ARCHAEOLOGY IN NEW ZEALAND

RADIOCARBON DATES FOR UMU TI FROM SOUTH CANTERBURY: DISCUSSION OF DATES AND EARLY SETTLEMENT OF THE SOUTH ISLAND

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INTRODUCTION

Many ^{14}C dates in New Zealand either remain unpublished or are not presented in an archaeological context. I prefer not to remain guilty of this 'oversight', and therefore this paper presents 34 radiocarbon dates on charcoal from Maori earth ovens which are compared with the excavation results.

If readers are not interested specifically in radiocarbon dates of umu ti sites, they might want to move on to the second part of this paper, where I discuss the problems with the ^{14}C dating of charcoal in New Zealand along with the results of the radiocarbon dates in a wider context of the settlement of southern New Zealand.

Large Maori ovens occur and have been recorded over wide areas of Canterbury, Otago and Southland. They are especially prevalent on the Otago Peninsula (Knight 1966) and in South Canterbury (Fankhauser 1986). Ethnographic accounts indicate that large ovens were used for cooking *Cordyline australis* (Maori collective name is ti) and have the name of umu ti (Anon. n.d.; Best 1976; Brunner 1952: 125). *Cordyline* was used throughout Polynesia as a carbohydrate source (Fankhauser and Brasch 1985; Fankhauser 1989; 1990) and the technology of cooking ti would have been taken to New Zealand with the first Polynesian settlers. Umu ti would have been contemporaneous with moa-hunter sites. The harvesting and cooking of ti ceased about AD 1850.

Earth ovens were investigated over a wide area of South Canterbury by site surveying and excavation to better understand their construction and use.

Two large area excavations of umu ti sites were carried out in South Canterbury near Waimate and Timaru. The excavation and interpretation of both major sites has been presented (Fankhauser 1986: 40-65). I have also published a map of all recorded umu ti sites in South Canterbury and a description of the Limestone Hills site (Fankhauser 1987). In addition to the major sites, 28 individual ovens were sampled over a wide area from the Waitaki river to Albury and Timaru in the north. In all excavations, charcoal samples were collected for wood identification to be used for radiocarbon dating and to determine the type of firewood used. Ovenstones were collected for use in the development of a thermoluminescence (TL) dating method.

I obtained nine radiocarbon dates for the Limestone Hills and Landsborough Road sites, which in most cases agreed with the interpretations of the stratigraphy. Six of the nine dates were for shallow ovens which were associated with umu ti. I interpreted these small earth ovens as serving a ceremonial purpose. Twenty-five radiocarbon dates were obtained for the 28 sampled ovens, indicating that the large umu ti studied were used throughout the prehistoric period. Both conventional and calibrated ^{14}C ages are presented.

Given the problems with the application of radiocarbon dating in New Zealand, it is desirable to have an independent dating method which not only can date sites unsuitable to radiocarbon, but also can provide comparisons to ^{14}C dates. TL dating is the best choice for an alternate dating method because it has a wide applicability and can date events in a short prehistory (Aitken 1985; 1990: 141-186). I developed an 'inclusion' method for dating ovenstones (Fankhauser 1986: 103-176; 1991). Six TL dates using this method are reported for umu ti and are compared with the radiocarbon dates.

One could get the impression that I have a somewhat pessimistic view of radiocarbon dating in New Zealand. I do, but it should be noted that the ^{14}C dating service in New Zealand is and always has been excellent. The problems have been with the samples and not the laboratories. These problems are not unique to New Zealand and exist in other parts of Polynesia, eg. Hawaii, where driftwood was used for firewood.

