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ANU RADIOCARBON DATE LIST VI

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The following list contains most of the measurements made during 1974, since our last list (R, 1973, v 15, p 241-251). All measurements were performed on a Beckman LS-200 Liquid Scintillation Spectrometer following previously published setting up (Polach, 1974), automatic cycling (Polach, 1969) and benzene synthesis (Polach and Stipp, 1966; Polach *et al*, 1972) procedures.

Ages are reported as *conventional radiocarbon ages* BP (Olsson, 1970, p 17) using, however, the *ANU Sucrose* contemporary radiocarbon dating standard (Polach, 1976, in press) as a frequent cross check of our 0.95 NBS Oxalic value. The *conventional radiocarbon ages* BP are corrected for isotopic fractionation based on either an estimated $\delta^{13}C$ value (Polach, 1976; Stuiver and Polach, 1977) with an uncertainty of estimate never smaller than ±2‰, or measured $\delta^{13}C$ value with an error of measurement never larger than ±0.2‰. The $\delta^{13}C$ values are expressed wrt to PDB; the error of estimate or measurement is incorporated in the age ± error calculation. The calculations, presentation and annotations follow the suggestions made by Stuiver and Polach (R, 1977, v 19, p 355-363). Thus $D^{14}C$ is the relative difference between the ^{13}C corrected sample activity (count rate) and the measured and ^{13}C corrected oxalic acid activity (count rate). The *conventional radiocarbon age* (t) is thus defined as

$$t = -8033 \ln \left(1 + \frac{D^{14}C}{1000} \right).$$

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SAMPLE DESCRIPTIONS

I. GEOLOGIC SAMPLES

A. Australia

Lake George series, New South Wales

Since 1820 Lake George has been dry 6 times and has never been deeper than 7.3m, although higher lake levels occurred in colder Late

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Quaternary times. Study of geomorphology, sediments and soils of surficial deposits of lake basin established a sequence of abandoned shoreline features up to 36m above lake bottom (Coventry, 1976; Coventry and Walker, 1977). Relative sequence of these deposits was determined by radiocarbon dating.

Samples, except for ANU-519, were coll by R J Coventry in 1970 within Lake George Basin (35° 25′ S, 149° 25′ E), ca 40km NE of Canberra, Australia and subm by Dept Biogeog & Geomorphol, ANU.

Detailed descriptions of sites sampled are included in Coventry (1973). Analyses, except for ANU-501 and -521/2, were made on handpicked charcoal fragments washed in hot 2N hydrochloric acid followed by washing with distilled water.

Other dates previously available within Lake George Basin are: GaK-962: 15,100 ± 300 BP; abandoned beach sediment 15m above lake base (Galloway, 1967); and GaK-2025: 3470 ± 210 BP, same beach complex as GaK-962 but different beach ridge (J N Jennings, October, 1976, oral commun).

ANU-501. **$D^{14}C$ = 930.9 ± 4.7‰** **21,470 ± 570**
Est $\delta^{13}C = -24.0‰$

Soft, finely divided, black charcoal in matrix of clay-rich angular gravel of probable fluvial origin, overlying bedrock at base of Fernhill Gully sec. Gravel overlain by rounded beach gravel related to highest level attained by Lake George during last Glacial Maximum. Gravel and large rootlets were removed by hand, sample crushed in a jaw-crusher, macerated in dilute HCl (pH=5.5), allowed to settle, supernatant water decanted; 700gm oven-dried surface crust containing charcoal-enriched fine sediment was used in 4 successive combustions and 673gm ash recovered. 1200 min count. *Comment* (RJC): pretreatment may not have removed all modern rootlet contamination and date is probably a little younger than expected. Same layer resampled and dates ANU-521/1, -521/2 obtained.

ANU-502. **$D^{14}C = -770.6$ ± 19.7‰** **11,830 ± 720**
Est $\delta^{13}C = -24.0‰$

Hard, yellow-black, partly mineralized charcoal fragments up to 10mm long in soil matrix. From lower aeolian sand layer of Fernhill Gully, immediately overlying ANU-501, -521 and overlain by ANU-505. Dilution, 16% sample (1560 min count). *Comment* (RJC): sample is about half expected age — possibly incorporated modern, decayed, intrusive root material in field sample.

ANU-503. **$D^{14}C = -536.2$ ± 61.9‰** **6170 ± 1150**
Est $\delta^{13}C = -24.0‰$

Small fragments of black charcoal in gravelly clay loam forming basal layer of Macgrogan Fan, directly overlying bedrock. Dilution, 4% sample (1840 min count).

ANU-504. **$D^{14}C = -964.6 \pm 10.6‰$** **$26,840^{+2860}_{-2100}$**

Est $\delta^{13}C = -24.0‰$

Partly mineralized, yellow-black charcoal in soil matrix. Some calcium carbonate nodules in this gravelly clay loam layer of North Barney Fan, overlying strongly weathered, basal gravel layer. Dilution, 25% sample (1820 min count).

ANU-505. **$D^{14}C = -946.3 \pm 6.8‰$** **23,490 ± 1100**

Est $\delta^{13}C = -24.0‰$

Strongly mineralized, hard, orange-black lumps of charcoal. Intermediate aeolian sand layer of Fernhill Gully overlying beach gravels deposited by Lake George during the last Glacial Maximum. From same layer as ANU-508; overlies ANU-501, -502, -521/1, -521/2 and overlain by ANU-507, -509, -510, -518. Dilution, 53% sample (1040 min counts).

ANU-506. **$D^{14}C = -509.4 \pm 19.4‰$** **5720 ± 320**

Est $\delta^{13}C = -24.0‰$

Small fragments of mineralized yellowish-black charcoal. From middle gravelly clay loam layer of Macgrogan Fan; overlies ANU-503 and overlain by ANU-520. Dilution, 20% sample (1120 min count).

ANU-507. **$D^{14}C = -96.1 \pm 17.6‰$** **810 ± 160**

Est $\delta^{13}C = -24.0‰$

Small, black charcoal fragments from lower A_2 and upper B_2 horizons of moderately differentiated yellow podzolic soil formed in aeolian clay exposed in Fernhill Gully. Dilution, 33% sample (740 min count). *Comment* (RJC): date is much younger than expected for soil of this degree of profile differentiation in clay-rich parent materials. Young age possibly due to incorporation of modern intrusive, decayed root material in field sample.

ANU-508. **$D^{14}C = -877.7 \pm 27.9‰$** **16,880 ± 2080**

Est $\delta^{13}C = -24.0‰$

Highly mineralized lumps of yellowish charcoal from C horizon of intermediate aeolian sand layer of Fernhill Gully. Layer is same as that for ANU-505. Dilution, 11% sample (1500 min count). *Comment* (HAP): pooled mean (Polach, 1969) of dates ANU-505 and ANU-508, both from same stratigraphic unit, is 21,030 ± 1270 BP.

ANU-509. **$D^{14}C = -416.1 \pm 10.3‰$** **4320 ± 145**

Est $\delta^{13}C = -24.0‰$

Highly mineralized, yellowish-black charcoal fragments up to 8mm long from base of upper aeolian sand layer of Fernhill Gully. ANU-518 from upper part, 1.5m stratigraphically higher, of same layer. Dilution, 13% sample (1140 min count).

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ANU-510. **$D^{14}C = -39.6 \pm 9.0‰$** **320 ± 80**
Est $\delta^{13}C = -24.0‰$

Black, soft and friable charcoal. Fernhill Gully: from gravelly sandy clay loam sediments at base of soil stratigraphic unit that consists of fluvially reworked aeolian sands. These sands were dated by ANU-509 and -518 (1080 min count).

ANU-511. **$D^{14}C = -604.6 \pm 9.0‰$** **7450 ± 190**
Est $\delta^{13}C = -24.0‰$

Small fragments of black, slightly mineralized charcoal. From gravelly clay loam C horizon of weakly differentiated red podzolic soil of middle fan terrace of Sheridan Fan. Dilution, 27% sample (2960 min count).

ANU-512. **$D^{14}C = -183.2 \pm 11.2‰$** **1630 ± 110**
Est $\delta^{13}C = -24.0‰$

Lumps of black, brittle charcoal up to 15mm long. Basal gravelly clay loam of Hadlow Fan with gray minimal prairie soil deposited by stream after it cut through beach ridge lying 15m above lake bottom. Dilution, 45% sample (1120 min count).

ANU-513. **$D^{14}C = -253.3 \pm 6.7‰$** **2350 ± 75**
Est $\delta^{13}C = -24.0‰$

Lumps of black, brittle charcoal. Sample from base of gravelly clay loam layer with gray minimal prairie soil in One Gum Fan truncated by high stand of lake when 7m deep (1120 min count).

ANU-514. **$D^{14}C = -422.0 \pm 6.0‰$** **4400 ± 85**
Est $\delta^{13}C = -24.0‰$

Lumps of black, brittle charcoal. Gravelly sandy loam layer of middle fan terrace of South Lees Fan with reddish minimal prairie soil (1100 min count).

