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Upper Pleistocene deposits of the Comprida Island (São Paulo State) dated by thermoluminescence method

KENITIRO SUGUIO[1], SONIA H. TATUMI[2], EMÍLIA A. KOWATA[2], CASIMIRO S. MUNITA[2] and ROSEMEIRE P. PAIVA[3]

[1]Instituto de Geociências – USP, Rua do Lago, 562 – Butantã, 05508-080 São Paulo, SP, Brasil
[2]Laboratório de Vidros e Datação – FATEC-SP, Bom Retiro, 011224-060 São Paulo, SP
[3]Divisão de Radioquímica – IPEN/CNEN-SP, Cx. Postal 11049, 05422-970 São Paulo, SP

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ABSTRACT

The Cananéia (Upper Pleistocene) and the Comprida Island (Holocene) formations, outcropping in the Comprida island (SP) have been mapped using geomorphological and lithological criteria. Only one sample of the Cananéia Formation, collected in the homonymous island in front of the Comprida Island, was beyond the limit of the standard radiocarbon method.

But since the publication of the geological map of the area in 1978, there has been some doubt on the real occurrence of Pleistocene deposits in southern extremity of Comprida Island.

This paper deals with the results of thermoluminescence (TL) ages of eight samples from Comprida Island, which corroborate the Pleistocene age assumed during mapping surveys of these deposits. On the other hand, possible interpretations of the obtained ages, in relation to their depositional environments and related northern hemisphere Quaternary glaciations, are presented.

Key words: thermoluminescence ages, Pleistocene, sea level, São Paulo State.

INTRODUCTION

The Comprida Island is a barrier-island like feature (Martin and Suguio 1978), situated at the Cananéia-Iguape coastal plain (Fig.1). It is separated from the continent by the ''Mar Pequeno'' estuarine channel, which is 400 to 1,200m wide.

This channel is divided southward into two branches around the Cananéia Island, thus giving origin to the ''Mar de Cubatão'' and the ''Mar de Cananéia''.

This island comprises a total area of 320km^2, being 3 to 5km wide and 70km long. Excluding a small hill (about 40m high) called ''Morrete'', at its southern tip, it is essentially sandy. More than 80% of the Island is composed of the Comprida Island Formation (Suguio and Martin 1994), which is Holocene in age. About 18% of the total area, situated at southern inner portion of the island, has been tentatively mapped by Suguio and Martin (1978), as the Upper Pleistocene Cananéia Formation (Suguio and Petri, 1973).

According to Suguio and Martin (1978), the Comprida Island evolutionary scheme, during the Quaternary, can be explained at least by the following stages:

