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DIRECT DATING OF NEANDERTHALIAN REMAINS AND ANIMAL BONES BY THE NON-DESTRUCTIVE GAMMA-RAY SPECTROMETRY: COMPARISON WITH OTHER METHODS

by

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ABSTRACT

A non-destructive gamma-ray spectrometry is used for the direct dating of fossil human bones and animal bones taken from several Neanderthalian and Mousterian sites in France, Italy and Spain.

1. For the Neanderthal child and adult remains from Fate cave (Finale Ligure, Italy), we obtained a U-Th age of 83 +35/–24 Kiloyears (ky) and a U-Pa age of 76 +18/–13 ky. These ages are in good agreement with the ESR ages of the two lower stalagmitic layers of this cave: 78 ± 9 ky and 78 ± 13 ky.

2. Animal bones from Tournal cave, Genay Breccia site (France) and Arbreda cave (Spain) are also dated. U-Th and U-Pa ages of these sites are respectively, 33 ± 8 ky and 33 ± 4 ky for Tournal cave, 82 +20/–16 ky and 75 ± 6 ky for Genay Breccia site, 85 +38/–28 ky and 83 +11/–9 ky for Arbreda cave.

1. INTRODUCTION

Recent developments of the gamma-ray spectrometry have made possible the determination of long-lived natural radionuclides such as U-238, U-234, Th-230 and Pa-231 (YOKOYAMA and NGUYEN, 1980, 1981a). This new technique does not need any chemical treatment and hence it is non-destructive. It is therefore particularly useful for the U-Th (and U-Pa) datings of very precious samples such as human fossil bones and was used to date the skull of Tautavel Man (YOKOYAMA and NGUYEN, 1981a,b).

Using this technique, we have dated the Neanderthalian remains from Fate cave in Northern Italy (GIACOBINI *et al.*, 1984). Animal bones of some mousterian sites are also dated with this method. In the present paper, the results of these datings are presented and compared with the results obtained with other methods.

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2. EXPERIMENTAL

A high purity germanium detector, ORTEC Gamma-X detector, is used with a micro-computor controled pulse height analyser, ENERTEC PC7182. The detector has a 9% relative efficiency and a resolution of 0.7 KeV at 63 KeV. The sample is counted for 1-5 weeks. Counting efficiencies are measured with mouldings made of a mixture of plaster and pitchblende. Activities of U-234 and Th-230 are determined from the gamma-rays emitted directly by these nuclides: 53.3 KeV and 67.7 KeV respectively. U-238 is determined from the gamma-rays of its short lived decay product Th-234: 63.3 KeV and 92.3+92.8 KeV. For the determination of Pa-231, gamma-rays of Th-227, Ra-223 and Ra-219 are used. Their energies are 269.4 KeV, 271.0 KeV and others (YOKOYAMA and NGUYEN, 1980, 1981b).

Figure 1 shows an example of gamma-ray spectra. The gamma-ray peaks used to the determination of U-238, U-234, Th-230 and Pa-231 are visible in this figure.

3. RESULT AND DISCUSSIONS

We dated Neanderthal child and adult bones from Fate cave (Final Ligure, Italy) and some animal bones from french and spanish Mousterian sites. Table 1 summarizes results.

3.1. Fate cave

G. Giacobini has identified human remains during a recent revision of the bone assemblage collected by G.B. Amerano in 1887-1888 from the Mousterian layers of the Caverna delle Fate (Cave of the Fairies), near Finale Ligure, Italy (GIACOBINI and LUMLEY de, 1983; GIACOBINI *et al.*, 1984). These human remains are a child frontal bone (Fate I), a child half mandible (Fate II) and an adult mandible fragment (Fate III).

A rapid preliminary gamma-ray measurement of each sample showed similar Ra-226/U-238 ratios: 0.51±0.14, 0.52±0.12 and 0.60±0.12 for Fate I, II and II respectively. This similarity suggests that their ages are virtually the same. Since the each sample alone was not sufficiently active, we decided to count them together. We obtained a U-Th age of 82 +35/–24 ky and a U-Pa age of 76 +18/–13 ky (the ages given in the text are rounded from the values given in Table 1). The good agreement between the U-Th age and the U-Pa age indicates that these samples were relatively well conserved and therefore we can place some degree of confidence in these ages.

Since these human remains are discovered from the old collection of the last century, it is impossible to know exactly their stratigraphic position in the cave deposit. These remains were taken in the corridor No. 3, where the deposits are inter-stratified by several stalagmitic layers. We have dated three principal stalagmitic layers by the ESR method. The details will be published elsewhere. We obtained an age of 40±12 ky for an upper layer (layer 2) and ages of 78±9 ky and 78±13 ky for two lower layers (layers 9 and 18) respectively.

