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Some Evidence of a Date of First Humans to Arrive in Brazil

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A calcite formation was found on a rockwall painting at Toca da Bastiana rockshelter at Serra da Capivara National Park, Piaui, Brazil. Thermoluminescence and EPR dating of this calcite gave an age of 35 to 43 ka, indicating that humans lived there prior to 35 ka ago. This result supports the radiocarbon dates ranging up to 48 ka BP found earlier for this site.

Keywords: DATING; THERMOLUMINESCENCE; EPR; RADIOCARBON; CALCITE.

Introduction

The question of who were the New World's first settlers and when they arrived has been constantly debated since 1927. According to the Clovis-first theory, the first humans to enter North America were hunters who came through the Bering Strait into Alaska about 11,500 years BP. In 1997 Dillehay concluded (based on excavations at Monte Verde, South Chile), that early humans lived in that part of South America 1000 years before the first Clovis site (Dillehay, 1997). Fiedel (2000) recently questioned Monte Verde's result. Systematic excavation by Niède Guidon since 1973 at archaeological sites in Serra da Capivara National Park, S. Raimundo Nonato, Piaui, Brazil, and radiocarbon dating of charcoals collected from several layers at the rockshelters called Toca da Pedra Furada, Guidon and Delibrias and Parenti (Guidon & Arnaud, 1991; Guidon & Delibrias, 1986; Parenti *et al.*, 1996) found ages ranging from 6200 to 48,500 years. Such results are accepted by some European archaeologists but not by many American ones.

Material and Dating Measurements

The Serra da Capivara National Park is known worldwide for numerous ancient rockwall paintings. In 1990 a calcite veneer, about 0·2 cm thick, 0·3 cm wide and 40 cm long, was found on such paintings at the rockshelter called Toca da Bastiana. A portion of this calcite was dated using EPR to 27 ka by Baffa Jr (1991). The remaining part of the same calcite was used in the present studies that comprised: (1) X-ray diffraction measurement for structural composition of the calcite, (2) thermoluminescence and (3) EPR dating. For dating measurements, the calcite sample was

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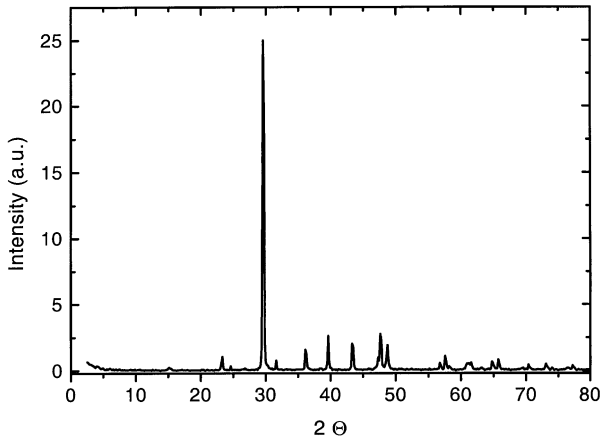

Figure 1. X-ray diffractogram of the calcite sample.

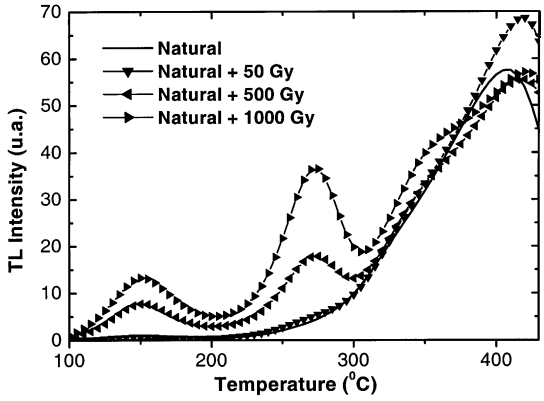

Figure 2. Glow curves for natural and natural plus γ-ray doses of 50, 500 and 1000 Gy.

pulverized with care (to avoid triboluminescence) and sieved to retain grain sizes from 0·08 to 0·180 mm and used for dating without any further treatment. TL glow curves, TL dose-response curve, plateau test and EPR dose-response curve were measured, under subdued daylight condition. Mercury lamp's room light was avoided during the whole experiment. For evaluation of the annual natural dose rate neutron activation method was used to find uranium, thorium and potassium content in the rockwall as well in the calcite deposit. For TL measurements Daybreak TL reader 1100 system was used with a heating rate of 2°C s^{-1}. The detection optics consists of EMI 9635QA photomultiplier tube coupled with a dark blue 7-59 and Schott BG-39 filters. Dry nitrogen flow is used during the TL read out. EPR measurements were carried out in Brüker: EMX system, operating at a microwave frequency of 9·762 GHz and power of 2·021 mW.