ANU-515. **$D^{14}C = -205.0 \pm 10.9‰$** **1840 ± 110**
Est $\delta^{13}C = -24.0‰$

Small fragments of black, brittle charcoal. From C horizon of gray minimal prairie soil formed in sediment of youngest alluvial fan terrace of North Lee Fan. Dilution, 37% sample (1560 min count).

ANU-516. **$D^{14}C = -256.7 \pm 32.2‰$** **2380 ± 360**
Est $\delta^{13}C = -24.0‰$

Small lumps of black, brittle charcoal. From C horizon of gray minimal prairie soil formed in sediment of youngest alluvial fan terrace of South Barney Fan. Dilution, 9% sample (2600 min count).

ANU-517. **$D^{14}C = -498.5 \pm 14.9‰$** **5540 ± 240**
Est $\delta^{13}C = -24.0‰$

Soft, friable, yellowish-black charcoal from medium to very coarse sand layer underlying 75cm beach gravel of Vault Embankment. Beach gravel was deposited when Lake George stood 12m deep and is overlain by aeolian sand similar to that dated by ANU-509 and -518. Dilution, 25% sample (1100 min count).

ANU-518. **$D^{14}C = -213.2 \pm 5.4‰$** **1930 ± 60**
Est $\delta^{13}C = -24.0‰$

Lumps of partly mineralized, yellowish-black charcoal up to 15mm long. From upper aeolian sand layer of Fernhill Gully sec dated also by ANU-509 (2560 min count).

ANU-519. **$D^{14}C = -984.8 \pm 35.7‰$** **Background**
Est $\delta^{13}C = -24.0‰$

Soft, partly mineralized, yellowish-brown, decomposed twigs and charcoal fragments. Remnant of K_4 terrace within Grove Creek Etch Basin, Gearys Gap (35° 06′ S, 149° 22′ E). This basin lies immediately W of Lake George Basin. Coll July, 1968 by P H Walker & M P Green, CSIRO, Division of Soils, Canberra, Australia. Dilution, 8% sample (1680 min count). *Comment* (HAP&RJC): result was reported in press (see below) as > 15,600 using 3σ criterion. Based on recommendations by Stuiver and Polach (R, 1977, v 19, p 362) it is reported here as *Background*. Sample is stratigraphically below and is consistent with previous dates (ANU-91-95) from younger soil stratigraphic units at this locality (R, v 10, p 182-183) and is discussed by Walker & Coventry (1976) and Coventry & Walker (1977).

ANU-520. **$D^{14}C = -346.4 \pm 17.3‰$** **3420 ± 220**
Est $\delta^{13}C = -24.0‰$

Lumps of yellowish-black, brittle charcoal up to 10mm long. From upper gravelly clay loam layer at Macgrogan Fan. Overlies both ANU-503 and -506. Dilution, 24% sample (1120 min count).

ANU-521/1. **$D^{14}C = -960.0 \pm 16.0‰$** **>23,800**
Est $\delta^{13}C = -24.0‰$

Soft, black, highly mineralized charcoal. Basal layer in Fernhill Gully, 35m downstream of ANU-501, overlain by beach gravel related to highest level attained by Lake George during last Glacial Maximum. Coll by H A Polach and R J Coventry, June 1971. Dilution, 15% sample (2600 min count). *Comment* (HAP): result was reported and pub (see refs, ANU-519, above) using 3σ criterion as > 21,400 BP. Recalculated result has *apparent age*, 25,900 ± 4100 BP, consistent with 521/2 below.

ANU-521/2. **$D^{14}C = -964.7 \pm 3.7‰$** **26,870 ± 900**
Est $\delta^{13}C = -24.0‰$

Sample as for ANU-521/1. Macerated in distilled water, allowed to settle, charcoal concentrated in this manner and treated as for other samples in series (1040 min count).

General Comment (RJC&HAP): most important conclusion from this dating program is that Lake George attained a level equal to its overflow point, 36m above lake bottom, during last Glacial Maximum between 27,000 BP, dates ANU-501, -521/1, -521/2, and 21,000 BP, pooled mean of dates ANU-505 and -508. This high lake level was achieved under cooler and drier conditions than at present (Coventry, 1976). These dates have also fixed ages of other more recent, relatively high lake levels, and of several phases of aeolian sand deposition and alluvial fan aggradation (Coventry & Walker, 1977).

ANU-294. Borenore Arch Cave, Orange, New South Wales, Australia

$D^{14}C = -968.4 \pm 6.5‰$ **$27,760^{+1860}_{-1510}$**

Est $\delta^{13}C = -24.0‰$

Guano sample coll from flowstone deposit, sandwiched between alluvium, 230 to 260cm below floor of Borenore Arch Cave 20km W of Orange, New South Wales, Australia (33° 15′ S, 148° 56′ E). Deposit recorded a period of absence of streams from their previous and subsequent channels, indicating a dry climatic phase in the area. Coll Sept 1968 and subm by R M Frank, Dept Biogeog & Geomorphol, ANU. Organic matter extracted using sod pyrophosphate (2460 min count). *Comment* (RMF): result corroborated period of dry climatic phase previously dated by 2 inorganic ^{14}C dates on calcium carbonate (R2457/4, 27,300 BP, with no standard deviation given; R2457/2, 27,900 ± 1500 BP; (Frank, 1972; 1973; 1975).

ANU-749. North-west Continental Shelf, Australia

$D^{14}C = -978.5 \pm 3.0‰$ **30,850 ± 1200**

Est $\delta^{13}C = 0.0‰$

Sample resembled shallow water "calcretes" correlated with last major low sea level stand at ca 18,000 BP in NW Australia. If sample were young enough to be dated, it would imply substantial tectonic movement in area. Dredged from sea floor at 282m water depth (13° 16′ S, 123° 37′ E) in 1967. 10% of surface material removed with dilute HCl. Coll and subm by H A Jones, Bureau Mineral Resources, Canberra, Australia. Oolitic limestone. Acid hydrolysis CO_2 (1120 min count). *Comment* (HAJ): results indicate that submarine lithification has occurred during Quaternary and that no sedimentation has taken place in Holocene (Jones, 1973).

ANU-646. Mt Schank, South Australia

$D^{14}C = -894.5 \pm 4.4‰$ **18,100 ± 350**

Est $\delta^{13}C = -24.0‰$

Soft charcoal in discrete fragments coll from buried soil forming upper surface of Burleigh dune (37° 56′ S, 140° 45′ E), major ridge trending NW-SE, and according to Sprigg (1952), consisting of Pleistocene aeolianite. Mt Schank is 12.9km SSW of Mt Gambier, South Australia. Estimates of age of volcanic activity of Mt Schank vary from 150,000 to 200,000 (Sprigg, 1952, p 115) to "quite late prehistoric time" (Fenner, 1921, p 185). Coll Jan 1971 and subm by E B Joyce, School Geol, Univ Melbourne, Australia (960 min count). *Comment* (EBJ): age of activity at Mt Schank was estimated as late Pleistocene to mid-Holocene, based on preservation of volcanic features in comparison with Mt Gambier (R, 1966, v 8, p 61) and other dated volcanoes (Joyce, 1974; 1975). Date obtained by ^{14}C is within this range. It clearly indicates that activity at Mt Schank was separate from that at Mt Gambier and was also distinctly earlier than activity at several Victorian volcanoes already dated by ^{14}C as early as mid-Holocene. This is oldest volcano in SE Australia directly dated by ^{14}C, although ^{14}C dates relating to earlier activity have been obtained, as well as K–Ar dates on flows dating to late-Pliocene. In light of ^{14}C date at Mt Schank it is now necessary to re-examine suggestion of Sprigg (1952) on relationship of Mt Schank activity and higher sea levels in area.

Melville Island series

Pockets of monsoon forest in N Australia seem to be relics of previously wide-spread, relatively continuous flora (Specht, 1958). The discovery of abandoned mound nest of *Megapodius freycinet tumulus* Gould in eucalypt forests on Karslake Peninsula, Melville I., Australia, (11° 20′ S, 130° 39′ E), indicates recent changes in extent of monsoon forest in area. This bird constructs mound nests only in monsoon forest and related plant communities. Over a hundred abandoned mound nests were found in area of 405ha at tip of Peninsula. Coll 1967 by G C Stocker, Forest Research Inst, Dept Natl Development; subm by Geophysics, ANU.

ANU-206. **$D^{14}C = -181.6 \pm 8.0‰$** **1610 ± 80**
Est $\delta^{13}C = -24.0‰$

Charcoal from interval 99 to 129cm below crest of abandoned mound nest 101m from nearest monsoon forest edge (1020 min count).

ANU-207. **$D^{14}C = -196.5 \pm 7.8‰$** **1760 ± 80**
Est $\delta^{13}C = -2.0‰$

Marine shells (*Telescopium telescopium* Linne) from same position in mound as ANU-206. 10%, outer shell surface, by weight leached away by acid (1020 min count). *Comment* (GCS): shells probably thrown near nest by aborigines and later scratched into nest by fowls. Mound is ca 183m from, and 9m above present maximum spring tide level. No other excavated mound contained shells.

