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ANU RADIOCARBON DATE LIST X

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^{14}C DATES FOR SIX AUSTRALIAN FRESHWATER LAKES

^{14}C ages were obtained for the Australian lakes recorded below in order to complement research into their magnetic stratigraphy and sedimentology. It has been possible to establish precise ^{14}C chronologies in six separate lakes, and also to compare ages obtained from stratigraphically equivalent horizons in different parts of the same lake so as to determine the reproducibility of these ages.

Sets of 54mm diam cores were collected by Charles Barton, Research School of Earth Sciences, ANU, from each of the maars using a 6m Mackereth corer (Mackereth, 1958), fitted with an orienting device (Barton and Burden, 1979) and a short 1.5m Mackereth corer (Mackereth, 1969) to recover undisturbed samples of the upper sediments. In Lakes Keilambete and Gnotuk coring terminated in a dense gray clay at 4m which plugged the ends of the core tubes. Ages are reported as ^{14}C yr BP, *ie,* corrected for isotopic fractionation and based on the Libby half-life of 5568 yr. The modern reference standard was ANU sucrose, secondary international calibration standard, correlated with 95% of ^{14}C activity of NBS oxalic acid, normalized to $\delta^{13}C = -19‰$ wrt PDB (Polach, 1979; Currie and Polach, 1980). All samples were washed in dilute HCl prior to combustion of the total organic fraction, with the exception of ANU-2051A which was a carbonate. Except where noted, the value for $\delta^{13}C$ is estimated as $-24.0 \pm 2.0‰$.

SAMPLE DESCRIPTIONS

Lake Bullenmerri series

Lake Bullenmerri lies in clover-leaf shaped volcanic basin in SW Victoria (38° 15′ S, 143° 07′ E), intersecting that of Lake Gnotuk at col on NW side. Upper 8m sediments are black to brown organic muds (typically 20 to 40% organic, 5% carbonate), more uniform in appearance and having fewer thin aragonite layers than Lakes Keilambete and Gnotuk. A comprehensive set of samples was obtained to determine reliability of ^{14}C ages in this fairly typical, mildly saline lacustrine environment.

ANU-1657. **$D^{14}C = -648.8 \pm 4.9‰$** **8410 ± 110**

Dark grayish lake sediment from weakly saline lake. Sample from bottom of Core B (580 to 593cm depth), and one of the furthest from lake center.

ANU-1659. **$D^{14}C = -607.2 \pm 23.4‰$** **7510 ± 490**

Piece of wood and lake sediment. Core B, 541 ± 0.5cm depth. Dilution, 15% sample.

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ANU-1660. **$D^{14}C = -169.9 \pm 8.5‰$** **1500 ± 80**

Dark gray lake sediment. Core B, 115 to 125cm.

ANU-1909. **$D^{14}C = -191.7 \pm 9.4‰$** **1710 ± 90**

Grayish-colored lake mud with probably some carbonate present. Core C, 23.5 to 28.5cm. Dilution, 31% sample.

ANU-1911. **$D^{14}C = -93.0 \pm 9.5‰$** **780 ± 80**

Grayish-colored lake mud with probably some carbonate present. Core C, 72.5 to 78.5cm. Dilution, 36% sample.

ANU-1793. **$D^{14}C = -223.7 \pm 7.9‰$** **2030 ± 80**

Dark gray to black lake mud. Core C, 150 to 159cm. Dilution, 49% sample.

ANU-1798. **$D^{14}C = -242.2 \pm 5.5‰$** **2230 ± 60**

Dark gray to black lake mud. Core C, 159 to 166cm.

ANU-1802. **$D^{14}C = -299.0 \pm 6.8‰$** **2850 ± 80**

Grayish-colored, fine-grained lake mud with substantial amount of carbon present. Core C, 166 to 173.5cm.

ANU-1805. **$D^{14}C = -360.1 \pm 8.3‰$** **3590 ± 100**

Dark grayish lake mud with carbonate present. Core C, 272 to 277cm. Dilution, 33% sample.

ANU-1790. **$D^{14}C = -450.5 \pm 6.9‰$** **4810 ± 100**

Dark gray to black lake mud. Core C, 377 to 382cm. Dilution, 49% sample.