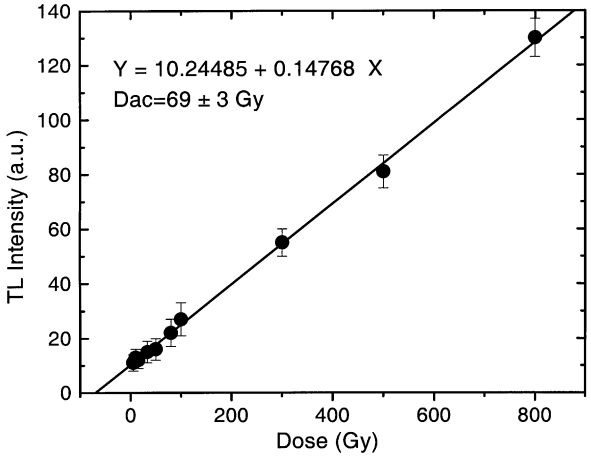

Figure 3. TL response vs. dose curve for 270°C TL peaks for natural plus additional laboratory dose. From this line Dac=69 ± 3 Gy is obtained.

Results

The X-ray diffractogram in Figure 1 shows that the sample was predominantly a calcite with a well defined intense peak at 2θ=30°. TL glow curves of natural and natural plus ^{60}Co gamma—dose of 10, 50, 100, 500 and 1000 Gy were recorded. Peaks are seen at 150, 270, 320 and 400°C. Figure 2 shows the typical glow curves. The plateau test not shown here indicates that 270°C TL peak can be used for dating but the 400°C peak is not suitable. Figure 3 shows the TL response of 270°C peak as function of the added dose. By extrapolating this curve to dose axis the accumulated dose Dac=(69·4 ± 3·0) Gy was obtained. Figure 4 shows CO_3^-, CO_3^{3-} and CO_2^- EPR signals of calcite. They were used to obtain EPR intensity vs. dose curve. All the three signals produced similar response curves. The extrapolation of these curves to dose axis produced a Dac=(68 ± 12) Gy (see Figure 5). This curve was fitted with the expression:

$$y = A\{1 - \exp[-B(x+C)]\},$$

where $A=12{\cdot}9 \pm 1{\cdot}04$, $B=(0{\cdot}00154 \pm 0{\cdot}0002)$ Gy^{-1} and $C=(68 \pm 12)$ Gy. x=added dose in Gy. Figure 6 shows Baffa Jr's result for comparison. It showed Dac=46·3 Gy. The neutron activation analysis of the rock fragment yielded (1·26 ± 0·04) ppm of ^{238}U, (0·96 ± 0·002) ppm of ^{232}Th, (16·4 ± 0·8) ppm of Rb and (0·37 ± 0·04) % of K. For calcite it yielded (1·06 ± 0·43) ppm of ^{232}Th and (0·28 ± 0·12) ppm of ^{238}U. From these values the annual dose rate Dan was calculated using Ikeya's equation (Ikeya, 1993):

$$D_U = 1{\cdot}60218 \times 10^{-10} \lambda_{238} N_{238}(\text{ppm}) \sum_i E_i\,(\text{mGy/a}) \quad \text{for } ^{238}\text{U-series}$$

$$D_{Th} = 0{\cdot}020514 N_{232}(\text{ppm}) \sum_i E_i\,(\text{mGy/a}) \quad \text{for } ^{232}\text{Th-series}$$

where λ_n and N_n (ppm) are, respectively, decay constant and concentration in ppm of nucleids of atomic number n. The internal dose rate in the calcite is

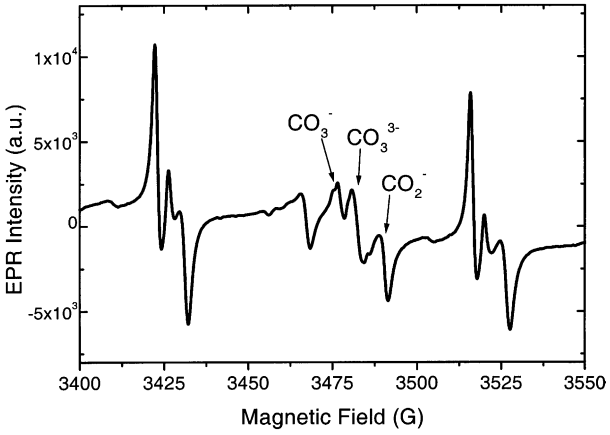

Figure 4. Spectrum of CO_3^-, CO_3^{3-} and CO_2^- EPR signal of calcite irradiated to 1000 Gy. These signal were used for dating.

