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Since its inception, the basic purpose of Radiocarbon has been the publication of compilations of ^{14}C dates produced by various laboratories. These lists are extremely useful for the dissemination of basic ^{14}C information.

In recent years, Radiocarbon has also been publishing technical and interpretative articles on all aspects of ^{14}C, especially in the Proceedings issues. The editors and readers agree that this expansion is broadening the scope of the Journal.

Another section is added to our regular issues, "Notes and Comments". Authors are invited to extend discussions or raise pertinent questions to the results of scientific investigations that have appeared on our pages. The section will include short, technical notes to relay information concerning innovative sample preparation procedures. Laboratories may also seek assistance in technical aspects of radiocarbon dating. Book reviews will also be included for special editions.

Manuscripts of radiocarbon papers should follow the recommendations in *Suggestions to Authors.** All copy (including the bibliography) must be typewritten in *double space*. Our deadline schedule is:

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Half life of ^{14}C. In accordance with the decision of the Fifth Radiocarbon Dating Conference, Cambridge, 1962, all dates published in this volume (as in previous volumes) are based on the Libby value, 5570 ± 30 yr, for the half life. This decision was reaffirmed at the 11th International Radiocarbon Conference in Seattle, Washington, 1982. Because of various uncertainties, when ^{14}C measurements are expressed as dates in years BP the accuracy of the dates is limited, and refinements that take some but not all uncertainties into account may be misleading. The mean of three recent determinations of the half life, 5730 ± 40 yr, (Nature, v 195, no. 4845, p 984, 1962), is regarded as the best value presently available. Published dates in years BP, can be converted to this basis by multiplying them by 1.03.

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Meaning of $\delta^{14}C$. In Volume 3, 1961, we endorsed the notation Δ (Lamont VIII, 1961) for geochemical measurements of ^{14}C activity, corrected for isotopic fractionation in samples and in the NBS oxalic-acid standard. The value of $\delta^{14}C$ that entered the calculation of Δ was defined by reference to Lamont VI, 1959, and was corrected for age. This fact has been lost sight of, by editors as well as by authors, and recent papers have used $\delta^{14}C$ as the observed deviation from the standard. At the New Zealand Radiocarbon Dating Conference it was recommended to use $\delta^{14}C$ only for age-corrected samples. Without an age correction, the value should then be reported as percent of modern relative to 0.95 NBS oxalic acid (Proceedings 8th Conference on Radiocarbon Dating, Wellington, New Zealand, 1972). The Ninth International Radiocarbon Conference, Los Angeles and San Diego, 1976, recommended that the reference standard, 0.95 times NBS oxalic acid activity, be normalized to $\delta^{13}C = -19‰$.

In several fields, however, age corrections are not possible. $\delta^{14}C$ and Δ, uncorrected for age, have been used extensively in oceanography, and are an integral part of models and theories. For the present, therefore, we continue the editorial policy of using Δ notations for samples not corrected for age.

* Suggestions to Authors of the Reports of the United States Geological Survey, 6th ed, 1978, Supt of Documents, U S Govt Printing Office, Washington, DC 20402.

CONTENTS

[RADIOCARBON, VOL 25, NO 3, 1983, P 797-802]

Radiocarbon

1983

^{14}C VARIATIONS FROM TASMANIAN TREES—PRELIMINARY RESULTS*

STEVE McPHAIL**, MIKE BARBETTI**, ROGER FRANCEY†, TREVOR BIRD‡, and JIRI DOLEZAL‡

ABSTRACT. Huon pine is endemic to Tasmania. It has well-defined annual rings, may live for over 2000 years, and is particularly resistant to decay. Celery-top pine has similar characteristics and may live for 800 years. As part of a multi-disciplinary study of these trees and their habitat, a simple wood pretreatment method for isotope analysis is described. The solvent-acid-alkali-acid sequence yields a value of $\Delta^{14}C = -16 \pm 6‰$ for AD 1941-45 Huon pine heartwood; $\Delta^{14}C$ for extracts containing various proportions of post-AD 1955 carbon are also presented. $\Delta^{14}C$ measurements on super-canopy and sub-canopy leaves from Celery-top pines are compared and used to place an upper limit of 10% on the amount of sub-canopy CO_2 assimilated by sapling leaves, originating from decaying litter-mass. ^{14}C ages from well-preserved logs illustrate the potential for a continuous Holocene chronology from 7400 years BP to the present. A 12,000-year-old Celery-top log has also been found.

INTRODUCTION

Huon pine (*Dacrydium* now *Lagarostrobos* (Quinn, 1982) *franklinii*) is a long-lived species confined mainly to river valleys in western and southern Tasmania. Individual specimens may live for more than 2000 years, while well-preserved logs of even greater antiquity may be found either on the surface or buried, since the wood is particularly resistant to decay. Celery-top pine (*Phyllocladus aspeniifolius*) has similar characteristics and may live for 800 years. The presence of well-defined annual rings in both Huon and Celery-top pines and coupling between variations in xylem growth and microclimate permit cross-dating and construction of long chronologies of ring-width series anchored in the present. Since their annual rings may be chemically treated so that only material assimilated in the year of growth remains, they can provide a long, accurate record of atmospheric variations in ^{14}C for the southern hemisphere.

SITE DETAILS

Wood collections were mainly carried out in a small area of rain forest on the middle reaches of the Stanley River. The area was lightly and selectively logged in the past so that cross-sections, 5 to 20cm thick, are easily obtained from tree stumps and fallen timber. The area also contains many ancient logs buried under 2 to 3m of river sediments. Some are exposed where the modern river cuts through the deposit; others were found by excavation. The site is within 23km of the Tasmanian West

* This paper was presented at the Eleventh International Radiocarbon Conference in Seattle, Washington, June 20-26, 1982.

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Coast in an area which, apart from some bushfires, was almost free of human influence. Winds are predominantly from the southwest, so that the composition of the troposphere largely represents that over the southern oceans. Rainfall is high, in excess of 2000mm per year. Huon pine is generally restricted to areas of permanent surface water (*ie,* along water courses or in swampy areas, eg, Pedley, Brown, and Jarman, 1980), whereas Celery-top pine is more widespread.

DENDROCHRONOLOGY

Ogden (1978) points to the relative complacency of Huon pine growth-ring series, thought to be induced by moist habitat. The absence of water stress in the Huon pine environment may be advantageous in that it minimizes carbon isotope fractionation arising from concentration gradients across the stomates (Francey and Farquhar, 1982). Preliminary studies on Huon pine from the Riveaux Creek area by T Bird have demonstrated infrequent occurrences of "missing" and "multiple" rings, which coupled with some ring-width variation, permit successful cross-dating and chronology development. La Marche and Pittock (1982) found Celery-top pine grew more after winters which were warmer and drier than average, but suggested that the variables tested (temperature and precipitation) were a measure of available light. Ring-width variation in Huon pine may also be due to changes in integrated light intensity in these wet forests, since Huon and Celery-top pine cross-date in many years.

PRETREATMENT METHODS

We developed a simple pretreatment method by which a suitable fraction of wood can be separated for isotope analysis. Although isolation of pure cellulose would have been a sure way to proceed, preparation time would have been excessively lengthy.

The remarkable resistance of Huon pine to decay (Millington *et al,* 1979) is due to the presence of oils and resins which inhibit the activities of micro-organisms. Since these oils and resins are mobile within the wood structure, it is important that pretreatment removes them. The de Vries method, of sequential acid, alkali, and acid extractions, when used on wood is somewhat successful in removing unwanted, mobile fractions. However, the success of the method with non-polar fractions such as oils and resins is limited because only highly polar water solutions are used. Following the suggestions of Head (ms; pers commun) we decided to supplement this method with a series of solvent extraction steps to remove these fractions. The acid and alkali solutions would ensure that those fractions such as hemicelluloses, which can be made water-soluble, were removed. The alkali extraction would also break down and remove the low molecular weight lignins. The residue would be composed principally of cellulose but include the high molecular weight lignins.

A Huon pine from the Gordon River area was selected to test this supplemented method. Wood was taken from the AD 1941-45 growth rings that, in this tree, had already undergone the sapwood-to-heartwood conversion. The cellulose of these rings would not have any post-AD 1955 "bomb-generated" ^{14}C in it but some heartwood extractives and the mobile fractions would show much higher ^{14}C concentrations.

Pretreatment was tested on 0.2mm thick wood shavings, by sequentially boiling and filtering, using: 1) 2:1 benzene:ethanol solution, 2) ethanol, 3) water, 4) 2M hydrochloric acid, 5) 2% sodium hydroxide (twice, using a fresh solution each time), 6) 0.1% phosphoric acid, and then 7) washing with distilled water until neutral. The last four steps parallel the de Vries method. Two subsamples of the finely shaved and homogenized wood from these rings were produced. One subsample was given the full treatment while the other was treated by the equivalent of the de Vries method alone.

The results of ^{14}C and ^{13}C determinations are shown in figure 1, where the extract labeled *Solvent* was produced by amalgamation and evaporation to dryness of the extracts from steps 1 and 2; *Acid* from steps 3 and 4, and *Alkali* from the acidified filtrate of step 5. Insufficient material was generated in either steps 6 or 7 to warrant separate carbon isotope measurements. *Residue* refers to material remaining after step 7. The relatively high $\Delta^{14}C$ for the solvent extract (318 ± 18‰) is slightly less than that for contemporary air at the time of felling ca 1974 (ca 400‰; Polach and Singh, 1980), implying that some of the extract was formed prior to 1962, but with a high proportion of more recent material, as expected from the known mobility of resins and oils in wood. If the solvent extraction steps are omitted, some, but not all, of this fraction finds its way into

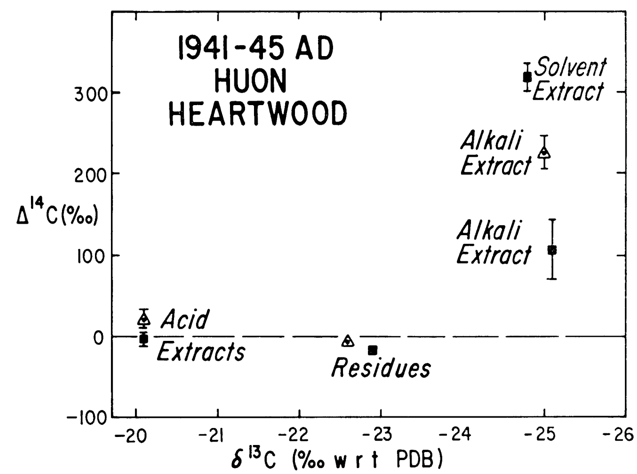

Fig 1. Carbon isotope measurements on chemical fractions of Huon pine wood from the AD 1941-45 growth rings. $\delta^{13}C$ values are relative to the PDB standard; $\Delta^{14}C$ values are normalized to $\delta^{13}C = -25‰$ and corrected for radioactive decay (Stuiver and Polach, 1977). The wood sample was divided and subjected to different pretreatment steps; results from the full method which included solvent extraction are shown as ■, whereas results for the second portion which was treated only with acid-alkali-acid steps are shown as △. Uncertainties are generally the size of the symbols (±0.1‰ for $\delta^{13}C$, ±6‰ for $\Delta^{14}C$) except where indicated by error bars. Full pretreatment extracts more post-AD 1955 carbon and yields slightly less residue with lower ^{14}C activity and more negative $\delta^{13}C$.

the alkali extract; some of the oils and resins can be made water soluble by basic but not acidic hydrolysis. Alkali extraction also removes another component, containing mainly lignin. As the sapwood-to-heartwood transition involves deposition of contemporary carbon, the $\Delta^{14}C$ of 107 ± 37‰ (alkali extract, after solvent extraction) indicated that the transition on the AD 1941-45 rings occurred within a few years centered ca 1958 (see Polach and Singh, 1980). Alternative explanations involve small but significant contributions to pre-1956 material by carbon of more modern origin. The $\delta^{13}C$ value indicates that the acid extract contains a component which is clearly different to those in the alkali and solvent extracts. Its $\Delta^{14}C$ of −2 ± 9‰ (after solvent extraction) indicates that it antedates the alkali extract. It probably contains principally hemicelluloses.

The residue, (*Residue,* fig 2) after full pretreatment, gives a $\Delta^{14}C$ value of −16 ± 6‰, in good agreement with results from the northern hemisphere (Stuiver and Quay, 1981). This implies that the method yields a residue which is essentially free from components more than 10 years younger than the rings themselves. In contrast, the residue produced from the de Vries method alone gives a $\Delta^{14}C$ value of −5 ± 6‰ indicating that post-AD 1955 components were not completely removed. This conclusion was previously reached for other species (Olsson, 1980).

^{14}C OF CONTEMPORARY LEAF MATERIAL

If canopies retain a significant proportion of CO_2 from decaying humus and litter, then significant levels of 'old' carbon might be re-assimilated and laid down in tree rings. To test this hypothesis, leaves were taken from a mature Celery-top pine (with all foliage above canopy height) and from a 2m sapling. The results of the $\Delta^{14}C$ and $\delta^{13}C$ determinations are given in table 1.

Due to the steadily declining $\Delta^{14}C$ in the atmosphere (at ca 16‰ per year since 1965) any contribution to sub-canopy CO_2 from decaying vegetable matter would increase its ^{14}C activity. For an anticipated carbon turnover time of 1 to 2 years for litter mass in this environment (based on data of Ajtay, Ketner, and Duvigneaud, 1979 and R M Gifford, pers commun), sub-canopy CO_2 would be a mixture between CO_2 of contemporary activity (taken as 293‰) and CO_2 with $\Delta^{14}C$ in the range 309 to 325‰. In these circumstances, the 1σ upper limit of the sub-canopy $\Delta^{14}C$, *ie,* 295‰, represents an upper limit of ca 10% as the proportion of sub-canopy CO_2 originating from litter and assimilated into the sapling leaves at 2m. Full details are given in Francey *et al,* (Isotopes in tree rings—Stanley River Collections 1981/82: CSIRO Tech paper, ms in preparation).

TABLE 1
Carbon isotope measurements on Celery-top leaves above and below canopy, 1980/81 season

Tree	SUA No.	Relationship to canopy	$\delta^{13}C$ (‰) PDB	$\Delta^{14}C$ (‰)
SRT 74	5008	Below	−29.6	286 ± 9
SRT 2	5009	Above	−24.0	293 ± 7

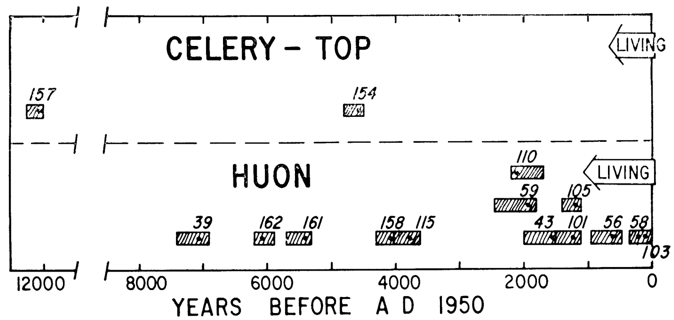

Fig 2. Approximate age ranges of preserved logs from which cross-sections have been collected at the Stanley River site. Numbers refer to our site catalogue, ● the calibrated ^{14}C ages (Klein *et al*, 1982) and ▨ the ages spanned by the rings in section. Many other buried logs have been sampled, but not yet dated.

POTENTIAL OF THE TASMANIAN PINE RECORD

The ages of some of the logs and stumps sampled in the field-work area are shown in figure 2. The outside of one Huon log (SRT-39) has a ^{14}C age of 6190 ± 60 yr bp (SUA-5004) corresponding to a calendar age of ca 7100 yr BP. It would appear likely in view of the well-distributed ages of the other samples, that wood with all ages between 7000 yr BP and the present will ultimately be found. The discovery of a Celery-top log with a ^{14}C age of 12,000 yr bp gives rise to the tantalizing prospect of an even longer record, especially since, though shorter-lived, Celery-top is easier to cross-date. A chronology based on Tasmanian pines stretching back to the late Pleistocene may be attainable.

ACKNOWLEDGMENTS

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[RADIOCARBON, VOL 25, NO 3, 1983, P 803-809]

THE QUESTION OF DIFFUSE SECONDARY GROWTH OF PALM TREES*

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ABSTRACT. ^{14}C activity measurements were used to investigate the growth pattern of the stem of a palm tree (*Cocos nucifera*) which does not form annual rings. The results reveal that there was no diffuse secondary growth (thickening of the stem) over the entire mature stem during the last 25 years of growth, with the exception of a restricted zone in the center at medium height.

INTRODUCTION

Knowledge concerning the anatomy and physiology of adult palm trees is still limited, and issues remain in dispute. One of these issues is the occurrence of so-called diffuse secondary growth, the existence of which is favored by some botanists (Tomlinson, 1961) and opposed by others (Pigott, 1964; Child, 1964; Tomlinson, pers commun). Comparing palms with other trees of the gymnosperm group or the dicotyledonous group, a fundamental difference is evident. Palms are thick at an early age and grow cylindrically in a vertical manner, whereas other (non-monocotyledonous) trees thicken with age, forming new tissue in the form of tree rings. This is why the former are thought to lack a secondary growth. However, it is questionable whether the thickening growth in the former ceases totally or continues in a manner that may be designated as "diffuse secondary growth." In this work, ^{14}C measurements made on a coconut palm that grew in Brazil were used to study the possibility of this secondary, thickening growth.

BOTANICAL DISCUSSION

The following is a survey of the specialized literature on palm anatomy and growth (Tomlinson, 1961; Tomlinson and Zimmermann, 1967). Palms, which are monocotyledons, are easily distinguished from most other woody plants by their typical leafy crowns, their unbranched stems, and leaf scars on the stem. The wood is also very different from that of gymnospermous or dicotyledonous trees, as can be seen from a transverse section of the stem (pl 1A): vascular bundles are dispersed all over the stem and are embedded in a more or less uniform parenchyma. Usually, the wood

* This paper was presented at the Eleventh International Radiocarbon Conference in Seattle, Washington, June 20-26, 1982.

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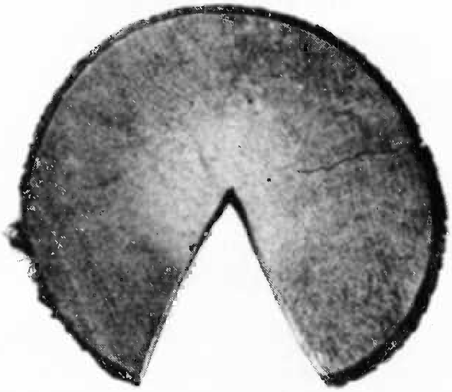
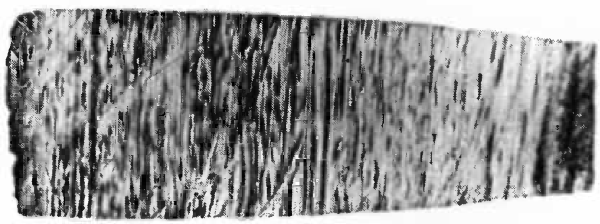
PLATE 1A



Transverse section of stem at 3.5m height above ground

PLATE 1B



Longitudinal section of stem at 5.5m height above ground. Note the dark, congested bundles in the cortical zone and the appearance of some inclined bundles passing to the surface of the stem.

is soft and succulent in the center, containing widely scattered vascular bundles, whereas the peripheral zone is much denser with congested bundles (pl 1B). This explains the enormous mechanical strength of palm stems. Palm wood of the cortical zone is one of the hardest tissues known in the plant kingdom. In the material studied here, bundles were dense in the cortical zone within the lower part of the stem and less dense elsewhere; no literature was found that accounts for this observation. The longitudinal course of single vascular bundles is more difficult to examine. Single leaf traces were followed through the stem (fig 1) and revealed:

1) Leaf traces that enter the stem at the leaf base pass across the cortex more or less horizontally towards the center of the stem.

2) The vascular bundles do not remain in the center, but rather pass gradually to the periphery.

3) The variability in the structure of vascular bundles seen at a single level is due to the systematic variation along the course of one individual leaf trace.

4) At their lower ends, the bundles probably end blindly.

5) The continuity of phloem and xylem is maintained by anastomosis, that is, by fusion with lower bundles.

6) The number of vascular bundles is about the same at any given height of the stem.

7) New vascular bundles do not arise in the center of a mature stem.

8) Old vascular bundles are not compressed at the stem periphery by new bundles growing in the center.

The anatomy of vascular bundles may be generally understood by examining their development near the apical meristem. The primary thickening near the apex accounts for the wide stem, with no secondary growth as in gymnospermous and dicotyledonous trees. However, some factors suggest a diffuse secondary growth. If expansion occurs, it is not due to any increase in the total number of vascular bundles, but it may be explained by enlargement of the fibrous bundle-sheaths and by expansion of ground tissue, with a possible longitudinal division of the expanding cells. In *Caryota* and in *Roystonea* (Oreodoxa) where a pronounced expansion was reported, the late separation of cell walls results in a lacunous, spongy ground tissue. Therefore, in one group of palms, the primary thickening growth may cease early, resulting in a cylindrical stem, and in another group, the thickening growth may be more continuous, producing a more conical stem. Some tissues, *ie,* the cortical fibrous bundles, the conducting tissues, and the bundle sheaths close to the phloem, do not contribute to diffuse secondary growth, but rather maintain their early-reached size.

Experimental methods to investigate the hypothesized diffuse secondary growth include the following:

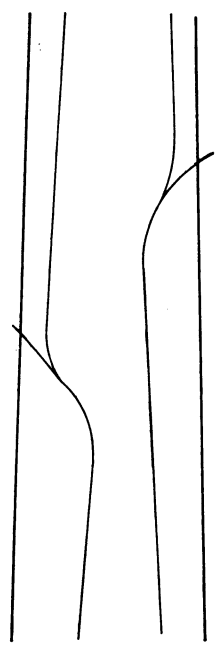


Fig 1. Course of single leaf traces in a palm stem

1) Direct measurements of the diameter of a single stem at a given height over a long period of time.

2) Measurements of the diameter of a single stem at different heights.

3) Comparison of cell dimensions of a single stem at different heights.

4) Comparison of the diameters of young and old palms at constant heights.

5) Comparison of cell dimensions of young and old palms at constant heights.

6) Measurements of the ^{14}C activity at different heights. (Parts of the stem that contain the natural pre-bomb ^{14}C levels have not incorporated the more recent nuclear bomb-produced ^{14}C.

Methods 2 and 4 are not very reliable because of systematic errors, but they are useful in obtaining a rough idea about diffuse secondary growth. For example, an ideally cylindrical growth is almost proof of the absence of secondary growth; unfortunately, the opposite does not hold true. Methods 3 and 5, although somewhat more reliable, are not totally faultless either. The problem with method 1 is obvious. Method 6 is used in this study.

RADIOCARBON ANALYSIS

^{14}C levels are presented here as $\Delta^{14}C$, the deviation in per mil (parts per thousand) of sample activity from the activity of the accepted 95% NBS oxalic acid standard. Results are isotopically normalized to a $\delta^{13}C$ of −25‰ (PDB).

From 1860 (approximately when the palm used in this study started growing) to 1910, the natural tropospheric $\Delta^{14}C$ (*uncorrected* for radioactive decay to AD 1950) was −12 ± 3‰ (Stuiver, 1982). Because of man's addition to the atmosphere of ^{14}C-free CO_2 from the combustion of fossil fuels, $\Delta^{14}C$ decreased from that value to −25 ± 5‰ during the period from 1910 to 1950. More recently, a drastic increase in ^{14}C levels took place due to the atmospheric nuclear weapons tests. Since 1953, atmospheric ^{14}C levels have been substantially higher than natural levels because of this input of bomb-produced ^{14}C. An excess of 900‰ above the natural level was reached in the troposphere at mid-latitudes of the northern hemisphere in 1963, and an excess of 650‰ was reached in the troposphere at mid-latitudes of the southern hemisphere in 1965 (Nydal, Lövseth, and Gulliksen, 1979). This artificial ^{14}C opened up the possibility of testing if carbon-containing material forms a closed system or not: If the material maintains the natural ^{14}C level, then there was no incorporation of new CO_2. The actual conditions are unique in the earth's history and probably will never be repeated in such an ideal manner.

The specimen investigated was a coconut palm (*Cocos nucifera*) found near Aracaju, Sergipe state, NE Brazil (ca 11° 00′ S, 37° 01′ W). The palm had grown at this near-sea-level location for 110 to 120 years. The stem was not cylindrical (fig 2), suggesting a marked diffuse secondary growth. Slices were cut from the stem at 1m intervals up the tree, but only selected sections were analyzed in this study. From each slice to be analyzed, samples were taken from the center (0 to 3 or 4cm from the center) and from the periphery (ca 0.5 to 2cm from the bark). At the Mt Soledad Radiocarbon Laboratory, the process went as follows: The wood was cut into matchstick-sized pieces and underwent the usual chemical pretreatment, consisting of extraction of mobile organic fractions by acetone followed by hot alkali and acid treatments. After rinses with distilled water, the wood was dried at 110°C and then combusted in an oxygen atmosphere on a high vacuum line. The resulting CO_2 was converted to acetylene via lithium carbide. The ^{14}C activity was determined by measuring decays for 2 days in each of 2 gas proportional counters. No decay correction from the year of growth to AD 1950 could be made, since palm trees do not form annual rings. A rough age correction could be made in the $\Delta^{14}C$ values if a constant rate of vertical tree growth were assumed: +11‰ would be added to the $\Delta^{14}C$ value at a height of 0m, with the prescribed correction being decreased by 0.8‰ per meter up the tree.

Figure 3 shows the results of the ^{14}C activity measurements for the palm, most of which are listed in Linick (1980). It is evident that only the uppermost, *ie*, youngest, parts of the stem have incorporated significant amounts of bomb ^{14}C. Despite the fact that the stem was not cylindrical, there was no pronounced secondary growth over most parts of the stem. It was to be expected that incorporation of man-made ^{14}C due to diffuse secondary growth would be most pronounced in the wood newly grown just before the beginning of the nuclear weapons tests in 1955, but high activity was restricted to the uppermost part of the stem, with a rather distinct delimitation. Although any ^{14}C level of > −30‰ could be

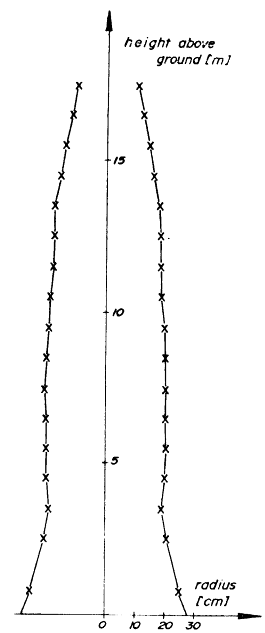


Fig 2. Dimensions of the palm stem investigated

the result of a mixture of carbon from years of different ^{14}C levels, the degree of incorporation of bomb ^{14}C below 15m height could generally have only been very small. The high activity in the center of the stem at a height of 9.4m is surprising and needs more investigation for proper interpretation. Two center samples from 9.4m height were measured, and they gave quite different $\Delta^{14}C$ values ($+87 \pm 8$ and $+13 \pm 4$), both of which are significantly higher than the ^{14}C levels in the other center and outside samples from 8.4 to 10.4m height. The high activity may be due to late growth to give the stem additional strength. Both center results at 9.4m may be valid, since an active vascular bundle might have been present in one part of the center of that disk of wood but not another part. It is worth noting that the high activity is coincident with the upper limit of the cylindrical part of the stem and the bottom of the conical part. Thus, it may be that the stem undergoes at a certain age a distinct modification in the center, only then assuming its final state. This zone may be correlated with the formation of the hard peripheral sclerotic zone composed of congested, dark vascular bundles and ground parenchymatic tissue (see pl 1B). The difference in ^{14}C activity between the periphery and the center at 12.4 to 16.4m heights is also significant; this observation indicates that cells in the center remain active for a longer period than do the cells near the cortex.

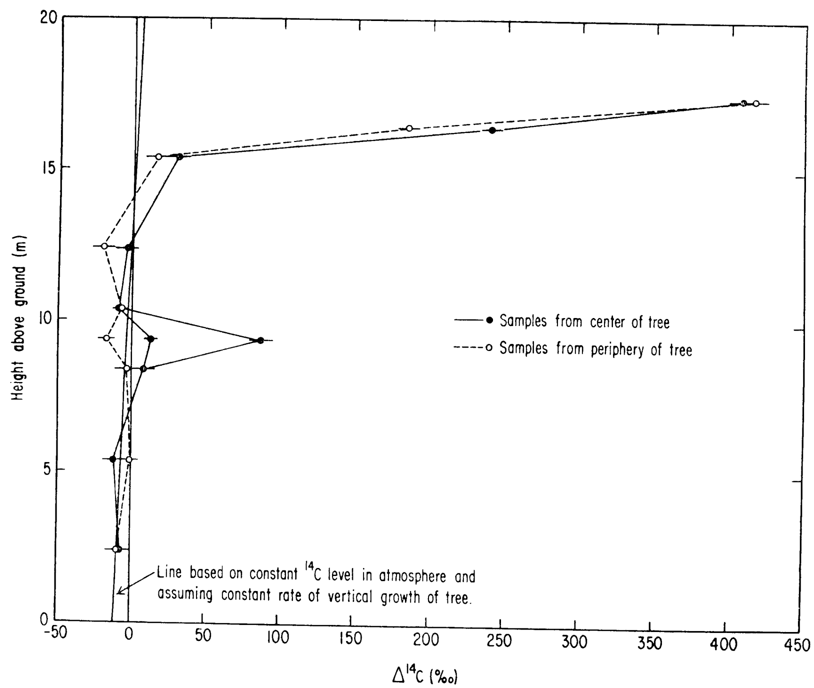


Fig 3. ^{14}C activity at different heights in stem of palm tree; samples from center and periphery of stem.

ACKNOWLEDGMENTS

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CARBON ISOTOPE ANALYSIS OF LAND SNAIL SHELLS: IMPLICATIONS FOR CARBON SOURCES AND RADIOCARBON DATING

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ABSTRACT. ^{13}C and ^{14}C analyses were performed on a series of modern Jamaican land snails in order to quantitatively determine the sources of shell carbon. A model of these carbon sources, the pathways by which carbon reaches the shell, and the fractionation processes involved are presented. The contribution of limestone to shell carbonate is variable but may comprise up to 33% of the shell. About 25-40% of shell carbonate is derived from plants and about 30-60% from atmospheric CO_2. Variation among populations and species with respect to ^{13}C and ^{14}C is attributed to the effects of limestone incorporation, snail size (as it affects CO_2 exchange rate), physiological characteristics (presence of urease, respiration rate), and activity patterns of the snails. A formula for correction for isotopic fractionation of ^{14}C of shell carbonate, based on ^{13}C measurements, is derived. Bicarbonate-aragonite fractionation is apparently very minimal. Shell organic carbon appears to be derived largely from plants but also to a lesser extent from inorganic hemolymph carbon. This introduces the possibility of a small age anomaly of shell organic ^{14}C due to limestone incorporation.

INTRODUCTION

An understanding of the factors controlling the isotopic composition of the carbon of land snail shells is of considerable importance to a variety of problems. Radiocarbon dating of land snail shells depends on estimating the original ^{14}C. This is determined by the relative contributions of carbon sources differing in isotopic composition, plus the effects of fractionation. Of particular importance is the incorporation of limestone into the shells, leading to an anomalous ^{14}C content (Goodfriend and Stipp, in press). Land snail shell ^{13}C has recently been investigated as a possible paleoecological indicator (Yapp, 1979; Magaritz, Heller, and Volokita, 1981; Magaritz and Heller, in press). Magaritz and Heller (in press) suggest that shell $\delta^{13}C$ may indicate microhabitat conditions or characteristics of vegetation. The isotopic composition of land snail shells may also provide information regarding the physiology of shell deposition.

Researchers do not agree on the source(s) of land snail shell carbonate. De Jorge and Haeser (1968) and Tamers (1970) suggested that CO_2 released from respiration of food is a source of shell carbonate carbon. Rubin, Likins, and Berry (1963) and Goodfriend and Stipp (in press) showed that ingested limestone is a shell carbonate source in some land snails. Campbell and Speeg (1969) demonstrated that the carbon in ^{14}C-labeled urea was incorporated into the shell carbonate of a land snail species. Still others (eg, De Niro and Epstein, 1978; Magaritz and Heller, in press) consider the source of shell carbonate carbon to be unknown. In this study we have used data on the age, ^{14}C content, and ^{13}C content of land snail shells to estimate the relative importance of the possible sources of shell carbonate.

Fractionation of carbon isotopes in various reactions leading to eventual deposition in shell would also affect the isotopic composition of the shell. In laboratory experiments of carbonate precipitation from inorganic solutions under equilibrium conditions, ^{13}C in aragonite, the calcium carbonate mineral of which land snails are composed (Bøggild, 1930), was fractionated by ca 2.7‰ relative to bicarbonate (Rubinson and Clayton, 1969). Empirical results indicate that in aquatic mollusks there is only a rather slight fractionation of shell carbonate carbon relative to the bicarbonate of the medium (Mook and Vogel, 1968; Fritz and Poplawski, 1974). Dissolution of gaseous CO_2 in water favors heavier isotopes, thus leading to a fractionation of ^{13}C of ca +8‰ of dissolved bicarbonate relative to gaseous CO_2 (Mook, Bommerson, and Staverman, 1974). If in some land snail shell carbon is derived from aerial CO_2, a more significant fractionation (relative to the medium) is to be expected than in aquatic mollusks.

Below we consider the possible sources of shell carbonate carbon and the possible pathways by which carbon reaches the shell. We then present ^{13}C and ^{14}C analyses of a series of modern pre- and post-bomb land snails from Jamaica (8 populations from limestone areas and 1 from a non-limestone area). From these data we estimate the contributions of the ultimate carbon sources to shell carbonate. These findings are discussed in relation to problems of ^{14}C dating of land snail shells — the possible use of ^{13}C data to estimate limestone anomaly and to correct for fractionation effects. We examine the factors controlling the carbon isotope content of shells and assess the potential for the use of ^{13}C as a paleoenvironmental indicator and for elucidating the mechanism of shell carbonate deposition. Finally, we analyze the shell organic fraction for ^{13}C and discuss its sources and suitability for ^{14}C dating. A list of the material analyzed is given in the appendix.

A MODEL OF CARBON FLOW INTO SHELL CARBONATE

There are three possible ultimate sources of carbon — plant carbon, atmospheric CO_2, and limestone — each differing in isotopic composition. These may end up as shell carbonate by a variety of pathways (fig 1).

Shell carbonate is deposited from bicarbonate in the extrapallial fluid (Wilbur, 1972). Laboratory studies of inorganic systems have shown aragonite carbon to be slightly positively fractionated with respect to the bicarbonate carbon from which it is precipitated (Rubinson and Clayton, 1969). Shell carbonate may also be dissolved internally under certain circumstances (Chan and Saleuddin, 1974; Poulicek and Jaspar-Versali, 1982). Bicarbonate in the extrapallial fluid is derived primarily from the bicarbonate of the hemolymph. But some might also be derived by direct diffusion of CO_2 from the environment at the mantle edge. A mechanism of CO_2 production (and not incidentally NH_3+ production, which raises the pH and thus favors carbonate deposition) in the mantle by breakdown of urea by urease has been demonstrated in land snails (Speeg and Camp-

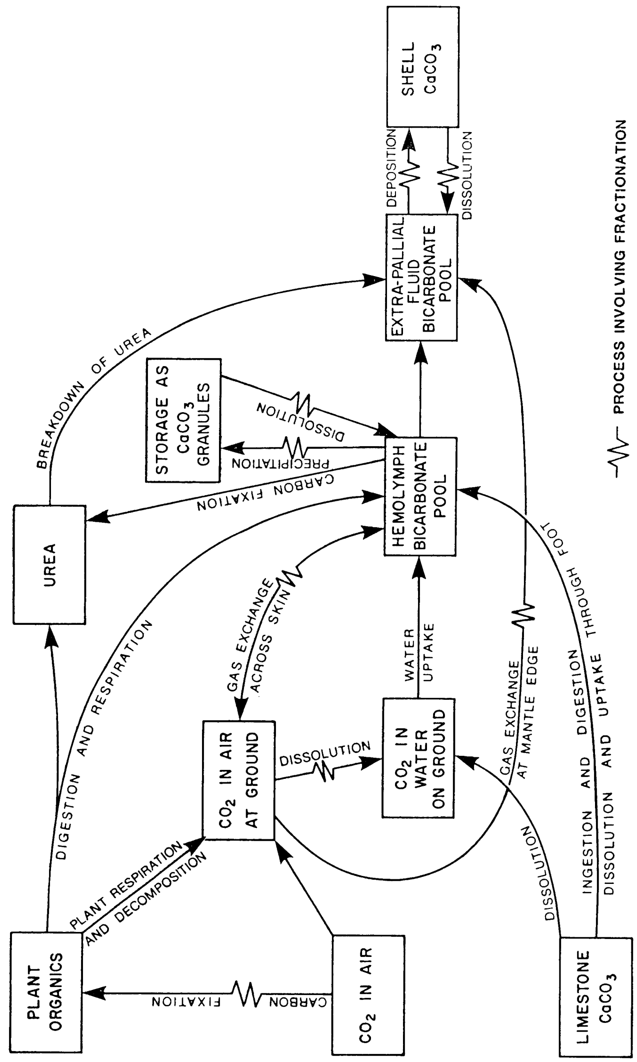

Fig 1. A model of possible shell carbonate carbon sources, pathways leading to deposition of carbon in the shell, and processes involving fractionation.

bell, 1968; Campbell and Speeg, 1969). The carbon of urea is derived from arginine, which is synthesized *de novo* in the ornithine cycle (Horne, 1973); the carbon fixation step occurs in the mitochondria. This carbon comes primarily from CO_2 released from the respiration of plant material in the citric acid (Krebs) cycle (Horne, 1977) and to a lesser extent from hemolymph bicarbonate (Tramell and Campbell, 1972), which diffuses into the mitochondria. Thus, the CO_2 released at the mantle by urea breakdown should be of predominantly plant origin. It should be noted that only some land snails possess urease. Other land snails generate NH_3^+ by the breakdown of adenosine, without the release of CO_2 (Campbell and Boyan, 1976; Loest, 1979). In these snails, shell carbonate should be primarily of hemolymph bicarbonate origin, while for snails with urease, it should be a mixture of hemolymph bicarbonate and urea carbon.

The isotopic composition of hemolymph bicarbonate is probably due to a variety of processes. CO_2 is exchanged across the skin with CO_2 in the air and equilibrates with bicarbonate, with a large associated fractionation effect. Some of the aerial CO_2 at the ground may be derived from decomposed plant material. Respiratory CO_2 is produced in mitochondria from ingested plant carbon and would diffuse into the hemolymph. Water on the ground, containing a small amount of dissolved CO_2, is taken up by land snails through the skin and perhaps also by drinking (Pusswald, 1948). This water would be rainwater, containing CO_2 derived from the atmosphere (with associated fractionation), CO_2 released from decomposition of leaves, and, in some areas, possibly some dissolved limestone carbonate. Major inputs of limestone-derived carbon may come from ingestion of limestone (Rubin, Likins, and Berry, 1963) and its subsequent dissolution in the gut and diffusion into the hemolymph, or from uptake through the foot of limestone dissolved by foot secretions (Frick, 1965). Carbonate may be stored as calcium carbonate granules, mostly in the foot and digestive gland. This carbonate is precipitated from the hemolymph and may be released back into it upon dissolution of the granules (Fournié and Chétail, 1982). Thus, hemolymph bicarbonate is probably a mixture of plant, atmospheric, and (in some areas) limestone carbon.

ESTIMATION OF THE CONTRIBUTION OF CARBON SOURCES TO SHELL CARBONATE

Since each of the ultimate sources of shell carbonate differs in isotopic composition, it is possible from knowledge of the age of shells and their ^{13}C and ^{14}C content to estimate the relative contribution of each of these sources. A number of assumptions must be made.

It is assumed that all carbon is ultimately derived only from air, plants (living or recently dead — the usual food source of snails), and limestone. Thus,

$$P_A + P_P + P_L = 1\,, \tag{1}$$

where P_A = the proportion of air-derived carbon, P_P = the proportion of plant-derived carbon, and P_L = the proportion of limestone-derived carbon in shell carbonate.

The ^{13}C content of shell carbon sources is assumed to be as follows:

$\delta^{13}C_P = -27‰$ (mean value for tropical plants; Degens, 1969);

$\delta^{13}C_L = 0$ (Craig, 1954);

effective $\delta^{13}C_A = +1‰$ (We assume the actual $\delta^{13}C_A = -7‰$ (Degens, 1969), but that this is fractionated by $+8‰$ (see above) upon dissolving in water in the snail or in water subsequently taken up by the snail).

$\delta^{13}C$ is defined as $1000[(R/R_{PDB})-1]$ where R is the $^{13}C/^{12}C$ ratio and PDB refers to the Pee Dee Belmnite, the standard against which ^{13}C is measured. The ^{13}C content of the shell ($\delta^{13}C_S$) would be

$$\delta^{13}C_S = \delta^{13}C_A\,(P_A) + \delta^{13}C_P\,(P_P) + \delta^{13}C_L\,(P_L) = P_A - 27\,P_P\,. \qquad (2)$$

In order to estimate the ^{14}C content of carbon sources, fractionation must be taken into account. Fractionation refers here to differential reaction rates of carbon isotopes and the differences in isotopic composition of compounds resulting from these. The correction factor for fractionation of material 1 relative to material 2 is given by

$$A_1 = A_2\,(R_1/R_2)^2\,, \qquad (3)$$

where A represents ^{14}C activity (Wigley and Muller, 1981).

Wood (with $\delta^{13}C = -25‰$, or $R = \left(1 + \frac{\delta^{13}C}{1000}\right) R_{PDB} = 0.975\ R_{PDB}$) serves as the standard against which ^{14}C activity is measured. Tropical plants are slightly deficient in heavier carbon isotopes (mean $\delta^{13}C = -27‰$). Their ^{14}C activity can be calculated as

$$A_P = A_{CW}\left(\frac{0.973\ R_{PDB}}{0.975\ R_{PDB}}\right)^2 = 0.996\ A_{CW}\,, \qquad (4)$$

where A_{CW} is the ^{14}C activity of contemporary wood, *ie,* wood at the time of shell deposition.

The ^{14}C activity of atmospheric CO_2 can be calculated, based on a $\delta^{13}C$ of $-7‰$, as:

$$A_{CO_2} = A_{CW}\left(\frac{0.993\ R_{PDB}}{0.975\ R_{PDB}}\right)^2 = 1.037\ A_{CW}\,. \qquad (5)$$

Gaseous CO_2 dissolving in an aqueous medium (snail hemolymph or water taken up by a snail) will be fractionated by a factor of $\alpha = \frac{R_{bicarbonate}}{R_{CO_2}} \approx 1.008$ (Mook, Bommerson, and Staverman, 1974; Emrich, Ehhalt, and Vogel, 1970). So the *effective* ^{14}C activity of atmospherically-derived carbon would be

$$A_A = A_{CO_2}\,(1.008)^2 = 1.016\ A_{CO_2}\,. \qquad (6)$$

Substituting from equation 5, we have

$$A_A = 1.016\,(1.037)\ A_{CW} = 1.054\ A_{CW}\,. \qquad (7)$$

The ^{14}C activity of limestone (A_L) is taken to be 0 since all limestones from which snails were collected were >50,000 years old, thus effectively lacking in ^{14}C.

