INTERNATIONAL SYMPOSIUM
ON
SEA LEVEL CHANGES AND QUATERNARY SHORELINES

(July 7 - 14, 1986 - São Paulo, Brazil)

SPECIAL PUBLICATION N.º 2

ANNOTATED BIBLIOGRAPHY ON QUATERNARY SHORELINES AND SEA-LEVEL CHANGES PRODUCED WITH DR. LOUIS MARTIN'S (ORSTOM) PARTICIPATION IN THE DECADE 1975-1985.

ORGANIZER: Kenitiro Suguio

-1986-

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Sponsorship: The Americas Subcomission of
INQUA Commission on Quaternary Shorelines

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ANNOTATED BIBLIOGRAPHY ON QUATERNARY SHORELINES AND SEA-LEVEL CHANGES PRODUCED WITH DR. LOUIS MARTIN'S (O.R.S.T.O.M.) PARTICIPATION IN THE DECADE 1975-1985.

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P R E F A C E

This is an annotated bibliography of about 75 papers produced with Dr. Louis Martin's participation between 1975 and 1985. These studies have been done under the auspices of the following international projects: IGCP Project 61 (Holocene Sea-Level Changes), IGCP Project 200 (Sea-Level Correlations and Applications), IGCP Project 201 (Quaternary of South America) and Americas Subcommission of INQUA Quaternary Shorelines Commission. The field surveys were financially supported mostly by FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo) and CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico). Brazilian and french specialists from O.R.S.T.O.M. (Institut Français de Récherche Scientifique et Téchnique pour le Développement en Coopération), University of São Paulo, Observatório Nacional (CNPq) and Federal University of Bahia were active in different phases of the studies.

Probably, beside the REMAC (Reconhecimento Global da Margem Continental Brasileira) Project, active from 1972 through June 1978, these papers represent significant contribution for the knowledge of the Quaternary coastal geology in Brazil. While the REMAC Project worked on the submerged areas, these studies are related to the emerged coastal regions.

July 1st, 1986

Kenitiro Suguio

BERNAT,M.; MARTIN,L.; BITTENCOURT,A.C.S.P. & VILAS BOAS, G. S., 1983. Datations Io-U du plus haut niveau marin du dernier interglaciaire sur le côte du Brésil:Utilisation du ^{229}Th comme traceur. C. R. Acad. Sc. Paris, t. 296, série II: pp. 197, Paris.

Five coral samples taken in a quarry near the town of Ilhéus (Bahia State, Brazil) analysed by spectrometry method for ^{230}Th and uranium isotopes (using ^{229}Th and ^{232}U as tracers) gave a mean age of 123,500 years. These first datings confirm the general stability of the Atlantic coast since that time.

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BITTENCOURT, A.C.S.P.; DOMINGUEZ, J.M.L.; FLEXOR, J.M.; MARTIN, L. & SUGUIO, K., 1982. Evolution du littoral brésilien au Quaternaire: influence des variations du niveau rélatif de la mer. Conferência Regional Latinoamericana da União Geográfica Internacional, Comissão de Ambientes Costeiros, Cabo Frio (RJ).

Depuis 1974, une étude systématique du Quaternaire marin brésilien a été entreprise par des chercheurs de l'ORSTOM (France) et des Universités de São Paulo et Bahia.

Grâce à de nombreuses datations absolues,deux hauts niveaux marins ont pu être mis en évidence. Le plus ancien a été daté de 120.000 ans B.P. A cette époque, le niveau rélatif de la mer se situait 8 $\pm$ 2m au-dessus du niveau actuel. L'existence de très vastes terrasses sableuses, liées à ce haut niveau marin, a pu être mis en évidence en de nombreuses régions. La partie terminale de la dernière transgression a été très bien étudiée sur la totalité du littoral des états de São Paulo, Bahia, Sergipe et sur une partie de ceux de Rio de Janeiro, Espírito Santo et Alagoas. Selon la région, le zéro actuel a été coupé entre 7000 et 6000 ans B.P.. Vers 5100 ans B.P., le niveau rélatif de la mer se situait 4 à 5 m au-dessus du niveau actuel. Il est évident que l'abaissement du niveau de la mer de 4 à 5 m au cours des 5000 dernières années a joué un rôle essentiel dans la sédimentation littorale. Et il est non moins évident que les modèles classiques de sédimentation littorale quaternaire, mis au point le plus souvent dans des régions où le niveau de la mer n'a

pas dépassé le zéro actuel, ne peuvent être utilisés au Brésil

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BITTENCOURT,A.C.S.P.; DOMINGUEZ,J.M.L.; MARTIN,L. & FERREIRA, Y. de A., 1982. Dados preliminares sobre a evolução do delta do Rio São Francisco (SE/AL) durante o Quaternário: Influência das variações do nível do mar. Atas IV Simpósio do Quaternário no Brasil: 49-68, Rio de Janeiro.

The coastal plain of the São Francisco River mouth developed from a "V" form inward coastal erosion on the Barreiras Formation (Pliocene). This coastal geomorphic feature was probably originated by the faults on the Precambrian basement, which were again in activity during Quaternary times. The first Pleistocene transgression that reach the area originated an outcliff on the Barreiras Formation,which was also probably influenced by the above mentioned faults. The following regressive event, during the dry weather, favoured the deposition of alluvial fans at the base of the Barreiras outcliff. The 120,000 years B.P. transgression partially eroded these alluvial fan deposits. A following regression left behind a series of beach ridges which reach heights of 8 to 10 meters. The last transgression that occurred at 5,200 years B.P. eroded most of the beach ridges constructed before and formed several lagoons on the landward side of the coastal plain. During the following drop of sea-level a new series of beach ridges were constructed: the landward ones with heights up to about 3.5 meters and the seaward ones with less than 1 meter heigh. Above the last ones, coastal dunes were deposited. Flood plain deposits occur in a small area of the central part of the coastal plain. This suggests that probably the São Francisco River was not the major source of sediment to the coastal plain deposits. The regressive event of the last 5,200 years B.P., which attains 5 meters, make available a significative amount of sediment to the longshore transport. These sediments, carried toward the south, were catched on the Barreiras inward erosion which worked as a sediment trap. An analysis of the distribution

of the sedimentary facies present on the coastal plain also suggests that the deposits on the southern part of the São Francisco delta was partially supplied by the river, while in the northern part the sediments were furnished by the longshore currents.

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BITTENCOURT,A.C.S.P.; MARTIN, L.; DOMINGUEZ,J.M.L. & FERREIRA, Y. de A., 1982. O Quaternário costeiro do Estado de Sergipe. XXXII Congr. Bras. Geol., Bol. nº 2 (Resumos e Breves Comunicações): pp. 92, Salvador.

O litoral do Estado de Sergipe se caracteriza pela não existência de afloramentos rochosos em contato com o mar, o que dificulta a coleta de amostras datáveis que permitam a reconstrução de antigas posições do nível relativo do mar. Entretanto, por analogia com os estudos anteriormente realizados para a região costeira do Estado da Bahia, foi possível a individualização de duas gerações de terraços marinhos, associados aos dois últimos episódios transgressivos que afetaram a costa leste brasileira durante o Quaternário. Os terraços marinhos construídos após o máximo da Penúltima Transgressão (120.000 anos A.P.) formam uma banda contínua e testemunham um antigo nível do mar situado 8 ± 2m acima do nível atual. Externamente a esses terraços antigos, e em posição topograficamente mais baixa, são encontrados os terraços marinhos construídos após o máximo da Última Transgressão (5.100 anos A.P.). As poucas reconstruções de antigas posições do nível relativo do mar que puderam ser feitas não mostram diferenças notáveis com a curva de variações do nível relativo do mar construída para região de Salvador.

