AGE CONSTRAINTS FOR CLASTIC SEDIMENTS FROM TWO CAVES IN THE JUNEE–FLORENTINE KARST, TASMANIA

by Rolan Eberhard

(with one table and three text-figures)

EBERHARD, R., 1997 (31:viii): Age constraints for clastic sediments from two caves in the Junee–Florentine karst, Tasmania. *Pap. Proc. R. Soc. Tasm.* 131: 67-72. https://doi.org/10.26749/rstpp.131.67 ISSN 0080-4703. Environment Australia, PO Box 787, Canberra, ACT, Australia 2601; formerly Forestry Tasmania.

Uranium-thorium dating of speleothems from two caves in the Junee–Florentine karst, Tasmania, provides some age constraints for associated clastic sediments including coarse dolerite-rich fluvial gravels, which underlie the three oldest dated speleothems. The results suggest minimum ages of 15 ± 5 ka, ~325 ka and >350 ka (two dates) for the gravels, implying that they are considerably older than the early Last Glacial age suggested previously for some fluvial gravels in other Junee–Florentine caves.
Key Words: **karst, caves, cave sediments, speleothems, radiometric dating, Pleistocene, Tasmania.**

INTRODUCTION

The Junee–Florentine karst area in central southern Tasmania is the location of numerous caves, many of which contain extensive alluvial deposits of allogenic origin. In particular, caves along the eastern margin of the karst with catchments on the Mount Field massif tend to be at least partially infilled with coarse alluvial gravels, predominantly rounded to angular dolerite clasts. It has been suggested that many former inflow caves remained quiescent for extended periods in the Pleistocene, due to blockage by clastic fills (Goede 1973). Application of radiometric dating methods to secondary carbonates that occur in association with the allogenic sediments provided an opportunity to obtain a preliminary indication of the possible ages of some of the cave deposits.

Previous work on cave sediments in the Junee–Florentine area has focussed on sites of archaeological and palaeontological interest, including Beginners Luck Cave, a relict stream cave located at 400 m a.s.l. in the Florentine Valley. The cave is characterised by thick deposits of coarse dolerite gravels and sands, that almost completely choke some of its passages. Beginners Luck Cave lacks a perennial stream today but appears to have been fed by significant runoff from slopes in the vicinity of Mount Dawson (1062 m — part of the Mount Field massif) when the cave fills were deposited. Various lines of evidence led Goede & Harmon (1983) to conclude that Beginners Luck Cave and some other Tasmanian caves had been affected by a period of widespread alluviation between about 75 and 50 ka. They refer to this as the "Beginners Luck Alluvial Phase". Much of the evidence for this age rests on their interpretation of weathering rind data for dolerite clasts within the alluvium at Beginners Luck Cave.

Many Tasmanian caves contain extensive deposits of allogenic alluvial fills ranging from sands and silts to large boulders. The alluvial fills are clearly relict in many cases, being located in passages that are no longer hydrologically active or comprising clasts that are too coarse to be accounted for by contemporary cave streams. Some of the deposits have been interpreted as Pleistocene fluvial and glaciofluvial sediments, although few sedimentary sequences have been dated with precision (Burns 1960, Goede 1969, Goede & Murray 1977, 1979, Goede & Harmon 1983, Kiernan 1983, 1984, 1991a, Houshold & Spate 1990).

THE JUNEE–FLORENTINE KARST

The Junee–Florentine karst is located at approximately latitude 42°40'S and longitude 146°30'E (fig. 1). The karst is formed in massive, folded Ordovician limestones, that underlie the major portion of the Florentine Valley. Contiguous limestone outcrops extend south along the western slopes of the Mount Field massif, approaching the township of Maydena ("Junee area") in the Tyenna River catchment. The karst is characterised by well-developed surface karst landforms and extensive cave systems (Goede 1973, Hume 1991, Eberhard 1994, 1996).