The ^{14}C activity of shell carbonate (A_S) would be the sum of the relative contributions of each of these three ultimate carbon sources:

$$
\begin{aligned}
A_S &= 0.996\,(A_{CW})(P_P) + 1.054\,(A_{CW})(P_A) + 0 \\
&= A_{CW}\,(0.996\,P_P + 1.054\,P_A)\,. \qquad (8)
\end{aligned}
$$

Thus, from equations 1, 2, and 8, we can calculate P_P, P_A, and P_L from $\delta^{13}C_S$, A_S, and A_{CW}. Rearranging equation 2, we have

$$P_A = 27\,P_P + \delta^{13}C_S\,. \qquad (9)$$

And substituting for P_A in equation 8, we get

$$A_S = A_{CW}\,[0.996\,P_P + 1.054\,(27\,P_P + \delta^{13}C_S)]\,. \qquad (10)$$

Solving this for P_P, we have

$$P_P = 0.03395\,\frac{A_S}{A_{CW}} - 0.03578\,\delta^{13}C_S\,. \qquad (11)$$

P_L can be conveniently calculated by rearranging equation 1:

$$P_L = 1 - (P_P + P_A)\,. \qquad (12)$$

For specimens collected in 1910 and before, A_{CW} was taken as 100% of modern wood[1] (A_{MW}) corrected for ^{14}C depletion due to age. This is calculated by

$$\text{year of collection} - 1950 = 8035\,\ln\frac{A_{CW}}{A_{MW}} \qquad (13)$$

(modified from Tamers, 1970). For 1932 specimens, depletion of ^{14}C due to the industrial (Suess) effect was corrected for by taking A_{CW} = 98% (Cain, 1979).

Post-1954 material was affected by the pronounced enrichment of ^{14}C due to the atomic bomb effect. Since the early 1960's, plant and atmospheric ^{14}C have been decreasing significantly (Barrette *et al*, 1980). Thus, to calculate A_{CW} the exact year that the shell carbonate was deposited must be known. This was possible only for one of the post-bomb populations, *Pleurodonte lucerna* from Green Grotto Caves. These specimens were collected as subadults and must have deposited the majority of the shell carbonate during the year they were collected (1981). For the other post-bomb *P lucerna*, the age of the snails at the time of collection was unknown. *P lucerna* may live for some 10 years or more but reaches full adult size in 2 or 3 years, after which it ceases to grow (Goodfriend, unpub observations). The degree of wear of the periostracum gives a rather rough indication of the age of the specimens. As a reference for A_{CW} estimates, recently fallen leaf litter (the food source for *Pleurodonte* and

[1] Defined as the ^{14}C activity of 1890 wood (pre-industrial effect) corrected to AD 1950.

many other land snails) was analyzed for ^{14}C. Leaf litter (*Ocotea staminea* [Griseb] Mez) collected in 1980 gave a ^{14}C value of 127% modern, corrected for fractionation ($\delta^{13}C = -29.29$) to 126% modern ($= A_{CW}$). To calculate A_{CW} for other years, we assumed that ^{14}C has been decreasing at the rate of 3% per year, based on the data of Barrette *et al* (1980). It should be noted that an uncertainty of two years for the year of shell deposition of adult post-bomb *Pleurodonte* would produce an uncertainty of 6% modern for estimated A_{CW}. Thus, the estimates for these specimens are only approximate.

For determination of ^{14}C of shell carbonate, shells were dissolved in H_3PO_4. The resultant CO_2 was converted to benzene and counted by liquid scintillation. For ^{13}C measurements of shell carbonate, shells were dissolved in H_3PO_4 and the resultant CO_2 analyzed in a mass spectrometer. The error of measurement for ^{13}C is $< 0.04‰$, and usually ca 0.01‰.

SOURCES OF SHELL CARBONATE CARBON AND FACTORS AFFECTING THEIR CONTRIBUTION TO SHELL CARBONATE

Table 1 gives the carbon isotope data for the specimens analyzed, plus estimates of the proportion of shell carbonate carbon derived ultimately from plants, atmospheric CO_2, and limestone. It is immediately evident that all three sources of carbonate carbon are relatively important in some or all populations. The limestone contribution is variable, indistinguishable from 0 in *Pleurodonte carmelita* (from a non-limestone area) and *P lucerna* from Heron Hill, given the uncertainties of the estimates. Limestone-derived carbon makes up nearly 1/3 of the shell in other populations (*P sublucerna*[2] from Port Antonio and *Urocoptis ambigua*). Plant-derived carbon makes up ca 25-40% of the shell. In most cases, carbon derived from the atmosphere is the most important shell component, contributing some 30-60% of shell carbonate carbon. Since some of the plant-derived carbon may enter the snail as CO_2 from the air (derived from plant decomposition), the atmosphere may be even more important as a proximal source of carbon than estimated here.

We expected that as the contribution of limestone increases, the $\delta^{13}C$ of the shell carbonate should also increase, since limestone is enriched in ^{13}C relative to observed shell carbonate values. We did find this relationship (fig 2) but it is relatively weak, with variation in the proportion of limestone-derived carbon accounting for only ca 1/4 of the variation in shell $\delta^{13}C$. A simple linear regression of $\delta^{13}C$ on proportion of limestone-derived carbon gives the y-intercept (estimated $\delta^{13}C$ with no limestone input to shell) as −9.89. If we assume that limestone has only a direct effect on $\delta^{13}C$ (*ie*, the proportion of limestone is independent of the $\delta^{13}C$ of the non-limestone portion of shell carbon), then shells with, eg, 0.30 of their carbon from limestone should theoretically have a mean value of $0.70\ (-9.89) + 0.30\ (0) = -6.92$. This is rather more than the value of

[2] *Pleurodonte sublucerna* and *P lucerna* comprise a semispecies complex. They are distinct in some areas but intergrade in other areas (Goodfriend, Clinal variation and natural selection in the land snail *Pleurodonte lucerna* in western St Ann Parish, Jamaica, ms in preparation).

TABLE 1

Carbon isotope analyses of shell carbonate of Jamaican land snails, with estimates of the proportion of carbon derived from various sources. A_S = measured ^{14}C activity of shell carbonate. A_{CW} = ^{14}C activity of contemporary wood (*ie*, wood at the time of shell deposition). P_P, P_A, and P_L represent the estimated proportion of shell carbonate carbon derived from plants, atmospheric CO_2, and limestone, respectively.

Species	N	Locality	Year of collection	A_S (% of modern wood) ± SD	Estimated A_{CW} (% of modern wood)	$\delta^{13}C$(‰)	P_P	P_A	P_L	$\frac{P_A}{P_P + P_A}$
Pleurodonte sublucerna	5	Port Antonio	1932	67.6 ± 1.1	98	−9.94	0.38	0.30	0.33	0.44
Pleurodonte lucerna	5	Heron Hill	1980	148 ± 0.7	ca 145	−10.32	0.40	0.58	0.01	0.59
Pleurodonte lucerna	5	Spaldings	1980	106 ± 0.8	ca 139	−9.46	0.36	0.38	0.26	0.51
Pleurodonte lucerna	5	Broom Hall	1980	129 ± 0.8	ca 136	−10.18	0.40	0.52	0.08	0.57
Pleurodonte lucerna	4	Green Grotto Caves	1981	119.4 ± 0.8	124	−9.85	0.38	0.55	0.07	0.59
Pleurodonte carmelita	6	Chester Vale	1932	100.5 ± 0.9	98	−9.59	0.38	0.62	0.01	0.62
Urocoptis ambigua	66	Somerset	1910	73.3 ± 1.4	99.5	−6.41	0.25	0.45	0.29	0.64
Eutrochatella pulchella	200	"Jamaica"	ca 1890	79.2 ± 0.8	99.3	−7.51	0.30	0.47	0.23	0.61
Poteria jamaicensis	12	Somerset	1910	93.4 ± 0.8	99.5	−8.36	0.33	0.57	0.10	0.63

−8.28 predicted by the regression. The slope of the theoretical line ($b = 9.90$) differs from the empirical slope with a $p \approx 0.30$ (t-test, 2-tailed). Thus this provides no convincing evidence that limestone has other than a direct effect on shell ^{13}C content. There are clearly other more important factors influencing ^{13}C levels. The result is that $\delta^{13}C$ is a fairly poor predictor of P_L and so is of limited use for estimation of age anomalies due to incorporation of limestone into the shell.

The various genera analyzed differ with respect to $\delta^{13}C$. In order to test the generality of this pattern, ^{13}C analyses were performed on additional species and populations (table 2). The two species of the prosobranch family Helicinidae (*Eutrochatella pulchella* and *Alcadia brownei*) and the three populations (2 species) of the pulmonate *Urocoptis* (family Urocoptidae) show relatively high ^{13}C content — higher than any of the eight *Pleurodonte* (family Camaenidae) analyzed. *Poteria* (family Poteriidae) have intermediate levels of ^{13}C. No consistent differences between pulmonate vs prosobranch taxa are observed.

Because these different species tend to differ in size, the ^{13}C differences found might be related to size rather than to taxonomic relationships. In order to clarify this problem, the internal volume of the shells was estimated by weighing the shell, filling it with water, and reweighing it. The internal volume of the shell was calculated as (mass after − mass before) × 1.0ml/g. Average-sized shells from the same populations as the specimens analyzed (or similarly sized shells from other populations of the same species) were used to estimate volume.

Apparent differences in ^{13}C among taxa are shown in figure 3. In the lower size range (< 4ml), volume and $\delta^{13}C$ seem to be correlated. However, no such relationship is seen among the larger *Pleurodonte*. The

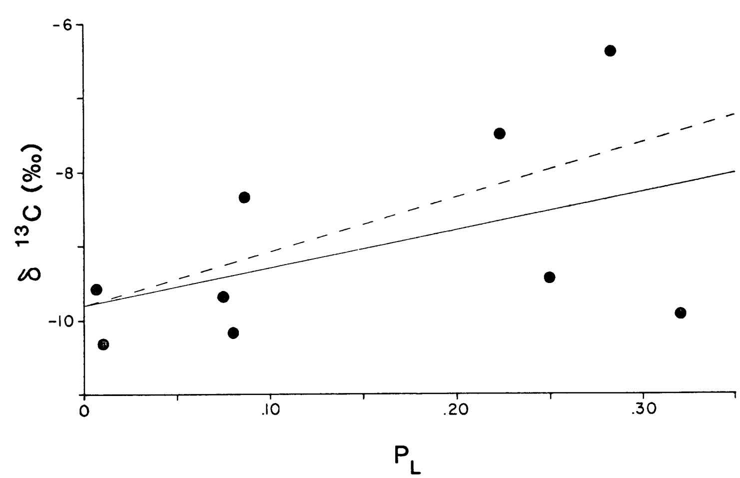

Fig 2. $\delta^{13}C$ of shell carbonate in relation to the proportion of shell carbonate carbon derived from limestone (P_L). $r = 0.494$ ($p > 0.05$). Regression line (solid line) is $\delta^{13}C = 5.36\ (P_L) - 9.89$ and $R^2 = 0.244$. Given the Y intercept as −9.89, the theoretical relationship (dashed line) is $\delta^{13}C = 9.90\ (P_L) - 9.89$.

TABLE 2
^{13}C analyses of shell carbonate carbon. *Pleurodonte lucerna* were analyzed individually

Species	N	Locality	$\delta^{13}C$(‰)
Pleurodonte lucerna	2	Colliston	−9.19, −9.34
Pleurodonte lucerna (juvenile)	1	Cedar Valley	−9.21
Pleurodonte lucerna (juvenile)	1	Rat Trap	−9.72
Pleurodonte lucerna	3	Cedar Valley	−10.33, −10.82, −11.44
Urocoptis ambigua	9	Martins Hill	−8.22
Urocoptis megacheila	2	Midgham	−9.12
Alcadia brownei	4	Higgin Land	−7.54
Poteria varians	4	Albion	−9.93
Poteria varians	3	Alexandria Pen	−10.33

juvenile *Pleurodonte* fall within the range of values for adults, although they are in the higher part of that range. At Cedar Valley, all adults have a lower $\delta^{13}C$ than the juvenile. Thus at least some variation in $\delta^{13}C$ seems to be size-dependent. Whether the general trend toward high ^{13}C with smaller size is an effect of differences among taxa or of size alone cannot be determined from these data.

Since the surface area/volume ratio increases with decreasing size, exchange with atmospheric CO_2 might be more important in smaller snails. This would lead to a greater dominance of aerial carbon relative to plant carbon (released from snail respiration) in smaller snails and therefore a relatively higher ^{13}C content of the shell. In order to test this relationship, the proportion of non-limestone carbon that is derived from atmospheric

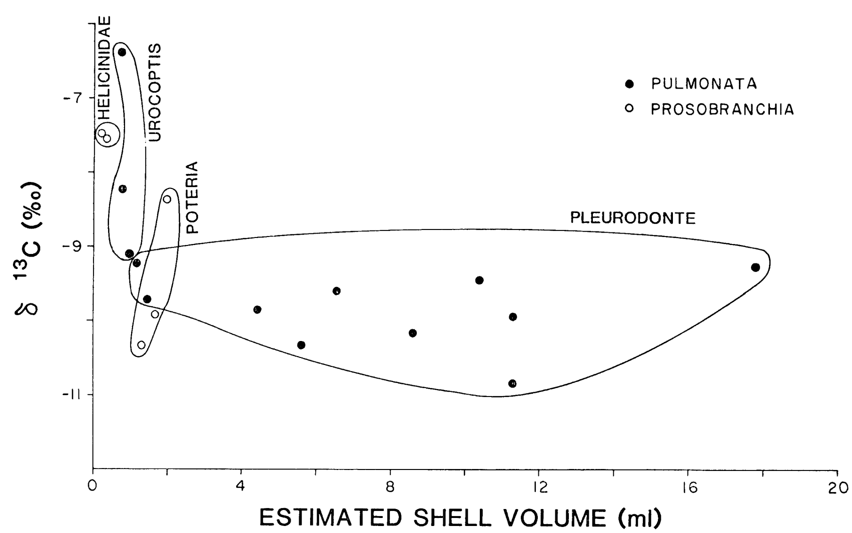

Fig 3. $\delta^{13}C$ of shell carbonate vs estimated shell volume.

sources ($P_A/[P_A + P_P]$) was compared to snail size. The direct effect of limestone on shell ^{13}C is thereby factored out. Figure 4 shows this relationship is very strong, with shell volume accounting for almost 3/4 of the variation in the aerial contribution to non-limestone shell carbonate carbon. This result is consistent with the proposed mechanism.

Note that the contribution of aerial carbon to the non-limestone portion of the shell is lower in shells with large amounts of limestone-derived carbon; the converse is true for shells with small amounts of limestone-derived carbon. These data suggest an interaction between the limestone and aerial contributions to the shell — limestone seems to differentially affect the aerial and plant carbon contributions. This relationship would account for the observation (see above) that the effect of limestone on shell $\delta^{13}C$ is slightly less than expected, although not significantly so. The mean $\delta^{13}C$ of limestone (0) is very close to the effective $\delta^{13}C$ of gaseous CO_2 (+ 1‰). Thus the enrichment in ^{13}C expected from the contribution of limestone is partially offset by a correlated decrease in the contribution of ^{13}C-rich aerial CO_2. The probable explanation for the relationship between limestone and aerial contributions is that since ingested limestone would release considerable amounts of CO_2 in the snail, the bicarbonate concentration of the hemolymph would be raised and diffusion of aerial CO_2 into the snail would be decreased. The contribution of plant-derived carbon to the hemolymph bicarbonate would not be affected if respiration is the major input of plant carbon.

Besides the effect of differences in size and limestone intake, variation in $\delta^{13}C$ among taxa might be caused by differences in their physiological and behavioral characteristics. Differences in respiration rate might produce differences in the plant contribution to shell carbonate. Taxa may

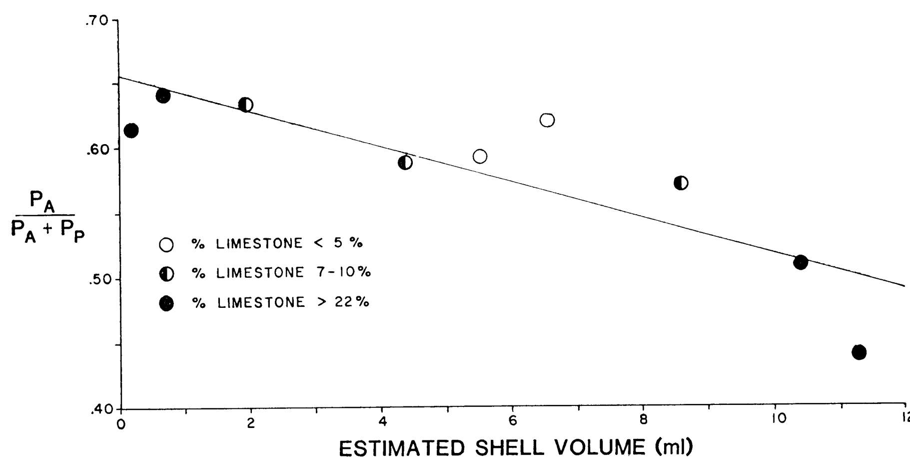

Fig 4. The proportion of non-limestone-derived shell carbonate carbon that is derived from the atmosphere vs estimated shell volume. The estimated percent of shell carbonate carbon derived from limestone is also indicated. The regression line is

$$\frac{P_A}{P_A + P_P} = -0.0137\ (\text{volume}) + 0.654;\ r = -0.851\ (p < 0.005)\ \text{and}\ R^2 = 0.724.$$

differ in the frequency of activity and, consequently, in rates of loss (by evaporation or through mucus during locomotion) and uptake of water from the ground. Exchange of CO_2 with the atmosphere when snails are resting retracted into their shells is probably relatively unimportant. The rate of exchange would be reduced due to smaller exposed surface area and immobility of the air around the snail. The fact that there are no consistent ^{13}C differences between prosobranchs (which close off the mouth of the shell with an operculum when resting) and pulmonates (which do not have opercula) argues against the importance of CO_2 exchange during inactivity. If exchange takes place primarily during activity, then differences in frequency of activity might produce differences in ^{13}C content. Variation in the relative importance of the urease mechanism in shell deposition may be an important determinant of shell carbonate carbon isotope levels. This is discussed in more detail below.

Magaritz and Heller (in press) propose that the ^{13}C content of shells of the land snail *Theba pisana* in Israeli deserts is largely determined through exchange with air. The ^{13}C content of the air would represent a combination of atmospheric CO_2 and plant-derived CO_2 resulting from respiration of dead plant material by decomposers. Part of the evidence for their conclusions comes from the observed enrichment of shell carbonate ^{13}C in juvenile snails relative to adults. The adults are believed to climb less than the juveniles and, thus, would be exposed more to air at the ground which might be expected to be relatively depleted in ^{13}C due to input from decomposition. Our data do not support this hypothesis of control of shell ^{13}C in Jamaican land snails. *Eutrochatella pulchella*, which lives exposed on top of (and sometimes under) limestone boulders, has almost exactly the same $\delta^{13}C$ as *Alcadia brownei*, which lives among leaf litter and forages on top of leaf litter (Goodfriend, unpub observations). *Poteria*, which live and forage among leaf litter, rarely coming to the surface, show intermediate ^{13}C levels. Thus, habitat would not seem to be an important determinant of shell carbonate ^{13}C levels in these snails.

Because of the variety of factors affecting shell carbonate $\delta^{13}C$, it seems unlikely that any generally applicable ecological (or paleoecological) interpretation of $\delta^{13}C$ can be made. However, in well-studied situations, the effects of some of these factors could be assessed quantitatively. These effects could then be subtracted out from shell $\delta^{13}C$, perhaps leaving a relatively pure ecological signal which could be used as a paleoenvironmental tool.

THE USE OF ^{13}C FOR CORRECTION FOR ISOTOPIC FRACTIONATION IN LAND SNAIL SHELL CARBONATE

In land snail shells that contain carbon derived from limestone, the relationship of ^{14}C and ^{13}C in the shell is not merely a function of fractionation processes but is due in part to mixing of carbon sources of different isotopic composition. Therefore, the standard fractionation correction factor (equation 3) cannot be applied. In shells without limestone-derived carbon, plants and atmospheric CO_2 are the only carbon sources. Plant carbon is derived from atmospheric CO_2 but its isotopic composition differs due to fractionation. The dissolution of CO_2 in aqueous media also involves fractionation. In a snail shell without limestone carbon, fractionation is responsible ultimately for all deviations of $\delta^{13}C$ from that of air. Therefore, in such shells, the standard correction for fractionation may be correctly applied.

For shells containing limestone-derived carbon, the carbon may be partitioned into two components: a limestone-derived portion (with $\delta^{13}C = 0$) and a non-limestone portion. The standard correction for isotopic fractionation may be applied only to this latter component. The ^{14}C activity of non-limestone carbon corrected for fractionation (A_{CNL}) would be

$$A_{CNL} = A_{NL} \left(\frac{R_{NL}}{R_{MW}} \right)^2 \quad , \tag{14}$$

where A_{NL} is the uncorrected ^{14}C activity of the non-limestone derived portion of shell carbonate, expressed as percent of modern wood (MW). The observed (uncorrected) ^{14}C activity of the shell carbonate (A_S) is the sum of the contributions of the two portions:

$$A_S = P_{NL} (A_{NL}) + P_L (0) \, . \tag{15}$$

Simplifying and rearranging, we have

$$A_{NL} = A_S / P_{NL} \, . \tag{16}$$

Substituting for A_{NL} in equation 14, we get

$$A_{CNL} = \frac{A_S}{P_{NL}} \left(\frac{R_{NL}}{R_{MW}} \right)^2 \quad . \tag{17}$$

Now, the ^{14}C activity of shell carbonate, corrected for fractionation (A_C) would be

$$A_C = P_{NL} (A_{CNL}) + P_L (0) \, . \tag{18}$$

Substituting for A_{CNL} from equation 17 and simplifying, we get

$$A_C = A_S \left(\frac{R_{NL}}{R_{MW}} \right)^2 \quad . \tag{19}$$

Thus, the correction factor is simply the term for the correction for fractionation between the non-limestone portion of the shell relative to modern wood.

To express this in terms of the observed ^{13}C content of the shell ($\delta^{13}C_S$), we note that

$$R_{NL} = \left(1 + \frac{\delta^{13}C_{NL}}{1000} \right) R_{PDB} \tag{20}$$

and that (since $\delta^{13}C_S = P_{NL} (\delta^{13}C_{NL}) + P_L (\delta^{13}C_L)$ and $\delta^{13}C_L$ is taken to be 0)

$$\delta^{13}C_{NL} = \delta^{13}C_S / P_{NL} . \tag{21}$$

Substituting for $\delta^{13}C_{NL}$ in equation 20 from equation 21, substituting this expression for R_{NL} in equation 19, and taking $\delta^{13}C_{MW}$ as 0.975 R_{PDB}, we get

$$A_C = A_S \left(\frac{1 + \frac{\delta^{13}C_S}{1000 \cdot P_{NL}} \cdot R_{PDB}}{0.975\ R_{PDB}} \right)^2 \tag{22}$$

or

$$A_C = 1.052\ A_S \left(1 + \frac{\delta^{13}C_S}{1000 \cdot P_{NL}} \right)^2 . \tag{23}$$

When $P_{NL} = 1$ (*ie,* when there is no limestone-derived carbon in the shell), equation 23 reduces to the standard correction.

Normally, P_{NL} would not be known for radiocarbon-dated material from a limestone area. Therefore, it is of interest to know how much difference variation in P_{NL} would make to estimates of corrected shell ^{14}C activity. We will examine the correction for fractionation for two extreme values of P_{NL}: $P_{NL} = 1$ and $P_{NL} = 0.65$ (the approximate observed minimum) and for the observed extreme values of $\delta^{13}C_S = -10.86‰$ and $-6.41‰$. For shells with no limestone-derived carbon ($P_{NL} = 1$), the fractionation-corrected ^{14}C activity (A_C) would be 1.039 A_S for $\delta^{13}C_S = -6.41‰$, and 1.029 A_S for $\delta^{13}C_S = -10.86‰$. For $P_{NL} = 0.65$, A_C would be 1.031 A_S for $\delta^{13}C_S = -6.41‰$ and 1.017 A_S for $\delta^{13}C_S = -10.86‰$. Thus, for shells with maximal limestone carbon content, the correction in ^{14}C activity due to fractionation is ca 1% (0.8 – 1.2%) less than the correction factor for shells without limestone-derived carbon. This error is quite small in comparison to the ^{14}C anomaly due to limestone-derived carbon.

HEMOLYMPH BICARBONATE ^{13}C AND ITS IMPLICATIONS FOR CARBON PATHWAYS TO SHELL CARBONATE AND BICARBONATE-CARBONATE FRACTIONATION

The small fractionation between aragonite and bicarbonate has been neglected in the analysis up to now. In an inorganic system with a large bicarbonate reservoir, precipitated aragonite was found to be enriched in ^{13}C by a factor of $\alpha = 1.0027$ relative to bicarbonate. This amounts to a $\delta^{13}C_{aragonite}$ ca 2.7‰ higher than $\delta^{13}C_{bicarbonate}$ (and an enrichment of ^{14}C by 0.54%). In order to test whether this fractionation also occurs in the land snail bicarbonate-aragonite system, the ^{13}C content of snail hemolymph bicarbonate and shell carbonate were measured.

We used four adult specimens of *Pleurodonte lucerna* which had been collected at Cedar Valley, southwestern St Ann Parish, Jamaica, in December, several weeks before the analyses, and which were maintained in the lab on Jamaican leaf litter. Hemolymph extraction was performed under a pure nitrogen atmosphere. The shells of the living snails were crushed and removed. The head-foot was cut longitudinally and the bodies were placed in 1mm nylon mesh and gently squeezed to extract the body fluids (hemolymph). This extract (ca 2ml volume) was poured into a vial and sealed with a rubber stopper. It was then removed from the nitrogen atmosphere and frozen. Several days later is was quickly thawed and analyzed immediately. 1N HCl was used to convert the bicarbonate pool to CO_2, which was collected and analyzed for ^{13}C. These results concerning hemolymph ^{13}C must be taken as preliminary. Ideally, measurements should be made on hemolymph of snails immediately after their removal from the field. And subadult specimens (in which the shell is still growing) would be preferred over adults.

The $\delta^{13}C$ of the hemolymph bicarbonate was −8.72‰ and the shell carbonate for three shells had a mean $\delta^{13}C$ of −10.86‰. Thus, in contrast to the situation predicted by lab studies of fractionation, shell carbonate is depleted in ^{13}C relative to hemolymph bicarbonate. Since whole shells were analyzed, the shell $\delta^{13}C$ represents an average $\delta^{13}C$ over ca 6 months of the year (growth occurs from April to September in this population). The hemolymph $\delta^{13}C$, however, represents a measurement at a particular time; this value may vary seasonally (Magaritz, Heller, and Volokita, 1981). Therefore, the estimated carbonate-hemolymph bicarbonate fractionation must be considered approximate.

There are good reasons not to expect the predicted equilibrium fractionation. Since the bicarbonate reservoir of the snail is relatively small, a positive fractionation of the initially deposited shell carbonate would produce a negative fractionation of the bicarbonate, which would counteract further fractionation effects in the shell. Furthermore, the deposition of shell carbonate may occur too rapidly for equilibrium to be reached. As an approximate estimate of the rate of turnover of bicarbonate in the process of shell deposition, let us consider Cedar Valley *Pleurodonte lucerna*. Adult snails have an average mass of ca 22g, of which ca 8g is shell and 14g body (wet mass). Ca 5g of the shell is deposited during the period of activity (about half the year) during the final year of maturation. If the shell is 95% calcium carbonate (Degens, Spencer, and Parker, 1967), this would represent 0.0475 moles of calcium carbonate. The body is ca 85% water, or ca 12g per individual. Taking an average hemolymph bicarbonate concentration of 20mM (Burton, 1969), a snail would contain ca 1.7×10^{-4} moles of bicarbonate. Over the course of half a year, this would have to be turned over ca 280 times to produce the observed rate of shell growth. Thus, neither the reaction rate nor the reservoir size is equivalent to the conditions under which lab experiments of fractionation were run.

Dissolution of atmospheric CO_2 at the mantle edge would seem to be unimportant, since this would tend to produce a higher shell carbonate $\delta^{13}C$ relative to hemolymph bicarbonate. The urease mechanism of shell deposition (discussed above) probably accounts for the observed aragonite-bicarbonate ^{13}C differences. Release of primarily plant-derived carbon from urea breakdown during shell deposition would decrease shell $\delta^{13}C$ relative to hemolymph. If we assume this is the only process accounting for aragonite-bicarbonate ^{13}C differences and that urea is entirely derived from plant carbon ($\delta^{13}C_U = -27$), then we can calculate the proportion of shell carbon that is derived from urea. Let P_U represent the proportion of shell carbonate carbon derived from urea. Then

$$\delta^{13}C_S = P_U\,(\delta^{13}C_U) + (1 - P_U)\,\delta^{13}C_H\,, \tag{24}$$

where $\delta^{13}C_H$ is the $\delta^{13}C$ of hemolymph bicarbonate. Substituting the observed values for Cedar Valley *Pleurodonte lucerna* we get

$$-10.86 = P_U\,(-27) + (1 - P_U)\,(-8.72)$$
$$\text{or} \quad P_U = 0.117\,.$$

Since ^{14}C analyses were not performed on these specimens, P_P is not known but is probably near 0.39 (the mean of *P lucerna* and *P sublucerna* in table 1). Urea-derived plant carbon would thus represent some 30% of this. Note that this is a minimum estimate of the urea contribution to shell carbon. If urea also contains some carbon derived from the bicarbonate pool (and it probably does — see Tramell and Campbell, 1972), or if there is some fractionation or diffusion of atmospheric CO_2 into the mantle associated with shell deposition, then the contribution of urea carbon would be higher than estimated.

Differences among taxa in the presence, absence, or quantitative importance of the urea breakdown (Loest, 1979) would be expected to produce differences in the contribution of plant carbon to shell carbonate and thus produce variation in ^{13}C content. Unfortunately, analysis of carbon isotopes has not been used to examine these aspects of the physiology of shell deposition. Such studies would probably be of considerable value in understanding the processes occurring during shell deposition.

ORGANIC CARBON IN LAND SNAIL SHELLS

The current development of accelerator methods to concentrate ^{14}C may make it possible in the near future to date much smaller quantities of carbon than is presently possible. As pointed out by Burleigh and Kerney (1982), this should make it possible to analyze shell organics for ^{14}C. Therefore, a knowledge of the source of shell organic carbon is of considerable interest. It has been assumed (De Niro and Epstein, 1978; Burleigh and Kerney, 1982) that land snail shell organics (which are primarily proteins) are derived entirely from ingested plant material and therefore, assuming no fractionation, should have a $\delta^{13}C$ identical to plant material.

We have performed ^{13}C analyses on shell organics of two species (table 3). For both species, the $\delta^{13}C$ is within the range observed for tropical plants (Degens, 1969) but both are a little lower than average. Due to the

TABLE 3
^{13}C analyses of shell organic carbon

Species	N	Locality	$\delta^{13}C$(‰)
Pleurodonte lucerna	2	Colliston	−25.89
Poteria varians	4	Albion	−26.22

variation in plant ^{13}C, it is not possible to tell whether these values differ from ingested plant material.

De Niro and Epstein (1978) carried out a series of experiments in which the ^{13}C content of plant material fed to land snails (*Helix aspersa*) was carefully controlled. They found the $\delta^{13}C$ of the newly deposited shell organics to be ca 1‰ higher than the diet, which is consistent with our own findings. This enrichment could not be accounted for by differential loss of lighter carbon by respiration or defecation, or by differential incorporation of lighter carbon into biomass. The possibility of differential incorporation of lighter carbon into excreted uric acid or into mucus lost during locomotion was suggested by the authors.

A more likely explanation for the enrichment of shell organic ^{13}C relative to ingested plants is that it contains some carbon derived from inorganic sources. Land snails are known to incorporate hemolymph bicarbonate into a number of amino acids: arginine (Horne, 1977; Tramell and Campbell, 1972), alanine, aspartic acid, glutamic acid (Awapara and Campbell, 1964), glycine, proline, and serine (Tramell and Campbell, 1972; Campbell and Speeg, 1968). Taken together, these amino acids make up a considerable portion of land snail shell protein (Degens, Spencer, and Parker, 1967).

In general, we can partition the shell organic carbon sources into plant material and hemolymph bicarbonate. Thus

$$\delta^{13}C_{SO} = (1 - P_H)\,(\delta^{13}C_P) + P_H\,(\delta^{13}C_H)\,, \tag{25}$$

where $\delta^{13}C_{SO}$ represents the $\delta^{13}C$ of shell organic carbon and P_H is the proportion of shell organic carbon derived from hemolymph bicarbonate. If we take $\delta^{13}C_P$ as −27‰ and $\delta^{13}C_H$ as −8.7‰ (measurement obtained for *Pleurodonte lucerna*, above), and if we assume that shell organic carbon has a $\delta^{13}C$ 1‰ higher than plants ($\delta^{13}C_{SO} = -26‰$), then

$$-26 = (1-P_H)\,(-27) + P_H\,(-8.7)$$
$$\text{or} \quad P_H = 0.0546\,.$$

So under these assumptions, ca 5% of the shell organic carbon is derived from hemolymph bicarbonate. In limestone areas, some of this bicarbonate will have been derived from limestone (Goodfriend and Stipp, in press) and thus the bicarbonate and shell organic fraction derived from it will be deficient in ^{14}C. If we take 1/3 as the upper limit of P_L, then up to 1/3 (0.0546) = 1.82% of shell organic carbon may be effectively lacking in ^{14}C. Using Tamer's (1970) formula, this amounts to an age anomaly of ca 150 years. For most dating purposes, this is not a serious error. But for certain archaeological purposes, this would not be acceptable.

Note that the estimate of P_H is a minimum estimate of the proportion of inorganic carbon fixed in shell organics. Many of the reactions in which carbon is incorporated into amino acids are associated with the TCA cycle or other reactions that take place in mitochondria (Gilles, 1970; Horne, 1977). Here CO_2 released from respiration of plant material would probably be a more important source for inorganic carbon. This carbon is included within the $(1-P_H)$ term in equation 25. Thus, the total proportion of inorganic carbon fixed in shell organics may considerably exceed the estimate for hemolymph-derived inorganic carbon.

CONCLUSIONS AND SUMMARY

1) From 0-33% of land snail shell carbonate carbon comes from limestone, while 25-40% is derived from plants, and 30-62% from atmospheric CO_2.

2) The proportion of limestone-derived carbonate carbon shows only a weak correlation with shell $\delta^{13}C$. Therefore, $\delta^{13}C$ is of limited use for calculating the proportion of limestone-derived carbon in radiocarbon dated material. The effect of limestone on shell ^{13}C content is obscured by other factors and by an apparent weak negative interaction with the atmospheric CO_2 contribution to the shell.

3) Different taxa tend to differ with respect to carbonate $\delta^{13}C$. This is probably in part due to size differences and consequent differences in the rate of exchange with atmospheric CO_2. Differences in physiology and activity patterns may also contribute to observed ^{13}C variation. The contribution of carbon from urea breakdown is probably an important source of variation among species.

4) The variety of factors affecting land snail shell carbonate $\delta^{13}C$ makes a generally applicable paleoecological interpretation of its level unlikely. However, $\delta^{13}C$ could still prove useful in specific well-studied situations.

5) A formula for correcting the ^{14}C activity of land snail shell carbonate for fractionation is presented. In shells with a high content of limestone-derived carbon, the effect of fractionation is ca 1% less than would be calculated by the conventional formula.

6) There is no evidence for fractionation during precipitation of land snail shell aragonite from bicarbonate.

7) $\delta^{13}C$ of land snail hemolymph bicarbonate is ca 2‰ higher than shell carbonate in adults collected in December. The difference is probably due to input of plant-derived carbon from urea breakdown in the mantle during shell deposition.

8) Shell organic carbon is largely derived from plant material but apparently also contains carbon derived from hemolymph bicarbonate. This makes it subject to a small age anomaly (estimated at up to ca 150 years) due to incorporation of carbon ultimately derived from limestone.

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Appendix

Land snails analyzed for carbon isotopes. Where indicated, voucher specimens are on deposit at the Academy of Natural Sciences of Philadelphia (ANSP) or the Florida State Museum (UF).

Alcadia brownei (Gray) Sta SN-153, E side of hill on W side of trail continuing from end of Rd No. 197, 1.3km N of junction with Alexandria-Alderton Rd, Higgin Land, St Ann, Jamaica; 580m elevation; 23-XI-1976; G Goodfriend (all specimens destroyed for analysis).

Eutrochatella pulchella (Gray) Jamaica (ANSP 183398).

Pleurodonte carmelita (Fér) Chester Vale, St Andrew, Jamaica; 955m; 1932; E A Andrews (ANSP 322415).

Pleurodonte lucerna (Müller) Sta BH, slope S of C Lindo's sugar factory, Broom Hall, SW of Cave Valley (St Ann), Clarendon, Jamaica; 640m; 22-XII-1980; G Goodfriend (UF 40248, 23-III-1977).

Pleurodonte lucerna Sta Ma-25, SW side of Heron Hill, at junction of Kendal Rd and Rte B6, Shooters Hill, N of Mandeville, Manchester, Jamaica; 425m; 7-IX-1980; G Goodfriend (UF 40247).

Pleurodonte lucerna Sta Ma-30, W side of hill along ridge, SE of Percy Junor Hospital, 1km W of junction at Spaldings (Clarendon), Manchester, Jamaica; 825m; 17-IX-1980; G Goodfriend (UF 40246).

Pleurodonte lucerna Sta SN-37, on low hill above entrance to Green Grotto Caves, S side of Rte Al, ca 4.3km E of junction at Discovery Bay, St Ann, Jamaica; 25m; 23-XII-1981; G Goodfriend (UF 40242, 5-I-1979).

Pleurodonte lucerna Sta SN-102, base of cliff on S side of end of rd through Colliston (from Lower Buxton), E of Brown's Town, St Ann, Jamaica; 505m; 20-IX-1976; G Goodfriend (UF 40244).

Pleurodonte lucerna Sta SN-137, N side of hill 150m S of Rd No. 146, 1.8km WSW of junction with Rte B3 at Clarksonville, Cedar Valley, St Ann, Jamaica; 610m; 23-XII-1981; G Goodfriend (UF 40243, XII-1978).

Pleurodonte lucerna Sta We-20, base of SW side of hill on N side of Lambs R — Rat Trap Rd, 0.8km E of junction at Rat Trap, Cow Park, Westmoreland, Jamaica; 350-365m; 27-XII-1981; G Goodfriend (UF 40245).

Pleurodonte sublucerna (Pilsbry) limestone hill just above reservoir spring and catchment basin, Port Antonio, Portland, Jamaica; 3-VII-1932; E A Andrews ("*P acuta lamarckii*", ANSP 162377).

Poteria jamaicensis (Gray) Somerset, Manchester, Jamaica; 1910; A Brown ("*Ptychocochlis jamaicensis*", ANSP 100850).

Poteria varians (C B Adams) Sta SN-141, escarpment 600m N of ruins of Alexandria House, Alexandria Pen, E of Alexandria, St Ann, Jamaica; 625-655m; 20-XI-1976; G Goodfriend (all specimens destroyed for analysis).

Poteria varians Sta SN-164, hill on SW side of Alexandria-Alderton Rd, ca 200m SSW of junction with rd to Albion House, Albion, St Ann, Jamaica; 655-680m; 22-XII-1976; G Goodfriend (all specimens destroyed for analysis).

Urocoptis ambigua (C B Adams) Somerset, Manchester, Jamaica; 1910; A P Brown (ANSP 101150).

Urocoptis ambigua Sta Ma-27, W side of hill at S end of red mud lake, ca 175m NNW of junction of old Kendal Rd and new bypass rd, Martins Hill, N of Mandeville, Manchester, Jamaica; 535m; 16-IX-1980; G Goodfriend (UF 40241).

Urocoptis megacheila (Chitty) Sta We-8, SW side of hill, 450m E of rd from Cave Valley to Delve Bridge, 0.7km S of junction with rd to Retrieve Mt, Midgham dist, Westmoreland, Jamaica; 200m; 1-I-1979; G Goodfriend (ANSP 353836).

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INGEIS RADIOCARBON LABORATORY DATES I*

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The Instituto de Geocronología Geología Isotópica (INGEIS) belongs to the Consejo Nacional de Investigaciones Cientifícas y Técnicas (CONICET) of Argentina and is supported by another six government institutions. Its headquarters are located in the Facultad de Ciencias Exactas y Naturales of the Universidad de Buenos Aires.

The ^{14}C laboratory of the Institute was established in 1977 for research on coastal geology, hydrogeology, archaeology, anthropology, and contamination measurements. The method employed is liquid scintillation counting of synthesized benzene using the basic technique of Tamers (1975) and Noakes *et al* (1965). Samples are converted to CO_2 (carbonates by perchloric acid dissolution; organics by combustion in an oxygen stream in a combustion system) then to C_2H_2 and finally, using 160g of Perlkator Catalyst activated for 4 hours at 360°C, to high purity benzene (99.994%, checked by gas chromatography). The average yields are over 90%. The activity measurements are done in a Packard-Tricarb 3255 liquid scintillation spectrometer using glass vials (low potassium content) of ca 20ml with a mixture of 5ml of synthesized benzene and 1.25ml of scintillation cocktail (7g of PPO and 0.5g of Me_2POPOP in 1l of scintillation-grade toluene). The upper part of the vial is wrapped in aluminum foil to reduce cross-talk of the photomultipliers. The dates reported here are calculated with a ^{14}C half-life of 5568 years. The modern reference is taken as 0.95 of the activity of the NBS ^{14}C standard. The oxalic acid is converted to CO_2 by reaction with a solution of $KMnO_4$ in sulfuric acid. Errors are reported as one standard deviation which includes the combined uncertainty of the background, reference, and sample. All ages are corrected to correspond to a $\delta^{13}C$(PDB) value of $-25‰$ and the standard activity is normalized to $\delta^{13}C = -19‰$. The $\delta^{13}C$ measurements are performed in the Stable Isotopes Laboratory of the Institute which works with a double collector mass spectrometer Micromass 602-D. Errors in $\delta^{13}C$ measurements are $\pm$ 0.3‰.

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* Contribution No. 53 of the Instituto de Geocronología y Geología Isotópica (INGEIS)

I. GEOLOGIC SAMPLES

Argentina

Pedro Luro series

Surface shells coll to determine ancient shorelines from Pedro Luro site, Buenos Aires Prov. Coll and subm 1978 by N Weiler and J O Codignotto.

AC-0026. **2160 ± 110** $\delta^{13}C = 1.8‰$

(39° 39′ 42″ S, 62° 09′ W) 2.5m asl; 3km from present shoreline.

AC-0027. **2590 ± 110** $\delta^{13}C = 1.1‰$

(39° 39′ 10″ S, 62° 07′ 30″ W) 2.5m asl; 1.25km from present shoreline.

AC-0028. **410 ± 100** $\delta^{13}C = 1.5‰$

(39° 38′ S, 62° 08′ W) 2.5m asl; 0.75km from present shoreline.

AC-0029. **6000 ± 150** $\delta^{13}C = 1.2‰$

(39° 39′ 20″ S, 62° 13′ 28″ W) 5m asl; 9.5km from present shoreline.

AC-0045. **5310 ± 120** $\delta^{13}C = 0.5‰$

(39° 37′ 40″ S, 62° 11′ W) 5m asl; 6.5km from present shoreline.

AC-0046. **6930 ± 130** $\delta^{13}C = 1.1‰$

(39° 36′ 24″ S, 62° 14′ W) 5m asl; 11.5km from present shoreline.

AC-0047. **3060 ± 120** $\delta^{13}C = 1.8‰$

(39° 37′ S, 62° 08′ W) 2.5m asl; 1.5km from present shoreline.

AC-0170. **3220 ± 100** $\delta^{13}C = 1.6‰$

(39° 40′ S, 62° 07′ W) 2.5m asl; 0.5km from present shoreline.

AC-0171. **1680 ± 90** $\delta^{13}C = 1.4‰$

(39° 38′ 50″ S, 62° 08′ 30″ W) 5m asl; 2.5km from present shoreline.

Mayor Buratovich series

Mollusk shells from Mayor Buratovich site, Buenos Aires Prov. Surface shells coll and subm 1978 by N Weiler and J O Codignotto.

AC-0044. **1600 ± 100** $\delta^{13}C = 1.0‰$

(39° 28′ 22″ S, 62° 03′ 25″ W) 2.5m asl; 1.25km from present shoreline.

1650 ± 80
AC-0048. $\delta^{13}C = 0.9‰$
(39° 28′ 25″ S, 62° 04′ W) 5m asl; 2km from present shoreline.