ANU-1753. **$D^{14}C = -461.6 \pm 9.6‰$** **4970 ± 140**

Black, highly organic lake mud. Core C, 382 to 387cm. Dilution, 35% sample.

ANU-1905. **$D^{14}C = -555.4 \pm 11.6‰$** **6510 ± 210**

Grayish-colored lake mud with probably some carbonate present. Core C, 479 to 485cm. Dilution, 19% sample.

ANU-1901. **$D^{14}C = -521.6 \pm 10.4‰$** **5920 ± 180**

Grayish-colored lake mud with probably some carbonate present. Core C, 515 to 520cm. Dilution, 23% sample.

ANU-1788. **$D^{14}C = -612.9 \pm 8.2‰$** **7630 ± 170**

Dark gray to black lake mud. Core C, 583 to 593cm. Dilution, 36% sample.

ANU-1904. **$D^{14}C = -543.6 \pm 6.8‰$** **6300 ± 120**

Grayish-colored lake mud with probably some carbonate present. Core C, 472 to 479cm. Dilution, 42% sample.

ANU-1912. **$D^{14}C = -157.6 \pm 8.5‰$** **1380 ± 80**

Grayish-colored lake mud with probably some carbonate present. Core D, 127.5 to 132.5cm. Dilution, 42% sample.

ANU-1792. **$D^{14}C = -104.4 \pm 8.2‰$** **890 ± 70**

Dark gray to black lake mud. Core D, 192 to 201.5cm.

ANU-1799. **$D^{14}C = -264.2 \pm 6.7‰$** **2460 ± 70**

Dark gray to black lake mud. Core D, 201.5 to 209cm.

ANU-1803. **$D^{14}C = -240.4 \pm 6.6‰$** **2210 ± 70**

Dark grayish lake mud with some carbonate. Core D, 211.5 to 216.5cm.

ANU-1806. **$D^{14}C = -352.2 \pm 7.6‰$** **3490 ± 90**

Dark grayish lake mud with some carbonate. Core D, 315.5 to 320cm. Dilution, 37% sample.

ANU-1789. **$D^{14}C = -449.6 \pm 6.3‰$** **4800 ± 90**

Dark gray to black lake mud. Core D, 404.5 to 409.5cm.

ANU-1754. **$D^{14}C = -453.6 \pm 8.2‰$** **4860 ± 120**

Black, highly organic lake mud. Core D, 409.5 to 414.5cm. Dilution, 44% sample.

ANU-1906. **$D^{14}C = -535.1 \pm 8.4‰$** **6150 ± 150**

Grayish-colored lake mud, with probably some carbonate present. Core D, 495.5 to 502.5cm. Dilution, 32% sample.

ANU-1907. **$D^{14}C = -633.7 \pm 21.3‰$** **8070 ± 480**

Grayish-colored lake mud with probably some carbonate present. Core D, 502.5 to 507.5cm. Dilution, 10% sample.

ANU-1902. **$D^{14}C = -537.7 \pm 8.8‰$** **6200 ± 150**

Grayish-colored lake mud with probably some carbonate present. Core D, 542.5 to 547.5cm. Dilution, 28% sample.

ANU-1908. **$D^{14}C = -131.0 \pm 9.9‰$** **1130 ± 90**

Grayish-colored lake mud with probably some carbonate present. Core E, 26 to 31cm. Dilution, 30% sample.

ANU-1910. **$D^{14}C = -170.2 \pm 9.3‰$** **1500 ± 90**

Grayish-colored lake mud with probably some carbonate present. Core E, 80 to 84cm. Dilution, 36% sample.

ANU-1794. **$D^{14}C = -222.2 \pm 10.3‰$** **2020 ± 110**

Dark gray to black lake mud. Core E, 141 to 148cm. Dilution, 33% sample.

ANU-1795. **$D^{14}C = -259.6 \pm 6.6‰$** **2420 ± 70**

Dark gray to black lake mud. Core E, 150 to 155cm.

ANU-1801. **$D^{14}C = -252.0 \pm 7.1‰$** **2330 ± 80**

Grayish-colored, fine-grained lake mud with substantial amount of carbonate present. Core E, 155 to 161.5cm.