Foi possível ainda colocar em evidência, notadamente na metade norte da região costeira sergipana, uma formação continental mais recente que a Formação Barreiras e mais antiga que o máximo da Penúltima Transgressão (120.000 anos A.P.). Este depósito é provavelmente correlacionável aos leques aluviais pleistocênicos descritos para a zona costeira do Estado da Bahia.

Finalmente, pode-se constatar a existência de várias gerações de dunas, das quais as mais antigas se colocam acima dos sedimentos da Formação Barreiras, e são sem dúvida anteriores a 120.000 anos A.P.

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BITTENCOURT,A.C.S.P.; MARTIN,L.; DOMINGUEZ,J.M.L. & FERREIRA, Y de A., 1983. Quaternário costeiro. In: Mapa Geológico do Estado de Sergipe. Ministério das Minas e Energia (DNPM) e Governo do Estado de Sergipe (Secretaria da Indústria, Comércio e Turismo).

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BITTENCOURT,A.C.S.P.; MARTIN,L.; DOMINGUEZ, J.M.L. & FERREIRA, Y. de A., 1983. Evolução paleogeográfica quaternária da costa do Estado de Sergipe e da costa sul do Estado de Alagoas. Rev. Bras. Geociên. 13(2): 93-97, São Paulo.

The coastal zones of the State of Sergipe and southern section of the State of Alagoas were studied using a Quaternary relative sea level variation approach. Six main events were recognized during the Quaternary evolution of these regions:

Event I - Pleistocene. The Most Ancient Transgression eroded, through the recession of a line of cliffs, the external front of the Barreiras Formation.

Event II - Pleistocene. Deposition of a series of coalescing alluvial fans at the foot of the aforementioned cliffs.

Event III - 120,000 years B.P. The Penultimate Transgression partially eroded during its course the Pleistocene coalescing alluvial fans.

Event IV - Pleistocene. A drop in sea-level following the maximum of the Penultimate Transgression allowed the construction of a coastal plain similar to the existing today.

Event V - 5,100 years B.P. The Last Transgression partially eroded the Pleistocene coastal plain. The river's mouths were drowned giving way to estuaries. Locally, systems

of barrier islands developed.

Event VI - Holocene. The lowering of sea-level that followed the maximum of the Last Transgression allowed the construction of the modern coastal plain.

During the events II, IV, and VI a sand dune development took place.

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BITTENCOURT,A.C.S.P.; MARTIN,L.; DOMINGUEZ,J.M.L. & FERREIRA, Y. de A., 1983. Mapa geológico do Estado de Sergipe (1:250.000). DNPM/Governo do Estado de Sergipe.

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BITTENCOURT,A.C.S.P.; MARTIN,L.; SUGUIO,K.; VILAS BOAS,G.S.& FLEXOR, J.M., 1980. Rôle des variations du niveau marin dans la sédimentation quaternaire du littoral des états de São Paulo et Bahia (Brésil). 26e.Congr. Géol. Inter. Séction 06, Thème 12.

Les variations du niveau rélatif de la mer au Quaternaire ont été le facteur principal de la sédimentation sur le littoral des états de São Paulo et Bahia. Les dépôts que l'on y rencontre sont liés aux deux derniers épisodes transgressifs qui ont dépassés le 0 actuel. Les fleuves, quand ils existent, ne semblent jouer qu'un rôle accessoire. De très vastes terrasses sableuses ont été construites après le maximum de l'avant dernier épisode transgressif que a atteint une côte de +8 à +10m et dont l'âge n'est pas connu avec précision (des coraux d'âge > 35 000 ans B.P. sont en datation). Le dernier épisode transgressif est bien connu grace à de nombreuses datations. Au cours des 7 000 dernières années, le niveau rélatif de la mer a oscillé autour de 0 actuel, passant par un maximum à +4,5 ($\pm$ 0,5)m vers 5 100 ans B.P. A cette époque, des réseaux de lagunes dont l'extension a varié en fonction des oscillations du niveau de la mer, ont pu s'installer. Durant les phases régressives, diverses générations de cordons formant des ensembles de plusieurs km de largeur ont été construites. Même la construction du "delta" du Rio Jequitinhonha a été grandement influencée par les

variations du niveau rélatif de la mer.

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BITTENCOURT,A.C.S.P.; VILAS BOAS,G.S.; FLEXOR,J.M. & MARTIN, L., 1978. Excursão sobre as formações quaternárias do litoral da região de Salvador, Bahia (Livro-guia). 1978 International Symposium on Coastal Evolution in the Quaternary: 115 pp., Salvador.

This guide-book has been prepared in order to serve as itinerary of the excursion on the Quaternary formations in the littoral of the region of Salvador, Bahia (Brazil) to be carried out during the period September 20 to 22/1978, as a part of the program of the 1978 International Symposium on Coastal Evolution in the Quaternary (São Paulo, Brazil) within the International Geological Correlation Programme Project 61 (Holocene Sea-Level Changes). The text is presented in Portuguese (pages 1 to 37), in French (pages 38 to 77) and in English (pages 78 to 115).

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BITTENCOURT,A.C.S.P.; VILAS BOAS, G.S.; FLEXOR, J.M. & MARTIN, L., 1979. Geologia dos depósitos quaternários do litoral do Estado da Bahia. In: Geologia e Recursos Minerais do Estado da Bahia, Textos Básicos, vol. 1: 1-21. Governo do Estado da Bahia (Secretaria das Minas e Energia).

Le Secrétariat des Mines et de l'Energie de l'État de Bahia a entrepris une série de publications destinées à divulguer les travaux sur les aspects les plus divers de la géologie de l'État. La première partie de cette série de publications comprend des textes sur la géologie régionale, la géotectonique, la géochronologie, la stratigraphie, la sédimentologie, la pétrographie, la géologie structurale, la géochimie théorique et la géomorphologie. La seconde partie comprend des textes sur la géologie économique, la métalogénie et l'économie minière. Dans le cadre de cette série de publications a été faite une brève synthèse sur le Quaternaire marin du littoral de l'État de Bahia.

BITTENCOURT,A.C.S.P.; MARTIN,L.; VILAS-BOAS,G. & FLEXOR, J. M., 1979.Quaternary marine formations of the coast of the State of Bahia (Brazil). Proceedings of the 1978 International Symposium on Coastal Evolution in the Quaternary: 232-253, São Paulo.

On the coast of the State of Bahia there is evidence of deposits left by the last three transgressions which reached levels above today's mean sea level. In the northern part of the coast the Precambrian shield is covered by sediments of the Barreiras Formation. Deposits of the last two transgressive events mentioned above are found there, and they are generally poorly developed. Along Todos os Santos Bay, deposits of the penultimate transgression(120.000 years B.P.) situated above today's sea level are not found, and only the deposits of the last transgression are known. These deposits however are not continuous, which may imply the existence of tectonic movements within the bay. Between Todos os Santos Bay and Itacaré, on the south, the sandy terraces formed during the aforementioned transgressions are well developped. Between Itacaré and the south of Ilhéus the Precambrian rocks either border the sea or are separated from it by Quaternary deposits of small extent. The paleobay of Itaipe, situated in the small sedimentary basin of Almada, is an exception. The southern part of the coast of the State of Bahia is characterized by the reappearence of the sediments of the Barreiras Formation bordering the sea. However, in some regions like Canavieiras, Belmonte, Alcobaça, Caravelas, Nova Viçosa and Mucuri, the deposits of sand left by the two last transgressions are very important. In the region of Caravelas crop out sediments of the antepenultimate transgression.

