ESR DATING AND DOSIMETRY

REPRINT

edited by
M. IKEYA AND T. MIKI

IONICS, TOKYO

ESR DATING OF SHELLS FROM SAMBAQUIS (BRAZILIAN SHELL MOUNDS)

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Abstract: Shells from four Sambaquis from the southern coast of São Paulo, Brazil, previously dated by ^{14}C were dated by ESR and results compared with ^{14}C for the determination of the annual dose rate DR = (1.6 ± 0.2) mGy/yr, to be used in future dating work of shells.

Introduction

Among the methods proposed for dating ancient materials radiation effects play an important role. Environmental radiation can produce electron-hole pairs or stable free radicals whose concentration can be correlated with the dose to which the material was exposed. If the total dose or archaelogical dose (AD) received by the sample is determined and the annual dose rate (DR) is known, the age can be calculated.

Thermoluminescence (TL) was first employed to determine AD on minerals and ceramics. More recently Electron Spin Resonance (ESR) was introduced for dating cave deposits (stalagmites and stalagtites) and bones by Ikeya (1975). The ESR technique can determine the AD by measuring the increase of signal upon artificial irradiation. ESR dating has some advantages compared to the most common methods such as TL, and U-Th series. This method has several advantages: it can be used for dating bones and carbonates as old as 10^7 years, the samples do not need chemical treatment, the amount of sample necessary is only a few miligrams and the sample is not destroyed during measurements.

Following the work of Ikeya and Ohmura (1981) on the dating of fossil shells with ESR we have investigated shells from Brazilian shell mounds (Sambaquis). These Sambaquis are cultural monuments where human remains such as bones have been found. We have previously dated some of these human bones using ESR (Mascarenhas et al. 1982). Ikeya and Ohmura have called attention to the important implications of shell dating in geology and geography, since only a small piece of shell in a sediment may eventually be used for ESR measurements. In the present context of Sambaquis the simultaneous dating of shells and bones may be also very important. In fact both samples (bones and shells) being chemically different may present completely different environments from a radiometric standpoint. We proposed in the present paper, following the same line of Ikeya and Ohmura (1981) to evaluate the annual dose-rate (DR) of radiation by choosing the most adequate shell type.

Materials and Methods

"Anomalocardia brasiliana" commonly called "berbigão" in Brazil was used because it is the most abundant shell along the Brazilian southern coast.

By choosing this shell to monitor the radiometric dose rate we may provide a background for future work in ESR dating of shells in the region. Sambaquis studied extended over the region limited by $48^{o}05'$ - $47^{o}25'$ longitude (WGr) and $25^{o}10'$ - $24^{o}50'$ latitude (S).

A total of four sambaquis from different locations were used for collecting the same type of shell (berbigão). These samples had been previously dated by ^{14}C method. Table 1 shows the Sambaquis used, the AD and the ^{14}C age determined at: Ba-Laboratory of Applied Nuclear Physics University of Bahia - Brazil, Gif - Laboratorie du Radiocarbom - Centre de Faibles Radioactives, Gif-Sur-Yvette-France and I-Isotopes-USA.

Samples were prepared in powder form with grain size less or equal to 1 mm and some 150 miligrams were used for ESR measurements.

A Varian E-109 X-band ESR spectrometer in the standard configuration was employed for the measurement of defect concentration. The shell powder was packed in thin gelatin capsules for irradiation and transfered to quartz tubes for ESR measurements. A ruby crystal was used as a secondary standard for the intercomparison of the radical concentration measured by ESR as proposed by Singer (1959).

For irradiation as ^{60}CO radiotherapic source Gammatron S

(Siemens) was used with a dose-rate 0.8 Gy/min.

Results and Discussion

Figure 1 shows the ESR signal of shells before (a) and after (b) artificial γ irradiation with g features appearing at $g_{//} = 2.001 \pm 0.001$ and $g_{\perp} = 2.005 \pm 0.001$. These signals are more simples than those found for other shells by Ikeya and Ohmura (1982). Folowing the convention of those authors our signals are similar to signals C and D and shows a typical axial symmetry.