ANU-208. **$D^{14}C = -243.3 \pm 7.2‰$** **2240 ± 80**
Est $\delta^{13}C = -24.0‰$

Charcoal from interval 76 to 104cm below crest of abandoned mound nest 283m from nearest monsoon forest edge. A very small monsoon forest relic of a few trees is 174m from mound (1020 min count).

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ANU-209. **$D^{14}C = -345.0 \pm 6.6‰$** **3400 ± 90**
Est $\delta^{13}C = -24.0‰$

Charcoal from interval 91 to 122cm below crest of abandoned mound nest 252m from nearest monsoon forest edge (1000 min count).

ANU-210. **$D^{14}C = -639.7 \pm 8.2‰$** **8200 ± 180**
Est $\delta^{13}C = -24.0‰$

Charcoal from interval 91 to 122cm below crest of abandoned mound nest 420m from nearest monsoon forest edge (1020 min count). *Comment* (GCS): mound is on S edge of area containing abandoned mound nests and may be close to old monsoon — eucalypt forest boundary.

ANU-211. **$D^{14}C = -453.8 \pm 6.0‰$** **4860 ± 90**
Est $\delta^{13}C = -24.0‰$

Charcoal from interval 61 to 91cm below crest of abandoned mound nest 402m from nearest monsoon forest edge (1060 min count).

General Comment (GCS): although abandoned mound nests are often found in monsoon forest communities throughout coastal region of Northern Territory, no other areas have as many nests in eucalypt forests as on N part of Karslake Peninsula. Considerable reduction in area occupied by monsoon forest must have occurred in this locality. Decline would have commenced after construction of mound represented by ANU-210, 8200 ± 180. Resistance of mounds to erosion and their absence from eucalypt forests in other areas suggests that monsoon forests have not all retreated and in most localities boundaries have been relatively stable during recent epoch.

Gawler River series

Samples coll from alluvium at depth 5.2m below surface of river terrace, 3.2km SW of Gawler, South Australia (34° 37′ S, 138° 43′ E). Hearths and tree trunk excavated from base of younger alluvium in valley of Gawler R. Hearths are quite numerous and are restricted to one level. Coll November 1967 by C R Twidale, Dept Geog, Univ Adelaide; subm by Australian Inst Aboriginal Studies.

ANU-204. **$D^{14}C = -29.0 \pm 8.1‰$** **235 ± 70**
Est $\delta^{13}C = -24.0‰$

Charcoal from hearth (1000 min count).

ANU-205. **$D^{14}C = -45.8 \pm 8.1‰$** **375 ± 70**
Est $\delta^{13}C = -24.0‰$

Wood, from tree trunk found *in situ* at base of younger alluvium (980 min count).

General Comment (CRT): results date period of fairly intense aboriginal occupation at site, maximum age of younger alluvium. Part of broader geomorphologic and stratigraphic study.

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B. New Guinea and Pacific Islands

Huon Peninsula series

Samples are from youngest reefs of Huon coral terraces, Papua New Guinea, described by Chappell (1974) and fall into 2 groups.

The 1st contains 9 samples from emergent Holocene reef, which are combined with previous ^{14}C and ^{230}Th and ^{234}U results (R, 1969, v 11, p 254-262; Veeh & Chappell, 1970; Bloom *et al*, 1974) to provide close dating control for study of relationships between Holocene sea level change and coral reef growth (Chappell & Polach, 1976).

The 4 samples of 2nd group come from Huon Reef Complex III, well dated by $^{230}Th/^{234}U$ as 40,000 yr old, and provide additional data to complement 1st study of diagenesis and ^{14}C contamination by Chappell & Polach (1972).

Interpretation of new and previous carbon-isotope data, together with uranium-series results, appears in Chappell *et al* (1974). Coll Aug 1971 and Aug 1973; subm by John Chappell, Dept Geog, ANU.

1) Holocene reef samples

These occur in vertical sequence from crest of reef to 8m below crest. Reef grew as sea level rose, and sample ages become younger upwards. Samples are listed in terms of depth below reef crest, rather than code numbers, as this makes clear age-depth relationship.

ANU-1250. **$D^{14}C = -560.9 \pm 7.4‰$** **6610 ± 140**
Est $\delta^{13}C = 0.0‰$

Goniastrea pectinata, 0.5m below crest (6° 7′ 30″ S, 147° 38′ 22″ E). Dilution, 61% sample (900 min count).

ANU-1190. **$D^{14}C = -606.8 \pm 4.3‰$** **7500 ± 90**
Est $\delta^{13}C = 0.0‰$

Goniastrea retiformis, 4m below crest, 100% aragonite (1580 min count).

ANU-1191. **$D^{14}C = -617.7 \pm 6.8‰$** **7720 ± 140**
Est $\delta^{13}C = 0.0‰$

Leptoria phrygia, 5.5m below crest (6° 13′ 20″ S, 147° 41′ 05″ E), 99% aragonite. Dilution, 52% sample (1500 min count).

ANU-1189. **$D^{14}C = -612.1 \pm 4.3‰$** **7610 ± 90**
Est $\delta^{13}C = 0.0‰$

Favia stelligera, 6m below crest (6° 7′ 30″ S, 147° 38′ 22″ E), 100% aragonite (1500 min count).

ANU-1249. **$D^{14}C = -616.9 \pm 5.0‰$** **7710 ± 110**
Est $\delta^{13}C = 0.0‰$

Pocillopora sp, 6.3m below crest, 97% aragonite (920 min count).

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ANU-1248. **$D^{14}C = -629.6 \pm 5.5‰$** **7980 ± 120**
Est $\delta^{13}C = 0.0‰$

Hydnophora mocroconus, 6.5m below crest, 100% aragonite (1020 min count).

ANU-1251. **$D^{14}C = -639.0 \pm 5.0‰$** **8180 ± 110**
Est $\delta^{13}C = 0.0‰$

Pocillopora sp, 7m below crest, 97% aragonite (920 min count).

ANU-1252. **$D^{14}C = -636.8 \pm 5.0‰$** **8140 ± 110**
Est $\delta^{13}C = 0.0‰$

Acropora humilis, 8m below crest, 100% aragonite (920 min count).

ANU-1253. **$D^{14}C = -622.6 \pm 5.2‰$** **7830 ± 110**
Est $\delta^{13}C = 0.0‰$

Goniastrea retiformis, 8.3m below crest, 100% aragonite (1000 min count).

General Comment (JC): Group 1 results are accepted as satisfactory ^{14}C age measurements. For comparison with terrestrial materials, sea water age correction, 400 ± 100 yr for Huon, must be subtracted (Chappell & Polach, 1976).

2) Late Pleistocene reef samples with diagenetic contamination

All from Huon Reef IIIb, Kanzarua area (6° 12′ 40″ S, 147° 41′ 40″ E), age 40,000 ± 2000 BP, based on $^{230}Th/^{234}U$ dates (Bloom *et al,* 1974).

ANU-1030. **$D^{14}C = -911.2 \pm 2.6‰$** **19,450 ± 240**
Est $\delta^{13}C = 0.0‰$

Coral (sp not id), 7% recrystallized to sparry low-Mg calcite (2100 min count).

ANU-1031. **$D^{14}C = -975.2 \pm 2.4‰$** **29,690 ± 830**
Est $\delta^{13}C = 0.0‰$

Coral (*Hydnophora exesa*) 3% recrystallized to sparry low-Mg calcite, $^{230}Th/^{234}U$ age 42,000 ± 3000 (Bloom *et al,* 1974, Sample L1353D) (2080 min count).

ANU-1302. **$D^{14}C = -968.2 \pm 2.5‰$** **27,710 ± 650**
Est $\delta^{13}C = 0.0‰$

Coral (sp not id), 6% recrystallized to sparry low-Mg calcite (1880 min count).

ANU-1033. **$D^{14}C = -895.8 \pm 6.3‰$** **18,170 ± 500**
Est $\delta^{13}C = 0.0‰$

Coral (*Symphyllia nobilis*) 3% recrystallized to sparry low-Mg calcite. Dilution, 44% sample (1520 min count).

General Comment (JC): ANU-1030-1033 have low percentage of recrystallization to sparry calcite, 3% to 7%, determined by x-ray diffrac-

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tion by method of Chappell & Polach, 1972. Apparent ^{14}C ages are substantially lower than accepted $^{230}Th/^{234}U$ age of their parent reef, and demonstrate intrinsic unreliability of corals, bearing only slight alteration, for ^{14}C dating of Late Pleistocene reefs (Chappell *et al*, 1974).

ANU-247. Central Watom Island, New Britain

$D^{14}C = -239.6 \pm 6.9‰$ 2200 ± 80

Est $\delta^{13}C = -24.0‰$

Finely dispersed charcoal in greenish volcanic soil, from Rakival village on island's NE coast (4° 5′ S, 152° 5′ E). Coll 1967 by C A Key, Prehist, ANU, subm by Prehist (1080 min count). *Comment* (CAK): sample immediately underlies ANU-72, 720 ± 57 (R, 1968, v 10, p 194) and should establish date for last major eruption of Rabaul volcanic complex.