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COSTA MAIA,M.C.A.; MARTIN,L.; FLEXOR,J.M. & AZEVEDO,A.E.G.de, 1984. Evolução holocênica da planície costeira de Jacarepaguá (RJ). An. XXXIII Congr. Bras. Geol., v. 1: 105-118, Rio de Janeiro.

During the Quaternary, the sea-level suffered several oscillations, resulting from the combination of global (glacio-eustatic) and local (isostasy, tectonism) factors.

There happened three great transgressions during the Quaternary, but just the last two are well known. The latest Transgression, the best known, started at 17,000 years B.P. and continued during the Holocene.

In Jacarepaguá Plain there is evidence of deposits left by the latest Transgression only. We can describe four evolutive stages in the Holocene. Stage I: 7,000 to 5,000 years B.P.; the drowned plain became partially isolated from the sea by a barrier island, which moved toward the land until the transgression's maximum; stage II, a regression allowed the barrier island's progradation, building the first progradation zone; stage III: 3,800 to 3,500 years B.P.; a new transgressive event partially eroded the first progradation zone; a new barrier island was established, isolating a new lagoon from the sea; stage IV, the sea-level lowered down until the present level; during the regression the second barrier island prograded, forming the second progradation zone.

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DOMINGUEZ,J.M.L.; BITTENCOURT, A.C.S.P. & MARTIN,L., 1981. Esquema evolutivo da sedimentação quaternária nas feições deltaicas dos rios São Francisco (SE/AL), Jequitinhonha (BA), Doce (ES) e Paraíba do Sul(RJ). Rev. Bras. Geociên. 11(4):227-237, São Paulo.

Quaternary sea-level fluctuations along the east coast of Brazil played an important role on the development of the coastal plains of the São Francisco, Jequitinhonha, Doce and Paraíba do Sul rivers. The following eight stages have been recognized representing the Quaternary evolution of these features: Stage 1 (Pliocene) - deposition of the Barreiras Formation as a series of alluvial fans; Stage 2 (Pleistocene) - the Most Ancient Transgression with erosion during its course of the external front of the Barreiras Formation; Stage 3 (Pleistocene) - deposition at the foot of the coastal cliffs, carved in the Barreiras sediments by the Most Ancient Transgression, of coalescing alluvial fans; Stage 4 (120,000 years B.P.) - The Penultimate Transgression

partially eroded the Pleistocene alluvial fans; Stage 5 - Drop of sea level, leading to the construction of coastal plains similar to those which exist today; Stage 6 (5,100 years B.P.) - the Last Transgression partially eroded and drowned the Pleistocene coastal plains, which became in part isolated from the open sea by barrier islands;Stage 7 - construction of intralagoonal deltas in the lagoonal systems associated with the aforementioned barrier islands; and Stage 8 - a regression allowed the development of present-day coastal plains.

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DOMINGUEZ,J.M.L.; BITTENCOURT,A.C.S.P. & MARTIN,L., 1983. O papel da deriva litorânea de sedimentos arenosos na construção das planícies costeiras associadas às desembocaduras dos rios São Francisco (SE/AL), Jequitinhonha (BA), Doce (ES) e Paraíba do Sul (RJ). Rev. Bras. Geociên. 13(2):98-105, São Paulo.

Wave-induced longshore drift played an important role in the construction of the Quaternary coastal plains associated with the São Francisco, the Jequitinhonha, the Doce and the Paraíba do Sul rivers. Geomorphic indicators shown on these coastal plains, e.g. spits, hooked spits, and lunate sandkeys, were used to determine the patterns of the littoral sand drift in these regions. It was possible to demonstrate, through the knowledge of these patterns, that the incorporation of littoral drifted sand sediments of these plains occurs mainly through a mechanism named herein as the groin-effect. According to this mechanism the river acts as a hydraulic groin, retaining on its updrift side, the littoral drifted sand sediments. As a consequence the updrift side progrades more rapidly than the downdrift one, which is nourished mainly by the sediments carried by the rivers. An asymmetry in facies distribution between downdrift and updrift sides results. The updrift side progrades through the addition of successive beach ridges, forming a continuous sand sheet, whereas at the downdrift side the progradation is promoted by the incorporation on sandy islands backed by mangrove swamps. The littoral sand drift can also promote an

intermitent migration of the river mouth in downdrift direction.

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DOMINGUEZ,J.M.L.; BITTENCOURT,A.C.S.P.; MARTIN,L.; LIMA, R. C.C. & COSTA,I.V.G., 1982. Roteiro de excursão geológica à planície costeira do Rio Jequitinhonha (BA) e às turfeiras associadas. XXXII Congr. Bras. Geol., Bol. nº 3 (Roteiro das excursões): 201-235, Salvador.

Quaternary sea-level fluctuations along the coast of the State of Bahia played an important role on the development of the Jequitinhonha river coastal plain. Nine stages were recognized representing the paleogeographic evolution of this plain: Stage 1 (Pliocene) - deposition of the Barreiras Formation as a series of alluvial fans; Stage 2 (Pleistocene) - the Most Ancient Transgression which erode, during its course, the external front of the Barreiras Formation; Stage 3 (Pleistocene) - deposition of coalescing alluvial fans at the foot of the coastal cliffs carved by the Most Ancient Transgression into the Barreiras Formation; Stage 4 (120,000 years B.P.) - the Penultimate Transgression partially eroded the Pleistocene alluvial fans; Stage 5 - descent of the sea level, leading to the construction of a coastal plain similar to those one that exists today; Stage 6 (5,100 years B.P.) - the Last Transgression partially eroded and drowned the Pleistocene coastal plain, which became, in part, isolated from the open sea by barrier islands; Stage 7 (5,100 to 3,800 years B.P.) - a new regression, enabled development of the first holocene Jequitinhonha River Progradation Zone. Coastline progradation was interrupted by another rise of sea level at 3,800 to 3,500 years B.P., which also caused lateral shifting of the river course; Stage 8 (3,500 to 2,700 years B.P.) at the new river mouth the second holocenic Jequitinhonha River Progradation Zone was constructed and again drowned during a rising sea level between 2,700 and 2,500 years B.P. This new event was the cause of a new shifting of the channel to its today's position; Stage 9 - after 2,500 years B.P., the present-day progradation zone

started its development.

The lagoonal zones created at the maximum of the Last Transgression (Stage 6) represent the most favourable sites for peat accumulation in the Jequitinhonha River coastal plain.

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DOMINGUEZ,J.M.L.; MARTIN,L. & BITTENCOURT,A.C.S.P.,1982. Evolução paleogeográfica do delta do Rio Jequitinhonha durante o Quaternário: Influência das variações do nível do mar. Atas IV Simpósio do Quaternário no Brasil: 69-92, Rio de Janeiro.

