom wrote his letter of March 10, he had already decided to leave Australia and one senses he was satisfied with what he had achieved: "... I have practically completed my investigation of the little fossil deposit at Wombeyan Caves and have found 14 species of animals ... I will be able to send an account to the next meeting of Linn. Soc.". His paper (Broom, 1896d) was read before the April meeting of the Society.

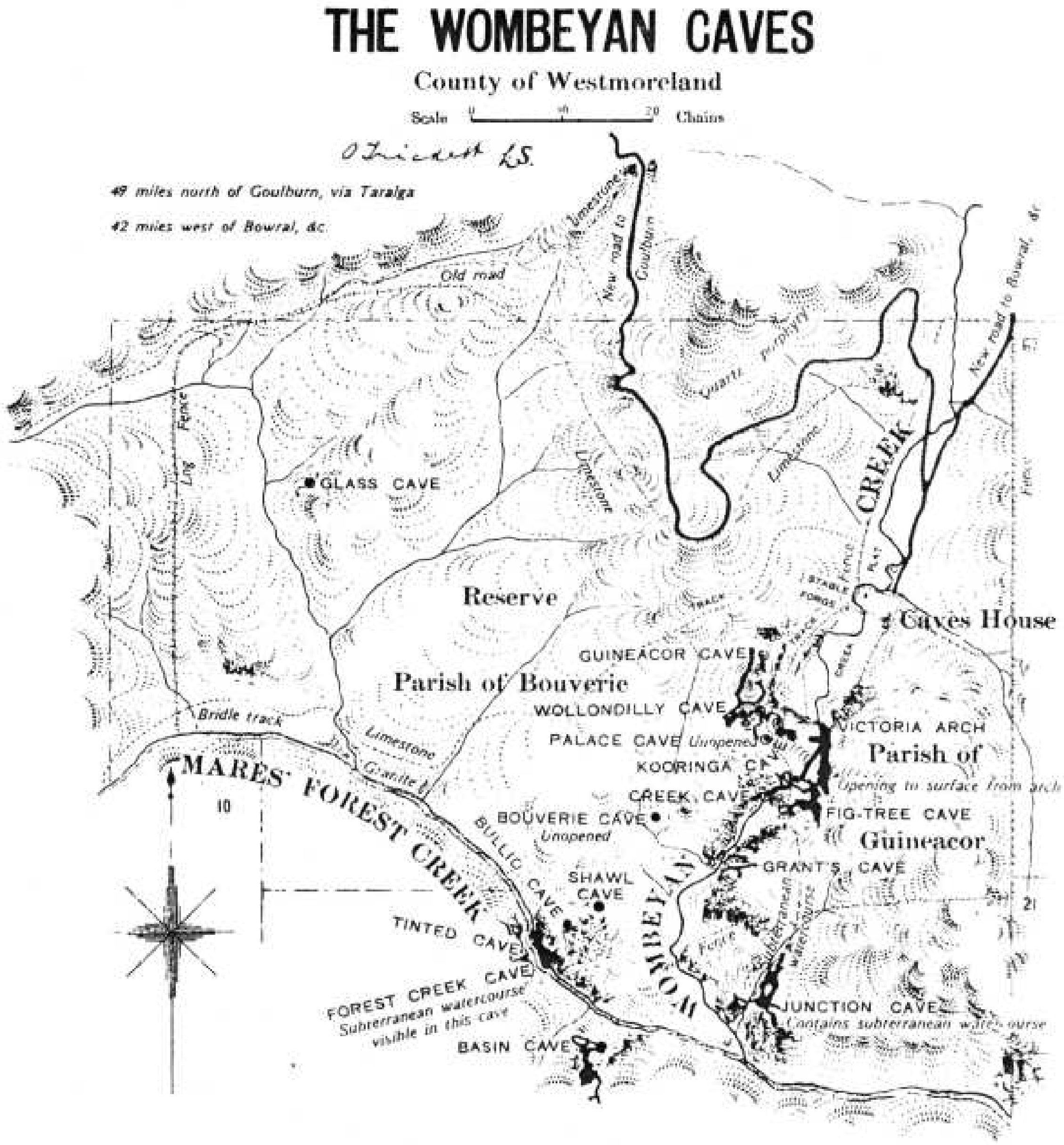



Figure 1. Broom's fossil bone deposit was found up-hill from the entrance to the Guineacor Cave. From "Guide to the Wombeyan Caves, New South Wales" by O. Trickett, 1906. (E. A. Lane Collection.)