Ambrym Island series

Samples coll by P J Stephenson, Geol Dept, Univ Coll, Townsville, Queensland, engaged in joint project with ANU, dating caldera formations and measuring magnetization of assoc lava flows of Ambrym I., New Hebrides (Stephenson *et al*, 1968). Samples ANU-86 and -87 coll at base of nuée ardente deposit, 30.5m thick. This is youngest deposit observed on flanks of original Ambrym volcanic cone, except for mantling ash from very young (historic) and recent eruptions. Nuée overlies succession of lavas and older pyroclastic rocks, which make up upper succession of flanks of main Ambrym original cone. They were erupted in late pre-caldera times.

ANU-86. $D^{14}C = -207.0 \pm 10.5‰$ 1865 ± 110

Est $\delta^{13}C = -24.0‰$

ANU-87. $D^{14}C = -218.5 \pm 10.8‰$ 1980 ± 115

Est $\delta^{13}C = -24.0‰$

Both samples of carbonized tree trunks from basal zone of nuée deposits. Coll at foot of exposure in Spring Creek (16° 11′ S, 168° 06′ E), 1km from coast, 30cm back from face and 1.5m above bed of creek. Both 1300 min determinations.

ANU-88. $D^{14}C = -193.2 \pm 10.9‰$ 1725 ± 110

Est $\delta^{13}C = -24.0‰$

ANU-89. $D^{14}C = -223.3 \pm 8.7‰$ 2030 ± 90

Est $\delta^{13}C = -24.0‰$

Both samples of carbonized tree trunks, from outcrop in bed of NE creek inside caldera rim (16° 13′ S, 168° 11′ E), 15cm back from face. ANU-88, 2040 min count; ANU-89, 1000 min count.

General Comment (PJS): the 2 groups of ages are consistent and give a minimum age for palaeomagnetic specimens beneath. Results show extreme youth of Ambrym caldera.

C. Africa

Walvis Bay series

Shelf sediments along, biologically, very productive coastal area off SW Africa, particularly near Walvis Bay, are noted for exceptionally high concentrations of organic matter (Calvert & Price, 1971). Inasmuch as sediments of this type may represent significant sinks for uranium in the ocean (Veeh, 1967; Baturin *et al*, 1971), an attempt was made to estimate rate at which uranium is accumulating in these sediments, on basis of dated secs of sediment cores raised from sea floor in this area. Sedimentation rates in terms of cm/1000 yr can be obtained by dividing age difference between top and bottom sec of each core into depth interval separating sample mid-points (Emery & Bray, 1962). Accumulation rate of uranium, or that of any other sediment component, can then be estimated if their concentrations in sediment are known. Such accumulation rate data are indispensable for geochemical balance calculations, yet few are available from critical areas.

Samples were hydrolized, using 50% HCl. Organic residues were separated by filtration. Where sufficient material was available both organic fraction and carbonate fraction were dated; otherwise only organic fraction was used. Coll 1968 by S E Calvert, Inst Oceanog Sci, Wormley, Godalming, U K; subm by H H Veeh, School Earth Sci, Flinders Univ South Australia.

ANU-450A. **$D^{14}C = -218.7 \pm 11.3‰$** **1980 ± 120**
Est $\delta^{13}C = 0.0‰$

Outer shelf, depth 134m (22° 56′ S, 14° 00′ E). Circe 175, sample represents ½ portion of homogenized 70 to 75cm interval of 21cm diam gravity core. Carbonate fraction, dilution, 43% sample (1080 min count).

ANU-450B. **$D^{14}C = -157.8 \pm 7.8‰$** **1380 ± 80**
$\delta^{13}C = -18.9‰$

Circe 175, sample represents remaining ½ portion of 70 to 75cm interval. Organic fraction (1120 min count).

ANU-451A. **$D^{14}C = +73.9 \pm 20.4‰$** **>Modern**
$\delta^{13}C = -0.2‰$

Circe 175, sample represents ½ portion of 0 to 10cm interval of same core as ANU-450A and B. Carbonate fraction, dilution, 11% sample (2860 min count).

ANU-451B. **$D^{14}C = -87.3 \pm 6.7‰$** **730 ± 60**
Est $\delta^{13}C = -20.0‰$

Circe 175, sample represents remaining ½ portion of 0 to 10cm interval. Organic fraction (1500 min count).

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ANU-452A. **$D^{14}C = -289.9 \pm 12.7‰$** **2750 ± 150**
$\delta^{13}C = -0.2‰$

Outer shelf, depth 119m (21° 52′ S, 12° 36′ E). Circe 189B, top 30cm of 4.5cm diam gravity core. Carbonate fraction, dilution, 34% sample (1120 min count).

ANU-452B. **$D^{14}C = -198.0 \pm 7.0‰$** **1770 ± 70**
Est $\delta^{13}C = -20.0‰$

Circe 189B, organic fraction (1100 min count).

ANU-453A. **$D^{14}C = -561.0 \pm 4.6‰$** **6610 ± 80**
$\delta^{13}C = 0.3‰$

Circe 189B, sample represents 60 to 84cm (bottom 24cm) of same core as ANU-452A and B. Carbonate fraction (1460 min count).

ANU-453B. **$D^{14}C = -374.9 \pm 7.7‰$** **3770 ± 100**
Est $\delta^{13}C = -20.0‰$

Circe 189B, organic fraction (740 min count).

ANU-454B. **$D^{14}C = -41.3 \pm 17.3‰$** **340 ± 150**
Est $\delta^{13}C = -20.0‰$

Outer shelf, depth 123m (22° 41′ S, 14° 08′ E). Circe 177B, top 30cm of 4.5cm diam gravity core. Organic fraction, dilution, 34% sample (720 min count).

ANU-455B. **$D^{14}C = -167.3 \pm 31.9‰$** **1470 ± 310**
Est $\delta^{13}C = -20.0‰$

Circle 177B, sample represents 110 to 130cm interval (bottom 20cm) of same core as ANU-454B. Organic fraction, dilution, 50% sample (740 min count).

ANU-456B. **$D^{14}C = -50.2 \pm 16.8‰$** **410 ± 140**
Est $\delta^{13}C = -20.0‰$

Outer shelf, depth 125m (22° 36′ S, 13° 56′ E). Circe 179B, top 30cm of 4.5cm gravity core. Organic fraction, dilution, 35% sample (740 min count).

ANU-457B. **$D^{14}C = -166.7 \pm 11.5‰$** **1470 ± 110**
Est $\delta^{13}C = -20.0‰$

Circe 179B, sample represents 80 to 110cm interval (bottom 30cm) of same core as ANU-456B. Organic fraction, dilution, 59% sample, (740 min count).

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Summary and General Comment (HHV&HAP):

Core no.	Sedimentation rate (cm/1000 yr) (1)	(2)	Uranium accumulation rate* ($\mu g/cm^2/1000$ yr) (1)	(2)
Circe 175	103	34	765	267
Circe 177B	88		676	
Circe 179B	65		723	
Circe 189B	29	15	464	232

* Derived from sedimentation rates and measured uranium concentrations in same cores (Veeh *et al*, 1974)
(1) Based on ^{14}C ages of organic fraction
(2) Based on ^{14}C ages of $CaCO_3$ fraction

It appears that sedimentation rates based on the $CaCO_3$ fractions are lower than those based on the organic fraction. In view of probability of dealing with reworked, or partly wind-derived material when analyzing bulk carbonate fraction in near shore sediments (Emery & Bray, 1962; Olsson & Eriksson, 1965) sedimentation rates based on ^{14}C ages of organic fraction are believed to be more reliable.

West Sahara series

The series deals with soils of West Sahara (South Morocco and Spanish Sahara), the genesis of calcareous crusts forming a major part of thesis for which dating was required. Samples treated by HCl hydrolysis of carbonate. Coll Oct and Nov 1953; subm by K Zimmerman, Inst Soil Sci, Bonn Univ.

ANU-609. **$D^{14}C = -951.3 \pm 3.0‰$** **24,270 ± 510**
$\delta^{13}C = -3.6‰$

Fine sandy limestone of calcareous crust. From E escarpment of plateau "Hameida Tel-lia", 6km SW of Tantan, Morocco (28° 24′ N, 11° 08′ W) (1500 min count).

ANU-610. **$D^{14}C = -634.1 \pm 5.2‰$** **8075 ± 115**
Est $\delta^{13}C = -5.0‰$

Laminated hard limestone of calcareous crust. From quartzite chain 7km NE of Tilemson, Morocco (28° 19′ N, 10° 27′ W) (1500 min count).

ANU-611. **$D^{14}C = -902.4 \pm 3.8‰$** **18,690 ± 320**
Est $\delta^{13}C = -5.0‰$

Dirty gray non-laminated limestone of calcareous crust. From same site as ANU-610 (1500 min count).

ANU-612. **$D^{14}C = -801.6 \pm 3.8‰$** **13,000 ± 155**
$\delta^{13}C = -4.6‰$

Fine sandy limestone of calcareous crust. From E slope of mt chain "Kdir Lemres" 11km NNE of Tilemson (28° 22′ N, 10° 53′ W) (1500 min count).