The ESR ages of the layers 9 and 10 are in good agreement with the age of the human remains. This agreement permits to postulate that these human remains come from the lower part of the deposit in the corridor No. 3.

According to the morphological studies of these remains (GIACOBINI *et al.*, 1984), Fate I (child frontal bone) has the appearance of an archaic Neanderthal with a marked postorbital narrowing. Fate III displays also classical Neanderthalian characteristics with minor archaic features. The morphology of these two remains is in close agreement with our dating. The child half mandible, however, having several modern features, for example its

small permanent canine, resembles the Hortus Neanderthals. These "modern" features may be attributed to the proper characteristics of a Mediterranean Neanderthal population. This interpretation may be supported by our preliminaly gamma-ray dating of Hortus IV mandible, which suggests a similar age as that of Fate samples.

3.2. Arbreda cave

This cave is situated near Serinya (Gerona) in the North-East of Spain. Discovered in 1947 by M.A. Corominas, the cave is actualluy excavated by N. Soler. A deposit of 9 m thick successively contains from the top to the bottom: a Neolithic layer, an Epipaleolithic one, two Solutrean ones, two Gravetian ones, Aurignacian ones and Mousterian ones. Some charcoal samples from the Upper Paleolithic layers are dated by G. Delibrias. Their ages are ranged between 17 320 y BP and 25 838 y BP. Some animal bones from these layers are also dated by the gamma-ray spectrometry and the ESR method (YOKOYAMA *et al.*, 1987).

The Mousterian layers of this cave are remarkable by the abundance of lithic tools and fauna. We dated an animal bone from the bottom of these layers. The results (Table 1) show a U-Th age of 85 +38/–25 ky and a U-Pa age of 83 +11/–9 ky. Again, we found a good agreement between the U-Th age and U-Pa age.

3.3. Tournal cave

Tournal cave at Bize is situated at 20 km North-West of Narbonne. The excavations carried out under the direction of A. Tavoso permit to understand its extremely complex stratigraphy comprising wells and drains. The deposit of this cave contains a succession of Magdalenian layers, Aurignacian layers and Mousterian layers. According to the C-14 datings made by J. Evin, the Magdalenian layers have an age between 12 550±210 y BP at the top and 14 250±450 y BP at its bottom. A Mousterian layer is dated to be 33 650±1 258 y BP.

We report here the results of the dating of a Cervides bone (Table 1). We obtained a U-Th age of 33 000±8 000 y and a U-Pa age of 33 000±4 000 y. These ages are in good agreement with the C-14 age and also with the ESR age of the same bone: 38 000±10 000 y.

3.4. Genay Breccia site

This open air site is situated at 30 km North of Avallon (Côte-d'Or). It was discovered in 1834. The excavations carried out by J. Joly and J.J. Puiségur between 1953 and 1960 yielded Neanderthalian remains (JOLY, 1955). Its deposit successively contains from the top to the bottom: a Neolithic layer, a series of light yellow layers (layers 8-11), a series of brown layes (layers 5-7), a series of red layers (layers 3-4) and a series of fairly red layers (layers 1-2). The last two series are consolideted in a breccia. Most of archaeological materials, animal bones and the Neanderthalian remains come from the layers 3-4. These human remains are fragments of a skull and 25 teeth, belonging to the same individual.

We dated two fragments of animal bone, M1-25 and 12-4. The samples are taken from the layer of the human remains. Two samples are measured together. We obtained a U-Th age of 82 +20/–16 ky and a U-Pa age of 75±6 ky.

These ages correspond to the beginning of Würm in good agreement with the estimation of Father Joly, based on the malacofauna (PUISSEGUR, 1962) and microfauna (CHALINE, 1972). The archaic characters of the Neanderthalian remains of Genay (LUMLEY de, 1976, 1987) and the characteristic of Genay's industry (PAUTRAT, 1987) are consistent with these ages. The macrofauna (PATOU, 1987) and the flora (RENAULT-MISKOVSKY and HAKIM, 1987), however, suggest a cold climate, which is

in manifest conflict with a warm climate estimated from the malacofauna and microfauna. It seems therefore that the Neanderthal of Genay lived in a climatically fluctuated phase of the beginning of Würm.

4. CONCLUSION

The non-destructive gamma-ray spectrometry being capable to date with the two independent methods, U-Th one and U-Pa one, is a good tool for the dating of Neanderthalian sites.