RADIOCARBON DATING RESULTS AND DISCUSSION

Table 1 lists the ^{14}C dates for umu ti and associated shallow earth ovens. All radiocarbon ages are presented as 'before present' (BP) referring to AD 1950 as 'present'. Conventional radiocarbon ages use the Libby half life of 5568 years for carbon-14. In standard radiocarbon terminology an uncalibrated or conventional age is indicated by 'BP', with 'cal BP' (or 'cal AD') indicating calibration. Conventional ages were calibrated using the University of Washington, Quaternary Isotope Laboratory, Radiocarbon Calibration Program 1987, REV 2.0, which uses data sets of Stuiver and Becker (1986). Decadal and bi-decadal calibrations gave identical results. Conventional ages were not reduced by 30 years before being converted to account for possible systematic age differences between the Northern and Southern Hemispheres (Stuiver and Becker 1986). Calibrated dates are presented with error limits of $\pm$ 2 σ, which has been recommended (Scott et al. 1983; Stuiver and Pearson 1986). Calibrated dates will be used mainly in this discussion. All AD dates presented here are cal AD and therefore are actual calendar dates as opposed to the practice of converting a conventional ^{14}C age to a calendar date by subtracting 1950 years, which can be misleading and in fact has no real meaning (cf. Caughley 1988; Anderson and McGovern-Wilson 1990).

Corrected radiocarbon ages range from 955 to less than 300 cal years BP, obtained on charcoal from 15 species of trees (Table 2). C-14 dates from Limestone Hills (LH) and Landsborough Road (LO) sites, the major umu ti sites excavated, will be discussed first.

Excavation results indicate LH oven 1 (LHO-1) is older than LH oven 2 and dating also indicates this difference. Excavation revealed oven 2 to be contemporary with the associated shallow oven (LH/F5,6) and, although the calibrated ages differ by 112 years, according to Ward and Wilson (1978) the dates are statistically indistinguishable (the calibrated age ranges overlap at 1 σ). The charcoal selected for dating (Table 2) probably has something to do with the difference in ages.

TABLE 1. C-14 ages from earth ovens in South Canterbury

Site ID	Site Number[1]	Grid Reference[1]	NZ Number[2]	$\delta^{13}C$ ($^0/oo$)[3]	Conventional C-14 Age[4]	Calibrated C-14 Age[5]
ASO	S118/9	519 382	6173	-23.94 ± .04	951 ± 47	916(957-759)
BB423	S127/141	329 969	6209	-25.41 ± .03	675 ± 30	666(680-567)
DLO	S118/15	475 106	6167	-23.93 ± .02	863 ± 47	773(919-687)
FLO	S118/11	492 380	6375	-24.21 ± .03	694 ± 34	670(686-573)
FPO	S119/10	619 272	6384	-26.34 ± .02	658 ± 34	662(677-557)
GSDO	S127/159	545 074	6300	-24.06 ± .03	< 250	< 300
HHO	S119/7	618 276	6174	-24.20 ± .02	840 ± 34	734(894-687)
HVA	S127/162	495 068	6166	-24.44 ± .06	< 250	< 300
HVB	S127/162	495 068	6411	-23.67 ± .04	< 250	< 300
LHO-1	S127/160	547 075	6169	-24.39 ± .05	909 ± 47	890;825;793(933-722)
LHO-2	S127/160	547 075	6168	-23.02 ± .02	666 ± 34	664(679-560)
LH/F5,6	S127/160	547 075	6362	-26.04 ± .06	568 ± 33	552(654-527)
LOK13	S111/31	736 511	6322	-22.64 ± .01	896 ± 34	789(922-727)
LO-1	S111/31	736 511	6391	-25.49 ± .02	895 ± 31	789(919-729)
LO-2	S111/31	736 511	6331	-24.07 ± .02	1040 ± 35	951(1051-922)
LO-3	S111/31	736 511	6420	-23.18 ± .07	664 ± 34	663(679-559)
LO-4	S111/31	736 511	6422	-23.30 ± .07	752 ± 34	683(725-667)
LO-5	S111/31	736 511	6431	-24.42 ± .04	874 ± 34	782(913-712)
MP1	S127/138	291 029	6210	-25.02 ± .01	609 ± 34	638;598;566(667-543)
MP2	S127/139	283 027	6409	-21.17 ± .02	718 ± 34	675(697-660)
NWO	S101/67	310 732	6321	-24.04 ± .04	652 ± 34	661(676-556)
R2D2	S101/64	303 741	6297	-25.35 ± .02	647 ± 30	659(673-556
SDO	S127/159	545 074	6170	-26.68 ± .01	< 250	< 300
TO	S118/10	478 368	6230	-26.43 ± .03	821 ± 49	725(903-680)
TTHO	S101/65	305 741	6364	-25.82 ± .05	657 ± 29	662(675-560)
UHTO	S128/6	591 790	6208	-25.77 ± .02	560 ± 29	549(645-526)
WO2	S127/145	231 039	6172	-28.02 ± .02	852 ± 31	749(902-695)
WO3	S127/146	231 038	6343	-25.33 ± .03	630 ± 34	650;585;576(671-549)
WO4	S127/144	233 039	6383	-26.14 ± .03	588 ± 29	626;612;557(660-539)
WO5	S127/147	230 037	6212	-23.73 ± .03	392 ± 29	484(512-327)
WO6	S127/147	230 037	6393	-26.73 ± .03	588 ± 34	626;612;557(662-535)
WO7/1	S127/142	229 035	6171	-24.68 ± .01	509 ± 46	532(635-500)
WO7/2	S127/142	229 035	6211	-26.14 ± .02	589 ± 34	627;611;558(663-536)
ZBO	S119/10	619 272	6419	-25.52 ± .05	1045 ± 40	955(1055-921)