Broom took much of the fossil material with him when he left Australia - very few specimens were placed in The Australian Museum (29). After arriving in Glasgow, he "exhibited a series of fossils from the bone breccia deposit which he had discovered recently in the neighbourhood of the Wombeyan Caves, N.S.W." and also "exhibited a collection of South Sea Island tortoiseshell, which served both as hook and bait." (30). It seems Broom was busy on his voyage home via the Pacific and the Americas.

Broom's deposit at Wombeyan lay undisturbed for 50 years. An account of its recent history has been written by Lane and Richards (1967) and additional information is given in Schram and Turnbull (1970). What is now known as the "Broom Cave Fauna" is still the subject of scientific study (Turnbull and Schram, 1973).

Dr. C.K. Brain, Director of the Transvaal Museum, was recently in Australia. It was at the Transvaal Museum that Broom spent his last years studying the Australopithecine cave sites in South Africa. Dr. Brain visited Wombeyan in December, 1973, accompanied by a party including the Curator of Fossils at The Australian Museum. One of the guides at the Caves, Mr. Gordon Chalker, led the party up the hill to inspect the small grassy hollow where Broom's palaeontological career began just 80 years ago.

## Life in Taralga

Meeting "important" people such as members of the Taralga medical committee must have been Broom's first job as Taralga's new doctor. Then his baggage had to be unpacked and for all his movement Broom did not travel light. Everything had to find a place - fossils he had collected in Scotland, North America and Australia, his skull collection, preserved lizards and mammals, and his books and papers.

At first, he was also busy with medical work. An influenza epidemic was sweeping the district when he arrived and the usual accident cases needed attention. "The Goulburn Herald" reported: "Mr. T. Walsh, a resident of this district, sustained a heavy fall from his horse through the bucking of the animal. It appears Mr. Walsh got on the beast without proper means of control, to cross a swamp ... (he) sustained a great shaking ... Dr. Broom, who has settled down here, is attending to the case." (31).

The doctor was keen to participate in social activities, at least for the first six months. There was the November picnic at Wombeyan Caves and his display in the non-competitive section of the Annual Show: "An interesting collection of mineral ores was shown by Dr. Broom and greatly admired." (32). On at least one occasion, Broom also seems to have made his fossil bone deposit the excuse for a social outing cum working bee. "The principal case was Alfred Duncan v. Dr. Brown (sic) ... he alleged that the doctor hired his coach to go to the Wombeyan Caves, taking with him six passengers ... The doctor disputed the claim on the grounds that the charge (£3.15.0) was excessive, and that he was not liable ... the bench decided the defendent was liable ... and gave a verdict for the amount and costs." (33).

Taralga N.S.W.
29 May 1895

Dear Mr Etheridge

Many thanks to you & Mr Waite for your kindness in determining my specimens. I was not aware that you took the trouble to return specimens or I would have sent others, I only having sent those I could spare.

If No 6 the "Small Acrobates" & No 4 the little Macedian form of Euphilobolus [illegible] are of any use I will be happy to present them. The Mouse &c you had better destroy as I don't want to see my name as a donor of "mouse".

I will send further specimens shortly to be returned in order to afford further Examination of "No 6" "No 4" "No 9" & "No 11"

Would you kindly inform me if the Museum is in possession of a form of extinct marsupial like following which I have discovered and which I think is new.

allied to the Plagiaulacidae and forming an interesting link between Neoplagiaulax & Hypsiprymnus

Dental formula of lower jaw. ~~Plagi~~

| | | |
|---|---|---|
| Ctenacodon | Pm 4 M 2 | Jurassic |
| Plagiaulax | Pm 3 M 2 | Jurassic |
| Ptilodus | Pm 2 M 2 | Eocene |
| Neoplagiaulax | Pm 1 M 2 | Eocene |
| * new form | Pm 1 M 3 | Pleistocene |
| Hypsiprymnus | Pm 1 M 4 | Recent |

If the form has not been previously discovered perhaps you might communicate a paper by me descriptive of it to the Linn. Soc. N.S.W.

