LATE PLEISTOCENE BONE DEPOSITS FROM A CAVE IN THE FLORENTINE VALLEY, TASMANIA

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(with six text figures, one table and five plates)

ABSTRACT

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A limestone shelter cave in the Florentine Valley, south-central Tasmania, has
yielded vertebrate remains. Two of the three sites excavated have yielded evidence
of the presence of elements of the Pleistocene megafauna. The morphology and
stratigraphy of the cave is described. Pleistocene deposits are shown to consist of
two units. A lower unit laid down by water with an admixture of roof fall and an upper
unit of angular limestone detritus derived from physical weathering within the cave
entrance. C-14 dating indicates a late Pleistocene age for material collected from
one of the sites. Its stratigraphic relationship to the other sites is discussed.

INTRODUCTION

Palaeontological and geomorphological investigations were carried out in Titans
Shelter, a limestone shelter cave, in 1976 and 1977. It is located just below the
crest of a limestone hill at an elevation of 400 m within the broad valley of the
Florentine River some 23 km north-northwest of Maydena (146°28'9"E, 42°34'57"S). It
is approximately 1.4 km south-southwest of Beginners Luck Cave where the authors have
previously investigated a Pleistocene archaeological bone site (Goede and Murray, 1977)
(figure 1).

Excavations were made at three sites (E, F and G) and all have yielded vertebrate
remains (figure 2). Site G proved the most rewarding containing a number of extinct
species which included *Macropus titan*, *Protemnodon* sp., *Sthenurus* sp., *Sarcophilus* sp.
and an unidentified diprotodontid. The bones at this site have been extensively
chewed and fragmented suggesting derivation from a carnivore's den - probably occupied
by *Sarcophilus*. The small passage from which the material entered the chamber is at
present inhabited by *Sarcophilus harrissii* as evidenced by fresh coprolites found
during some of our visits.

CAVE DESCRIPTION

The cave has developed in well-bedded Ordovician limestone (Gordon Limestone)
locally dipping south-west at an angle of some 25°. The cave is shown in plan in
figure 2 and in longitudinal section in figure 3. The cave mouth is situated in a
steep anti-dip slope close to the crest of the hill and consists of a wide, low
opening (5 x 2.2 m) facing north-east (plates 1 and 2). The cave floor slopes steeply
inwards at a maximum angle of 35° from the crest of a natural rampart approximately
three metres outside the roof line of the entrance. The roof of the entrance chamber
looks unstable and descends in a series of steps formed by roof fall parallel to the
bedding. Despite the unstable appearance of the roof there has been little recent
roof fall as evidenced by joint-aligned rows of spongy stalactitic formations covered
by algal growth.

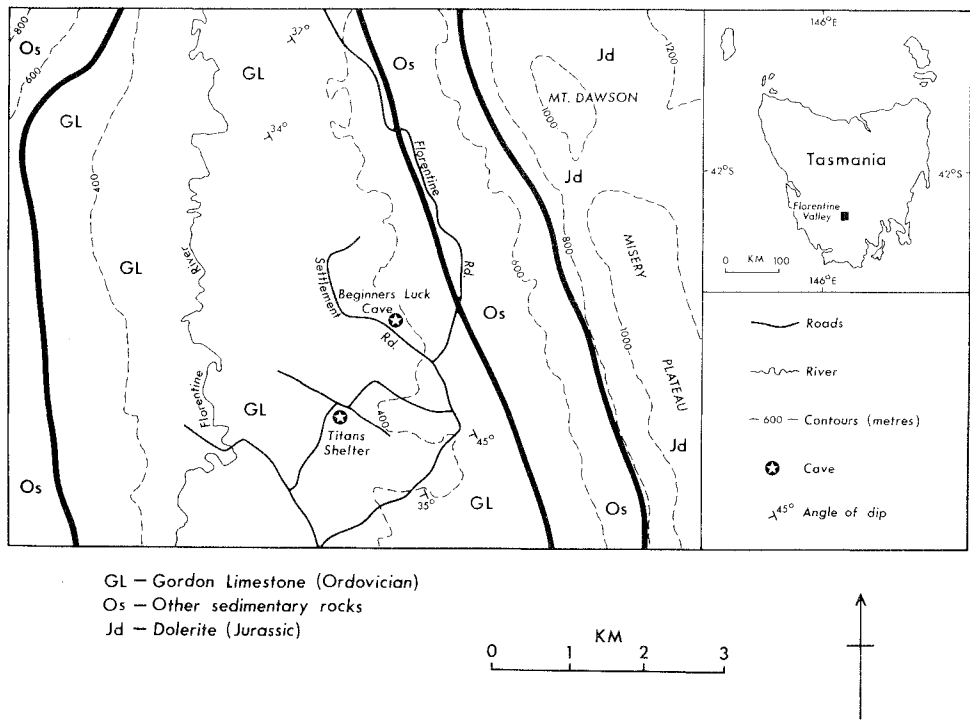Late Pleistocene bone deposits from the Florentine Valley

FIG. 1.- Locality and lithological map of part of the Florentine Valley (lithology after Corbett 1963).