a) *First stage* – During the Cananéia transgression

Correspondence to: Kenitiro Suguio
*Member of Academia Brasileira de Ciências

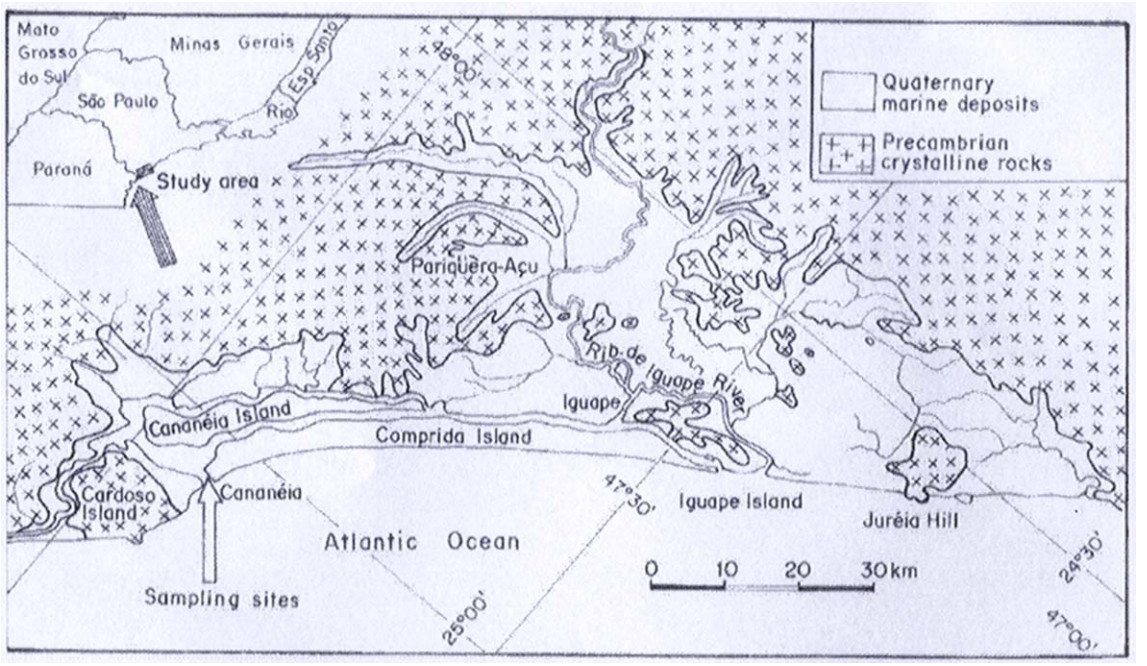

Fig. 1 – Quaternary Cananéia-Iguape coastal plain (southernmost São Paulo State), and the Comprida Island with indication of sampling sites.

(120ky B.P.) culmination stage (8 ± 2m) above the present level, sea reached the foot of the ''Serra do Mar'' coastal ranges. In this period, transitional clayey-sandy sediments, overlain by shallow marine transgressive sands, covered the Tertiary Pariqüera Açu Formation continental deposits.

b) *Second stage* – With the beginning of regression, beach ridges started to be deposited on top of sandy sediments.

c) *Third stage* – This phase corresponds to the northern hemisphere L.G.M. (Last Glacial Maximum), when sea level was always lower than the present one. In fact, it was more than 100m below the present level about 17.5ky B.P. (Correa 1996), when rivers deeply eroded sedimentary deposits of the Cananéia Formation.

d) *Fourth stage* – During the Holocene Santos transgression, sea encroached upon lowlands, and started forming extensive lagoonal systems where clayey-sandy deposits, commonly rich in organic matter, were deposited. In the meantime, sea eroded much higher-lying portions of the Cananéia Formation, and redeposited eroded sands to form Holocene shallow-marine sandy deposits.

e) *Fifth stage* – After the Holocene sea-level culmination stage (about 5.5kyB.P.) which reached 4 to 5m above present level, sea level returned to the present position and regressive beach ridges were formed. Some minor fluctuations of sea level, during the Santos transgression final part, produced different beach ridge generations. On the Comprida Island, at least two Upper Pleistocene and Holocene beach ridge generations, separated by a more-or-less swampy and low-lying zone, can be followed for about 50km.

Based on the above-mentioned stages, it is possible to summarize the Comprida Island geologi-