Yours truly
R. Broom

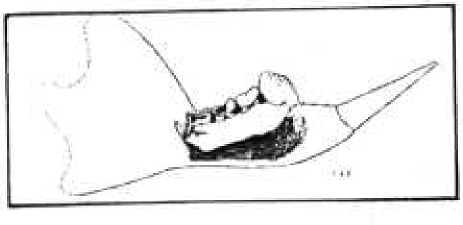


Plate 3. Letter from Broom to Robert Etheridge, Curator of The Australian Museum. (Australian Museum Archives.) The tiny drawing shows the large grooved premolar in the lower jaw of an "extinct marsupial" he later called Burramys parvus. The inset of his published drawing (Broom, 1896a) is for comparison.

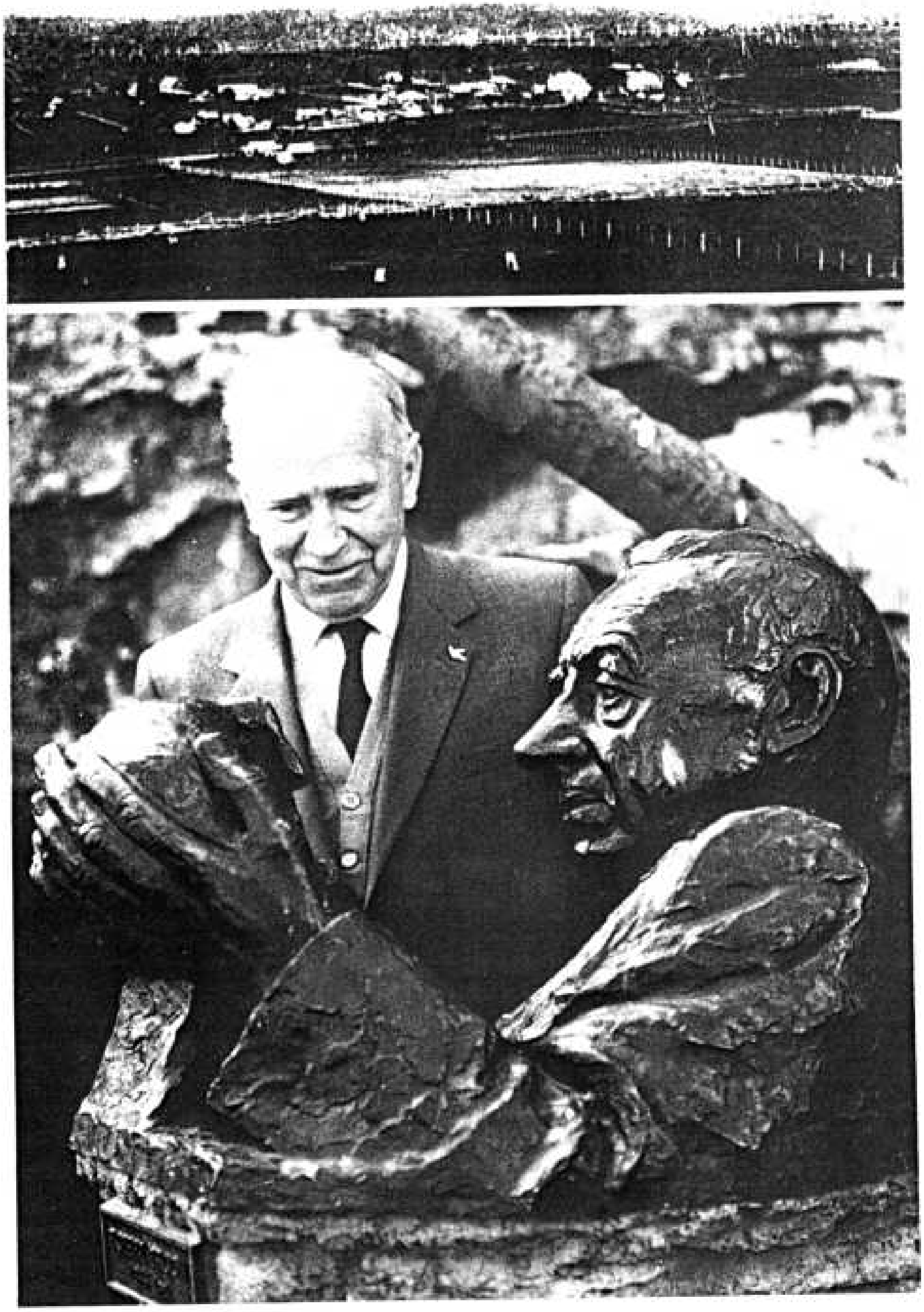


Plate 4. Top: Panoramic view of Taralga where Broom's palaeontological studies began. (From Town and Country Journal, 3 August, 1910, p. 37 - Public Library of New South Wales.)
Bottom: Professor Raymond Dart, first to describe fossil "ape-man" from South Africa, with the bronze bust of Broom at Sterkfontein Cave. The bust was unveiled on 1 December, 1966 at the opening of the Robert Broom Museum. (Courtesy Transvaal Museum.)

Generally, Broom's practice was undemanding though it occasionally took him on long rides on horseback. He had plenty of time for "microscope work during much of every day, and in the nights hunting 'possums' whenever there was a moon". Possum hunting with his friend Walter Scott of Golspie secured him a series of several hundred pouch young for study. Fifty years later, Broom still had Trichosurus embryos in his cupboard (Findlay, pers. comm.).

Although Broom collected many of his own specimens, he built up quite a network of willing locals and even people from farther afield (34). Among the specimens he received were newly mated echidnas, a foetal calf and a chick with four wings. It is tempting to imagine that some locals, still suffering from the effects of drought and the '93 depression, settled their accounts with suitable offerings. Broom's activities must have seemed innocent enough, however, for the medical committee asked him to stay on for another one-year term.

It was an advantage being so close to the source of scientific material, but Broom had to overcome a self-imposed isolation in a place without library or laboratory. His father, John Broom, helped from Edinburgh by copying out the contents of papers and duplicating drawings. John Broom wrote: "I can partly understand the vastness of the field ... It seems to stimulate you. I can see plainly however that whilst you may be well situated in some respects for this study of comparative anatomy that you must be terribly handicapped in a remote place like yours ... One cannot help noticing how the ground is monopolized by men who are as it were at headquarters ... a better position cannot come at once or just when one wants it, and possibly for a time Taralga or some similar