GL — Gordon Limestone (Ordovician)
Os — Other sedimentary rocks
Jd — Dolerite (Jurassic)

The floor is partly covered by slabs of roof fall - the largest being 2.0 x 2.3 x 0.35 m. These are partly imbedded in a dull yellowish brown (10 YR/4/3) (Standard Soil Color Chart 1965) cave earth mixed with an abundance of smaller limestone fragments and containing significant amounts of charcoal and organic matter. Much of the surface charcoal was derived from burning of slash in the summer of 1975-76 following clearfelling.

The entrance chamber has maximum dimensions of 8 x 9 m with a maximum ceiling height of 2.3 m. Along the south-western wall approximately 40 cm below the ceiling a wide, low-roofed extension slopes downward at an angle of 20° becoming too tight for human penetration after about three metres. It has a bedrock ceiling and a floor consisting of clastic sediments.

At the lowest point of the entrance chamber the roof steps down to a point where large roof fall originally blocked further access. A small opening against the south-western wall was enlarged to provide entry to a second chamber.
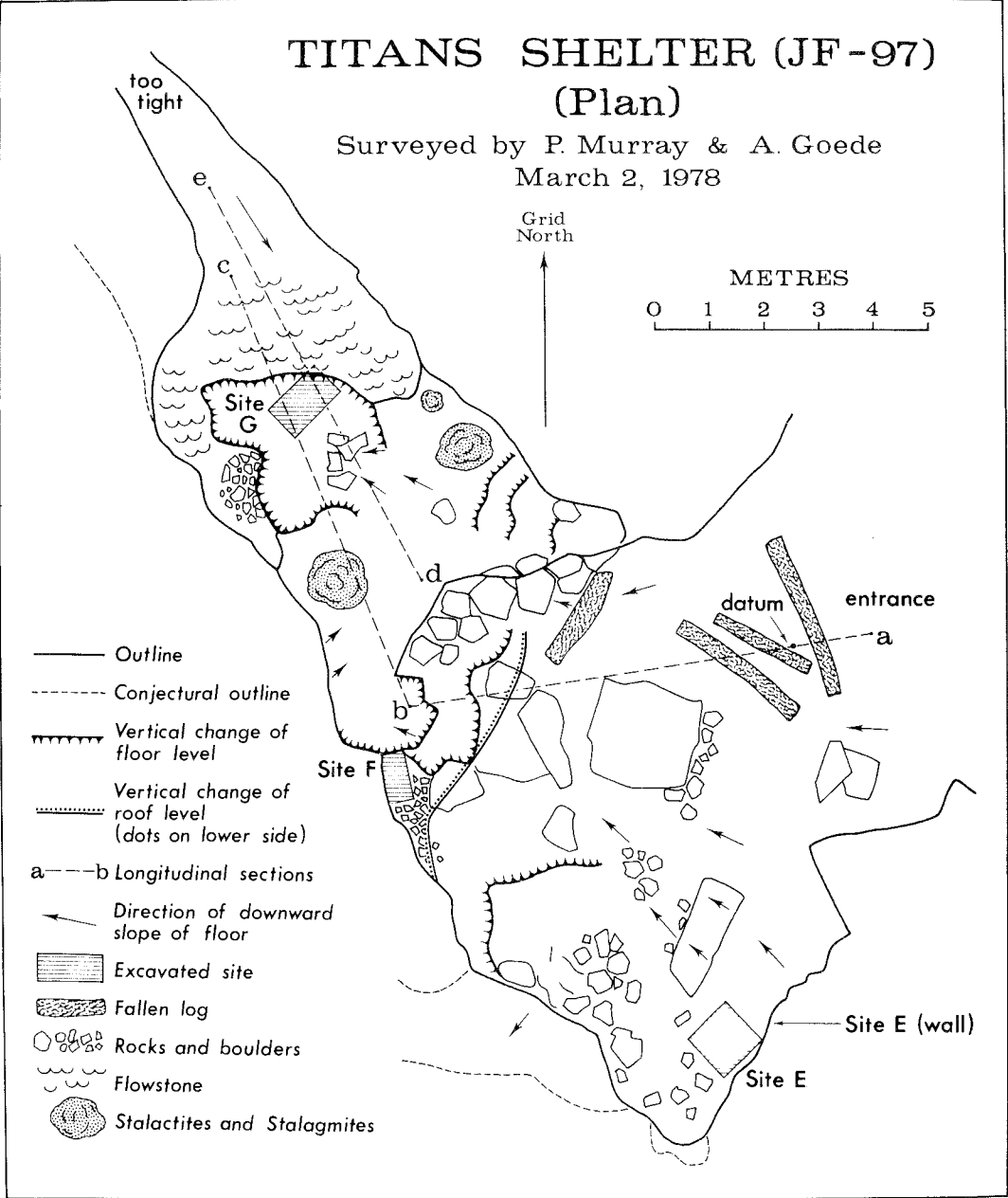
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TITANS SHELTER (JF-97)
(Plan)

Surveyed by P. Murray & A. Goede
March 2, 1978

too tight

e

c

Grid North

METRES

0 1 2 3 4 5

Site G

d

datum   entrance

a

b

Site F

Outline

Conjectural outline

Vertical change of floor level

Vertical change of roof level (dots on lower side)

a — — b Longitudinal sections

Direction of downward slope of floor

Excavated site

Fallen log

Rocks and boulders

Flowstone

Stalactites and Stalagmites

Site E (wall)

Site E

FIG. 2.- Plan survey of Titans Shelter.