1. Site numbers (NZAA) and grid references are for NZMS1 topographical maps.
2. NZ Number is the NZ C-14 number assigned by the Institute of Nuclear Sciences, Wellington.
3. Values for $\delta^{13}C$ determined with respect to PDB.
4. Conventional C-14 ages calculated with respect to 0.95 NBS Oxalic Acid Std and old $T_{1/2}$ (5568 years). Ages are in years before 1950 (BP) and errors are one standard deviation.
5. University of Washington, Quaternary Isotope Lab, Radiocarbon Calibration Program 1987, REV. 2.0 used for calibrating dates with reference to datasets of Stuiver and Becker (1986). Ages are presented as: cal BP(age range of two standard deviations). Some samples have more than one age because of multiple intercepts in the calibration curve.

TABLE 2. Charcoal species from earth ovens in South Canterbury

Site ID	Species	Comments On Charcoal
ASO	*Podocarpus totara/hallii*	Mixed outermost and unknown
BB423	*Myrsine australis*	Smallish stems and relatively young wood
DLO	*Podocarpus totara/hallii*	Outer unburned wood, adjacent inner charcoal
FLO	*Podocarpus spicatus*	Outer, smaller stems, mixed age
FPO	*Podocarpus spicatus*	Outer and mixed age
GSDO	*Hebe, P. totara/hallii* (m)	Hebe stems selected
HHO	*Podocarpus totara/hallii*	Mixed outermost and unknown
HVA	*L. scoparium, P. crassifolius* (m)	Stems, outer wood with < 20 growth rings
HVB	*Leptospermum ericoides*	Small stem wood
LHO-1	*Podocarpus totara/hallii*	Outermost charcoal where possible
LHO-2	*Podocarpus totara/hallii*	Outer unburned wood, adjacent inner charcoal
LH/F5,6	*P. totara/hallii, Hebe* (m)	Mainly outer totara and smaller hebe stems
LOK13	*Podocarpus totara/hallii*	Unable to sort outer wood, mixed age
LO-1	*P. totara/hallii, P. spic.* (m)	Outer and mixed age
LO-2	*Podocarpus totara/hallii*	Mixed age
LO-3	*Podocarpus spicatus*	Mixed age
LO-4	*P. spicatus, C. australis* (m)	Mixed age
LO-5	*Podocarpus spicatus*	Mixed age
MP1	*Myrsine australis*	Smallish stems and relatively young wood
MP2	*Olearia, M. australis*	Small stem wood
NWO	*P. totara/hallii, Coprosma* (m)	Small stems, outer wood, < 30 growth rings
R2D2	*M. australis, Hymenanthera?* (m)	Smallish stems and relatively young wood
SDO	*Coprosma, Nothofagus*	Smaller stems, probably < 20 growth rings
TO	*Hoheria/Plagianthus*	Unknown age
TTHO	*Myrsine australis*	Mainly small stems
UHTO	*Lophomyrtus abcordata*	Slow growing but relatively short life span
WO2	*Sophora microphylla*	Smaller stems and outermost char.; rings unknown
WO3	*Sophora microphylla*	Relatively short lived
WO4	*Hoheria/Plag.* (m), *Coprosma*	Small stems and mixed age
WO5	*M. australis, Hymenanthera?* (m)	Smallish stems and relatively young wood
WO6	*M. australis, S. microphylla* (m)	Mainly smaller stems
WO7/1	*Coprosma*	Stem wood, probably < 10 growth rings
WO7/2	*Myrsine australis*	Small stems and relatively young wood
ZBO	*Podocarpus spicatus*	Mainly outer, and mixed age