3600 ± 90
AC-0049. $\delta^{13}C = 0.6‰$
(39° 28′ S, 62° 09′ W) 5m asl; 9.5km from present shoreline.

2850 ± 80
AC-0050. $\delta^{13}C = 1.2‰$
(39° 25′ S, 62° 08′ 15″ W) 3m asl; 5km from present shoreline.

1240 ± 80
AC-0051. $\delta^{13}C = 1.1‰$
(39° 29′ 46″ S, 62° 05′ 11″ W) 5m asl; 2km from present shoreline.

Villalonga series

Mollusk shells from Villalonga site, Buenos Aires Prov. Surface shells coll and subm 1979 by N Weiler and J O Codignotto.

3850 ± 90
AC-0052. $\delta^{13}C = 1.0‰$
(39° 57′ S, 62° 20′ W) 3m asl; 0.25km from present shoreline.

9460 ± 120
AC-0053. $\delta^{13}C = 1.5‰$
(39° 57′ 35″ S, 62° 20′ 30″ W) 4m asl; 1km from present shoreline; 1.5m depth.

5920 ± 100
AC-0054. $\delta^{13}C = 1.7‰$
(39° 56′ 30″ S, 62° 20′ W) 7.5m asl; 2.2km from present shoreline.

Mar del Plata series

Marine shells from Mar del Plata site and surroundings, Buenos Aires Prov. Coll and subm 1980 by E J Schnack, Centro Geol Costas, Mar del Plata.

2830 ± 80
AC-0062. $\delta^{13}C = 0.7‰$
Mar Chiquita (37° 37′ 03″ S, 57° 18′ 50″ W) 1.5m asl; 0.3 to 0.45m depth.

2880 ± 80
AC-0063. $\delta^{13}C = 1.8‰$
Mar Chiquita (37° 37′ 03″ S, 57° 18′ 50″ W) 1.5m asl; 0.3 to 0.45m depth.

3110 ± 80
AC-0064. $\delta^{13}C = 0.7‰$
Atlántida Medaland (37° 27′ 53″ S, 57° 13′ 10″ W) 2.3m asl; 0.5 to 0.6m depth.

2920 ± 80
AC-0065. *$\delta^{13}C$ = 1.2‰*
Vivoratá (37° 34′ 05″ S, 57° 26′ 24″ W) 1.2m asl; 0.8m depth.

2700 ± 60
AC-0066. *$\delta^{13}C$ = 0.0‰*
Vivoratá (37° 34′ 05″ S, 57° 26′ 24″ W) 1.2m asl; 0.8m depth.

1340 ± 60
AC-0100. *$\delta^{13}C$ = –4.1‰*
Mar del Plata (37° 47′ 08″ S, 57° 27′ 20″ W) 2.5m asl; surface sample.

3840 ± 70
AC-0101. *$\delta^{13}C$ = 0.5‰*
Mar del Plata (37° 27′ 14″ S, 57° 15′ W) 2.4m asl; 0.2 to 0.5m depth.

3620 ± 60
AC-0102. *$\delta^{13}C$ = –0.8‰*
Mar del Plata (37° 27′ 14″ S, 57° 15′ W) 2.4m asl; 0.2 to 0.5m depth.

3430 ± 90
AC-0206. *$\delta^{13}C$ = –0.1‰*
Mar de Cobo (37° 46′ 15″ S, 57° 26′ 40″ W) 2m asl; surface sample.

Mar Chiquita series

Marine shells from Mar Chiquita site, Buenos Aires Prov (37° 44′ S, 57° 26′ 30″ W). Coll and subm 1980 by C Gentili, Fac Ciencias Exactas y Naturales, Univ Buenos Aires.

4880 ± 90
AC-0106. *$\delta^{13}C$ = –0.4‰*
Depth: 1.6m.

4810 ± 90
AC-0107. *$\delta^{13}C$ = 2.6‰*
Depth: 0.85m.

3830 ± 80
AC-0108. *$\delta^{13}C$ = 1.9‰*
Depth: 0.4m.

Bahía Blanca series

Mollusk shells from Bahía Blanca site, Buenos Aires Prov and surroundings. Coll and subm 1980 by E Farinati, Univ Nacional del Sur.

5980 ± 130
AC-0118. *$\delta^{13}C$ = 2.6‰*
Punta Cigueñas (38° 55′ S, 62° 03′ W) 3m asl; 1m depth.

14,250 ± 180
AC-0120. *$\delta^{13}C$ = 1.4‰*
Estancia Los Blancos (38° 59′ S, 62° 22′ W) 10m asl; 2m depth.

AC-0121. **6650 ± 100**
$\delta^{13}C = 0.9‰$

Empalme Aguará (38° 43′ S, 62° 20′ W) 8m asl; 2m depth.

AC-0169. **19,140 ± 250**
$\delta^{13}C = 1.4‰$

Baterias (39° 24′ S, 62° 07′ W) 5m asl.

AC-0178-I. **35,500 ± 2100**
$\delta^{13}C = -20.2‰$

AC-0178-II. **35,000 ± 2000**
$\delta^{13}C = -20.2‰$

Highly carbonized wood (*Austrocedrus chilensis*?) from 2m gravel bed, underlying 1.5m non-cemented gravel, W front of Sierra Catan-Lil, 10km from Rahue, Neuquén Prov (39° 22′ S, 70° 56′ W). Coll and subm 1980 by J Fernández, INGEIS. *Comment* (JF): Sierra Catan-Lil was probably forested and free of ice at that time, in probable coincidence with an interstadial.

La Calera series

Shells (*Erodona mactroides*) from test pit in Estancia La Calera, Gualeguay Dept, Entre Ríos Prov (33° 25′ S, 58° 35′ W). Coll and subm 1980 by J Fernández.

AC-0126. **5410 ± 110**
$\delta^{13}C = -2.3‰$

0.3m below surface.

AC-0127. **5280 ± 100**
$\delta^{13}C = -2.1‰$

0.5m below surface.

AC-0128. **5490 ± 110**
$\delta^{13}C = -1.4‰$

0.8m below surface.

AC-0129. **5530 ± 110**
$\delta^{13}C = -2.2‰$

1.2m below surface.

General Comment (JF): dates show Holocene shoreline, 4 to 5m asl ("Querandinense" ingression).

Río Negro series

Marine shells from Río Negro site, coll and subm 1980 by J O Codignotto.

AC-0137. **3370 ± 80**
$\delta^{13}C = 2.5‰$

Sample from right shore of Río Negro (41° 00′ 45″ S, 62° 47′ 08″ W).

AC-0138. **1030 ± 80**
$\delta^{13}C = 2.6‰$

Sample from dune, 400m from present shoreline (41° 00′ 00″ S, 62° 39′ 38″ W).

AC-0140. **2930 ± 90**
$\delta^{13}C = 2.1‰$

Marine shells mixed with coarse sand, 500m from present shoreline (40° 58′ 07″ S, 62° 34′ 38″ W).

AC-0141. **13,400 ± 190**
$\delta^{13}C = 1.5‰$

Marine shells buried in coarse sand, 3000m from present shoreline (40° 55′ 09″ S, 62° 31′ 47″ W).

San Blas series

Marine shells from San Blas site, Buenos Aires Prov. Coll and subm 1980 by N Weiler and J O Codignotto.

AC-0057. **8920 ± 120**
$\delta^{13}C = 2.1‰$

Sample 6km SW of San Blas Town (40° 35′ 00″ S, 62° 16′ 35″ W). Marine shells from dune of partially cemented sand.

AC-0058. **17,000 ± 220**
$\delta^{13}C = 1.4‰$

Sample 2km N of Estancia La Serrana (40° 34′ 36″ S, 62° 18′ 42″ W).

AC-0059. **33,200 ± 1500**
$\delta^{13}C = 0.9‰$

Samples 2km N of Estancia La Serrana (40° 34′ 36″ S, 62° 18′ 42″ W). *Comment* (JOC): even though AC-0058 and -0059 were coll in same place, age difference is attributed to different conservation of the two samples.

Camarones series

Marine shells along shore between Camarones and Bahía Bustamante, coll and subm 1980 by J O Codignotto.

AC-0165. **32,900 ± 1300**
$\delta^{13}C = 2.1‰$

(44° 44′ 51″ S, 65° 41′ 15″ W) 200m from present shoreline.

AC-0164. **38,900 ± 2800**
$\delta^{13}C = 1.8‰$

(44° 45′ 56″ S, 65° 41′ 15″ W) 300m from present shoreline.

AC-0163. **4370 ± 100**
$\delta^{13}C = 1.6‰$

(44° 47′ 34″ S, 65° 41′ 23″ W) 100m from present shoreline.

AC-0168. **32,200 ± 1200**
$\delta^{13}C = -1.1‰$

Shells from gravel (44° 49′ 11″ S, 65° 43′ 30″ W) 800m from present shoreline.

AC-0166. **7520 ± 120**
$\delta^{13}C = 1.5‰$

(44° 42′ 42″ S, 65° 40′ 30″ W) 400m from present shoreline.

3860 ± 100
AC-0167. $\delta^{13}C = 2.7‰$

Shells from gravel (44° 48′ 06″ S, 65° 42′ 30″ W) 100m from present shoreline.

31,800 ± 1400
AC-0150. $\delta^{13}C = 1.6‰$

Shells from gravel and sands (45° 04′ 08″ S, 66° 30′ 09″ W) 1000m from present shoreline.

30,900 ± 1100
AC-0151. $\delta^{13}C = 1.5‰$

Shells from gravel (45° 04′ 01″ S, 66° 28′ 23″ W) 1000m from present shoreline.

2880 ± 90
AC-0152. $\delta^{13}C = 3.5‰$

Shells from gravel, 300m from present shoreline (45° 04′ 08″ S, 66° 28′ 14″ W).

2030 ± 90
AC-0153. $\delta^{13}C = 1.4‰$

Shells from gravel, 50m from present shoreline (45° 04′ 11″ S, 66° 28′ 09″W).

36,000 ± 2000
AC-0154. $\delta^{13}C = 1.6‰$

Shells from sandy gravel, 3km from present shoreline (45° 02′ 28″ S, 66° 27′ 08″ W).

37,300 ± 2400
AC-0155. $\delta^{13}C = 1.0‰$

Shells from muddy-gravel, 3km from present shoreline (45° 02′ 08″ S, 65° 25′ 31″ W).

>43,000
AC-0156. $\delta^{13}C = 2.1‰$

Shells from muddy-sands (45° 01′ 39″ S, 66° 25′ 00″ W).

Península Valdés series

Marine shells along coast between Punta Norte and Punta Cantor sites, Chubut Prov. Coll and subm 1980 by J O Codignotto.

4180 ± 100
AC-0157. $\delta^{13}C = 2.6‰$

Shells from gravel, 200m from present shoreline (42° 05′ 24″ S, 63° 45′ 00″ W).

5100 ± 100
AC-0158. $\delta^{13}C = 1.7‰$

Shells from coarse gravel, 1000m from present shoreline (42° 07′ 34″ S, 63° 44′ 00″ W).

1330 ± 80
AC-0159. $\delta^{13}C = 2.1‰$

Shells from middle gravel, 300m from present shoreline (42° 07′ 34″ S, 63° 44′ 00″ W).

5730 ± 100
AC-0160. *$\delta^{13}C = 2.1‰$*
Shells from middle gravel, 700m from present shoreline (42° 13′ 30″ S, 63° 37′ 30″ W).

38,700 ± 2700
AC-0161. *$\delta^{13}C = 0.2‰$*
Shells from muddy gravel, 400m from W coast of Caleta Valdés (42° 24′ 00″ S, 63° 36′ 20″ W).

2160 ± 90
AC-0162. *$\delta^{13}C = 2.5‰$*
Shells from gravel, 20m from W coast of Caleta Valdés (42° 24′ 18″ S, 63° 36′ 20″ W).

Caleta Olivia series

Marine shells along coast between Punta Maqueda and Bahía Lángara, Santa Cruz Prov. Coll and subm 1978-1980 by J O Codignotto.

2800 ± 70
AC-0040. *$\delta^{13}C = 1.7‰$*
Shells from gravel, 150m from present shoreline (46° 23′ 30″ S, 67° 32′ 37″ W).

39,000 ± 3600
AC-0041. *$\delta^{13}C = 1.2‰$*
Shells from gravel, 150m from present shoreline (46° 20′ 10″ S, 67° 34′ 30″ W).

2300 ± 120
AC-0042. *$\delta^{13}C = 0.6‰$*
Shells from gravel, 100m from present shoreline (46° 20′ 52″ S, 67° 34′ 10″ W).

5750 ± 120
AC-0130. *$\delta^{13}C = 1.5‰$*
Shells from gravel, 200m from present shoreline (46° 03′ 17″ S, 67° 37′ 30″ W).

4230 ± 100
AC-0131. *$\delta^{13}C = 1.7‰$*
Shells from gravel, 300m from present shoreline (46° 06′ 20″ S, 67° 38′ 06″ W).

1590 ± 70
AC-0132. *$\delta^{13}C = 0.5‰$*
Shells from gravel, 350m from present shoreline (46° 15′ 41″ S, 67° 36′ 00″ W).

25,800 ± 600
AC-0133. *$\delta^{13}C = 1.7‰$*
Shells from muddy and sandy sediments, 200m from present shoreline (46° 19′ 08″ S, 67° 34′ 37″ W).

AC-0134. **27,600 ± 700**
$\delta^{13}C = 0.9‰$

Shells from muddy sands, cemented with carbonates (46° 20′ 51″ S, 67° 34′ 22″ W).

AC-0135. **28,700 ± 850**
$\delta^{13}C = 0.5‰$

Shells from sandy gravels (46° 34′ 36″ S, 67° 24′ 45″ W).

AC-0136. **31,000 ± 1100**
$\delta^{13}C = 2.7‰$

Shells from muddy sands (46° 24′ 03″ S, 67° 32′ 20″ W).

AC-0207. **28,400 ± 800**
$\delta^{13}C = 1.2‰$

Shells from sandy gravel (46° 32′ 59″ S, 67° 26′ 17″ W).

AC-0208. **27,500 ± 700**
$\delta^{13}C = 1.5‰$

Shells from sandy gravel (46° 32′ 59″ S, 67° 26′ 17″ W).

AC-0209. **29,600 ± 1100**
$\delta^{13}C = 0.6‰$

Shells from sandy muddy gravels (46° 08′ 06″ S, 67° 37′ 30″ W).

AC-0210. **5750 ± 110**
$\delta^{13}C = 1.1‰$

Shells from gravels (46° 04′ 00″ S, 67° 37′ 30″ W).

AC-0211. **1550 ± 90**
$\delta^{13}C = 1.3‰$

Shells from gravels (46° 01′ 21″ S, 67° 35′ 15″ W).

Puerto Lobos series

Marine shells from terraces and beach ridges in Chubut Prov, near sea and border with Río Negro Prov. Coll and subm 1980 by J O Codignotto.

AC-0144. **20,300 ± 350**
$\delta^{13}C = 1.5‰$

Shells buried in coarse sand and gravel (42° 00′ S, 65° 04′ W).

AC-0145. **30,400 ± 1120**
$\delta^{13}C = 1.9‰$

Shells buried in coarse gravel (42° 00′ S, 65° 05′ W).

AC-0146. **32,100 ± 1400**
$\delta^{13}C = 1.7‰$

Shells buried in fine and middle gravel with coarse sand (42° 00′ S, 65° 06′ W).

AC-0147. **40,800 ± 4000**
$\delta^{13}C = -0.2‰$

Shells mixed with gravel (42° 00′ S, 65° 08′ W).

AC-0142. **750 ± 80**
$\delta^{13}C = 2.5‰$

Shells mixed with coarse and middle sand (42° 00′ S, 65° 03′ W).

AC-0143. **3310 ± 90**
$\delta^{13}C = 2.3‰$

Shells buried in very coarse sand with gravel (42° 00′ S, 65° 03′ W).

II. ARCHAEOLOGIC SAMPLES

Picunches series

Fragments of ostrich eggshell (*Rhea americana*) from sand-dunes site with archaeologic evidences in NW Patagonia, assoc with bones (mammals, birds, and fishes), fluvial shells, stone artifacts, and pottery. Coll and subm 1980 by J L Balbuena.

AC-0205. **1700 ± 90**
$\delta^{13}C = -8.6‰$

Médano Estancia La Porteña (38° 35′ S, 70° 20′ W). Sample assoc with early Neolithic pottery and microlithic arrowheads (weight, 332 to 1016mg) mainly of obsidian. *Comment* (JLB): first date for microlithic techniques in NW Patagonia.

AC-0197. **980 ± 80**
$\delta^{13}C = -7.9‰$

Médano Arroyo Cohunco (38° 34′ S, 70° 35′ W). *Comment* (JLB): date corresponds with Neolithic occupation in Patagonia; arrowheads of obsidian assoc with ceramics with high relief decoration.

Codihue series

Charcoal from arroyo Codihue cave, Neuquén (38° 28′ S, 70° 35′ W) assoc with stone artifacts, eggshell, and animal bones. Coll and subm 1980 by J L Balbuena.

AC-0199. **270 ± 80**
$\delta^{13}C = -21.6‰$

Sample from entrance of cave, Level 1, 0.0 to 0.15m.

AC-0200. **1380 ± 90**
$\delta^{13}C = -21.5‰$

Sample from inside cave, Level 1.

AC-0201. **1280 ± 90**
$\delta^{13}C = -20.2‰$

Sample from inside cave, Level 1. *Comment* (JLB): these data correspond to first level of cave. Deeper layers are under study.

Túnel series

Charcoal from Túnel site, assoc with oldest known archaeol evidence of maritime adaptation in Beagle Channel region (54° 49′ 15″ S, 68° 09′

44″ W). Sea canoe nomads with economy based on sea lion (*Arctocephalus australis*) hunting, complemented with guanaco (*Lama guanicoe*), birds, fishes, cetaceous, and mollusk consumption. In addition to generalized lithic technology, bone industry is specialized (detachable harpoon heads for sea lions, barbed fixed harpoon heads for fishes, bird bone awls for basketry, chisels, and cross-base wedges for woodworking, etc). Cultural expression shows discontinued occupation of site for ca 200 yr. Bed dated by INGEIS was also dated by Rocasolano (CSIC-310; 6070 ± 70 and Beta Analytic (β-3270: 6200 ± 100). Upper levels of same cultural manifestation were also dated by Rocasolano (CSIC-309: 5960 ± 70; CSIC-308: 5850 ± 70; CSIC-305: 5920 ± 90) and by Beta (β-2819: 6140 ± 130).

First human occupation known, yielded by lower bed, was also dated (β-2517: 6980 ± 110 and shows very short occupation by small group of pedestrian hunters adapted to hinterland resources. Coll and subm 1978 by L Orquera and E L Piana.

5700 ± 170

AC-0236. $\delta^{13}C = -21.5‰$

"E" layer, Sq III.

5020 ± 100

AC-0237. $\delta^{13}C = -23.5‰$

"E" layer, Sq III. *Comment* (ELP): coll for testing sampling technique; probably contaminated.

5690 ± 180

AC-0238. $\delta^{13}C = -23.0‰$

"E" layer, Sq II.

Haichol cave series

Charcoal from Haichol cave (38° 35′ S, 70° 40′ W), E front of Cordillera de los Andes, 1000m asl, near Las Lajas city, Neuquén. Coll and subm 1979 by J Fernández.

7020 ± 120

AC-0069. $\delta^{13}C = -22.5‰$

Charcoal, Unit 16A2-17A2; 1.55 to 1.65m depth.

5050 ± 100

AC-0231. $\delta^{13}C = -21.3‰$

Charcoal, Unit 16B4-17B4; 1.9 to 2m depth.

5530 ± 110

AC-0232. $\delta^{13}C = -21.7‰$

Charcoal, Unit 16B4-17B4; 2 to 2.1m depth.

General Comment (JF): inhabitants of cave were hunters of guanacos (*Lama guanicoe*), edentates, minor rodents, etc, and gatherers of seeds (*Araucaria araucana*). Lithic industry is characterized by mill stones, stemless projectile points, end scrapers, and naturally worn edges of obsidian flakes. Data correspond to aceramic levels.

Truquico salt mine series

Shells and wood from Indian underground salt mine at Truquico, near Chos Malal, Neuquén (37° 27′ S, 70° 17′ W). Coll and subm 1976 by J Fernández.

350 ± 70
AC-0002. $\delta^{13}C = -5.9‰$

Shells (*Diplodon* sp).

630 ± 80
AC-0004. $\delta^{13}C = -21.6‰$

Wood from axe handle.

590 ± 80
AC-0005. $\delta^{13}C = -23.4‰$

Wood from axe handle.

General Comment (JF): samples measured to determine when mining began. Data show that it started prior to Hispanic and Araucanian domination and Huayna Capac conquest of Chile (15th century). Axes are xylolithic tools used in mining and were preserved buried in salt.

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[RADIOCARBON, VOL 25, NO 3, 1983, P 843-866]

GLIWICE RADIOCARBON DATES IX

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The following list contains most of the measurements of geologic samples made during 1979 and 1980 using carbon-dioxide-filled proportional counters. Samples with laboratory numbers > 1000 were counted with counter No. 1 (L1), and those with numbers < 1000, with counter No. 3 (L3), described by Mościcki and Zastawny (1977). Actual parameters of both counters were given in our previous date list (R, 1982, v 24, p 172).

Methods of sample pretreatment follow, with some minor modifications, those described by Olsson (1979). Some samples of peat, peaty mud, and gyttja were dated using both alkali-soluble fractions, precipitated by adding appropriate amounts of hydrochloric acid, and insoluble residue. The results obtained for series of such paired samples were discussed by Pazdur (1982) and conclusions are similar to those of Sheppard, Ali, and Mehringer (1979).

Combustion and purification lines were described by Pazdur *et al* (1979), the electronic system, designed and described by Bluszcz and Walanus (1980), is built of CAMAC units produced by POLON Enterprise, Warsaw. Measurement of any sample, including background and modern samples, consists of a series of 20 to 25 partial measurements of 100 minutes duration. Partial results obtained in such series were analyzed automatically at the computing center (Pazdur and Walanus, 1979a). Age calculations are based on contemporary value equal to 0.95 of the activity of NBS Oxalic Acid standard and on the Libby half-life of ^{14}C. Ages are reported as conventional ^{14}C dates in years before AD 1950. No corrections for isotopic fractionation in nature are made for samples presented in this list. Errors quoted ($\pm 1\sigma$) include estimated overall standard deviations of count rates of the unknown sample, contemporary standard, and background (Pazdur & Walanus, 1979a). In spite of our proposition (Walanus & Pazdur, 1980), infinite dates are reported according to 2σ criterion, as recommended by Stuiver and Polach (1977, p 362).

Most samples in this list were dated for investigations within the IGCP 158 Project "Paleohydrology of the temperate zone", Subproject A "Fluvial environment". A brief report on the activities of the Polish Group of the IGCP 158 Project was given by Starkel (1981a), the results obtained up to 1981 were presented at the Symposium "Paleohydrology of the temperate zone", Poznań, Poland, 1981, Sept 22-28 (Kozarski & Tobolski, 1981; Starkel, 1981b,c). All dates made for studies connected with Subproject 158B "Lake and mire environments" (Berglund, 1979) will be included in our next date list.

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The authors wish to thank Helena Skorupka for her excellent technical assistance in laboratory.

SAMPLE DESCRIPTIONS

I. GEOLOGIC SAMPLES

A. Poland

Gardno series

Peat from layers of varying thickness overlying sandy deposits and underlying gyttja in basin of Gardno Lake, Slovinian coastline. Coll and subm 1980 by Adam Wojciechowski, Inst Geog, Adam Mickiewicz Univ, Poznań. Samples dated for geomorphol and strat studies of basal deposits of Gardno Lake. Deposits underwent pollen (Zachowicz, 1977) and diatom analysis (Zaborowska, 1977). Profile Ga-A3 is 1200m W of Łupawa R mouth to Gardno Lake (54° 39′ N, 17° 09′ E); coll Jan 1980. Profile Ga-D2 taken at S shore of lake ca 600m N of Retowo village (54° 38′ 20″ N, 17° 07′ 30″ E); coll Feb 1980.

Gd-1286. Gardno Ga-A3a **9090 ± 70**

Carex peat from depth 255 to 260cm below water level, top of peat layer ca 1m thick, overlain by shell gyttja.

Gd-1288. Gardno Ga-A3b **10,280 ± 120**

Carex-Phragmites peat from base of peat layer at depth 350 to 356cm below water level, at contact of medium-grained sands.

Gd-1285. Gardno Ga-D2a **5380 ± 50**

Carex-Phragmites peat from depth 135 to 140cm below water level, top of peat layer ca 1.2m thick, overlain by brown gyttja.

Gd-827. Gardno Ga-D2b **10,140 ± 150**

Carex-Phragmites peat from base of peat layer at contact with gray humus sand, depth 245 to 252cm below water level.

Lubiatowo series

Peat from layer ranging from 1.5 to 3m underlain by medium and coarse-grained sands and overlain by fine-grained eolian (?) sands and peaty soil on coastal river plain near Baltic shore 1km W of Lubiatowo village (54° 48′ N, 17° 51′ E), E of Łeba, Gardno-Łeba Plain, Slovinian coastline. Coll Aug 1979 and subm by Sylwester Skompski, Geol Inst, Warsaw.

Gd-749. Lubiatowo L-8:sol **8640 ± 200**

From lowermost part of peat layer at contact with sands, depth 2.9 to 3m, alkali-soluble fraction. *Comment*: undersized, diluted.

Gd-1216. Lubiatowo L-8:ins **8200 ± 100**

Same sample, insoluble fraction.

Gd-748. Lubiatowo L-1:sol **1350 ± 70**

From uppermost part of peat layer at contact with sands, depth 1.5 to 1.7m, alkali-soluble fraction.

Gd-1215. Lubiatowo L-1:ins **1030 ± 60**

Same sample, insoluble fraction.

Białogóra series

Peat from layer in fine-grained sands ranging from 0.7 to 2.4m on coastal river plain, 1.2km ENE of Białogóra village (54° 49′ N, 17° 59′ E), NW of Zarnowieckie Lake, W part of Karwieńska Plain, 5m asl. Coll July 1979 and subm by Sylwester Skompski.

Gd-746. Białogóra B-7:sol **4470 ± 220**

From lowermost part of peat layer, depth 2.3 to 2.4m, alkali-soluble fraction. *Comment*: undersized, diluted.

Gd-745. Białogóra B-7:ins **4820 ± 100**

Same sample, insoluble fraction.

Gd-747. Białogóra B-1:sol **1750 ± 80**

From uppermost part of peat layer, depth 0.8 to 1m, alkali-soluble fraction.

Gd-1211. Białogóra B-1:ins **1620 ± 80**

Same sample, insoluble fraction.

Zalew Wislany series

Organogenic sediments from Zalew Wiślany (54° 23′ 07″ N, 19° 42′ 47″ E). Core 3a, 10m long taken at water depth 3m, reaching Pleistocene gray morainic till at depth 8.8m. Coll April 1979 and subm by Bogusław Rosa, Inst Geog, Dept Geomorphol and Quaternary Geol, Gdańsk Univ, Gdynia.

Gd-1238. Zalew Wislany 1 **6730 ± 60**

Highly-decomposed homogeneous peaty slime without visible faunal remains, depth 5.5 to 5.75m, central part of peaty mud horizon ranging from 5.26 to 5.91m, overlain by poludine horizon.

Gd-1237. Zalew Wislany 2 **7120 ± 100**

Highly-decomposed peat, brown at top and dark gray at base, depth 6 to 6.27m.

Gd-1239. Zalew Wislany 3 **7600 ± 90**

Gray clotty peat, depth 6.9 to 7.15m. *Comment* (BR): characteristic consistency of this peat layer indicates temporal drying of peat-bog surface which means lowering of groundwater level and, at depth 6.88m, contact with local transgression or beginning of local flood.

Gd-1240. Zalew Wislany 4 **9390 ± 110**

Highly-decomposed peat, depth 7.3 to 7.5m.

Gd-772. Zalew Wislany 5 **11,090 ± 150**

Highly-decomposed peat, depth 7.5 to 7.7m.

Gd-773. Zalew Wislany 6 **11,240 ± 110**

Peaty slime rich in organic matter, brown at top and brown-gray at base, depth 7.7 to 7.95m.

Pomorsko station series

Sandy peat from top of peat layer filling up Odra R paleomeander and overlain by sandy sediments forming alluvial cones, 1km SE of Pomorsko RR sta (52° 02′ 40″ N, 15° 32′ 40″ E), 7.5km SW of Sulechów, Cigacice-Krosno sec of Warsaw-Berlin Pradolina. Coll and subm 1979 by Bolesław Nowaczyk, Inst Geog, Adam Mickiewicz Univ, Poznań.

Gd-1195. Pomorsko sta 15/79/BN:sol **1460 ± 50**

Below older alluvial cone, depth 351 to 361cm, coll Aug 1979, alkali-soluble fraction dated.

Gd-726. Pomorsko sta 15/79/BN:ins **1720 ± 70**

Same sample, insoluble fraction.

Gd-1189. Pomorsko sta 16/79/BN:ins **1520 ± 80**

Below younger alluvial cone, depth 92 to 100cm, coll Oct 1979, insoluble fraction dated. *Comment* (BN&MFP): samples dated for systematic geomorphol and strat studies of dunes and lacustrine sediments in vicinity of Pomorsko (Nowaczyk, 1974; 1976; 1979; Nowaczyk & Tobolski, 1979; 1981); for other dates from this area, see Nowaczyk *et al* (1982) and next sec.

Czmoniec series

Organic sediments from peaty paleomeander of younger generation, Warta R valley near Czmoniec, ca 10km N of Srem, Great Poland Lowland (52° 11′ N, 17° 00′ E). Coll July 1978 by Stefan Kozarski and Kazimierz Tobolski; subm 1980 by KT to supplement earlier dates from this site (R, 1982, v 24, p 187). Dated for systematic studies of Warta R paleomeanders initiated by Stefan Kozarski in 1967 and now included into IGCP 158A Project (Kozarski, 1981b,c; Okuniewska & Tobolski, 1981; Tobolski, 1981).

Gd-818. Czmoniec Cz I/78A/110-115 **3300 ± 120**

Wood peat with sand, top of peat layer at contact with detritus gyttja, depth 110 to 115cm. *Comment*: undersized, diluted.

Gd-817. Czmoniec Cz I/78A/144-150 **3550 ± 80**

Coarse detritus gyttja, with sand, top of gyttja layer at contact with wood peat layer, depth 144 to 150cm.

Zabno series

Channel deposits from paleochannels on terrace III of Warta R valley (Antczak, 1981; Kozarski, 1981b; Kozarski & Rotnicki, 1977) with traces of braided river flow, ca 3km W of recent Warta R channel at Zabno village (52° 11′ 32″ N, 16° 54′ 09″ E), 30km S of Poznań, Srem sec of Warsaw-Berlin Pradolina. Coll March 1980 by Barbara Antczak; subm 1980 by Stefan Kozarski, Inst Geog, Adam Mickiewicz Univ, Poznań. Dated for investigations in IGCP 158A Project.

Gd-812. Zabno IM **6300 ± 790**

Organogenic silt from layer 30cm thick between two series of coarse and medium-grained sands, depth 1.06m. *Comment*: very small sample, undersized, diluted.

Gd-819. Zabno III Da **2200 ± 270**

Wood remnants, coarse fraction, from series of coarse- and medium-grained sands, depth 1.1m. *Comment*: undersized, diluted.

Gd-810. Zabno III Db **4560 ± 120**

Wood remnants, fine fraction from same series of sands.

General Comment (BA): samples dated to estimate end of period of water outflow on terrace III. Dates younger than expected, other dates from organic deposits filling up paleomeanders on terrace II are Gd-387, 11,430 ± 630; Gd-381, 9780 ± 340; Gd-380, 9770 ± 230 (R, 1979, v 21, p 167) and Gd-239, 9650 ± 240 (R, 1978, v 20, p 406); for general discussion of problem, see Kozarski (1981b) and Kozarski and Rotnicki (1977).

Gd-851. Sław-1 **7320 ± 170**

Wood, single fragments found at depth 2m in layer of sedge-reed peat in fossil peat bog at SW part of Sławskie Lake (51° 52′ 40″ N, 16° 02′ 22″ E), ca 1km NW of Radzyń village, Sławskie Lakeland, Great Poland Lowland. Coll May 1979 and subm by Jerzy Janczak, Inst Meteorol and Water Economy, Poznań.

Wieruszów series

Samples from base layers of organic deposits filling up cut-off paleomeander channels on valley floor of Prosna R near Wieruszów, SE part of Great Poland Lowland. Coll March 1980 and subm by Karol Rotnicki, Inst Geog, Adam Mickiewicz Univ, Poznań. Samples dated for reconstruction of paleohydrol conditions in middle course of Prosna R during Holocene in connection with IGCP 158A Project (Kozarski & Rotnicki, 1977).

Gd-1274. Szpot 1/80KR **6390 ± 60**

Silt with admixture of plant remnants, depth 115 to 125cm, overlying coarse-grained sands and covered with peat, 850m N of small village Szpot, 6.5km S of Wieruszów (51° 14′ 20″ N, 18° 10′ 17″ E).

Gd-1275. Szpot 4/80KR **5660 ± 60**

Silt with plant remnants, depth ca 1m, 550m W of Prosna R, 7.5km S of Wieruszów (51° 13′ 53″ N, 18° 10′ 13″ E).

Gd-1280. Dobrygosć 9/80KR **5600 ± 60**

Peaty gyttja from base of layer separating two peat layers, depth 78 to 85cm, 300m SE of forester lodge Dobrygość, 300m W of Prosna R, 5km S of Wieruszów (51° 15′ 00″ N, 18° 10′ 02″ E).

Gd-1283. Dobrygosć 11/80KR **8590 ± 70**

Peat from base of lower peat layer, depth 142 to 150cm, same loc.

Gd-811. Dobrygosć 17/80KR **6320 ± 80**

Peat from base of peat layer overlying thin layers of organic silt and silt with plant remnants, depth 170 to 180cm, 1km S of forester lodge Dobrygość, 5.5km S of Wieruszów (51° 14′ 46″ N, 18° 09′ 52″ E).

Gd-1284. Dobrygosć 18/80KR **9050 ± 80**

Silt with admixture of plant remnants, depth 200 to 210cm, same loc.

Sobieseki series

Organic deposits in form of layers in Würmian flood deposits on terrace 2 of Prosna R in N part of Grabów Basin, built of lacustrine silts, flood silts, and fine-grained sands and thin layers of peat, peaty silt, and silty peat with sand admixture, from 20 to 30cm thickness, accumulated from beginning of Würm till first phase of Upper Pleni-Würm. Total thickness of deposits on terrace 2 exceeds 35m. Two profiles were taken near Sobieseki village (51° 38′ N, 18° 18′ E), ca 19km SE of Kalisz, profile I; coll June 1979 by Józef Wiśniewski; profile II coll Nov 1979 by Karol Rotnicki; subm 1980 by Karol Rotnicki. Samples dated for systematic studies of paleogeog and stratigraphy of Würmian deposits in Great Poland Lowland (Rotnicki, 1966).

Gd-758. Sobieseki SO-IA/79:sol **26,070 ± 900**

Peaty silt with sand admixture, depth 835 to 840cm, alkali-soluble fraction.

Gd-1219. Sobieseki SO-IA/79:ins **26,080 ± 550**

Same sample, insoluble fraction.

Gd-755. Sobieseki SO-IB/79:sol **26,070 ± 910**

Peaty silt with sand admixture, depth 840 to 845cm, alkali-soluble fraction.

Gd-1220. Sobieseki SO-IB/79:ins **25,460 ± 450**

Same sample, insoluble fraction.

Gd-752. Sobieseki SO-IIA/79:sol **26,300 ± 1200**

Peaty silt with sand admixture, depth 535 to 550cm, alkali-soluble fraction.

Gd-753. Sobieseki SO-IIA/79:ins 27,000 ± 1100

Same sample, insoluble fraction.

Gd-756. Sobieseki SO-IIB/79:sol 27,960 ± 680

Sandy peat, depth 705 to 725cm, alkali-soluble fraction.

Gd-757. Sobieseki SO-IIB/79:ins 27,780 ± 590

Same sample, insoluble fraction.

General Comment (KR): organic silt from continuous layer at depth 520 to 550cm in Weglewice, 30km S of Sobieseki, from similar strat position, yielded dates $35,100 \begin{array}{l} +1000 \\ -900 \end{array}$ and $36,400 \begin{array}{l} +1200 \\ -1000 \end{array}$; Lu-1632 and -1632A, (R, 1980, v 22, p 1055-1056).

Konin-Maliniec series

Organogenic interbeddings in series of sediments of stagnant water overlain by series of cross-stratified fluvioglacial sandy gravel sediments and morainic sediments in form of two-partite flow till of Leszno phase of Vistulian Glaciation in Konin-Maliniec site, ca 5km N of Konin (52° 16′ N, 18° 15′ E); coll and subm 1979 by Wojciech Stankowski, Inst Geog, Adam Mickiewicz Univ, Poznań. Konin-Malinies site was presented during field excursion of Symposium on Vistulian Stratigraphy as one of ref sites of Vistulian in Poland (Kozarski, 1980; 1981a). Morphology, stratigraphy, and chronology of site in morainic upland in hinterland of marginal zone of Poznań phase was studied by Borówko-Dłuzakowa (1967; 1979), Stankowski (1979; 1980), Stankowska and Stankowski (1979), Tobolski (1979a,b) and Pazdur and Walanus (1979b), whose results were summarized briefly by Pazdur, Stankowski, and Tobolski (1980). Upper fossil flora level, 5 to 10cm thick, Maliniec II, found at depth 431 to 439cm in fine-grained sands with load deformation structures which penetrate to half thickness of fluvioglacial series, is composed of strongly sanded silts, lime silts with abundant plant detritus, and sanded and silted mossy peats with dominant macrofossils of *Drepanocladus resolvens* (main component), *Calliergon turgescens*, and *C trifarium* (id. by K Karczmarz) and represents accumulation in shallow, very wet tundra peat bog with calciphile mosses growing together with sedges in area of dwarf shrub willows. Lower fossil flora level, Maliniec I, at depth 678 to 753cm, is composed of 8 layers different in lithology and containing genetically different organogenic sediments with no traces of post-sedimentary deformations and representing complete sequence of climatic and vegetational changes of cool interstadial period with 4 distinct pollen zones (Tobolski, 1979a,b). Maliniec I level could be provisionally assigned to Moershoofd interstadial complex (Tobolski, 1979a; Kozarski, 1980; 1981a).

Gd-646. Maliniec II; KM-XII-B 22,230 ± 480

From Maliniec II level, layer XII, depth 431 to 439cm, alkali-soluble fraction.

Gd-645. Maliniec II; KM-XII-C **22,050 ± 450**

Same sample, insoluble fraction.

Gd-647. Maliniec I; KM-VII-A **34,000 +2300 −1800**

From top of Maliniec I level, layer VIII, depth 678 to 690cm, pollen zone D with *Betula nana, Empectrum,* and *Arctostophylos uva-ursi. Comment* (MFP): acid-soluble fraction dated, undersized, diluted.

Gd-1077. Maliniec I; KM-VIII-B **>42,900**

Same sample, alkali-soluble fraction.

Gd-1076. Maliniec I; KM-VIII-C **>42,500**

Same sample, insoluble fraction.

Gd-668. Maliniec I; KM-I-A **25,000 ± 1000**

From base of Maliniec I level, layer I, depth 740 to 748cm, pollen zone A with *Salix* and *Equisetum. Comment* (MFP): acid-soluble fraction dated, undersized, diluted.

Gd-1105. Maliniec I; KM-I-B **>41,200**

Same sample, alkali-soluble fraction.

Gd-671. Maliniec I; KM-I-C **>40,700**

Same sample, insoluble fraction.

General Comment (MFP): for general discussion of significance of Konin-Maliniec site for chronology and strat of Vistulian in Poland, see Kozarski (1980; 1981a). Organic horizons with ^{14}C dates close to those from Maliniec II level from profiles in German Democratic Republic and European part of USSR were described by Cepek (1965) and Krasnov (1978), respectively.

Gd-769. Młodocin 5 **1150 ± 90**

Black earth soil in form of thin layer at depth 60cm overlain by series of fluvial and lacustrine fine-grained sands in Noteć R valley in Młodocin village (52° 53′ 29″ N, 17° 52′ E), 750m NW of Wolickie Lake. Coll Aug 1977 by M Sinkiewicz; subm 1979 by Władysław Niewiarowski, Inst Geog, Mikołaj Kopernik Univ, Toruń.

Tuliszków series

Organic deposits of Vistulian age from vicinity of Tuliszków, Turek Uplands, Great Poland Lowland, S of Warta Pradolina. Coll Oct 1979 and subm by Alicja Mańkowska, Geol Inst, Warsaw. Dated to establish reach-line of Vistulian Glaciation in Konin-Tuliszków-Turek area and determine age and genesis of Złote Góry Mts glacial forms (Kawecki, 1969; Mańkowska, 1975).

Gd-785. Wymysłów s1193 **31,200 ± 800**

Peaty mud in form of layer in fossil river channel at depth 1.9 to 2.1m in Wymysłów village (52° 04′ N, 18° 20′ E) near Tuliszków, overlain by fossil soil, fine- and medium-grained sands, and boulder clay.

Gd-786. Zdzary s466 **>27,000**

Peat from series of paludal sediments, depth 2.1 to 2.2m in Zdzary village (52° 08′ N, 18° 16′ E), overlain by fine sands and boulder clay. *Comment*: undersized, diluted.

Gd-1251. Zdzary s743 **41,400 +3000 −2200**

Peaty mud from series of lacustrine sediments at depth 1.6 to 1.7m overlain by clayey mud, silt, and boulder clay in Zdzary village (52° 08′ 30″ N, 18° 16′ E). *Comment* (AM): pollen analysis by Zofia Borówko-Dłuzakowa indicates pollen spectrum representing cold phitophases of pine-birch forest of Pleistocene period.

General Comment (MFP): all dates of this series obtained on alkali-soluble fraction of sample, precipitated by adding appropriate amount of HCl.

Przyłubie series

Peat from thin fossil organic layer in substratum of flood plain of Wisła R valley, Toruń-Bydgoszcz Basin, ca 17km W of Toruń, near Przyłubie village (53° 03′ 24″ N, 18° 19′ 20″ E); coll and subm 1979 by Anna Tomczak, Inst Geog, Mikołaj Kopernik Univ, Toruń (Galon, 1934; Niewiarowski & Tomczak, 1969; Tomczak, 1981).

Gd-1248. Przyłubie A **1870 ± 70**

From top part of organic layer, depth 60cm, at contact with overlying layer of clayey silt with admixture of organic matter.

Gd-1249. Przyłubie B **5480 ± 60**

From base of organic layer at contact with underlying fine-grained sands, depth 1.85m. *Comment* (AT): pollen analysis of base layer of peat indicates Atlantic or younger age.

Podgórz series

Peat from series of organic sediments filling former bed of Wisła R, flood plain on left bank of Wisła R valley, Toruń-Bydgoszcz Basin, Podgórz, Toruń (52° 59′ 30″ N, 18° 35′ E); coll Nov 1979 and subm by Anna Tomczak.

Gd-1250. Podgórz A **710 ± 45**

Well-decomposed black peat from top of uppermost peat layer at contact with overlying series of clayey silt with plant fragments, depth 90 to 95cm.

Gd-784. Podgórz B **3190 ± 280**

Wood peat with undecomposed plant fragments from base of lowermost peat layer, depth 4.8 to 4.85m, at contact with underlying sands. *Comment* (AT): pollen analysis of lowermost peat layer by Bozena Noryśkiewicz indicate Atlantic or younger age.

Rzeczkowo series

Organic sediments filling up former bed of Wisła R, flood plain on right bank of Wisła R valley, Toruń-Bydgoszcz Basin, ca 17km W of Toruń, near Rzęczkowo village (53° 07′ 06″ N, 18° 21′ 27″ E). Coll Oct 1979 by Anna Tomczak and Władysław Niewiarowski; subm 1980 by Anna Tomczak.