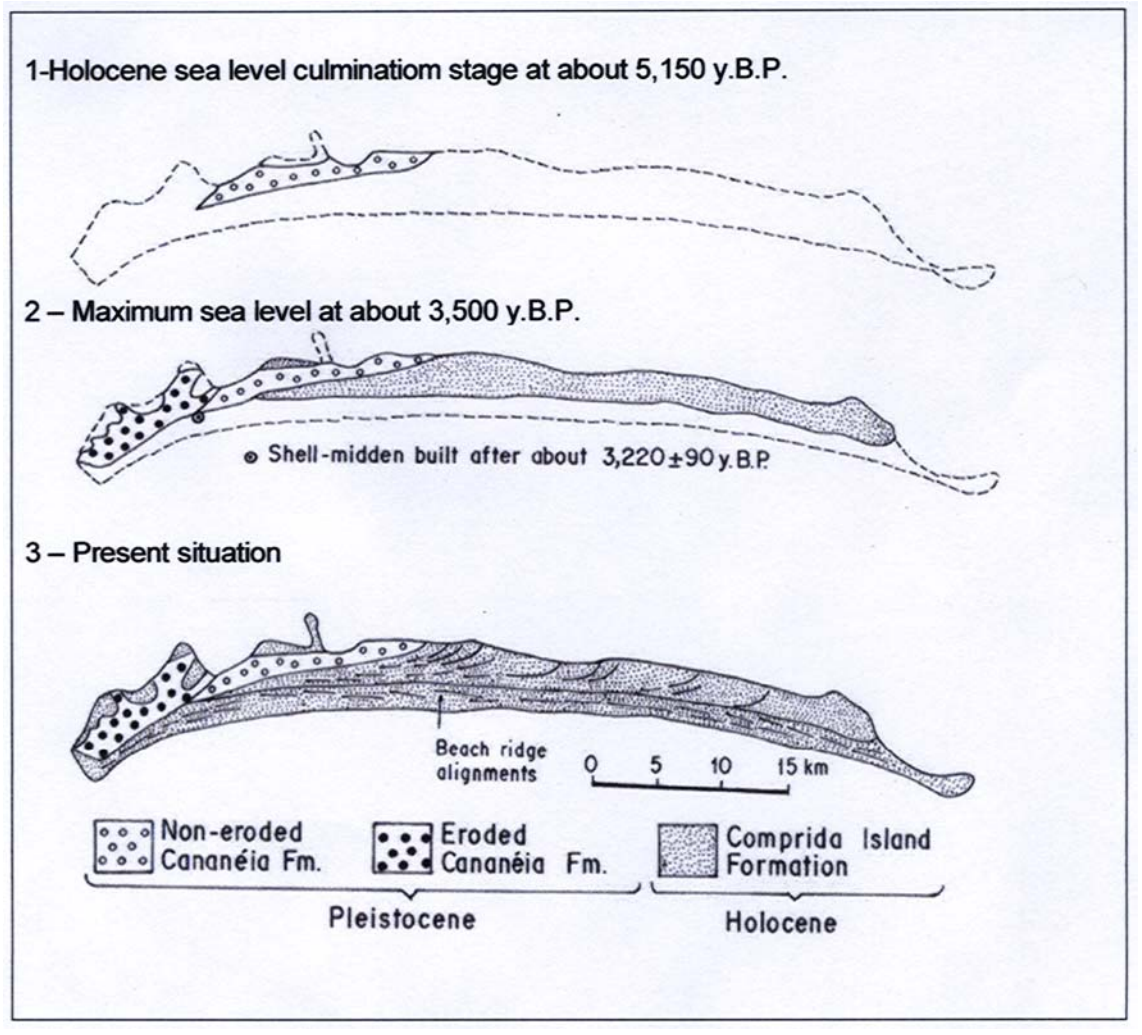

Fig. 2 – Comprida Island evolutionary scheme, during the Holocene, according to Martin and Suguio (1978).

cal evolution during the Holocene (Fig. 2). After the first sea-level culmination stage (about 5.5ky B.P.), when only ''Morrete'' and northern half of the Cananéia Formation were emerged, the island ''grew'' toward the Iguape town (see Fig. 1). The curved beach ridges, easily visible on aerial photos, confirm this generation model. During a small transgression, that took place prior to the second culmination stage (about 3.5ky B.P.), the above-mentioned beach ridges were partially eroded. Southward, near Boguaçu river, there is a shell-midden on the first ridge, between the low-lying zone and the sea. This shell-midden has been dated as 3.22 ± 0.09 ky B.P. (Ba-307), and as 3.09 ± 0.11 ky B.P. (Gif-3645). Abundant whale bones contained in this shell-midden are suggestive of its construction near the shore, at the beginning of external Holocene beach ridges construction. This low-lying terrain proves clearly that part of the island, between low-lying zone and ocean, was entirely formed after the second maximum sea level (3.5ky B.P.).