Notes:
1. Species identifications and comments by B.P.J. Molloy, DSIR, Botany Division, Christchurch.
2. (m) = minor amount.

The raised-rim oven at Landsborough Road (LOK13) has a radiocarbon age of 789 cal yr BP. The most recent shallow oven, LO-1, thought to be contemporary with it (i.e. the last time it was used and abandoned), has an identical age which certainly gives a strong indication for a similar event. A previous use of the main oven (umu ti were reused) should have had oven LO-2 associated with it (LO-2 was located below LO-1). This age of 951 cal yr BP is earlier (2 σ errors nearly meet), but certainly too early for a practical reuse of the main oven. Apparently some very old totara was used to fire this oven. LO-5 (782 cal yr BP) should be the oldest oven because it was under LO-1 and LO-2. The age of 951 for LO-2 has to be impossible if the stratigraphy is considered; age inversions are common with charcoal dates. Ages of 663 and 683 years cal BP for LO-3 and LO-4 are reasonable considering that they are stratigraphically later than other ovens and LO-3 is on top of LO-4.

The radiocarbon dates for the most part agree with the stratigraphy. However, all ovens in the above sites were dated with podocarp charcoal with its inbuilt age (McFadgen 1982). The inbuilt age comes not only from the age of the tree, but also includes the time from death to use as firewood. This latter time can be considerable in a climate such as Canterbury's. For example, 'fallen logs, obviously pre-dating European deforestation' are still found in the eastern part of the South Island (Molloy et al. 1963). This is certain to lead to problems in accurate dating.

Several dates from sampled ovens as in the LH and LO sites are derived from mixed-age charcoals of podocarp species (Table 2). These ages are for trees and not the use of earth ovens! Other ^{14}C ages have been determined from shorter-lived species and as a whole are younger. Ages of less than 300 cal BP are obtained when there is a combination of short-lived species and small stems with less than 20 growth rings. The ovens less than 300 BP, with the exception of GSDO, are large umu ti and, unlike all other umu ti, are rectangular. This is a distinctive style change from circular umu ti. Rectangular umu ti have been described for the North Island (Stack 1893: 26; Hay 1915: 15) and also in a manuscript (Anon. n.d.) relating the way the Ngati Mamoe and Ngai Tahu harvested and cooked ti. This probably indicates a method of umu ti construction unique to these tribes and may indicate northern influence for the Classic culture along with certain weapons and ornaments (eg. mere and hei-tiki) (Anderson 1983: 31-42).