TITANS SHELTER (Longitudinal Section)

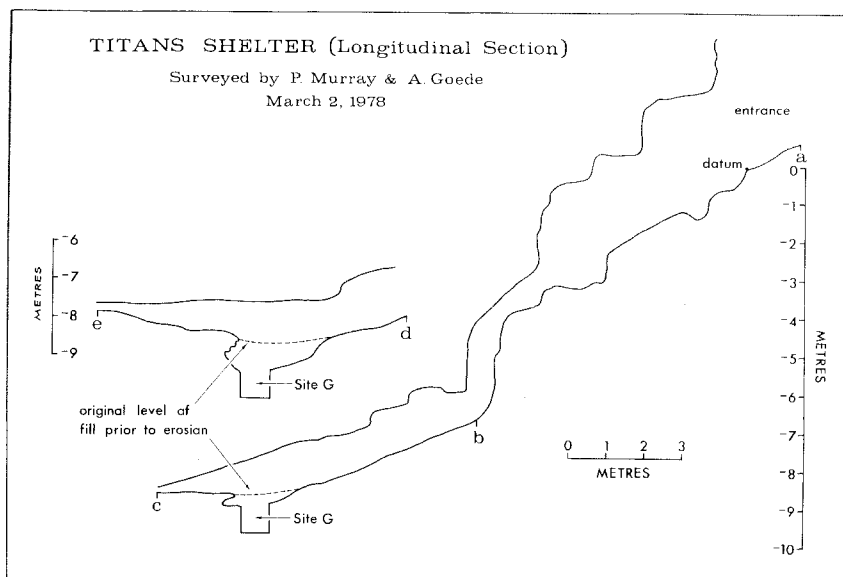Surveyed by P. Murray & A. Goede
March 2, 1978

FIG. 3.- Longitudinal section of Titans Shelter.

This chamber is six metres long and up to five metres wide with the floor sloping towards a low point near the north-western extremity. Here, prior to excavation of site G, a circular pit approximately one metre deep and with a maximum diameter of 60 cm had been eroded in the dissected cave fill making up the floor.

At the north-western extremity of the chamber the floor rises again and a flow-stone covered slope leads to a low tunnel which soon becomes too tight to allow further exploration. A draught is present possibly indicating another connection with the surface.

EXCAVATION SITES AND ASSOCIATED SEDIMENTS

Three sites were excavated within the cave, two in the entrance chamber and one in the second chamber.

Site E was located below the south-eastern wall of the entrance chamber (figure 2). In the lower wall above the level of the pit and a little to the north-east some bones and bone fragments were exposed in remnant cave fill containing abundant angular limestone fragments. In the upper 20 cm there is a sparse dull yellowish brown (10 YR/5/4) matrix while the lower 20 cm has an openwork texture. The rock fragments generally range from a few mm to 10 cm in diameter with a modal range of 2-4 cm. Occasional larger fragments up to 30 cm are present. This site is referred to as Site E (wall) in figure 2. Site E was selected because of its proximity to this wall exposure and also because it was one of the few areas in the entrance chamber where large blocks of limestone were absent from the surface. Excavation of a one metre square area on this sloping site revealed a thin uncompacted surface layer of dull
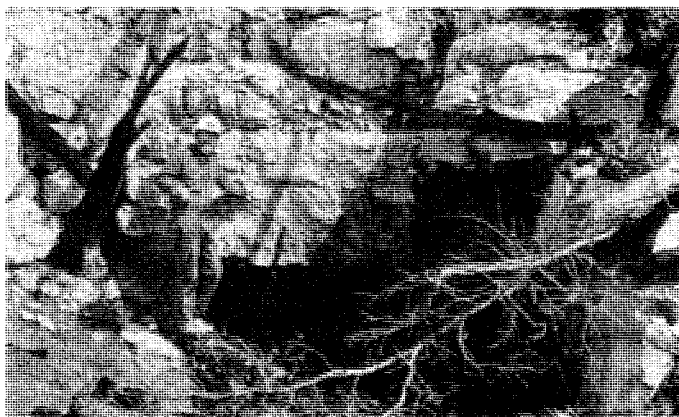
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PLATE 1 (top).- View of limestone hill with entrance to Titans Shelter
    visible below crest.
PLATE 2.- Entrance to Titans Shelter.
PLATE 3 (bottom).- Seiving for bone fragments outside the cave entrance.