The karst is surrounded by mountainous areas with high points at the summits of Mount Field West (1434 m), Wylds Craig (1337 m) and Mount Mueller (1245 m). These mountains and associated elevated areas have been subject to glacial and periglacial action in the Pleistocene. Periglacial processes are still active to a minor extent at higher altitudes in the area. On the basis of current evidence, most of the karst remained free of the direct action of glacial ice in the Pleistocene. Evidence that glaciers descended to the level of the karst, which reaches a maximum altitude of about 800 m a.s.l., appears to be confined to the upper Florentine Valley, south of Tim Shea, and the Lawrence Rivulet area (Corbett 1964, Peterson 1969, Brown *et al.* 1989). Some caves with catchments on the slopes of the glaciated Mount Field massif are likely to have been subject to glacial meltwater flows and glaciofluvial sedimentation. Seasonal snowmelt continues to be a significant source of runoff in the catchment of these caves. Thick, dolerite-rich diamictons mantle the karst on the slopes of the massif and are interpreted as primarily the result of enhanced periglacial slope instability during Pleistocene cold climate episodes.

The karst is now covered by wet sclerophyll and mixed forests, some of which have been harvested for timber in recent decades. The present climate of the area is moist and cool; records from Maydena (267 m a.s.l.), near the southeastern margin of the karst indicate mean maximum

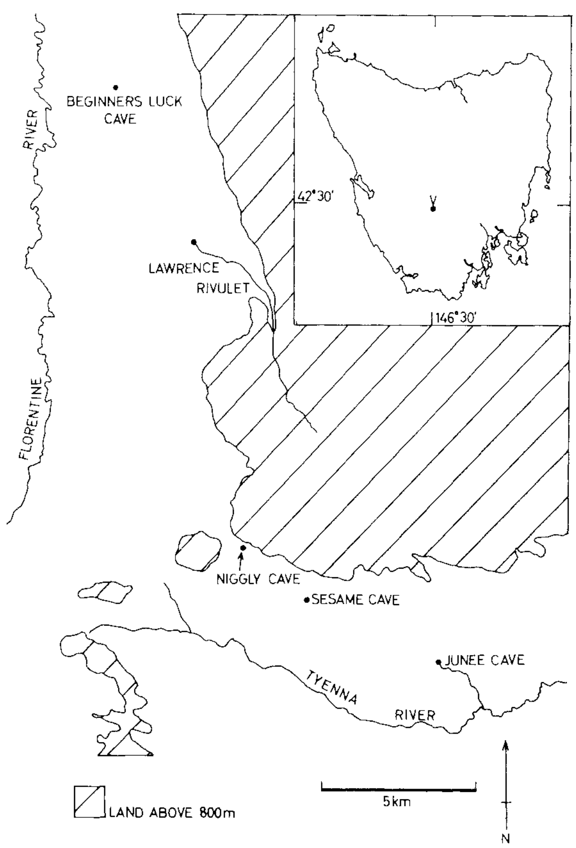

FIG. 1 — Locality map showing caves referred to in the text.

and minimum annual temperatures of 15.7°C and 5.0°C and a mean annual precipitation of 1219 mm (Bureau of Meteorology 1988).

CAVE DEPOSITS

Niggly Cave

Niggly Cave is an active inflow cave located at 740 m a.s.l. on the western slopes of Florentine Peak in the Mount Field National Park. The cave descends steeply to a base-level conduit at an altitude of about 350 m a.s.l. and is a confirmed tributary of the Junee Cave outflow in the Tyenna River catchment (Hume 1991). The upper part of the cave is a horizontal streamway, sections of which contain a prominent calcite false floor. The false floor comprises a 100–200 mm thickness of flowstone that completely bridges the 1–2 m wide streamway in places. The false floor is suspended approximately 1 m above the base of the streamway and the minor perennial stream which it now contains. Rounded dolerite cobbles, up to 200 mm diameter, occur along the base of the passage and are cemented to the underside of the false floor. There is little evidence of ongoing clastic sedimentation, and the larger dolerite clasts appear beyond the competence of the contemporary cave stream.