Gd-1246. Rzeczkowo A **940 ± 60**

Well-decomposed peat from top of peat layer, depth 30 to 35cm, overlain by clayey silt.

Gd-780. Rzeczkowo B **5580 ± 120**

Black peat from base of peat layer, depth 1.4 to 1.47m.

Gd-781. Rzeczkowo C **9760 ± 260**

Gray clayey gyttja from base of gyttja layer, depth 2.15 to 2.2m. *Comment*: undersized, diluted.

General Comment (AT): introductory pollen analysis of profile by Bozena Noryśkiewicz yielded following age estimates: A—younger than Atlantic, B—Atlantic, C—Younger Dryas. Samples from Przyłubie, Podgórz, and Rzęczkowo profiles dated for studies of changes of Wisła R valley between Toruń and Solec Kujawski during Late Glacial and Holocene, as part of IGCP 158A Project.

Warsaw-Płock Wisła River valley series

Peat and gyttja from base of organogenic layers filling paleochannels on Wisła R flood plain, Wisła R valley between Warsaw Depression and Płock Depression (Wiśniewski, 1981). Coll Sept 1979 and subm 1980 by Edward Wiśniewski, Inst Geog & Spatial Org, Dept Geomorphol & Hydrol of Lowland, Polish Acad Sci, Toruń.

Gd-741. Wasosz 1:sol **5200 ± 150**

Gyttja from depth 3.95 to 4.25m, in Wąsosz near Piaski village (52° 26′ N, 19° 49′ E), 6km NE of Gąbin, alkali-soluble fraction.

Gd-740. Wasosz 1:ins **5250 ± 250**

Same sample, insoluble fraction. *Comment*: undersized, diluted.

Gd-733. Wykowo 5:sol **3360 ± 150**

Gyttja from depth 3.7 to 3.95m from Wykowo village (52° 29′ N, 19° 52′ E), 13km SE of Płock, alkali-soluble fraction.

Gd-735. Wykowo 5:ins **3850 ± 100**

Same sample, insoluble fraction.

Gd-1199. Wola Ładowska 2:sol **8450 ± 100**

Peat from depth 1.52 to 1.72m in Wola Ładowska village (52° 02′ N, 20° 02′ E), 2.5km N of Iłowo, alkali-soluble fraction.

Gd-1200. Wola Ładowska 2:ins **7520 ± 100**

Same sample, insoluble fraction.

Gd-1207. Podgórze 4:sol **5610 ± 70**

Peat from depth 0.8 to 1m in Podgórze village (52° 04′ N, 20° 03′ E), 10km W of Wyszogród, alkali-soluble fraction.

Gd-1204. Podgórze 4:ins **6290 ± 60**

Same sample, insoluble fraction.

Gd-732. Nowa Wies 3:sol **9540 ± 240**

Gyttja from depth 3.95 to 4.2m in Nowa Wieś (52° 21′ N, 20° 08′ E), 6:5km ENE of Iłowo, alkali-soluble fraction. *Comment*: undersized, diluted.

Gd-1202. Nowa Wies 3:ins **9660 ± 110**

Same sample, insoluble fraction.

Rembertów series

Sandy peat from layer at depth 1.5 to 1.55m overlain by dune sands on uppermost flood terrace of Wisła R, Mazowiecka Plain, 1km NE of Rembertów (51° 16′ N, 21° 13′ E). Coll Oct 1978 by Zdzisława Sarnacka; subm 1980 by M D Baraniecka, Geol Inst, Warsaw.

Gd-1236. Rembertów:sol **410 ± 45**

Alkali-soluble fraction.

Gd-770. Rembertów:ins **440 ± 60**

Same sample, insoluble fraction.

Kobylarnia series

Peat from layer 1.8m thick underlain by silt, Wisła R valley, Kobylarnia village, N part of Sandomierz Basin (50° 33′ N, 21° 48′ E). Coll Sept 1979 and subm 1980 by Elzbieta Mycielska-Dowgiałło, Dept Geog & Regional Studies, Warsaw Univ (Mycielska-Dowgiałło, 1972).

Gd-1297. Kobylarnia 1a **6890 ± 70**

From depth 70cm.

Gd-1298. Kobylarnia 1b **8570 ± 100**

From depth 1.3 to 1.5m.

Gd-1299. Kobylarnia 1c **11,640 ± 100**

From lowermost layer, depth 1.8m.

Gd-808. Dobromierz S-79-73 **1150 ± 110**

Peat from thin layer between two series of gravels in alluvial fan, depth 1m, Dobromierz (50° 50′ N, 16° 20′ E), Sudety Mts. Coll Nov 1979 and subm 1980 by Alfred Jahn, Geog Inst, Wrocław Univ, Wrocław.

Gd-194. Smogornia **4900 ± 100**

Peat from base of peat-bog Smogornia in Karkonosze, Sudety Mts, S Poland (50° 41′ N, 15° 40′ E), alt 1400m asl, depth 2m, in contact with thin layer of sandy clay overlying 45cm thick layer of granitic rubble (regolith). Coll and subm 1972 by Alfred Jahn. *Comment* (AJ): base of other peat bog in Jakuszyce, same region, was dated to 10,075 ± 210 BP (Dumanowski, Jahn, & Szczepankiewicz, 1962).

Jasiołka River valley series

Peat from base of peat layer at contact with lacustrine chalk, overlain by clays and ablation till in Jasiołka R valley, Jasło-Sanok Depression. Coll Aug 1979 and subm by Antoni Wójcik, Geol Inst, Carpathian Branch, Cracow.

Gd-1233. Roztoki 1:ins **9870 ± 110**

From fossil lake sediments on terrace of Jasiołka R valley, profile XVI, depth 3.95 to 4m, in Roztoki village (49° 44′ 44″ N, 21° 32′ 50″ E) (Szafer & Jaroń, 1935; Szafer, 1948). *Comment*: insoluble fraction dated.

Gd-1232. Roztoki 1: 1st sol **9850 ± 110**

Same sample, 1st alkali-soluble extract dated.

Gd-766. Roztoki 1: 2nd sol **9920 ± 100**

Same sample, 2nd alkali-soluble extract dated.

General Comment (AW): both early studies (Szafer & Jaroń, 1935; Szafer, 1948) as well as results of actual pollen analysis indicate cold period from end of Pleistocene.

Gd-1235. Roztoki 3 **10,950 ± 120**

From fossil lake sediments on terrace of Jasiołka R valley, profile XV (Szafer, 1948) in Roztoki village (49° 44′ 36″ N, 21° 32′ 52″ E), depth 2.66 to 2.7m. *Comment* (AW): preliminary results of pollen analysis indicate cold period; expected age: Late Glacial.

Gd-767. Tarnowiec 5 **7930 ± 110**

From contact of peat layer with uppermost layer of lacustrine chalk, valley floor of left tributary of Jasiołka R, ca 1.1km from Tarnowiec (49° 44′ 25″ N, 21° 35′ 55″ E), depth 1.4 to 1.45m. *Comment* (AW): expected age based on provisional pollen analysis by Krystyna Harmata—beginning of Holocene/end of Pleistocene.

Gd-1243. Jedlicze 8 **36,700 ± 2100**

Wood (*Picea* or *Larix* sp), id. by Kazimierz Szczepanek, in lowest part of peat layer 0.8m thick at depth 4.3 to 4.4m in Jedlicze, Brzozowa St (49° 43′ 30″ N, 21° 39′ 30″ E). Coll Oct 1979 by Kazimierz Szczepanek and Antoni Wójcik; subm by Antoni Wójcik. Peat layer overlain by clay, fossil soil, and 2 layers of till separated by thin layer of fossil soil. *Comment* (AW): results of provisional pollen analysis of peat layer indicate Brorup Interstadial.

San River series

Wood from San R valley, Sandomierz Basin. Coll May 1980 and subm by Andrzej Szumański, Dept Geol, Wasaw Univ, Warsaw. Dated for studies of evolution of San R valley during Late Glacial and Holocene in connection with IGCP 158A Project (Szumański, 1972; 1981).

Gd-838. Lezajsk S1 **7080 ± 90**

From layer of gray-black silt with plant remains, depth 3m, overlain by gray-yellow loamy mud and yellow loess-like mud in buried oxbow of San R, rendzina terrace B. Coll from exposure at channel bank near Lezajsk (50° 30′ N, 22° 40′ E).

Gd-1300. Rudnik S2 **660 ± 50**

From top of series of gray fine-grained sands diagonally laminated with single trunks, overlain by gray-brown loamy mud and yellow loess-like mud, terrace 3 of San R valley at Rudnik (50° 50′ N, 22° 22′ E), depth 3m.

Grabiny-Latoszyn series

Wood, mostly from individual oak trunks, and charcoal from alluvial sequence in gravel pit between Grabiny and Latoszyn, left bank of Wisłoka R valley (50° 03′ N, 21° 22′ E), ca 4km SW of Dębica, Carpathian Foreland. Gravel-pit Latoszyn, ca 1.5km long, belongs to series of ref sites in Wisłoka R valley studied in IGCP 158A Project by Leszek Starkel and coworkers (Starkel, 1981d). S part of gravel-pit with profiles A and C is on terrace level IID, 189 to 190.5m asl (Mamakowa *et al*, 1981, p 64-67, fig 26), gently inclined to E and encompassing large mature paleochannel with cut meander neck resembling present channel, with outcrops revealing 4 parts of sediments of different age within exposed sequence, ca 7m, underlain by series of gravels ca 14m thick. N part of gravel pit with profile B is on terrace level IIA, ca 187m asl with sequence of sediments, 7 to 14m thick, consisting of top sandy alluvial loam, upper gravels, sands, and lower gravels. All samples but one coll 1978 and 1979 by Ewa Niedziałkowska, Leszek Starkel, and members of ^{14}C lab staff; subm by Leszek Starkel, Dept Geomorphol & Hydrol, Inst Geog, Polish Acad Sci, Cracow.

Gd-509. Grabiny-Latoszyn NII **2260 ± 120**

Oak wood, external fragment of trunk ca 1m diam, N part of gravel pit, provenience unknown. Coll and subm 1977 by Bolesław Kawalec, Rzeszów.

Gd-1011. Grabiny-Latoszyn 070878/1 **2730 ± 70**

Wood, small trunk ca 3cm diam from silty organic detritus layer at depth ca 3.5m in profile B, N part of gravel-pit. *Comment* (MFP): pollen spectrum of silty detritus layer (Mamakowa *et al*, 1981, p 67, fig 27) reveals high frequency of *Abies*.

Gd-582. Grabiny-Latoszyn 180578/1 2420 ± 50

Oak trunk from gravels overlying sandy muds, profile B in N part of gravel pit, depth ca 2.5m.

Gd-581. Grabiny-Latoszyn 170878/4 5990 ± 80

Oak trunk, 50cm diam, from profile A1 in S part of gravel pit, from series of lower gravels at depth 5.3m. *Comment* (MFP): pollen analysis of clayey mud sample coll from environs of this trunk made by Kazimiera Mamakowa reveals *Abies* pollens, numerous culture indicators with different types of cereals (*Secale cereale, Triticum* type, *Hordeum* type, and high frequency of *Plantago lanceolata*) (Mamakowa *et al,* 1981, p 65, fig 27).

Gd-600. Grabiny-Latoszyn 170878/2 5950 ± 70

Oak trunk 50cm diam from profile A1*bis,* ca 5m E of profile A1, same series of lower gravels at depth ca 5m. *Comment* (MFP): sample of clayey mud from environs of this trunk reveals high frequency of *Abies* pollen.

Gd-580. Grabiny-Latoszyn 170878/1 5920 ± 60

Oak trunk 50cm diam from S part of gravel pit, same series of lower gravels at depth ca 5m, ca 25m N of samples Gd-581 and -600.

Gd-1009. Grabiny-Latoszyn 160878/3 960 ± 70

Oak trunk 60cm diam from series of upper gravels in S part of gravel pit at depth ca 2m, ca 10m E of sample Gd-600.

Gd-1012. Grabiny-Latoszyn 160878/1 890 ± 70

Oak trunk 25cm diam, same loc.

Gd-1014. Grabiny-Latoszyn 170878/LS 105 ± 45

Charcoal from series of unconsolidated covering deposits consisting of clayey, silty and sandy layers on E slope of terrace IID, S part of gravel pit near profile A4 at depth ca 1m. *Comment* (LS&MFP): top layer of this series was previously destroyed. Using Stuiver (1978) correction curve, calendar age of sample can be estimated as < 300 BP. This implies that migration of channel did not take place before 2nd half of 17th century AD. This agrees well with observations of Strzelecka (1958) from Wisłok R valley where old sinuous paleochannels were active to mid-18th century.

Gd-597. Grabiny-Latoszyn 101078/LS 7990 ± 110

Rounded piece of wood from same series near sample Gd-1014. *Comment* (LS): probably redeposited from right bank sites of early Holocene deposits in Podgrodzie area ca 4km upstream (Alexandrowicz *et al,* 1981; Mamakowa & Starkel, 1977).

Gd-1145. Grabiny-Latoszyn A-14 710 ± 80

Wood from tree-trunk with branches found in profile A-14, S part of gravel pit ca 120m N of profile A1, at base of upper series of sandy gravels, depth ca 2m.

Gd-707. Grabiny-Latoszyn A-15 **2860 ± 150**

Organic detritus from series of sands and silts of ob facies at top of gravel series, profile A-15 in S part of gravel pit, depth ca 3m. *Comment*: undersized, diluted.

Gd-1146. Grabiny-Latoszyn C-5 **480 ± 60**

Wood fragments from series of muds with organic detritus overlain by sands with some gravels, ca 1.5m below sandy base of paleochannel visible in relief, profile C-5 close to profile A-14, S part of gravel pit, depth 3.5m. *Comment* (LS): this paleochannel does not appear active on Mieg's map from AD 1780 (Mieg, 1779-1782).

Gd-1148. Grabiny-Latoszyn C-5a **1830 ± 70**

Twigs from same layer, probably redeposited material.

Gd-583. Grabiny-Latoszyn 170878/4 **5540 ± 80**

Oak trunk 50cm diam from lower gravel series near profile A1 in S part of gravel-pit.

Gd-578. Grabiny-Latoszyn 080878/1 **4540 ± 60**

Oak trunk 55cm diam, S part of gravel pit. *Comment* (MFP): displaced, provenience unknown.

General Comment (LS): based on results of palynol investigations showing *Abies* pollens and numerous culture indicators, our previous view (Awsiuk *et al*, 1980) on age of gravels should be revised assuming that tree trunks of *Quercus* sp were reworked from lower bed at break of Subatlantic period. Only strongly consolidated gravels below 5.9m can be recognized as Atlantic.

B. Norway

Gd-660. Elisebreen **1660 ± 130**

Tundra peat in form of layer 5cm thick underlain by brown loamy gravels and covered with fresh lodgement till, depth 60cm, in forefield of Elisebreen Glacier, Oscar II Land, NW Spitsbergen (78° 37′ 45″ N, 12° 07′ E). Coll July 1978 by Bozena Noryśkiewicz; subm by Władysław Niewiarowski. Dated to establish age of Elisebreen Glacier transgression (Niewiarowski, 1982).

Werenskiold series

Peat from surface of ice in marginal part of Werenskiold Glacier, SW Spitsbergen (77° 04′ 55″ N, 15° 15′ 20″ E). Coll July 1979 by Henryk Chmal; subm 1980 by Alfred Jahn.

Gd-803. Werenskiold W-1 **510 ± 50**

Found 150m from ice front.

Gd-1267. Werenskiold W-2 **750 ± 60**

Found 200m from ice front.

Ytre Kjaes series

Peat from palsa hill in peat bog on coastal plain, Ytre Kjaes, Porsangen Fjord, Nord Norway (70° 30′ N, 25° 30′ E). Coll June 1979 and subm 1980 by Alfred Jahn.

Gd-1266. Ytre Kjaes N-79-7 **970 ± 45**

From contact of unfrozen peat with permafrost, depth 30cm.

Gd-809. Ytre Kjaes N-79-6 **4760 ± 120**

From lowermost unfrozen peat layer 10cm thick at depth ca 1.2m. *Comment* (MFP): for earlier dates from palsa and thufur-type hills and other permafrost structures, see R, 1980, v 22, p 63-64.

C. Mongolia

Gd-823. Tot 225/KR **17,860 ± 230**

Remnants of rush plants with admixture of lake clay in continuous layer at depth 4.75m, overlain by layer, 2m thick, of lacustrine silt with plant admixture and lacustrine clay covered with stratified fluvial sands, in Tot-Nuurin Khot-nor Basin, 5km SW of Tot Lake, ca 20km S of small village Gallut (46° 40′ N, 100° 5′ E), S Khangai Mts. Coll July 1975 and subm 1980 by Karol Rotnicki. Sampling point is in central part of tectonic basin filled with lacustrine sediments of great Pleistocene pluvial lake, alt ca 2000m asl. *Comment* (KR): upper layer of plant remnants yielded date 17,220 ± 155. For more detailed inf, see Klimek and Rotnicki (1978).

II. SOIL SAMPLES

Fractions of soil organic matter from fossil soil horizons in dune sands were dated to check suitability of simple pretreatment procedure, consisting of acid-alkali-acid treatment, for reliable dating of fossil soil horizons developed from dune sands. Pretreatment of soil samples, described by Pazdur (1982), includes enrichment of organic matter by sedimentation in distilled water, treatment with 2% HCl at 80°C or 100°C for 1 hr (or at room temp for 24 hr), evaporation of acid-soluble fraction and washing of acid-insoluble fraction, similar treatment with sodium hydroxide, precipitation of alkali-soluble fraction by adding appropriate amount of HCl, washing of alkali-insoluble residue, and final treatment of acid-insoluble, alkali-insoluble residue with 2% HCl at 80°C for 30 min or with 1% HCl at room temp for ca 24 hr. Samples from soil horizons in Troszyn pretreated with 4% solutions of HCl and NaOH yielded amount of insoluble residue too small for accurate dating. For some soil samples age measurements were also made on total soil organic matter.

Troszyn series

Soil fraction samples from 3 fossil soil horizons in N part of parabolic dune, Troszyn, 7km E of Wolin, W Pomerania (53° 32′ N, 14° 45′ E). Coll and subm Nov 1978 by Bolesław Nowaczyk and M F Pazdur.

Gd-1087. Troszyn 78/1: total **720 ± 50**

Gd-664. Troszyn 78/1: acid-sol 510 ± 110

Gd-665. Troszyn 78/1: alkali-sol 1010 ± 60

From upper soil horizon at depth ca 80cm. *Comment* (MFP): charcoal from this soil horizon yielded date 1580 ± 70, Gd-546 (R, 1982, v 24, p 183).

Gd-657. Troszyn 78/2: total 2170 ± 70

Gd-690. Troszyn 78/2: acid-sol 2020 ± 210

Gd-1100. Troszyn 78/2: alkali-sol 2320 ± 50

From middle soil horizon at depth 3.8m. *Comment* (MFP): 2 charcoal samples assoc with this horizon yielded dates, 2300 ± 170 and 2440 ± 60, Gd-528 and -537 (R, 1982, v 24, p 183).

Gd-1088. Troszyn 78/3: total 3500 ± 60

Gd-683. Troszyn 78/3: acid-sol 2790 ± 220

Gd-666. Troszyn 78/3: alkali-sol 3600 ± 70

From lowest soil horizon at depth 6.4m. *Comment* (MFP): charcoal from fire-layer at top of soil horizon yielded date, 3130 ± 70, Gd-529 (R, 1982, v 24, p 183).

General Comment (MFP&BN): acid-soluble fractions of all samples did not produce enough CO_2 to fill counter to normal pressure. Dates on both total organic matter and alkali-soluble fraction agree well with corresponding dates on charcoal for middle and lowest soil horizons. For youngest soil level, rejuvenation due to rootlet penetration and infiltration of recent soluble organic matter is possible. More detailed discussion of dune structure and results of ^{14}C dating is given by Karczewski and Nowaczyk (1978) and Nowaczyk and Pazdur (1982).

Pomorsko series

Soil and wood samples from 4 horizons of semihydromorphic and peaty soils in transverse dune close to glacial trough filled with lime gyttja and peat, Pomorsko (52° 05′ 06″ N, 15° 31′ 50″ E), Cigacice-Krosno sec of Warsaw-Berlin Pradolina, Great Poland Lowland. Coll and subm Nov 1978 by Bolesław Nowaczyk and M F Pazdur. Geomorphol and geol investigations of dune and glacial trough were made by Nowaczyk (1974; 1976; 1979); pollen analysis of biogenic sediments by Nowaczyk and Tobolski (1979; 1981); malacol analysis by Alexandrowicz (1980) and Alexandrowicz and Nowaczyk (1982), and pedol studies by Kowalkowski (1977a,b). Numerous flint artifacts from top of dune were analyzed by Michał Kobusiewicz (Nowaczyk *et al*, 1982) indicating several phases of human occupation by Komorniki, Janisławice, Swiderian, and Lusatian cultures. Descriptions of organic horizons and content of organic matter are given by Kowalkowski (1977a, fig 3).

Gd-739. Pomorsko 78/1: acid-sol 1100 ± 210

Gd-1064. Pomorsko 78/1: alkali-sol 710 ± 40

Semihydromorphic muck soil developed postsedimentarily in upper part of younger eolian sands; coll from top of organic layer at depth 100 to 105cm. Organic matter content ca 4%.

Gd-642. Pomorsko 78/1H: acid-sol 1250 ± 70

Gd-634. Pomorsko 78/1H: alkali-sol 1310 ± 60

Same level, from base of soil layer at depth 105 to 115cm, organic matter content 2%.

Gd-636. Pomorsko 78/2: acid-sol 1850 ± 50

Gd-1067. Pomorsko 78/2: alkali-sol 2440 ± 60

Gd-1069. Pomorsko 78/2: res 2580 ± 60

Semihydromorphic postsedimentary peaty soil in lower part of younger eolian sands, top of organic layer at depth ca 1.9m, organic matter content 5%.

Gd-637. Pomorsko 78/2H: acid-sol 1790 ± 100

Gd-1068. Pomorsko 78/2H: alkali-sol 2270 ± 50

Sample from top of same layer, ca 2m from previous sampling point.

Gd-641. Pomorsko 78/3H: acid-sol 2770 ± 60

Gd-1070. Pomorsko 78/3H: alkali-sol 3070 ± 60

Gd-648. Pomorsko 78/3H: res 2200 ± 70

From semihydromorphic horizon of boggy soil with marked postsedimentary features, depth ca 2.5m, organic matter content ca 6%.

Gd-653. Pomorsko 78/4H: acid-sol 3650 ± 80

Gd-1086. Pomorsko 78/4H: alkali-sol 4110 ± 60

Gd-655. Pomorsko 78/4H: res 3480 ± 70

From trisegmentary organic horizon 10cm thick, consisting of lower muck horizon formed postsedimentarily in stabilized boggy sands and upper synsedimentary muck horizon separated by thin peat layer, depth 2.8m, organic matter content from 10 to 20%.

Gd-1043. Pomorsko 78/5A 7090 ± 50

Pinus and *Larix* cones from thin layer of eolian sands overlying layer of calcareous gyttja, 5m thick, underlying oldest soil, depth 3m.

Gd-643. Pomorsko 78/5B 10,200 ± 120

Unid. wood fragments, same loc. *Comment* (BN&MFP): date of Gd-1043 determines end of accumulation of calcareous gyttja; date of Gd-643 on wood seems too old, probably wood fragments redeposited from older sediments. Oldest layer of calcareous gyttja from pine phase of Alleröd dated palynologically by Kazimierz Tobolski (see Nowaczyk, 1976) has ^{14}C date, 11,380 ± 275, Gd-378 (R, 1979, v 21, p 166). Detailed discussion of validity of ^{14}C dates of soil fractions and comparison with results of other studies is given by Nowaczyk *et al* (1982).

Rabsztyn series

Soil and charcoal samples from fossil soil levels covered by dune sands in Rabsztyn, 4km NE of Olkusz, NW part of Ojców Plateau (50° 18′ 30″ N, 19° 36′ 30″ E). Coll and subm May 1979 by Bolesław Nowaczyk and Tadeusz Szczypek.

Gd-1206. Rabsztyn 79/1: alkali-sol **430 ± 50**

Gd-736. Rabsztyn 79/1: res **260 ± 120**

From uppermost soil horizon covered with series of well-stratified sands and recent soil; Site 1 in N part of dune, depth 0.6m.

Gd-1118. Rabsztyn 79/2: total **1170 ± 60**

Gd-680. Rabsztyn 79/2: alkali-sol **1360 ± 70**

Gd-679. Rabsztyn 79/2: res **1320 ± 70**

From middle soil horizon overlain by well-laminated sands, same loc, depth ca 2m.

Gd-718. Rabsztyn 79/2W: charcoal **2640 ± 150**

Fine charcoal from same soil horizon. *Comment*: undersized, diluted.

Gd-1120. Rabsztyn 79/3: total **6460 ± 70**

Gd-681. Rabsztyn 79/3: alkali-sol **6630 ± 80**

From lowermost soil horizon between 2 series of unstratified sands, depth ca 3m, same loc.

Gd-729. Rabsztyn 79/4: alkali-sol **800 ± 60**

Gd-1197. Rabsztyn 79/4: res **750 ± 60**

From soil horizon 20cm thick in central part of dune, Site 2, depth 2.5m.

Gd-1122. Rabsztyn 79/5: total **1380 ± 60**

Gd-1121. Rabsztyn 79/5: alkali-sol **1390 ± 60**

Gd-1117. Rabsztyn 79/5: res **1480 ± 60**

From soil horizon in S part of dune, Site 3, depth ca 2m.

Gd-1116. Rabsztyn 79/6: total **840 ± 60**

Gd-728. Rabsztyn 79/6: alkali-sol **900 ± 70**

Gd-730. Rabsztyn 79/6: res **920 ± 130**

From soil horizon in E part of dune, Site 4, depth 2m.

Gd-1114. Rabsztyn 79/6W: charcoal **810 ± 60**

Large pieces of charcoal from same loc.

General Comment (MFP): in general, good agreement is seen between dates of alkali-soluble fraction and insoluble residue for all dated samples of soil humus; dates on total soil organic matter are in all cases younger than other corresponding dates from same sample. Detailed discussion of results of ^{14}C dating and their comparison with results of geomorphol, geol, and strat studies of dune is given by Nowaczyk, Pazdur, and Szczypek (1982); background inf on geomorphol and chronol of dune-forming processes in vicinity is given by Szczypek (1977; 1980).

Grodzewo series

Charcoal and sandy humus from fossil soil horizons in dune at Grodzewo (52° 34′ N, 14° 08′ E), 25km W of Skwierzyna, Toruń-Eberswald Pradolina, W part of Gorzów Basin, Great Poland Lowland. Coll and subm Nov 1978 by Bolesław Nowaczyk and M F Pazdur.

Gd-632. Grodzewo 78/1W **2160 ± 60**

Fine charcoal from upper part of middle soil level, depth 1.6 to 1.73m.

Gd-629. Grodzewo 78/2W **2590 ± 60**

Fine charcoal from lower part of middle soil level, depth 1.86 to 2.03m.

Gd-779. Grodzewo 78/3H: alkali-sol **4120 ± 130**

Gd-783. Grodzewo 78/3H: res **4000 ± 180**

Soil fractions from lowest soil horizon, depth 2.42 to 2.73m. *Comment*: undersized, diluted.

Budzyń series

Charcoal and sandy humus from fossil soil level in parabolic dune 5km W of Budzyń (52° 53′ 30″ N, 16° 56′ 50″ E), Gniezno Uplands, Great Poland Lowland. Coll 1979 and subm 1980 by Bolesław Nowaczyk.

Gd-1208. Budzyń 17/79H: alkali-sol **970 ± 60**

Gd-1209. Budzyń 17/79H: res **990 ± 50**

Soil fractions, depth 2m.

Gd-1201. Budzyń 17/79W **1120 ± 60**

Charcoal, same loc.

General Comment (BN): other dates on charcoal from soil horizons in dune are 11,400 ± 320 and 925 ± 125, Gd-357 and -371 (R, 1979, v 21, p 166).

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INSTITUT ROYAL DU PATRIMOINE ARTISTIQUE RADIOCARBON DATES IX

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This list contains the results of ^{14}C age determinations obtained at the laboratory in 1981-1982. Samples are analyzed in three new proportional counters which are described in R, 1980, v 22, p 442. Our installation differs from that of Heidelberg in that our filling gas is methane.

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I. GEOLOGIC SAMPLES

A. Belgium

IRPA-411. Zoniënbos **180 ± 80**

Wood (*Fagus*) from Zoniënbos in Brabant (50° 48′ 14″ N, 4° 48′ 17″ E) at 125cm below surface. Coll Dec 1980 and subm Jan 1981 by R Langohr, Univ Gent, Belgium. *Comment*: expected date 10,000-13,000 BP (Langohr, 1981).

IRPA-452. De Haan **2470 ± 50**

Shells from sand dunes at De Haan in W Vlaanderen (58° 18′ N, 3° 05′ E) at 130cm below surface. Coll Aug 1982 and subm Sept 1982 by F Verhaeghe, Univ Gent. *Comment*: result used to date sand dune formation in coastal plain; agrees with expected age.

Ipenrooi series

Material from peat bog sec at Ipenrooi, Antwerpen (51° 28′ 40″ N, 4° 45′ 04″ E). Coll and subm 1980 by L Beyens, Univ Antwerpen, Belgium. In 75cm core, pollen was taken every 2cm.

IRPA-391. Ipenrooi-ven 1 **7350 ± 120**

Peat from 75 to 74cm. Atlantic age expected.

IRPA-472. Ipenrooi-ven 2 **5200 ± 90**

Peat from 73 to 72cm. Atlantic age expected.

IRPA-392. Ipenrooi-ven 3 **3280 ± 80**

Peat from 60 to 56cm. Sub-boreal age expected.

IRPA-393. Ipenrooi-ven 4 **1160 ± 100**

Peat from 52 to 48cm. Sub-atlantic age expected.

IRPA-394. Ipenrooi-ven 5 **260 ± 80**

Peat from 42 to 37cm. Sub-atlantic age expected.

IRPA-404. Ipenrooi-ven B **3105 ± 90**

Peat from 56 to 48cm from profile similar to IRPA-392. Sub-boreal age expected.

General Comment: dates agree with pollen analysis (Beyens, 1982).

IRPA-403. Meerle **9020 ± 120**

Peat from bog sec at Meerle, Antwerpen (51° 28′ 50″ N, 4° 46′ 49″ E). Coll and subm 1980 by L Beyens. In core of 88cm, many pollen samples and one for ^{14}C dating were taken from 85 to 83cm. This profile is related to Ipenrooi series. *Comment* (LB): date is perhaps too young; expected date: 9660 BP (Beyens, 1982).

Bredene series

Peat from coastal plain at Bredene in W Vlaanderen (51° 14′ 20″ N, 2° 57′ 30″ E). Coll and subm 1981 by C Verbruggen, Univ Gent. Dating results and pollen analysis indicate beginning and end of peat growth.

IRPA-437. Sample 1 **5550 ± 100**

Base of peat layer.

IRPA-438. Sample 2 **1940 ± 90**

Top of peat layer.

IRPA-439. Adinkerke 193DB5M53 **7790 ± 130**

Clayey peat from marine deposits at Adinkerke in W Vlaanderen (51° 04′ 30″ N, 2° 35′ 15″ E). Coll and subm 1981 by C Verbruggen. *Comment*: dates agree well with beginning of Atlantic.

Dunes series

Peat from coastal plain in W Vlaanderen. Coll Oct 1980 by R De Ceunynck and M Van Strydonck and subm Oct 1980 by R De Ceunynck, Univ Gent. Results are used to study stratigraphy of sand dunes.

IRPA-405. De Panne AC 37 **3090 ± 80**

Base of peat layer (51° 04′ 02″ N, 2° 34′ 47″ E).

IRPA-436. Nieuwmunster 48HB10 bis **440 ± 70**

Peat from layer at 183cm below surface (51° 17′ 29″ N, 3° 03′ 45″ E).

IRPA-447. De Panne DW5A **Modern**

Wood from sand layer, 110 to 180cm below surface (51° 04′ N, 2° 34′ E).

IRPA-448. De Panne DW5B **Modern**

Soil with sand, 180 to 195cm below surface (51° 04′ N, 2° 34′ E).

IRPA-449. De Panne DW5C **1310 ± 70**

Peat from layer, 225 to 255cm below surface (51° 04′ N, 2° 34′ E).

Mark series

The following results complete previously pub list (R, 1981, v 23, p

345-346) of samples from alluvial plain of Mark R in W Vlaanderen, Hainaut and Brabant. Coll and subm 1981-1982 by W Huybrechts, Geol Inst, Free Univ Brussels.

IRPA-440. Lessines B 80/4/3(1) 5800 ± 90

Clayey peat from layer, 260 to 290cm below surface (50° 44′ N, 3° 53′ E).

IRPA-441. Lessines B 80/4/3(2) 8370 ± 120

Peat with vegetable residues, 405 to 440cm below surface (50° 44′ N, 3° 53′ E).

IRPA-442. Galmaarden B 80/8/27 1730 ± 80

Wood from sand layer, 180 to 200cm below surface (50° 45′ N, 3° 57′ E).

IRPA-443. Moerbeke B 80/2/12(2) 6710 ± 100

Peat with vegetable residues, 330 to 355cm below surface (50° 45′ N, 3° 55′ E).

IRPA-444. Moerbeke B 80/2/12(3) 8470 ± 120

Peat from layer, 390 to 430cm below surface (50° 45′ N, 3° 55′ E).

IRPA-445. Moerbeke B 80/2/12(1) 8000 ± 90

Clayey peat with pieces of wood, 355 to 390cm below surface (50° 45′ N, 3° 55′ E).

IRPA-473. Enghien B 81/6/19 1700 ± 70

Peat from layer, 110 to 125cm below surface (50° 41′ N, 4° 00′ 30″ E).

IRPA-481. Galmaarden B 80/6/37(1) 8700 ± 110

Peat from layer, 585 to 595cm below surface (50° 45′ N, 3° 37′ E).

IRPA-482. Galmaarden B 80/6/37(2) 6490 ± 100

Clay from layer, 606 to 614cm below surface (50° 45′ N, 3° 37′ E).

IRPA-484. Galmaarden B 82/6/16(2) 9090 ± 110

Peat with shell residues, 620 to 630cm below surface (50° 45′ N, 3° 37′ E).

IRPA-485. Marcq B 82/6/41 990 ± 80

Clayey peat from layer, 290 to 300cm below surface (50° 40′ N, 3° 59′ E).

General Comment (WH): dates confirm previous results and describe continuous peat growth in alluvial plain, beginning ca 9000 BP, ending ca 5500 BP. In parts of basin upstream, peat layer is much younger, ca 2000 to 1000 BP.

B. Africa

IRPA-501. Murama 160 ± 70

Charcoal at alt of Murama, Bujumbura (2° 33′ N, 2° E), from low terrace of Ruzizi R at 300cm above lake Tanganika. Coll by L Ilunga, Free Univ Brussels, and subm Oct 1980 by C Baeteman. *Comment*: young date can be explained by hydrography of area.

Taourga series

Organic material and calcareous crust from Taourga, Algeria (36° 10′ 12″ N, 3° 05′ 17″ E). Coll and subm Feb 1981 by L Bock, Fac Agronom Gembloux, Belgium. *Comment*: dates are used in morphol and pedol study in which soils and calcareous crusts are assoc (Bock and Mathieu, 1982).

IRPA-429. 2.5 **5210 ± 260**

Organic material extracted from vertisol.

IRPA-430. 24.3 **3820 ± 210**

Organic material extracted from red soil, diluted, 27% sample.

IRPA-431. IV_1 **10,940 ± 140**

Calcareous crust from basin.

IRPA-432. C_3 **24,650 ± 620**

Calcareous crust from E border of upland.

IRPA-433. I_3 **34,080 ± 1940**

Calcareous crust from border of upland.

II. ARCHAEOLOGIC SAMPLES

A. Belgium

St-Lambert series

The following results complete previously pub list (R, 1981, v 23, p 349-350) from archaeol excavation at Place St-Lambert, Liège (50° 38′ 45″ N, 5° 34′ 30″ E). Coll Aug 1980 by M Van Strydonck and subm Aug 1980 by J Alénus-Lecerf, Nat Service Excavations, Belgium.

TABLE 1
St-Lambert radiocarbon dates

IRPA no.	Ref (Sample no.)	Material	Depth (cm)	^{14}C age	Expected age (AD)
-395	7	Wood	200 under wall	1010 ± 30	<1185
-396	7	Mortar	Street level	2130 ± 50 $\delta^{13}C = -15.8‰$	<1185
-397bis	6	Mortar	300 to 400 under wall	1660 ± 40 $\delta^{13}C = -12.8‰$	>1185
-398	6	Mortar	Street level	2700 ± 50 $\delta^{13}C = -12.1‰$	>1185
-399	7	Mortar	200 under wall	1060 ± 50 $\delta^{13}C = -17.0‰$	<1185
-400	2	Mortar	Street level	1290 ± 50 $\delta^{13}C = -12.4‰$	>1185
-401	6	Wood (pile)	Under wall	800 ± 70	
-402	6	Wood (pile)	Under wall	550 ± 70	
-479		Charcoal		740 ± 70	
-480		Wood (pile)		490 ± 110	

General Comment: charcoal and wood yielded dates that agree well; mortar carbonate gave old ages probably caused by infiltration from several floods (Van Strydonck, Dupas, and Dauchot-Dehon, 1982).

Antwerpen series

Mortar from "Onze-Lieve-Vrouw" cathedral and from three houses in Antwerpen (51° 13′ 16″ N, 4° 23′ 60″ E). Coll 1981 by M Van Strydonck, A De Nayer, and R Tijs, Dienst Monumentenzorg Antwerpen, and subm 1981 by M Van Strydonck. Samples were taken from pillars of cathedral at 150 to 600cm above street level and from floors or walls of houses.

TABLE 2
Antwerpen radiocarbon dates

IRPA no.	Ref	Material	Depth (cm)	^{14}C age	Expected age (AD)
-412	3rd pillar S	Mortar	150 above street level	610 ± 30 $\delta^{13}C = -15.4‰$	1420-1435
-413	6th pillar S	Mortar	180 above street level	580 ± 30 $\delta^{13}C = -14.3‰$	1420-1435
-414	3rd pillar N	Mortar	250-300 above street level	410 ± 30 $\delta^{13}C = -13.8‰$	1420-1435
-415	5th pillar N	Mortar	600 above street level	760 ± 30 $\delta^{13}C = -16.0‰$	1420-1435
-418		Mortar	Foot of pillar	Modern $\delta^{13}C = -19.4‰$	1420-1435
-416	House Rodenborg	Mortar	15-20 under floor	Modern $\delta^{13}C = -9.3‰$	1550
-420	House on "Grooten Helm" ground	Mortar*	In wall	840 ± 90 $\delta^{13}C = -9.7‰$	1500
-421	"Jacob Jordaens" House	Mortar*	In wall	1120 ± 80 $\delta^{13}C = -11.9‰$	1640

General Comment: mortar samples were first examined to separate fractions containing chalk carbonate from those containing carbonate formed after mortar preparation (Van Strydonck, Dupas, and Dauchot-Dehon, 1982). Dates for pillar of cathedral agree with expected ages. Mortars with (*) are diluted, 80% sample.

Vrasene series

Mortar and charcoal from Vrasene in O Vlaanderen (51° 13′ N, 4° 12′ E). Coll and subm Aug 1980 by R Van Hove.

IRPA-422. Vr K80/II/5, 6/A **940 ± 90**

Charcoal from 115cm below street level.

IRPA-424. Sleuf 80/I **1090 ± 120**
$\delta^{13}C = -14.7‰$

Mortar from foot of pillar of Romanesque church. *Comment*: diluted, 48.5% sample.

IRPA-425. Sleuf 80/II **3935 ± 10**
$\delta^{13}C = -22.5‰$

Mortar from foot of pillar of Romanesque church.

IRPA-426. Vr K80/II/C_2 **820 ± 70**

Charcoal from top of leveling layer under oldest floor level.

General Comment (RVH): IRPA-422 and -426 corroborated archaeol and stratigraphic data. IRPA-425 is too old.

Gent series

Wood from Gent in O Vlaanderen (51° 06′ N, 3° 45′ E) at 100 to 200cm below street level. Coll and subm 1980 by V Van Doorne, Dienst Monumentenzorg Gent.

IRPA-409. Profile B-C **1260 ± 70**

IRPA-410. Profile A-D **330 ± 80**

General Comment: archaeol date: 12th-14th centuries AD.

Flobecq series

Samples from Flobecq, Hainaut (50° 44′ 50″ N, 3° 43′ 34″ E). Coll and subm by A Roolant, Fed archéol Wallonie. Samples are stratigraphically defined (Faider-Feytmans, 1980).

IRPA-427. Sample 1 **1910 ± 130**

Peat from layer in Roman well. *Comment*: diluted, 40.16% sample.

IRPA-428. Sample 2 **2000 ± 80**

Wood from Roman well.

IRPA-446. Waasmunster **1940 ± 60**

Wood from Roman well in Waasmunster, O Vlaanderen (51° 06′ 25″ N, 4° 05′ 12″ E). Coll and subm Aug 1981 by C Verbruggen. *Comment*: result agrees with archaeol date: 1st century AD.

Wortegem-Petegem series

Charcoal from "Oud Kasteel" site along Schelde R at Wortegem-Petegem, O Vlaanderen (50° 50′ 01″ N, 3° 33′ 19″ E). Coll and subm 1982 by D Callebaut, Nat Service Excavations (Callebaut, 1981).

IRPA-474. Pe 77/1 **990 ± 60**

Sample from furnace. Archaeol date: 9th-10th century AD.

IRPA-475. Pe 77/6 **1550 ± 80**

Sample from fireplace in wooden house. This oldest building dates from 8th century AD, following stratigraphic data.

IRPA-478. KZ B2 III **560 ± 60**

Charcoal from furnace in Abbey church at St-Gillis-Dendermonde, O Vlaanderen (51° 01′ 11″ N, 4° 06′ 42″ E). Coll 1981 by A Stroobants, Oudheidkundige Kring van het Land Dendermonde and subm 1982 by D Callebaut. *Comment*: archaeol date: AD 1228-1667.

IRPA-486. Webbekom **2260 ± 70**

Grain of wheat from Webbekom, Brabant (50° 58′ 05″ N, 5° 04′ 26″

E). Coll and subm 1980 by P Vermeersch, Univ Leuven. *Comment*: archaeol date: Iron age.

IRPA-495. WV 8219 **2270 ± 70**

Wood from calcined beam at Waudrez, Hainaut (50° 25′ 50″ N, 4° 09′ 08″ E). Coll and subm Sept 1982 by Ph Dekegel, Cercle archéol Waudrez. *Comment*: sample from Roman level; expected date: 1st-3rd century AD.

IRPA-500. A **1185 ± 50**

B **1190 ± 50**

Wood (*Alnus*) from plank in Veemarkt at Antwerpen (51° 13′ N, 4° 23′ E) 250cm under street level. Coll Jan 1982 by M Van Strydonck and T Oost, Oudheidkundige Mus Antwerpen; subm Jan 1982 by M Van Strydonck. *Comment*: expected date: 12th-13th century AD.

IRPA-453. **940 ± 50**

Wood from dugouts at Austruweel, Antwerpen (51° N, 4° E). Coll 1910-1911 by Rahir, Mus Royaux Art Hist (Rahir, 1911; 1913); subm Sept 1982 by M Van Strydonck. Sample divided in fine parts and dated separately. Results are shown in table 3 which gives per mil depletion with regard to standard (Stuiver and Polach, 1977).

TABLE 3
Wood samples from Austruweel

IRPA-453.	$D^{14}C$ ‰
1	−0.1026
2	−0.1153
3	−0.1014
4	−0.1184
5	−0.1133
Mean	−0.1102

General Comment (MVS): result shows that dugouts date from Middle ages and not from Iron age as expected (Ellmers, 1978; Van Strydonck, Dauchot-Dehon, and Heylen, in press). Dates are confirmed by Lv-826, -827: 1050 ± 65, 820 ± 45 (Dauchot-Dehon *et al*, 1982).