Quaternary sea-level fluctuations along the coast of the State of Bahia played an important role on the development of the Jequitinhonha River Delta Plain. Six stages were recognized representing the paleogeographic evolution of this delta cycle: I) Stage 1 (120,000 years B.P.) the coastal plain was completely drowned; II) Stage 2 - with a drop of sea level, a delta similar to what exist today was constructed; Stage 3 (5,200 years B.P.) - a new transgression partially drowned the Pleistocene Delta,which was in part isolated from the sea by barrier-islands; IV) Stage 4 (5,200 to 3,800 years B.P.) - a new regression allowed development of the first Jequitinhonha River Holocene Delta. The deposition of this deltaic sedimentation was interrupted by another rise of sea-level at 3,800 to 3,500 years B.P., which also caused lateral shifting of the river course; V) Stage 5 (3,500 to 2,700 years B.P.) - at the new river mouth the second Jequitinhonha River Holocene Delta was constructed and again drowned during a rising sea-level between 2,700 and 2,500 years B.P. This new event was the cause of a new shifting of the channel to its today's position. VI) Stage 6 (after 2,500 years B.P.) - the present-day delta initiated its development.

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DOMINGUEZ,J.M.L.; MARTIN,L.; BITTENCOURT,A.C.S.P.; FERREIRA, Y. de A. & FLEXOR, J.M., 1982. Sobre a validade da utilização do termo delta para designar as planícies costeiras associadas às desembocaduras dos grandes rios da costa leste/nordeste brasileira. XXXII Congr. Bras. Geol., Bol. nº 2 (Resumos e Breves Comunicações): pp. 92, Salvador.

No início da década de 70 G. BACOCCOLI classificou as zonas de progradação associadas às desembocaduras dos rios Paraíba do Sul (RJ), Doce (ES), Jequitinhonha (BA), São Francisco (SE/AL), Jaguaribe (CE) e Parnaíba (MA/PI) como deltas do tipo "altamente destrutivos dominados por ondas" atribuindo aos mesmos uma idade holocênica. Esta classificação foi em seguida acolhida por numerosos pesquisadores.

Estudos desenvolvidos pelos autores do presente trabalho nas zonas de progradação dos rios Paraíba do Sul, Doce, Jequitinhonha e São Francisco mostraram que uma parte dessas planícies costeiras é constituída por terraços marinhos de idade pleistocênica, associados à Penúltima Transgressão (120.000 anos A.P.). Durante o máximo da Última Transgressão (5.100 anos A.P.), quando o nível do mar se posicionou cerca de 5m acima do nível médio atual, essas zonas de progradação foram afogadas e substituídas por sistemas laguna/ilha barreira. No evento regressivo que se seguiu foram depositados os terraços marinhos que constituem a porção holocênica dessas feições. Esses terraços foram construídos basicamente a partir de sedimentos expostos na plataforma continental e por aqueles mobilizados ao longo da costa pelos sistemas de deriva litorânea. Estes estudos também concluiram que durante a história da progradação dessas planícies costeiras os rios a elas associados desempenharam um papel secundário como supridores de sedimentos.

Na zona de progradação do Rio Parnaíba não foram identificados terraços marinhos, sendo a planície costeira constituída basicamente por dunas e mangues. Essa região, ao que tudo indica, experimentou durante o Quaternário evolução um pouco diferente das demais zonas de progradação da costa leste.

O caso do Rio Jaguaribe deve ser também dissociado dos outros, uma vez que se pode constatar que a zona de progradação associada a sua desembocadura é em verdade constituída por dunas que se colocam acima da Formação Barreiras.

Fica evidente que a utilização do termo "delta", no sentido clássico para designar essas feições, é inadequado, visto que o termo implica nos rios a elas associados terem desempenhado um papel ativo como supridores de sedimentos durante a sua construção, o que parece não ter ocorrido. Deve-se ressaltar entretanto que o fluxo fluvial desempenha um papel importante no sentido em que se comporta como um obstáculo ao trânsito litorâneo de sedimentos, à semelhança de um molhe construído perpendicularmente a linha de costa.

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FLEXOR, J.M. & MARTIN, L., 1978. Sobre a utilização da razão $^{13}C/^{12}C$ no estudo da origem dos arenitos de praia da região de Salvador (Bahia). An. XXX Congr. Bras. Geol., v. 2:880-886, Recife.

There are two major theories concerning the origin of beach-rock cement. In the first, the source of beach-rock cement is related to carbon species dissolved in seawater. The second theory suggests freshwaters highly charged with CO_2 and saturated in $CaCO_3$, which lost their CO_2 causing carbonate crystallization. Studies of beach-rocks on the Itaparica Island (Bahia, Brazil) by CAMPOS (1976) have shown that these two mechanisms coexist. In fact, measurements of $^{13}C/^{12}C$ isotopic ratios in a beach-rock under cementation have shown $\delta 13_C \tilde{=} + 1.3^{o}/oo$ (PDB). However, $^{13}C/^{12}C$ measurements of cement from another contemporary beach-rock located in a Holocenic terrace under cocoanut trees have shown $\delta^{13}C$ values $\tilde{=} - 9.0^{o}/oo$(PDB). This indicates that some cement was formed from marine carbon while others include ^{13}C typical of freshwater. Isotopic measurements in fossil beach-rocks of Salvador region (Bahia) have shown $^{13}C/^{12}C$ ratios to be near $\delta^{13}C \tilde{=} +3^{o}/oo$ (PDB). This result eliminates second process for these fossil beach-rocks. An emersion of sands after their deposition

is not necessary to explain the cementation process. This situation thus eliminates the possibility of dating negative oscillations of relative sea-level by dating the cement of beach-rocks in this region.

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FLEXOR, J.M. & MARTIN, L. 1979. Sur l'utilisation des grès coquilliers de la région de Salvador (Brésil) dans la reconstruction des lignes de rivages holocènes. Proceedings of the 1978 International Sympsium on Coastal Evolution in the Quaternary: 343-355, São Paulo.

Il existe sur les plages de Salvador de nombreux bancs de grès coquilliers dont les sables se sont déposés à des époques au cours desquelles le niveau de la mer était différent du niveau actuel. L'étude des stratifications et des caractéristiques granulométriques de ces grès permet de reconstruire avec une précision acceptable la position du niveau moyen de la mer au moment du dépôt des sables. La datation au ^{14}C des coquilles les plus fraîches permet de connaître l'époque du dépôt. La cimentation des sables a pu se faire, soit à partir des carbonates dissous dans l'eau de mer, soit à partir des débris carbonatés contenus dans les sables préalablement dissous par de l'eau douce et ultérieurement recristallisés. Ce second mécanisme implique une émersion de la formation sableuse. Dans ce cas, l'âge du ciment pourraît dater une oscillation négative du niveau de la mer. Malheureusement, les valeurs du $\delta^{13}C$(PDB) des carbonates des ciments étudiés montrent que ceux-ci ont une origine marine indiscutable. De plus, les datations au ^{14}C du ciment sont incohérantes et n'indiquent absolument pas l'époque au cours de laquelle s'est produite la cimentation.

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FLEXOR,J.M.; MARTIN,L. & SUGUIO,K., 1978. Sobre a utilização da razão isotópica $^{13}C/^{12}C$ na determinação de paleo ambientes lagunares. An. XXX Congr. Bras. Geol., v. 2:887-896, Recife.