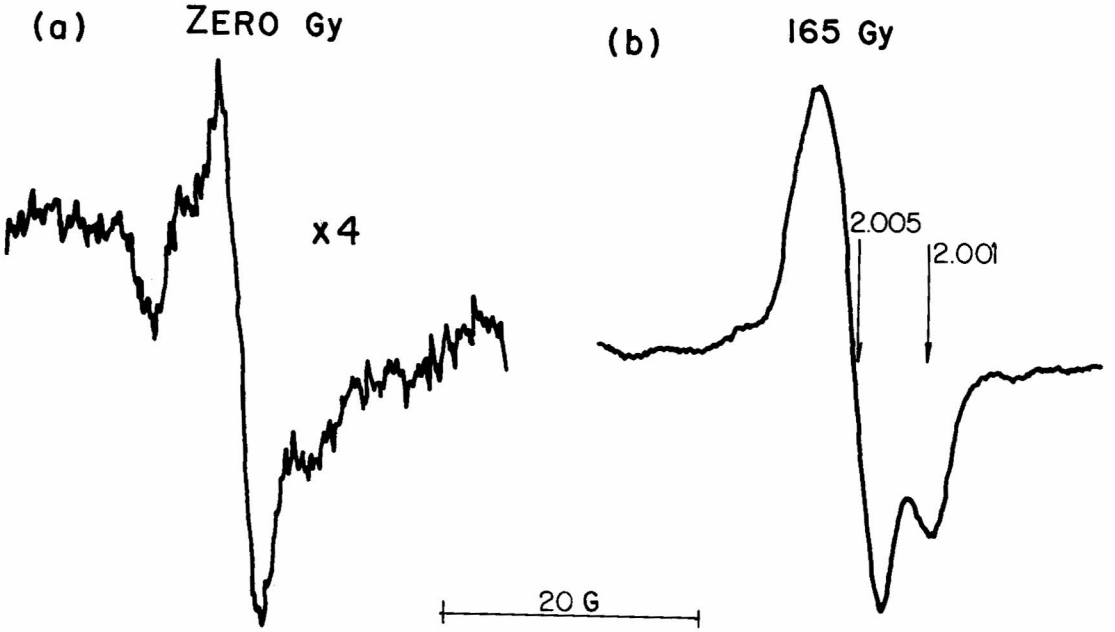

FIG.1

ESR spectrum of Anomalocardia Brasiliana Shell, before (a) and after artificial γ irradiation (b).

Figure 2 shows the signal intensity increasing upon irradiation with ^{60}CO. A linear fitting is made with the equation $I = I_o (I+D/AD)$. Assuming that at zero age there is no ESR signal the archeological dose (AD) can be obtained by extrapolating to zero ESR signal intensity. Table I shows the results obtained for the four Sambaquis in this work. A mean dose rate of (1.6 ± 0.2) mGy/yr can be obtained for future work of dating berbigão shell from other Sambaquis of the same region.