Until presently, the probable age of the Cananéia Formation outcrops in the Comprida Island was considered only as older than 35ky B.P. (Gif-3844). This age was based on a radiocarbon age of small organic remains (vegetal debris), collected in

the Cananéia Island in front of the Comprida Island (Suguio and Martin 1978). Only the field criteria, as for example, its dark brownish color or hardness, seen to be unsatisfactory to identify Cananéia Formation outcrops, have been used. Therefore, TL ages as here presented are very important.

MATERIALS AND METHODS

Eight sand samples (Tables I and II) were collected from anomalously lowered probable Cananéia Formation, in the southern part of the Comprida island. Four of these were collected at two shallow excavations (about 1.00m deep), located about 1 km from the southern extremity of the island (Table I).

Moreover, at the southernmost tip of the Comprida Island, four additional samples were collected in two different layers below present terrain surface levels of vertical sea cliffs (Table II).

The collected samples were washed with water and subsequently treated with 10% HCl and 30% H_2O_2 to remove carbonate and organic matter. Quartz grains were obtained by density separation in sodium-polytungstate (SPT), with a density of 2.62g/cm^3. After, the samples were washed in 10% HF solution to remove quartz particles outer layer during 45 min, and then in 10% HCl for two hours to remove HF-related compounds. All samples were washed with distilled water after each step, and grain sizes from the 88-180 μm interval were selected for this study.

All γ-rays irradiations were performed with a ^{60}Co source of the IPEN-CNEN-SP (Instituto de Pesquisas Energéticas e Nucleares – Comissão Nacional de Energia Nuclear) laboratory.

TL measurements were made on Daybreak Nuclear and Medical Systems Incorporated, Model 1100-Series Automated TL/OSL System; a combination of a Schott BG-39 and a Kopp 7-59 detection filters was used, resulting in transmission of luminescence signal between 320 and 480nm.

Paleodose values were evaluated by ''Regeneration Method'' cited by Aitken (1998).

Annual doses rates were determined assuming a cosmic rays contribution of 180 μGy/y and the Bell's equations (Aitken 1998). Uranium, thorium and potassium contents were determined by Neutron Activation Analysis (NAA). About 100mg of samples and standards of U, Th and K were irradiated in the swimming pool research reactor (IEA-Rim), at a thermal neutron flux of about 5×10^{12} ncm^{-2}s^{-1} during 8 hours. This reactor belongs to the IPEN-CNEN-SP laboratory. The gamma spectra were obtained after 7 and 15 days decay times using a Ge hyperpure detector, model GX-2020 from Canberra, FWHM 1.9keV gamma peak of ^{60}Co, and a 8192 channel S-100 Canberra MCA. Natural radioactive content results are shown in Table III.

INTERPRETATIONS AND FINAL CONSIDERATIONS

Two older ages, from lower portions of the sea cliffs, can be correlated with the final part of the Riss-Würm interglacial stage (oxygen-isotope stage 5). Other six samples, from upper or shallower portions of the Cananéia Formation, indicated the Würm glacial stage (oxygen-isotope stages 2-4). Therefore, the basal portions of the Cananéia Formation outcrops, in the Comprida Island, could represent the end of the Riss-Würm transgression shallow-marine sands, and the upper parts could be considered as Würm regression eolian deposits.

Bigarella (1946), in his pioneer work on the Paraná State coastal plain, considered mangrove as a geological unit (sedimentary environment) and, probably impressed by its coffee-powder like dark brownish color. He assumed that the Cananéia Formation could have been deposited within mangrove swamps, calling them ''mangrovites''. However, this formation presents primary sedimentary structures, which are suggestive of shallow-marine deposits (Suguio and Petri 1973, Suguio and Martin 1978, Suguio and Barcelos 1978, Tessler and Suguio 1987). After some years, Bigarella (1954) perceived his mistake in using the word ''mangrovite'', and proposed its abandonment.