The development of the false floor is presumed to reflect the following sequence of events: (1) accumulation of allogenic alluvium on the floor of the passage, (2) reduction or cessation of stream activity, followed by flowstone deposition onto the clastic substrate, (3) resumption of stream flow, accompanied by the flushing away of clastic material temporarily sealed beneath the flowstone. A similar mode of formation is postulated for flowstone remnants which bridge passages in Tunnel Cave, Benmore, New South Wales (Frank 1973).

Fragments of flowstone resulting from natural collapse and breakage of the Niggly Cave false floors were sampled for radiometric dating (sample N1).

A second calcite sample was obtained downstream of the false floor in an abandoned vadose canyon containing remnants of an interbedded sequence of fine gravels, sands and clays. These sediments include frequent calcite bands and survive on rock ledges high in the canyon. A 50 mm stalagmite formed upon the clastic sequence was sampled (sample N2).

Sample collection sites in Niggly Cave and the stratigraphy of sedimentary deposits associated with the dated speleothems are shown in figure 2.

Sesame Cave

Sesame Cave is a former inflow cave located at 570 m a.s.l. some 2 km southeast of Niggly Cave and also on the western slopes of the Mount Field massif. The cave descends in a series of vertical steps interspersed with sections of horizontal passage, reaching a depth of more than 200 m below the higher of its two entrances. Sesame Cave is located within the karst catchment of Junee Cave and is presumed to be part of an extensive conduit network associated with that cave (Eberhard 1994).

The upper passages in Sesame Cave contain a sizeable chamber where a deeply eroded sequence of bedded allogenic sediments at least 7 m thick is present. Four broad litho-stratigraphic units may be differentiated within the deposit:
(1) A basal unit ~1.8 m thick, consisting of subangular to moderately rounded allogenic gravels in an orange clay matrix. The principal constituent rock type of the gravels is dolerite in clasts up to 300 mm diameter. Dolerite gravels exposed at the surface of the deposit appear to be deeply chemically weathered, to the extent that some of the larger clasts are almost completely decomposed. This unit is considered to be an alluvial deposit that would have required the action of a high-energy stream to reach its present location.
(2) A heterogeneous sequence of interbedded fine gravels, sands and clays, with a total thickness of about 1 m. Lenses of calcite up to 40 mm thick are frequent and, in places, show evidence of impressions of polygonal mud cracks. This unit appears to unconformably overlie (1) and is considered to reflect relatively low-energy fluvial conditions intetspersed with periods of carbonate deposition.
(3) A ~1 m thickness of sizeable limestone blocks of angular form, that have a chaotic arrangement. Interstices between the blocks are filled with finer sediment, similar to that of the overlying unit (4). This unit is considered to be a cave collapse facies.
(4) An upper unit comprising sands and fine gravels with a few clay lenses. The sediments are laminated and are in the order of 4 m thick. This unit is considered to be fluvial in origin.
A calcite horizon towards the base of (2) was sampled (sample S2).