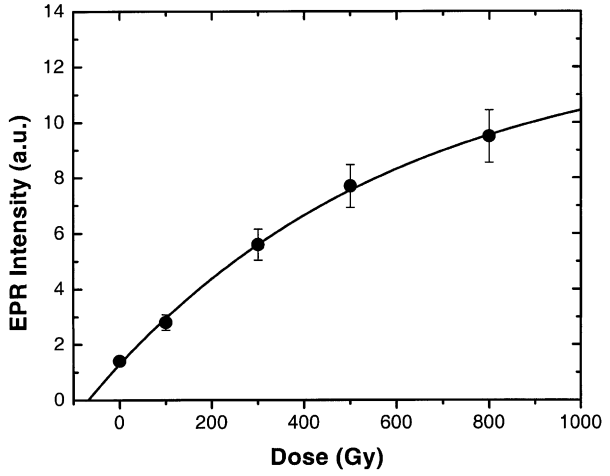

Figure 5. EPR intensity vs. added dose.

found to be $(0{\cdot}5 \pm 0{\cdot}1)$ mGy/a and from the rock, $(1{\cdot}18 \pm 0{\cdot}05)$ mGy/a. Assuming cosmic-ray contribution as 250 μGy/a, a total of Dan$=(1{\cdot}93 \pm 0{\cdot}1)$ mGy/a is obtained for the annual dose rate.

Experimental errors are not included in the Table 1, but an error of about 1550 years is estimated for the TL method. The error is much larger for EPR technique and it is estimated to be about 5000 years.

Discussion

Wintle (1978) argued that in stalagmites the source of natural radiation dose is the uranium decay chain, which is known to be in disequilibrium. During the weathering of rocks uranium is readily oxidized. It is then soluble and groundwater can remove it. On the other hand, thorium is more difficult to be dissolved. During the formation of stalagmite only uranium

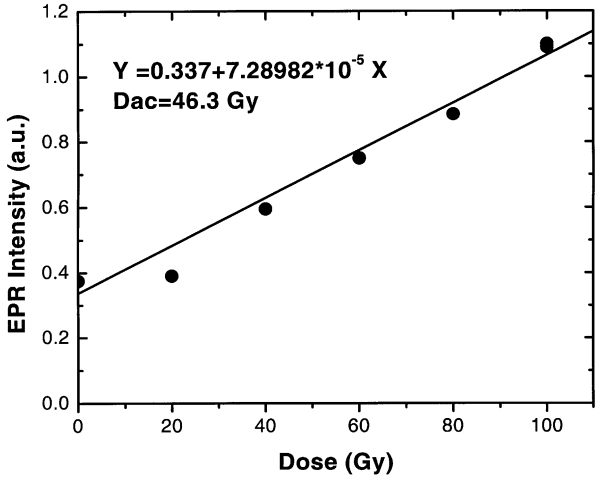

Figure 6. EPR intensity vs. dose curve obtained by Baffa Jr (1991).

Table 1. Age of calcite sample using Dac (TL), Dan (EPR) and Dan (neutron activation) and Dan (TL dosimeter)

Measurements technique	Dac (Gy)	Dose rate measuring methods	Dan (mGy/a)	Age (ka)
TL	69·3	Neutron–activation	1·93	35·9
EPR	68·3	Neutron–activation	1·93	35·35

atoms are incorporated. In the process of weathering, fractionation of the uranium isotopes also occurs, resulting an enhancement of concentration of ^{234}U with respect to the parent ^{238}U.

In the present case, the analysis by neutron activation technique does not suggest a disequilibrium. Furthermore, ^{232}Th in calcite was about twice the Th value in the rock. Therefore, we used the usual Ikeya equation to estimate the annual dose rate. We also took into consideration the fact that α-ray from the rock caused irradiation in the calcite only within the depth of about 50 μm from the surface. Therefore, in the dose rate calculation α contribution from the rock was neglected. The escape of ^{220}Rn-ions, was also considered negligible both from the rock and calcite, except from their surface. Since the calcite was formed in rock shelter, the fading effect of sunlight is neglected.

It is likely that the calcite strip on the painting was not formed at once and the end position dated by Baffa Jr is younger than the remaining part dated in the present work.

Conclusion

From the present work we can conclude that the calcite was formed on the rockwall paintings at least about 36 ka ago. Hence, human beings that painted them did

it before 36 ka. This value reinforces results obtained by archaeologists at Serra da Capivara using ^{14}C-method. Neves & Pucciarelli (1991) and Neves *et al.* (1999) analysed a female skull found at Lapa Vermelha archaeological site in Minas Gerais State, Brazil and concluded that it has Negroid characteristics. It is commonly accepted that the ancestors of North and South American Indians are of mongoloid type. Similar findings were reported concerning human skulls found in Kennewick and Spirit Cave in the United States.

Although little probable, the possibility of migration from Australia and surrounding islands across the Pacific Ocean or from Africa across the South Atlantic Ocean, more than 50 ka years ago, cannot be discarded.

Acknowledgements

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