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Fluorine Dating of a Human Talus from Hijiridake Cave

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Abstract Fluorine dating approach indicates that a human talus remain found in March 1983 at Hijiridake Cave in Oita Prefecture, Japan, may be referred to the Pleistocene; probably the end phase of this epoch in consideration of archaeological contexts of the cave.

Introduction

Hijiridake Cave, located in the southern part of Oita Prefecture in Kyushu, is one of the important palaeoanthropological and archaeological sites in Japan. Excavations in 1962 of the limestone cave sediments there (GOTO, 1964; KAGAWA, 1967) yielded human bones with a micro-blade industry of around ~14 kyr BP (see SUZUKI, 1984) and with artefacts of the mediaeval times. In March 1983, some additional skeletal remains happened to come to light when three archaeologists, Messrs. Chuji SUZUKI, Hideki YAMASHITA and Shunichi WATANUKI, looked over the cave site. Of these remains, a human left talus has received attention from Professor Jiro IKEDA taking notice of the sensibly fossilized conditions and morphological characteristics.

To examine the possibility of the surface find, talus specimen, belonging to the Pleistocene epoch, the fluorine dating method (see OAKLEY, 1951, 1980; MATSU'URA, 1982) has been applied as reported here. Lacking an adequate 'pilot series' (see OAKLEY, 1951) of animal remains from the same and/or neighbouring sites, bone specimens of known ages deriving from limestone caves or fissures in Honshu have been also assayed, and a compilation of analytical data both past and newly obtained forms a tentative reference for the fluorine dating of the talus in question.

Materials and Methods

Compact tissue samples of bone remains, unearthed from Locality 3 of Ube-Kosan Quarry, Tanuki-ana Cave, Taishaku Yosekura Rock-shelter, and Taishaku Kannondo Cave (Fig. 1), were prepared just as described in MATSU'URA (1982) and analysed for fluorine using the fluoride electrode technique (e.g. MATSU'URA, 1981a). The buffer medium employed in the electrode measurement is of 0.125 M HCl–0.25 M NaCitrate–0.075 M KNO_3 system (MATSU'URA, 1984).

A sample of the human talus from Hijiridake Cave was prepared by making two separated drill holes in *substantia spongiosa* and mixing the powder so obtained. This

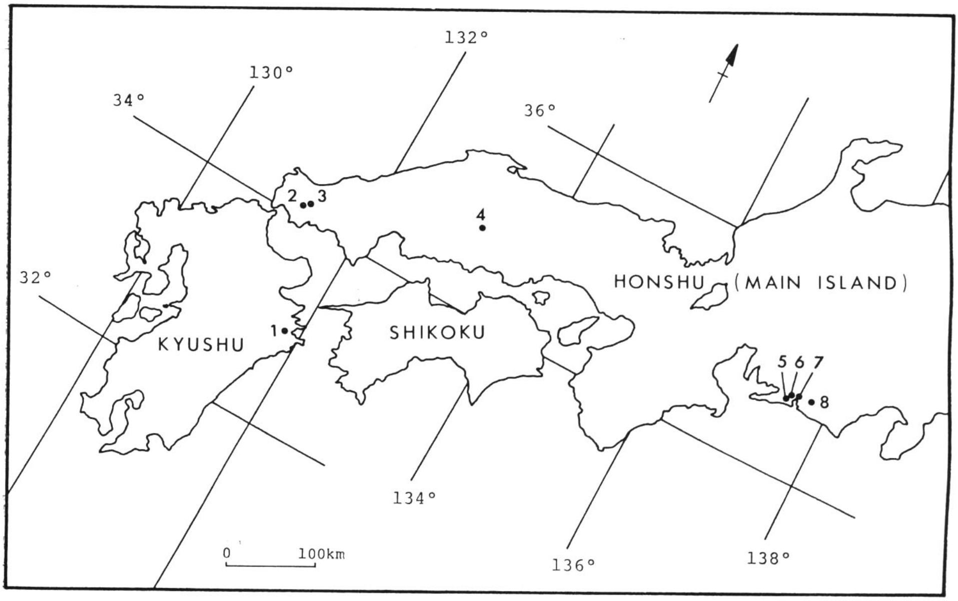

Fig. 1. Locations of fossil-bearing sites involved in this paper.

