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Chronometric Dating of Bone from Namib IV Acheulean Site, South West Africa/Namibia

By

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Abstract The association of fossil bone, including *Elephas recki*, with an Acheulean handaxe and cleaver industry at the ancient kill/butchery site of Namib IV is the earliest evidence for man in the Namib desert. Faunal and typological parallels with east African sites suggested a mid-Pleistocene date, which this program of uranium-series, ESR and racemization dating has corroborated with a most probable age estimate of 347^{+78}_{-48} kyr BP.

Introduction

Namib IV is an artefact concentration, with associated bone, found on a pan calcretes surface at 23°47′S 15°20′E in the dune sea of the central Namib desert. The assemblage includes a heavy-tool component of handaxes and cleavers, scattered over an area of 62,500 m^2. A systematic survey was made in 1979 and further faunal remains collected in 1981 (SHACKLEY, 1980, 1985). Many of the artefacts and bones were still lightly cemented on their ventral sides into deflation surfaces of lacustrine carbonates, possibly slightly altered by surface pedogenesis. The fauna consisted of mineralised and fragmented bone and tooth remains from *Elephas recki* (minimum 8 individuals), an indeterminate alcelaphine antelope (2 individuals) and a second, large-medium antelope (3 individuals) together with 1 small horse and 1 buffalo (all identified by Professor Richard KLEIN). The elephant remains are fortunately largely composed of diagnostic tooth fragments whose thin enamel, hypsodonty and tight enamel folding suggest a late stage of *Elephas recki*, probably comparable with MAGLIO's Stage 4 (MAGLIO, 1973) as represented in Olduvai Bed IV of mid-Pleistocene date. The relatively small quantities of bone and stone recovered, and the nature of the assemblage, make it unlikely that Namib IV represents a major camp site, and the material is seen as the debris of a few short-term visits at some stage in the mid-Pleistocene.

A dating program on the Namib IV bone was set about in 1982, involving chemical analysis, racemization, electron spin resonance (ESR) and uranium-series methods. The present paper reports the preliminary results of this project.

Material and Methods

Dense cortex of a bone fragment (code no. 3) from Namib IV was subjected to uranium-series dating, ESR dating and fluorine analysis. Racemization dating was applied to another compact bone specimen (code no. 1) from the same site. The analytical techniques have been described elsewhere: e.g. KOMURA & SAKANOUE (1967) for uranium series, IKEYA (1985) for ESR, MATSU'URA (1981) for fluorine, and MATSU'URA & UETA (1980) for racemization.

Results and Discussion

$^{230}Th/^{234}U$ Dating

The results of the radiochemical analysis and the calculated date are given in Table 1. Contamination of any significant amount of thorium, including ^{230}Th, from the environment to the sample interferes with the age determination. In this case, the absence of detectable ^{232}Th (commom thorium) gives evidence for lack of such contamination. This implies that all ^{230}Th activity in the fossil bone is authigenic, thus no correction for the initial ^{230}Th tha would have accompanied non-radiogenic ^{232}Th is necessary.

The bulk of the uranium now in the bone sample is believed to be due to diagenetic gains from the burial media during fossilization. Provided that no uranium loss by leaching has taken place, the ^{230}Th date of 347^{+78}_{-48} kyr BP should represent a minimum age estimate.

ESR Dating

Table 2 shows the ESR measurement result of the total dose of natural radiation (TD) to which the bone had already been exposed; together with the contents of elements involved in the age estimation, and the external gamma-ray dose rate (Dex) measured with thermoluminescence dosimeters of $CaSO_4$ (Tm) embedded at Namib

Table 1. Radiometric data and uranium-series age for fossil bone from Namib IV.

Sample code	U* (ppm)	Activity (dpm/g)				^{230}Th age† ($\times 10^3$ years)
		^{238}U*	^{234}U*	^{232}Th	^{230}Th*	
3	65.1	20.73 ±0.41	29.82 ±0.55	<1**	31.57 ±0.39	347 +78 −48

* Determined by alpha spectrometry.
** Below the detection limit of gamma-ray measurement.
† Calculated using ^{230}Th half-life of 75,200 years and ^{234}U half-life of 245,000 years.

IV for 18 months.

One should note that ESR provides only TD which increases with the lapse of time. Unless the annual dose or the radiation environment is assessed precisely, the age can not be obtained. Bone is virtually an "open" system, presenting some difficulties in evaluating the past dose rate (IKEYA, 1983, 1985). For converting the measured TD into age, here are taken the following assumptions:

1) a linear accumulation of uranium from the initial zero ppm to the present level (IKEYA, 1983, 1985),
2) a continuous fluorine accumulation at a constant rate (Recent unpublished experimental results by IKEYA suggest the reduction of ESR signal intensity by fluorination of bone. See IKEYA, 1985.),
3) 50% rate of radon loss out of the bone, which has been estimated from high-resolution gamma-ray spectroscopy.