ANU-1804. **$D^{14}C = -357.2 \pm 6.5‰$** **3550 ± 80**

Dark grayish lake mud with carbonate present. Core E, 244 to 249cm. Dilution, 48% sample.

ANU-1791. **$D^{14}C = -454.2 \pm 8.6‰$** **4860 ± 130**

Dark gray to black lake mud. Core E, 343 to 348cm. Dilution, 36% sample.

ANU-1752. **$D^{14}C = -542.2 \pm 8.7‰$** **5970 ± 150**

Black, highly organic lake mud. Core E, 348 to 353cm. Dilution, 25% sample.

ANU-1903. **$D^{14}C = -563.3 \pm 8.6‰$** **6650 ± 160**

Grayish-colored lake mud with probably some carbonate present. Core E, 459 to 464cm. Dilution, 29% sample.

ANU-1800. **$D^{14}C = -619.0 \pm 4.1‰$** **7750 ± 90**

Dark gray to black lake mud. Core E, 580 to 590cm.

ANU-1943. **$D^{14}C = -591.0 \pm 6.0‰$** **7180 ± 120**

Organic lake mud. Core H, 490 to 510cm.

ANU-1944. **$D^{14}C = -635.6 \pm 5.8‰$** **8110 ± 130**

Organic lake mud. Core H, 580 to 600cm.

ANU-1945. **$D^{14}C = -643.9 \pm 4.5‰$** **8290 ± 100**

Organic lake mud. Core H, 660 to 675cm.

ANU-1946. **$D^{14}C = -711.7 \pm 3.5‰$** **9990 ± 100**

Black organic mud. Core H, 790 to 805cm.

ANU-1947. **$D^{14}C = -750.6 \pm 3.3‰$** **11,150 ± 110**

Pale brown organic mud. Core H, 820 to 835cm.

ANU-1948. **$D^{14}C = -779.8 \pm 3.7‰$** **12,150 ± 140**

Pale brown organic lake mud. Core H, 930 to 950cm.

ANU-1949. **$D^{14}C = -820.0 \pm 3.5‰$** **13,770 ± 160**

Pale brown organic lake mud. Core H, 990cm to end of core.

ANU-1951. **$D^{14}C = -755.5 \pm 4.2‰$** **11,320 ± 140**

Orange organic lake mud. Core I, 933 to 947cm.

ANU-1952. **$D^{14}C = -797.2 \pm 3.0‰$** **12,820 ± 120**

Orange organic lake mud. Core I, 1045 to 1060cm.

ANU-1953. **$D^{14}C = -822.9 \pm 3.0‰$** **13,900 ± 140**

Orange-gray calcareous mud. Core I, 1075 to 1090cm.

ANU-2032. **$D^{14}C = -843.2 \pm 4.8‰$** **14,890 ± 250**
Grayish organic mud. Core I, 1120 to 1130cm.

ANU-1954. **$D^{14}C = -865.2 \pm 2.5‰$** **16,100 ± 150**
Black organic mud. Core I, 1160 to 1173cm. Sample reaches lowest point of any core in Lake Bullenmerri.

ANU-1955. **$D^{14}C = -709.2 \pm 3.8‰$** **9920 ± 110**
Carbonate-rich organic mud. Core J, 715 to 730cm.

General Comment: this 16,000-year sequence of dates indicates continuous sedimentation in Lake Bullenmerri throughout interval, including period ca 15,000 to 10,000 yr BP when Lakes Gnotuk and Keilambete were dry. Many of dated samples (20 pairs) were from magnetically equivalent horizons in four different cores. In three cores, 11 pairs of samples were from vertically adjacent stratigraphic levels. Age differences for these paired results were more than 20% for 5 of magnetically correlated pairs and for 4 of stratigraphically adjacent pairs. This demonstrates that standard counting uncertainties (typically $< 5\%$) are a poor indication of true errors in ^{14}C ages of these sediments (Barton and Polach, 1980). ANU-1951 to -1954 also used to support analyses carried out by J R Dodson (1979).

