Thirty Thousand Years of Human Colonization in Tasmania: New Pleistocene Dates

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Basal dates of 30,420 years before present (BP) from a limestone cave in the Florentine River valley and 30,840 BP from a sandstone rockshelter in the Shannon River valley on the edge of the central Tasmanian highlands indicate colonization of Tasmania 8,000 years earlier than previously thought. These data indicate that people arrived before the Bassian Bridge was exposed about 23,000 years ago and support evidence that Tasmania and Australia may have been connected intermittently during the past 50,000 years. The dates support earlier suggestions that the Tasmanian inland was an important focus for systematic occupation and exploitation by human groups and dispel a belief that the Aboriginal economy 30,000 years ago was based on littoral, lacustral, and riverine resources. The absence of megafauna at both sites points to their extinction by 30,000 years ago in Tasmania. The people inhabiting Tasmania at this time, together with those at Monte Verde in Chile, were the most southerly humans on Earth.

THE DISTRIBUTION OF AUSTRALIAN Pleistocene Aboriginal populations has been characterized as widespread, with low densities possessing little regional variation (*1–3*). This has been supported in part by the nature of the archeological evidence, being geographically diverse and poorly preserved with relatively few material remains. The presence of rich Pleistocene limestone cave deposits in southwest Tasmania has led to the challenging of this view and to a reevaluation of the nature of Tasmanian Pleistocene human populations (*4*). Evidence emerging from recent excavations in the area suggests that a regionally coordinated economic system functioned over a wide area of this zone during the last glacial stage (*5*). How far this extended, and was linked to, southeast Tasmania was not known as no Pleistocene sites had been found there (*6*). The aim of recent excavations was to identify the eastern limits of the southwest system and to examine the possibility that distinctive regional economic systems existed within the two zones during the Pleistocene. To date, only a portion of the excavated material has been analyzed.

Two rockshelters, Bluff Cave and site ORS 7, were excavated from December 1987 through February 1988. They lie at the division of two environmental zones in south central Tasmania: to the west, a fold-structured geology vegetated by temperate rainforest and to the east, a fault-structured geology vegetated by dry sclerophyll forest (Fig. 1).

Bluff Cave is a small limestone shelter situated at an altitude of 400 m in the Florentine valley. The cave faces southeast and is surrounded by wet sclerophyll scrub and rainforest vegetation. In a cultural deposit 60 cm deep, a basal age of 30,420 ± 690 years before present (BP) (Beta-25881) and an age of 11,630 ± 200 BP (Beta-25877), 5 cm below the surface, have been found. Nine additional dates, all conventional carbon-14 dates, support the antiquity of the site (Table 1). The anomaly in unit 11/1 may be due to mixing or interleaving of hearth material during occupation.

Of the six sedimentary layers (Fig. 2), the lower three are sterile whereas the upper three have rich evidence of occupation. The lowest layer is a deposit of hard calcium carbonate. Overlying this is a manganese-coated cobble bed and a bright yellow silty clay.

Layer three lies directly on top of the yellow silty clays. This is culturally rich, containing approximately 12,000 stone flakes, bone, and high concentrations of charcoal. Animal remains include a range of modern fauna, bird bone, and emu egg shell. The matrix is composed of sticky, alkaline (*p*H 8.5), brown clays derived from the yellow deposit below.

Layer two is a brown, alkaline (*p*H 8.5) soil cemented by calcium carbonate. Charcoal and stone flakes are abundant. The bone is less fragmented and much of it was recovered intact. The range of animal species found here is similar to those in layer three.

Layer one is a calcium carbonate flowstone sealing the whole deposit. The bone remains are dominated by small mammals like the broad-tooth rat (*Mastacomys fuscus*). Small stone flakes occur throughout, whereas a large core and several artifacts lay on its surface, suggesting infrequent visits to the shelter before final abandonment.