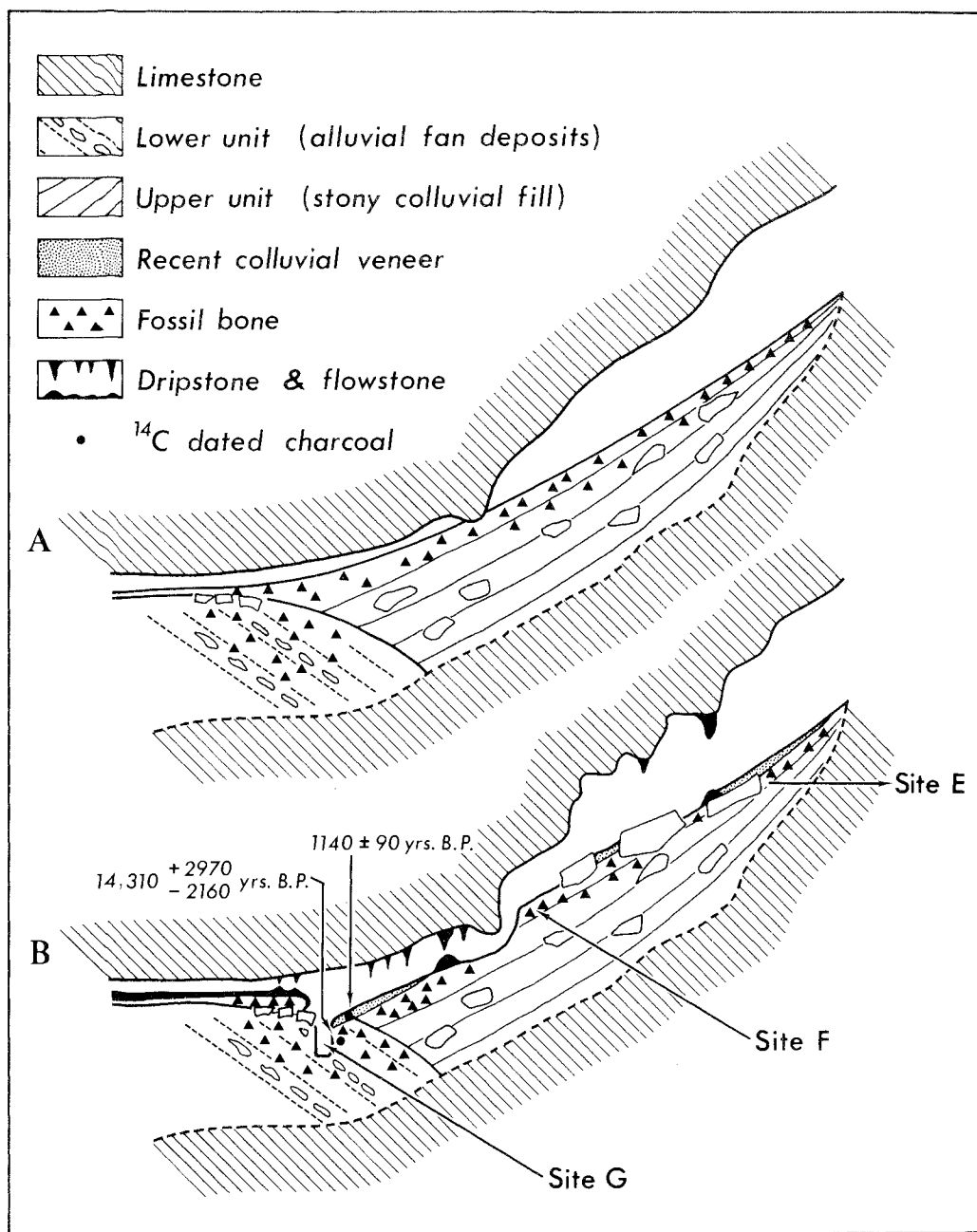Late Pleistocene bone deposits from the Florentine Valley

FIG. 4.- Diagrammatic evolutionary sequence of depositional and erosional phases.
A, end of Pleistocene. B, present day.

yellowish brown (10 YR/5/3) stony earth thickening downslope and locally containing
numerous small bones. There was a steeply dipping contact with marked erosional un-
conformity between it and the underlying sediments. These sediments form a continuous
sediment body with the E wall sediments but are stratigraphically lower in the
sequence. They consist of a loosely packed rock rubble in a partial matrix of bright
brown (7.5 YR/5/6) earth. Voids are common and there is abundant evidence of sub-
sequent deposition of spongy calcium carbonate by percolating water. The stone size
tends to increase towards the base of the exposure with many fragments from 5 to 20
cm in diameter.

The sediments contained a number of bone fragments, many of them broken. A
single fragment of angular grey quartzite was also discovered (dimensions 49.0 x 56.5
mm). This represents the only piece of non-limestone rock found so far in any of the
sediments examined in this cave. Although it is tempting to suggest that it was
brought to the cave by man it shows no clear evidence of being an artifact. Excava-
tion of site E was abandoned because of the decreasing bone content with depth and
increasing problems with large blocks of roof fall.

Site F consists of a remnant of undissected cave fill preserved against the west
wall of the entrance chamber near its lowest point (figures 2 and 4). The deposit
consists of an accumulation of limestone fragments ranging in size from angular chips
a few mm in diameter to fragments up to 15 cm. The modal size range is approximately
1 to 3 cm. In the upper part of the deposit the fragments are contained in a sparse
matrix of reddish brown (5 YR/4/6) clay rich sediment but downwards this grades into
an openwork accumulation of angular rock fragments frequently coated with spongy
calcium carbonate. The exposure shows at least one metre of sediments of which the
top 40 cm are rich in fossil bone and have been excavated. Cementation of the deposit
is quite variable ranging from strongly cemented to loose and friable.