The lower section of Sesame Cave is characterised by a

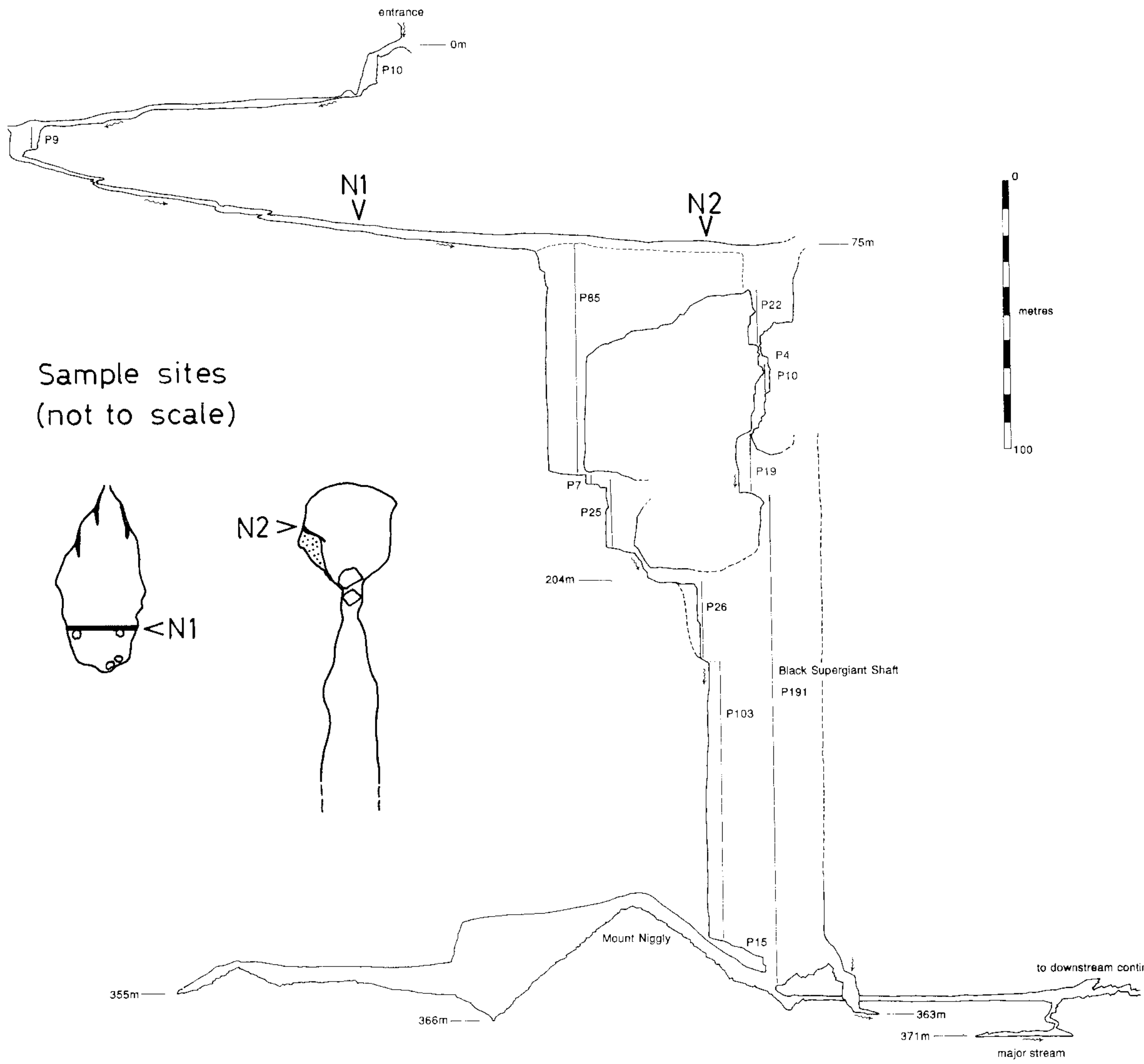

FIG. 2 — Niggly Cave showing sample collection sites and straigraphy of the dated deposits. The cave is depicted in vertical cross-section (after Eberhard 1994).

deeply incised vadose canyon where a calcite false floor, similar to that in Niggly Cave, is presenr. A similar sequence of events is assumed to have formed the false floors at both sites. Whereas the Niggly Cave false floors reach a maximum thickness of about 300 mm, the Sesame Cave floors are more massive, reaching a thickness of 1.5 m in places. Flowstone at the base of the false floor was collected for dating (sample S1).