Site ORS 7 is a large sandstone shelter perched above the deeply incised Shannon River valley on the edge of the Tasmanian high plateau. It faces northeast at an altitude

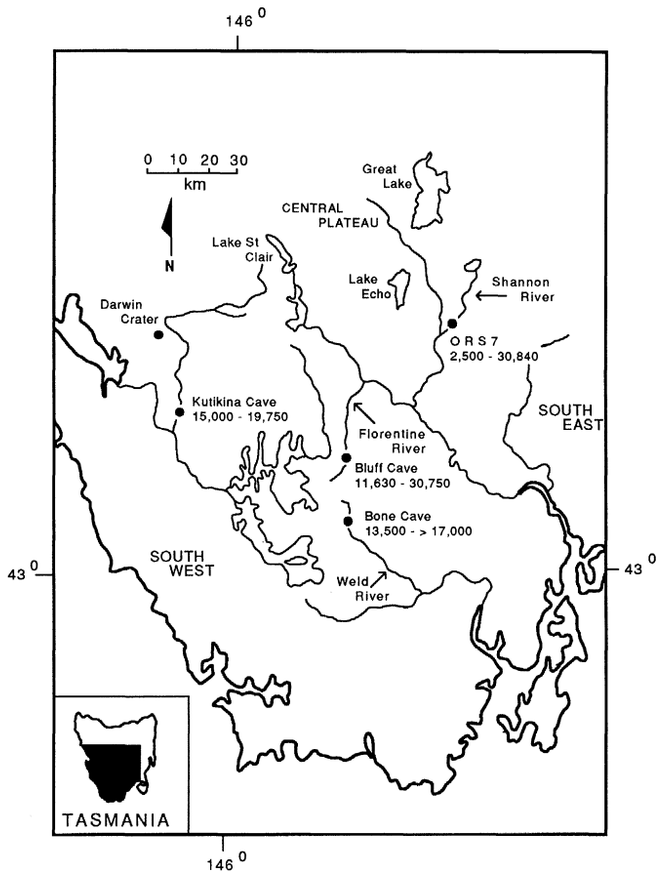

Fig. 1. Southwest and south central Tasmania showing the location of Bluff Cave and ORS 7 and the distribution of Pleistocene archeological sites.

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of 440 m. The vegation is open dry eucalypt forest with pasture and native grasses covering the surrounding land. Radiocarbon assays indicate human occupation between 30,840 ± 480 BP (Beta-23404 and ETH-3724) and 2,450 BP (Beta-25620) (Table 2). The oldest date was obtained by accelerator mass spectrometry (AMS) and was collected from an in situ hearth. A carbon-14 age of 16,200 ± 590 BP (Beta-27054) was assayed from 0.3 g of carbon obtained from 5 cm below sample Beta-23404/ETH-3724 and is anomalous with the AMS date. Given the older dates from in situ hearths 25 cm above, the small proportion of modern carbon (in this case 0.03 g) needed to contaminate old charcoal (7), and the sample size measured, Beta-27054 is considered to have been contaminated.

Although 3 m^3 of deposit has been excavated containing about 2,000 artifacts, only 0.60 m^3 of it has been analyzed in detail. From this, a total of 548 artifacts have been recorded. The cultural deposit is 55 cm deep and was dug in 5-cm spits. It consists of four sedimentary layers (Fig. 2), the lowest of which is a loose, yellow sand, containing blocks of rounded roof fall. This layer is sterile and has a *p*H of 6.

Layer three is a heavily cemented, yellow-brown, alkaline (*p*H 8) sandy soil, containing laminar roof fall and a total of 371 artifacts. The 30,840 BP date came from spit 9 containing 179 stone artifacts. A date of 19,080 BP was obtained from a small hearth in spit 5, while a date of 17,660 BP was obtained from a fire pit dug into its western edge. This spit contains 22 artifacts and reflects occupation during the onset of glacial conditions. Bone is preserved, and the artifacts from this layer are unretouched flakes.

Layer two is a slightly less compacted, alkaline (*p*H 9), sandy soil with a reddish hue. A date of 18,480 BP was assayed from a hearth in spit 4, and a date of 10,440 BP was obtained from spit 3. Faunal remains are sparse and stained with manganese. The 96 artifacts from here are flakes without retouching. Emu eggshell occurs as small broken angular pieces throughout the layer.

Layer one is a loose sandy deposit disturbed by animals. A date of 2,450 BP was assayed from an in situ hearth 5 cm below the surface. The matrix is composed of burnt organic matter, charcoal, and 177 stone artifacts. A small proportion of these are retouched.

The small sample excavated from Bluff Cave (~1 m^3) contains about 30,000 stone flakes and many kilograms of bone. The faunal component shows the use of resources such as emu eggs, kangaroos, and birds; the notion that the paleohunters used a targeting strategy concentrating only on wallabies thus needs modification (*4*). The presence of emu eggs at Bluff Cave and site ORS 7 would indicate at least a late winter, early spring occupation. No remains of extinct megafauna were found at either site.

