

NON-CONCORDANCE OF RADIOCARBON AND AMINO ACID  
RACEMIZATION DEDUCED AGE ESTIMATES ON HUMAN BONE

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ABSTRACT. Radiocarbon determinations, employing both decay and direct counting, were obtained on various organic fractions of four human skeletal samples previously assigned ages ranging from 28,000 to 70,000 years on the basis of their D/L aspartic acid racemization values. In all four cases, the  $^{14}\text{C}$  values require an order of magnitude reduction in age.

INTRODUCTION

Some of the earliest  $^{14}\text{C}$  measurements carried out in 1948-1949 were concerned with the question of the antiquity of Homo sapiens in the Western Hemisphere (Arnold and Libby, 1950). By the mid-1960's,  $^{14}\text{C}$  values were being used to establish the presence of human populations in the New World at a maximum of ca 12,000 to 13,000  $^{14}\text{C}$  years BP (Haynes, 1967). In the early 1970's,  $^{14}\text{C}$  values on the "collagen" (typically, the acid-insoluble) fraction of human bone samples (cf Hassan and Hare, 1978; Taylor, 1980) were used to adjust the upper limit upward to ca 20,000 to 25,000  $^{14}\text{C}$  years (Berger et al, 1971; Berger, 1975). By the mid 1970's, amino-acid racemization (Bada and Protsch, 1973) and its application to bone samples from anatomically modern Homo sapiens from central and southern California (Bada and Helfman, 1975) provided aspartic acid derived age assignments up to as much as 70,000 years (Sunnyvale skeleton).

Based, in part, on the  $^{14}\text{C}$  and amino acid racemization estimates of age, several archaeologists conversant with the evidence (MacNeish, 1976; 1978) suggested that human populations moved into North America more than 35,000 to 50,000 years ago. Recently, the amino acid racemization values were used as evidence to support a view that human populations arrived in the New World as early as the last interglacial (Carter, 1980). The 70,000-year age of the Sunnyvale skeleton has even been cited to support the view that modern Homo sapiens evolved in the New World (Goodman, 1981).

At the same time, several geochemists have been quite skeptical concerning the validity of such age assignments on bone (Hare, 1974; Bender, 1974; Williams and Smith, 1977; Von Endt, 1979; Kessels and Dungworth, 1980). An undercurrent of

uncertainty prevails concerning the validity of some  $^{14}\text{C}$  and amino acid racemization values assigning ages older than ca 15,000 years to New World human skeletal remains (Willey, 1978, p 269-270; Taylor and Payen, 1979; Meighan, 1983). There is clearly a need to resolve some basic questions focused on both  $^{14}\text{C}$  and amino acid racemization deduced ages on presumed early New World human skeletal samples.

#### DATA AND DISCUSSION

Up to 1982, there were ten published examples in which North American Homo sapiens skeletal materials were assigned ages older than about 15,000 years BP based on direct  $^{14}\text{C}$ , amino acid racemization, and/or uranium series determinations on bone. The oldest values are assigned by the amino acid racemization technique. These include, in order of the age indicated by D/L aspartic acid racemization values, the Sunnyvale (70,000 years), Haverty or Angeles Mesa (>50,000 years), and Del Mar (41,000-48,000 years) skeletons. This paper reports direct comparisons between  $^{14}\text{C}$  and amino acid deduced age estimates for the two oldest skeletons as well as comparisons on samples assigned somewhat younger ages (37,000 and 28,000 years) by the amino acid racemization method. The method of preparation of the organic fractions of the bone samples used for the  $^{14}\text{C}$  analysis in the UCR laboratory is presented in figure 1.