Allogenic clasts, embedded in the underside of the Sesame Cave false floors, indicate that the original substrate on which the flowstone was deposited included well-rounded dolerite gravels, up to boulder size. One extant clast has a diameter of ~1 m; other clasts are in the order of 100–300 mm diameter. Most of the original deposit has been lost to erosion.

Sample collection sites in Sesame Cave and the stratigraphy of sedimentary deposits associated with the dated speleothems are shown in figure 3.

RADIOMETRIC DATING

Radiometric determinations were undertaken at the Australian Nuclear Science and Technology Organisation Environmental Radiochemistry Laboratory (uranium series) and at Beta Analytic Inc. (USA) (radiocarbon). All of the samples were massive crystalline deposits of low permeability and lacking obvious exogenic exclusions. This reduces the possibility of misleading results, due to preferential leaching of ^{234}U by cave waters, resulting in too great an age being calculated (Harmon *et al.* 1975, Gascoyne *et al.* 1978). Uranium levels in all samples were found to be sufficient for uranium series dating. Results are presented in table 1.

An initial attempt to date the N1 sample, using the ^{14}C method, revealed an age in excess of 43.5 ka (Beta-69657) and beyond the limit of dating by that method.

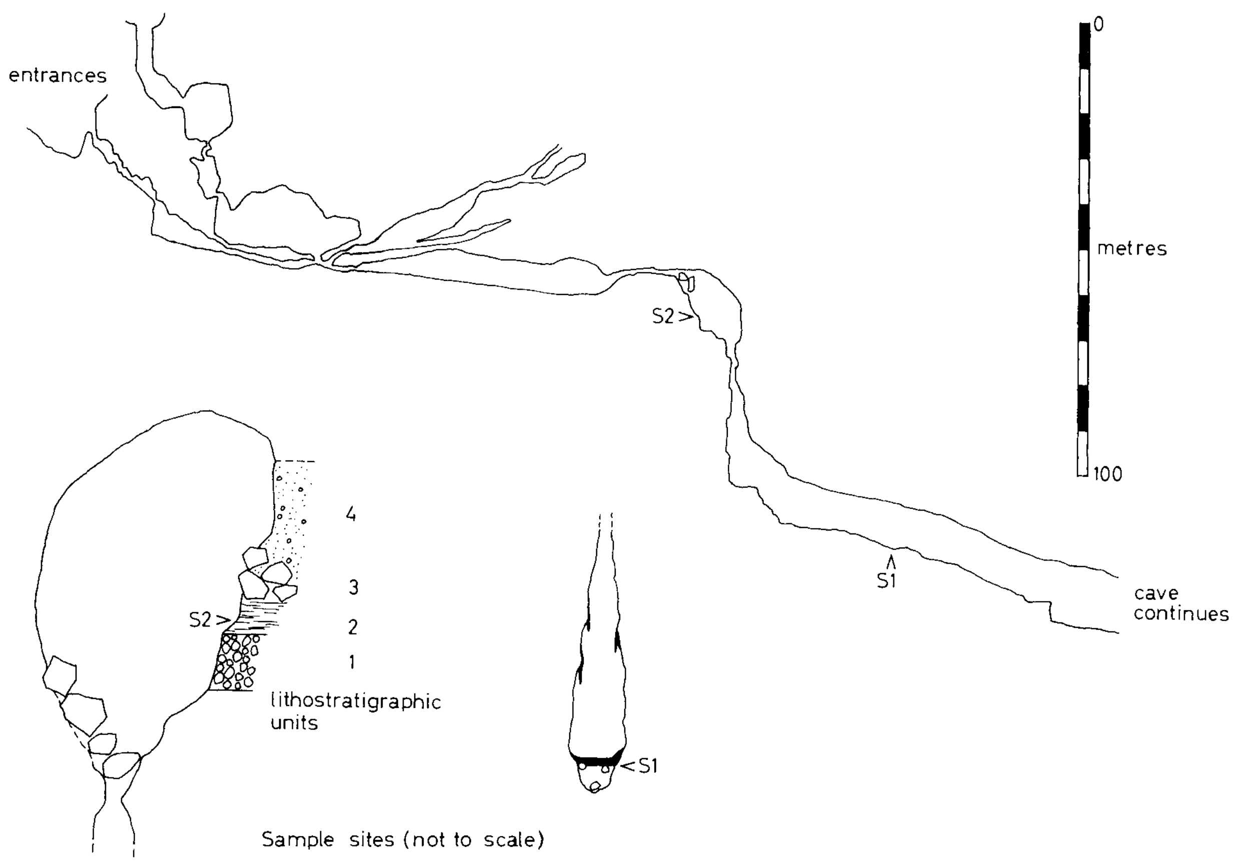

FIG. 3 — Sesame Cave showing sample collection sites and stratigraphy of the dated deposits. The cave is depicted in vertical cross-section (after Tunny et al. *1982).*

TABLE 1
Uranium concentrations, isotope activity ratios and calculated ages for speleothems

	Sample* (lab no.)			
	N1 (LH3572)	N2 (LH3573)	S1 (LH3574)	S2 (LH3575)
U (ppm)	0.4332	0.9227	0.06008	0.3748
error	0.0192	0.0359	0.00589	0.0176
$^{230}Th/^{232}Th$	146.6	22.55	15.46	18.52
error	53.5	8.38	4.84	3.27
$^{230}Th/^{234}U$	1.288	0.1403	1.004	1.061
error	0.075	0.0129	0.123	0.072
$^{234}U/^{238}U$	1.3201	0.7708	1.211	0.9058
error	0.3120	0.0438	0.0163	0.0612
Calculated age (ka)	>350	15 ± 5	325 ± 500/100	>350

* N1, N2 from Niggly Cave; S1, S2 from Sesame Cave. All from Junee–Florentine karsr, Tasmania.

DISCUSSION

Samples N1 and S1 were obtained from flowstone laid down on coarse allogenic cave fills. The size of some extant clasts suggests a high-energy stream environment, particularly at the S1 site. The radiometric determinations imply deposition of the clastic sediment prior to 350 ka at Niggly Cave and prior to ~325 ka at Sesame Cave. Formation of the S1 flowstone at about 325 ka may suggest a significant phase of chemical sedimentation at this site during the interglacial period of marine isotope stage 9, as globally defined. An interglacial environment would be consistent with the large scale of the Sesame Cave flowstone deposit, taking into account evidence from speleothem growth-frequency studies that interglacial periods were times of increased speleothem activity (Atkinson *et al.