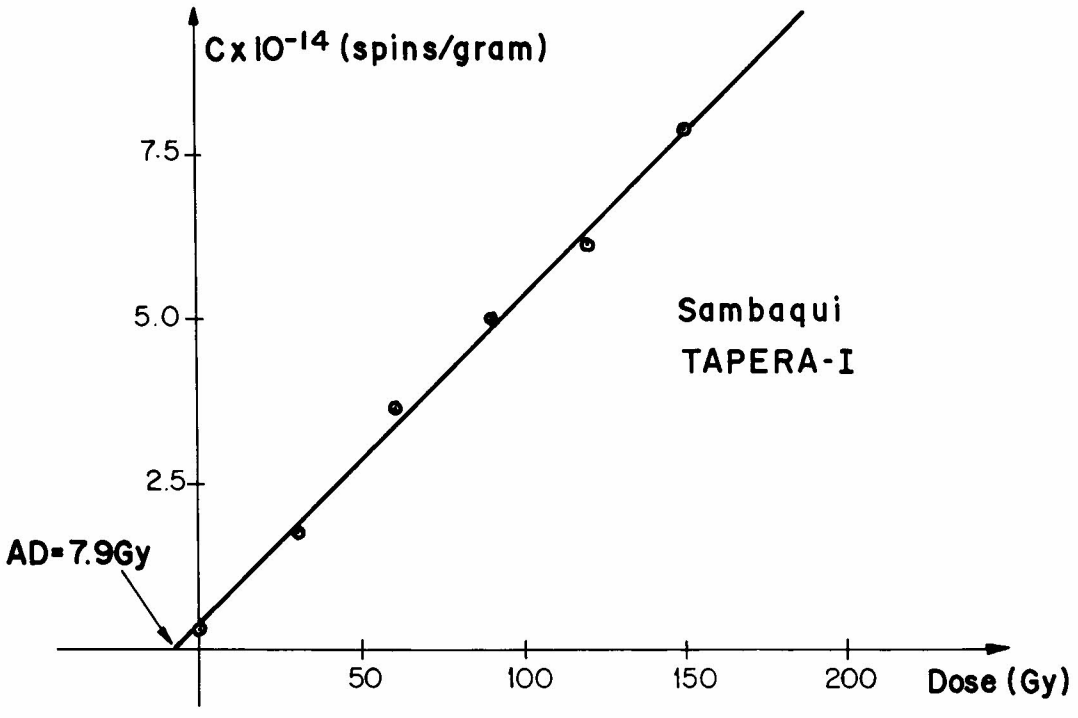

FIG.2

ESR signal enhancement as a function of additive artificial dose.

TABLE I

AD's Obtained for ^{14}C Dated Sambaquis.

SAMBAQUI	AGE ^{14}C (Y_r)	AD(GY)
ITAPUA	5070-BA	7.0
BRANCO	4400-GIF	6.0
BATATAL	4920	7.8
TAPERA I	3960-BA	7.9

Ikeya and Ohmura (1981) found an annual dose rate (DR) of 0.4 mGy/yr for sea shells from northern Japan. Mascarenhas et al. (1982) found a DR of 10 mGy/yr for bones buried in the same Sambaquis of the present work. It is interesting to note that the DR found for Brazilian sea shells do not agree with the Japanese DR nor with the DR found for bones at the same sites. This can reflect two facts: the first one is that the radioactive content of soil in Japan and in Brazil is different. It is known that the beaches where the shells were collected possesses a high concentration of monazite sands and rare earth oxides originated from the alkaline rocks of the region. The second fact is related to shell structure itself,

shells have a more rigid and impermeable structure that probably alters little with time. On the other hand bones are porous allowing an easy exchange of ions with the soil replacing some of the hydroxiapatite strucutural ions by radiactive elements.

The southern coast of São Paulo comprises and aboundant source of archeological materials. More than 85 sambaquis are known in the region and only 30 have been dated by the ^{14}C method. There are spectulations about the sea level oscillations in the past (Fairbridge 1976) and detailed dating of these Sambaquis can be of help to clarify sea level variations (Garcia, 1979) and ESR appears an appropriate potential tool for this task.

Aknowledegments

The authors are grateful to Dr.Caio Del Rio Garcia and Dra. Dorath Pinto Uchoa from the Instituto Pre-Historia, University of S.Paulo for kindly supplying us with the samples.

The cooperation of the radiotherapy staff from the Hospital das Clinicas - FMRP - University of São Paulo for the use of radiation sources and discussion with R.L.Zimmerman are acknowledged.

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Campo	Dado
*****	Documento 1 de 1
No. Registro	000750904
Tipo de material	PARTE DE MONOGRAFIA/LIVRO - NACIONAL
Entrada Principal	Baffa, Oswaldo
Título	Esr dating of shells from sambaquis (brazilian shells mounds).
Imprenta	Tokyo : Ionics, 1985.
Descrição	p. 139-143.
Autor Secundário	Mascarenhas, Sérgio (*)
Fonte	Ikeya, M (*), ed. Esr Dating and Dosimetry, Tokyo : Ionics, 1985
Unidade USP	FFCLRP -- FAC DE FILOSOFIA, CIÊN LETRAS DE RIBEIRÃO PRETO
Unidade USP	IFQSC-F -- INST DE FÍSICA DE SÃO CARLOS
Localização	IFSC PROD001710