The Sunnyvale skeleton was excavated in 1973 from an exposed section of the Sunnyvale East Drainage Channel in the southern portion of San Francisco Bay, California (Lajoie, Peterson, and Gerow, 1980). An anthropometric examination showed the skeleton was a morphologically fully modern, nearly complete female, statistically indistinguishable in 32 standard measurements and indices from a local population of females previously dated by  $^{14}\text{C}$  and cultural association to between ca 400 and 1600  $^{14}\text{C}$  years ago (Gerow, 1981). Both archaeological and geologic contexts pointed to a late to middle Holocene age. The skeleton was found in a well-defined grave pit 2.7m deep. The pit was excavated through a layer of dispersed freshwater shell that yielded ages of 10,110±260 (I-8084) and 10,430±150 (I-6476)  $^{14}\text{C}$  years BP. Charcoal associated with a bone artifact found ca 400m south of the burial and ca 2m deep, in sediments similar to those in the burial pit, yielded an age of 4460±95  $^{14}\text{C}$  years BP (I-6977). On this evidence Lajoie, Peterson and Gerow (1980) and Gerow (1981) argued that the Sunnyvale skeleton was less than 10,000 years and probably less than 4500 years.

Four  $^{14}\text{C}$  ages have been obtained, by both decay and direct counting on three organic fractions of post-cranial bone of the Sunnyvale skeleton. Decay counting was done by a 500cc