1, Hijiridake Cave in Honjo-mura, Minami-amabe-gun, Oita Prefecture; 2, Locality 3 of Ube-Kosan Quarry in Mine City, Yamaguchi Prefecture; 3, Tanuki-ana Cave in Shuho-cho, Mine-gun, Yamaguchi Prefecture; 4, Taishaku Yosekura Rock-shelter and Taishaku Kannondo Cave in Tojo-cho, Hiba-gun and in Jinseki-cho, Jinseki-gun, Hiroshima Prefecture, respectively; 5, Ushikawa Fissure in Toyohashi City, Aichi Prefecture; 6, Suse Cave in Toyohashi City, Aichi Prefecture; 7, Tadaki Fissure in Mikkabi-cho, Inasa-gun, Shizuoka Prefecture; 8, Gansuiji (Negata) Fissure in Hamakita City, Shizuoka Prefecture.

was then analysed for fluorine by the same method mentioned above, and for phosphate by normal volumetry after precipitation as ammonium phosphomolybdate (see MATSU'URA, 1982).

Results and Comments

Table 1 gives average fluorine content in *substantia compacta* of bones from calciferous sediments in the central and southwest part of the Main Island of Japan. Individual analyses obtained in the present work are tabulated in Tables 2–5.

The accumulation rate of fluorine in bone substances is so dependent on burial environments that comparison of fluorine content should be made between skeletal materials from comparable matrix (OAKLEY, 1951, 1980; MATSU'URA, 1982). Table 1 strongly suggests that the fluorine test may assist the relative dating of bone remains deriving from limestone cave/rock-shelter deposits and fissure fillings. For example, as far as the specimens from the two sites in Taishaku Ravine are concerned (Table 1,

Table 1. Fluorine content of bones of known age from several limestone sites in Central and Southwest Honshu, Japan (see Fig. 1).

Age		Fluorine content (%)+		No. of specimens	Source
Relative++	Absolute (kyr BP)	Mean	S.D.		
Upper Holocene	~3.5†	0.049	0.014	5	Taishaku Yosekura
Lower Holocene		0.200	0.125	8	Taishaku Kannondo Layer 19
Lower Holocene		0.23	0.08	7	Suse
Lower Holocene		0.339	0.073	5	Tanuki-ana
beginning Holocene to ending Pleistocene		0.480	0.127	13	Taishaku Kannondo Layers 20–22
late Upper Pleistocene		0.36	0.05	4	Gansuiji Animal A†††
late Upper Pleistocene	~16††	0.489	0.138	7	Taishaku Kannondo Layer 23B
late Upper Pleistocene	22.9*	0.665	0.153	11	Taishaku Kannondo Layer 25B
Upper Pleistocene		0.81	0.26	10	Tadaki
Upper Pleistocene		0.84	0.06	10	Gansuiji Animal B†††
Upper Pleistocene (~ending Middle Pleistocene?)		0.91	0.24	6	Ushikawa
late Middle Pleistocene	~200**	0.866	0.187	22	Locality 3 of Ube-Kosan Quarry

\+ Derived from analytical data from TANABE (1962, 1966) for Suse, Hamakita, Tadaki Ushikawa, and from Tables 2–5 in this paper for the others.

++ Based on faunal contexts (TAKAI & HASEGAWA, 1966; KAMEI *et al.*, 1981; KAWAMURA, 1984; and others), archaeological contexts (SUGIHARA *et al.*, 1976; SHIOMI *et al.*, 1976) and/or chronometric dating results.

† After ICHIKAWA *et al.* (1978) and radiocarbon dates.

†† See MATSU'URA & UETA (1980) or MATSU'URA (1981b).

††† A=upper layer bones, B=lower layer bones.

* MATSU'URA & UETA (1980); see MATSU'URA (1981b).

** Through uranium-series dating of a travertine sample by KOMURA & HAYASHI (1983, personal communication).

4, 5), the content of this element varies consistently with age.

The data in Table 1 would lead us to suppose that a level of 0.5%F can be a provisional reference for a fossil bone from a limestone site in the general area seen in Fig. 1 to be attributed to the Pleistocene in age.

Now let us concern ourselves with the human talus from Hijiridake. The analyses of the cancellous tissue sample yielded F=0.634% and P_2O_5=22.8%, which derive a fluorine/phosphate ratio of $100\times F/P_2O_5=2.78$. This phosphate measurement gives evidence that the bone sample suffered appreciable contamination from soil particles or extraneous mineral matter, since compact regions of fossilized bones carry ca. 32–36% P_2O_5 content in general (see MATSUBARA, 1980; MATSU'URA, 1982 and unpublished data; and others). The above result for fluorine, thus, has been 'diluted' and should be compensated for the contamination (see MATSU'URA, 1982) so as to be compared with data on compact bones. A correction of the fluorine measurement on the Hijiridake talus sample to 34% P_2O_5, as an expected phosphate content of fossil bone with little contamination, yields a value of 0.95%F.

Two skull fragments belonging to Layer III Man 1 and 2 of Hijiridake, which are of the End Pleistocene in age, are reported to have 0.56%F and 0.55%F respectively; and a mediaeval human remain from the same site, 0.2%F (TANABE in OGATA, 1981).