ANU-613. **$D^{14}C = -860.3 \pm 3.6‰$** **15,810 ± 240**
$\delta^{13}C = -3.7‰$

Sandy limestone of calcareous crust with embedded fine gravelly fragments of non-carbonate rock. Crust overlays that of ANU-614. From valley of Wadi Mazcor, 1km SW of spring, 14km NNEE of Tilemson (28° 23′ N, 10° 50′ W) (1480 min count).

ANU-614. **$D^{14}C = -901.6 \pm 3.5‰$** **18,630 ± 300**
$\delta^{13}C = -5.7‰$

Fine sandy limestone of calcareous crust; gray, slightly yellowish brown, mottled. From same site as ANU-613; from naturally exposed wall of Wadi (1140 min count).

ANU-615. **$D^{14}C = -972.3 \pm 3.2‰$** **28,810 ± 980**
$\delta^{13}C = -5.7‰$

Very pure limestone cores of rounded gravel stones. From summit of N sec of Entayat Mts, 55km NNW of Tichla, Spanish Sahara (21° 58′ N, 15° 11′ W) (1120 min count).

ANU-616. **$D^{14}C = -950.9 \pm 3.3‰$** **24,210 ± 560**
$\delta^{13}C = -1.8‰$

Slightly sandy limestone of calcareous crust. From wall of small dry watercourse in narrow pass between N and S secs of Entayat Mts, Spanish Sahara (21° 57′ N, 15° 13′ W) (1100 min count).

ANU-617. **$D^{14}C = -945.0 \pm 3.9‰$** **23,300 ± 470**
$\delta^{13}C = -3.1‰$

Sandy limestone of calcareous crust with some embedded rock fragments. From low river terrace of Wadi Tueirga, Spanish Sahara (21° 54′ N, 15° 09′ W) (1120 min count).

ANU-974. **$D^{14}C = -930.9 \pm 2.9‰$** **21,470 ± 350**
$\delta^{13}C = -3.1‰$

Sandy limestone of calcareous crust. From highest terrace of Wadi Saguia el Hamra near Aaium, Spanish Sahara (27° 09′ N, 13° 12′ W) (1500 min count).

ANU-975. **$D^{14}C = -986.7 \pm 2.5‰$** **$34,690^{+1630}_{-1360}$**
Est $\delta^{13}C = -5.0‰$

Sandy limestone of calcareous crust. From 1st (lowest) terrace, 3km W of Tantan, Morocco (28° 26′ N, 11° 07′ W) (2000 min count).

ANU-976. **$D^{14}C = -918.0 \pm 3.7‰$** **20,090 ± 370**
$\delta^{13}C = -1.6‰$

Fine sandy limestone of calcareous crust with embedded fine gravelly fragments of non-carbonate rock (mostly quartzite). From low-lying sediment plain near Tilemson, Morocco (28° 17′ N, 10° 54′ W) (960 min count).

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ANU-977. **$D^{14}C = -983.0 \pm 2.6‰$** **$32{,}740^{+1320}_{-1130}$**

$\delta^{13}C = -1.5‰$

Slightly coarse sandy limestone of calcareous crust from 1 to 1.5m below top of exposed wall of well-pit on small level plateau between 2 wadi systems within Ausert Mts, Spanish Sahara (22° 34′ N, 14° 18′ W) (1680 min count).

ANU-978. **$D^{14}C = -975.3 \pm 2.9‰$** **29,730 ± 990**

$\delta^{13}C = -2.5‰$

Coarse sandy and gravelly limestone of calcareous crust; 3 to 3.5m below top of same profile as ANU-977 (1400 min count).

ANU-980. **$D^{14}C = -937.1 \pm 3.5‰$** **22,230 ± 460**

$\delta^{13}C = -1.7‰$

Limestone with embedded sand and rock fragments. From flat level plateau of divide between 2 wadi systems in W part of Entayat Mts, 56km NNW of Tichla, Spanish Sahara (21° 58′ N, 15° 13′ W) (1020 min count).

ANU-981. **$D^{14}C = -966.2 \pm 2.8‰$** **27,210 ± 700**

$\delta^{13}C = -1.0‰$

Limestone of calcareous crust. From 40 to 50cm depth of same profile as ANU-616 (1460 min count).

ANU-982. **$D^{14}C = -965.6 \pm 2.9‰$** **27,060 ± 700**

$\delta^{13}C = -3.0‰$

Sandy limestone of calcareous crust. From 50cm depth of same profile as ANU-617 (1440 min count).

General Comment (KZ): with exception of ANU-609 and -975, samples from S of area (ANU-615-617, -977-982) are, on average, older than those from N (ANU-610-614, -974 and -976), perhaps due to better preservation or preferential accumulation of younger crust in N.

Since calcareous crusts developed as accumulation horizons within aeolian soils and sediments, crusts are, in principle, independent of geomorphologic surfaces. Therefore, relatively young crusts could appear on older surfaces, eg, ANU-609 on an old Tertiary plateau and ANU-974 on a high terrace of Pliocene age.

The aeolian soils and sediments with calcareous crusts could have been deposited on top of each other several times in the Quaternary. Therefore, in a single profile, younger crusts can appear at the top and older ones at the bottom of the profile. Examples are: ANU-613 above -614, ANU-616 above -981, ANU-617 above -982.

The lower, *ie,* older parts of such multilayered profiles can be exposed by erosion. In this way, a relatively older crust can appear on younger geomorphologic surfaces, whereas on non-eroded or only partly eroded older geomorphologic surfaces the upper parts of the profile, *ie,* a younger crust can be preserved. Examples are: ANU-975 on a

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lower younger surface compared to ANU-609 on a higher older surface.

Many of the caliche crusts were younger than expected. There are indications that several times during the Quaternary phases of crust development and crust destruction cyclically alternated with each other, due to climatic oscillations. Each previously developed crust could have been influenced by the succeeding cycles of crust dissolution and renewed lime accumulation. These processes can penetrate into a considerable depth of the profiles through fissures, and can rejuvenate the older crusts. Sometimes a lower layer of a profile seems to be more affected than a layer nearer to the surface, eg, ANU-978 compared to ANU-977.

The laminar crusts were deposited subsequently on the non-laminar crust material and must therefore be relatively younger, as in the case of the laminated hard limestone, ANU-610, on the non-laminated one, ANU-611.

II. ARCHAEOLOGIC SAMPLES

Australia

Lake Victoria series

Charcoal and shells (*Velesunio ambiguus*) coll from aboriginal middens in red paleosol near top of Nulla Nulla Sand, lower of 2 formations in large dune systems on E side of Lake Victoria, New South Wales, Australia. Dating to correlate aeolian processes, river regime, changing fauna and paleo climate with activities of aborigines. 10% of shell surface was hydrolyzed using dilute HCl; charcoal was treated with hot 2N HCl, rinsed with distilled water. Coll 1969 and subm by E D Gill, then at Natl Mus Victoria (Gill, 1973a, b).

ANU-404A. **$D^{14}C = -887.2 \pm 4.3‰$** **17,530 ± 320**
Est $\delta^{13}C = 0.0‰$

Shells (*Velensunio ambiguus*) (34° 01′ S, 141° 20′ E) (960 min count).

ANU-404B. **$D^{14}C = -791.7 \pm 31.1‰$** **12,600 ± 1300**
Est $\delta^{13}C = 0.0‰$

Charcoal assoc with shell ANU-404A. Dilution, 7% sample (3040 min count). *Comment* (HAP): small sample size of 404B precluded reduction of error. Statistical agreement is ambiguous ($z = 3.7$, Polach, 1972) thus, possibility still exists that both results relate to same event. Charcoal results ANU-404B should be used to interpret site history.

ANU-405. **$D^{14}C = -861.9 \pm 4.6‰$** **15,900 ± 280**
Est $\delta^{13}C = 0.0‰$

Shells (*Velesunio ambiguus*) 5m below top of Nulla Nulla Sand (33° 59′ S, 141° 17′ E) (960 min count).

ANU-422. **$D^{14}C = -875.2 \pm 4.0‰$** **16,720 ± 260**
$\delta^{13}C = -2.4‰$

Shells (*Velesunio ambiguus*) (33° 56′ S, 141° 15′ E) (1000 min count). *Comment* (EDG): dating to cross-check shells against charcoal, and to date midden (GaK-2515, 15,300 ± 500 BP; Gill, 1973a, p 58).

ANU-423. **$D^{14}C = -4.7 \pm 9.7‰$** **Modern**
Est $\delta^{13}C = -24.0‰$

Wood charcoal from small shoots. Sample from one of series of middens in horizon of gulch on side of Lake Victoria, with no dune system. Numerous gulches represent at least 2 periods when erosion dominated over deposition, latter usually being in form of stratified piedmont fans (33° 58′ S, 141° 13′ E) (1010 min count). *Comment* (EDG): modern date shows that break-up of terrain, eg, with wide-spread gullying, occurred since European occupation. Assay also dates latest lithification by secondary carbonate, *ie*, it is contemporary process in some places at least, and provides minimal date for aboriginal bones and middens cemented by this carbonate.