Interestingly, two umu ti dated to less than 300 cal BP contain kanuka (*Leptospermum ericoides*) and manuka (*L. scoparium*) which are 'nurses' for forest trees. Two others (SDO, GSDO), in close proximity to three ovens which only contained totara (LHO-1, LHO-2, LH/F5,6), had charcoal identified as hebe, coprosma, beech, and a minor amount of totara. The forest was apparently regenerating with some totara in its midst.

The presence of a variety of woods for use in ovens indicates that wood was not selected, but whatever was available was used. Podocarps may have been preferred when they were available as shown by the frequency of use (Table 2).

Ovens ZBO and FPO are adjacent, with HHO a short distance away, but their ages differ markedly. This could be viewed as ti exploitation in one area over a long period of time (c.300 years). What is probably the case, however, is the use of podocarps giving mixed-age charcoals, so no age conclusions can be made.

Wainui umu ti (WO) are also in close proximity to one another and have an age range from 484 to 749 cal yr BP. Three of these ovens have the same age (WO4, WO6, WO7/2), so this may represent intensive oven building in one area over a short time period. WO2 and WO3 are adjacent and show a difference in calibrated ages of >100 years. Oven WO7 was the only type found to have two uses with one oven on top of the other. The ^{14}C dates agree with the stratigraphy.

Ovens TTHO and R2D2 are within 100 m of each other and NWO is on the same hill. Their calibrated ages are within a range of 10 years, possibly indicating a short period of ti exploitation in this area. However, no definite conclusions can be made if allowances are made for counting errors and possible differences in the ages of trees.

In Table 3, the charcoal samples are compared to the dates produced. It can be seen that the oldest ages are predominantly from the podocarp species. The youngest ages are from shorter-lived species, especially when young stem wood is selected (Table 2).

TABLE 3. Number of charcoal samples of the identified species from earth ovens giving a corrected C-14 date in the given age intervals

Species	<300	300-500	500-600	600-700	700-800	800-900	>900
Podocarpus spicatus				4	1,1m		1
P. totara/hallii group	1m		1	2	4	1	2
Myrsine australis		1	1	6			
Sophora microphylla			1	1m	1		
Hoheria/Plagianthus sp.				1m	1		
Olearia sp.				1			
Cordyline australis				1m			
Coprosma sp.	1		1	1,1m			
Hymenanthera sp.?		1m		1m			
Hebe sp.	1		1m				
Lophomyrtus abcordata			1				
Leptospermum ericoides	1						
Leptospermum scoparium	1						
Nothofagus sp.	1						
Pseudopanax crassifolius	1m						

Notes:
1. Information in this table is from Table 1 (calibrated BP ages) and Table 2 (charcoal species). Where multiple calibrated ages for a particular sample fall into two age intervals, the age interval with the majority of ages was assigned.
2. "m" indicates a minor amount of a particular species occurring in a charcoal sample for C-14 dating.

Where there is a combination of stem wood and short-lived species the ^{14}C ages produced may be acceptable. Although it may not be wise to do so, I will give the following list of sites by Site ID as having acceptable charcoal dates: BB423, GSDO, HVA, HVB, MP1, MP2, R2D2, SDO, TTHO, UHTO, WO5, WO6,W O7/1 & 2, and possibly NWO and WO4. The maximum age of a site in this list is 675 cal yr BP. However, even with stems and short-lived species there will be some inbuilt age and there is no way to estimate this. I can only conclude that when long-lived species are found in an archaeological context, it may not be worth the time, effort and expense involved to obtain a radiocarbon date.

Nevertheless, it is evident that *C. australis* was harvested and cooked throughout the prehistoric period in South Canterbury. This is reasonable given that Polynesians took the technology of *Cordyline* cooking with them to New Zealand and knew it was a good carbohydrate source.

FURTHER DISCUSSION ON RADIOCARBON DATES

I will now give a broader interpretation to the dates which were detailed above.