place is fitting ...". Even from Taralga, Broom was soon to make new friends with similar interests. Professor J.T. Wilson and Dr. Grafton Elliot Smith of Sydney University helped him with the literature and cut some difficult tissue sections. Broom, in turn, supplied them with specimens they needed. These gentlemen nominated Broom for membership of the Linnean Society of N.S.W. (35), and the Secretary, J.J. Fletcher, and another member, A.G. Hamilton, also helped Broom.

Robert Etheridge and Edgar Waite at The Australian Museum performed the identifications Broom needed for his work on Jacobson's organ and sent him specimens to compare with the ones he was excavating at the caves. Broom, however, became irritated when the Museum was unable to send all the specimens he required: "I used to imagine that The Australian Museum would have an almost perfect collection of described forms but it seems you have one or two blanks." (36). To satisfy his curiosity and collector's instinct, Broom sent numerous other specimens for identification, including "a peculiar coralline structure I once picked up in the old country (which you might kindly return together with the box)." (37).

Although in many ways a disciplined scientist, Broom had an almost childish obscession to collect all manner of things and this was to last through a lifetime. His house at Taralga must have had at least one large room devoted to his study and "Museum". Specimens, skins and the odd live animals probably spilled into other rooms. An extract from one of his papers (Broom, 1897) indicates the sort of household Mary Broom had to manage: "A young (wombat) was brought to me from (Mt Werong) ... when put in the yard it would at times fancy a moving fowl as its mother ... much to the astonishment of the fowl ... Sometimes it would be after a dog or a pig ... At night it was left wrapped up in furs in a corner of the room adjoining the bedroom ... if the door were left open it would try to climb up on to the bed. It seemed to feel the cold very much, and would often climb on to the open hearth and lie before the fire. After having had the little wombat for only about a week, it pined and died". Compared with this, the Broom house in Douglas, South Africa, was positively macabre. Broom was studying racial differences among African tribes and the "linen-cupboards were full of skulls ... On the kitchen stove a decapitated human head might be stewing in a paraffin tin to get the flesh off the skull, and in the garden the worms would be cleansing some skeleton which had been surreptitiously buried in a shallow grave".