ANU-421. **$D^{14}C = -89.5 \pm 19.1‰$** **750 ± 170**
Est $\delta^{13}C = -22.0‰$

Bone fragment from aboriginal burial near top of Nulla Nulla Sand (30° 59′ S, 141° 21′ E). Bones from 1 of 16 skeletons at site. Coll March, 1969 by R Blackwood and G Douglas for Natl Mus, Victoria; subm by E D Gill (Blackwood & Simpson, 1973). Human bone, collagen, obtained by acid hydrolysis (Longin, 1971). Dilution, 22% sample (1060 min count).

Lindsay River series

Fragments of aboriginal skeletons coll from burial grounds in 2 dunes, Lindsay I., Lindsay R, Victoria, Australia (35° 05′ S, 141° 02′ E). Bones from lowest 4 skeletons of 16 in tight mass grave. Many other burials in area. Coll by R Blackwood and K Simpson, Natl Mus, Victoria; subm by E D Gill.

ANU-420A. **$D^{14}C = +482.4 \pm 160.0‰$** **>Modern**
$\delta^{13}C = -26.0‰$

Water soluble bone fraction: crushed bone boiled in distilled water in pressure cooker (103kPA) for 30min (pH slightly alkaline) and water soluble fraction recovered and dated. Dilution, 2% sample (2080 min count). Result is mean of 2 dates $D^{14}C/1 = +379.2 \pm 163.9‰$. $D^{14}C/2 = +585.6 \pm 163.0‰$.

ANU-420B. **$D^{14}C = -232.6 \pm 7.9‰$** **2130 ± 85**
$\delta^{13}C = -7.6‰$

Bone carbonate: water insoluble residue of ANU-420A treated with 30% cold acetic acid to hydrolyze bone carbonate (1120 min count).

ANU-420C. **$D^{14}C = -432.1 \pm 12.9‰$** **4550 ± 185**
$\delta^{13}C = -14.0‰$

Bone apatite: acetic acid hydrolysis residue of ANU-420B treated with 50% cold HCl to recover acetic acid insoluble carbonate, *ie*, apatite (Haynes, 1968). Dilution, 32% sample (1100 min count).

ANU-420D. **$D^{14}C = -359.3 \pm 28.7‰$** **⩾3580 ± 370**

Est $\delta^{13}C = -24.0‰$

Acid insoluble residue; collagen (Berger *et al*, 1964): after washing and drying total acid, insoluble residue of ANU-420C was ignited. Dilution, 7% sample (7320 min count).

General Comment (HAP): validity of bone dating (Olsson *et al*, 1974; Polach, 1971; Haynes, 1968) can be established only if relating isolated fraction ages to environmental conditions or burial site. ANU-420A > Modern reflects post-depositional contamination with contemporary ^{14}C, of water soluble extract, collagen, fulvic and humic acids. Bone carbonate, ANU-420B, reflects age of pedogenic intrusive and exchangeable carbonate from environment and is not valid bone dating medium. Agreement between bone apatite and bone collagen results generally can be taken as validating bone age determination (*viz* refs quoted above). However, in presence of established humic contamination, ANU-420A, acid insoluble residue collagen, ANU-420D, can not be deemed contamination free and results must be considered as equal to or greater than (⩾) 3580 ± 370 BP. This agrees with ANU-420C apatite, which most likely represents age of burial at 4550 ± 185 BP.

III. ARCHAEOMAGNETIC SAMPLES

Australia

Murray River series

In August 1972 6 new sites, with small concentrations of charcoal and well-baked clayey silt, were found in sec of ancient point-bar deposit exposed by modern river-bank erosion on Murray R, New South Wales, Australia (35° 56′ S, 144° 28′ E). Pellets of charcoal and lumps of baked sediment, ranging in size from 1cm to ca 15cm across, and occasionally undisturbed baked sediment were found interspersed with soft unbaked sediment and are thought to result from burning of logs, tree stumps or roots. Unoriented samples of baked sediment are being used in study of ancient geomagnetic field strength, and radiocarbon dates were obtained as part of this study (Barbetti, 1973). The ^{14}C ages reported here, together with ANU-692 and -693 (R, 1973, v 15, p 250), indicate approx constant growth rate for this particular point-bar. All samples, except where noted, were dated using acid and alkali insoluble charcoal fraction. Coll 1970 by M Barbetti, subm by Research School Earth Sci, ANU.

ANU-699. **$D^{14}C = -432.3 \pm 4.4‰$** **4450 ± 60**

Est $\delta^{13}C = -24.0‰$

Charcoal and uniformly baked sediment 3m below top of bank, 75m downstream from ANU-693 (R, 1973, v 15, p 250). Result is error-weighted mean of 2 determinations on different chemical fractions of same charcoal samples: ANU-699/1, alkali soluble fraction, 4540 ± 80 BP, 1220 min count and ANU-699/2, alkali insoluble fraction, 4560 ± 90 BP, 1240 min count. *Comment* (HAP): this internal comparison

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demonstrates absence of contamination by soil acids with significantly different age than original charcoal.

ANU-700. **$D^{14}C = -432.5 \pm 8.1‰$** **4550 ± 120**
Est $\delta^{13}C = -24.0‰$

Mixed charcoal and baked sediment 2.5m below top of bank, 20m downstream from ANU-699 (1200 min count).

ANU-1084. **$D^{14}C = -434.6 \pm 17.3‰$** **4580 ± 250**
Est $\delta^{13}C = -24.0‰$

Elongated vertical structure (possibly sec of collapsed root tunnel) between 3m and 4m below top of bank, 19m downstream from ANU-700 (2080 min count).

ANU-1085. **$D^{14}C = -336.0 \pm 5.8‰$** **3290 ± 70**
Est $\delta^{13}C = -24.0‰$

Mixed charcoal and baked sediment 3m below top of bank, 122m downstream from ANU-1084 (1340 min count).

ANU-1086. **$D^{14}C = -243.0 \pm 6.2‰$** **2240 ± 70**
Est $\delta^{13}C = -24.0‰$

Mixed charcoal and lumps of baked sediment 4m below top of bank, 110m downstream from ANU-1085 (1300 min count).

ANU-1087. **$D^{14}C = -121.3 \pm 6.9‰$** **1040 ± 60**
Est $\delta^{13}C = -24.0‰$

Charcoal and baked earth distributed along bedding plane 60cm to 70cm below top of bank, 107m downstream from ANU-1086 (1240 min count).

Lake Mungo

In August 1972, a newly-exposed ancient aboriginal oven was discovered in Lake Mungo lunette, New South Wales, Australia (33° 48′ S, 142° 54′ E). This oven, for which a ^{14}C age is reported here, was 350m S of a group of ancient fireplaces reported previously (ANU-667, -680-683; R, 1973, v 15, p 246-247). These ancient fireplaces have been investigated as part of detailed archaeomagnetic study of sites in SE Australia (Barbetti, 1973; 1972; Barbetti & McElhinny, 1972).

ANU-698. **$D^{14}C = -957.2 \pm 4.1‰$** **25,310 ± 810**
Est $\delta^{13}C = -24.0‰$

Aboriginal oven at base of greenish-gray sandy clay of Mungo soil-sedimentary unit (4020 min count). *Comment* (MB): age agrees well with stratigraphic evidence and previous dates (R, 1973, v 15, p 246-247).

IV. VEGETATION SAMPLES

Papua New Guinea

Kainantu series

Peat from Noreikora swamp, 12.9km SE of Kainantu, alt 1650m (6° 24′ S, 145° 53′ E) E Highlands Dist, Papua New Guinea, coll during vegetation history project. Samples coll with peat borer 1966, Bore Hole NK14, by J M Powell; subm by Dept Biogeog & Geomorphol, ANU.

ANU-83. $D^{14}C = -101.5 \pm 12.2‰$ **860 ± 110**
Est $\delta^{13}C = -25.0‰$

Gray-brown peat, coll by piston sampler over horizontal area of 1 to 2sqm, at depth 220 to 230cm. Dilution, 80% sample (1300 min count).

ANU-84. $D^{14}C = -424.6 \pm 5.7‰$ **4440 ± 80**
Est $\delta^{13}C = -25.0‰$

Gray-brown compacted, fibrous peat, coll with piston sampler over horizontal area of 1 to 2sqm, at depth 345 to 355cm (1300 min count). *General Comment* (JMP): stratigraphy of swamp suggests relatively simple history. Total depth of sediments is 400cm; 2 zones of peat occur with layer of gray clay, 50 to 60cm depth, interpolated. ANU-84 dates early part of lower peat while ANU-83 dates beginning of 2nd phase of peat formation. Pollen diagrams directly correlated with these dates are not yet completed; preliminary analysis suggests that both dates will be important in interpreting human influences on vegetation surrounding swamp.

Mt Hagen Series A

Samples from Draepi swamp, 12.9km NNW of Mt Hagen township, W Highlands Dist, Papua New Guinea on Baiyer R Divide, alt 1890m (5° 42′ S, 144° 10′). Coll by J M Powell during vegetation history project. Samples coll 1966 and 1967 with a piston sampler over horizontal area of 1sqm, DR159/T83, subm by Dept Biogeog & Geomorphol, ANU.