Site G is located at the lowest point of the cave and has been briefly described
in an earlier paper (Goede, Murray and Harmon 1978). Prior to excavation it consisted
of a circular erosion pit approximately one metre deep and with a maximum diameter of
60 cm. The exposure of numerous small bone fragments in the sides of the pit prompted
selection of the site for excavation. The pit was itself located in the floor of a
larger erosional depression the outline of which is clearly shown in figure 2 as a
vertical change in floor level. The sedimentary sequence is partially capped by flow-
stone deposition from water entering the chamber from the north-west (figures 2 and 4).

The upper unit of the underlying sediments is up to 70 cm thick and is best
exposed to the west of the site and above the level at which excavation started. The
deposit is strongly cemented and consists of limestone fragments from a few mm to 30
cm in diameter with a modal size range from 2 to 10 cm. There is a sparse matrix of
poorly-sorted, dull yellow orange (10 YR/6/4) sediments containing significant amounts
of fragmented bone. There is an erosional gap at floor level which separates it from
the lower unit exposed in the pit.

To the north of the pit the upper unit rests on the lower one but the two are
separated by a layer of limestone slabs approximately 30 cm thick produced by roof
fall. The upper unit is poorly exposed here due partly to heavy post depositional
incrustation of carbonate and partly to subsequent excavation of animal burrows below
the flowstone cap. There appears to be a higher proportion of matrix, yellowish brown
(10 YR/5/6) in colour, and also containing bone fragments.

The overall slope of the surface of the upper unit indicates that the sediments
originated from the present entrance. This unit represents the last major phase of
clastic deposition in the cave and the sediments are similar to those exposed at
sites E and F with which they are correlated. The erosional depression around site G

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has been excavated largely within the upper unit, the material having apparently been removed through the erosional gap between it and the lower unit.

The lower unit consists of at least 90 cm of brown to bright brown (7.5 YR/4/6 to 5/6) cave earth with a significantly lower stone content than the upper unit. This material was originally exposed in the walls of the pit which was excavated to form a flat-floored rectangular excavation with dimensions of 75 x 120 cm and with depth varying from 75 to 95 cm due to the slope of the floor. The deposit is rich in small bone fragments in a state of preservation varying from very good to soft and crumbly. The nature of the bone fragments, to be discussed later, indicates that the material originated from a carnivore's den (probably *Sarcophilus*).

The sediments show poorly developed bedding dipping towards the south-east with apparent angles of dip of 25°-35°. A similar depositional slope is indicated by a roof fall horizon. In contrast to the overlying bed the sediments have been derived from the constricted passage entering the chamber from the north-west. Their nature indicates deposition by slow moving water in the form of a fan with intermittent roof fall contributing. The sediments are locally penetrated by modern roots several of which had to be cut during excavation.

Charcoal collected from the deposit from the south-eastern wall of the excavation at a depth of between 58 and 75 cm below the surface was carefully inspected for possible modern root contamination and pretreated prior to dating with boiling 2N HCl solution. The age was determined as $14,310 \pm ^{2970}_{2160}$ years BP (GaK-6875).

The sections (figure 4) show that on the north-western side of the pit the older sediments are overlain by a low mound of much more recent reddish brown (5 YR/4/6) sediment which accumulated as a result of animal burrowing (probably by *Vombatus ursinus*) in the upper unit. This is clearly a recent event postdating the dissection of the upper unit.

On the south-eastern side of the pit the sediments of the lower unit are overlain by a thin (< 10 cm) layer of loose charcoal rich sediment which accumulated as a thin mantle after dissection of the older deposits. Charcoal from this layer was pretreated with boiling 2N HCl solution and yielded a late Holocene date of 1140 ± 90 years BP (GaK-6874).

FAUNAL ANALYSIS

Samples of fossil vertebrate remains were recovered from three sites in Titans Shelter. Site E yielded insufficient material for statistical analysis. Sites F and G both contained numerous whole and fragmentary bones in sufficient quantity to permit comparison with other Florentine Valley cave deposits.

Site E: A clear faunal demarcation between Holocene and Pleistocene sediments was apparent in this test excavation. The upper, probably mid to Late Holocene stratum contains only small mammal remains which represent regurgitated predatory bird pellets. The marsupial mouse *(Antechinus swainsoni)* and the long-tailed rat *(Pseudomys higginsi)* are the dominant elements in the deposit. A single canine of a Peramelid (probably *Perameles*) was also recovered.

The lower brown stratum contained *Thylogale billardieri*, *Macropus rufogriseus* and *Dasyurus viverrinus*.

Site F: A total of 659 specimens of fossil bone was excavated from a small area of less than .5m^2 excavated to an average depth of 25 cm. About two-thirds of these remains were identifiable to genus. Nearly 10 per cent of the sample was composed of

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unbroken long bones
(plate 4).