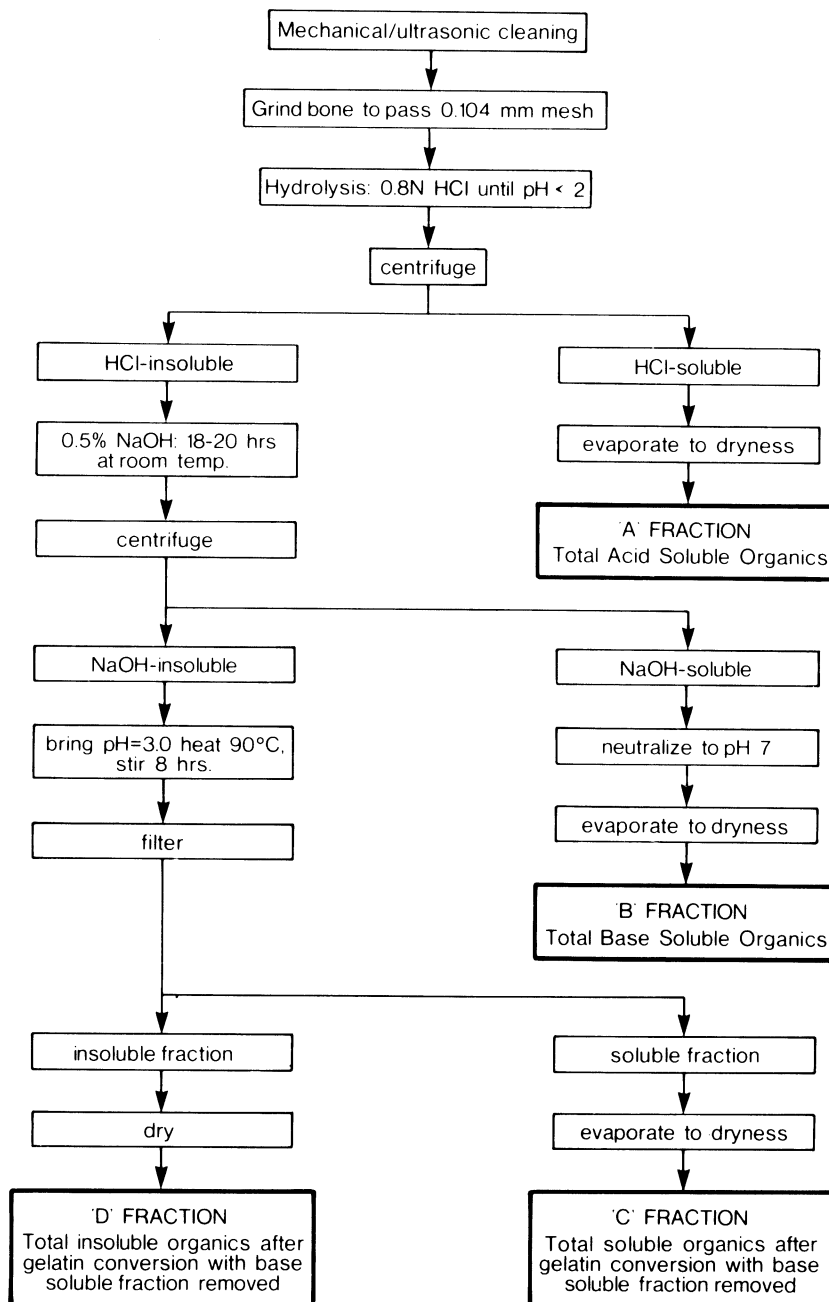


Fig 1. Preparation of organic fraction of bone for <sup>14</sup>C analysis. See also Taylor 1980, 1982.

CO<sub>2</sub> gas proportional counter (Taylor, 1975). Insufficient carbon yield from two of the organic fractions required the use of direct counting. The analyses were made at the NSF Regional Facility for Radioisotope Dating at the University of Arizona with sample gases prepared at the UCR laboratory; details are discussed in Chapter VIII (Donahue *et al*, 1983). The direct counting values are identified in table 1 by the dual laboratory number, ie, UCR-1437A/AA-50 with AA identifying a University of Arizona Accelerator determination. All four <sup>14</sup>C determinations on the Sunnyvale skeleton support a middle Holocene age assignment in the range between 3500 and 5000 <sup>14</sup>C years BP in contrast to the aspartic acid racemization deduced age.

In 1924, a group of human skeletons were found between 5.75 and 7m deep in an area ca 1m<sup>2</sup> during trenching operations being carried out by the Haverty Construction Company in the Baldwin Hills area of western Los Angeles County, California (Stock, 1924). The horizontal proximity of the skeletons strongly suggest that all of the skeletons were interred at the same time. Interest in the age of the Haverty or Angeles Mesa skeletons was heightened by the 1970 <sup>14</sup>C determination on the Los Angeles (Baldwin Hills) human skeleton which was recovered in 1936 ca 0.8km north of Haverty at a depth of 4m (Lopatin, 1940; G Kennedy, pers commun). Its <sup>14</sup>C age, >23,600 years BP, was obtained on the total amino acid fraction of a portion of the skull (Berger *et al*, 1971; Berger, 1975). Subsequently, a D/L aspartic acid racemization value of 26,000 years was obtained using the <sup>14</sup>C-dated Laguna human skull to provide the temperature calibration (Bada and Helfman, 1975). With the same temperature calibration, an aspartic acid measurement on the Haverty skeleton resulted in an inferred age of greater than 50,000 years (Austin, 1976, p 5; Masters, pers commun). By contrast, the four <sup>14</sup>C determinations on the Haverty skeletons by three radiocarbon laboratories point to a middle Holocene age in the range between ca 5000 and 8000 <sup>14</sup>C years.

The La Jolla Shores skeleton (SDM 16755) was unearthed in 1926 during construction operations at the San Diego Museum of Man (SDM) W-2 site. As an *Olivella* shell bead was cemented to one of the ribs, the remains were interpreted as a burial. The sample was collected by M J Rogers and stored at the Museum of Man until selected for amino acid racemization analysis by George F Carter. The Laguna skull was used as the SDM 16755 "calibration" sample for the purpose of inferring its aspartic acid racemization age of 28,000 years BP (Bada, Schroeder, and Carter, 1974). Three <sup>14</sup>C values on La Jolla Shores bone obtained by two laboratories place its age at less than 2000 years. The D/L aspartic acid ratios of both bone and teeth from the Riverside or San

TABLE 1. North American human skeletal samples with direct  $^{14}\text{C}$  and amino-acid racemization-deduced ages. Details of the method of preparing bone for  $^{14}\text{C}$  analysis in the UCR laboratory is presented in figure 1.