ANU-85. $D^{14}C = -137.7 \pm 7.5‰$ **1190 ± 70**
Est $\delta^{13}C = -25.0‰$

Very fine black detritus mud, from 5 successive bores at 250 to 260cm depth (1400 min count).

ANU-249. $D^{14}C = -365.3 \pm 6.5‰$ **3650 ± 85**
Est $\delta^{13}C = -24.0‰$

Very fine black detritus mud, from 365 to 375cm depth (980 min count).

ANU-250. $D^{14}C = -896.8 \pm 3.9‰$ **18,250 ± 370**
Est $\delta^{13}C = -24.0‰$

Dark red-brown wood and leaf detritus, from 440 to 450cm depth (980 min count).

ANU-192. $D^{14}C = -943.2 \pm 3.9‰$ **23,040 ± 570**
Est $\delta^{13}C = -24.0‰$

Water-logged wood near junction of organic red-brown detritus and inorganic volcanic ash, 525 to 535cm depth. Coll from single borehole (1360 min count).

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General Comment (JMP): dates are directly correlated with pollen diagram DR159. ANU-192 provides maximum age near deposit base while ANU-250 dates top of Pollen Zone H. Pollen spectra within this zone indicate that forest was present both locally and regionally. ANU-249 dates base of Pollen Zone J; by this time non-forest vegetation had increased greatly relative to forest, probably as a result of human interference. ANU-85 dates top of Pollen Zone J: pollen spectra within zone indicate that there were nearly equal areas of forest and non-forest vegetation present in the region. The overlying pollen spectra, in Pollen Zone K, indicate that areas of forest and non-forest have become more or less stabilized with the forest slightly less extensive than in Zone J.

ANU-253. **$D^{14}C = -470.5 \pm 6.1‰$** **5110 ± 100**
Est $\delta^{13}C = -24.0‰$

Coarse black detritus mud, coll from DRII/29 at 210 to 220cm depth (1060 min count).

ANU-254. **$D^{14}C = -985.5 \pm 3.0‰$** **$34{,}000^{+2000}_{-1500}$**
Est $\delta^{13}C = -24.0‰$

Dark red-brown wood and leaf detritus, from DRII/29 at 385 to 395cm depth (2020 min count).

ANU-194/1. **$D^{14}C = -975.5 \pm 3.2‰$** **29,800 ± 1250**
Est $\delta^{13}C = -24.0‰$

Dark red-brown wood and leaf detritus, from DRII/29 at 695 to 705cm depth (1380 min count).

ANU-194/2. **$D^{14}C = -982.0 \pm 2.4‰$** **32,250 ± 1100**
Est $\delta^{13}C = -24.0‰$

Portion of same sample as 194/1 (3000 min count). *Comment* (HAP): agreement between duplicates, ANU-194/1 and -194/2, involving independent sample pretreatment and benzene synthesis is excellent ($z = 1.5$, Polach, 1972). Thus, a pooled mean ANU-194, $D^{14}C = -980.1 \pm 2.2$, age = 31,470 ± 900 BP can be calculated.

General Comment (JMP): dates correlate directly with pollen diagram DR/II/29. ANU-194 and -254 date period covered by Pollen Zones F, G, and part of H. These zones are characterized by forest dominance, locally and regionally. Stratigraphically lowest date is 31,470 ± 900 yr BP, pooled mean ANU-194, while upper date is $34{,}000 \begin{smallmatrix}+2000\\-1500\end{smallmatrix}$ yr BP, ANU-254. Ranges of the 2 dates, as defined by 2 standard deviations from each mean, overlap. Hence, sediment may have been laid down betwen 29,670 and 38,000 yr ago. But, the lowest part of Pollen Zone H in Column DR159 is dated to 23,040 ± 570 yr BP, ANU-192, so that youngest date possible for this position in DR/II/29 remains somewhat too old. ANU-253 dates base of Pollen Zone J: by this time much forest had been destroyed and woody non-forest and grassland vegetations were widespread. During Zone J, a balance between forest and non-forest areas was achieved and maintained; more recently, Zone K, a bit more exploitation of forest took place.

ANU-255. **$D^{14}C = -250.1 \pm 7.6‰$** **2310 ± 90**

Est $\delta^{13}C = -24.0‰$

Charcoal in brown-black peat, from cooking pit, DRII/40C, at 140 to 145cm depth (1000 min count).

ANU-276. **$D^{14}C = -383.4 \pm 6.8‰$** **3880 ± 90**

Est $\delta^{13}C = -24.0‰$

Coarse brown-black peat underlying archaeol ditch. Coll from peat column, DRII/40A, at 180 to 185cm depth (1000 min count).

ANU-277. **$D^{14}C = -247.0 \pm 7.6‰$** **2280 ± 90**

Est $\delta^{13}C = -24.0‰$

Mixed peat and volcanic ash infilling ditch base. Coll from peat column, DRII/40A, at 160 to 165cm depth (1000 min count).

General Comment (JMP): dates are directly correlated with pollen diagrams DR/II/40A and DR/II/40B. ANU-276 provides a further date for area near base of Pollen Zone J, comparable to ANU-249 and -253. ANU-255 provides 1st direct evidence of human use of Draepi area. Correlated stratigraphically with column DR/II/40B, this date is near center of Pollen Zone J, when mosaic of forest and non-forest vegetations was present locally and regionally. Gardening of part of site was undertaken at about same time as evidenced by ANU-277, and was probably fairly widespread.

Mt Hagen Series B

Samples from Manton swamp archaeol site, 9.7km E of Mt Hagen township, Upper Wahgi valley (5° 50′ S, 144° 18′ E), alt 1585m. Coll 1967 by J M Powell, during vegetation history project. Subm by Dept Biogeog & Geomorphol, ANU.

ANU-251. **$D^{14}C = -109.3 \pm 17.3‰$** **930 ± 155**

Est $\delta^{13}C = -24.0‰$

Waterlogged wooden stake embedded in black mud and sand, M6/129, at 129 to 136cm depth. Taken from column cut from side of modern drain (1020 min count).

ANU-252. **$D^{14}C = -456.5 \pm 6.1‰$** **4900 ± 90**

Est $\delta^{13}C = -24.0‰$

Waterlogged wood lying at base of zone of mixed coarse brown detritus and volcanic ash, M6/195, at 195 to 200cm depth. Taken from column cut from side of modern drain (1140 min count).

General Comment (JMP): dates are directly correlated with pollen diagram M6. ANU-252 gives maximum age for base of pollen diagram since it lies below lowest sample, 161cm, of diagram and because wood,

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itself, may have been old at time of incorporation. It compares well, however, with dates for other wood samples, ANU-44 (R, 1968, v 19, p 193) and ANU-288, stratigraphically near base of organic sediment. Lowest pollen spectra of diagram, Zone B, indicate woody non-forest vegetation was dominant on surrounding slopes at this time; partial clearance of forest had taken place but little grassland had developed. ANU-251 dates base of Pollen Zone D. This is a stratigraphically disturbed zone, covering period during which swamp was being gardened. Date is relatively too young compared with other date available for base of zone (ANU-43; R, 1968, v 19, p 193); it may be stratigraphically displaced or it may indicate use of this part of swamp at more recent time. Pollen spectra within zone as a whole indicate increased importance of certain trees, shrubs, and herbs compared with earlier zones; they may have been domesticated by this time.

ANU-288. **$D^{14}C = -455.3 \pm 6.1‰$** **4880 ± 90**
Est $\delta^{13}C = -24.0‰$

Wood lying within coarse brown wood and peat detritus, MTH34, at 195cm depth. Coll from archaeol Trench D, by R J Lampert, subm by Dept Prehistory, ANU (1320 min count).

ANU-289. **$D^{14}C = -56.9 \pm 8.6‰$** **470 ± 75**
Est $\delta^{13}C = -24.0‰$

Wooden stake, MTH37, lying between 35 to 65cm depth, marking junction of black mud and upper undisturbed yellow-brown fibrous peat. Coll from archaeol Trench D by R J Lampert, subm by Prehistory Dept (1100 min count).

General Comment (JMP): samples from within 1sqm horizontal area of Column M1 and may be correlated with M1 pollen diagram. ANU-288 provides maximum age near base of pollen zone A. Pollen spectra of this zone indicate that some forest was present on surrounding slopes but that woody non-forest vegetation was dominant. ANU-289 dates top of Pollen Zone D. It may be considered as maximum age for abandonment of swampland. Pollen spectra of Zone E, immediately above, indicate renewed impact on forests of surrounding slopes, followed by their partial recovery and stabilization of forest and non-forest areas.

References

Barbetti, Michael, 1972, Geomagnetic field behavior between 25,000 and 35,000 yr BP and its effect on atmospheric radiocarbon concentration: a current report: 8th internatl conf radiocarbon dating proc, New Zealand, 1972, p A104-A113.