The material shows
evidence of both pre and
post depositional altera-
tions by predators and
rodents. Tooth marks
attributable to marsupial
carnivores appear on four
per cent of the specimens
(figure 5). Eroded
compact bone surfaces
suggest that some of the
fragments may have passed
through the digestive
system of a carnivorous
animal. These comprise
another four per cent of
the sample. Six per
cent of the remains con-
sist of small fragments
of long bones that
appear to be the result
of chewing. In addition,
a few bones (1%) have
paired, narrow grooves
running perpendicular

PLATE 4.- Sample of bone material collected from Site F.

to the long axis of the bone or crests on bones. These grooves closely approximate
the dimensions of the occlusal surfaces of *Mastacomys fuscus* incisors.

The broken bone fragments in site F fall primarily into four shape categories:
oblique (27%) transverse (35%) longitudinal fractures (27.5%) and spiral fractures
(3%). The longitudinal fractures appear to be the result of natural weathering pro-
cesses. Experiments by Miller (1975) suggest that freezing, thawing and drying of
fresh bone results in longitudinal cracks that extend into the medullary cavity.
Many of the transverse cracks also appear to be due to postmortem exposure to extremes
of atmospheric conditions. Oblique and spiral fractures probably occurred while the
bone was relatively fresh. The presence of collagen in the bone facilitates this type
of damage when shearing forces are applied or when a bone is struck solidly with a
heavy object. In site F this could be due primarily to roof fall and secondarily to
the activity of carnivores.

Site F contained seven mammal and one bird species (table 1). The remains of a
falcon (*Falco* sp.) and the unusually large number of *Dasyurus viverrinus* remains (120
elements) suggest that owls employed the shelter as a roost. Nineteen very large
macropodid elements have been assigned to *Macropus titan*. A single metatarsal IV of
Sthenurus sp. was also recovered. *Macropus rufogriseus* is the most common species
from site F, comprising 44% of identifiable remains. *Thylogale billardieri* and
Macropus titan remains were less common (respectively 7% and 5%). *Sthenurus* is
comparatively rare.

The overall representation of skeletal remains shows an expected predominance of
axial elements (18%), poor representation of the cranium (3.1%) and good representation
of mandibles (9.1%). Pes elements were greatly over represented in the sample (21%).

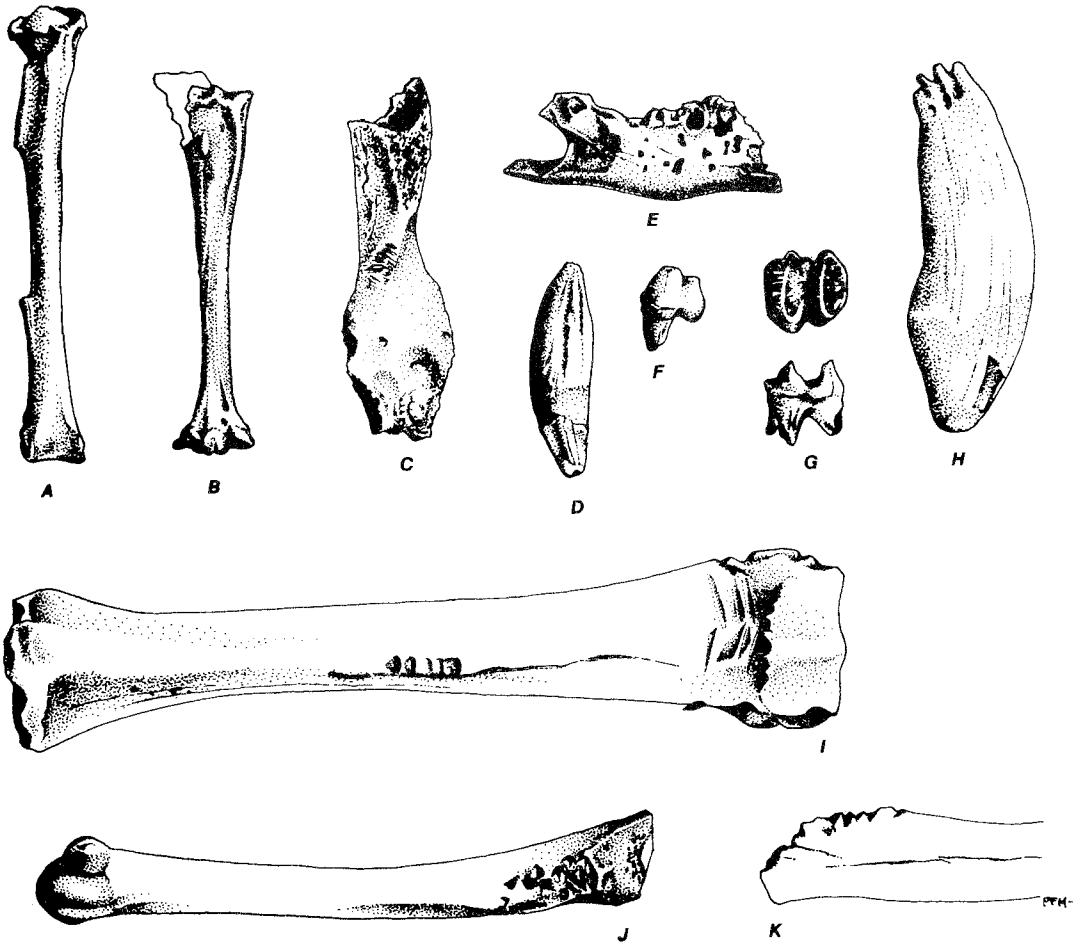Late Pleistocene bone deposits from the Florentine Valley