Technologically the stone tools from Bluff Cave are similar to those found in the other sites in southwest Tasmania (*4, 6, 8, 9*). Thumbnail scrapers, which make their first appearance at Kutikina Cave 17,000 BP, appear in Bluff Cave about 21,500 BP, pointing to the earlier development of these artifacts.

The proportions of raw material types used at Bluff Cave are, however, quite differ-

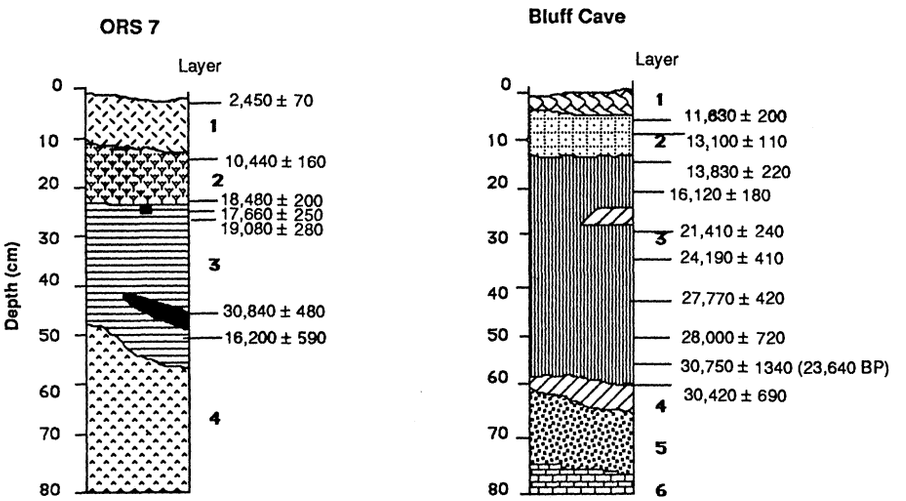

Fig. 2. Schematic representations of the stratigraphy and location of carbon-14 dates from Bluff Cave and ORS 7.

Table 1. Radiocarbon dates from Bluff Cave, Florentine River valley. The dates reported from both sites are radiocarbon years before A.D. 1950. The half-life of radiocarbon is taken as 5,568 years and 95% of the activity of the National Bureau of Standards oxalic acid (original batch) used as a modern standard. The quoted errors are from the counting of the modern standard, background, and sample being analyzed. They represent one standard deviation based on the random nature of the radioactive disintegration process. All dates are based on one sample per unit and spit. By international convention, no corrections were made for DeVries effect, reservoir effect, or isotope fractionation in nature.

Layer	Unit	Depth (cm)	Date (BP)	Sample	Material
1	2/1	5	11,630 ± 200	Beta-25877	Charcoal
2	3/1	10	13,100 ± 110	25381	Charcoal & soil
3	4/1	15	13,830 ± 220	25878	Charcoal
3	5/1	20	16,120 ± 180	27075	Charcoal
3	6/1	30	21,410 ± 240	27076	Charcoal
3	7/2	35	24,190 ± 410	25879	Charcoal
3	9/1	42	27,770 ± 420	25880	Charcoal
3	10/1	50	28,000 ± 720	28323	Charcoal
3	11/1	53	23,640 ± 310	25382	Charcoal & soil
3	11/1	55	30,750 ± 1340	28324	Charcoal
3	11/2	60	30,420 ± 690	25881	Charcoal

Table 2. Radiocarbon dates from site ORS 7, Shannon River valley. Sample ETH-3724 was calculated by AMS technique and measurements were made in triplicate at the Eidgenossische Technische Hochschule University in Zurich. The date has been corrected by carbon-13 for total isotope effect generated in nature and during the physical and chemical laboratory procedures.

Layer	Spit	Depth (cm)	Date (BP)	Sample	Material
1	1	5	2,450 ± 70	Beta-27078	Charcoal
2	3	15	10,440 ± 160	27079	Charcoal
3	4	22	18,480 ± 200	27077	Charcoal
3	5	23	17,660 ± 250	25620	Charcoal
3	5	25	19,080 ± 280	27080	Charcoal
3	9	45	30,840 ± 480	23404 & ETH-3724	Charcoal
3	9	50	16,200 ± 590	27054	Charcoal

ent from other southwest sites and reflect the distinctive geology of the area. The presence of crystal quartz indicates contact with Bone Cave and the Weld River, 25 km to the south where deposits of the material are known (*5*).