The $^{13}C/^{12}C$ ratio of typical marine carbonate is, in general, characterized by positive $\delta^{13}C$ values in comparison with the standard PDB. However, shells of typically freshwater mollusks exhibit a $^{13}C/^{12}C$ ratio whose $\delta^{13}C$ is markedly negative, reaching values of about - 13°/oo (PDB), due to the absorption of decomposed organic matter derived from land plants which have the following characteristic values: $\delta^{13}C$ = -11°/oo (PDB) for the tropical Gramineae (Hatch-Slack photosynthetic cycle) and $\delta^{13}C$ = -26°/oo (PDB) for temperate zone trees and Gramineae (Calvin-Benson photosynthetic cycle). Thus, it is reasonable to admit that the mollusk shells in lagoonal environments, where all conditions intermediate between marine and freshwater environments are present, must show intermediate values for the $^{13}C/^{12}C$ ratios of their carbonates.

The coastline of southern State of São Paulo is characterized by a series of Quaternary sedimentary plains drained by poor to well developed lagoonal systems. In this region, the sea level has fluctuated around its present mean level during the past 6,500 years, and the oscillations were reflected by changes in the extensions of the lagoonal areas.

The shells of mollusks from the seaward sides of the lagoons presented $\delta^{13}C$ = -0.66 ± 0.64°/oo (PDB) and from inland part $\delta^{13}C$ = -4.17 ± 1.21°/oo (PDB), while those from the intermediate zones exhibited $\delta^{13}C$ (PDB)= -1.87 ± 0.73°/oo (PDB).

On the other hand, shells of different ages sampled from the same area presented values of $\delta^{13}C$ that change with sea-level oscillations. During the transgressive period, characterized by a strong marine influence, the $\delta^{13}C$ values were less negative, whereas during the regressive period, when a continental influence was dominant, the $\delta^{13}C$ values were more negative.

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FLEXOR, J.M., MARTIN,L. & SUGUIO, K., 1979. Utilization du rapport isotopique $^{13}C/^{12}C$ comme indicateur d'oscillations lagunaires. Proceedings 1978 International

Symposium on Coastal Evolution in the Quaternary: 358-375, São Paulo.

Les mesures isotopiques effectuées sur les carbonates des coquilles des "sambaquis" disséminés dans la plaine quaternaire sédimentaire de Cananéia-Iguape confirment qu'à une même époque, les valeurs de $\delta^{13}C$(PDB) varient en fonction de la position géographique. En effect, dans les parties internes des lagunes où l'influence continentale est la plus forte, les valeurs de $\delta^{13}C$ (PDB) sont nettement négatives et tendent vers les valeurs des carbonates des coquilles des organismes d'eau douce. Par contre, dans les parties externes des lagunes où l'influence continentale est moins importante, les valeurs de $\delta^{13}C$ (PDB) sont nettement moins négatives et tendent vers les valeurs des carbonates des coquilles des organismes marins. Dans ce cas, le $\delta^{13}C$(PDB) peut être un bon indicateur du paléomilieu lagunaire. En revanche, en un même point de la lagune, les valeurs de $\delta^{13}C$ (PDB) varient dans le temps en fonction des oscillations du niveau de la lagune, elles-mêmes liées aux oscillations du niveau moyen relatif de la mer. En période transgressive, les valeurs du $\delta^{13}C$(PDB) deviennent moins négatives et en période régressive elles deviennent plus négatives. Dans ce cas, les variations du $\delta^{13}C$(PDB) sont un indicateur des oscillations lagunaires. Enfin les valeurs du $\delta^{13}C$(PDB) peuvent apporter des informations supplémentaires permettant de préciser l'allure des courbes de variation du niveau moyen rélatif de la mer.

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FLEXOR,J.M.; MARTIN,L.; SUGUIO, K.; VILAS-BOAS,G.S. & BITTENCOURT,A.C.S.P., 1980. Utilisation du rapport $^{13}C/^{12}C$ comme indicateur des dépôts littoraux marins, lagunaires et continentaux, sur les côtes du Brésil. 26^{e}. Congr. Géol. Intern., Séction 10, Thème 11.

Le rapport $^{13}C/^{12}C$ des carbonates exprimé en $\delta^{13}C$ (PDB) présente un spectre de valeurs assez étendu en fonction de la nature plus ou moins continentalle de l'environnement où ils se sont formés. Des études faites sur le littoral de

l'état de Bahia ont montré que le mode de cimentation des grès de plage pouvait être déterminé par le valeur du $\delta^{13}C$ (PDB) du ciment. De même, on a pu vérifier que carbonates des coquilles des lagunes paulistes présentaient des valeurs du $\delta^{13}C$(PDB) intermediaires entre celles des carbonates des coquilles marines et continentalles. A une même époque, ces valeurs varient en fonction de la position géographique: dans les zones lagunaires externes les valeurs $\delta^{13}C$(PDB) sont peu négatives alors qu'elles sont beaucoup plus dans les zones internes. Dans ce cas le $\delta^{13}C$(PDB) est un très bon indicateur du paleomilieu lagunaire. Par contre, dans une même région lagunaire, mais à des époques différentes, les valeurs du $\delta^{13}C$(PDB) sont un bon indicateur des oscillations de la surface lagunaire et en conséquence, des variations du niveau marin.

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FLEXOR,J.M.; MARTIN,L.; SUGUIO,K. & DOMINGUEZ,J.M.L., 1984. Gênese dos cordões litorâneos da parte central da costa brasileira. Restingas: Origem, Estruturas,Processos (L.D. Lacerda et al., ed.): 34-45, Niterói (RJ).

The origin of beach ridges occurring in the central part of the Brazilian coast is explained in terms of the relative sea-level drop during the Holocene and from its consequences in the transport of sand derived from the adjacent inner shelf. It is shown that the longshore currents have played an essential role in the construction of the sandy terraces and that the beach ridges correspond to beach bar crests successively left during the progradation of the coast.

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GUIMARÃES,M.M.M. & MARTIN,L., 1978. Diferenciação morfoscópica das areias da região nordeste de Salvador: Cronologia da deposição. An. XXX Congr. Bras. Geol., v. 2:897-904, Recife.

A study of grain shape has revealed the existence of various types of sands amongst the sand deposits at

northeast of Salvador. We show in this paper that the formation of the various deposits is directly related to the major event that marked the Quaternary.

Radiometric dating (carbon) and detailed mapping around Salvador furnish evidence that sandy terraces occurring above present sea-level were formed during the two last major transgressive events. An old line of coastal cliffs of the Barreiras Formation is the only evidence of an earlier transgression. At the base of these cliffs, continental sands are present, the mode of occurrence of which indicate a semi-arid climate. These sands were deposited in the period between the one-but-last transgression and the previous one. Between the last and one-but-last transgressions, dunes were formed at the surface of the continental and marine sands, while fluvial sands were deposited. The latter indicate a climate slightly drier than the present one.

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LEÃO,Z.M.A.N., BITTENCOURT,A.C.S.P.; DOMINGUEZ,J.M.L.; NOLASCO, M.C. & MARTIN,L., 1985. The effects of holocene sea-level fluctuations on the morphology of the Brazilian coral reefs. Proceedings of the Vth International Coral Reef Congress Tahiti, vol.2:101.

The most common growth form of the Brazilian coral reefs is coral pinnacles with unusual mushroom-like form called "chapeirões". Adjacent "chapeirões" coalesce on top, whereby forming large compound reef structures which do not display the marked zones of the Caribbean reefs and have horizontal tops that stay completely uncovered during low waters.