Lake Gnotuk series

Recent bathymetric profiles (Curry, 1970; Timms, 1976) show Lake Gnotuk in SW Victoria (38° 16′ S, 143° 07′ E) is uniform, flat-bottomed and steep-sided volcanic lake, similar to Lake Keilambete. Dense gray clay and ash (Yezdani, ms) were found at depths ca 3.5m, plugging bottom of most cores, underlying banded gray muds, which in turn are overlain by fine-grained organic muds (10 to 20% organic carbon) with much white aragonite laminae (12% carbonate) which provide precise stratigraphy. *Ostracod* shells are common, increasing in density at ca 3m. *Coxiella striata* shells are scattered through homogeneous black muds between 135cm and 190cm, in core GC, the master core.

ANU-1987. **$D^{14}C = -402.7 \pm 5.1‰$** **4140 ± 70**
Black organic mud. Core B, 130 to 140cm.

ANU-1988. **$D^{14}C = -511.5 \pm 4.3‰$** **5750 ± 70**
Black organic mud. Core B, 190 to 200cm.

ANU-1989. **$D^{14}C = -596.6 \pm 4.6‰$** **7290 ± 100**
Black organic mud. Core B, 250 to 260cm.

ANU-1990. **$D^{14}C = -683.5 \pm 4.7‰$** **9240 ± 120**
Black-gray organic mud. Core B, 310 to 320cm.

ANU-1936. **$D^{14}C = -96.2 \pm 8.5‰$** **810 ± 80**
Organic lake mud. Core G1C, 5 to 10 and 10 to 15cm.

ANU-1935. **$D^{14}C = -152.2 \pm 7.6‰$** **1330 ± 70**

Lake mud with carbonate laminae. Core G1C, 50 to 56, 56 to 61, and 61 to 66cm.

ANU-2031. **$D^{14}C = -307.1 \pm 7.8‰$** **2950 ± 100**

Dark grayish lake mud. Core G, 40 to 54cm.

General Comment: above dates compare favorably with those obtained by Yezdani (ms; Barton, Bowler, and Polach, ms in preparation). Regression line extrapolates to age of 295 ^{14}C yr at water-sediment interface, which is estimated from adjacent short cores to be 27cm above top of core GC. This does not necessarily imply any systematic contamination from ancient carbon within lake. In view of high internal consistency of ^{14}C ages, it is probable that step at 2000-3000 yr BP in Keilambete ages would also appear in more comprehensive set of Gnotuk ages.

Lake Keilambete series

Lake Keilambete floor is uniformly flat to ca 200m offshore (38° 13′ S, 142° 52′ E) in SW Victoria. Within this region aragonite laminae < 1mm thick can be traced in each core, such stratigraphic markers indicating very undisturbed sediments.

ANU-1807. **$D^{14}C = -659.0 \pm 3.5‰$** **8640 ± 80**

Grayish, fine-grained lake mud with some carbonate present. Core F, 390 to 405cm.

ANU-1808. **$D^{14}C = -718.9 \pm 3.2‰$** **10,190 ± 90**

Dark grayish lake mud with carbonate present. Core F, 420 to 440cm.

ANU-2053. **$D^{14}C = -277.5 \pm 7.5‰$** **2610 ± 90**

Dark grayish lake mud. Core J, 50 to 70cm.

ANU-2054. **$D^{14}C = -353.0 \pm 7.6‰$** **3500 ± 100**

Dark grayish lake mud. Core J, 100 to 120cm.

ANU-2055. **$D^{14}C = -438.2 \pm 5.0‰$** **4630 ± 80**

Dark grayish lake mud. Core J, 160 to 180cm.

ANU-2056. **$D^{14}C = -525.0 \pm 6.4‰$** **5980 ± 110**

Dark grayish lake mud. Core J, 225 to 245cm.

General Comment: after calibration and correction for water content and salinity, all dates give highly consistent sequence including comparison with previous dates on same area — "K4" (Bowler and Hamada, 1971), dated and reported as recommended by Stuiver and Polach (1977).

Valley Lake series

Valley Lake is 2nd largest of 4 lakes in recent volcanic craters at Mt Gambier, in SE corner of S Australia (37° 51′ S, 140° 46′ E). All 4 cores

have clearly defined 8 to 10cm band of extremely fine-grained creamy white aragonite above graded column of calcareous tuff. These are overlain by ca 1m black freshwater organic mud, rich in shells (id by B J Smith, Nat Mus Victoria, as "assemblage of ostracod and freshwater bivalve *Pisidium* sp. These are found in freshwaters low in dissolved salts and usually permanent").