Nobody knows why Broom decided to leave Australia. Possibly he wanted to visit his father who was ill in Scotland, or perhaps he felt he could best build on his growing reputation by "breaking new ground" elsewhere. Then there was his Wanderlust, a constant desire to see new things and places (38).

When Broom left Australia in May, 1896 (39), he took his museum with him. Apart from a few specimens in The Australian Museum and an enlarged hollow on the hill at Wombeyan, little remains to mark his stay in Australia. Wombeyan, where his long palaeontological career began, is now an important fossil site following the discovery of other cave deposits. Perhaps, one day, it might be appropriate to erect a small building near the Caves, similar to the Robert Broom Museum at Sterkfontein (Plage 4, bottom), 9,000 miles away in South Africa.

Acknowledgments

I wish to thank Professor G.H. Findlay, Department of Dermatology, University of Pretoria, for his useful advice and the Director and Trustees of the Transvaal Museum for permission to publish Plates 2 and 4 (bottom). I should also like to thank Mr. J.A. Mahoney, Dept. of Geology, University of Sydney, and Dr. A. Ritchie, Curator of Fossils, The Australian Museum, who helped locate some reference material, including Broom's correspondence with Etheridge. The Trustees of The Australian Museum have given permission to use the Museum's archive material. The originals of the photographs used in Plates 1 and 4 (top) are held in the Archives Office of New South Wales and the Public Library of New South Wales.

References

Broom, R. 1894 : Notes on the Anatomy of a Form of Cyclopean, with Remarks on the Significance of Cyclopeans. Trans. nat. Hist. Soc. Glasg., 4: 31-34.

Broom, R. 1896a : On a Small Fossil Marsupial with Large Grooved Premolars. Proc. Linn. Soc. N.S.W., 10, 1895: 563-567.

Broom, R. 1896b : On a Small Fossil Marsupial Allied to Petaurus. Proc. Linn. Soc. N.S.W., 10, 1895: 568-570.

Broom, R. 1896c : On the Organ of Jacobson in an Australian Bat. Proc. Linn. Soc. N.S.W., 10: 1895: 571-575.

Broom, R. 1896d : Report on a Bone Breccia Deposit near the Wombeyan Caves in N.S.W., with Descriptions of Some New Species of Marsupials. Proc. Linn. Soc. N.S.W., 21: 48-61.

Broom, R. 1897 : Notes on Some Australian Marsupials. Trans. nat. Hist. Soc. Glasg., 4, 1896: 351-354.

Broom, R. 1898 : On the Lizards of the Chillagoe District. Proc. Linn. Soc. N.S.W., 22, 1897: 639-645.

Dart, R.A. 1951 : Robert Broom - His Life and Work. S. Afr. J. Sci., 48 (1): 3-19.

Findlay, G.H. 1972 : Dr. Robert Broom, F.R.S. Palaeontologist and Physician 1866-1951. A Biography, Appreciation and Bibliography. A.A. Balkema, Cape Town, Pp.157.

Lane, E.A., Richards, A.M. 1963 : The Discovery, Exploration and Scientific Investigation of the Wellington Caves, New South Wales. Helictite, 2 (1): 1-51.

Lane, E.A., Richards, A.M. 1967 : Burramys parvus Broom, a Living Fossil. Helictite, 5: 30-34.

Mahoney, J.A. and Ride, W.D.L. 1975 : Index to the Genera and Species of Fossil Mammalia Described from Australia and New Guinea between 1838 and 1968. West. Aust. Mus. spec. Pub., No.6: 1-250.

Ride, W.D.L. 1960 : The Fossil Mammalian Fauna of the Burramys parvus Breccia from the Wombeyan Caves, New South Wales. J. Roy. Soc. West. Aust., 43: 74-80.

Ride, W.D.L. 1970 : A Guide to the Native Mammals of Australia. Melb., Oxford Univ. Press, Pp.249.