IRPA-378. Br 79/1/19 **1920 ± 70**

Peat from Roman site in Belgian coastal plain at Bredene (51° 14′ 24″ N, 2° 57′ 33″ E). Coll and subm 1981 by H Thoen, Univ Gent. This sample completes previously pub list (R, 1981, v 23, p 348-349).

B. Yugoslavia

Zadar series

Mortar from St-Donat church in Zadar, Croatia (44° 06′ 48″ N, 15° 14′ 04″ E). Subm Oct 1981 by D Srdoč, Inst "Rudjer Boškovic," Zagreb. The two samples were coll very carefully with precise description of locations. Mortar samples were first examined to separate fraction containing chalk carbonate from those containing carbonate formed after mortar preparation.

1610 ± 70

IRPA-498. Zadar 1 $\delta^{13}C = -12.1‰$

510 ± 70

IRPA-499. Zadar 2 $\delta^{13}C = -9.5‰$

General Comment (DS): lime used to make mortars in Middle ages was prepared in primitive kilns where decomposition of limestone was not complete due to low firing temperature. Also, sand used for mortars was pure limestone, *ie*, dead carbonate. This may explain why date for IRPA-498 is too old. More surprising is date for IRPA-499 that is too young, but we cannot exclude much younger mortar, since church was reconstructed, and destroyed, several times in history.

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UNIVERSITY OF LUND RADIOCARBON DATES XVI

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INTRODUCTION

Most of the ^{14}C measurements reported here were made between October 1981 and October 1982. Equipment, measurement, and treatment of samples are as reported previously (R, 1968, v 10, p 36-37; 1976, v 18, p 290; 1980, v 22, p 1045).

Age calculations are based on a contemporary value equal to 95% of the activity of NBS oxalic acid standard (No. 4990A) and on the conventional half-life for ^{14}C of 5568 yr. Results are reported in years before 1950 (years BP). Errors quoted with the dates are based on counting statistics alone and are equivalent to ± 1 standard deviation ($\pm\sigma$).

Corrections for deviations from $\delta^{13}C = -25.0‰$ in the PDB scale are applied for almost all samples; also for marine shells. The apparent age for marine material due to the reservoir effect must be subtracted from our dates on such samples.

The remark "undersized; diluted", in *Comments* means the sample did not produce enough CO_2 to fill the counter to normal pressure and "dead" CO_2 from anthracite was introduced to make up the pressure. "% sample" indicates amount of CO_2 derived from the sample present in the diluted counting gas; the rest is "dead" CO_2. Organic carbon content reported for bone samples is calculated from yield of CO_2 by combustion of gelatine remaining after treatment. Organic carbon lost during treatment is not included in calculated percentage.

The description of each sample is based on information provided by the submitter.

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SAMPLE DESCRIPTIONS

I. GEOLOGIC SAMPLES

A. Sweden

Spjälkö series

Sediment from former Littorina bay at Spjälkö, S Blekinge (56° 10′ N, 15° 13′ E). Lu-341 through -349 coll 1969 by R Liljegren; subm by B E Berglund; all other samples coll 1976 and 1981 (Lu-1984) and subm by R Liljegren, Dept Quaternary Geol, Univ Lund. Dating is part of study of biol development and water-level changes in area (Liljegren, 1982). All samples pretreated with HCl; Lu-1984 received additional treatment with NaOH. Elevations above present sea level.

6890 ± 80
Lu-341. Spjälkö 1 $\delta^{13}C = -28.0‰$
Limnic fine detritus gyttja, +3.78 to 3.80m.

6850 ± 80
Lu-342. Spjälkö 2 $\delta^{13}C = -25.0‰$
Slightly brackish algal gyttja, +3.80 to 3.82m.

6670 ± 75
Lu-343. Spjälkö 3 $\delta^{13}C = -19.1‰$
Brackish algal gyttja, +3.89 to 3.91m.

6480 ± 75
Lu-344. Spjälkö 4 $\delta^{13}C = -20.4‰$
Brackish algal gyttja, +3.98 to 4.00m.

6250 ± 75
Lu-345. Spjälkö 5 $\delta^{13}C = -17.9‰$
Brackish fine detritus gyttja, rich in algae, +4.06 to 4.08m.

6090 ± 75
Lu-346. Spjälkö 6 $\delta^{13}C = -17.9‰$
Brackish fine detritus gyttja, rich in algae, +4.21 to 4.23m.

6080 ± 70
Lu-347. Spjälkö 7 $\delta^{13}C = -16.6‰$
Brackish fine detritus gyttja, rich in algae, +4.27 to 4.29m.

5520 ± 70
Lu-348. Spjälkö 8 $\delta^{13}C = -17.2‰$
Brackish fine detritus gyttja, rich in algae, +4.49 to 4.51m.

5260 ± 65
Lu-349. Spjälkö 9 $\delta^{13}C = -18.2‰$
Brackish fine detritus gyttja, rich in algae, +4.51 to 4.53m.

5820 ± 65
Lu-1899. Spjälkö 10 $\delta^{13}C = -16.8‰$
Brackish fine detritus gyttja, rich in algae, +4.43 to 4.45m.

5850 ± 65
Lu-1898. Spjälkö 11 $\delta^{13}C = -16.9‰$
Clayey fine detritus gyttja, rich in algae, +4.53 to 4.55m.

5540 ± 65
Lu-1897. Spjälkö 12 $\delta^{13}C = -14.5‰$
Clayey fine detritus gyttja, +4.63 to 4.65m.

4110 ± 65
Lu-1984. Spjälkö 13, insoluble $\delta^{13}C = -26.3‰$
Sedge and reed peat from isolation level, +4.75 to 4.76m, insoluble fraction.

3920 ± 55

Lu-1984A. Spjälkö 13, soluble $\delta^{13}C = -26.1‰$

Acid-precipitated part of NaOH-soluble fraction, +4.75 to 4.76m.

7650 ± 75

Lu-1954. Ängdala 1981, insoluble $\delta^{13}C = -29.2‰$

Insoluble organic fraction of clay gyttja from sediment layer, ca 15cm thick, overlain by large chalk boulder at Ängdala, Kvarnby, S Scania (55° 36′ N, 13° 07′ E). Coll 1981 by R Liljegren and M Thelaus; subm by R Liljegren. Pretreated with HCl and NaOH.

7410 ± 70

Lu-1954A. Ängdala 1981, soluble $\delta^{13}C = -27.5‰$

Acid-precipitated part of NaOH-soluble fraction from Lu-1954.

2610 ± 80

Lu-2018. Bjäresjö $\delta^{13}C = -26.1‰$

Magnocaricetum or brushwood peat from 5.4 to 5.5m below water surface in reconnaissance core from Lake Bjäresjö, 5km NW of Ystad, S Scania (55° 27.5′ N, 13° 45.3′ E). Coll 1982 and subm by B E Berglund, Dept Quaternary Geol, Univ Lund. Peat is overlain by ca 3.8m lake sediments. Water depth ca 1.6m at coring point. Dated to obtain approx age of peat surface. No pretreatment. (1-day count.)

Lu-1939. Herrängsviken la, Åsnen **12,320 ± 170**

Clay with some organic matter (<0.3% organic carbon) from Herrängsviken, Lake Åsnen, S Småland (56° 42′ N, 14° 38′ E). Depth 6.16 to 6.23m below water surface. Coll 1981 and subm by S Björck, Dept Quaternary Geol, Univ Lund. Dated to demonstrate difficulty to obtain reliable dates on bulk sediments with very low organic content (see Björck and Håkansson, 1982). Date is ca 1200 yr older than expected from previous dates for separated coarse detritus from comparable levels at Herrängsviken (R, 1982, v 24, p 198-199). Pretreated with HCl. Sample undersized; diluted; 33% sample. (4 1-day counts.) No ^{13}C measurement. Water depth 1.3m at sampling point.

780 ± 45

Lu-1958. Våxtorp $\delta^{13}C = -24.5‰$

Charcoal from depression in wind-blasted large boulder uncovered from eolian sand in gravel pit at Våxtorp, Halland (56° 25′ N, 13° 07′ E). Coll 1981 and subm by H Svensson, Dept Phys Geog, Univ Lund. Site described by Svensson (1981).

Dags Mosse Series I

Peat from S part of Dags Mosse, SW of Lake Tåkern, Östergötland (58° 19.5′ N, 14° 42′ E). Coll 1980 by H Göransson and M Thelaus; subm by H Göransson, Dept Quaternary Geol, Univ Lund. Results of previous study in area pub by Magnusson (1964). Dating is part of study of human influence on vegetation in S Östergötland (*cf* Göransson, 1977, p 107-127;

1982). Uppermost ca 1m peat removed previously by peat-cutting. Samples are from core taken with Livingstone sampler, 10cm diam. Depths given below refer to present bog surface.

5370 ± 60

Lu-1964. Dags Mosse 1, coarse, insoluble $\delta^{13}C = -24.6‰$

Coarse fraction of minerotrophic radicel peat, insoluble part, 283.5 to 286.5cm. Upper part of *Tilia-Quercus-Ulmus* sub-zone (*cf* Göransson, 1977, p 98). *Comment*: pretreated with HCl and NaOH.

5320 ± 60

Lu-1964A. Dags Mosse 1, fine and soluble $\delta^{13}C = -25.1‰$

Fine fraction and acid-precipitated part of NaOH-soluble fraction, 283.5 to 286.5cm.

5200 ± 60

Lu-1965. Dags Mosse 2, coarse, insoluble $\delta^{13}C = -24.6‰$

Coarse fraction of minerotrophic radicel peat, insoluble part, 274 to 276cm. Just below initial phase of elm decline. *Comment*: pretreated with HCl and NaOH.

5250 ± 60

Lu-1965A. Dags Mosse 2, fine and soluble $\delta^{13}C = -25.3‰$

Fine fraction and acid-precipitated part of NaOH-soluble fraction, 274 to 276cm.

5180 ± 60

Lu-2015. Dags Mosse 15 $\delta^{13}C = -23.8‰$

Minerotrophic peat, 268 to 271cm. Very beginning of elm decline. *Comment*: pretreated with HCl.

5020 ± 70

Lu-1966. Dags Mosse 3 ($\delta^{13}C = -25.7‰$)*

Minerotrophic radicel peat, 258.5 to 261.5cm. Continuing elm decline. *Comment*: pretreated with HCl and NaOH; charred in nitrogen atmosphere before burning. Sample undersized; diluted; 83% sample.

4860 ± 60

Lu-1967. Dags Mosse 4, coarse, insoluble $\delta^{13}C = -26.1‰$

Coarse fraction of minerotrophic radicel peat, insoluble part, 248.5 to 251.5cm. *Ulmus* only 1%. *Comment*: pretreated with HCl and NaOH; charred in nitrogen atmosphere before burning.

4760 ± 60

Lu-1967A. Dags Mosse 4, fine and soluble $\delta^{13}C = -25.4‰$

Fine fraction and acid-precipitated part of NaOH-soluble fraction, 248.5 to 251.5cm.

4550 ± 60

Lu-1968. Dags Mosse 5, insoluble $\delta^{13}C = -25.9‰$

Peat from transition minero/ombrotrophic peat, 238.5 to 241.5cm, insoluble part. Absolute *Ulmus* min (0.7%) after decline. First finds of

* No ^{13}C measurement. $\delta^{13}C$ used is mean value for Lu-1964 to -1973.

Plantago lanceolata. *Comment*: pretreated with HCl and NaOH; charred in nitrogen atmosphere before burning.

4480 ± 60
Lu-1968A. Dags Mosse 5, soluble $\delta^{13}C = -25.4‰$

Acid-precipitated part of NaOH-soluble fraction, 238.5 to 241.5cm.

4690 ± 60
Lu-1969. Dags Mosse 6 $\delta^{13}C = -25.7‰$

Ombrotrophic peat, 233.5 to 236.5cm. *Ulmus* rising to 1.3%. *Comment*: only mild pretreatment with HCl and NaOH; charred in nitrogen atmosphere before burning.

4590 ± 60
Lu-1970. Dags Mosse 7 $\delta^{13}C = -26.5‰$

Ombrotrophic *Eriophorum vaginatum* peat, 228.5 to 231.5cm. Start of regeneration phase (1.5% *Ulmus*, 4.9% *Tilia*, *Corylus* increasing from 16 to 30%). *Comment*: only mild pretreatment with HCl and NaOH; charred in nitrogen atmosphere before burning.

4450 ± 60
Lu-1971. Dags Mosse 8 $\delta^{13}C = -25.6‰$

Ombrotrophic *Eriophorum vaginatum* peat, 218.8 to 221.2cm. Continuing regeneration phase (4.7% *Ulmus*). *Comment*: only mild pretreatment with HCl and NaOH; charred in nitrogen atmosphere before burning.

4350 ± 60
Lu-1972. Dags Mosse 9 $\delta^{13}C = -26.1‰$

Dark, highly humified *Sphagnum* peat, 213.5 to 216.5cm. *Comment*: only mild pretreatment with HCl and NaOH; charred in nitrogen atmosphere before burning.

4310 ± 60
Lu-1973. Dags Mosse 10 $\delta^{13}C = -25.6‰$

Dark, highly humified *Sphagnum* peat, 208.5 to 211.5cm. *Comment*: only mild pretreatment with HCl and NaOH; charred in nitrogen atmosphere before burning.

4060 ± 55
Lu-1974. Dags Mosse 11 $\delta^{13}C = -26.4‰$

Dark, highly humified *Sphagnum* peat, 198.5 to 201.5cm. *Comment*: only mild pretreatment with HCl and NaOH; charred in nitrogen atmosphere before burning.

4070 ± 55
Lu-1975. Dags Mosse 12 $\delta^{13}C = -25.9‰$

Chocolate-colored, highly humified *Sphagnum* peat, 195 to 198cm. *Comment*: only mild pretreatment with HCl and NaOH; charred in nitrogen atmosphere before burning.

3980 ± 55
Lu-1976. Dags Mosse 13 $\delta^{13}C = -25.5‰$

Chocolate-colored, highly humified *Sphagnum* peat, 188.5 to 191.5cm.

Comment: only mild pretreatment with HCl and NaOH; charred in nitrogen atmosphere before burning.

3650 ± 55

Lu-1977. Dags Mosse 14 $\delta^{13}C = -26.2‰$

Chocolate-colored, highly humified *Sphagnum* peat, 178.5 to 181.5cm. *Comment*: only mild pretreatment with HCl and NaOH; charred in nitrogen atmosphere before burning.

St Rögöl series

Fine detritus gyttja from Lake St Rögöl, NE Småland (57° 32′ N, 16° 33′ E). Alt 20m; area 6.7ha. Coll 1981 and subm by T Persson, Dept Quaternary Geol, Univ Lund. Dated as part of study of human influence on vegetational development in area. Samples pretreated with HCl. Water depth at sampling point, 2m.

1400 ± 50

Lu-1987. St Rögöl, Sample 15 $\delta^{13}C = -29.4‰$

Gyttja from 35 to 37.5cm below sediment surface. Rising frequency of cereal pollen.

1740 ± 50

Lu-1988. St Rögöl, Sample 19 $\delta^{13}C = -30.1‰$

Gyttja from 45 to 47.5cm below sediment surface. *Picea* pollen percentages increasing.

Baldringe series

Peat from Coring Site III in Baldringe area, ca 4km N of Sövestad, S Scania (55° 32.2′ N, 13° 48.3′ E). Coll 1981 by L-O Jönsson and B Liedberg-Jönsson; subm by M Hjelmroos-Ericsson, Dept Quaternary Geol, Univ Lund. No pretreatment.

1090 ± 45

Lu-1997. Baldringe III:1 $\delta^{13}C = -27.4‰$

Dark gray peat with radicels and wood remains, 48 to 50cm below peat surface.

3680 ± 55

Lu-1998. Baldringe III:2 $\delta^{13}C = -22.8‰$

Magnocaricetum peat with wood remains, 177.5 to 182.5cm below peat surface.

B. Iceland

8740 ± 95

Lu-1996. Flateyjardalur $\delta^{13}C = -18.8‰$

Gyttja from lake at Flateyjardalur, N Iceland (66° 05′ 55″ N, 17° 54′ 20″ W). Sample from 522.5 to 527.5cm below sediment surface in 560cm long profile. Alt of lake ca 25m. Coll 1977 by H Norddahl and G Hjaltason; subm by H Norddahl, Dept Quaternary Geol, Univ Lund. *Comment*: pretreated with HCl. Sample undersized; diluted; 53% sample. (3 1-day counts.) Sample from lowest 5cm of same profile dated at 9650 ± 120 BP (Lu-1433: R, 1979, v 21, p 395).

Icelandic recent marine shell series

Bivalve shells from various parts of coast of Iceland, selected from mollusk colln of Zool Mus, Copenhagen, by L A Simonarson, Sci Inst, Univ Iceland, Reykjavik. Coll between 1898 and 1939; subm by O Ingolfsson, Dept Quaternary Geol, Univ Lund. Dated to gain information about reservoir effects in coastal waters of Iceland.

505 ± 35
Lu-2006. Reykjavik 1900 $\delta^{13}C = +1.0‰$

Shells (*Mytilus edulis*) coll alive in 1900 by A C Johansen at 3m depth outside Reykjavik, SW Iceland (65° 10′ N, 22° 00′ W). *Comment*: expected ^{14}C age of mollusks living in 1900 is 110 ± 20 BP, corrected for reservoir effect (see Olsson, 1980, p 670). Thus, reservoir age is 395 ± 40 yr.

430 ± 41
Lu-2007. Djúpivogur 1898 $\delta^{13}C = +0.1‰$

Shells (*Mytilus edulis*) coll alive in 1898 by H Jønsson at ca 6m depth outside Djúpivogur, E Iceland (64° 40′ N, 14° 15′ W). *Comment*: expected reservoir-corrected ^{14}C age: 110 ± 20 BP. Reservoir age: 370 ± 46 yr.

480 ± 41
Lu-2008. Seydisfjördur 1926 $\delta^{13}C = -0.3‰$

Shells (*Macoma calcarea*) coll alive in 1926 by Tåning at 40m depth in Seydisfjördur, E Iceland (65° 17′ N, 14° 00′ W). *Comment*: expected reservoir-corrected ^{14}C age: 110 ± 20 BP. Reservoir age: 370 ± 46 yr.

470 ± 35
Lu-2009. Faxaflói 1926 $\delta^{13}C = +0.1‰$

Shells (*Macoma calcarea*) coll alive in 1926 by Tåning at 33m depth in Faxaflói, SW Iceland (64° 20′ N, 22° 30′ W). *Comment*: expected reservoir-corrected ^{14}C age: 110 ± 20 BP. Reservoir age: 360 ± 40 yr.

500 ± 42
Lu-2010. Faxaflói 1939 $\delta^{13}C = +1.7‰$

Shells (*Arctica islandica*) coll alive in 1939 by Einarsson at 48m depth in Faxaflói, SW Iceland (64° 07′ N, 22° 12′ W). *Comment*: expected reservoir-corrected ^{14}C age: 130 ± 20 BP. Reservoir age: 370 ± 47 yr.

440 ± 34
Lu-2011. Skjálfandi 1926 $\delta^{13}C = +2.1‰$

Shells (*Arctica islandica*) coll alive in 1926 by Tåning at 22m depth at Skjálfandi, N Iceland (66° 00′ N, 17° 30′ W). *Comment*: expected reservoir-corrected ^{14}C age: 110 ± 20 BP. Reservoir age: 330 ± 40 yr.

General Comment: weighed mean value of reservoir age for coastal waters of Iceland is 365 ± 20 yr, based on this series. Results will be treated in more detail elsewhere (Håkansson, ms in preparation). Corrections for deviations from $\delta^{13}C = -25‰$ PDB are applied also for these samples.

Icelandic Subfossil Marine Shell Series I

Marine shells from SW Iceland, coll 1980 and 1981 and subm by O Ingolfsson. Dated as part of study of Late Weichselian ice recession in area.

12,470 ± 110
$\delta^{13}C = +0.3‰$

Lu-2055. Laxá

Shells (*Hiatella arctica*) from marine silt, alt 25m, at Laxá, N of Akranes, SW Iceland (64° 24′ N, 21° 50′ W). There are indications that site was overridden by latest ice advance in area. *Comment*: outer 25% of shells removed by acid leaching. Sample undersized; diluted; 80% sample. (3 1-day counts.)

11,330 ± 80
$\delta^{13}C = +0.5‰$

Lu-2056. Súlvá

Shells (*Mya truncata*) found *in situ* with *Portlandia arctica* (not dated) in marine silt; ca +2m at Súlvá, N of Akranes (64° 24′ N, 21° 57′ W). Silt probably deposited in distal position in front of latest ice margin in area. *Comment*: outer 27% removed by acid leaching. (3 1-day counts.) *General Comment*: corrections for deviations from $\delta^{13}C = -25‰$ PDB are applied. No corrections are made for reservoir age of living marine mollusks.

C. Spitsbergen

Kapp Linné series

Whale bone from fossil beach ridge at Kapp Linné, Isfjord, West Spitsbergen (78° 04′ N, 13° 38′ E). Coll 1979 and subm by J Åkerman, Dept Phys Geog, Univ Lund. Dated as part of study of elevated shorelines in area (*cf* Åkerman, 1980). Collagen extracted as described previously (R, 1976, v 18, p 290) without NaOH treatment. Only dense bone material used for dating.

9680 ± 90
$\delta^{13}C = -14.9‰$

Lu-2019. Kapp Linné, Flya

Collagen from well-preserved jaw bone of unid. whale. *Comment*: organic carbon content: 5.5%.

9790 ± 90
$\delta^{13}C = -15.9‰$

Lu-2020. Kapp Linné, RK179

Collagen from well-preserved skull? bone fragment of unid. whale. *Comment*: organic carbon content: 6.0%.

D. Switzerland

Lu-2002. Petit-Saconnex **11,560 ± 280**

Wood fragments and conifer needles from top of deposit overlain by basal till at Petit-Saconnex, Budé, SE Switzerland (46° 13′ 50″ N, 6° 08′ 30″ E). Coll 1964; subm by C Reynaud, Dept Geol, Univ Geneva. *Comment*: very small sample; diluted; 23% sample. (3 1-day counts.) No ^{13}C measurement.

Lu-2053. Grotte du Poteux **3870 ± 60** $\delta^{13}C = -19.9‰$

Collagen from bones of Horseshoe Bat (*Rhinolopphus euryale,* id by V Aellen, Mus Nat Hist, Geneva) from Grotte du Poteux at Saillon, Valais, S Switzerland (46° 10′ N, 7° 11′ E). Coll 1981 by Arlettaz and Praz; subm by V Aellen. *Comment*: collagen extracted as described previously (R, 1976, v 18, p 290) with NaOH treatment. Organic carbon content: 0.8%. Sample undersized; diluted; 61% sample. (3 1-day counts.)

E. Bulgaria

Tschokljovo Marsh Series I

Peat from Tschokljovo marsh, W Bulgaria (42° 22′ N, 22° 50′ E). Alt 870m. Coll 1980 by S Tonkov; subm by E Bozilova, Biol Fac, Univ Sofia. Dating is part of palaeoecol study belonging to IGCP Sub-proj 158B (Berglund, 1979). Peat classified by submitter as *Phragmites*-type peat for all samples. Lowermost sample is from core (Lu-1989); all other samples are from wall of dug trench. All samples pretreated with HCl. Lu-1990, -1991, and -1994 received additional treatment with NaOH, and soluble fractions were precipitated with HCl and dated separately. Depths refer to surface of upper peat layer.

Lu-1989. Tschokljovo, Sample 6 **6300 ± 65** $\delta^{13}C = -26.5‰$

Sample from separate peat layer, 400 to 405cm, underlain and overlain by clay.

Lu-1990. Tschokljovo, Sample 5 **3010 ± 55** $\delta^{13}C = -25.9‰$

Depth 274 to 279cm. Insoluble fraction.

Lu-1990A. Tschokljovo, Sample 5, soluble **3130 ± 55** $\delta^{13}C = -25.4‰$

Acid-precipitated part of NaOH-soluble fraction from Sample 5.

Lu-1991. Tschokljovo, Sample 4 **2470 ± 50** $\delta^{13}C = -25.5‰$

Depth 230 to 240cm. Insoluble fraction.

Lu-1991A. Tschokljovo, Sample 4, soluble **2380 ± 50** $\delta^{13}C = -26.5‰$

Acid-precipitated part of NaOH-soluble fraction from Sample 4.

Lu-1992. Tschokljovo, Sample 3 **2430 ± 50** $\delta^{13}C = -25.4‰$

Depth 149 to 152cm.

Lu-1993. Tschokljovo, Sample 2 **2380 ± 50** $\delta^{13}C = -25.2‰$

Depth 140 to 144cm.

Lu-1994. Tschokljovo, Sample 1 **1710 ± 50** *$\delta^{13}C = -24.1‰$*

Depth 72 to 80cm. Insoluble fraction.

Lu-1994A. Tschokljovo, Sample 1, soluble **1860 ± 50** *$\delta^{13}C = -26.0‰$*

Acid-precipitated part of NaOH-soluble fraction from Sample 1.

F. Jamaica

Negril Morass Series II

Peat from coastal wetland at Negril, W Jamaica (18° 20′ N, 78° 20′ W). Coll 1982 and subm by G Digerfeldt, Dept Quaternary Geol, Univ Lund. Dating is part of study of development of coastal wetland and eustatic sea-level changes in area. For other dates from Negril Morass, see R, 1982, v 24, p 203-204. Depths given are below surface. Peat classification is preliminary (based on field observations). All samples pretreated with HCl.

Negril Morass 1

Lu-2022. Negril Morass 1, 140 to 150cm **2340 ± 50** *$\delta^{13}C = -38.1‰$*

Sedge peat, highly humified. *Comment*: low $\delta^{13}C$ value checked by second ^{13}C measurement.

Lu-2023. Negril Morass 1, 340 to 350cm **3560 ± 60** *$\delta^{13}C = -24.7‰$*

Mangrove peat, slightly humified.

Lu-2024. Negril Morass 1, 540 to 550cm **4560 ± 60** *$\delta^{13}C = -25.8‰$*

Mangrove peat, slightly humified.

Lu-2025. Negril Morass 1, 740 to 750cm **5930 ± 70** *$\delta^{13}C = -28.8‰$*

Mangrove peat, highly humified.

Lu-2026. Negril Morass 1, 935 to 945cm **6960 ± 70** *$\delta^{13}C = -28.3‰$*

Mangrove peat, highly humified.

Negril Morass 2

Lu-2027. Negril Morass 2, 240 to 250cm **3630 ± 60** *$\delta^{13}C = -26.0‰$*

Mangrove peat, moderately humified.

Lu-2028. Negril Morass 2, 437 to 447cm **5680 ± 60** *$\delta^{13}C = -27.6‰$*

Mangrove peat, highly humified.

Negril Morass 3

Lu-2029. Negril Morass 3, 140 to 150cm **2260 ± 50** *$\delta^{13}C = -25.5‰$*

Mangrove peat, slightly humified.

Lu-2030. Negril Morass 3, 340 to 350cm **4270 ± 60** $\delta^{13}C = -25.6‰$

Mangrove peat, slightly humified.

Lu-2031. Negril Morass 3, 570 to 580cm **5970 ± 70** $\delta^{13}C = -27.3‰$

Mangrove peat, highly humified.

Negril Morass 4

Lu-2032. Negril Morass 4, 240 to 250cm **3810 ± 60** $\delta^{13}C = -25.9‰$

Mangrove peat, moderately humified.

Lu-2033. Negril Morass 4, 440 to 450cm **4740 ± 60** $\delta^{13}C = -26.4‰$

Mangrove peat, highly humified.

Lu-2034. Negril Morass 4, 670 to 680cm **6220 ± 70** $\delta^{13}C = -25.3‰$

Mangrove peat, highly humified.

Negril Morass 5

Lu-2035. Negril Morass 5, 140 to 150cm **2110 ± 50** $\delta^{13}C = -27.0‰$

Mangrove peat, highly humified.

Lu-2036. Negril Morass 5, 340 to 350cm **3650 ± 60** $\delta^{13}C = -26.2‰$

Mangrove peat, moderately humified.

Lu-2037. Negril Morass 5, 540 to 550cm **5310 ± 60** $\delta^{13}C = -24.2‰$

Mangrove peat, moderately humified.

Lu-2038. Negril Morass 5, 762 to 772cm **6610 ± 70** $\delta^{13}C = -29.0‰$

Mangrove peat, moderately humified.

Negril Morass 6

Lu-2039. Negril Morass 6, 80 to 90cm **1370 ± 45** $\delta^{13}C = -26.7‰$

Mangrove peat, moderately humified.

Lu-2040. Negril Morass 6, 240 to 250cm **3730 ± 60** $\delta^{13}C = -26.5‰$

Mangrove peat, highly humified.

Lu-2041. Negril Morass 6, 390 to 400cm **5100 ± 60** $\delta^{13}C = -26.4‰$

Mangrove peat, highly humified.

Negril Morass 7

Lu-2042. Negril Morass 7, 140 to 150cm **1760 ± 50** $\delta^{13}C = -26.1‰$

Sedge peat, highly humified.

Lu-2043. Negril Morass 7, 340 to 350cm **3190 ± 50** $\delta^{13}C = -26.4‰$
Mangrove peat, slightly humified.

Lu-2044. Negril Morass 7, 540 to 550cm **4480 ± 60** $\delta^{13}C = -26.0‰$
Mangrove peat, slightly humified.

Lu-2045. Negril Morass 7, 740 to 750cm **5240 ± 60** $\delta^{13}C = -25.9‰$
Mangrove peat, slightly humified.

Lu-2046. Negril Morass 7, 940 to 950cm **5910 ± 70** $\delta^{13}C = -26.3‰$
Mangrove peat, slightly humified.

Lu-2047. Negril Morass 7, 1140 to 1150cm **6670 ± 70** $\delta^{13}C = -27.3‰$
Mangrove peat, slightly humified.

Lu-2048. Negril Morass 7, 1295 to 1305cm **8070 ± 80** $\delta^{13}C = -23.1‰$
Mangrove peat, highly humified.

Lu-2049. Negril Morass, at E canal **4370 ± 60** $\delta^{13}C = -27.6‰$
Depth 230 to 240cm. Mangrove peat, highly humified.

Lu-2050. Negril Morass, 200m W of E canal **4450 ± 60** $\delta^{13}C = -27.3‰$
Depth 305 to 315cm. Mangrove peat, highly humified.

Lu-2051. Negril Morass, 600m E of Crystal Water **8080 ± 80** $\delta^{13}C = -26.1‰$
Depth 1195 to 1205cm. Mangrove peat, highly humified.

Lu-2068. Negril Morass, 220 to 230cm **6220 ± 70** $\delta^{13}C = -27.8‰$
Peat. Coll 1981 by M Hendry.

G. Bahamas

Lu-2100. Bimini, Sample 17 **1950 ± 50** $\delta^{13}C = +1.6‰$

Single shell (*Strombus* sp) from poorly-cemented grainstone forming beach cliff, 2m high, 200m S of "Paradise point," Bimini, NW Bahamas (25° 46′ N, 79° 19′ W). Coll 1982 by A Strasser and E Davaud; subm by A Strasser, Geol Inst, ETH Zürich, Switzerland. *Comment*: outer 54% removed by acid leaching. Correction for deviation from $\delta^{13}C = -25‰$ PDB is applied also for shell samples. No correction is made for apparent age of living marine mollusks caused by reservoir effect.

II. ARCHAEOLOGIC SAMPLES

A. Sweden

Skateholm Series II

Charcoal from settlement area (Early Ertebølle culture) at Skateholm, Tullstorp parish, S Scania (55° 23′ 10″ N, 13° 29′ E). Coll 1980 and 1981 by L Larsson and B Troy; subm by L Larsson, Inst Archaeol, Univ Lund. Preliminary excavation repts pub by Larsson (1980; 1981). Skateholm II denotes separate settlement discovered in 1981 close to Skateholm (I). For other dates from area, see R, 1982, v 24, p 205-206. All samples pretreated with HCl and NaOH.

2530 ± 50
Lu-1955. Skateholm (I), Structure 11 $\delta^{13}C = -25.0‰$

Charcoal (mainly Pomoideae and *Crataegus* or *Sorbus* sp) id by T Bartholin, from Structure 11 (hearth).

2520 ± 55
Lu-1985. Skateholm, Structure 19 $\delta^{13}C = -23.9‰$

Charcoal (*Fraxinus*) id by T Bartholin, from Structure 19 (hearth).

7000 ± 70
Lu-1995. Skateholm (I), x=80, y=126 $\delta^{13}C = -23.9‰$

Charcoal (*Quercus, Corylus avellana, Ulmus,* and Pomoideae) id by T Bartholin, from cultural layer; x=80, y=126.

5470 ± 105
Lu-1956. Skateholm II, x=100, y=100 $\delta^{13}C = -25.0‰$

Charcoal from cultural layer; x=100, y=100; depth 50 to 60cm. *Comment*: sample undersized; diluted; 35% sample. (3 1-day counts.)

6050 ± 100
Lu-1957. Skateholm II, x=100, y=101 $\delta^{13}C = -24.5‰$

Charcoal (*Quercus, Ulmus,* and *Corylus avellana*) id by T Bartholin, from cultural layer; x=100, y=101; depth 50 to 60cm. *Comment*: sample undersized; diluted; 41% sample. (3 1-day counts.)

8050 ± 75
Lu-1983. Kams, Gotland $\delta^{13}C = -18.0‰$

Collagen from human tibia from destroyed grave at Kams, Lummelunda parish, Gotland (ca 57° 45.7′ N, 18° 26′ E). Date of colln and name of collector unknown; subm by L Larsson. Expected age: Late Mesolithic (ca 6000 BP). *Comment*: organic carbon content: 5.4%. Collagen extracted as described previously (R, 1976, v 18, p 290) without NaOH treatment.

2730 ± 50
Lu-1982. Löddesborg 1981 $\delta^{13}C = -24.5‰$

Charcoal (*Fraxinus* and *Corylus avellana*) id by T Bartholin, from hearth-pit in settlement area at Löddesborg, W Scania (55° 43′ N, 12° 59′ E). Coll 1981 and subm by K Jennbert-Spång, Inst Archaeol, Univ Lund. Assoc with transverse arrowhead and flint waste indicating Ertebølle culture. Dated as complement to Löddesborg series (R, 1982, v 24, p 207). Pretreated with HCl and NaOH.

6280 ± 80

Lu-1945. Havtäppan *$\delta^{13}C = -23.7‰$*

Charcoal from partly wave-washed settlement layer overlain by sand at Havtäppan, Risanäs, S Blekinge (56° 11′ N, 15° 16′ E). Alt 7.5m. Coll 1972 by T Persson and K-A Björkqvist; subm by R Liljegren, Dept Quaternary Geol, Univ Lund. Artifact assemblage indicates Ertebølle culture (Liljegren, 1982, p 61-62).

Fotevik Series I

Wood from preliminary marine-archaeol study of area with Late Viking-age stone blocking in bay Fotevik, SW Scania (55° 28′ N, 12° 56′ E). Coll Aug 1981 by O Crumlin-Pedersen; subm by E Cinthio, Inst Archaeol, Univ Lund. Rept of study pub by collector (Crumlin-Pedersen, 1981). Two flint tools were found near blocking indicating human activity in area during Stone age. Samples pretreated with HCl and NaOH.

7380 ± 70

Lu-1999. Fotevik 1a/1981 *$\delta^{13}C = -25.2‰$*

Wood from part of oak trunk (No. D1872) with ca 60 annual rings preserved.

7070 ± 70

Lu-2000. Fotevik 3/1981 *$\delta^{13}C = -25.2‰$*

Wood from part of oak branch from surface of clay bottom below stones of blocking (Crumlin-Pedersen, 1981, p 27-28).

880 ± 45

Lu-2001. Fotevik 5/1981 *$\delta^{13}C = -25.4‰$*

Wood from pole of beech (diam 7 to 9cm) directly below planks of wrecked boat (Crumlin-Pedersen, 1981, p 14, 27-28).

7330 ± 70

Lu-2067. Kungstorp *$\delta^{13}C = -26.2‰$*

Sample from remnants of wooden construction in mouth of small stream near Kungstorp at bay Fotevik, S Scania (55° 26.3′ N, 12° 58.3′ E). Coll 1982 and subm by L Ersgård, Inst Archaeol, Univ Lund. Pretreated with HCl and NaOH.

5080 ± 60

Lu-2054. Kvarnby 1975, Structure 3 *$\delta^{13}C = -24.3‰$*

Charcoal from 4.4m depth in Neolithic flint mine at Kvarnby, S Scania (55° 35′ N, 13° 07′ E). Coll 1975 and subm by I Håkansson, Inst Archaeol, Univ Lund. For other dates from flint mines in area, see R, 1980, v 22, p 1058; 1981, v 23, p 398. Pretreated with HCl and NaOH.

410 ± 55

Lu-2012. Utvängstorp *$\delta^{13}C = -24.4‰$*

Wood from medieval relic, known as S:t Sigfrid's pilgrim staff, kept in church of Utvängstorp, Mullsjö dist, E Västergötland (58° 02′ 30″ N, 13° 52′ 30″ E). Subm by B Hjohlman, Skaraborg Co Mus. *Comment*: no pretreatment; small sample; diluted; 68% sample. (3 1-day counts.)

B. Ireland

Carrowkeel series

Peat and wood from bog in Treanscrabbagh Valley, N of Cairn B and WNW of Cairns C and D of Carrowkeel megalithic cemetery (Burenhult, 1980a, p 112-115), Bricklieve Mts, Co Sligo (54° 03′ N, 8° 23′ W). Coll Aug 1981 by H Göransson, M Thelaus, and M A Timoney; subm by H Göransson, Dept Quaternary Geol, Univ Lund and G Burenhult, Inst Archaeol, Univ Stockholm. Pollen analysis by H Göransson. Preliminary palynol results reported by Göransson (1981). Dating and palynol are parts of The Carrowmore Project (Burenhult, 1980a; 1980b; 1981). Results of previous study of peat deposits in Treanscrabbagh Valley pub by G F Mitchell (1951). For other dates from area, see R, 1961, v 3, p 28-29. Wood sample coll from surface of minerotrophic peat left after peat-cutting. Peat core coll using Russian-type peat borer. Depths refer to original bog surface at top of remaining peat wall close to sampling point (cf Göransson, 1981, fig 77, p 189).

5830 ± 65

Lu-1961. Carrowkeel, Sample I $\delta^{13}C = -26.5‰$

Minerotrophic peat, 397.5 to 402.5cm. Temporary decrease of *Quercus, Ulmus,* and *Alnus*; strong increase of *Betula* and microscopic charcoal particles. *Comment*: no pretreatment; small sample.

5640 ± 65

Lu-1962. Carrowkeel, Sample II $\delta^{13}C = -26.5‰$

Minerotrophic peat, 387.5 to 393cm. Very strong temporary increase of *Quercus*; increase of *Ulmus, Alnus,* and Gramineae; low *Betula* value. *Comment*: no pretreatment; small sample.

5270 ± 60

Lu-1963. Carrowkeel, Sample III $\delta^{13}C = -26.7‰$

Minerotrophic peat, 380 to 385cm. Start of *Plantago lanceolata* curve. *Comment*: no pretreatment; small sample.

4010 ± 55

Lu-1960. Carrowkeel, *Salix* $\delta^{13}C = -25.3‰$

Wood from stump (*Salix*) id by T Bartholin; depth 294cm. *Comment*: pretreated with HCl and NaOH.

Ballygawley Lough series

Gyttja from Ballygawley Lough (see Göransson, 1981, p 181), 5.8km SE of Carrowmore megalithic cemetery and ca 7km S of town of Sligo (54° 12.5′ N, 8° 28′ W). Coll Aug 1981 by H Göransson and M Thelaus; subm by H Göransson and G Burenhult. Dated as part of same project as Carrowkeel series, above. Depths refer to water surface. Water depth 0.9m at sampling point. No pretreatment; small samples.

Lu-2003. Ballygawley Lough, Sample 1 + 2 **3850 ± 85** $\delta^{13}C = -24.9‰$

Algal gyttja (230 to 235cm) and black detritus gyttja (225 to 230cm). *Comment*: Samples 1 and 2 were too small to date separately; undersized; diluted; 37% sample. (3 1-day counts.)

Lu-2005. Ballygawley Lough, Sample 3 **2490 ± 110**

Black detritus gyttja, 220 to 225cm. *Comment*: sample undersized; diluted; 22% sample. (3 1-day counts.) No ^{13}C measurement.

Lu-2021. Carrowmore, Strand Hill 1981 **5220 ± 60** $\delta^{13}C = -22.8‰$

Peat from deposit exposed at low sea level outside Strand Hill, ca 6km WNW of Carrowmore megalithic cemetery, Co Sligo (54° 16′ N, 8° 36′ W). Coll 1981 and subm by H Göransson and G Burenhult. For other dates from area, see Carrowmore Series I and II (R, 1981, v 23, p 399-402; 1982, v 24, p 211). Pretreated with HCl.

C. Greece

Lu-2052. Asine, Argolis **2820 ± 50** $\delta^{13}C = -24.1‰$

Charcoal from Layer 6b in settlement Area E of acropolis of Asine, Argolis region, NE Peloponnesus (37° 31′ 45″ N, 22° 52′ 30″ E). Coll 1972 by S Dietz; subm by B Wells, Dept Classical Studies, Univ Lund. Sample Assoc with Early Protogeometric pottery. Results of excavation will be pub by Wells (ms in preparation). Pretreated with HCl and NaOH.

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MOSCOW MV LOMONOSOV STATE UNIVERSITY RADIOCARBON DATES II SEA LEVEL INDICATORS FROM COASTAL USSR

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INTRODUCTION

The following list summarizes the post-1970 laboratory results of ^{14}C dating of ancient sea-level indicators from the coasts of the Soviet Union. One of the aims of the International Geologic Correlation Programme Project No. 61 "Sea level movements during the last deglacial hemicycle" is the global cataloguing and mapping of ancient sea levels. The laboratory, which acts as the USSR National curator for these age measurements obtains dates sampled from its own expeditions and from other institutions of the country.

The list of ^{14}C dated sea-level indicators from the Soviet coasts was sent to Walter S Newman, Queens College, City University of New York, at his request for use in an enlarged world catalogue and maps.

Global mapping and modeling require reference to the laboratory code (MGU) number[1], latitude-longitude position, present elevation, date, and material of each sea-level indicator. A brief site description is published below. Some of the dated sea levels are evidently tectonically deformed but that is not our concern here. For samples younger than 7000 ^{14}C years, we adduce not only the direct age measurements but also the corrected dates in parentheses. We have chosen for correction the dendrochronologic calibration curve of Michael and Ralph (1973).

^{14}C dating was performed by the liquid scintillation method. To exclude from dating recrystallized mollusk shells, we use an x-ray diffractometric method. For a brief description of measurement procedures and methodologic aspects, see Glushankova *et al* (1980) and Kaplin (1976).

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We thank P A Kaplin, the Head of the Laboratory, the Head of the National working group on Project No. 61 IGCP, for advice in our research. We are also greatly indebted to all of those who submitted samples for dating.

Arctic Ocean Coasts

MGU-IOAN-129. Spitzbergen Is **8360 ± 140**

Wood from ancient driftwood trunk, NE Barentz I. (78° 6′ N, 22° 2′ E), from scarp of limnodeltaic terrace, at 48m alt. Sample subm by M G Groswald, Inst Geog, Acad Sci, USSR.

[1] Dates obtained jointly with the Inst Oceanology, Acad Sci, USSR, are lettered MGU-IOAN.

Laptev Sea series

Samples subm by A Sidorchuk, Moscow State Univ.

840 ± 250
MGU-326. Yana River delta (880 ± 250)

Wood from main channel, left bank, 84km from mouth (71° 1′ N, 136° 1′ E). Sample from marine terrace at 8m alt.

1970 ± 150
MGU-327. Yana River delta (1870 ± 150)

Wood from main channel, left bank, 32km from mouth (71° 4′ N, 135° 8′ E). Sample from marine terrace at 6m alt.