——— 1973, Archaeomagnetic and radiocarbon studies of Aboriginal fireplaces: unpub PhD thesis, Canberra, Australian National University, 197 p.

Barbetti, Michael and McElhinny, Michael, 1972, Evidence of a geomagnetic excursion 30,000 yr BP: Nature, v 239, p 327-330.

Barbetti, Michael and Polach, Henry, 1973, ANU radiocarbon date list V: Radiocarbon, v 15, p 241-251.

Baturin, G N, Lochenov, A V, and Senin, Yu M, 1971, Uranium concentration in recent ocean sediments in zones of rising currents: Geochem Internatl, v 8, p 281-286.

Berger, R, Horney, A G, and Libby, W F, 1964, Radiocarbon dating of bone and shell from their organic components: Science, v 144, p 999-1001.

Blackwood, Robert and Simpson, K N G, 1973, Attitudes of aboriginal skeletons excavated in the Murray Valley region between Mildura and Renmark, Australia: Natl Mus Victoria Mem, v 34, p 99-150.

Bloom, A L, Broecker, W S, Chappell, John, Matthews, R K, and Mesolella, K J, 1974, Quaternary sea level fluctuations on a tectonic coast: new $^{230}Th/^{234}U$ dates from the Huon Peninsula, New Guinea: Quaternary Research, v 4, p 185-205.

Calvert, S E and Price, N B, 1971, Recent sediments of the South West African shelf: Inst Geol Sci, rept no. 70/16, p 171-185.

Chappell, John, 1974, Geology of coral terraces, Huon Peninsula, New Guinea: a study of Quaternary tectonic movements and sea level changes: Geol Soc America Bull, v 85, p 553-570.

Chappell, John, Broecker, W S, Polach, H A, and Thom, B G, 1974, Problem of dating Upper Pleistocene sea levels from coral reef areas: Internatl Coral Reef symposium, 2nd, Brisbane, Australia, Proc, Gt Barrier Reef Comm, v 2, p 563-571.

Chappell, John and Polach, H A, 1972, Some effects of partial recrystallization on ^{14}C dating Late Pleistocene corals and molluscs: Quaternary Research, v 2, p 244-252.

——— 1976, Holocene sea level change and coral reef growth at Huon Peninsula, New Guinea: Geol Soc America Bull, v 87, p 235-240.

Coventry, R J, 1973, Abandoned shorelines and the Late Quaternary history of Lake George, New South Wales: unpub PhD thesis, Canberra, Australian National Univ, 319 p.

——— 1976, Abandoned shorelines and the Late Quaternary history of Lake George, New South Wales: Jour Geol Soc Australia, v 23, p 249-273.

Coventry, R J and Walker, P H, 1977, Geomorphological significance of Late Quaternary deposits of the Lake George area, NSW: Australian Geographer, v 13, p 369-376.

Emery, K O and Bray, E E, 1962, Radiocarbon dating of California Basin sediments: American Assoc Petroleum Geologists Bull, v 46, p 1839-1856.

Fenner, Charles, 1921, The craters and lakes of Mount Gambier, South Australia: Roy Soc South Australia Trans, v 45, p 169-205.

Frank, R M, 1972, Sedimentary and morphological development of the Borenore Caves, New South Wales, I: Helictite, v 10, p 75-91.

——— 1973, Sedimentary and morphological development of the Borenore Caves, New South Wales, II: Helictite, v 11, p 27-44.

——— 1975, Evidence from Late Quaternary climatic change: cave sediments in Central Eastern New South Wales: Australian Geog Studies, v 13, p 154-168.

Galloway, R W, 1967, Dating of shore features at Lake George, New South Wales: Australian Jour Sci, v 29, p 477.

Gill, E D, 1973a, Geology and geomorphology of the Murray River region between Mildura and Renmark, Australia: Nat Mus Victoria Mem, no. 34, p 1-97.

——— 1973b, Palaeopedology of the Murray River region between Mildura and Renmark, Australia: Nat Mus Victoria Mem, no. 34, p 241-252.

Haynes, Vance, 1968, Radiocarbon: analysis of inorganic carbon of fossil bone and enamel: Science, v 161, p 687-688.

Jones, H A, 1973, Marine geology of the northwest Australian continental shelf: Australian Bur Min Resources, Geol Geophys Bull, no. 136, 102 p.

Joyce, E B, 1974, Australia, *in*: Westgate, J A and Gold, C M (eds), World bibliography and index of Quaternary tephrochronology: Edmonton, Alberta, Univ Alberta, sponsored by INQUA and supported by UNESCO.

——— 1975, Quaternary volcanism and tectonics in Southeastern Australia: Roy Soc New Zealand Bull no. 13, Quaternary Studies, selected papers from IX INQUA cong, Christchurch, New Zealand, 1973, p 169-176.

Kigoshi, Kunihiko and Kobayashi, Hiromi, 1966, Gakushuin natural radiocarbon measurements V: Radiocarbon, v 8, p 54-73.

Longin, R, 1971, New method of collagen extraction for radiocarbon dating: Nature, v 230, p 241-242.

Olsson, I, U, 1970, The use of oxalic acid as a standard, *in*: Olsson, I U, (ed), Radiocarbon variations and absolute chronology, 12th Nobel symposium Proc: New York, John Wiley & Sons, p 17.

https://doi.org/10.1017/S0033822200009176 Published online by Cambridge University Press

Olsson, I U, El-Daoushy, F M A F, Abd-El-Mageed, A I, and Klasson, M, 1974, A comparison of the different methods for pretreatment of bones: Geol Fören Stockholm Förh, v 96, p 171-181.

Olsson, I U and Eriksson, K G, 1965, Remarks on the ^{14}C dating of shell material in sea sediments: Progress in Oceanog, v 3, p 253-266.

Polach, H A, 1969, Optimization of liquid scintillation radiocarbon age determinations and reporting of ages: Atomic Energy in Australia, v 12, no. 3, p 21-28.

——— 1971, Radiocarbon dating of bone organic and inorganic matter: a progress report on the Australian experience, *in*: Radiocarbon users conference Proc: Wellington, New Zealand, p 165-181.

——— 1972, Cross checking of NBS oxalic acid and secondary laboratory radiocarbon dating standards, *in*: 8th internatl conf on radiocarbon dating Proc: New Zealand, p 688-717.

——— 1974, Application of liquid scintillation spectrometers to radiocarbon dating, *in*: Liquid scintillation counting: recent developments: Stanley P E and Scoggins, B A (eds), San Francisco, Academic Press, p 153-171.

——— 1975, Radiocarbon dating as a research tool in archaeology: hopes and limitations, *in*: Barnard, Noel (ed), Symposium on scientific methods of research in the study of ancient Chinese bronzes and Southeast Asian metal and other archaeological methods, Proc: Natl Gallery Vivtoria, Melbourne, Australia, p 255-298.

——— 1976, Arizona 1850 wood and ANU sucrose radiocarbon dating standards: progress report on international cross-calibration with NBS oxalic, *in*: 9th (Libby) internatl conf on radiocarbon dating Proc: in press.

Polach, H A, Chappell, John, and Lovering, J F, 1969, ANU radiocarbon date list III: Radiocarbon, v 11, p 245-262.

Polach, H A, Golson, J, Lovering, J F, and Stipp, J J, 1968, ANU radiocarbon date list II: Radiocarbon, v 10, p 179-199.

Polach, H A, Gower, John, and Fraser, Ian, 1972, Synthesis of high purity benzene for radiocarbon dating by the liquid scintillation method, *in*: 8th internatl conf on radiocarbon dating Proc: Lower Hutt, New Zealand, p 145-157.

Polach, H A and Stipp, J J, 1967, Improved synthesis techniques for methane and benzene radiocarbon dating: Internatl Jour Applied Radiation & Isotopes, v 18, p 359-364.

Specht, R L, 1958, The geographical relationships of the flora of Arnhem Land: American-Australian scientific expedition to Arnhem Land Rec, v 3, p 415-478.

Sprigg, R C, 1952, The geology of the south-east province, South Australia, with special reference to Quaternary coast-line migrations and modern beach developments: Geol Survey South Australia Bull no. 29, 120 p.

Stephenson, P J, McCall, G J, LeMatire, R W, and Robinson, G P, 1968, The Ambrym Island research projects: New Hebrides Anglo-French Condominium Geol Survey Ann Rept for 1966, p 9-15.

Stuiver, Minze and Polach, Henry A, 1977, Discussion, Reporting of ^{14}C data: Radiocarbon, v 19, p 355-363.

Veeh, H H, 1967, Deposition of uranium from the ocean: Earth and Planetary Sci Letters, v 3, p 145-150.

Veeh, H H, Calvert, S E, and Price, N B, 1974, Accumulation of uranium in sediments and phosphorites on the South West African shelf: Marine Chemistry, v 2, p 189-202.

Veeh, H H and Chappell, John, 1970, Astronomical theory of climatic change: support from New Guinea: Science, v 167, p 862-865.

Walker, P H and Coventry, R J, 1976, Soil profile development in some alluvial deposits of eastern New South Wales: Australia Jour Soil Res, v 14, p 305-317.