Numerous ^{14}C dates from the top of the reefs, being older than 3,000 years B.P., provide evidence to suggest that these coral reefs reached heights above today's sea level and this would only occur if the Holocene sea level along Eastern Brazil had higher stands than the present position.

These extensive and exposed reef flat surfaces were formed by erosion of the upper part of the reefs that occurred during sea-level fluctuations in late Holocene time, along the eastern coast of Brazil.

MARTIN,L.; BITTENCOURT,A.C.S.P.; FLEXOR,J.M.; SUGUIO,K. & VILAS BOAS,G.S., 1980. Modifications de la morphologie du littoral des états de Bahia et São Paulo (Brésil) en fonction des variations du niveau marin. 26e. Congr. Géol. Intern., Section 08, Symposium 23.

Le littoral de l'état de São Paulo borde le "planalto" atlantique brésilien du sud-est qui forme un relief de 900 à 2 000m. Celui de l'état de Bahia borde la dorsale précambrienne du Brésil oriental (souvent recouverte de sédiments continentaux cénozoiques) et le bassin d'enffondrement mésozoique du Recôncavo. Dans la zone côtière, ces unités forment des reliefs de 50 à 200m. Le deux derniers épisodes transgressifs qui ont dépassé le 0 actuel ont laissé sur le continent des témoins très importants. De vastes terrasses sableuses ont été construites après le maximum de l'avant dernier épisode transgressif que a atteint une côte de +8 à +10m et dont l'âge est mal connu (des coraux d'agê > 35 000 ans B.P. sont en datation). A cette époque, la mer a atteint le pied des reliefs et la côte fut partout haute et découpé. Le dernier épisode transgressif est bien connu grace à de nombreuses datations. Au cours des 7 000 dernières années, le niveau rélatif de la mer a oscillé autour du 0 actuel passant par un maximum à +4,5 (± 0,5)m vers 5 100 ans B.P. A cette époque, des réseaux lagunaires dont l'extension a varié en fonction des oscillations du niveau marin ont pu se former. Durant les phases régressives, diverses générations de cordons formant des ensembles de plusieurs km de largeur ont été construites.

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MARTIN,L.; BITTENCOURT,A.C.S.P.; FLEXOR,J.M.; SUGUIO,K, & VILAS BOAS,G.S., 1981. Modifications de la morphologie littoral des états de Bahia et São Paulo (Brésil) en fonction des variations du niveau marin. Océanis (Série de Documents Océanographiques), v. 7, fasc. 4:409-414, France.

The coast of the State of São Paulo borders the southern Brazil Atlantic highland with a relief of 900 to 2,000m. The coast of the State of Bahia is situated on the Eastern Brazilian Precambrian Uplift and the Recôncavo Meso-

zoic Basin, frequently covered by Cenozoic continental deposits. In the coastal zone, these two geological formations form reliefs of 50 to 200m. The last two transgressive events, which reached a maximum superior to the present mean sea-level, left very important geological records on the continent. Wide sand terraces were built after the maximum of the penultimate transgressive episode, which reached a height of + 6 to + 8m about 120,000 years ago. At that time, the sea reached the base of the relief, and everywhere the coast was high and cliffy. The last transgressive event is well known, thanks to many radiocarbon datings. During the past 7,000 years the relative sea-level has oscillated around today's zero level, reaching several maxima. The lagoonal system, whose extension varied in parallel with the oscillations of the sea-level, were formed at that time. During the regressive phases, many generations of beach ridges, several kilometers wide, were built.

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MARTIN,L. BITTENCOURT,A.C.S.P.; FLEXOR,J.M. & VILAS BOAS, G. S., 1984. Evidências de um tectonismo quaternário nas costas do Estado da Bahia. An. XXXIII Congr. Bras. Geol., v. I, V Simpósio do Quaternário no Brasil: 19-35, Rio.

Continental margins of Atlantic type are generally considered stable and seismically inactive. However, the present morphology of some parts of the coast of the State of Bahia, namely at the Recôncavo Basin, shows a neotectonic activity through the lowering of fossil shorelines. This activity is related to the reactivation, during the Quaternary, of faults limiting the several crustal blocks which form the sedimentary basin. These deformations are not uniform in the whole basin.

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MARTIN,L,; BITTENCOURT,A.C.S.P.; FLEXOR,J.M.; SUGUIO,K. & DOMINGUEZ,J.M.L., 1984. Neotectonic movements on a passive continental margin: Salvador region,Brazil.

Symposium on Neotectonics and Sea Level Variations in the Gulf of California Area, Abstracts Volume: pp. 119, México.

Continental margins of Atlantic type are generally considered stable and seismically inactive. However, the present morphology of some parts of the coast of the State of Bahia, namely at the Recôncavo Basin, shows a neotectonic activity through the lowering of fossil shorelines. This activity is related to the reactivation, during the Quaternary, of faults limiting the several crustal blocks which form the sedimentary basin. These deformations are not uniform in the whole basin.

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MARTIN,L.; BITTENCOURT,A.C.S.P. & VILAS BOAS,G.S., 1981.Différentiation sur photographies aériennes des terrasses sableuses marines pleistocènes et holocènes du littoral de l'état de Bahia (Brésil). Revue Photo-Intérpretation nº 3, fasc. 4-5, Paris.

On rencontre le long du littoral de l'état de Bahia des témoins de deux grands épisodes transgressifs quaternaires. Au cours de la partie finale de l'épisode transgressif le plus ancien (que nous appellerons avant-dernière transgression) et au début de la régression que a suivi, se sont formées de vastes terrasses d'une altitude de 6 à 8m. En profondeur ces sables présentent une couleur brune due à la présence secondaire de matière organique diffuse. L'origine marine de ces dépots est attestée par la présence, en surface, d'anciens cordons littoraux et, en profondeur, de terriers fossilisés de Callianassa (arthropodes marins). Il est intéressant de noter que ces cordons anciens présentent un aspect particulier caractérisé par la présence de larges crêtes sableuses et un espacement relativemente grand des zones intercordons. Plusieurs datations au ^{14}C ont montré que ces dépôts étaient plus anciens que 32 000 ans B.P. Des coraux en cours de datation par la méthode U/Th devraient permettre de préciser l'époque de cet épisode transgressif. Toutefois, selon les données de la litérature, nous pouvons penser que

celui-ci s'est produit entre 80 000 et 120 000 ans B.P.

A l'extérieur de la terrasse pléistocène, on rencontre une autre terrasse marine sableuse riche en coquilles et dont le sommet se situe de 4 à 5m au-dessus du niveau actuel de la mer. Ces dépôts datés de l'Holocène présentent en superficie des alignements de cordons très bien marqués. L'aspect de ceux-ci est très différent de celui des cordons de l'avant dernière transgression: les crêtes sont plus fines et les zones inter-cordons sont plus proches les unes des autres. Cette différence peut être observée le long de tout le littoral de l'état de Bahia ainsi que long du littoral pauliste.

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MARTIN,L.; BITTENCOURT,A.C.S.P. & VILAS BOAS,G.S., 1982. Primeira ocorrência de corais pleistocênicos da costa brasileira: Datação do máximo da penúltima transgressão. Ciência da Terra, 3:16-17, Salvador.