The alpha-ray efficiency for defect production (k) is also a factor of the dose rate. The k-value is generally 0.1–0.2 (IKEYA, 1983). Using k=0.15, which has yielded reasonable ESR ages for corals (IKEYA & OHMURA, 1983), we have a ESR date of ~140 kyr BP for the Namib IV specimen. This calculation involves a model of ^{238}U-series disequilibrium (IKEYA, 1983, 1985; IKEYA & OHMURA, 1983). The k-value of 0.15 may be reduced, close to zero, where the high ^{238}U content of the bone is due to the localisation of this element along surface layers, cracks and crevices, and/or to the occurrence as void fillings. This shifts the ESR date towards the older side, and a tentative use of k=0 generates 350 kyr BP; this might be refined by a fission track map of the uranium distribution within the bone.

Table 2. Analytical data for ESR dating of Namib IV specimen.

Sample code	^{238}U (ppm)	^{232}Th (ppm)	K_2O (%)	F (%)	Dex* (mGy/y)	TD* (Gy)
3	65.1†	~0†	0.1	1.54	0.5	500

* See text.
† See Table 1.

As was stated previously, the age evaluation assumes a constant uptake of fluorine. However, if the fluorine content in bone can be expressed by an irreversible first-order rate equation as presented by MATSU'URA (1982), it shifts the ESR age again to the old side. Refined ages will be published elsewhere when further studies are completed.

Racemization Dating

Racemization analysis on the total hydrolysate of a fossil bone (code no. 1) from Namib IV yielded D/L amino acid ratios of 0.35 for alanine, 0.15 for valine, and 0.16 for alloisoleucine/isoleucine. BADA (1981) has shown that the Pleistocene rate constant of the isoleucine epimerization (i.e. k_{iso}) in fossil teeth from the Olduvai Gorge corresponds to an average integrated palaeotemperature of ~16°C and that this

k_{iso} value is also applicable to bones from the same region. The present day mean annual air temperature at Olduvai is ~23°C (HAY, 1976; BADA, 1981), while at Gobabeb, the nearest first-order weather station to Namib IV, it is 20.5°C (GOUDIE, 1972). Provided that a difference of this magnitude had occurred in the Pleistocene and that the 2.5°C disparity represents the difference of the average temperatures to which the fossil specimens from Namib IV and Olduvai have been exposed, the Namib k_{iso} constant (yr^{-1}) can be estimated from the following equation (see BADA *et al.*, 1973, and BADA, 1981):

$$\ln \{k_{iso}/(1.3\times10^{-6})\}=\{(33.4\times10^{3})/1.987\}\cdot[(-2.5)/\{289\times(289-2.5)\}]$$

Using the k_{iso} value (7.8×10^{-7} yr^{-1}) calculated as above and the measured D-alloisoleucine/L-isoleucine ratio a date of ~200 kyr BP is obtained. It should, however, be noted that older bones are susceptible to contamination by secondary amino acids. Such contamination would introduce mainly L-amino acids, and in this case L-isoleucine not D-alloisoleucine. The order of the amino acid racemization observed in the Namib specimen (i.e. alanine<isoleucine<valine) is compatible with the sequence expected from elevated temperature kinetics experiments (BADA *et al.*, 1973; DUNGWORTH *et al.*, 1976), suggesting that the bone sample was not badly contaminated. The isoleucine dating thus represents a significant minimum age estimate although an *in situ* calibration of the racemization rate constants (see MASTERS, 1982; MATSU'URA & UETA, 1980) and analysis with fractionation treatment (MATSU'URA & UETA, 1980) of further specimens such as fossilized teeth would provide a better and more reliable chronology of Namib IV.

In conclusion, this joint work has been clarifying the age of the Namib IV archaeological site. The ^{230}Th date of 347^{+78}_{-48} kyr BP may be taken for the present as a most substantial and quoteable age estimate.

The suggested date accords well with the typological and faunal affinities of Namib IV, which has close parallels with many east African sites especially Olorgesailie which ISAAC (1977, 1978) considers dates to 400–500 kyr BP. Analogous Acheulean industries calibrated by K-Ar dating include Kapthurin in the central Rift Valley falling within the range 0.23–0.7 my BP (TALLON, 1978), Kilombe (site GqJhl), which postdates a trachyphonolite dated at 1.7 ± 0.05 my BP (BISHOP, 1978), and Chesowanja (site 10/4) with a maximum age of 1.42 ± 0.07 my BP (HOOKER & MILLER, 1979; GOWLETT *et al.*, 1981). The new dates confirm the provisional assignment of Namib IV to the mid-Pleistocene on typological and faunal grounds, and make it the earliest dated human activity in the Namib desert.

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