* 1978, Goede & Harmon 1983). However, the S1 result is close to the limit of uranium series dating and needs to be interpreted cautiously.

Sample S2 was obtained from a calcite horizon within a relatively complex sedimentary sequence elsewhere in Sesame Cave. The dated calcite forms part of a sequence of interbedded fine gravels, sands and clays, which unconformably overlies coarse allogenic gravels with a high proportion of moderately rounded dolerite clasts. Both deposits are interpreted as primarily fluvial in origin and relate to events that occurred prior to 350 ka on the basis of the S2 result. The infinite date for sample S2 does not constrain the age of the overlying sediments, which include a presumed cave collapse facies and alluvial sands and gravels.

Radiometric evidence concerning the ages of the N1, S1 and S2 speleothems and associated clastic deposits bears comparison with a uranium series date of >400 ka, obtained by Goede & Harmon (1983), for speleothem material overlying gravelly alluvium in Exit Cave at Ida Bay in southern Tasmania. However, whereas the Exit Cave alluvium now lies 25 m above the active stream, in a cave considered to have developed over a long and complex evolutionary history (Goede 1969, Houshold & Spate 1990, Kiernan 1991b), the morphology and topographic context of the Junee–Florentine caves containing the dated sediments are less obviously suggestive of great age. Niggly Cave is an active inflow, developed below an entrance at the unconformity between the limestone and overlying impervious strata. In this situation, allogenic runoff from the overlying rocks could be expected to facilitate karstification and the rapid initiation of cave passages under vadose conditions. Sesame Cave is no longer an active inflow, although the passages within it are dominantly vadose in character and appear to have originated in response to allogenic runoff sinking underground, some distance below the unconformity. Sesame Cave is located in an area where the bedrock is generally mantled by deep slope deposits, which have promoted surface drainage across the limestone in a number of instances. Here, variation in the thickness of the slope mantles, rather than the site of the unconformity, is interpreted as a primary control on the location of streamsinks.