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REFERENCES

CHALINE J., 1972. Les rongeurs du Pléistocène moyen et supérieur de France. *Cahiers de Paléontologie*, C.N.R.S., 233-234.

GIACOBINI G. and LUMLEY de M.A., 1983. Restes humains néandertaliens de la Caverna delle Fate (Finale, Ligurie Italienne). *Anthropologie* 87, 142-144.

GIACOBINI G., LUMLEY de M.A., YOKOYAMA Y. and NGUYEN H.V., 1984. Neanderthal child and adult remains from a Mousterian deposit in Northan Italy (Caverna delle Fate, Finale Ligure). *J. Human Evolution* 13, 687-707.

JOLY Abbé J., 1955. Découvertes de restes néandertaliens en Côte-d'Or. *C.R.Ac.Sci. Paris* 240, 2253-2255.

JOLY Abbé J., 1987. La Brèche de Genay, Côte d'Or. *Anthropologie* 91, 75-86.

LUMLEY de M.A., 1976. Les Néandertaliens dans le Nord et le Centre. *In:* H. de LUMLEY (ed.), *La Préhistoire Française*, Tome I. C.N.R.S. Paris, 587-594.

LUMLEY de M.A., 1987. Les restes humains néandertaliens de la Brèche de Genay, Côte d'Or. *Anthropologie* 91, 119-162.

PATOU M., 1987. La grande faune de la Brèche de Genay (Côte-d'Or). Fouilles de l'Abbé Joly. *Anthropologie* 91, 97-108.

PAUTRAT Y., 1987. L'industrie lithique de la Brèche de Genay, Côte d'Or. *Anthropologie* 91, 113-118.

PUISSEGUR Abbé J.J., 1962. Les mollusques et leur signification climatique dans le gisement paléolithique de Genay. *Bull. sci. de Bourgogne* 21, 159-170.

RENAULT-MISKOVSKY J. and HAKIM A., 1987. Nouvelle fouille de la Brèche de Genay (Côte-d'Or): Etude pollinique. *Anthropologie* 91, 91-95.

YOKOYAMA Y. and NGUYEN H.V., 1980. Direct and non-destructive dating of marine sediments, manganese nodules, and corals by high resolution gamma-ray spectrometry. *In:* E.D. GOLDBERG *et al.* (eds)., *Isotope Marine Chemistry*, Uchida Rokakuho, Tokyo, pp. 259-289.

YOKOYAMA Y. and NGUYEN H.V., 1981a. Datation directe de l'Homme de Tautavel par la spectrométrie gamma, non destructive, du crâne humain fossile Arago XXI. *C.R.Ac.Sci. Paris* 292, Série III, 741-744.

YOKOYAMA Y. and NGUYEN H.V., 1981b. Direct dating by non destructive gamma-ray spectrometry of human fossil skull Arago XXI, fossil animal bones and stalagmites of the Caune de l'Arago at Tautavel. *In:* H. de LUMLEY and J. LABEYRIE (eds.), *Absolute Dating and Isotope Analysis in Prehistory – Methods and Limits,* CNRS, Paris, pp. 355-375.

YOKOYAMA Y., NGUYEN H.V., QUAEGEBEUR J.P., LE HASSIF G., and ROMAIN O., 1987. Datation par la spectrométrie gamma non destructive et la résonance de spin électronique (ESR) du remplissage de la grotte de l'Arbreda. *Cypsela* (to be published).

TABLE 1

Direct dating of human and animal bones by the non destructive gamma-ray spectrometry

	Fate Italy Man Mandibles	Arbreda Spain Animal Radius ?	Tournal France Cervidas Tibia	Genay France Animal n.d.
U(ppm)	3.68	17.3	23.3	8.37
U-234/U-238	1.189±0.223	1.096±0.207	1.007±0.118	1.068±0.121
Th-230/U-234	0.542±0.117	0.549±0.117	0.261±0.048	0.534±0.070
Th-230/Th-232	29	> 390	110	51
Pa-231/U-235	0.797±0.865	0.827±0.035	0.503±0.043	0.795±0.025
U-Th age (y)	82600^{+35300}_{-24300}	85100^{+38200}_{-25300}	32800^{+7600}_{-6900}	82000^{+19700}_{-15600}
U-Pa age (y)	75500^{+18300}_{-13100}	83000^{+10700}_{-8700}	33100^{+4300}_{-3900}	75000^{+6200}_{-5400}
Age (y) by other methods				
C-14	n.d.	n.d.	33650±1250	n.d.
ESR calcite	78000±9000	n.d.	n.d.	n.d.
ESR bone	n.d.	n.d.	38000±10000	n.d.