Finally, the field criteria based on the observation of outcrops or the characteristics of the beach-

TABLE I

Sample names, paleodoses, annual doses and ages of sediments collected in the southern extremity of the Comprida island.

Excavation site	Samples (depth m)	Paleodose (Gy)	Annual dose (μGy/y)	Age (ky)
1	I - A (0.5)	9.89 ± 0.49	623 ± 126	15.9 ± 4.0
	II - A (1.0)	12.59 ± 0.63	456 ± 17	27.6 ± 2.4
2	I - B (0.5)	10.65 ± 0.53	623 ± 126	17.1 ± 3.5
	II - B (1.0)	13.12 ± 0.66	470 ± 16	27.9 ± 2.3

TABLE II

Sample names, paleodoses, annual doses and ages of sediments collected in the southernmost tip of the Comprida island.

Sea cliffs	Samples (depth m)	Paleodose (Gy)	Annual dose (μGy/y)	Age (ky)
1	III - A (3.20)	27.06 ± 1.35	346 ± 11	78.3 ± 7.2
	III - B (1.10)	19.30 ± 0.97	563 ± 20	34.3 ± 3.0
2	IV - A (3.15)	26.74 ± 1.34	315 ± 14	84.8 ± 1.8
	IV - B (0.90)	23.66 ± 1.18	512 ± 18	46.2 ± 3.9

TABLE III

Sample names and related natural radioisotope contents.

Excavation	Samples (depth m)	K-40 (%)	U-235 + 238 (ppm)	Th-232 (ppm)
1	I - A (0.5)	0.080 ± 0.018	1.04 ± 0.71	3.26 ± 1.70
	II - A (1.0)	0.35 ± 0.02	0.70 ± 0.06	1.24 ± 0.02
2	I - B (0.5)	0.080 ± 0.018	1.04 ± 0.71	3.26 ± 1.70
	II - B (1.0)	0.38 ± 0.02	0.48 ± 0.05	2.19 ± 0.03
Sea cliffs				
1	III - A (3.2)	0.39 ± 0.02	0.37 ± 0.05	0.91 ± 0.02
	III - B (1.1)	0.065 ± 0.006	0.82 ± 0.07	2.26 ± 0.03
2	IV - A (3.15)	0.23 ± 0.02	0.27 ± 0.05	0.85 ± 0.02
	IV - B (0.90)	0.056 ± 0.004	0.83 ± 0.06	1.55 ± 0.03

ridge alignment patterns, as seen on aerial photos (Martin et al. 1998), must be considered as insufficient to distinguish the Cananéia (Upper Pleistocene) from the Comprida Island (Holocene) formations. Dark brownish color is also present in younger Holocene deposits, and in the case of the Cananéia Formation, this represents an epigenetic color, probably acquired during the Holocene.

RESUMO

As formações Cananéia (Pleistoceno superior) e Ilha Comprida (Holoceno), aflorantes na Ilha Comprida (SP), foram mapeadas com base em critérios geomorfológicos e litológicos. Uma amostra da Formação Cananéia, coletada na ilha homônima em frente à Ilha Comprida, apresentou idade superior ao alcance do método convencional de radiocarbono.

Deste modo, desde a publicação de mapas geólogos da área em 1978, havia algumas dúvidas sobre a real ocorrência de depósitos pleistocênicos na extremidade sul desta ilha.

Neste trabalho, são apresentados os resultados de idades TL de oito amostras, coletadas na Ilha Comprida, que vieram corroborar a idade pleistocênica atribuída durante o mapeamento geológico desses depósitos. Por outro lado, são apresentadas as possíveis interpretações das idades encontradas, em relação aos seus ambientes deposicionais e aos eventos glacias quaternários do hemisfério norte.

Palavras-chave: idades por termoluminescência, Pleistoceno, nível do mar, Estado de São Paulo.

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