Goede (1973) has suggested that the blockage of streamsinks during cold climate episodes has been an important factor in the development of an extensive system of dry valleys developed below present and former streamsinks in the Junee area. In recent times, landslides that appear to be associated with the destabilising effects of forest fires have resulted in the partial blockage of at least two streamsinks on the slopes of Mount Field West and Wherretts Lookout (Eberhard 1992, 1994). Blockage of inflow points may well have occurred on multiple occasions at Niggly Cave, with fluvial excavation of infilling sediments (or the initiation of new conduits) enabling subterranean conduits to recapture the drainage. This scenario would constrain the rate of cave development in an otherwise favourable situation and may have facilitated the survival of cave sediments potentially susceptible to erosion by fluvial processes. In the case of Sesame Cave, abandonment of the inflow point is probably explicable in terms of the upstream retreat of the sinking point and its capture (or recapture) by other subterranean conduits, developed below entrances at higher altitude.

Sample N2 provides a minimum age for remnants of bedded sands and gravels of presumed fluvial origin in an abandoned vadose passage in Niggly Cave. The radiometric result implies that the clastic sediments are older than ~15 ka by some unknown amount, probably considerably so, given their location in a passage that is now stranded high above the level of active streamways. The age of the dated speleothem material conforms to a pattern of Late Pleistocene carbonate deposition in Tasmanian caves, particularly between 30 and 10 ka, established by Goede & Harmon (1983). These authors report a cluster of dates at 15–19 ka, which they interpret as reflecting rapid climatic amelioration, following a Last Glacial Maximum at about 18 ka.

CONCLUSIONS

Allogenic alluvial fills, ranging from coarse dolerite-rich boulders to sands and clays, are a prominent feature of caves with catchments on the slopes of Mount Field massif in the Junee–Florentine karst area. Radiometric dating of associated secondary carbonates indicates that alluviation occurred prior to ~325–350 ka in at least two caves. This contrasts with a presumed early Last Glacial age for fluvial gravels in nearby caves at lower altitude in the Florentine Valley, which has been suggested primarily on the basis of weathering rind evidence (Goede & Harmon 1983). Clearly, there is considerable scope for further investigation of the cave sediment record of the Junee–Florentine karst. It is now evident that some of the caves are of considerable antiquity, and that they contain sedimentary sequences which extend well back into the Pleistocene.

ACKNOWLEDGEMENTS

Work reported here was carried out as part of the Junee–Florentine Karst Study funded by Forestry Tasmania from its District Conservation Fund. The Tasmanian Parks and Wildlife Service contributed to the project by providing a permit to collect material from Niggly Cave for dating. Kevin Kiernan provided valuable comments on an earlier draft of this paper; his support throughout the Junee–Florentine Karst Study is gratefully acknowledged.

REFERENCES

ATKINSON, T.C., HARMON, R.S., SMART, P.L. & WALTHAM, A.C., 1978: Plaeoclimatic and geomorphic implications of 230Th/234U dates on speleothems from Britain. *Nature* 272: 27–28.

BROWN, A.V., MCCLENAGHAN, M.P., TURNER, N.J., BAILLIE, P.W., MCCLENAGHAN, J. & CALVER, C.R., 1989: Geol. Atlas 1:500 000 Ser. Sheet 73 (8112N). *HUNTLEY.* Explan. Rep. Geol. Surv. Tasm.