I think the settlement of South Canterbury and much of southern New Zealand occurred around 700-750 years BP (c.1275 cal AD). McCulloch and Trotter (1975) come to similar conclusions, but set the date at 800 BP. Note that 800 BP for wood samples corresponds to 705 cal yr BP or 1245 cal AD. After settlement was established, the population probably was fairly constant or even increased up and through the late (Classic) period.

The ^{14}C dates which I have, if viewed differently than usual (i.e. not relating them directly to archaeological events), can reveal a pattern consistent with the statements in the preceding paragraph (see Fig. 1). If settlement occurred around 1275 cal AD, then wood (charcoal) being dated is up to ~275 years older than the ovens it was used to fire. There is no reason to surmise that dates over 675 cal BP are dating archaeological events. There is a peak in the number of dates at 600 to 700 years cal BP. (An interval of 600-700 cal BP corresponds approximately to 600-800 BP.) This interval coincides closely with deforestation by fires generally attributed to Maori (Cumberland 1962; Molloy et al.1963; McGlone 1983; 1989). In a summary of charcoal remains from forest fires McGlone (1983: 14) states, 'There are no dates of tree remains from lowland eastern South Island younger than 590 ± 50 yr BP [670-520 cal BP, 2 σ].' This particular sample of totara was from Banks Peninsula (Molloy et al. 1963). Molloy (1977) concludes that forests in the Waimakariri River valley were destroyed by fire between 500 and 600 years BP. According to McGlone (1983) forests in the Rakaia River system were destroyed at the same time. The coincidence of this conclusion with the pattern of dates in Fig. 1 is striking, and may well be of significance.

If settlement did not occur until about 1275 AD as I propose, then it did not take long for the Maori to initiate the destruction of forests. Fires were probably started to clear tracks and areas around settlements (McGlone 1983). In the dry areas of the eastern South Island small fires could easily have become raging infernos destroying large areas of forest.

Once the forests were burnt there was an abundance of dead timber which would supply camp fires (and umu ti) for hundreds of years. Of course, using this for firewood leaves charcoal which is of the order of 600 years BP and older. This should leave a gap in ^{14}C dates, which is exactly what is observed. There will still be some charcoal with ages less than 500-600 years BP because there was always dead wood around from regenerating forest. Given this

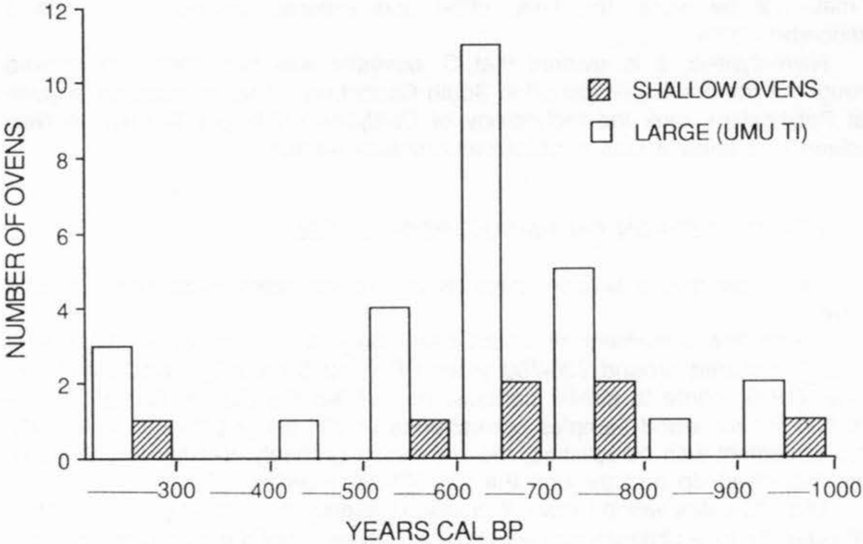

Fig. 1. Graph of number of ovens from South Canterbury corresponding to indicated time periods. Calibrated ages are from Table 1.

interpretation, I see a constant exploitation of *C. australis* in South Canterbury from initial settlement up to European contact.