Schram, F.R., Turnbull, W.D. 1970 : Structural Composition and Dental Variations in the Murids of the Broom Cave Fauna, Late Pleistocene, Wombeyan Caves Area, N.S.W., Australia. Rec. Aust. Mus., 28: 1-24.

Turnbull, W.D., Schram, F.R. 1973 : Broom Cave *Cercartetus*, with Observations on Pygmy Possum Dental Morphology, Variation and Taxonomy. Rec. Aust. Mus., 28 (19): 439-464.

Wakefield, N.A. 1972 : Palaeoecology of Fossil Mammal Assemblages from Some Australian Caves. Proc. R. Soc. Vict., 85 (1): 1-26.

Watson, D.M.S. 1952 : Robert Broom 1866-1951. Obit. Not. Fell. R. Soc. Lond., 8: 38-70.

## Notes

A.M. - Archives of The Australian Museum

A.O. - Archives Office of N.S.W.

M.L. - Mitchell Library

P.L. - Public Library of N.S.W.

1. Findlay's book, "Dr. Robert Broom, F.R.S." (see Findlay, 1972 in references), can be obtained from the Transvaal Museum, Pretoria, for R7.50 plus postage.

2. Dart (1951), Watson (1952) and others.

3. Shipping list X217, for 1892, passengers arriving (A.O.).

4. This extract has been taken from Findlay's book but was originally published in a popular article "The Australian Blacks", *Stellenbosch Students Quarterly*, 6 (3), 1905: p.16.

5. See Lane and Richards (1963) for a history of these deposits. Bone breccia has also been found in the Borenore district, just east of Cudal.

6. Broom's original letter has been lost, but Robert Etheridge (then Acting Curator of the Museum) replied on 25 October 1893 after apologising for his delay.

7. Minutes of meeting of New South Wales Medical Board, December 13, 1893 (A.O.).

8. e.g. The Sydney Morning Herald, Aug. 25, 1894, p.14, col. 7 (P.L.).

9. Aust. med. Gaz., 13, 1894: 260-261.

10. The Goulburn Herald, Oct. 1, 1894, p.4, col. 1. An item from the Taralga correspondent (M.L.).

11. Taken from "My First 20 Years in Science", a Broom MS published for first time in Findlay, pp. 114-116.

12. Several more papers were written in South Africa, based on specimens and notes Broom took with him. A bibliography of Broom's papers is given in Findlay (1972), and Watson (1952).

13. The Goulburn Herald, Wed. Nov. 14, 1894, p.4, col. 5. An item from the Taralga correspondent (M.L.).

14. Entry no. 94/20892 Register of Letters received, Dept. of Mines and Agriculture (A.O.). Letter and reply apparently destroyed.

15. The correspondence is apparently destroyed. However, a note dated 4 February 1895 in the Department's Index to Register of Letters Received states "That his application to do some palaeontological work at Wombeyan Caves be reconsidered" (A.O.).

16. Findlay, p.16. Also see below discussion of Leigh and Etheridge's visit to Wombeyan Caves in early 1896.

17. Broom's actual words (Findlay, pers. comm.).

18. In the event, this was unnecessary. On the same day that he wrote to Etheridge (29 May 1895) he was elected a member of the Society.

19. An abstract of this paper was published in Abstr. Proc. Linn. Soc. N.S.W., 26 June, 1895. Broom withdrew the paper in October 1895 but it was read in an amended form under the title "On a Small Fossil Marsupial with Large Grooved Premolars" at the November 27 meeting of the Society. Specimens showing lower jaws *in situ* were exhibited at the meeting. The paper, under the new title, was published in April 1896 (Broom, 1896a) together with four more of his papers read at the same meeting, including one on another species from the deposit (Broom, 1896b).

20. See Lane and Richards (1967) and Ride (1970) for accounts of the discovery of this species.

21. Burramys parvus is the only one of Broom's new scientific names for the Wombeyan fauna to be recognized today (Wakefield, 1972). Broom's other names have been synonymised with those of previously described species.

Wakefield (1972) also discusses the age of Broom's deposit and the palaeoclimate of Wombeyan and the Buchan area, Victoria, where B. parvus remains have also been found in cave deposits.