FIG. 5.- Drawing of selected fossil remains from sites F and G. A, tibiotarsus of
Falco sp.; B, tarsometatarsus of *Falco* sp.; C, humerus of *Macropus rufogriseus*
showing tooth marks and damage to distal and proximal ends by gnawing; E, mandible
of *M. rufogriseus* showing attack by snails; D, upper left canine of *Sarcophilus*
sp.; G, left M^3 of *Sthenurus* sp. (occlusal and buccal views); H, I^1 of
?Zygomaturus; I, metatarsal IV of *Macropus titan* showing marks probably made by a
carnivore near distal end and marks made by rodent(s) in the middle of the shaft;
J, metatarsal V of *Macropus titan* showing tooth marks near proximal end; K, side
view of same.
A, B, C, E, I, J, K; x 0.57.
D, F; x 0.7.
G x 0.86.
H x 0.65.

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TABLE 1

SPECIES IDENTIFIED IN TITANS SHELTER

Species	Site F		Site G
	Minimum Number	Total Remains Identified	Minimum Number
Falco sp.	1	10	–
Dasyurus viverrinus	18	120	1
Sarcophilus sp.	–	–	4
Pseudocheirus peregrinus	–	–	2
Vombatus ursinus	–	–	1
Sthenurus	1	1	3
Protemnodon	–	–	2
Macropus titan	4	19	8
Thylogale billardieri	2	29	4
Macropus rufogriseus	5	178	5
?Zygomaturus	–	–	1
Mastacomys fuscus	5	44	4

Site G: This sample primarily consists of small, apparently chewed bone fragments averaging between 2 and 3 cm in length. The vast majority of these fragments are technically unidentifiable, although the limited faunal assemblage present in these sites would allow generic assignment on the basis of element size alone. Identification of species and estimates of minimum numbers of individuals are based entirely on isolated teeth and jaw fragments containing teeth (table 1).

Site G contains more species than Site F, but this is probably due to the much larger sample obtained from this location. The total number of fragments exceeds 5000. A representative sample of site G material consisting of 215 specimens was measured by placing each piece in one of seven two-centimetre categories. This was compared with the Site F sample (figure 6).

In site G the number of fragments in the size categories of between 8 and greater than 12 cm is practically nil. In site F there is at least a small representation in each of these larger categories (figure 6, plates 4 and 5). A χ^2 test suggests that the differences in size distribution of bone fragments at the two sites is highly significant (χ^2 = 50.13, v = 4, p < .001).

The most likely explanation for the difference in size of fragments is that site G represents water sorted and transported material. It seems very likely that the initial assemblage of fossil material represented only in part at site G is a large deposit. Unfortunately, the passage leading to its probable source is too narrow to negotiate.

PALAEOECOLOGY

The modern Florentine Valley fauna consists of species known to inhabit wet sclerophyll and rainforest biomes throughout Tasmania. Samples of fauna from Late Holocene deposits in the valley contain the remains of *Ornithorhynchus, Tachyglossus, Antechinus swainsoni, Dasyurus maculatus, Sarcophilus harrisii, Thylacinus cynocephalus* (now presumed extinct), *Perameles gunnii, Vombatus ursinus, Potorous tridactylus, Thylogale billardieri, Macropus rufogriseus, Pseudocheirus peregrinus* and *Pseudomys higginsi*. Despite the relatively large samples of fossil material from sites F and G, a substantial number of these species are not represented. Important absences include the tiger cat *(D. maculatus)*, the marsupial mouse *(Antechinus swainsoni)*, the velvet

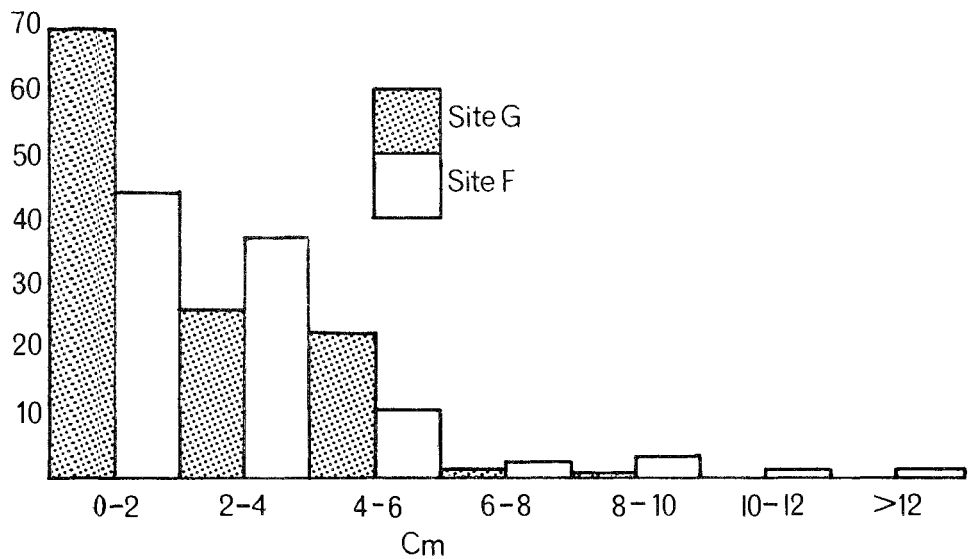Late Pleistocene bone deposits from the Florentine Valley

FIG. 6.- Size distribution of bone fragments for sites G (n = 215), and site F (n = 659).