3640 ± 300
MGU-329. Yana River delta (3850 ± 300)

Peat from main channel, right bank, 13km from mouth (71° 5′ N, 136° 2′ E). Sample from marine terrace at 2m alt.

Longa Strait series

Samples subm by L V Tarakanov, Moscow State Univ.

1370 ± 140
MGU-574. Billings Cape (1459 ± 140)

Peat from N lagoon coast, 0.9km W of Billings settlement (69° 8′ N, 176° 1′ E). Sample from ledge of bar at 2.5m alt.

3007 ± 170
MGU-575. Billings Cape (3116 ± 170)

Peat from N lagoon coast, 2.7km E of Billings settlement (69° 8′ N, 176° 2′ E). Sample from ledge of bar at 2.1m alt.

3650 ± 170
MGU-576. Billings Cape (3850 ± 170)

Peat from N lagoon coast, 7.2km E of Billings settlement (69° 8′ N, 176° 0′ E). Sample from ledge of bar at 1.8m alt.

Taimir series

Samples subm by M G Groswald.

MGU-450. Taimir Lowland 25,000 ± 250

Mollusk shells, 100% aragonite (*Mya truncata, Cytrodaria jenissea, Hiatella arctica, Astarte montagui striata*) from Ulakhan-Gurakh, right bank, 6km from Novaya R confluence, 45km NNW of Khatanga settlement (72° 3′ N, 102° 3′ E). Sample from marine terrace at 50 to 55m alt.

MGU-451. Taimir Lowland 30,000 ± 300

Mollusk shells (*Mya truncata, Hiatella arctica, Astarte montagui striata, Macoma calcarea, Cyrtodaria* sp) from Selebir R, upper reaches, 40km NW of Khatanga settlement (72° 2′ N, 102° 0′ E). Sample from marine terrace at 60m alt.

MGU-452. Taimir Lowland **15,300 ± 500**

Mollusk shells (*Mya* sp, *Astarte* sp, *Macoma* sp, *Hiatella* sp) from Ushkan Kamen Heights, Dudypta R, left bank, 90km from mouth of Boganida R at 120m alt (71° 8′ N, 93° 2′ E).

Far East Coasts

Western Kamchatka series

Samples coll by lab expedition; subm by V F Ivanov and L G Nikiforov.

MGU-IOAN-68. W Kamchatka **35,000 ± 700**

Wood from 5.5km N of Kihchik R mouth, 350m from lake shore (53° 6′ N, 156° 0′ E). Sample from scarp of terrace at 1m alt.

MGU-IOAN-185. W Kamchatka **37,000 ± 2100**

Buried peat from Utka R near Mitoga settlement (53° 0′ N, 156° 0′ E). Sample from scarp of terrace at 25 to 30m alt.

MGU-60. W Kamchatka **31,000 ± 900**

Wood from peaty layer from modern sea cliff in marine terrace at 6.2m alt (52° 9′ N, 156° 0′ E).

MGU-202. W Kamchatka **45,000**

Wood from same loc as MGU-IOAN-185 at 12.3m alt.

Chukotka series

Samples coll by lab expedition; subm by A A Svitoch and V S Khorev.

MGU-201. Chukotka **27,000 ± 2000**

Plant remains from Anadyr estuary, Dionisiy cape (64° 7′ N, 177° 3′ E). Sample from scarp of terrace at 23m alt.

MGU-311. Chukotka **31,500 ± 850**

Peat from Osinovaya R, right bank, 2km from mouth (64° 7′ N, 175° 0′ E). Sample from scarp of plane surface at 21.5m alt.

MGU-312. Chukotka **44,000**

Peat from same loc as MGU-311.

MGU-314. Chukotka **37,500 ± 800**

Wood from SW coast of Anadyr estuary, 1.5km N of Khluzny stream (64° 6′ N, 177° 3′ E). Sample from scarp of marine terrace at 7m alt.

7060 ± 200
MGU-320. Chukotka **(7740 ± 200)**

Peat from Anadyr estuary coast, 2km N of fishing factory (64° 6′ N, 177° 3′ E). Sample from scarp of 1st marine terrace at 2.2m alt.

7010 ± 160
MGU-321. Chukotka **(7680 ± 160)**

Plant remains from same loc as MGU-320 at 2.3m alt.

MGU-340. Chukotka **11,800 ± 200**

Peat from Onemen Bay coast (64° 5′ N, 176° 8′ E). Sample from scarp of marine terrace at 4.8m alt.

MGU-341. Chukotka **8950 ± 200**

Peat from same loc as MGU-340 at 2.9m alt.

MGU-342. Chukotka **8200 ± 100**

Peat and plant remains from same loc as MGU-320 (64° 6′ N, 177° 3′ E) at 3.9m alt.

MGU-383. Chukotka **11,600 ± 100**

Peat from Koluchinskaya inlet, rear part of Belyanka spit (67° 1′ N, 174° 7′ W) at 0.5m alt. Subm by L A Zhindarev, MGU.

Kresta Bay series

MGU-384. Kresta Bay **30,000 ± 1100**

Mollusk shell, 100% aragonite from Kresta (Cross) Bay, E coast, S of Perkla stream mouth (65° 7′ N, 178° 7′ W). Sample from scarp of marine terrace at 10.5m alt.

MGU-385. Kresta Bay **30,000 ± 380**

Mollusk shell, 100% aragonite from Kresta Bay, E coast, 8km N of Konergino settlement (66° 1′ N, 178° 6′ W). Sample from slope of watershed plain at 7.2m alt.

MGU-386. Kresta Bay **35,000 ± 530**

Mollusk shell, 100% aragonite from same loc as MGU-384 (65° 6′ N, 178° 7′ W) at 17.5m alt.

5900 ± 110
MGU-393. Kresta Bay **(6480 ± 110)**

Peat from same loc as MGU-320 (64° 6′ N, 177° 3′ E) at 1.6m alt.

MGU-394. Kresta Bay **7700 ± 320**

Plant remains from same loc as MGU-393 at 2.4m alt.

6120 ± 220
MGU-398. Kresta Bay **(6770 ± 220)**

Peat from same loc as MGU-394 at 1.6m alt.

Dionisiya River Mouth series

3150 ± 80
MGU-402. Dionisiya R **(3300 ± 80)**

Plant remains from excavation of ancient spit at 2.8m alt, 1.5km N of mouth (64° 7′ N, 177° 3′ E).

4180 ± 100
MGU-403. Dionisiya R **(4400 ± 100)**

Plant remains from same loc as MGU-402 at 2m alt.

MGU-454. Dionisiya R **4000 ± 100 (4360 ± 100)**

Peat from recent marine terrace at 0.5 to 1m alt (64° 7′ N, 177° 3′ E).

MGU-478. Dionisiya R **9900 ± 500**

Peat from crest of ancient spit (64° 6′ N, 177° 3′ E) at 4.5m alt.

MGU-455. Dionisiya R **4200 ± 120 (4500 ± 120)**

Peat from same loc as MGU-454 at 0.6m alt.

Japan Sea series

Samples coll by lab expedition and A M Korotky, Vladivostok, Geol Inst, Far East Sci Center, Acad Sci, USSR.

MGU-IOAN-227. Vostok Gulf **11,000**

Peat from 16m depth at 1.7 to 2m from basal surface (42° 8′ N, 132° 7′ E). Subm by A M Korotky.

MGU-IOAN-229. Barabashevka R mouth **7360 ± 160**

Peat from lagoonal deposits in scarp of terrace at 0.2m alt (42° 9′ N, 131° 4′ E). Subm by A M Korotky.

MGU-263. Partizanskaya R mouth **6260 ± 110 (6980 ± 110)**

Mollusk shells from marine terrace (42° 8′ N, 133° 0′ E). Sample from well at –9m alt; subm by A I Shlukov, MGU.

MGU-264. Partizanskaya R mouth **5790 ± 110 (6370 ± 110)**

Mollusk shells from same loc as MGU-263 at –6m alt.

MGU-305. Kievka Bay **38,000**

Peat from Chinchasovaya inlet, 2nd submerged terrace, 30m depth, 1.5km from coast at 0.15 to 3.4m from basal surface (42° 9′ N, 134° 0′ E).

MGU-307. Vostok Gulf **42,000**

Peaty silt from 2nd submerged terrace, 26m depth, 0.5 to 1m from basal surface (42° 8′ N, 132° 7′ E).

MGU-323. Chernaya R mouth **2880 ± 200 (2950 ± 200)**

Peat from scarp of lagoonal terrace at 3m alt (43° 1′ N, 134° 3′ E). Subm by A M Korotky.

MGU-324. Chernaya R mouth **4450 ± 100 (4890 ± 100)**

Peat from same loc as MGU-323 at 2.1m alt.

MGU-325. Zolotoy Rog Gulf (Golden Gulf) **29,000 ± 250**

Algae peat from 7.3m depth, 6.5 to 6.8m from basal surface (43° 1′ N, 131° 3′ E).

MGU-408. Zerkalnaya Bay **2950 ± 60**

Mollusk shells from 20m depth, 3.2 to 3.3m from basal surface (44° 1′ N, 135° 8′ E).

3300 ± 100
MGU-409. Rudnaya Bay **(3490 ± 100)**

Mollusk shells from 20m depth, 0.91 to 1.4m from basal surface (44° 2′ N, 135° 9′ E).

3950 ± 800
MGU-461. Zerkalnaya R mouth **(4320 ± 800)**

Coal overlying marine pebble from archaeol site on scarp of terrace at 1.8m alt (44° 0′ N, 135° 6′ E). Subm by V P Stepanov, MGU.

5700 ± 80
MGU-501. Zerkalnaya R mouth **(6300 ± 80)**

Wood from scarp of low flood plain at 1.5m alt (44° 0′ N, 135° 6′ E). Subm by S S Karpukhin, MGU.

MGU-515. Zerkalnaya Bay **10,680 ± 260**

Silt for analysis of humic acid fraction, 35m depth, in submerged terrace, 4 to 3.8m from basal surface (44° 1′ N, 135° 8′ E). Subm by A I Vvedenskaya, MGU.

MGU-516. Rudnaya Bay **12,190 ± 700**

Silt for analysis of humic acid fraction, 20m depth, in submerged terrace, 4.1 to 4.5m from basal surface (44° 2′ N, 135° 9′ E). Subm by A I Vvedenskaya.

MGU-518. Rudnaya Bay **10,300 ± 260**

Silt for analysis of humic acid fraction, 33m depth, in submerged terrace, 3.3 to 3.4m from basal surface (44° 2′ N, 135° 9′ E). Subm by A I Vvedenskaya.

1227 ± 120
MGU-538. Kema R mouth **(1270 ± 120)**

Wood from scarp of terrace at 1.8m alt, 0.6km from coastline (45° 4′ N, 137° 3′ E). Subm by A M Korotky.

1270 ± 30
MGU-539. Kema R mouth **(1320 ± 30)**

Wood from same loc as MGU-538 at 1.1m alt.

2270 ± 120
MGU-540. Kema R mouth **(2851 ± 120)**

Wood from 2.5km S of mouth from scarp of marine terrace at 3.7m alt. Subm by A M Korotky.

4320 ± 90
MGU-544. Valentin Bay **(4670 ± 90)**

Coal overlying marine pebble from archaeol site at Titova tombolo at 1.8m alt. Subm by V P Stepanov, MGU.

MGU-546. Kema R **2870 ± 50**
(2940 ± 50)

Peat from Khomushina stream mouth from scarp of lagoonal terrace at 1.2m alt (45° 3′ N, 137° 3′ E). Subm by A M Korotky.

MGU-559. Adimi Bay **2500 ± 170**
(2538 ± 170)

Wood from 2.5km S of Adimi R mouth from scarp of marine terrace at 2.2m alt (47° 2′ N, 139° 0′ E). Subm by A M Korotky.

MGU-608. Rudnaya Bay **2910 ± 600**
(3000 ± 600)

Silt lens in sand deposits from ancient spit at 1.7m alt, 1km S of Rudnaya R mouth (44° 1′ N, 135° 8′ E). Subm by A I Shlukov, MGU.

MGU-638. Peter the Great Gulf **28,000**

Peaty silt from 22m depth of submerged terrace, 3.3m from basal surface (42° 6′ N, 131° 3′ E). Subm by A V Porotov, MGU.

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SIMON FRASER UNIVERSITY RADIOCARBON DATES II

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This list reports measurements made on archaeologic samples by our laboratory from September 1980 to May 1982. Results of measurements made during that period which lack review by submitters will be reported in a subsequent date list. Dates were obtained by liquid scintillation counting of benzene using the laboratory procedure outlined previously (R, 1982, v 24, p 344-351). All dates are expressed in ^{14}C years relative to AD 1950 based on the Libby half-life for ^{14}C of 5568 yr. The laboratory standard continues to be ANU sucrose. Data analysis is now performed with the aid of an RT-11 microcomputer interfaced with our Packard model 3255 LS counter. Dates have been corrected for isotopic fractionation only when the $\delta^{13}C$ value is given. No corrections have been made for natural ^{14}C variations. The following descriptions of samples are based on information provided by the submitters.

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A. Canada

British Columbia

Shuswap house-pit series

Charcoal and bone from EdQs 14 site (50° 30′ 09″ N, 119° 04′ 06″ W) N side of Shuswap R, 6.43km E of township of Enderby. This site consists of 3 small (5m diam) house-pit depressions and 86 small (1 to 2m) circular, cellar cache-pit depressions. Previous archaeol research in region suggested that rectilinear house-pits were local architectural specialization and were in use for over 1000 yr, ca AD 650 to 1750. The following ^{14}C dates appear to confirm this hypothesis. Samples coll and subm by Gordon Mohs, Dept Archaeol, Simon Fraser Univ.

SFU-50. **490 ± 130**

Charcoal from S wall of House-pit I, 20cm below surface. Sample dates main occupational horizon within house pit.

SFU-51. **870 ± 180**

Charcoal from pocket of fire-cracked rock at base of main component of House-pit II, 20 to 30cm below surface. Sample dates upper occupational horizon within house pit.

SFU-56. **430 ± 100**

Charcoal from cultural deposits on floor of House-pit I, 60 to 70cm below surface. Sample dates main occupational horizon within House-pit I.

SFU-57. **980 ± 100**
$\delta^{13}C = -23.4‰$

Collagen extracted from deer antler from rimfall deposits on S side of House-pit I, 20 to 30cm below surface. This is only date of earlier component of site.

Kain Meat Cache site

SFU-73. **480 ± 100**
$\delta^{13}C = -17.9‰$

Collagen from unid. mammal bone in soil matrix 0 to 10cm beneath rock cairn at DiLw-12 site (49° 51′ 35″ N, 99° 49′ 45″ W). Sample dates this type of feature to Late Prehistoric period. Sample coll and subm by B A Nicholson, Dept Archaeol, Simon Fraser Univ.

Kain Butchering site

Collagen from unid. mammal bones excavated at DiLw-11 site (49° 51′ 30″ N, 99° 50′ 00″ W). Site contains at least two superimposed occupations. Samples coll and subm by B A Nicholson.

SFU-72. **1700 ± 100**
$\delta^{13}C = -18.8‰$

Collagen from mammal bone 50 to 70cm below surface.

SFU-75. **290 ± 100**
$\delta^{13}C = -18.8‰$

Collagen from mammal bone 10 to 25cm below surface.

Unnamed Site I

SFU-74. **1780 ± 100**
$\delta^{13}C = -18.8‰$

Collagen from unid. mammal bone from lower terrace at DiLx-3 site (49° 52′ 00″ N, 99° 55′ 10″ W). Sample coll and subm by B A Nicholson.

Canal Flats series

Charcoal and peat from EbPw-1 site (50° 11′ 00″ N, 115° 49′ 10″ W), E side of Columbia Lake, 3.2km N of Canal Flats. Site covers area 11ha and is characterized by 2 surface depressions and 2 pictograph panels. Samples coll and subm by Gordon Mohs.

SFU-77. **110 ± 80**

Charcoal from base of rock-lined pit depression 40 to 50cm below surface. Sample dates roasting pit. *Comment*: green residue present in combustion bomb after combustion indicates possible grease residue in sample.

SFU-78. **3160 ± 100**

Charcoal from charcoal lens adjacent to pictograph panel. As much ocher was recovered above and below this lens; sample subm to date panel.

SFU-79. **800 ± 80**

Charcoal from layer of hearth rock from floor of house pit 20 to 30cm below surface. Sample represents only known date for house pit occupation with Rocky Mt trench.

SFU-80. **480 ± 80**

Charcoal from post cavity on rim of roasting pit depression 30 to 40cm below surface.

SFU-89. **330 ± 80**

Charcoal from layer of hearth rock of roasting pit 20 to 30cm below surface. *Comment*: sample consistent with SFU-80 from same feature.

SFU-99. **100 ± 80**

Charcoal from layer of hearth rock near center of roasting pit 20 to 30cm below surface.

SFU-108. **140 ± 80**

Peat-like organic matter from rock-lined pit depression at base of roasting pit. *Comment*: date is consistent with SFU-77 and -99 from same feature.

Kitselas Canyon Series I

Charcoal excavated from Paul Mason site, GdTc-16 (54° 36′ 28″ N, 128° 25′ 04″ W), E side of Skeena R, Kitselas Canyon, 16km NE of Terrace. This is village site at + 138m. Samples subm to date beginning and length of occupation; coll and subm by G F MacDonald for Parks Canada, P O Box 2989, Calgary, Alberta.

SFU-132. **3130 ± 100**

Charcoal.

SFU-133. **3780 ± 120**

Charcoal.

SFU-134. **3230 ± 160**

Charcoal.

SFU-135. **890 ± 160**

Charcoal.

Edziza series

Charcoal, wood, and peat from archaeol survey of Mt Edziza region (57° 20′ to 35′ N, 130° 30′ to 45′ W). Samples coll and subm by Knut Fladmark, Dept Archaeol, Simon Fraser Univ.

SFU-129. **4870 ± 120**
$\delta^{13}C = -25‰$

Charcoal from 35 to 40cm below surface, overlying gray ash layer and underlying compact organic clays. Sample subm to date assoc flake artifacts from HiTp63. *Comment*: sample too small for base rinse. *Comment* (KRF): sample dates microblade component at Ohio level.

SFU-141. **2850 ± 160**
$\delta^{13}C = -24.3‰$

Charcoal from dark humic soil matrix 14 to 17cm below surface. *Comment*: sample too small for base rinse. *Comment* (KRF): sample dates non-microblade cultural occupation, HiTp1.

SFU-142. **1430 ± 160**
$\delta^{13}C = -25‰$

Wood from 25cm below surface, subm to date assoc obsidian flake artifacts. *Comment* (KRF): min limiting date on microblade component, HiTp1.

SFU-143. **260 ± 80**
$\delta^{13}C = -26.4‰$

Charcoal from bulk sample 7cm below surface. *Comment* (KRF): min limiting date for non-microblade component, HiTp1; actual age better represented by SFU-141.

SFU-144. **Modern**

Charcoal from hearth feature, 5 to 10cm below surface. *Comment* (KRF): feature is prehistoric, date must reflect recent contamination.

SFU-145. **600 ± 80**
$\delta^{13}C = -23.4‰$

Charcoal from 4 to 6cm below surface, subm to date assoc calcined bone and obsidian flakes. *Comment* (KRF): dates isolated hearth and flaking sta, HiTp1.

SFU-146. **8470 ± 120**
$\delta^{13}C = -27.1‰$

Peat from 115cm below surface, subm to date basal sediments. *Comment* (KRF): min age for stabilization of modern drainage and slopes, and beginning of organic sedimentation at modern tree line.

SFU-147. **3910 ± 120**
$\delta^{13}C = -23.5‰$

Charcoal. *Comment* (KRF): dates upper, non-microblade cultural level at HiTp63.

SFU-262. **1140 ± 80**
$\delta^{13}C = -25‰$

Charcoal from 8cm below surface, subm to date assoc concentration of flakes. *Comment* (KRF): min limiting date on microblade component.

SFU-263. **4990 ± 130**
$\delta^{13}C = -26.4‰$

Peat from 37cm below surface, subm to date lowest ash layer. *Comment* (KRF): directly overlies same ash overlain by SFU-129. I suggest that this date should be adjusted 1σ to 4860 BP.

4630 ± 100

SFU-264. $\delta^{13}C = -26.5‰$

Peat from 35cm below surface. *Comment* (KRF): directly antedates massive fall of coarse tephra and postdates earlier fine ash fall.

SFU-265. **Modern**

Peat overlying highest ash layer just below bog surface. *Comment* (KRF): top 10 to 20cm of bog affected by solifluction.

4560 ± 170

SFU-266. $\delta^{13}C = -25‰$

Peat underlying lowest ash layer, 40cm below surface. *Comment* (KRF): date is too recent, considering SFU-129 and -263 overlying same ash. I suggest 2σ adjustment to 4900 BP.

SFU-267. **Modern**

Peat overlying cinder layer 20cm below surface. *Comment* (KRF): too recent; sample probably affected by recent organic contamination or solifluction mixing.

Northwest Territories

Karluk Island series

Collagen from bones excavated at two sites on coast of Karluk (75° 30′ N, 97° 16′ W). Samples subm to determine Paleo-Eskimo occupation of Arctic Archipelago. Samples coll and subm by J W Helmer, Arctic Inst North America, Calgary, Alberta.

1440 ± 120

SFU-85. $\delta^{13}C = -21‰$

Collagen from mixed land mammal bone (Arctic fox, musk-ox, polar bear) excavated from midden site, QjLd-17, at S end of island, + 4 to 6m.

2530 ± 120

SFU-82. $\delta^{13}C = -21‰$

Collagen from Arctic fox bone. Sample coll from midden site, QjLd-21, on W coast of island, + 10 to 11m.

Bathurst Island series

Collagen from mammal bone excavated from two sites near tip of Markham Point, Bathurst. Samples coll and subm by J W Helmer.

1520 ± 200

SFU-87. $\delta^{13}C = -17.7‰$

Collagen from musk-ox bone and antler excavated at longhouse site, QiLf-25, + 7m.

2330 ± 120

SFU-81. $\delta^{13}C = -19.5‰$

Collagen from musk-ox bone excavated from tent-ring site, QiLf-4, + 11 to 12m.

Alberta

SFU-119. **2820 ± 80**
$\delta^{13}C = -19‰$

Collagen from bison bone excavated at Strathcona Science Park site, FiPi-29, Edmonton (53° 33′ N, 113° 22′ W). Bone is from bison-processing area of Middle Prehistoric lithic workshop and habitation site. Sample subm to date earliest occupation of site; coll and subm by Jon Driver, Dept Archaeol, Simon Fraser Univ. *Comment* (JD): date probably too late for earliest (Oxbow) component due to mixing and compressed stratigraphy.

Ontario

Fox Lake Project series

Charcoal from CdHk-3 site, Ontario (46° 36′ 45″ N, 81° 43′ 45″ W). Samples coll and subm by Christopher Hanks, Dept Sociol and Anthropol, Univ British Columbia. See also Hanks (ms) for additional information.

SFU-151. **690 ± 180**

Charcoal from feature believed to be hearth from Woodland period.

SFU-152. **170 ± 120**

Charcoal to date base of culture-bearing podzol layer.

SFU-153. **370 ± 90**

Charcoal from feature believed to be hearth of Woodland origin.

SFU-154. **610 ± 80**

Charcoal from feature believed to be hearth, assoc with single body sherd of ceramic vessel.

SFU-155. **1450 ± 250**

Charcoal from feature believed to be hearth with Late Woodland assoc.

SFU-169. **480 ± 260**

Charcoal from feature related to Woodland period occupation.

SFU-170. **1320 ± 700**

Charcoal from feature consisting of reduction flakes made of graywacke. *Comment*: sample too small for base rinse.

SFU-171. **1840 ± 350**

Charcoal subm to date base of culture-bearing podzol layer.

Peace River Series I

Charcoal and bone from HbRf-62 site (56° 11′ 47″ N, 120° 55′ 35″ W), from low terrace at confluence of Peace and Moberly Rivers, + 426m. Samples coll and subm by Diana Alexander for Peace River Archaeol Proj, Dept Archaeol, Simon Fraser Univ.

SFU-165. **3750 ± 280**

Charcoal from 20 to 25cm below surface, subm to date assoc lithic and bone material.

SFU-166. **3650 ± 300**
$\delta^{13}C = -20.4‰$

Collagen from antler 25 to 30cm below surface. Sample subm to date assoc lithic concentration.

Vallican Series I

Charcoal from DjQj-1 site (49° 33′ 23″ N, 117° 39′ 15″ W), from 2nd and 3rd major terrace above Slocan R, 0.7km NW of confluence of Little Slocan and Slocan Rivers. Village and burial site with 2000 yr min occupation. Samples date several cultural depressions; coll and subm by Gordon Mohs.

SFU-175. **260 ± 100**

Charcoal from base of matrix containing Late Prehistoric material 15 to 20cm below surface. Sample subm to date max age of Late Prehistoric deposits and assoc quartz crystal microblade core.

SFU-176. **Modern**

Charcoal from hearth 27 to 29cm below surface in circular cultural depression. Sample subm to date depression and assoc artifacts.

SFU-177. **1250 ± 120**

Charcoal from burial cavity 20 to 30cm below surface. Sample subm to date burial.

SFU-178. **260 ± 200**

Charcoal from hearth 55 to 60cm below surface. Sample subm to determine amount of embankment slumpage and river erosion at site.

SFU-179. **480 ± 200**

Charcoal from concentration of faunal remains 3 to 6cm below surface. Sample subm to date latest occupation of cultural depression during Late Prehistoric period.

SFU-180. **1040 ± 110**

Charcoal from black soil matrix within circular house-pit depression. Sample subm to date occurrence of circular house-pit type.

SFU-181. **1780 ± 80**

Charcoal from hearth 45 to 65cm below surface. Sample subm to date earliest occupation of cultural depression.

SFU-182. **1170 ± 260**

Charcoal from hearth 58 to 80cm below surface. Sample subm to establish intermediate date of occupation of cultural depression.

SFU-183. **860 ± 400**

Charcoal from soil matrix 85 to 87cm below surface in cultural depression. Sample subm to date occupation of depression.

SFU-184. **790 ± 150**

Charcoal from hearth 25 to 29cm below surface in rectangular depression. Sample subm to date period of Kutenai occupation of site.

SFU-185. **220 ± 100**

Charcoal from soil matrix 13 to 25cm below surface in cultural depression. Sample subm to date latest occupation.

SFU-186. **980 ± 250**

Charcoal from hearth 13 to 20cm below surface in cultural depression. Sample subm to determine min age that small circular depressions were used in Slocan area.

SFU-187. **Modern**

Charcoal from hearth 5 to 20cm below surface in cultural depression. Sample subm to date upper component of depression.

SFU-188. **700 ± 110**

Charcoal from soil matrix 23 to 30cm below surface in circular house-pit depression. Sample subm to date upper component of house-pit and assoc midden deposits.

SFU-189. **1020 ± 150**

Charcoal from soil matrix 52 to 54cm below surface in house-pit depression. Sample subm to date lower component of house-pit and assoc tools.

SFU-190. **1860 ± 150**

Charcoal from hearth 90 to 100cm below surface in house-pit depression. Hearth feature probably antedates construction of house-pit; sample thus establishes max date of use of house-pit.

SFU-191. **750 ± 90**

Charcoal from hearth 47 to 52cm below surface located centrally within platform excavated into terrace embankment. Sample subm to date occupation of feature.

SFU-192. **110 ± 80**

Charcoal from hearth 25 to 35cm below surface in platform excavated into terrace. Sample subm to date utilization of feature.

SFU-193. **700 ± 100**

Charcoal from lowermost component of house-pit depression. Sample subm to date earliest occupation of house pit.

SFU-194. **760 ± 140**

Charcoal from base of platform 40 to 43cm below surface. Sample subm to date utilization of feature.

SFU-198. **2210 ± 180**

Charcoal from hearth 44 to 50cm below surface in circular house-pit depression. Sample subm to date use of house pit.

B. Tanzania

Tanzania Series I

Charcoal from DkBl1 sites. Samples coll and subm by F T Masao, Nat Mus Tanzania, Dar Es Salaam.

SFU-137. **2020 ± 360**

Charcoal from 1.1m below surface from gravel layer in silty matrix. Sample subm to date assoc lithic artifacts.

SFU-138. **2290 ± 100**

Charcoal from 0.8m below surface in layer of compacted silty clay. Sample subm to date assoc microlithic artifacts.

SFU-139. **2230 ± 160**

Charcoal from 0.8m below surface in layer of compacted silty clay. Sample subm to date assoc microlithic artifacts.

SFU-140. **2590 ± 120**

Charcoal from 70 to 80cm below surface in layer of silty gravel. Sample subm to date assoc microlithic and megalithic artifacts.

C. Fiji

1000 ± 100

SFU-118. Rotuma $\delta^{13}C = -17.5‰$

Collagen from human bone excavated from site Rot 2-9, Risumu, Dist Oinafa (12° 27′ 28″ S, 177° 21′ 34″ E). Sample from 90 to 100cm below surface dates site on Rotuma where first Tongan immigrants landed. Sample coll and subm by Richard Shutler, Jr, Dept Archaeol, Simon Fraser Univ. *Comment* (RS): according to Rotuman mythology, Risumu is site where first Tongans landed. Therefore, it is probable that this sample dates Tongan arrival.

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[RADIOCARBON, VOL 25, NO 3, 1983, P 908-918]

TALLINN RADIOCARBON DATES VII

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This list comprises age measurements carried out at the Institute from 1979 to 1981. Anticoincidence variant was applied to attain higher counting efficiency of a 2-channel scintillation device. The introduction of a plastic scintillator as an active guard around the detector in the 2π geometry decreases the influence of high energy cosmic radiation and reduces the background ca 35 to 75% (Rajamäe & Punning, 1980). The application of an active guard with 4π geometry has proved most effective; as a result, the background decreased 85% to 0.65cpm with the volume of scintillation cocktail 5ml. We have improved our methods for decreasing the actual error of the background. The application of a control channel and consideration of barometric effect results in the increase of dating limits of up to 5000-6000 years (Rajamäe, 1981). Samples are calculated using a half-life of 5568 ± 30 years for ^{14}C. Results are reported in years before 1950. $\delta^{13}C$ measurements were performed on the mass-spectrometer MI-1201 and are reported with PDB as a reference standard. The reproducibility of results is ±0.2‰.

GEOLOGIC SAMPLES

Estonian SSR

Männikjärve series

Männikjärve Bog, ca 300ha, lies on S slope of Pandivere upland and belongs to Endla Bog system. Organic deposits, 765m thick are made up of 490cm bog peat, 50cm transition peat, 110cm mire peat. Peat deposits overlie sapropel, 150cm thick. Samples coll and pollen analyses 1978 by M Ilomets, Inst Geol, Acad Sci, ESSR.

Lab no.	^{14}C date	Depth (cm)	Sample	Degree of decomposition
Tln-364	690 ± 50	77-87	*Sphagnum* peat	8
-365	1450 ± 50	186-196	*S fuscum* peat	5
-394	1970 ± 50	235-245	*Sphagnum* peat	10
-366	2060 ± 40	286-296	*S fuscum* peat	5
-396	2780 ± 50	353-363	*Sphagnum* peat	5
-397	3340 ± 60	468-478	Medium peat	5
-367	3510 ± 80	500-510	Transitional *sphagnum* peat	25
-368	4370 ± 80	590-600	Fen peat	15
-395	4390 ± 50	646-656	Fen sedge peat	25
-369	9430 ± 70	743-753	Sapropel	—

Leeni series

Leeni Bog, 180ha, lies on SW slope of Sakala upland ca 20km from town of Kilingi-Nomme. Peat coll by hand-drilling in central part of bog from deposit, 470cm thick, of which 380cm is peat. Samples coll and pollen analyses 1978 by M Ilomets.

Lab no.	^{14}C date	Depth (cm)	Sample	Degree of decomposition
Tln-402	200 ± 50	80-88	*Sphagnum* peat	10
-403	690 ± 40	160-170	Tussock *sphagnum* peat	5
-405	1000 ± 50	224-234	*S fuscum* peat	12
-404	1750 ± 40	268-276	*Sphagnum* peat	12
-379	2170 ± 40	323-331	*S fuscum* peat	10
-377	2420 ± 40	344-352	*Sphagnum* peat	30
-399	4080 ± 40	388-396	Transitional reed peat	70
-400	7770 ± 50	420-428	*Sphagnum* reed peat	20
-401	8320 ± 100	454-462	Sapropel	—

Tln-384. Korveküla **48,000 +11,000 −4460**

Upper part of sapropel from borehole 10km N of Tartu. Sapropel overlain by sandy loam and sands with organic remains. Sample dated on humus separated from sapropel. Coll 1978 by J M Punning and R Rajamäe.

Tln-398. Tostamaa **4920 ± 40**

Charred wood remains from 400cm depth, windward slope of dune, Tostamaa peninsula. Coll 1978 by E Martin, Inst Geol.

Tln-413. Viitka **10,950 ± 80**

Plant remains from borehole near Viitka settlement, SE Estonia. Sandy loam with organic remains underlies reddish brown till, 350cm thick. Coll 1979 by E Liivrand, Inst Geol.

Tapa series

Tln-430. Tapa **8470 ± 70**

Peat underlying lacustrine marl, 320cm thick, near town of Tapa, N Estonia. Palynol data by R Männil dates accumulation of marl to Boreal (Martma, Punning, & Putnik, 1981). Coll 1979 by T Martma and H Putnik, Inst Geol.

Tln-516. Tapa **6650 ± 50**
$\delta^{13}C = -5.4‰$

Lake marl from depth 80 to 90cm.

Tln-517. Tapa **7880 ± 60**
$\delta^{13}C = -5.7‰$

Lake marl from depth 180 to 190cm.

Tln-519. Tapa **9160 ± 80**
$\delta^{13}C = -4.2‰$

Lake marl from depth 310 to 320cm from contact with underlying peat. Results show that effect of "hard" water has made sample older.

Karuküla series

Tln-443. Karuküla **≥51,000**

Large tree trunk from intermorainic deposits in Karuküla sec, Borehole 2, in SW Estonia, near town of Kilingi-Nomme. Structure of section: humus horizon, till, sand, organic deposits (wood peat with wood remains, sapropelite), silt. Dated on cellulose fraction. Coll 1979 by J M Punning and R Rajamäe.

Tln-461. Karuküla **≥52,000**

Same as Tln-443. Dated on lignin fraction.

Tln-452. Karuküla **≥51,000**

Same as Tln-443, Borehole 5. Dated on cellulose fraction.

Tln-466. Karuküla **≥52,000**

Same as Tln-452. Dated on lignin fraction.

Kunda series

Tln-497. Kunda **5670 ± 50**

Well-decomposed peat, 200cm thick, overlying lake marl from bog near Kunda, at depth 115 to 120cm. Coll 1980 by R Karukäpp, Inst Geol.

Tln-501. Kunda **8530 ± 70**

Well-decomposed peat at depth 196 to 198cm.

Tln-500. Kunda **9180 ± 300**

Well-decomposed peat from basal layer at depth 198 to 200cm.

Lahepera series

Lake, 102ha, E Estonia from relatively deep depression comprising thick sapropel layer (mean thickness 6 to 8m, max 13m). Three stages of lake development assoc with evolution of Peipsi-Pihkva lake basin. Mean accumulation rate of sapropel is 0.7 to 0.9mm/yr. In different climatic periods deposition rate fluctuated from 0.5 to 1.6mm/yr depending upon depth of basin (Palu *et al*, 1981). Coll 1981 by Ü Paap, Inst Geol.

Tln-547. **1020 ± 60**

Depth 220 to 230cm.

Tln-548. **1560 ± 140**

Depth 270 to 280cm.

Tln-499. **2250 ± 130**

Depth 400 to 410cm.

Tln-502. **2860 ± 70**

Depth 510 to 520cm.

Tln-503. **6680 ± 80**

Depth 810 to 820cm.

Tln-504. **8180 ± 80**

Depth 890 to 900cm.

Latvian SSR

Tln-475. Vetsatiki **38,000 +3500 −2400**

Organic submorainic deposits from sec near Vetsatiki farm, Satiki settlement, Saldusi dist. Acccording to M Krukle, Geol Bd, Council Ministers, Latvian SSR, peat with sandy sapropel, 30cm thick, underlies till (60cm) and gray clay (170cm). Dated on biodetritus fraction $\geqslant$ 1mm. Coll 1978 by M Krukle.

Tln-480. Shupulkalni **10,600 ± 50**

Wood peat from sec near Shupulkalni farm, Gubensky dist. Peat layer, 10cm thick, underlies medium sands, 180cm thick. Coll 1980 by J M Punning and R Rajamäe.

Tln-483. Lejasciems **36,000 +3300 −2300**

Submorainic organic deposits on right bank of Gauja R near Lejasciems settlement. Scattered plant macrofragments overlain by till (550cm), medium sands with cryoturbation structures (85cm). According to pollen analysis by O Kondratiene (Arslanov *et al*, 1975) pollen types characteristic of periglacial flora prevail in submorainic complex. Earlier ^{14}C dates for same sec by H Arslanov are 32,260 ± 730: Lu-159 and 34,500 ± 790: Lu-311B (Arslanov *et al*, 1975). Coll 1980 by R Vaikmäe, K Joers, and R Rajamäe, Inst Geol.

Lithuanian SSR

Ratnichja section series

Exposure near estuary of Ratnichja R, town of Drusnininkai. Gyttja and peat with wood remains underlie sandy-clayey deposits. According to palynol data by O Kondratiene (1965) organic deposits are of Mikulian age. Deposits were dated previously by ^{14}C lab in Vilnius to 27,400 ± 440: Vs-56 (wood); 36,800 ± 1300: Vs-57 (peat) and by Tartu ^{14}C lab as 40,860 ± 50: TA-441 (wood) and 40,560 ± 600: TA-440 (peat) (Vonsavicius & Baltrunas, 1974). Coll 1977 by V Vonsavicius, Geol Bd, Council Ministers, Lithuanian SSR.

Tln-310. **$\geqslant$50,000**

Lignin fraction from wood in lowermost part of organic layer.

Tln-311. **$\geqslant$50,000**

Cellulose fraction from same wood.

Tln-406. **$\geqslant$50,000**

Cellulose fraction from wood in upper part of organic layer.

Tln-445. **≥50,000**

Peat from upper part of organic layer.

Tln-467. Dange **39,000 +1200 −1000**

Organic deposits from right bank of Dange R near Gvildziai settlement overlain by reddish brown till (100cm), various-sized sands (710cm), and silts (45cm). Coll 1978 by M Krukle. Dated on fraction insoluble in cold alkaline solution.

Tln-481. Dange **≥55,000**

Fraction soluble in cold alkaline solution from Tln-467.

Byelorussian SSR

Tln-414. Borisova Gora **≥53,000**

Wood remains from Borisova Gora, right bank of Zapadnaya Dvina R near town of Surazh. Sample from humus horizon overlying limestone and overlain by till. Coll 1980 by J M Punning and R Rajamäe.

Tln-424. Konevichi **35,000 ± 1300**

Peat from intermorainic deposits in scarp on left bank of Konevichi stream, flowing into Zapadnaya Dvina R. Clay loam with layers of well-decomposed peat overlain by till (ca 800cm) and sands (to 500cm). Coll 1979 by R Vaikmäe, K Joers, and R Rajamäe.

Tln-451. Konevichi **33,000 ± 950**

Peat (biodetritus) from same layer as Tln-424. Dates on fraction ≥0.25mm.

Kasplyane section series

Sec in scarp on right bank of Kasplyane R ca 5km upstream from town of Surazh. Sec from top downwards: fine sand (175cm), purple till (480cm), and silt with layers of plant detritus (observable thickness, 210cm). Coll 1979 by R Vaikmäe, K Joers, and R Rajamäe. Dated on fraction of biodetritus ≥0.25mm insoluble in alkaline solution.

Tln-425. **18,850 ± 80**

Sample from depth 20 to 30cm below moraine base.

Tln-473. **18,480 ± 470**

Sample from depth 80 to 85cm below moraine base.

Tln-472. **19,900 ± 180**

Sample from depth 110 to 115cm below moraine base.

Brigitpole section series

Sec lies on left bank of Zapadnaya Dvina R near Brigitpole settlement, ca 3km upstream from town of Surazh. Sec from top downwards: sands of different grain sizes (530cm), till (150cm), fine sand with scattered plant detritus (65cm), clayey silt with layers of plant detritus (observable thickness, 65cm). Coll 1979 and 1980 by J M Punning and R Rajamäe. Inversion in ages may be due to allochthonous bedding of organic remains (Punning *et al*, 1982).

Tln-426. **30,000 ± 250**

Coll 1979 from topmost layer of organic remains ca 40cm below moraine base.

Tln-429. **17,300 ± 80**

Plant detritus from solifluction lenses ca 150cm below moraine base. Coll 1979.

Tln-438. **18,060 ± 90**

Coll 1979 from depth 150cm below moraine base.

Tln-484. **18,600 ± 130**

Coll 1980 from depth 140cm below moraine base.

Tln-482. **21,000 ± 110**

Coll 1980 from depth 150cm below moraine base.

Drichaluki section series

Sec in scarp on left bank of Usvyacha R (right tributary of Zapadnaya Dvina R) 2.5km upstream from town of Surazh. Sec from top downwards: clay loam (95cm), sands of different grain sizes (20cm), till (125cm), varved clay (25cm), fine sand (110cm), silt with interlayers of plant remains (100cm). Dates from ^{14}C lab at Leningrad State Univ on plant remains place culmination of last glacial transgression at ca 17,000 to 18,000 yr ago (Arslanov *et al*, 1971). Recurrent field work (1972-1980) and ^{14}C dates showed that submorainic plant detritus represents mixture of primary and redeposited (Mikulian?) organic matter (Punning *et al*, 1982). Coll 1979 and 1980 by J M Punning and R Rajamäe.

Tln-435. **18,100 ± 500**

Picea remains separated from macrofragments and sampled from depth 170cm below moraine base, id. by M Ilomets.

Tln-437. **18,700 ± 1000**

Betula nana remains separated from macrofragments by M Ilomets from same sample as Tln-435.

Tln-469. **15,960 ± 180**

Coll 1979 from depth 280cm below moraine base.

Tln-508. **22,000 ± 450**

Coll 1980 from same depth as Tln-469.

Tln-471. **17,880 ± 240**

Coll 1979 from depth 140cm below moraine base.

Tln-487. **19,760 ± 240**

Coll 1980 from same depth as Tln-471.

Tln-470. **20,000 ± 150**

Coll 1979 from depth 110cm below moraine base.

Tln-486. **19,700 ± 220**

Coll 1980 from same depth as Tln-470.

Arkhangelsk and Murmansk Districts of RSFSR

Tln-383. Koleshki **$47,000^{+5900}_{-3400}$**

Peat from sec in scarp on right bank of Vaga R, tributary of Severnaya Dvina R, ca 3km downstream from estuary of Koleshki R. Sample from upper part of *Bryales* peat layer at alt +550 to 590cm. Coll 1979 by R Rajamäe.

Tln-410. Varzuga **≥52,000**

Shells (*Chlamus islandica*) from sec on left bank of Varzuga R near village of Pletnego Poroga. Shells embedded in marine deposits overlain by till. Coll 1978 by R Rajamäe.

Tln-411. Varzuga **≥51,000**

Shells (*Macoma calcarea*) from same complex as Tln-410.

Tln-439. Imandra **8860 ± 60**

Peat underlying marine deposits from depth 135 to 140cm on bank of Imandra Lake. Coll 1979 by B Koshetchkin, Inst Geol, Kola Branch, Acad Sci, USSR.

Tln-474. Sija **≥55,000**

Wood remains from Sija sec on left bank of Severnaya Dvina R. Sample from clayey silt overlying sands with shells. Coll 1978 by R Rajamäe.

West Spitsbergen

Tln-363. Semmeldalen **4010 ± 40**

Plant detritus from 60m terrace in Semmeldalen valley. Coll by L Troitsky, Inst Geog, Acad Sci, USSR.

Wijdefjorden series

Samples coll from estuaries of valleys Helmdalen and Reinbokdalen. Dates help establish rate of neotectonic uplifts in N part of West Spitsbergen. Coll 1978 by L Troitsky.