Age dating work on a coral from Olivença, Bahia(Brazil) has disclosed the first occurrence of a pleistocene coral along the Brazilian coast. This coral has its top at the present high tide level and is covered by a series of beach ridges formed after the maximum of the penultimate transgression that rose above present sea-level. Five determinations by the Ionium (^{230}Th)/Uranium method produced ages ranging from 116,000 to 142,000 years B.P., indicating that maximum in the area to have taken place 120,000-125,000 years B.P., consistent with its documentation in other parts of the world. At that time, mean sea-level was 8 $\pm$ 2m above the present.

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MARTIN,L.; BITTENCOURT,A.C.S.P.; VILAS-BOAS,G.S. & FLEXOR,J.M., 1979. Introdução ao estudo do Quaternário do litoral do Estado da Bahia-Trecho Salvador-Ilhéus. Rev. Bras. Geociên. 9(4):309-320, São Paulo.

The extension of the Brazilian coast between Salva-

vador and Ilhéus shows evidence of two distinct episodes of transgression in the Quaternary, deduced from the observation of sandy littoral deposits above the present mean sea-level: a) one, older, related to the event of 120,00 years B.P.(Late Pleistocene) and, b) the other, more recent, related to the end of the last great transgression (Holocene). After the deposition of the Barreiras Formation (Pliocene) under a continental and dry climate, followed period of humid climate, succeded by a new dry period, when a new detritic continental formation has been deposited. Before the maximum of the last-but-one transgression (120,000 years B.P.) the climate became humid again, and since that time it has not presented any appreciable variation.

The Quaternary deposits have been submitted,locally, to deformations connected to sinking and tilting of blocks.

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MARTIN,L.; BITTENCOURT,A.C.S.P.; VILAS BOAS,G.S. & FLEXOR,J. M., 1980. Mapa geológico do Quaternário costeiro do Estado da Bahia (Escala 1:250.000) - texto explicativo. Coordenação de Produção Mineral, 57 pp., Salvador, Bahia.

A área aqui considerada está compreendida entre os paralelos 11°20' e 18°15' de latitude sul, com uma extensão litorânea de cerca de 1.120km. Quanto a sua largura,bastante variável, está estritamente condicionada a um dos significados do termo "costa", conforme definido por AGI (1972), e que será aqui adotado: "Uma faixa de terra que se estende da linha de praia, continente adentro, até a primeira grande mudança nas características do relevo". Em alguns locais ela chega a alcançar cerca de 20km de largura, como na região de Caravelas-Nova Viçosa, enquanto que, em outros, desaparece e se confunde com a linha de praia, como na região de Cumuruxatiba, onde os sedimentos terciários são diretamente esculpidos pelo mar em falésias vivas.

Na grande maioria de sua extensão, trechos de Ilhéus para o extremo sul, e de Arembepe para o extremo norte, o limite interior da costa é demarcado por antigas falésias,

de idades quaternárias, entalhadas nos sedimentos terciários. Na Baía de Todos os Santos e na região imediatamente ao sul, até Itacaré, o limite interno é predominantemente marcado pelas elevações constituídas de sedimentos mesozóicos.Por fim, ao norte de Salvador, e entre Itacaré e Ilhéus, de maneira descontínua, aqui e ali, a costa é limitada no interior por relevos do embasamento pré-cambriano.

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MARTIN,L.; DOMINGUEZ,J.M.L.; SUGUIO,K.; BITTENCOURT,A.C.S.P. & FLEXOR,J.M., 1983. Schéma de la sédimentation quaternaire sur la partie centrale du littoral brésilien. Cah. O.R.S.T.O.M., Sér. Géol., XIII(1):59-81, Paris.

In the Quaternary, the central part of the Brazilian coastline suffered considerable variations in the relative sea-level. It was possible to identify three high sea-levels. The last two whose relative sea-level was situated at a maximum of 8 $\pm$ 2m (120,000 years B.P.) and 4.5 $\pm$ 0.5m (5,100 years B.P.) above the current level left considerable records, which could be identified through numerous absolute datings. The submergence and then the emergence of this coast towards 5,100 years B.P. are of first importance to understand the mechanisms of the Holocene littoral sedimentation. As a matter of fact, from 5,100 years B.P. onwards, the decrease in the relative sea-level gave rise to large amounts of sands from the near platform. These sands deposited on the beach were reworked by the littoral drift and moved up to a trap which allowed them to accumulate. It seems obvious that streams played a secondary role in the deposition of sands but an important role as a trap (obstruction to littoral transport), which accounts for the existence of prograded zones linked to the mouth of a stream or not.

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MARTIN,L. & FLEXOR,J.M., 1983. Correlações entre as variações do nível do mar nos últimos 7.000 anos e a formação de turfeiras no litoral brasileiro. I Encontro sobre Turfa, Secretaria de Minas e Energia do

Estado do Rio de Janeiro.

A formação de turfa implica na existência de um meio redutor aquático permanente ou temporário. A evolução do litoral brasileiro no decorrer dos últimos 7.000 anos criou condições extremamente favoráveis ao aparecimento de inúmeras zonas deste gênero. Com efeito, estudos sobre as variações do nível relativo do mar, nos últimos 7.000 anos, no litoral brasileiro, mostram que, em média, aquele esteve em submersão até cerca de 5.100 anos B.P. (nesta época, o nível relativo do mar estava situado entre 4 e 5 m acima do nível atual) e, em seguida, em emersão. Durante a parte final do período de submersão, as zonas baixas do continente, notadamente as partes inferiores dos vales, foram invadidas pelo mar em elevação, tendo se formado uma vasta rede lagunar. Além disto, sistemas de ilhas barreiras/lagunas (características de períodos de submersão) apareceram. A partir dos 5000 anos B.P. com o abaixamento do nível do mar, todas as lagunas tenderam a secar. Algumas transformaram-se em zonas pantanosas favoráveis ao desenvolvimento de turfeiras, outras transformaram-se em lagos sem comunicação com o oceano, onde puderam se depositar turfas finas (sapropelitos) e, finalmente, algumas mantiveram comunicação com o mar, mas diminuiram consideravelmente de superfície. Torna-se pois evidente que as reconstruções da evolução costeira são de grande utilidade na compreensão dos mecanismos da formação das turfeiras litorâneas e na sua localização.

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MARTIN,L.; FLEXOR,J.M.; BITTENCOURT,A.C.S.P. & DOMINGUEZ, J. M.L., 1984. Registro do bloqueio de circulação atmosférica meridiana na geometria dos cordões litorâneos da costa brasileira. An. XXXIII Congr. Bras. Geol., v. I, V Simpósio do Quaternário no Brasil: 133-144, Rio de Janeiro.

Regressive beach ridges record the direction of coastal transport and thus indirectly the quadrant in which the sea waves have reached the coast. The Rio Paraíba do Sul coastal plain beach ridges show that during the last 5,000

years the coastal transport occurred permanently from south to north, indicating the dominancy of a S to SE sea swell. Similarly, the Rio São Francisco coastal plain beach ridges show that during the same period the coastal transport occurred from north to south, indicating the predominance of a NE sea swell. However, in the Rio Doce coastal plain, the beach ridges show that between 5,100 and 3,900 years B.P., the coastal transport occurred from north to south and after 3,600 years B.P., from south to north, indicating the dominancy of S to SE sea swell. This inversion in the direction of the coastal transport seems to be related to an epoch in which the meridian atmospheric circulation was blocked, causing a predominance of NE sea swell.