Five pieces of the impactite, Darwin glass (*10*), were excavated from the deposits, the lowest being associated with a date of ~27,770 BP. It suggests contact with the Darwin meteorite crater 75 km to the west. A journey of over 100 km down the principal river systems would have been involved in bringing this stone into the Florentine valley. Its appearance at Bluff Cave predates its introduction into Kutikina Cave by 10,000 years. The presence of the distinctive raw materials and tool types at Bluff Cave links it into a network of human activity centered on southwest Tasmania during the Pleistocene.

No common southwest raw materials such as chert, crystal, and milky quartz or Darwin glass were excavated from site ORS 7. The majority of stone raw materials excavated are locally available. In addition, no thumbnail scrapers were recorded from ORS 7. Although alkaline soil conditions occur at both sites, the amount of faunal remains preserved at each is significantly different. The distinct pattern of late Pleistocene artifact assemblages, raw materials, and fauna found between the southwest and southeast regions suggest adaptations to distinctive, but related environments.

These results are important in three ways. First, they push back the timing of human colonization of Tasmania at least 8,000 years; second, they indicate human exploitation of upland environments 10,000 years earlier than previously recorded on the Australian mainland (*11, 12*) and 20,000 years earlier in Tasmania (*13*); and third, they suggest that by 30,000 years ago megafauna was extinct in Tasmania. The first is significant in light of the recent evidence for sea level fluctuations in the Bass Strait area between 55,000 and 10,000 years ago (*14–16*). These data suggest three periods prior to the onset of the last glacial (25,000 to 10,000 years ago) when Tasmania was connected to the Australian mainland by the exposed Bassian Rise, the longest extending from 37,000 to 29,000 years ago. This approximates the oldest secure date for human occupation in Greater Australia (40,000 years) from eastern New Guinea (*17*). The possibility now arises that humans reached Tasmania 36,000 years ago when a drop in sea level of 55 m exposed a portion of the Bassian Rise.

The second import of the dates is that although Pleistocene human presence in central Tasmania had been previously demonstrated (*6*), the new data indicate occupation of the southern edge of the flat, exposed highlands prior to, and during the height of, the last glacial period. This area carried the largest Tasmanian ice sheet 18,000 years ago. It suggests that people were less concerned with extreme climatic conditions and more intent on the systematic exploitation of a range of environments economically important to them.

The absence of extinct fauna at both sites raises questions about evidence from the Florentine valley suggesting the coexistence of humans and megafauna 20,000 years ago (*6*). An earlier notion that these animals became extinct 11,000 years ago due to vegetational changes is not supported by the present data (*18*). Although specialized kill and consumption sites away from rockshelters cannot be ruled out, the evidence points to an early extinction of these animals prior to human arrival in south central Tasmania. The data further indicate that at this stage of colonization, people were not limited to a narrow littoral and marine economy (*19, 20*) but were focusing on inland environmental zones, hunting a range of modern terrestrial fauna.

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Scanning Tunneling Microscopy of Uncoated recA-DNA Complexes

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Uncoated recA-DNA complexes were imaged with the scanning tunneling microscope (STM). The images, which reveal the right-handed helical structure of the complexes with subunits clearly resolved, are comparable in quality to STM images of metal-coated specimens. Possible conduction mechanisms that allow STM imaging of biological macromolecules are discussed.

THE RESOLVING POWER OF THE STM for analyzing structural and electronic properties of metal and semiconductor surfaces is now well established. We have showed that biological specimens coated with a thin conducting film can be analyzed with the STM and that with this technique molecular details can be revealed (*1*). Recent STM work on organic molecules (*2, 3*), adsorbed on a conducting support, extended the possible application of STM to macromolecules classically thought to be insulating. Tunneling on uncoated organic matter with large three-dimensional structure, such as biological macromolecules, has been reported (*4–9*). However, it was necessary that the specimen be coated with a conducting film or replicated (*10*) to obtain a resolution of structural details comparable to that obtainable with the transmission electron microscope (TEM) (*1, 11*). We report that recA-DNA complexes adsorbed from solution onto a salt-coated conducting film and kept humid during measuring can reproducibly yield high-quality STM images.

The recA-DNA complexes were formed in the presence of ATP-gamma-S (the nonhydrolyzable analog of adenosine triphosphate) under conditions that promote the

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