Tln-375. Reinbokdalen **8680 ± 60**

Shells from surface of 10m terrace.

Tln-372. Reinbokdalen **9650 ± 50**

Shells from 50m terrace.

Tln-334. Reinbokdalen **9330 ± 70**
Shells from 60m terrace.

Tln-376. Helmdalen **8460 ± 50**
Shells from 4m terrace.

Tln-374. Helmdalen **8910 ± 60**
Shells from 10m terrace.

Tln-370. Helmdalen **8980 ± 60**
Shells from 20m terrace.

Tln-371. Helmdalen **9440 ± 60**
Shells from 30 to 35m terrace.

Tln-373. Helmdalen **9460 ± 70**
Shells from surface of 50m terrace.

Faksedalen series

Samples from moraine before Gulfaksedalen glacier in Faksedalen valley (Grosswald, 1972). Coll 1978 by L Troitsky.

Tln-388. **8530 ± 70**
Shells in sand layer at alt 4m above river level.

Tln-381. **8610 ± 60**
Shells in till at alt 13m above river level.

Tln-378. **8990 ± 50**
Shells in till at alt 20m above river level.

Tln-380. **9480 ± 80**
Shells in till at alt 40m above river level.

Tln-389. **9310 ± 80**
Shell fragments on surface of distal slope of till ridge at alt 45m above river level.

Tln-393. **7680 ± 60**
Wood from till at alt 10m above river level.

Lomfjord series

Samples from marine terraces in estuary of Fakseelva R flowing into Lomfjord. Coll 1978 by L Troitsky.

Tln-385. **8910 ± 60**
Shells from 11m terrace.

Tln-386. **8610 ± 50**
Shells from 20m terrace.

Tln-392. **8670 ± 70**

Shells from 32m terrace.

Tln-387. **9050 ± 50**

Shells at depth 3m in 40m terrace.

Tln-382. **9480 ± 50**

Shells from surface of 70m terrace.

Tln-390. Reindalen **8730 ± 90**

Shells from surface of 35m terrace in lower part of Reindalen valley near Pluto hut. Coll 1978 by A Makejev, Inst Geog.

Adventdalen series

Peat deposit, 200m thick on left bank of Adventdalen valley. Coll 1979 by L Troitsky.

Tln-427. **4700 ± 60**

Peat from depth 20 to 25cm.

Tln-428. **5470 ± 70**

Peat from depth 75 to 85cm.

Tln-436. **5570 ± 60**

Peat from depth 120 to 130cm.

Wijdefjorden series

Samples from sea terrace in central part of Wijdefjorden on Dirksodden cape. Coll 1979 by L Troitsky.

Tln-442. **9200 ± 100**

Hiatella arctica and *Mya truncata* from 13m terrace in valley of Kunna R.

Tln-447. **9380 ± 110**

Hiatella arctica and *Mya truncata* from 18m terrace.

Tln-446. **9580 ± 70**

Hiatella arctica and *Mya truncata* from 23 to 24m terrace near Reitern Lake.

Tln-468. **9000 ± 330**

Hiatella arctica and *Mya truncata* from 26 to 27m terrace near Reitern Lake.

Tln-441. **9360 ± 60**

Mya truncata from 30 to 32m terrace near Reitern Lake.

Tln-449. Brögger **9390 ± 80**

Chlamus islandica, Serriptes groenlandicus, and *Mya truncata* from till surface near glacier margin W Brögger. Coll 1979 by L Troitsky.

Caucasus

Tln-416. Bezengi **8000 ± 350**

Finely dispersed coal particles from buried soil in lower part of exposure near estuary of left tributary of Cherek-Bezengi R. Buried soil overlain by 5 till horizons in zone of Jukakhiiskyi marginal glacier formations. Pollen analysis by L Serebryannyi dates formation of soil to Early Holocene. Coll 1977 by N Golodkovskaya and L Serebryannyi, Inst Geog.

Halde series

Bog is near Halde village in depression of hummocky till. Peat deposit, 170cm thick, lies on till. Coll 1979 by J M Punning and L Serebryannyi.

Tln-478. **1270 ± 50**

Grayish-black peat from depth 50 to 55cm.

Tln-477. **1700 ± 70**

Brownish-black peat from depth 95 to 100cm.

Tln-476. **1870 ± 50**

Brownish-black peat from depth 145 to 150cm.

GEOCHEMICAL SAMPLES

In order to adjust coefficients of fractionation of carbon in different types of plants and to establish variations in ^{14}C activity in atmosphere (C_3 and C_4) variable terrestrial and aquatic plants coll in S Estonia 1978-1980. CO_2 samples coll from atmosphere during vegetational period (Punning *et al*, 1981). Coll by T Pärnik, Inst Experimental Biol, Acad Sci, Estonian SSR.

Lab no.	Colln date	Species	^{14}C ‰	$\delta^{13}C$ ‰	Δ ‰
Tln-355	1978	*Zea mays*	+367 ± 6.0	−11.0	+329
-358	1978	*Lathyrus pratensis*	+339 ± 5.0	−25.7	+341
-359	1978	Carex	+332 ± 5.0	−25.5	+333
-418	1978	CO_2 from atmosphere	+360 ± 7.4	−15.8	—
-453	1979	Phragmites	+335 ± 6.0	−26.6	+340
-460	1979	*Typha latifolia*	+320 ± 6.5	−27.8	+333
-454	1979	*Betula*	+341 ± 6.0	−28.2	+351
-450	1979	*Zea mays*	+371 ± 7.5	−13.4	+340
-465	1979	CO_2 from atmosphere	+365 ± 6.0	−13.8	+334
-505	1980	*Betula*	+324 ± 5.5	—	—
-506	1980	*Typha latifolia*	+306 ± 7.0	—	—
-518	1980	*Zea mays*	+343 ± 6.0	—	—
-515	1980	CO_2 from atmosphere	+326 ± 8.0	−10.7	+287
-549	1981	*Medicago*	+296 ± 4.5	—	—
-550	1981	*Betula*	+294 ± 7.0	—	—
-551	1981	*Typha latifolia*	+298 ± 8.0	—	—

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UNIVERSITY OF GEORGIA RADIOCARBON DATES VII

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Radiocarbon dates reported in this date list are totally derived from a cooperative effort between the Romanian Institute of Geology and Geophysics and the Center for Applied Isotope Studies (CAIS). The project was carried out between 1972 through 1978. The purpose of the study was to add to the knowledge of the various stages of the Holocene development of the Danube and Black Sea (Ghenea *et al,* 1971; Panin, 1976).

The Center continues to use the benzene method for sample preparation, liquid scintillation counting, and operational procedures as reported in Date List V (Noakes and Brandau, 1976). Ages quoted for this date list are calculated with a 1σ counting error which includes statistical variation of sample count as well as background and standard. The modern standard used was the 95% NBS oxalic acid with reference year of 1950.

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DANUBE DELTA AND BLACK SEA LITTORAL DEPOSITS

Sample coll from deltaic and shallow marine Black Sea sediments of Danube Delta, fore-delta area, and from borings in fluvial deposits of tributaries of Ialomita R in Romanian sub-Carpathian region. Samples consisted largely of mollusk shells, peat, and some bone. When omitted, geog coordinates are same as previous sample. Depths are given in meters.

GEOLOGIC SAMPLES

Romania

Letea-Caraorman Spit series

Shell deposits of initial Letea-Caraorman Spit (Panin, 1976).

UGa-703. (R-8) 35,100 ± 1620

(Paphia senescens, Paphia discrepans) 2.5m (45° 12′ 12″ N, 29° 24′ 24″ E), coll by D C Jipa.

UGa-701. (R-13-e) **>40,000**
(*Ostrea edulis*) 2.5m (45° 12′ 08″ N, 29° 24′ 10″ E), coll by N Panin.

UGa-890. (R-13-a) **11,600 ± 120**
(*Cardium edule*) 3m, coll by S Panin.

UGa-891. (R-13-b) **15,010 ± 160**
(*Chione gallina*, Crisan) 3m, coll by S Panin.

UGa-892. (R-13-c) **24,200 ± 450**
(*Thericium vulgatum*) 3m, coll by S Panin.

UGa-1152. (R-13-d) **39,600 ± 5400**
(*Chlamys glabra*) 3m, coll by S Panin.

UGa-702. (R-1542) **25,000 ± 540**
(*Ostrea edulis, Paphia* sp, *Gastrana fragilis, Chione gallina*) 3m (45° 12′ 02″ N, 29° 24′ 06″ E), coll by S Panin.

UGa-893. (R-1544) (*Cardium edule*) **6900 ± 80**
2.8m (45° 12′ 00″ N, 29° 24′ 10″ E), coll by S Panin.

UGa-1032. (R-1544) (*Chione gallina*) **2960 ± 70**
2.8m, coll by S Panin.

UGa-1044. (R-1544) (*Paphia senescens*) **13,880 ± 150**
2.8m, coll by S Panin.

UGa-1052. (R-1544) (*Ostrea edulis*) **19,680 ± 380**
2.8m, coll by S Panin.

UGa-1061. (R-1544) (*Donax trunculus*) **5270 ± 80**
2.8m, coll by S Panin.

UGa-1062. (R-1544) (*Thericium vulgatum*) **30,850 ± 5500**
2.8m, coll by S Panin.

UGa-1176. (R-1544) (*Mytilus galloprovincialis*) **4320 ± 90**
2.8m, coll by S Panin.

UGa-713. (R-1742) **11,200 ± 130**
(*Ostrea edulis, Cardium edule, Solen vagina,* etc) 2m (45° 16′ 22″ N, 29° 26′ 56″ E), coll by S Panin.

UGa-700. (R-1547), Grindul Răducu **29,780 ± 950**
(*Ostrea edulis, Mytilus galloprovincialis*) 2.5m (45° 12′ 45″ N, 29° 25′ 11″ E), coll by S Panin.

UGa-1153. (R-1672) (*Paphia senescens*) **>40,000**
0.5m (45° 10′ 10″ N, 29° 23′ 20″ E), coll by D C Jipa.

UGa-1154. (R-1672) (*Cardium edule*) **10,600 ± 240**
0.5m, coll by D C Jipa.

UGa-1155. (R-1672) (*Chione gallina*) 7400 ± 200
0.5m, coll by D C Jipa.

UGa-1157. (R-1672)
(*Mytilus galloprovincialis*) 10,100 ± 230
0.5m, coll by D C Jipa.

UGa-1186. (R-1672) (*Paphia discrepans*) 10,190 ± 290
0.5m, coll by D C Jipa.

UGa-1818. (R-2152) 10,420 ± 330
(*Chione gallina*) 2m (45° 06′ 00″ N, 29° 21′ 00″ E), coll by N Panin.

UGa-879. (R-1662) (*Cardium edule*) 9130 ± 100
2m (45° 06′ 10″ N, 29° 21′ 49″ E), coll by D C Jipa.

UGa-880. (R-1662) (*Chione gallina*) 7460 ± 90
2m, coll by D C Jipa.

UGa-710. (R-1663) 33,190 ± 1100
(*Ostrea edulis, Cardium edule, Paphia senescens, Mytilus galloprovincialis*) 3m (45° 04′ 50″ N, 29° 21′ 25″ E), coll by D C Jipa.

UGa-1161. (R-1832) (*Paphia discrepans*) 10,160 ± 130
1.8m, coll by S Panin.

UGa-1162. (R-1832) (*Paphia senescens*) 27,150 ± 1520
1.8m, coll by S Panin.

UGa-1166. (R-1832) (*Cardium edule*) 6950 ± 150
1.8m, coll by S Panin.

UGa-1167. (R-1832) (*Chione gallina*) 7440 ± 200
1.8m, coll by S Panin.

UGa-1168. (R-1832) (*Paphia* sp) 13,560 ± 390
1.8m, coll by S Panin.

UGa-1179. (R-1832) (*Ostrea edulis*) >40,000
1.8m, coll by S Panin.

UGa-1164. (R-1833) (*Paphia senescens*) >40,000
2.8m (45° 03′ 00″ N, 29° 21′ 40″ E), coll by S Panin.

UGa-1169. (R-1833) (*Cardium edule*) 5920 ± 140
2.8m, coll by S Panin.

UGa-1184. (R-1833) (*Chione gallina*) 6460 ± 100
2m, coll by S Panin.

UGa-1151. (R-1834) (*Paphia senescens*) >40,000
3.2m (45° 04′ 10″ N, 29° 21′ 45″ E), coll by S Panin.

UGa-1165. (R-1834) (*Paphia senescens*) >40,000
Split of UGa-1151, same sp coll by S Panin from 3.2m.

UGa-1170. (R-1834) (*Cardium edule*) 9920 ± 100
3.2m, coll by S Panin.

UGa-1185. (R-1834) (*Ostrea edulis*) 12,080 ± 120
3.2m, coll by S Panin.

UGa-735. (R-DD27), Sf Gheorghe 9390 ± 110
(*Cardium edule, Ostrea edulis, Cerithium vulgatum, Chione gallina, Mytilus galloprovincialis*) 19m (44° 59′ 59″ N, 29° 17′ 50″ E), coll by N Mihăilescu.

UGa-1160. (R-1671) 4950 ± 220
(*Cardium edule*) 0.5m (45° 12′ 08″ N, 29° 23′ 10″ E), coll by D C Jipa.

UGa-1150. (R-1831) 5430 ± 40
(*Cardium edule*) 0.8m (45° 01′ 55″ N, 29° 20′ 50″ E), coll by S Panin.

Sfîntu Gheorghe Delta series

Shell deposits of Sfîntu Gheorghe I. Delta (Panin, 1976).

UGa-705. (R-1659) 22,910 ± 490
(*Ostrea edulis, Paphia senescens*) 2.5m (45° 07′ 56″ N, 29° 22′ 21″ E), coll by D C Jipa.

UGa-708. (R-1566) 14,240 ± 150
(*Ostrea edulis, Paphia senescens*) 0.6m (45° 08′ 00″ N, 29° 22′ 23″ E), coll by S Panin.

Caraorman formation series

Mostly shell deposits of Sulina Delta stage of Danube Delta (Panin, 1976).

UGa-883. (R-1546) (*Chione gallina*) 5610 ± 80
3m (45° 12′ 00″ N, 29° 24′ 08″ E), coll by S Panin.

UGa-884. (R-1546) (*Cardium edule*) 5530 ± 80
3m, coll by S Panin.

UGa-734. (R-1735) 5520 ± 80
(*Cardium edule, Monodacna caspia, Dreissena polymorpha,* etc) 1.8m (45° 12′ 10″ N, 29° 24′ 31″ E), coll by N Panin.

UGa-704. (R-1736) 7140 ± 90
(*Cardium edule, Dreissena polymorpha, Donacilla cornea,* etc) 1.8m (45° 12′ 12″ N, 29° 24′ 56″ E), coll by N Panin.

UGa-1796. (R-2150) (*Cardium edule*) 6660 ± 260
1.2m (45° 07′ 55″ N, 29° 22′ 50″ E), coll by N Panin.

UGa-1798. (R-2150) (*Chione gallina*) 4960 ± 310
1.2m, coll by N Panin.

UGa-1808. (R-2149) (*Chione gallina*) 3680 ± 360
1m (45° 07′ 30″ N, 29° 22′ 55″ E), coll by N Panin.

UGa-1812. (R-2149) (*Cardium edule*) 7810 ± 490
1m, coll by N Panin.

UGa-1813. (R-2149) (*Spisula subtruncata*) 15,650 ± 2730
1m, coll by N Panin.

UGa-709. (R-1563) 5660 ± 100
(*Ostrea edulis, Donacilla cornea, Donax trunculus,* etc) 0.8m (45° 05′ 00″ N, 29° 24′ 46″ E), coll by S Panin.

UGa-1173. (R-1826) (*Cardium edule*) 6260 ± 160
2m (45° 04′ 45″ N, 29° 24′ 00″ E), coll by D C Jipa.

UGa-1174. (R-1826) (*Chione gallina*) 13,360 ± 260
2m, coll by D C Jipa.

UGa-1175. (R-1826) (*Mytilus galloprovincialis*) 3340 ± 110
2m, coll by D C Jipa.

UGa-1178. (R-1826) (*Paphia discrepans*) 8800 ± 210
2m, coll by D C Jipa.

UGa-1072. (R-1827) Peat 4750 ± 110
2.5m (45° 04′ 45″ N, 29° 24′ 02″ E), coll by D C Jipa.

UGa-1177. (R-1827) (*Cardium edule*) 5150 ± 230
2.5m, coll by D C Jipa.

UGa-1180. (R-1828) (*Cardium edule*) 3200 ± 90
2m (45° 04′ 45″ N, 29° 24′ 08″ E), coll by N Panin.

UGa-1094. (R-1828) Peat 3910 ± 80
2m, coll by N Panin.

UGa-1182. (R-1828) (*Chione gallina*) 2580 ± 110
2m, coll by N Panin.

UGa-1183. (R-1828) (*Spisula subtruncata*) 4370 ± 220
2m, coll by N Panin.

UGa-1156. (R-1829) (*Cardium edule*) 3440 ± 160
2.8m (45° 04′ 45″ N, 29° 24′ 12″ E), coll by S Panin.

UGa-1158. (R-1829) (*Chione gallina*) 4470 ± 210
2.8m, coll by S Panin.

UGa-1181. (R-1830) (*Cardium edule*) 4350 ± 140

1.55m (45° 04′ 45″ N, 29° 24′ 18″ E), coll by S Panin.

UGa-1187. (R-1830) (*Chione gallina*) 4760 ± 310

1.55m, coll by S Panin.

UGa-711. (R-1570) 3540 ± 70

Shell from Lumina fossil bar of Sulina Delta stage of Danube Delta (Panin, 1976) (*Ostrea edulis, Cardium edule, Chione gallina,* etc) 2m (45° 02′ 22″ N, 29° 27′ 20″ E), coll by S Panin.

UGa-712. (R-1749) 8130 ± 100

Shell from Roşu fossil bar series of Sulina Delta stage of Danube Delta (Panin, 1976) (*Cardium edule, Paphia* sp, *Mytilus galloprovincialis*) 1.8m (45° 02′ 46″ N, 29° 30′ 48″ E), coll by N Panin.

Ivancea fossil bar series

Shell deposits of Sulina Delta stage of Danube Delta (Panin, 1976).

UGa-1171. (R-1824) (*Corbula mediterranea*) 2590 ± 200

1.25m (45° 05′ 00″ N, 29° 31′ 30″ E), coll by S Panin.

UGa-1172. (R-1824) (*Cardium edule*) 4820 ± 110

1.25m, coll by S Panin.

UGa-1188. (R-1824) (*Spisula subtruncata*) 3170 ± 290

1.25m, coll by S Panin.

UGa-1801. (R-1902) 3570 ± 180

(*Cardium edule*) 1.5m (45° 00′ 04″ N, 29° 30′ 40″ E), coll by N Panin.

Letea formation series

Shell deposits of Sulina Delta stage of Danube Delta (Panin, 1976).

UGa-714. (R-1553) 4850 ± 80

(*Cardium edule, Ostrea edulis, Spisula subtruncata,* etc) 1m (46° 16′ 25″ N, 29° 29′ 35″ E), coll by S Panin.

UGa-715. (R-1540) 3710 ± 70

(*Ostrea edulis, Chione gallina, Chlamys glabra, Cardium edule, Mytilus galloprovincialis*) 0.8m (45° 16′ 22″ N, 29° 31′ 56″ E), coll by S Panin.

UGa-716. (R-1716) 2730 ± 70

(*Ostrea edulis, Cardium edule*) 1.2m (45° 15′ 36″ N, 29° 33′ 32″ E), coll by N Panin.

UGa-697. (R-1711) 3180 ± 70

(*Mytilus galloprovincialis, Spisula subtruncata, Dreissena polymorpha,* etc) 2.5m (45° 14′ 24″ N, 29° 35′ 25″ E), coll by N Panin.

UGa-698. (R-1635) Grindul Cherhanoi 2640 ± 70

(*Spisula subtruncata, Ostrea edulis, Mytilaster lineatus,* etc) 1.5m (45° 14′ 06″ N, 29′ 35′ 20″ E), coll by D C Jipa.

UGa-696. (R-1534) Grindul Schiopu 4610 ± 70

(*Chione gallina, Donacilla cornea, Donax trunculus,* etc) 2m (45° 12′ 45″ N, 29° 35′ 46″ E), coll by S Panin.

UGa-717. (R-1648) 3700 ± 70

(*Ostrea edulis, Monodacna caspia, Cardium edule,* etc) 0.2m (45° 18′ 00″ N, 29° 33′ 13″ E), coll by D C Jipa.

Letea formation series

Shell deposits of Chilia Delta stage (Panin, 1976).

UGa-608. (R-1018) 3530 ± 70

(*Cardium edule, Spisula subtruncata, Chione gallina,* etc) 0.3m (45° 23′ 06″ N, 29° 33′ 50″ E), coll by S Panin.

UGa-627. (R-1124) 4470 ± 90

(*Ostrea edulis, Spisula subtruncata, Paphia rugata,* etc) 0.5m (45° 21′ 45″ N, 29° 30′ 32″ E), coll by D C Jipa.

UGa-628. (R-1012) 2930 ± 80

(*Cardium edule, Ostrea edulis, Donacilla cornea,* etc) 0.6m (45° 21′ 45″ N, 29° 33′ 43″ E), coll by S Panin.

UGa-1795. (R-3103) Periprava 3690 ± 120

(*Cardium edule*) 2.1m (45° 22′ 45″ N, 29° 33′ 30″ E), coll by S Panin.

UGa-1797. (R-3102) Periprava 3890 ± 110

(*Cardium edule*) 2.05m (45° 22′ 54″ N, 29° 33′ 40″ E), coll by S Panin.

UGa-1804. (R-3037) Sfistofca 1540 ± 170

(*Chione gallina*) 2.2m (45° 16′ 50″ N, 29° 36′ 12″ E), coll by S Panin.

UGa-1823. (RS-1) Setul Cardon Modern

Animal bones from 2.5m (45° 16′ 35″ N, 29° 12′ 30″ E), coll by M Settel.

UGa-1809. (R-2131) 2320 ± 170

Shell (*Cardium edule*) represents Crasnicol fossil bar series of Sfîntu Gheorge II Delta stage (Panin, 1976), from 1m (44° 52′ 00″ N, 29° 19′ 00″ E), coll by N Panin.

Sf Gheorge arm series

Shell deposits of the Sfîntu Gheorge II Delta stage (Panin, 1976), zone S of Sf Gheorge arm.

UGa-1792. (R-1934) (*Spisula subtruncata*) 1670 ± 210

2m (44° 50′ 30″ N, 29° 30′ 00″ E), coll by S Panin.

UGa-1790. (R-1934) (*Cardium edule*) 1470 ± 160
2m, coll by S Panin.

UGa-1788. (R-1927) Cherhanaua Ciotic 150 ± 110
(*Cardium edule*) 1m (44° 49′ 20″ N, 29° 30′ 00″ E), coll by S Panin.

UGa-1163. (R-1802) Grindul Tigănus 1760 ± 70
(*Corbula mediterranea*) 0.85m (44° 53′ 40″ N, 29° 21′ 06″ E), coll by D C Jipa.

UGa-1811. (R-1943) 1210 ± 970
(*Cardium edule*) 0.8m (44° 48′ 02″ N, 29° 17′ 18″ E), coll by S Panin.

UGa-1799. (R-1938) 2070 ± 210
(*Cardium edule*) 1.8m (44° 48′ 50″ N, 29° 14′ 30″ E), coll by S Panin.

UGa-1825. (R-2246) Grindul Coşna 2100 ± 160
(*Cardium edule*) 2.5m (44° 49′ 00″ N, 29° 12′ 30″ E), coll by S Panin.

UGa-1800. (R-2729) 1930 ± 160
(*Cardium edule*) 0.85m (44° 47′ 50″ N, 29° 10′ 10″ E), coll by N Panin.

Razelm Lake series

Shell deposits of Sfîntu Gheorge II Delta stage (Panin, 1976).

UGa-739. (R-33R4b) Modern
(*Monodacna caspia, Hypanis plicatus, Adacna vitrea, Cardium edule*) 2.2m (44° 59′ 24″ N, 29° 02′ 25″ E), coll by N Mihăilescu.

UGa-740. (R-34R17) 1060 ± 60
(*Cardium edule, Monodacna caspia, Hypanis plicatus, Abra ovata*) 2.2m (44° 56′ 35″ N, 28° 48′ 45″ E), coll by N Mihăilescu.

UGa-742. (R-35R30b) 1090 ± 60
(*Monodacna caspia, Hypanis plicatus, Cardium edule, Abra ovata*) 2.2m (44° 48′ 58″ N, 28° 59′ 33″ E), coll by N Mihăilescu.

UGa-743. (R-36R51b) Golvita Lake 1290 ± 60
(*Cardium edule, Monodacna caspia, Abra alba, Rissoa splendida, Hypanis plicatus*) 2.2m (44° 43′ 45″ N, 28° 56′ 58″ E), coll by N Mihăilescu.

Rînec fossil bar series

Deposits of Coşna-Sinoe Delta stage (Panin, 1976).

UGa-1806. (R-2671) 1510 ± 200
(*Cardium edule*) 0.3m (44° 45′ 30″ N, 29° 06′ 00″ E), coll by N Panin.

UGa-1815. (R-2675) 3080 ± 490
(*Cardium edule*) 0.7m (44° 44′ 50″ N, 29° 03′ 30″ E), coll by N Panin.

Lupilor fossil bar series

Shell deposits of Coşna-Sinoe Delta stage (Panin, 1976).

UGa-600. (R-3) 2420 ± 100

(*Cardium edule*) 0.2m (44° 38′ 23″ N, 28° 50′ 12″ E), coll by N Panin.

UGa-601. (R-4) 1890 ± 70

(*Chione gallina, Pitar rudis, Donax* sp, *Donacilla cornea, Paphia* sp) 0.3m (44° 38′ 24″ N, 28° 50′ 12″ E), coll by N Panin.

UGa-1805. (R-2602) 2160 ± 580

(*Cardium edule*) 0.6m (44° 40′ 00″ N, 28° 22′ 56″ E), coll by S Panin.

Histria formation series

Shell deposits of Coşna-Sinoe Delta stage (44° 30′ 18″ N, 28° 45′ 50″ E) (Panin, 1976), coll by N Panin.

UGa-592. (R-1) 2060 ± 70

(*Cardium edule*) 1.2m.

UGa-593. (R-2) 1490 ± 70

(*Mytilus galloprovincialis, Chione gallina, Donax* sp, *Donacilla* sp, *Tellina* sp) 1m.

Matita depression series

Shell deposits of back zone of initial spit.

UGa-745. (38DD-600) 3400 ± 180

(*Cardium edule, Dreissena* sp, *Abra alba, Hydrobia ventrosa, Monodacna caspia*) 3m (45° 17′ 10″ N, 29° 22′ 28″ E), coll by N Mihăilescu.

UGa-746. (39DD-604) 4600 ± 240

(*Cardium edule, Dreissena polymorpha*) 2.15m (45° 16′ 57″ N, 29° 22′ 11″ E), coll by N Mihăilescu.

UGa-747. (40DD-604) 5610 ± 210

(*Cardium edule, Hydrobia ventrosa, Monodacna caspia,* etc) 2.15m, coll by N Mihăilescu.

UGa-748. (R-42 Bcg-2b+3) Belciug Lake Modern

(*Dreissena polymorpha*) 10.5m (44° 57′ 00″ N, 29° 25′ 12″ E), coll by N Mihăilescu.

UGa-1791. (R-3038) Matita II 3430 ± 80

(*Cardium edule*) 1.8m (45° 17′ 15″ N, 29° 20′ 12″ E), coll by N Panin.

UGa-1787. (R-3131) Lopatna 1 4300 ± 90

(*Abra* sp) 1.5m (45° 17′ 10″ N, 29° 21′ 00″ E), coll by S Panin.

UGa-1786. (R-3132) Lopatna 2 4390 ± 100

(*Cardium edule*) 1.5m, coll by S Panin.

UGa-724. (R-1588) Grindul Chilia 1030 ± 70

Shell from back zone of initial spit of Chilia promontory, 0.4m (45°

19′ 40″ N, 29° 18′ 00″ E) (*Dreissena polymorpha, Monodacna caspia, Adacna vitrea, Viviparus* sp), coll by S Panin.

Roşca-Suez bar series

Shell deposits of back zone of initial spit.

UGa-1810. (R-3036) Suez (Suez Channel) 1850 ± 70

(*Cardium edule*) 1.8m (45° 18′ 30″ N, 29° 23′ 55″ E), coll by N Panin.

UGa-1807. (R-3041) Rosca (Rosca Channel) 1380 ± 70

(*Cardium edule*) 2m (45° 20′ 30″ N, 29° 22′ 00″ E), coll by N Panin.

UGa-718. (R-1735) Grindul Stipoc 2770 ± 70

Lamellibranches and fragments from back zone of initial spit on Stipoc Bar, 0.8m (45° 15′ 55″ N, 29° 13′ 30″ E), coll by N Panin.

Mamaia littoral bar series

Shell deposits from bore hole on Mamaia littoral bar.

UGa-607. (R-5) 26,920 ± 700

(*Spisula subtruncata, Chione gallina, Gafrarium* sp, etc) 22 to 23m (44° 16′ 29″ N, 28° 37′ 17″ E), coll by G Caraivan.

UGa-629. (R-9) 3130 ± 80

(*Cardium edule, Mytilus galloprovincialis, Chione gallina, Donacilla cornea, Nassarius reticulatus*) 6m, coll by G Caraivan.

UGa-1794. (RG-1) 3050 ± 90

Fluviatile deposit from Cricov R on alluvial plain of Ialomita R tributaries (44° 45′ 32″ N, 25° 56′ 17″ E) (Ghenea *et al*, 1971). (*Cepaea vindobonensis, Planorbis corneus, Tropidiscus planorbis,* and *Valvata piscinalis*) 0.6m, coll by C Ghenea.

Prahova River Valley series

Samples from alluvial plain of Ialomita R tributaries (Ghenea *et al*, 1971).

UGa-1803. (RG-2) 5550 ± 3810

Fluviatile deposit, gastropod fragments, 0.5m (44° 46′ 49″ N, 26° 20′ 16″ E), coll by C Ghenea.

UGa-1822. (RG-3) 3860 ± 90

Wood, 0.5m, coll by C Ghenea.

UGa-1824. (RG-4) Năianca valley 2550 ± 320

Bone, 0.3m (45° 03′ 10″ N, 26° 30′ 07″ E), coll by C Ghenea.

Dîmbovita Valley series

Samples from alluvial plain of Ialomita R tributaries (Ghenea *et al*, 1971).

UGa-1821. (RG-5) **2460 ± 70**

Wood, 0.45m (44° 25′ 56″ N, 26° 06′ 22″ E), coll by C Ghenea.

UGa-1820. (RG-6) **2410 ± 60**

Peat, 0.5m (44° 26′ 00″ N, 26° 04′ 58″ E), coll by C Ghenea.

ARCHAEOLOGIC SAMPLES

Romania

Argamum series

Samples from Argamum, ancient Greek-Roman city on Dolojman promontory.

UGa-1816. (RA-1) **2040 ± 100**

Dirt and charcoal, 0.5m (44° 24′ 15″ N, 28° 24′ 30″ E), coll by D C Jipa.

UGa-1817. (A-1) **1980 ± 130**

Charcoal, coll by D C Jipa.

UGa-1819. (A-2) **2240 ± 70**

Charcoal, coll by D C Jipa.

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[Radiocarbon, Vol 25, No 3, 1983, P 930-935]

UNIVERSITY OF MIAMI RADIOCARBON DATES XXIII

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The following radiocarbon dates are a partial list of samples measured for a variety of projects and materials since May 1982. Chemical and counting procedures remain the same as indicated in R, v 20, p 274-282.

Calculations are based on the 5568-year Libby ^{14}C half-life. Precision is reported as one-standard deviation based only on statistical counting uncertainties in the measurement of the background, NBS modern standard, and sample activities. $\delta^{13}C$ values are measured relative to PDB and reported ages are corrected for isotopic fractionation by normalizing to −25‰.

I. GEOLOGIC SAMPLES

United States

Indiana

Muncie Glacial series

Peat and lake sediments coll from bogs on Union City Moraine and Knightstown Moraine, Muncie area. Samples dated to determine Lake Erie Lobe (Wisconsin Glacial Sheet) retreat rate. Coll and subm 1982 by H Roepke, Ball State Univ, Muncie, Indiana.

UM-2555. Bog 1, 2m — **12,150 ± 110**
$\delta^{13}C$ = −24.5‰

Peat coll from shallow bog on Union City Moraine at depth 2m (40° 13′ N, 85° 08′ W).

UM-2556. Bog 1, 2.8-3m — **12,650 ± 130**

Peat/sediment from shallow bog on Union City Moraine coll from 2.8 to 3m (40° 13′ N, 85° 08′ W).

UM-2557. Bog 1, 2.8-3m — **14,580 ± 120**
$\delta^{13}C$ = −24.6‰

Lake sediment from shallow bog on Union City Moraine coll at depth 2.8 to 3m as was core sample UM-2556 (40° 13′ N, 85° 08′ W).

UM-2558. Bog 2, 1m — **10,560 ± 90**

Peat coll at 1m depth from shallow bog on Knightstown Moraine (39° 47′ N, 84° 52′ W).

UM-2559. Bog 2, 2m — **14,660 ± 200**
$\delta^{13}C$ = −24.4‰

Peat coll from shallow bog at 2m depth on Knightstown Moraine (39° 47′ N, 84° 52′ W).

UM-2560. Bog 3, 8m — **10,260 ± 270**
$\delta^{13}C$ = −24.3‰

Lake sediment from deep bog on Union City Moraine coll at depth 8m (40° 13′ N, 85° 08′ W).

General Comment (DGH): without further study, results are presently inconclusive.

Michigan

Lake Superior series

Fine-grained lake sediments coll W of Keweenaw Peninsula in Lake Superior. Core samples dated to support hyperbolic X-radiographs which suggested presence of contourites. Rapid sedimentation rate was expected within contourite feature as compared to slower rate of deposition outside contourite feature area. Contourite feature was at water depth 241m while sediments not assoc with contourite feature were coll at depth 269m. At present, results are inconclusive. Samples coll Aug 1981 and subm Feb 1982 by J Halfman and T Johnson, Univ Minnesota, Duluth.

UM-2597. LRTN81-13Bx, 0-10cm **2860 ± 70**

Gray lake sediments from surface of contourite feature (47° 30.7′ N, 88° 9.9′ W).

UM-2598. LRTN81-13Bx, 10-20cm **2040 ± 100**

Gray lake sediments from contourite feature (47° 30.7′ N, 88° 9.9′ W).

UM-2599. LRTN81-13Bx, 26-36cm **3580 ± 100**

Gray lake sediments within contourite feature (47° 30.7′ N, 88° 9.9′ W).

UM-2600. LRTN81-21Bx, 0-10cm **2060 ± 70**

Gray lake sediments not assoc with contourite feature (47° 34.1′ N, 88° 12.3′ W).

UM-2601. LRTN81-21Bx, 34-45cm **2100 ± 60**

Gray lake sediments coll from core outside of contourite feature (47° 34.1′ N, 88° 12.3′ W).

Mississippi

Lower Mississippi Valley series

Core samples of glacial loess deposits were taken from roadcuts along US 61 Bypass 3km N of Interstate 20, Vicksburg (32° 22′ N, 90° 49′ W) and from sites adjacent to Mississippi R, Natchez (31° 32′ N, 91° 25′ W). Terrestrial snail shells coll and dated to determine stratigraphic correlations between loess beds in area and as basis for subsequent thermoluminescence dating of feldspar and quartz grains in loess. Samples coll 1981 by K Pye, Dept Earth Sci, Cambridge Univ and subm 1981 by K Pye, R Johnson, and R Hatfield, Univ Miami, Florida.

UM-2570. VS2-RJ-1 **10,000 ± 100**

Shells (*Triodopsis*) coll at 2.7m depth from yellow-brown loess in Vicksburg.

UM-2571. RH/VS2-4 **15,730 ± 170**

Unid. shell coll at 4m depth from yellow-brown loess in Vicksburg.

UM-2572. RH/VS2-1 **16,620 ± 130**

Shells (*Triodopsis, Mesodon*) coll at 5.7m from bottom of yellow-brown loess bed. TL dates on polymineral mixtures of quartz and feldspar 15.9 ± 1.1ky agree well with ^{14}C ages.

UM-2573. RH/VS2-3 **17,130 ± 200**

Unid. snail shells coll at 9.7m from slightly weathered clayey loess bed.

UM-2574. VS2-RJ-2 **17,560 ± 200**

Unid. shells coll at 15m from top of dark brown clayey loess bed.

UM-2575. RH/VS2-5 **20,800 ± 210**

Shells (*Triodopsis*) coll at 15.5m from middle of dark brown clayey loess bed. Subsequent TL dates on polymineral grains are ca 22.9 ± 1.2ky.

UM-2576. RH/VS1-8 **23,400 ± 340**

Unid. shells from Vicksburg-type sec coll at 15.5m from dark brown clayey loess. Type sec is 2km N of main sampling area VS2 in Vicksburg. Sample dated to provide bed correlation with VS2 and UM-2575.

UM-2577. RH/NDQ-9 **16,180 ± 160**

Shells (*Triodopsis*) coll 8.5m below top sec in unweathered carbonate bearing loess in Natchez.

UM-2578. RH/NH61-10 **18,620 ± 250**

Unid. shells coll from dark brown clayey loess unit 0.75m thick at depth 5.5m. Sample coll from W side Hwy 61, 8.3km N of Mississippi R Bridge in Natchez.

UM-2579. RH/NH61-11 **19,300 ± 360**

Shells (*Triodopsis*) coll from lowermost 50cm of gray-brown loess at depth 5m. Sample from same loc as UM-2578.

UM-2580. RH/NRI-12 **21,400 ± 390**

Unid. shells coll from basal 30cm of brown clayey loess at depth 10.5m. Sample coll from Natchez Bluffs in Natchez.

UM-2581. RH/RNI-13 **21,700 ± 250**

Shells from uppermost 30cm of reddish clayey loess immediately underlying UM-2580. Bed represents paleosol; thus, ^{14}C date is probably invalid or shells were worked down from bed above (UM-2580).

General Comment (RAJ): overall, ^{14}C dates provide general correlation between Natchez and Vicksburg, considering inherent problems assoc with pulmonate gastropod shells. TL data thus far correlate well with ^{14}C dates and may substantiate problem with UM-2581.

New Hampshire

Bottomless Pit Bog series

Peat, lake bottom sediment, and glacial flour samples from Bottomless Pit Bog near Lebanon (43° 45′ N, 72° 14′ W). Samples were dated to determine chronology of soil evolution in Bottomless Pit Bog watershed since last glaciation. Coll 1982 by D Ryan and S Minnis, Univ Miami, Coral Gables.

UM-2561. BP1m **1160 ± 80** $\delta^{13}C = -27.6‰$

Sedge peat at 1m depth; overlain by living heath mate with no open water. Pretreated with HCl; not NaOH.

UM-2562. BP2m **2850 ± 100** $\delta^{13}C = -27.0‰$

Peat from depth 2m. Pretreated with HCl; not NaOH.

UM-2563. BP3m **3950 ± 90** $\delta^{13}C = -27.2‰$

Basal peat from depth 3m. Dates approx initiation of sedge peat deposition in bog. Pretreated with HCl; not NaOH.

UM-2564. BP4m **4520 ± 70** $\delta^{13}C = -27.5‰$

Uppermost lake bottom sediment sample. Fine particulate muck. Dates approx termination of lake bottom sedimentation in bog. Pretreated with HCl; not NaOH.

UM-2565. BP5m **6900 ± 100**

Lake bottom sediment at depth 5m. Pretreated with HCl; not NaOH.

UM-2566. BP6m **8300 ± 120**

Basal lake sediment at depth 6m. Dates approx initiation of lake bottom sedimentation. Pretreated with HCl; not NaOH.

UM-2567. BP7m **10,280 ± 180**

Glacial flour/lake bottom sediment interface at depth 7m. Dates approx entrance of first organics in region since full recession of Wisconsin Glacial. Pretreated with HCl; not NaOH.

UM-2568. BP8m **16,480 ± 190** $\delta^{13}C = -3.0‰$

Glacial flour sample at depth 8m. Date shown is for inorganic C (*ie*, $CO_3^{=}$) fraction. Anomalously alkaline layer, pH ca 8.5; % $CaCO_3$, 3-4. Dated for approx initial sedimentation in lake following glaciation and prior to vegetational growth. No pretreatment.

UM-2569. BP8m **18,000 ± 1050** $\delta^{13}C = -19.3‰$

Glacial flour sample from depth 8m. Dates organic C fraction. Very little organic carbon found at this depth. Dated for approx period of algal life in lake, as possible explanation for precipitation of inorganic $CaCO_3$ due to depletion of CO_2 in water. Pretreated with HCl; not NaOH.

II. ARCHAEOLOGIC SAMPLES

United States

Florida

Hontoon Island series

Peat, wood, charcoal, and marine shells coll from archaeol excavation at Hontoon Island State Park (28° 52′ 30″ N, 81° 22′ 30″ W). Samples dated to re-examine previous analyses of nearby site which exhibits discrepancy between stylistic pottery analysis of St Johns Pottery and ^{14}C dates on assoc material. Sample coll and subm 1982 by B Purdy, Univ Florida, Gainesville and C Barker, Univ Miami.

200 ± 50
UM-2602. CBHIZ1 #7 $\delta^{13}C = -26.2‰$

Peat coll 60cm below ground surface; HCl pretreatment only.

1060 ± 50
UM-2603. CBHIZ2 #6 $\delta^{13}C = -26.5‰$

Wood coll 70cm below surface from peat layer; HCl and NaOH pretreatment.

260 ± 50
UM-2604. CBHIZ2 #8 $\delta^{13}C = -24.6‰$

Charcoal coll 74cm below surface in peat layer; HCl pretreatment only.

400 ± 70
UM-2605. CBHIZ2 #9 $\delta^{13}C = -24.6‰$

Charcoal, same as UM-2604; HCl and NaOH pretreatment.

UM-2606. CBHIZ3 #3 **800 ± 50**

Charcoal coll 122cm below surface; HCl and NaOH pretreatment.

UM-2607. CBHIZ3 #4 **870 ± 50**

Charcoal, same as UM-2606; HCl pretreatment only as check for humic acids.

1020 ± 50
UM-2608. CBHIZ3 #1 $\delta^{13}C = -26.3‰$

Wood coll 122cm below surface from same context as UM-2606. Sample submerged below water level in peat-shell matrix; HCl and NaOH pretreatment.

1120 ± 50
UM-2609. CBHIZ3 #10 $\delta^{13}C = -1.0‰$

Shell (*Mercenaria*) coll 122cm below surface from same context as previous samples from 122cm.

1140 ± 70
UM-2610. CBHIZ3 #2 $\delta^{13}C = +1.3‰$

Shell (*Busycon*) 125 to 130cm below surface from peat matrix.

UM-2611. CBHIZ4 #5 **1020 ± 50**

Wood coll 140cm below surface from peat matrix; HCl and NaOH pretreatment.

References

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[Radiocarbon, Vol 25, No 3, 1983, P 936-943]

VIENNA RADIUM INSTITUTE RADIOCARBON DATES XIII

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Measurements have continued with the same proportional counter system, pretreatment procedure, methane preparation and measurement, and calculation, as described previously (R, 1970, v 12, p 298-318). Uncertainties quoted are single standard deviations originating from standard, sample, and background counting rates. No $^{13}C/^{12}C$ ratios were measured. Sample descriptions have been prepared in cooperation with submitters.

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SAMPLE DESCRIPTIONS

I. GEOLOGIC, LIMNOLOGIC, AND BOTANIC SAMPLES

Austria

VRI-759. Opponitz, NÖ **8790 ± 130**

Gyttja from organic layer between calcareous tuff with mollusk shells in Haselgraben E Opponitz (47° 52′ 40″ N, 14° 49′ 30″ E), Lower Austria. Coll 1981 and subm by Ilse Draxler, Geol BA, Vienna. *Comments* (ID): palynology points to favorable Würm climatic phase. (HF): date contradicts palynology. No NaOH pretreatment.