PLATE 5.- Sample of bone material collected from Site G.

furred rat *(R. lutreolus)* and the potoroo *(Potorous tridactylus)*. These mammals are typical fern gully and rainforest edge species. However, certain constituents of the fossil fauna suggest the presence of some type of arborescent vegetation and/or scrub, particularly *Pseudocheirus*, *Sthenurus* and *Thylogale*. The large kangaroo, *M. titan* was probably similar to the modern grey kangaroo in preferring open sclerophyll and wood-land savanna habitat. *Mastacomys fuscus* is a relict species in Tasmania. Its distribution during the Late Pleistocene was greatly expanded, while *Rattus lutreolus* and *Pseudomys* spp. appear to have been very rare. *M. fuscus* may have preferred

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open sedge and grassland habitats. It is today confined to cool, wet sedgeland and grassland associations. The Titan Shelter assemblage appears to represent an open vegetation type community consisting of some sclerophyll forest elements and some low scrub situated within grasslands.

HISTORY AND AGE OF SEDIMENTATION

The lower unit excavated at site G represents the oldest sediments exposed in the cave. The base is not exposed as it was not possible to deepen the excavation further without digging into collapse material at the base of the pre-existing erosion pit. Unlike the upper unit the provenance of the sediments is from the north-westerly trending passage that continues on from the second chamber. The nature and bedding of the material indicates accumulation by running water in a low energy environment con- temporaneous with intermittent roof fall. A very short distance of transport is suggested by the nature of the bone content.

Extinct fauna is represented throughout the excavated depth. Charcoal is not common and at only one place occurred in sufficient quantity to permit C14 dating $(14,310 \; ^{+2970}_{-2160}$ years BP). The large standard error is due to the small size of the sample. The date indicates a late Pleistocene age. This date has been quoted by Goede, Murray and Harmon (1978) as evidence of Late Pleistocene survival of megafauna in the Florentine Valley. However, it cannot be regarded as conclusive evidence. Since the bone content has been reworked the possibility exists that the bone is sig- nificantly older than the charcoal with which it is associated.

The upper unit is exposed in the banks above the level of excavation site G. The upper horizons of the same unit were examined at sites E (wall), E and F while some of the lower horizons are exposed in the squeeze below site F. Beds with limestone frag- ments in a sparse matrix alternate with layers of open work fragments. Both bone and matrix seem to be concentrated in the upper horizons but bone is relatively abundant only at site E.

The upper unit appears to have accumulated as a result of gravitational movement downslope of material produced by roof fall and physical weathering. The nature of this deposit suggests cold and probably dry conditions during its formation. It is similar in character to the upper unit described from site P in Beginners Luck Cave (Goede and Murray 1977) and the two deposits may be of similar age. The increase in the content of bone and matrix in the upper horizons may reflect a gradual moderation of climatic conditions.

Unfortunately the unit contains no significant amounts of charcoal that would enable it to be dated. There is no evidence of a significant time gap between the accumulation of the upper and lower units. The upper unit is believed to represent the final phase of Pleistocene deposition prior to the climatic warming which led to the invasion of forests at about 11,500 C14 years BP (Macphail 1975).

It is followed by a long period when erosion by seepage water and deposition of calcium carbonate were the dominant processes. Lack of physical weathering and wide- spread chemical deposition suggest mild and wet climatic conditions which may have persisted through much of the Holocene. Patchy cementation and local spongy carbonate deposition within the late Pleistocene fills probably also occurred during this time.

Following this episode there was very restricted clastic deposition in late Holocene times. This seems to have been due to the activities of birds and burrowing animals and also to occasional disturbance of the forested surface environment by fire. An episode of fire disturbance is dated at 1140 ± 90 years BP.

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CONCLUSIONS

An unknown thickness of late Pleistocene deposits partially filled Titans Shelter and can be subdivided into two units. The lower unit was deposited by running water with an admixture of rockfall. The fragmentary bone content represents a late Pleistocene megafauna and suggests surface vegetation conditions rather different from the dense wet sclerophyll forest present in historical times. The C14 date obtained from the unit has been used by Goede, Murray and Harmon (1977) as evidence for the late survival of Pleistocene megafauna in Tasmania but the large standard error of the date combined with the possibility that the bone material may be older than the sediments in which it occurs must throw some doubt on the evidence.

The younger unit indicates cold and dry conditions with evidence of fauna indicated only in the upper horizons. Accumulation may have occurred under conditions of maximum cold during the last glaciation with some amelioration towards the end.

The balance then swung to a dominance of sediment removal by running water and speleothem formation during the wetter and milder conditions of the Holocene. The most recent events are minor erosion and sedimentation due to biological activity in the cave and fire disturbance of the surface environment.

ACKNOWLEDGEMENTS

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