22. This indicates Broom had permission to work the deposit on the hill.

23. Broom again wrote to the Dept. of Mines late in 1895 possibly requesting permission to examine fossils in their collection. A note (No. 95/21224) dated 14 Nov. 1895 in the Register of Letters Received (A.O.) states: "To reply to letter re Dr Broom's app. for fossils". Alternatively, "app. for fossils" may have been shorthand for "application to prospect for fossils".

24. Curator's Report (to the Trustees) for December-January, 1895-6. Australian Museum, Feb. 1, 1896 (unpublished) A.M.).

25. Curator's Report (to the Trustees) for the Month of February, 1896. Australian Museum, March 2, 1896 (unpublished) (A.M.). In the published report of the trip (Ann. Rep. Aust. Mus., 1896, p.5), Etheridge omits reference to importance of the deposit and adds: "To the researches of Dr R. Broom ... the deposit has yielded the remains of six extinct animals, the type specimens of which he has generously presented to the Museum.".

26. Chalker did not send the specimens until August (letter, 8 Aug. 1896, from Etheridge to Pittman (Govt. Geologist) asking "to have Mr Chalker again reminded" to forward the specimens). Etheridge apparently collected only one specimen of breccia (Museum Collector's Report, 25 Aug. 1896 (A.M.)).

27. Letter from Etheridge to Chalker, 25 Feb. 1896 (in "Curator's Copy Book" - copies of other Etheridge letters mentioned are in "Letter Books").

28. See Findlay, p.16. Leigh may have been instructed to check on Broom's activities but it is unlikely that he officially asked Etheridge to help in the "investigation". Etheridge would have mentioned any official request when requesting permission to go on the trip. Etheridge probably went out of interest and also to collect limestone specimens. At the time, the Museum was planning a display on limestone from different

localities. He had visited Jenolan Caves a few months earlier.

29. Some of the Wombeyan material was exhibited by Fletcher at the June 1896 meeting of the Linnean Society after Broom had left Australia. Fletcher then passed the specimens to The Australian Museum (letter, 16 July 1896, from Etheridge to Fletcher, which said in part: "With regard to Dr Broom's fossils - are those you sent me the lot?, because they do not correspond with the (Broom's) figures. For instance ... (then follow examples). Perhaps Broom did not leave all with you"). Known locations of Broom's type material are given in Wakefield (1972) and Mahoney and Ride (1975).

Broom gave many specimens to the Anatomical Museum in the Medical Faculty, University of Edinburgh (Ride, 1970). He probably took fossil specimens to South Africa. Perhaps they were among the Australian material he still had in his cupboard in 1942 (Findlay, pers. comm.).

30. Proc. nat. Hist. Soc. Glasg., 4th August, 1896 (1897), p.393.

31. The Goulburn Herald, 12 Oct. 1894, p.3, col. 1. News item from Taralga correspondent (M.L.).

32. The Goulburn Herald, 8 Mar. 1895, p.2, cols. 2-5. Taralga P. (Pastoral) and A. (Agricultural) Association (M.L.).

33. The Goulburn Herald, 8 May 1895, p.4, cols. 1-2. News item from Taralga correspondent (M.L.). Broom was occasionally misnamed "Dr Brown" in the Goulburn press.

34. Broom used the same technique later in the South African Karroo, coming to excellent terms with farmers who kept him supplied with fossil reptiles.

35. Minutes of Council Meeting, May 1895, Linnean Soc. N.S.W. (M.L.).

36. Letter to Etheridge, 8 Nov. 1895.

37. Ibid.

38. Also, perhaps Broom had difficulties with the medical committee. After he left Taralga, the Committee attempted to bring "the outlying portions of the district in touch with its utility" and succeeded in getting the new Dr Sproule "to make liberal concessions to families numerically small".

The Goulburn Herald, May 29, 1896, p.5, col. 3.

39. The Goulburn Herald, 6 Mar. 1896, p.4, col. 1: "Departure of Dr Broom ... This gentleman ... contemplates taking his departure in a few months' time ... During his residence here the doctor had acquired a very good practice, and was much esteemed in his professional capacity ...". May 1 issue, p.3, col. 7: "Dr Broom ... will be leaving in the course of a few days for Scotland, where I understand it is the doctor's intention to settle down ...".

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