Locality	Age/technique*	Fraction employed for $^{14}\text{C}$	Reference
1 Los Angeles (Angeles Mesa), California (Haverty)	>50,000(A) (CX-1140) 5200+400(C) 7900+1440(C) (UCLA-1924A) 5680+180(C) (UCR-1349A) 5280+180(C) (UCR-1349D) >23,600(C) (UCLA-1430) 26,000(A)	- Total bone organics after pyrolysis Total acid-insoluble organics with base extraction Total acid-soluble organics	Austin, 1976; P Masters pers commun S Brooks, pers commun R Berger, pers commun This report
2 Los Angeles (Baldwin Hills), California	>23,600(C) (UCLA-1430) 26,000(A)	Total acid-insoluble organics after gelatin conversion with base-soluble fraction removed Total amino acids (ion exchange chromatography)	This report Berger et al., 1971
3 San Diego, La Jolla Shores (W-2, SDM 16755), California	28,000(A) 1770+790(C) (UCR-1511D) 1850+200(C) (UCLA-2368) 1930+200(C) (UCLA-2384) 37,000(A)	- Total acid insoluble organics after gelatin conversion with base soluble fraction removed Gelatin fraction Gelatin Fraction	Bada, Schroeder, and Carter, 1974 Bada, Schroeder, and Carter, 1974 This report R Berger, pers commun R Berger, pers commun
4 San Jacinto (Riverside), California	3020+140(C) (UCR-1420A) 70,000(A) 4390+150(C) (UCR-1437A) 3600+600(C)** (UCR-1437A/AA-50) 4850+400(C)** (UCR-1437B/AA-52) 4650+400(C)** (UCR-1437D/AA-51)	Total acid-soluble organics Total acid-soluble organics Total acid-soluble organics Total base-soluble organics Total insoluble organics after gelatin conversion with base soluble fraction removed	R Berger, pers commun Bada, et al., 1979; P Masters, pers commun This report Bada and Helfman, 1975 This report This report This report This report
5 Sunnyvale, California			

\* (C) =  $^{14}\text{C}$  value, (A) = aspartic acid racemization value

\*\* Preliminary values for the  $^{14}\text{C}$  determinations obtained by direct counting at the NSF Regional Facility for Radiosotope Dating at the University of Arizona were originally reported with respect to 5050 BC wood. The values cited here represent a large number of subsequent measurements and have been expressed in  $^{14}\text{C}$  years BP.

Jacinto skeleton was published by Bada *et al*, 1979. This skeleton had been recovered in 1938 by H Garbani at the Charlotte Site near San Jacinto in Riverside County, California (H Garbani, pers commun). The  $k_{asp}$  value used to determine the aspartic acid racemization age of the La Jolla Shores (and Laguna skull) sample has been employed to calculate an aspartic acid racemization age of approximately 37,000 years for the San Jacinto skeleton (P Masters, pers commun). Its  $^{14}C$  age is approximately 3000 years.

#### CONCLUSION

A significant number of amino acid racemization ages on bone have previously been validated by their concordance with  $^{14}C$  values. An example of this is the  $^{14}C$  and aspartic acid racemization dates on the Los Angeles (Baldwin Hills) skeleton. In other instances, however, the racemization deduced values can be significantly anomalous. Such is the case for the ages assigned to the Sunnyvale, Los Angeles (Angeles Mesa/Haverty), La Jolla Shores, and San Jacinto (Riverside) skeletons. In all four instances, the  $^{14}C$  values require an order of magnitude reduction in age. Future studies will be required to determine what factors are involved in causing these samples to yield greatly inflated racemization-deduced ages.

#### ACKNOWLEDGMENTS

Research support of the UCR Radiocarbon Laboratory by NSF Grant BNS 7815069 and 8011764 (Anthropology Program), the dedicated laboratory assistance of P Ennis, A Payen, C Prior, and P J Slota, Jr, and the collaboration of D J Donahue, T H Zabel, A J T Jull, and P E Damon (University of Arizona) is gratefully acknowledged. The Regional Accelerator Facility at the University of Arizona is supported by an NSF Regional Instrumentation Facilities Grant. This is contribution number 82/12 of the Institute of Geophysics and Planetary Physics, University of California, Riverside.

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