n.d.: not determined

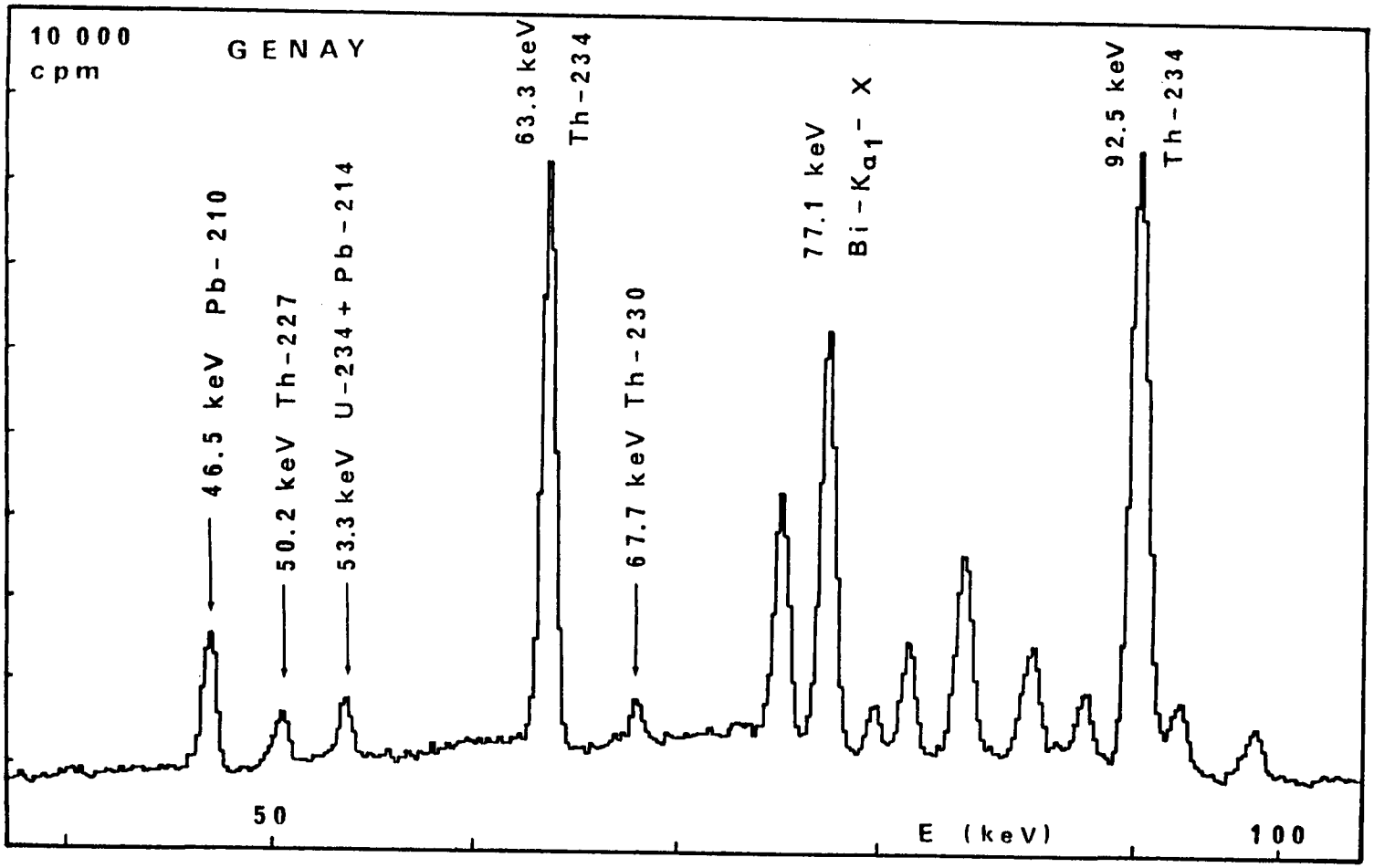

FIGURE 1

Gamma-ray spectrum of an animal bone sample taken from the Neanderthalian skull layer of the Brèche de Genay, Bourgogne, France (counting time: 19856 min.). In this figure, the gamma-rays emitted from Th-230, U-234, Th-234 (descendant of U-238) and Th-227 (descendant of Pa-231) are visible. For the determination of Pa-231, gamma-ray of higher energies are also used.