Lungötz series, Salzburg

Peat with wood pieces from peat deposit cut by Lammer R, Lammertal Valley, W Lungötz (47° 30′ N, 13° 21′ E), Salzburg. Coll 1981 and subm by Heinz Slupetzky, Geog Inst, Univ Salzburg.

General Comments (HS): information on bog growth is expected. (HF): humic acid fraction was used for peat dating to eliminate wood detritus.

VRI-736a. Sample I, peat **3510 ± 90**

Peat with sand from base (—3.5m) of peat layer, 3m thick, in 1st fluvial terrace of Lammer R, now above recent river bed, but in high water zone.

VRI-736b. Sample I, wood **Modern**

Wood in Sample I. *Comment* (HF): date shows nuclear weapons influence. Wood obviously washed in.

VRI-737a. Sample II, peat **2320 ± 80**

Peat with sand from uppermost layer (—0.5m).

VRI-737b. Sample II, wood **2180 ± 100**

Wood in Sample II.

Gastein series, Salzburg

Material from bottom of Unterer Bockhart-See, at present nearly completely drained for dam construction. Deep erosional gullies in exposed lake sediment provide access for sampling as much as 7m below sediment surface. Unterer Bockhart-See, 1845m asl, near Gastein (47° 04′ 45″ N, 13° 03′ 10″ E), Salzburg. Coll 1981 and subm by Friedrich Kral, Univ Bodenkultur, Vienna.

General Comments (FK): dates palynologically determined events. (HF): contaminating wood detritus excluded by use of NaOH extract only. The following sample depths are relative to sediment surface.

VRI-760. BO II/0-8 **1190 ± 80**

Sandy gyttja at 2.1m in zone with thin dark and light layers underlying coarse sand layer, 1.5m thick, possibly assoc with gold mining. *Comment* (FK): dates palynologically determined max in pasturing activity.

VRI-761. BO II/125-135 **3140 ± 90**

Sandy gyttja at ca 3.3m in dark-colored zone with few thin sand layers. *Comment* (FK): dates palynologically determined beginning of pasturing activity or 1st local human influence.

VRI-762. BO II/130 **3030 ± 120**

Pine cones in Sample VRI-761.

VRI-763. BO II/182 **3050 ± 90**

Cembra wood in Sample VRI-764.

VRI-764. BO II/180-185 **3480 ± 90**

Sandy gyttja at 3.9m in dark-colored zone with thin sand layers. *Comment* (FK): dates pasturing activity in outlying areas palynologically traceable by air-borne pollen. Younger stem, VRI-763, may have sunk ca 50cm in soft sediments to this older layer.

VRI-765. BO III/8-12 **4800 ± 90**

Sandy gyttja at ca 5.4m in dark zone without sand layers. *Comment* (FK): dates increase of *Abies* pollen.

VRI-766. BO III/88-92 **7180 ± 110**

Sandy gyttja at ca 6.2m in dark zone without sand layers. *Comment* (FK): dates max alt of timber line (*Pinus, Cembra*).

VRI-767. BO III/165-175 **9690 ± 360**

Gyttja with much sand at ca 7m in relatively light-colored zone with partly-coarse sand. *Comment* (FK): dates immigration and spread of *Alnus* and *Pinus*.

VRI-781. BO I/40-50 **1250 ± 80**

Sand with gyttja and wood detritus, with several dark and light layers, at 40 to 50cm. *Comment* (FK): dates beginning of present environment, nearly free of trees. Provides min age for underlying homogeneous coarse sand zone possibly related to gold and silver mining.

VRI-782. BO II/55-65 **2080 ± 80**

Sandy gyttja and wood detritus interspersed with dark lake sediment at 2.6m. *Comment* (FK): dates beginning of corn pollen and wood regression in vicinity.

Hochlantsch series, Steiermark

Calcareous sinters at Mt Hochlantsch area, between Teichalm hut and Zechner Hube (47° 21′ 50″ N, 15° 26′ 50″ E), near Bruck an der Mur, Styria. Coll 1981 by Hannes Gollner, subm by H W Flügel, Inst Geol and Paläont, Univ Graz.

General Comment (HWF): dated to study temporal correlation between carbonate sinters in cleft of disturbance (Sample A) and in dissolving fissure of Devon lime (Sample B) that cross each other.

VRI-771. Sample A **1.9 ± 0.4% modern**

VRI-772. Sample B **26.4 ± 0.5% modern**

Comment (HF): recent value, 100% modern, provides max ages: Sample A: 31,700 ± 1600, Sample B: 10,700 ± 160 BP.

Seefeld series, Tirol

Peat from different depths of Katzenlochmoor at foot of Mt Hohe Munde (47° 20′ 39″ N, 11° 07′ 16″ E), near Seefeld, Tirol. Coll 1981 and subm by Sigmar Bortenschlager, Bot Inst, Univ Innsbruck.

General Comment (SB): dates pollen diagram.

VRI-625. Base **8630 ± 130**

Peat from base. *Comment* (SB): dates beginning of peat growth.

VRI-628. 140-143 **8450 ± 120**

Sphagnum peat from depth 140 to 143cm. *Comment* (SB): dates *Picea* increase.

VRI-626. 92-95 **7470 ± 120**

Sphagnum peat with *Eriophorum* from depth 92 to 95cm. *Comment* (SB): dates beginning of arboreal pollen decrease.

VRI-627. 72-75 **7100 ± 180**

Sphagnum peat with *Eriophorum* from depth 72 to 75cm. *Comment* (SB): dates end of arboreal pollen decrease.

Kirchbichl series, Tirol

Detritus-gyttja in profile of former lake, Kirchbichl watering place (47° 30′ 36″ N, 12° 05′ 26″ E), Tirol. Coll 1981 by Burgi Wahlmüller; subm by Sigmar Bortenschlager.

General Comments (BW): dates pollen diagram. (HF): no humic acid separation.

VRI-690. 453-460 **8050 ± 130**

Sample at depth 453 to 460cm. *Comment* (BW): dates spread of *Picea.*

VRI-691. 670-677 **9070 ± 140**

Sample at depth 670 to 677cm. *Comment* (BW): dates end of clay deposition.

VRI-692. 695-702 **9430 ± 130**

Sample at depth 695 to 702cm. *Comment* (BW): dates beginning of clay deposition.

VRI-768. Kienberg, Tirol **Modern**

Humic acids from lowest layer of $O_f(O_h/A_h)$ horizon of Ranker on landslip block near Kienberg/Jerzens im Pitztal (47° 08′ N, 10° 45′ E), Tirol. Coll 1981, extracted and subm by Gerhard Heiss and Irmentraud Neuwinger, Forstl BVA, Innsbruck. *Comment* (IN): date of landslip was hoped for. (HF): date shows nuclear weapons influence.

Telfs series, Tirol

Soil from Griessbach alluvial cone, Telfs (47° 18′ N, 11° 04′ E), Tirol. Coll 1982 and subm by Irmentraud Neuwinger.

General Comment (IN): dates top layer of alluvial cone.

VRI-769. Sample 102/82 **Modern**

Humic acids extracted from lowest layer of A_h horizon of Rendzina, –20 to –25cm, ca 20m E of VRI-741 (R, 1982, v 24, p 225). *Comment* (HF): date shows nuclear weapons influence.

VRI-785. Sample 17a/82 **4250 ± 100**

Charcoal of buried A_h horizon, –80 to –100cm. *Comment* (HF): dendrochronol age, 2820 to 3240 BC (Suess, 1979).

VRI-784. Sulzberg, Vorarlberg **Modern**

Wood from plant layer, –50cm in lake marl, Unterlitten near Sulzberg (47° 32′ N, 9° 55′ E), Vorarlberg. Coll 1982 and subm by Ilse Draxler. *Comments* (ID): interval from Middle ages to present is expected from palynology. (HF): date shows nuclear weapons influence.

CSSR

Vysoke Tatry series

Peat (VT-1-A) from bog near Trojhranne pless lake (49° 13′ 15″ N, 20° 13′ 50″ E), 1650m asl, Vysoke Tatry. Coll 1981 by Heinz Hüttemann; subm by Sigmar Bortenschlager.

General Comment (HH): dates pollen diagram.

VRI-629. 110-100 **2290 ± 90**

Sphagnum-Eriophorum peat at depth, –110 to –100cm. *Comment* (HH): dates beginning of cultural phase.

VRI-697. 155-150 **3640 ± 90**

Sphagnum-Eriophorum peat at depth, −155 to −150cm. *Comment* (HH): dates both EMW and *Pinus* increase and *Picea* decrease. No humic acid separation.

VRI-698. 55-50 **890 ± 70**

Cyperaceae peat at depth, −55 to −50cm. *Comment* (HH): dates beginning of intensive human activity including land clearance. No humic acid separation.

Riesengebirge series

Peat and wood from Pancica bog near Elbebaude, 1325m asl (50° 46′ 45″ N, 15° 32′ 30″ E), Mt Riesengebirge. Coll 1982 by Heinz Hüttemann; subm by Sigmar Bortenschlager, Bot Inst, Univ Innsbruck.

General Comments (HH): dates pollen diagram. (HF): no humic acid separation.

VRI-693. 180-185 **4710 ± 90**

Sphagnum peat at depth 180 to 185cm. *Comment* (HH): dates supposed burning horizon.

VRI-694. 125-130 **4280 ± 90**

Sphagnum peat at depth 125 to 130cm. *Comment* (HH): dates 1st clearing activity.

VRI-695. 85-90 **2460 ± 80**

Brown moss *Carex* peat at depth 85 to 90cm. *Comment* (HH): dates climax of intensive cultural phase.

VRI-696. 25-30 **610 ± 80**

Sphagnum-Trichophorum peat at depth 25 to 30cm. *Comment* (HH): dates beginning of modern culture phase.

VRI-707. 200 **4750 ± 90**

Root of pine at depth 200cm.

Greece

Lailias series

Samples of bog 1420m asl at Lailias (41° 16′ 14″ N, 23° 35′ 30″ E). Coll 1980 by A Gerassimidis; subm by Nikolaos Athanasiadis, Inst Forstbot, Aristotelion Univ, Thessaloniki.

General Comment (NA): dates pollen diagram. Pretreatments were unnecessary.

VRI-746. 58-61 **250 ± 80**

Carex-Sphagnum peat with modern roots at depth 58 to 61cm.

VRI-747. 127-132 **910 ± 80**

Dy with modern roots at depth 127 to 132cm.

VRI-748. 175-200 **1870 ± 140**

Dy with coarse sand at depth 175 to 200cm.

Flamboyro series

Peat from bog near Flamboyro (40° 15′ 24″ N, 22° 09′ 36″ E), Mt Pieria, 1650m asl. Coll 1980 by A Gerassimidis; subm by Nikolaos Athanasiadis.

General Comment (NA): dates pollen diagram. Pretreatments were unnecessary.

VRI-749. 48-52 **520 ± 80**

Peat with roots at depth 48 to 52cm.

VRI-750. 120-125 **1960 ± 80**

Peat with roots and clay at depth 120 to 125cm.

Kokkini Brissi-Pieria series

Peat and dy at Kokkini Brissi (40° 17′ 55″ N, 22° 09′ 38″ E), Pieria Mt, 1420m asl. Coll 1981 by A Gerassimidis; subm by N Athanasiadis.

General Comment (NA): dates pollen analysis. No pretreatment.

VRI-751. 63-68 **<200**

Clayey peat at depth 63 to 68cm; contaminated by rootlets.

VRI-752. 170-175 **610 ± 80**

Clayey dy at depth 170 to 175cm; contaminated by rootlets.

II. ARCHAEOLOGIC AND HISTORIC SAMPLES

Austria

Stillfried an der March series, NÖ

Charcoal from different loci of W rampart cut of prehistoric bulwark on Kirchberg hill, Stillfried (48° 25′ N, 16° 50′ E), near Angern an der March, Lower Austria. Coll 1977 by C Eibner, Inst Ur- u Frühgesch, Univ Vienna.

VRI-773. Sample ST 7225 **1950 ± 80**

W rampart cut, 140 to 150cm below level, 16.25m run, 140 to 160cm S of N profile 1980.

VRI-774. Sample ST 7226 **2480 ± 80**

W rampart cut, below pit bldg, 14.5 to 15.5m run, 110 to 180cm S of N profile 1980.

VRI-783. Geras, NÖ **680 ± 80**

Human bones from burials at −175cm, excavated at S face of church of Stift Geras (48° 47′ N, 15° 42′ E), Dept Horn, Lower Austria. Coll 1982 and subm by Ambros Josef Pfiffig, Stift Geras. *Comments* (AJP): early slave settlement is suggested. Reconstruction of Stift Geras after 1650 disturbed burials. (HF): de Vries corrected age (Suess, 1970) is AD 1270 ± 80.

VRI-739. Traunkirchen, OÖ **2480 ± 90**

Wood remnants of prehistoric lake dwelling, −2m below water level from bottom of Lake Traunsee, near Traunkirchen (47° 51′ N, 13° 47′ E), Upper Austria. Coll 1981 and subm by Johann Offenberger, Bundesdenkmalamt, Vienna. *Comment* (JO): date points to Hallstatt period. de Vries-effect correction (Suess, 1970), including standard deviation, yields 800 to 600 BC.

Hallstatt series, OÖ

Samples from wooden rust overlain by Roman layer, −2m below Echerntalweg near S parking lot, Hallstatt (47° 33′ 30″ N, 13° 39′ E), Oö. Coll 1980 by Hubert Unterberger, subm by Chr Farka, Bundesdenkmalamt, Vienna.

General Comment (HF): dates prove only some samples are of Roman origin.

VRI-743. Hallstatt 1 **1670 ± 80**

Comment (HF): de Vries correction provides Roman date, AD 330 $^{+90}_{-80}$ (Suess, 1970).

VRI-744. Hallstatt 2 **<300**

VRI-775. Attersee, OÖ **4610 ± 100**

Wooden piling at bottom of Lake Attersee, −2m below water level, sample Abtsdorf II 197/1-1982, near Abtsdorf (47° 53′ 48″ N, 13° 31′ 58″ E), Upper Austria. Coll 1982 by Union Tauchklub Wels; subm by Johann Offenberger. *Comment* (JO): dates Neolithic lake dwelling.

VRI-742. Innsbruck, Tirol **300 ± 90**

Human bones, from −2m at N portal in great court of Hofburg Castle, Innsbruck (47° 17′ N, 11° 25′ E), Tirol. Coll 1981 at gas-line installation; subm by Werner Platzer, Anatom Inst, Univ Innsbruck. *Comments* (WP): loc of medieval cemetery, abandoned in AD 1501. (HF): de Vries correction (Suess, 1970) yields calendric date, AD 1480 $^{+40}_{-30}$.

Spain

Canary Islands series

Shell remains from different depths of shell heap. Conchero El Julan, S of Hierro I, Canary Is. Coll 1982 by Herbert F Nowak; subm by Hans Biedermann, Inst Canarium, Hallein. *Comments* (HB): dated for study of Canarian Megalith culture. (HF): surface leaching pretreatment.

VRI-777. El Julan 1 **1010 ± 80**

Depth −0.02 to −0.05m.

VRI-778. El Julan 2 **1140 ± 80**

Depth −0.50 to −0.55m.

VRI-779. El Julan 3 **1260 ± 80**

Depth −0.98 to −0.99m.

VRI-780. El Julan 4 **1420 ± 80**

Depth −1.09 to −1.10m.

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[RADIOCARBON, VOL 25, NO 3, 1983, P 944-955]

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INDEX

Volume 25, Nos. 1 to 3, 1983

ARCHAEOLOGIC SAMPLES

ARCHAEOLOGIC SAMPLES

Date	Culture or Period	Sample No.	No.	Pg.
	CANADA (continued)			
1840±350		-171	3	904
1780± 80		-181	"	905
1780±100		- 74	"	900
1700±100		- 72	"	"
1520±200	Paleo-Eskimo	- 87	"	903
1450±250	Late Woodland	-155	"	904
1440±120	Paleo-Eskimo	- 85	"	903
1430±160		-142	"	902
1320±700		-170	"	904
1250±120		-177	"	905
1170±260		-182	"	"
1140± 80		-262	"	902
1040±110		-180	"	905
1020±150		-189	"	906
980±250		-186	"	"
980±100		- 57		900
890±160		-135	"	901
870±180		- 51	"	899
860±400		-183	"	906
800± 80		- 79	"	901
790±150	Kutenai	-184	"	906
760±140		-194	"	907
750± 90		-191	"	906
700±100		-193	"	"
700±110		-188	"	906
690±180	Woodland	-151	"	904
610± 80		-154	"	"
600± 80		-145	"	902
490±130		- 50	"	899
480±100	Late Prehistoric	- 73	"	900
480± 80		- 80	"	901
480±260	Woodland	-169	"	904
480±200		-179	"	905
430±100		- 56	"	899
370± 90	Woodland	-153	"	904
330± 80		- 89	"	901
290±100		- 75	"	900
260± 80		-143	"	902
260±100	Late Prehistoric	-175	"	905
260±200		-178	"	"
220±100		-185	"	906
170±120		-152	"	904
140± 80		-108	"	901
110± 80		-192	"	906
110± 80		- 77	"	900
100± 80		- 99	"	901
Modern		-144	"	902
Modern		-265	"	903
Modern		-267	"	"
Modern		-176	"	905
Modern		-187	"	906
	CYPRUS			
5180± 60	Neolithic	BM-1908	1	46
5120± 45	"	-1907	"	"
5030± 80	"	-1906	"	"
	CZECHOSLOVAKIA			
3820±210	Misassoc	Ly-2245	1	99
	ECUADOR			
1960± 40	Jambeli	BM-1689	1	46
1475± 35	"	-1688	"	"
	EGYPT			
3180±140		BM-1846	1	46
	FIJI			
1000±100	Tongan	SFU-118	3	907
	FRANCE			
≥35,800	Mousterian	Ly-1898	1	119
≥34,200	Early Aurignacian	-1031	"	"
36,000 1300	Mousterian	-1676	"	"
33,200 1500	Late Mousterian	-2428	"	118
≥32,000	Paleolithic	-2038	"	120
≥29,000	Early Aurignacian	-1895	"	119
29,000 860	Paleolithic	-2351	"	120
27,700 1100	Mousterian	-1793	"	119
25,870 830	Late Paleolithic	-1896	"	"

Date	Culture or Period	Sample No.	No.	Pg.
	FRANCE (continued)			
25,800 ± 700	Paleolithic	Ly-1863	1	118
$24,400^{+2000}_{-1600}$	Late Mousterian	-1595	"	"
24,200±1100	Early Magdalenian	-1835	"	116
22,960±840	Castelperronian	-2193	"	119
21,950±350	Paleolithic	-2101	"	118
21,100±540	Proto-Aurignacian	-2192	"	119
20,100±500	Solutrean	-1984	"	117
20,100±310	Late Mousterian	-2217	"	118
20,060±450	Solutrean	-1983	"	117
19,310±790	Paleolithic	-2279	"	"
18,180±1070	Magdalenian	BM-1914	"	47
18,050±230	"	-1913	"	"
18,020±270	Late Solutrean	Ly-2228	"	116
17,490±520	Early Magdalenian	-1394	"	"
17,420±390	"	-1836	"	"
17,400±460	"	-1834	"	"
15,830±400	Middle Magdalenian	-1830	"	115
15,440±400	Paleolithic	-1998	"	"
14,770±970	Magdalenian	-1675	"	119
14,530±510	"	-1232	"	"
14,280±440	"	-2275	"	114
14,280±160	Magdalenian III	-2100	"	115
13,980±510	Azilian	-1598	"	116
13,790±420	Magdalenian	-1897	"	119
13,570±260	"	-2352	"	114
13,370±340	"	-2154	"	114
13,320±360	"	BM-1916	"	47
13,090±270	"	Ly-2046	"	114
12,860±320	Magdalenian IV	-1894	"	119
12,770±420	Paleolithic	-2184	"	113
12,710±200	Magdalenian	-2355	"	114
12,690±530	Azilian	-1392	"	116
12,620±250	Late Magdalenian	-2296	"	113
12,600±1100	Magdalenian	-1605	"	112
12,500±210	Magdalenian IV	-1231	"	119
12,450±330	Late Magdalenian	-1906	"	113
12,180±130	Magdalenian	BM-1912	"	47
11,870±290	Azilian	-1832	"	116
11,850±280	"	-1833	"	"
11,750±430	Late Magdalenian	-1905	"	113
11,680±330	Azilian	-1391	"	116
11,450± 70	Magdalenian	BM-1911	"	47
11,290±320	Azilian	Ly-1390	"	116
11,200±800	Magdalenian	-1861	"	118
9060±800	Sauveterrian	-1979	"	112
8850±190	Mesolithic	-2107	"	"
8740±230	Sauveterrian	-2411	"	"
8730±890	Azilian	-1393	"	116
8730±170	Mesolithic	-2297	"	111
8620±380	Sauveterrian	-2200	1	"
8570±320	"	-1978	"	112
8450±350	"	-2364	"	"
8200±750	"	-1980	"	"
7270±240	Mesolithic	-2365	"	111
6580±400	Recent Rubané	-1828	"	106
6500±230	Tardenoisian	-1935	"	109
6450±160	Recent Rubané	-1736	"	106
6440±350	Aberrant	-2047	"	114
6280±320	Sauveterrian	-2410	"	112
6220±230	Recent Rubané	Ly-1737	"	106
6200±190	"	-1735	"	"
6190±210	"	-1797	"	108
6140±210	"	-1734	"	106
6130±200	Neolithic post-Rubané	-1824	"	"
6110±140	Recent Rubané	-2324	"	"
6070±140	Pre-Chassean/Chassean	-1944	"	108
6050±160	Late Recent Rubané	-2463	"	107
6030±130	Recent Rubané	-2327	"	106
6030±130	"	-2322	"	"
6010±220	Neolithic post-Rubané	-1825	"	"
6000±120	Recent Rubané	-2331	"	"
5980±110	"	-2333	"	"
5960±150	"	-2336	"	"
5960±170	"	-2321	"	"
5940±210	Mesolithic	-1934	"	109
5930±190	Recent Rubané	-1829	"	106
5910±130	"	-2330	"	"
5860±170	Neolithic	-2243	"	105
5860±300	Recent Rubané	-1827	"	106
5860±190	"	-2323	"	"
5840±140	"	-2335	"	"
5800±170	"	-2332	"	"
5700±150	Chassean	-1772	"	103
5660±150	"	-1768	"	"

Date	Culture or Period	Sample No.	No.	Pg.
	FRANCE (continued)			
5660±140	Chassean	Ly-1791	1	103
5600±210	"	-1378	"	104
5590±130	"	-1985	"	105
5540±120	"	-1769	"	103
5530±320	Menneville group	-2326	"	106
5530±150	Cerny	-2455	"	108
5490±310	Chassean	-1867	"	105
5440±130	Chassean/Chalcolithic	-2434	"	102
5380±140	Chassean	-1770	"	103
6480±160	"	-1771	"	"
5360±510	Recent Rubane	-1826	"	106
5350±270	Middle Neolithic	-1860	"	105
5340±130	Late Roessen	-2371	"	106
5340±190	Chassean	-2084	"	104
5330±130	Late Roessen	-2370	"	106
5310±470	Early Chassean	-1987	"	104
5290±300	Chassean	-1864	"	"
5260±200	Middle/Late Neolithic	-2458	"	107
5230±300	Middle Neolithic	-1889	"	105
5220±140	Chassean	-1767	"	103
5200±250	Early Chassean	-1596	"	104
5140±170	Middle/Late Neolithic	-2462	"	107
5100±180	"	-2456	"	"
5100±160	Menneville group	-2329	"	106
5030±100	Chassean	-2194	"	104
5020±200	"	-2247	"	"
5020±150	Michelsberg	-2334	"	106
5010±140	Middle Neolithic	-2077	"	"
4970±200	"	-2075	"	103
4970±140	Middle/Late Neolithic	-2461	"	107
4900±210	"	-2459	"	"
4880±120	Chassean/Michelsberg	-2518	"	102
4870±160	Middle/Late Neolithic	-2457	"	107
4830±150	Chassean	-2076	"	103
4810±120	Michelsberg	-2328	"	106
4970±260	Chassean	-2289	"	104
4770±160	Middle/Late Neolithic	-2460	"	107
4750±270	Chassean	-1408	"	105
4740±140	"	-2246	"	104
4710±150	Neolithic	-1688	"	102
4670±190	Chassean	-2083	"	104
4560±930	"	-1865	"	"
4550±130	SOM	-2348	"	101
4550±150	Chassean	-1738	"	102
4540±210	Late Chassean	-1349	"	104
4530±140	Chassean	-2304	"	"
4460±110	Late Neolithic	-2464	"	108
4390±160	Chalcolithic	-1941	"	101
4380±140	Late Neolithic	-1903	"	"
4340±290	Late Neolithic/ Early Bronze	-2288	"	98
4310±130	Late Neolithic	-1962	"	101
4250±130	"	-2007	"	100
4240±200	Late Chassean	-2303	"	104
4240±160	Chassean/Chalcolithic	-2432	"	102
4200±160	Late Neolithic/ Early Bronze	-2180	"	97
4170±140	Late Neolithic	-2008	"	100
4060±100	Neolithic/Chalcolithic	-2078	"	100
4010±140	Late Neolithic	-2417	"	101
3990±110	Chalcolithic/ Early Bronze	-2213	"	100
3840±190	Chassean/Chalcolithic	-2431	"	102
3800±130	Late Neolithic	-1750	"	99
3760±150	Bronze Age	-1868	"	98
3750±240	Late Neolithic	-1989	"	100
3740±130	"	-2305	"	"
3730±190	Cremation	-1806	"	97
3720±140	Chalcolithic	-1904	"	99
3660±130	"	-2295	"	"
3650±250	Early/Middle Bronze	-1831	"	97
3590±180	Chassean/Chalcolithic	-2433	"	102
3550±220	Late Neolithic/ Early Bronze	-2287	"	98
3540±230	Early Bronze	-2244	"	96
3480±140	Middle Bronze	-1773	"	"
3210±160	Bronze (?)	-2259	"	99
3130±150	Cerny	-1776	"	106
3080±240	Late Bronze	-1866	"	96
3030±450	Bronze Age	-1986	"	"
2900±130	Late Bronze	-2054	"	95
2770±160	"	-2325	"	96
2770±130	Middle Bronze III	-2005	"	95
2700±140	Late Bronze	-1951	"	96
2650±100	Hallstatt/LaTène	-2242	"	94

Date	Culture or Period	Sample No.	No.	Pg.
	FRANCE (continued)			
2550±100	Late Bronze III	-2056	1	95
2520±200	Chalcolithic (?)	-1975	"	99
2520±120	Iron Age	-2037	"	95
2510±130	Late Hallstatt	-1807	"	93
2470±300	Iron Age I/II	-1862	"	"
2420±180	Iron Age I	-1912	"	94
2420±110	Late Hallstatt	-2222	"	"
2410±130	Iron Age	-2036	"	95
2390±120	"	-1971	"	94
2370±100	"	-2191	"	"
2240±160	"	-2082	"	93
2210±130	Historic	-1879	"	86
2190±250	Late Hallstatt/ Early LaTène	-2354	"	93
2150±128	Late Hallstatt	-2353	"	"
2100±140	Protohistoric	-2104	"	91
2060±120	Middle LaTène	-2300	"	93
2020±110	Gallo-Roman	-2344	"	88
2010±130	Neolithic re-use	-1969	"	98
1880±220	Misassoc	-2439	"	88
1750±160	"	-2437	"	"
1660±160	Chalcolithic	-2214	"	99
1640±300	Misassoc	-2009	"	93
1640±140	High Middle Ages	-1876	"	87
1610±130	"	-2293	"	86
1490±120	Middle Bronze re-use	-2053	"	95
1420±200	Middle Age	-1801	"	87
1260±140	Gallo - Roman	-2199	"	85
1180±190	Middle Age	-1777	"	87
1180±130	High Middle Age	-1875	"	"
1130±430	Misassoc	-1808	"	92
1130±120	High Middle Age	-2179	"	86
1080±140	Middle Age	-1874	"	87
1010±130	"	-1878	"	86
1010±140	"	-1872	"	"
1010±130	Misassoc	-1974	"	98
900±110	Middle Age	-2252	"	85
880±140	"	-1880	"	86
870±150	"	-1871	"	"
830±120	Medieval	BM-1979	"	48
830±100	"	-1978	"	"
750±140	Middle Age	Ly-1991	"	85
730±130	"	-2293	"	86
710±150	"	-1990	"	85
610±150	"	-2273	"	87
600±120	"	-2272	"	"
580±230	Historic	-2274	"	85
490±160	"	-1845	"	"
490±120	"	-1877	"	87
440± 60	Medieval	BM-1977	"	48
380±120	Historic	Ly-2306	"	86
240±160	Misassoc	-1968	"	98
Modern	Iron Age	-2010	"	92
"	Misassoc	-1970	"	112
	GREECE			
6400± 80	Neolithic	BM-2020	1	48
5510±390	"	-2021	"	"
4300±230	Late Bronze	Ly-1779	"	97
3700±270	"	-1778	"	"
2820± 50	Protogeometric	Lu-2052	3	890
	HUNGARY			
6840±110	Neolithic	BM-1863	1	49
6830± 60	"	-1868	"	"
6620± 60	"	-1866	"	"
6600± 80	"	-1870	"	"
6580± 60	"	-1862	"	48
6470± 70	"	-1871	"	49
6190±140	"	-1865	"	"
6090± 60	"	-1864	"	"
6080± 60	"	-1860	"	48
5730± 90	"	-1867	"	49
5630±140	"	-1861	"	48
	IRAN			
3920±250	Bronze Age	Ly-1148	1	92
3690±130		-2302	"	"
3620±130	Hissar	-2031	"	"
3580±130	Bronze Age	-1147	"	"
3440±220		-2249	"	"
1940± 80		-1065	"	"
1650±100		-2248	"	"
1410±140		-1149	"	"

ARCHAEOLOGIC SAMPLES

Date	Culture or Period	Sample No.	No.	Pg.
	IRELAND			
5830± 65	Mesolithic	Lu-1961	3	889
5640± 65	"	-1962	"	"
5270± 60	Mesolithic/Neolithic	-1963	"	"
5220±110	"	-2021	"	890
4010± 55	Neolithic	-1960	"	889
3850± 85	"	-2003	"	890
2490±110	Early Iron Age	-2005	"	"
	MARTINIQUE			
2200±210	Arawak	Ly-2197	1	90
1630±220	"	-2196	"	"
	MOROCCO			
5900±210	Neolithic	Ly-2149	1	110
	PAKISTAN			
33,000±3000	Neolithic	Ly-1946	1	109
8440±250	"	-1950	"	"
5830±190	"	-1947	"	"
5720±730	"	-1948	"	"
5530±180	"	-1949	"	"
5360±310	Chalcolithic	-1945	"	"
4380±170	Neolithic	BM-1940	"	50
4310±120	"	-1939	"	"
4250±110	"	-1934	"	"
4190±140	Bronze Age	Ly-1528	"	109
4140±230	Neolithic	BM-1935	"	50
4040±200	Kot Dijian	-1944	"	51
3960±140	Bronze Age	Ly-1529	"	109
3910± 70	Kot Dijian	BM-1942	"	50
3890±230	"	-1936	"	"
3810± 60	"	-1938	"	"
3790± 60	"	-1945	"	51
3750±100	"	-1949	"	"
3730± 50	"	-2062	"	53
3700± 80	"	-1946	"	51
3700± 60	"	-1943	"	"
3690±450	"	-1941	"	"
3600± 60	"	-1948	"	"
3580±110	"	-2063	"	53
3570±130	Bronze Age	Ly-1527	"	109
2120± 20	Historic	BM-1963	"	52
2090± 90	"	-1965	"	"
2080± 80	"	-1964	"	"
2050± 80	"	-1961	"	"
2050± 60	"	-1955	"	"
2010± 40	"	-1958	"	"
2000± 45	"	-1957	"	"
1990± 60	"	-1951	"	51
1950± 50	"	-1959	"	52
1930± 50	"	-1953	"	"
1920±170	"	-1952	"	"
1830± 40	"	-1954	"	"
1805± 35	"	-1956	"	"
1795± 35	"	-1950	"	51
1740± 40	"	-1950	"	"
870± 50	Medieval	-1947	"	"
	PERU			
2380± 70	Chanapata	BM-1633	1	54
	POLAND			
15,490±310	Magdalenian	Ly-2454	1	115
14,600±240	"	-2453	"	"
	ROMANIA			
2240± 70	Greek - Roman	UGa-1819	3	929
2040±100	"	-1816	"	"
1980±130	"	-1817	"	"
	SENEGAL			
4830±770	Iron Age	Ly-1603	1	89
1960±400	"	-2048	"	90
1910±210	Protohistoric	-2159	"	"
1580±130	"	-1937	"	89
1550±140	"	-1745	"	"
1470±210	"	-1741	"	"
1460±220	"	-1743	"	"

Date	Culture or Period	Sample No.	No.	Pg.
	SENEGAL (continued)			
1410±140	Misassoc	-2188	1	89
1170± 90	Protohistoric	-2049	"	90
970±150	"	-1742	"	89
920±100	Iron Age	-2033	"	"
790±100	Protohistoric	-2034	"	90
Modern	"	-1993	"	88
"	"	-1992	"	"
"	"	-1994	"	"
"	"	-1995	"	"
"	"	-1996	"	"
"	"	-1997	"	"
	SPAIN			
19,510±330	Middle Solutrean	Ly-2428	1	117
19,480±260	"	-2426	"	"
19,390±260	Upper Solutrean	-2424	"	"
19,030±320	Middle Solutrean	-2425	"	"
19,000±280	"	-2429	"	"
18,310±260	Upper Solutrean	-2423	"	"
18,250±300	"	-2421	"	"
17,050±290	"	-2422	"	"
15,800±350	Early Magdalenian	-1965	"	113
13,400±150	Middle Magdalenian	-2427	"	117
9530±300	Azilian	-1964	"	113
4760± 50	Beaker	BM-1994	"	55
4240±140	Late Neolithic/ Chalcolithic	Ly-1963	"	101
3720± 35	Beaker	BM-1981	1	55
3380± 50	Bronze Age	-1995	"	"
3040± 45	"	-1927	"	54
3020± 45	"	-1925	"	"
2960± 40	"	-1924	"	"
2915± 45	"	-1928	"	"
2880± 35	"	-1926	"	"
2645± 40	"	-1998	"	55
2090± 50	Tavla	-2003	"	56
1890± 35	"	-2004	"	"
1710± 60	Misassoc	-1982	"	55
1560± 80	Tavla	-2005	"	56
1420± 80	Canarian Megalith	VRI-780	3	943
1260± 80	"	-779	"	"
1140± 80	"	-778	"	942
1010± 80		-777	"	"
855± 35	Misassoc	-1993	"	55
	SWEDEN			
8050± 75	Mesolithic	Lu-1983	3	887
7380± 70	"	-1999	"	888
7330± 70	"	-2067	"	"
7070± 70	"	-2000	"	"
7000± 70	"	-1995	"	887
6280± 80	Ertebolle	-1945	"	888
6050±100	"	-1957	"	887
5470±105	"	-1956	"	"
5080± 60	Mesolithic/Neolithic	-2054	"	888
2730± 50	Bronze Age	-1982	"	887
2530± 50	Late Bronze/Iron Age	-1955	"	"
2520± 55	"	-1985	"	"
880± 45	Viking Age	-2001	"	888
410± 55	Medieval	-2012	"	"
	SYRIA			
3620± 50	Agade	BM-1972	1	57
3590± 50	"	-1971	"	"
3590± 45	"	-1973	"	"
3440± 50	Agade/Ur III	-1970	"	"
	TANZANIA			
2590±120		SFU-140	3	907
2290±100		-138	"	"
2230±160		-139	"	"
2020±360		-137	"	"
	THAILAND			
1810±210	Late Prehistoric	BM-2016	1	57

ARCHAEOLOGIC SAMPLES

Date	Culture or Period	Sample No.	No.	Pg.
	UNITED STATES			
	California			
10,260±340	Paleo-Indian	UCLA-1795A	1	131
9040±210	"	-1795B	"	"
7750±400	"	-1795C	"	"
3270± 70	Central California (CC) Early Horizon	-1891A	"	133
3130±230	CC Middle Horizon	-1791F	"	132
3050±130	CC Early Horizon	-1891B	"	133
2870±240	CC Early Middle Horizon	-1786C	"	132
2860±120	CC Middle Middle Horizon	-1786B	"	"
2150±190		-1958	"	135
2040±350	Cairn burial	-1771B	"	130
1960± 50		-1789B	"	"
1950± 60		-1951A	"	134
1910± 60		-1955	"	135
1720± 50	"Central" cemetery	-1771A	"	130
1620±400		-1952A	"	135
1440± 50		-1789A	"	130
1250±230	Misassoc	-1792E	"	132
1200±100		-1952B	"	135
1190±130	CC Middle/Late Horizon/ Transitional Phase	-1792D	"	132
1090±100		-1959	"	135
1000±300	Late Horizon/ Prehistoric	-1920B	"	134
1000± 50	CC Early Horizon	-1724C	"	130
950± 50	CC Early Phase 1 Middle/Late Horizon Transitional Phase	-1792C	"	132
940± 50	CC Middle/Late Horizon Transitional Phase	-1792B	"	"
870± 50	CC Early Phase 1 Late Horizon	-1792A	"	"
680± 40	North Coast (NC) Middle Horizon	-1853B	"	133
660± 60	CC Early Horizon	-1724A	"	130
620± 60	NC "Tlotlic," Borax Lake Pattern	-1913B	"	134
600± 60	CC Early Horizon	-1724F	"	130
590± 50	Phase 1 CC Late Horizon	-1793B	"	133
470± 50	Phase 1/Phase 2 CC Late Horizon	-1793D	"	133
470±120	Early Phase 1 CC Late Horizon	-1786A	"	131
450±100	CC Early Horizon	-1724B	"	130
440± 50	Phase I CC Late Horizon	-1793A	"	133
440± 80		-1960	"	135
430±110	Late Horizon/ Protohistoric	-1920A	"	134
430± 80	CC Early Horizon	-1724B	"	130
390± 90		-1950	1	134
370± 50	Phase 1/Phase 2 CC Late Horizon	-1793C	"	133
350± 50		-1953	"	135
<300	Houx Pattern NC Range	-1913A	"	134
<300		-1957	"	135
280± 40		-1951B	"	134
280± 60		-1954	"	135
170± 60	CC Early Horizon	-1724D	"	130
120± 45	Southern Pomo	-1794C	"	131
	Florida			
7650±160	Little Salt Spring	UM-2163	1	141
7550±120	Archaic	-2227	"	142
6780±130	"	-2169	"	"
6670± 80	"	-2087	"	"
6630± 80	"	-2088	"	"
6520±130	"	-2085	"	"
6430± 90	Little Salt Spring	-2161	"	141
5680±120	Archaic	-2226	"	142
5500± 80	"	-2170	"	"
5330± 80	Little Salt Spring	-2161	"	141
2790± 60	"	-2164	"	"
1590± 40	Glades II	-2402	"	"
1570± 40	"	-2399	"	"
1570± 40	"	-2404	"	"
1550± 40	"	-2400	"	"
1530± 40	"	-2398	"	"
1480± 40	"	-2405	"	"
	Florida (continued)			
1430 ± 70	Little Salt Spring	-2160	1	141
1400 ± 40	Glades II	-2403	"	"
1380 ± 70	Little Salt Spring	-2172	"	"
1280 ± 40	Glades II	-2401	"	"
1140 ± 70	Hontoon Island	-2610	3	934
1120 ± 50	"	-2609	"	"
1060 ± 50	"	-2604	"	"
1020 ± 50	"	-2608	"	"
1020 ± 50	"	-2611	"	935
870 ± 50	"	-2607	"	934
800 ± 50	"	-2606	"	"
400 ± 70	"	-2605	"	"
260 ± 50	"	-2604	"	"
200 ± 50	"	-2602	"	"
103% Modern	Little Salt Spring	-2159	"	141
	Missouri			
920 ± 70	Late Woodland	WIS-1400	1	152
860 ± 70	"	-1402	"	153
	South Dakota			
2370 ± 70	Archaic	WIS-1309	1	154
1950 ± 70	Middle Woodland	-1373	"	"
1410 ± 70	"	-1377	"	155
1250 ± 70	"	-1372	"	154
1190 ± 70	Middle Missouri	-1348	"	153
1180 ± 70	Middle Woodland	-1359	"	154
1110 ± 70	"	-1371	"	"
1070 ± 70	Middle Missouri	-1346	"	153
980 ± 70	"	-1349	"	"
960 ± 70	"	-1350	"	"
930 ± 70	"	-1352	"	"
920 ± 70	"	-1375	"	155
900 ± 70	"	-1347	"	153
830 ± 70	"	-1368	"	155
810 ± 70	"	-1351	"	153
770 ± 70	"	-1374	"	155
700 ± 70	"	-1376	"	"
650 ± 70	"	-1370	"	"
400 ± 70	Late Prehistoric	-1358	"	154
	Tennessee			
1630 ± 80		WIS-1313	1	155
250 ± 70		-1306	"	"
200 ± 70		-1307	"	"
	Wisconsin			
1890 ± 80	Prairie Phase	WIS-1309	1	157
1880 ± 80	"	-1276	"	156
1790 ± 90	Lane Farm Phase	-1312	"	"
1670 ± 70	Millville Phase	-1335	"	157
1620 ± 70	"	-1308	"	"
1150 ± 70	Effigy Mound Culture	-1336	"	"
1030 ± 80	Late Woodland	-1311	"	156
1030 ± 70	"	-1378	"	158
960 ± 80	Effigy Mound Culture	-1271	"	156
860 ± 80	Late Woodland	-1310	"	"
830 ± 70	Lakes Phase	-1340	"	157
750 ± 70	"	-1339	"	"
	YUGOSLAVIA			
1610 ± 70	Middle Ages	IRPA-498	3	874
510 ± 70	"	-499	"	"

GEOLOGIC SAMPLES

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GEOLOGIC SAMPLES

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GEOLOGIC SAMPLES

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-380	"	"
-381	"	149
-382	"	"
-385	"	"
-386	"	150
-387	"	"
-388	"	149
-431	"	147
-448	"	146
-449	"	"
-456	"	146
-457	"	147
-607	"	148
-632	"	147
-634	"	149
-635	"	"
-755	"	150
-807	"	147

Sample no.	No.	Page no.
VRI		
-625	25/3	938
-626	"	"
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-628	"	938
-629	"	939
-690	"	"
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-771	"	938
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-781	"	937
-782	"	938
-784	"	939
-785	"	"

Sample no.	No.	Page no.
WIS		
-1275	25/1	162
-1278	"	"
-1303	"	159
-1304	"	"
-1305	"	"
-1314	"	159
-1315	"	160
-1316	"	"
-1317	"	"
-1318	"	158
-1319	"	162
-1320	"	"
-1321	"	159
-1322	"	"
-1323	"	"
-1324	"	160
-1325	"	"
-1326	"	162
-1327	"	165
-1328	"	"
-1329	"	166
-1330	"	"
-1331	"	"
-1332	"	163
-1333	"	"
-1334	"	"
-1337	"	160
-1338	"	"
-1341	"	161
-1342	"	"
-1343	"	"
-1344	"	158
-1345	"	"
-1353	"	167
-1354	"	"
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-1360	"	161
-1361	"	"
-1362	"	162
-1363	"	"
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-1365	"	"
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-1367	"	"
-1379	"	165
-1380	"	163
-1381	"	"
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-1385	"	"
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-1387	"	"
-1388	"	"
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-1390	"	"
-1391	"	158
-1392	"	166
-1393	"	"
-1394	"	"
-1395	"	165
-1396	"	"
-1397	"	163
-1398	"	165
-1399	"	166
-1401	"	"
-1403	"	167
-1404	"	"
-1405	"	158
-1406	"	164
-1407	"	"

Vol 25, No. 3 Radiocarbon 1983

CONTENTS