Comparison of lines of the fluorine data presented before argues the talus in question to date well back to the Pleistocene. However, acknowledging the possible fluctuation in fluorine content of bones from a given stratum (see Tables 1–5, and MATSU'URA, 1982), and considering that the earliest evidence for human occupation of Hijiridake Cave occurs in a micro-blade phase of around ~14 kyr BP (GOTO, 1964; KAGAWA, 1967; SUZUKI, 1984), it is concluded at present that the human talus specimen may be also assigned to that Sendoki (i.e. Preceramic: see TSURUMARU, 1984) cultural stage.

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Table 2. Analysis of fluorine in compact bone of animal remains from Locality 3 of Ube-Kosan Quarry.

Specimen	Thickness of compact tissue at analysed part (mm)	Fluorine content (%)	Specimen	Thickness of compact tissue at analysed part (mm)	Fluorine content (%)
long bone, shaft	2.4	0.541	cervid?, femur?, shaft	2.9	0.915
long bone?, shaft?	3.4	0.577	long bone, shaft	1.4	0.915
indeterminate	2.5	0.599	long bone, shaft	2.8	0.929
long bone, shaft	3.0	0.633	indeterminate	1.8	0.938
cervid, antler	4.2	0.668	indeterminate	1.5	0.950
long bone, shaft	2.6	0.719	long bone, shaft	2.2	0.967
long bone, shaft	1.6	0.799	indeterminate	2.5	1.03
cervid, femur, shaft	2.6	0.812	long bone, shaft	1.4	1.08
long bone, shaft	2.7	0.815	long bone?, shaft?	1.1	1.14
long bone, shaft	2.5	0.820	indeterminate	1.8	1.15
long bone?, shaft?	1.8	0.894	long bone, shaft	3.5	1.16

Table 3. Analysis of fluorine in compact bone of Early Holocene animal remains from Tanuki-ana Cave.

Specimen	Thickness of compact tissue at analysed part (mm)	Fluorine content (%)	Specimen	Thickness of compact tissue at analysed part (mm)	Fluorine content (%)
rib	1.0	0.269	long bone, shaft	1.9	0.377
rib	1.1	0.289	long bone, shaft	2.1	0.447
long bone, shaft	2.0	0.315			

Table 4. Analysis of fluorine in compact bone of human remains from a later Late Jomon stratum of Taishaku Yosekura Rock-shelter.

Specimen	Thickness of compact tissue at analysed part (mm)	Fluorine content (%)	Specimen	Thickness of compact tissue at analysed part (mm)	Fluorine content (%)
female, radius, shaft	3.5	0.033	female, tibia, shaft	1.7	0.057
male, radius, shaft	1.7	0.043	male, femur, shaft	5.7	0.070
female, femur, shaft	6.1	0.044			

Table 5. Analysis of fluorine in compact bone of animal remains from Taishaku Kannondo Cave.

Specimen	Layer	Thickness of compact tissue at analysed part (mm)	Fluorine content (%)
long bone, shaft	upper 19	2.9	0.117
metacarpus, shaft	mid. 19	6.2	0.060
cervid, metacarpus, shaft	mid. 19	3.6	0.114
long bone, shaft	mid. 19	3.6	0.127
deer, metacarpus, shaft	mid. 19	3.1	0.141
long bone, shaft	lower 19	4.1	0.325
long bone, shaft	lower 19	4.8	0.331
long bone, shaft	19	4.5	0.384
deer, rib	mid. 20	1.3	0.408
long bone, shaft	mid. 20	2.1	0.538
long bone, shaft	lower 20	3.3	0.261
deer, tibia, shaft	lower 20	3.2	0.302
long bone, shaft	20	3.0	0.526
long bone, shaft	20	2.5	0.552
long bone, shaft	20	3.4	0.632
rib	lower 21	1.1	0.272
proximal phalange	21	2.7	0.500
long bone, shaft	21	2.7	0.576
long bone, metaph. part	22	2.5	0.535
proximal phalange	22	2.0	0.536
long bone, shaft	22	3.0	0.605
rib	23B	2.4	0.303
phalange	23B	2.8	0.321
long bone, shaft	23B	3.5	0.470
long bone, shaft	23B	3.7	0.477
irregular bone	23B	—	0.592
long bone, shaft	23B	2.1	0.621
long bone, shaft	23B	2.6	0.640
long bone, shaft	25B	2.5	0.486
long bone, shaft	25B	3.9	0.503
long bone, shaft	25B	3.2	0.556
long bone, shaft	25B	2.9	0.564
long bone, shaft	25B	3.0	0.570
long bone, shaft	25B	3.1	0.581
long bone, shaft	25B	3.2	0.712
cervid, humerus, shaft	25B	4.2	0.724
long bone, shaft	25B	2.9	0.841
long bone, shaft	25B	2.3	0.868
long bone, shaft	25B	—	0.910