ANU-2051A. **$D^{14}C = -854.1 \pm 2.9‰$** **15,450 ± 160**
Est $\delta^{13}C = -5.0 \pm 2.0‰$

Carbonate mud, containing some organic material. Carbonate fraction. Core A, 117 to 124cm.

ANU-2051B. **$D^{14}C = -822.3 \pm 7.9‰$** **13,900 ± 370**

Carbonate mud containing some organic material. Organic fraction. Core as for ANU-2051A. *Comment*: carbonate fraction (ANU-2051A) is significantly different from organic fraction, which must be considered as having most reliable age. Dilution, 31% sample.

ANU-2125. **$D^{14}C = -308.0 \pm 7.1‰$** **2960 ± 90**

Lake mud. Core B, 40 to 50cm.

ANU-2126. **$D^{14}C = -390.0 \pm 5.7‰$** **3960 ± 80**

Lake mud. Core B, 80 to 90cm.

ANU-2052. **$D^{14}C = -536.6 \pm 4.2‰$** **6180 ± 80**

Grayish lake mud. Core B, 110 to 120cm.

ANU-1809. **$D^{14}C = -991.6 \pm 1.9‰$** **38,400 $^{+2070}_{-1640}$**

Dark grayish lake mud with carbonate present. Core D, 107 to 117cm.

General Comment: date obtained for ANU-1809 prompted more detailed research into cores chronology. Correlation between cores VD and VB for ANU-1809 is based on equal sedimentation rates between tuffs and may be in error by ca ± 5cm. It was unusual to find sufficient organic material in aragonite sample for result. Within organic muds monotonic age sequence is consistent with uniform deposition since ca 6000 yr BP.

Lake Purrumbete

Lake Purrumbete is freshwater lake in circular crater 8km SE of Camperdown, Victoria (38° 17′ S, 143° 14′ E). Floor is flat and sides unusually steep. Four cores recovered but only one ^{14}C date obtained.

ANU-1658. **$D^{14}C = -534.1 \pm 6.5‰$** **6140 ± 110**

Dark gray lake sediment. Bottom of core D, 580 to 590cm, from center of lake.

Lake Muir series

Organic-rich deposits were sampled from 3 sites in SW West Australia of which only Cowerup Swamp, peat bog at N end of Lake Muir was sampled for ^{14}C dates (34° 30′ S, 116° 39.5′ E).

ANU-1918. **$D^{14}C = -220.4 \pm 7.1‰$** **2000 ± 70**

Grayish-colored lake mud with probably some carbonate present. Core A, 8 to 11cm. Dilution, 45% sample.

ANU-1919. **$D^{14}C = -385.7 \pm 6.1‰$** **3910 ± 80**

Grayish-colored lake mud with probably some carbonate present. Core B, 8 to 13cm.

ANU-1917. **$D^{14}C = -796.2 \pm 10.8‰$** **12,800 ± 480**

Grayish-colored lake mud with probably some carbonate present. Core B, 79 to 102cm. Dilution, 19% sample. Sample contained max amount of dark material found in clay and approx defines base of lake excavation.

ANU-1916. **$D^{14}C = -195.8 \pm 7.1‰$** **1750 ± 70**

Grayish-colored organic lake mud with probably some carbonate present. Core C, 10 to 15cm.

ANU-1915. **$D^{14}C = -270.3 \pm 6.6‰$** **2530 ± 70**

Grayish-colored organic lake mud with probably some carbonate present. Core D, 5 to 117cm.

General Comment: results suggest that organic-rich freshwater lake sediments contain insufficient magnetic material and have water contents which are too high for useful paleomagnetic research.

SUMMARY

Recently, comparison was made between historic and observed magnetic data, archaeomagnetic data from aboriginal fireplaces, and paleomagnetic data from Lakes Keilambete, Bullenmerri, and Gnotuk (Barton and Barbetti, 1982). The study indicated that, although ^{14}C chronologies from these lakes are internally consistent, ^{14}C ages for upper sediments, and probably entire sequences, are systematically too old by ca 450 ^{14}C years (350 calendar years). The effect is not readily apparent from wet sedimentation rate curves due to greatly increased sedimentation in modern times.

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