BUREAU OF METEOROLOGY, 1988: *CLIMATIC AVERAGES AUSTRALIA.* Australian Government Publishing Service, Canberra.

BURNS, K.L., 1960: Cave deposits at Maracoopa Cave. *Bull. Tasm. Caverneering Club* 4: 31–36.

CORBETT, K.D., 1964: Geology of the Florentine Valley Area. BSc Hons thesis, Univ. Tasm.

EBERHARD, R., 1992: A report on karst in the Westfield Road area, Florentine Valley. Unpubl. rep. For. Commn, Hobart.

EBERHARD, R., 1994: *Inventory and Management of the Junee River Karst System, Tasmania.* Rep. For. Tasm., Hobart.

EBERHARD, R., 1996: *Inventory and Management of Karst in the Florentine Valley, Tasmania.* Rep. For. Tasm., Hobart.

FRANK, R.M., 1973: Sedimentary and morphological development of the Benmore Caves, New South Wales. *Helictite* 2: 27–44.

GASCOYNE, M., SCHWARCZ, H.P. & FORD, D.C., 1978: Uranium series dating and stable isotope studies of speleothems: Part 1 — theory and techniques. *Br. Cave Res. Assoc. Trans.* 5: 91–111.

GOEDE, A., 1969: Underground stream capture at Ida Bay, Tasmania, and the relevance of cold climatic conditions. *Aust. Geogr. Stud.* 7: 41–48.

GOEDE, A., 1973: Hydrological observations at the Junee Resurgence and a brief regional description of the Junee Area, Tasmania. *Helictite* 11(1): 3–24.

GOEDE, A. & HARMON, R., 1983: Radiometric dating of Tasmanian speleothems — evidence of cave evolution and climate change. *J. Geol. Soc. Aust.* 30: 89–100.

GOEDE, A. & MURRAY, P., 1977: Pleistocene man in south central Tasmania: evidence from a cave site in the Florentine Valley. *Mankind* 11: 2–10.

GOEDE, A. & MURAY, P., 1979: Late Pleistocene bone deposits from a cave in the Florentine Valley, Tasmania. *Pap. Proc. R. Soc. Tasm.* 113: 39–52.

HARMON, R., THOMPSON, P., SCHWARCZ, H.P. & FORD, D.C., 1975: Uranium-series dating of speleothems. *Bull. Nat. Speleol. Soc.* 37: 21–33.

HOUSHOLD, I. & SPATE, A., 1990: Geomorphology and hydrology of the Ida Bay karst area. Unpubl. rep. Dep. Parks, Wildl. Heritage, Tasm.

HUME, N.G., 1991: Hydrological and speleological investigation of the Junee–Florentine karst, south west Tasmania. BA Hons thesis, Univ. Tasm.

KIERNAN, K., 1983: Relationship of cave fills to glaciation in the Nelson River Valley, central western Tasmania. *Aust. Geogr.* 15: 367–375.

KIERNAN, K., 1984; Land use in karst areas: Forestry operations and the Mole Creek Caves. Unpubl. rep. For. Commn & Natl Parks Wildl. Serv., Tasm.

KIERNAN, K., 1991a: The extent of Late Cainozoic glaciation in the central highlands of Tasmania, Australia. *Arct. Alp. Res.* 22(4): 341–354.

KIERNAN, K., 1991b: The Exit Cave quarry, Ida Bay karsr system, Tasmanian World Heritage Area: A hydrogeological perspective. Unpubl. rep. Dep. Parks, Wildl. Heritage, Tasm.

PETERSON, J.A., 1969: The cirques of southeastern Australia: Studies in morphology and distribution; history and significance. Unpubl. PhD thesis, Monash Univ.

TUNNY, R., MCKINNON, J., COOPER, A. & WAILES, T., 1982: Map of Sesame Cave. *Speleo Spiel* 177.

(accepted 4 February 1997)