Is there dating evidence other than radiocarbon charcoal dates with which to assess the prehistoric settlement of Canterbury and the southern South Island? I am excluding charcoal dates because experience in New Zealand has shown them to be unreliable for dating archaeological sites (McCulloch and Trotter 1975; McFadgen 1982; Law 1984). Even twigs cannot be expected to give reliable dates (Trotter 1968). Furthermore, although charcoal has been identified and selected since 1976, it is still necessary to carefully screen dates to include only those from short-lived species with a known number of growth rings. As noted above there will still be an unknown inbuilt age.

McCulloch and Trotter (1975), Caughley (1988), and Anderson and McGovern-Wilson (1990) have given lists of ^{14}C dates for moa-hunter sites in the South Island. There is repetition in these lists, with that of Anderson and McGovern-Wilson being most complete. Radiocarbon dates from marine shells and moa bone are included. These dates might be looked at as being more reliable than charcoal for giving the age of archaeological sites (Law 1984; Caughley 1988), although there are problems with dating of marine shells (Stuiver et al.1986; Head 1991) and collagen (Gillespie 1989). No cal BP ages on moa bone collagen from Canterbury are greater than 700 years. A collagen date of 1525 ± 60 BP from Timpendean is probably from 'natural' bone; Anderson and McGovern-Wilson (1990: 45) come to the same conclusion. Using the amended list of Anderson and McGovern-Wilson (1990), taking into account hemisphere reservoir differences, i.e. -30 years (Stuiver et al. 1986), and calculating marine dates according to McFadgen and Manning (1990), the oldest date for marine shell (NZ2718) is 738 cal yr BP. This and a replicate sample with ages agreeing to within 10 years are from Avoca Point (Trotter 1980). McFadgen (1987) reinterpreted this site and states, '...the question must be raised as to whether the Fyffe site [Avoca Point] dates are contemporary with human occupation.' No doubt, the same question can be raised for marine shell dates from some other sites and it may be significant that the majority of marine shell ages are less than 650 cal BP.

Finally, radiocarbon and TL ages (Fankhauser 1986: 103-176; 1990) from some umu ti are compared in Table 4. The TL ages have been adjusted to years before 1950 for comparison with ^{14}C ages.

TABLE 4. Time of umu ti use determined by C-14 and TL dating

Oven	Species[1]	Conventional C-14 Age[2]	Calibrated C-14 Age[2]	TL Age[3]
ASO	*Podocarpus totara/hallii* group	951 ± 47	916(957-759)	625 ± 112
DLO	*Podocarpus totara/hallii* group	863 ± 47	773(919-687)	671 ± 71
TO	*Hoheria/plagianthus* group	821 ± 49	725(903-680)	586 ± 88
LHO-2	*Podocarpus totara/hallii* group	666 ± 34	664(679-560)	373 ± 100
WO5	*Myrsine australis*, *Hoheria/plagianthus* group (m)[4]	392 ± 29	484(512-327)	432 ± 67
SDO	*Coprosma sp., Nothofagus sp.*(m)[4]	< 250	< 300	225 ± 31

1. Species identification on charcoal was done by B.P.J. Molloy, DSIR, Botany Division, Christchurch, N.Z.
2. Conventional and calibrated C-14 ages are from Table 1. Errors for conventional ages are one standard deviation. Calibrated ages are presented as: cal BP(age range of two standard deviations).
3. Error in TL age is one standard deviation. Ages quoted are before 1950 for comparison with C-14 ages.
4. (m) indicates a minor amount of species in charcoal.

All TL ages are less than the corrected ^{14}C ages giving a mean difference of 175 years older for radiocarbon dates on charcoal. All long-lived species (totara) give large differences between TL and corrected ^{14}C ages, while shorter-lived species give either large or small differences. These results are not unexpected! In New Zealand archaeology, I think TL dating can give more accurate dates than ^{14}C dating, especially ^{14}C dating of charcoal. With TL dating the event, i.e. a camp-fire, a cooking fire or the firing of an umu ti, is being dated. I have developed a TL dating method for heated greywacke stones. Greywacke exists over large areas of the South and North Islands (Dickinson 1971; Suggate 1978). I see no major problems in obtaining routine TL dates with a standard error of ~8-10 %. Perhaps more TL dates can be obtained on umu ti stone samples which are still available; the radiocarbon dates have already been done (Table 1).

With the availability now of ^{14}C accelerator mass spectrometry dating in New Zealand there is the possibility of dating young short lifespan wood. For example, *Cordyline australis* was found in three earth ovens (NWO, LOK13 and LO-4) which were ^{14}C dated with podocarp charcoal. *C. australis* is likely to be young if found in or near umu ti because only young plants were harvested. In fact, an intact *C. australis* stem 8 cm in diameter was found in the Landsborough umu ti (LOK13) and would have been <10 years old. It would have been interesting to compare the date of this specimen with podocarp charcoal. It could have been dated with conventional ^{14}C dating techniques, but in the other earth ovens only small fragments existed which would require AMS dating. Perhaps similar situations exist to escape from dealing with mixed charcoals, with their uncertain dating outcome. Problems of sample contamination still exist.

Reiterating, the problem with charcoal ^{14}C dates is that the tree is being dated and not the archaeological event. Few people collect fresh wood for fires and the Maori were no exception. They would have collected wood which was standing or fallen and dead for possibly hundreds of years.

The outcome of the available dates points to a settlement of Canterbury around 700 BP (750 BP maximum) with rapid settlement of the rest of southern New Zealand.

Even though the radiocarbon ages which I obtained are certainly too old for many ovens, there are some important conclusions (with consideration) which can be made: (1) ti was harvested and cooked in earth ovens throughout the entire prehistoric period in South Canterbury; (2) there is no indication that it was of lesser importance at any time in this period; (3) any wood available was used although podocarps when available were predominantly used; and (4) the style of umu ti changed dramatically after 1650 AD from round to rectangular.

CONCLUSIONS

All umu ti excavated were circular except for three rectangular ones dated to <300 cal yr BP. Rectangular umu ti may be a style peculiar to the Ngati Mamoe and Ngai Tahu.

Radiocarbon dates show ovens were used throughout the prehistoric period. The majority had ages between 600 and 700 cal yr BP, and I think this is a consequence of using dead timber for centuries following forest fires of this period. It appears that certain types of wood were not preferred, although podocarps were chosen when available. Most groups of ovens have a short time span of use according to radiocarbon dates, but this is only speculative given the vagaries of ^{14}C dating on charcoals in New Zealand.

The TL ages for umu ti were up to 326 ± 121 years (1 σ) less than conventional radiocarbon ages, but this is to be expected given that ^{14}C dates were for charcoal from trees rather than the use of earth ovens. Marine shell may give better radiocarbon dates than charcoal. Where ovenstones are available and marine shell is not (eg. all ovens in this research), I think the answer to reliable dates is TL dating and since greywacke is so widespread in New Zealand, this method can be broadly applied. TL dates could help resolve an accurate prehistoric sequence for both the South and North Islands of New Zealand.

I have argued that the initial settlement of South Canterbury and southern New Zealand occurred about 1275 cal AD. It is doubtful whether existing radiocarbon dates can give a true picture of initial Polynesian settlement and pattern of colonisation. A fuzzy picture might appear if ^{14}C dates on marine shell and charcoal are rigorously (mercilessly!) screened. Most pre-1976 charcoal dates would be automatically rejected. This would probably leave few dates to work with, but a few good dates might lessen some of the present arm waving in New Zealand archaeology.

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