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MARTIN,L.; FLEXOR, J. M.; BLITZKOW, D. & SUGUIO, K., 1985. Indications of geoid changes along the Brazilian coast during the last 7,000 years. Fifth International Coral Reef Congress, Tahiti.

Many radiocarbon ages have allowed us to reconstruct sea-level changes during the past 7,000 years along 2,000 km of the Brazilian coastline. From these data, it has been possible to define sea-level fluctuation curves for different sectors. Despite these curves being very similar in shape,it is possible to observe some differences in amplitude which cannot be fortuitous.

The geoid map of Brazil shows that the coastline of the State of Bahia, approximately in the N-S direction, is parallel to the isobases of the geoidal height. In this case, shifts between different sea-level curves are not observed: for instance the 5,100 years B.P. maximum is everywhere situated 5.0m above the present level. Otherwise, the coastline of the States of São Paulo and Paraná, in the NE-SW direction, intercepts the isobases of the geoidal height. In this case, the sea-level curves are clearly shifted: for instance the 5,100 years B.P. maximum varies between 4.5 and 2.5m above the present level.

The possibility of neotectonic movements being eliminated, it can be deduced that these shifts could have been caused by a deformation of the present geoid surface.

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MARTIN,L.; FLEXOR,J.M.; KOUSKY, V. & ALBUQUERQUE CAVALCANTI, I. F. de, 1984. Inversions du sens du transport littoral enregistrées dans les cordons littoraux de la plaine côtière du Rio Doce (Brésil). Possible liaison avec des modifications de la circulation atmosphérique. C. R. Acad. Sc. Paris, t. 298, série II, nº 1:25-27, Paris.

Regressive beach ridges record the direction of coastal transport and thus indirectly the quadrant in which the sea waves have reached the coast. In the Rio Doce coastal plain the record of an inversion of the direction of coastal transport between 5,000 and 4,000 years B.P. has been detected. This inversion seems to be related to an epoch in which the meridian atmospheric circulation was blocked, causing a predominance of NE sea swell.

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MARTIN,L.; FLEXOR,J.M. & SUGUIO,K., 1984. Enrégistrement des périodes de fortes et faibles énergies à l'embouchure d'un fleuve. Le cas du Rio Paraíba do Sul (Brésil). Implications climatiques. C.R. Acad. Sc.Paris, t. 299, série II, nº 10: 661-664, Paris.

The degrees of roundness of sands from the terraces on both sides of the Paraíba do Sul river mouth show that the river-carried sediments are deposited periodically along the northern part. The deposit corresponds to river flooding periods and thus to rainy epochs. By comparison with ^{14}C datations already obtained, it becomes possible to propose a chronology of these rainy periods during the last 5,000 years.

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MARTIN,L.; FLEXOR,J.M. & SUGUIO,K., 1985. Auscultation des

cordons littoraux fossiles dans un but de reconstruction paléoclimatique: Exemples brésiliens. Séminaire "Climat et Développement", ORSTOM, Paris, octobre 1985.

Une étude détaillée des formations littorales de la partie centrale de la côte brésilienne a permis de mettre en évidence des inversions du sens du transport littoral dans la plaine côtière du Rio Doce. Celles-ci ne peuvent s'expliquer que par une modification du régime de la houle dominante en relation avec une modification importante de la circulation atmosphérique.

Par ailleurs, les caractéristiques morphoscopiques des grains de sable des cordons littoraux situés de part et d'autre de l'embouchure du Rio Paraíba do Sul ont permis de mettre en évidence une alternance de phases de haute et faible énergies de ce cours d'eau en rélation avec des variations de la pluviosité sur son bassin versant.

Par combinaison avec des datations chiffrées (^{14}C), il est possible d'entreprendre une chronologie de ces événements et, éventuellement, des variations climatiques correspondantes.

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MARTIN,L.; FLEXOR,J.M.; VILAS-BOAS,G.S.; BITTENCOURT,A.C.S.P. & GUIMARÃES, M.M.M., 1979. Courbe de variation du niveau relatif de la mer au cours des 7 000 dernières années sur un secteur homogène du littoral brésilien (nord de Salvador-Bahia). Proceedings of the 1978 International Symposium on Coastal Evolution in the Quaternary: 264-274, São Paulo.

Une courbe de variation du niveau rélatif de la mer au cours des 7000 dernières années sur un secteur homogène du littoral brésilien de 25 km (nord de Salvador) a été construite. Celle-ci montre que:

a) le zéro a été coupé pour la première fois vers 7000 ans B.P.;

b) vers 5200 ans B.P., le niveau moyen rélatif de la mer est passé par un prémier maximum qui s'est situé en-

viron 4,8m au-dessus du niveau actuel;

c) vers 3800 ans B.P., le niveau moyen rélatif de la mer est passé par un minimum au cours duquel il devait être voisin ou légèrement inférieur au niveau actuel;

d) vers 3500 ans B.P., le niveau rélatif de la mer est passé par un second maximum qui situé à plus de 3m au-dessus du niveau actuel;

e) vers 2700 ans B.P., le niveau rélatif de la mer est passé par un second minimum au cours duquel il devait être voisin du niveau actuel;

f) vers 2400 ans B.P., le niveau rélatif de la mer est passé par un troisième maximum situé 2,5m au-dessus du niveau actuel;

g) à partir de cette époque le niveau moyen rélatif de la mer est revenu progressivement vers le zéro actuel. Vers 1000 ans B.P., il se situait 1m au-dessus du niveau actuel.

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MARTIN,L.; MÖRNER, N.A.; FLEXOR,J.M. & SUGUIO, K., 1982. Reconstrução de antigos níveis marinhos do Quaternário. Publ. CTCQ/SBG-IGUSP, 154 pp., Rio de Janeiro.

Após estudar por vários anos as antigas linhas de costa do Quaternário no Brasil, resolvemos divulgar alguns conhecimentos sobre os problemas envolvidos na reconstrução espacial e temporal de antigas linhas de costa. Porém, antes de entrar no assunto propriamente dito, são discutidos alguns aspectos gerais do Quaternário, enfatizando de modo especial a complexidade e a interação dos mecanismos envolvidos nessas pesquisas.

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MARTIN,L. & SUGUIO,K., 1975. The State of São Paulo coastal marine quaternary geology: The ancient strandlines. An. Acad. Bras. Ciênc., 47 (suplemento): 249-263. Rio de Janeiro.

The State of São Paulo coast shows two different aspects limited by the Bertioga region. The southwestern half is formed by well developed quaternary marine formations with emergence characteristics. This coast, not absolutely stable, was probably tectonically active during the Quaternary, but with minor influence in Recent Quaternary sedimentation.

In the region of Cananéia-Iguape (southwest) the coastal plain is mainly constituted by a transgressive marine sandy deposits, 5 to 8m above the present sea level, denominated Cananéia Formation. Locally, this formation was carved by the latest marine transgression, probably 3m above the present sea-level, originating an abrasion terrace. Radiocarbon datings are in process and will provide the sufficient knowledge to establish the ages of these two transgressive marine phases.

Below the Cananéia Formation a brackish water sandy-clayey deposit is found. Conglomeratic fluviatile deposits, that may be correlated to the Pariquera-Açu Formation (probably Pliocene) are under the above mentioned transitional brackish water deposits.

Other quaternary transgressive events are not registered in the State of São Paulo opposed with that occurs in the Rio Grande do Sul State. It is possible that the short coastal plain areas propitiated an easiest destruction of the subsequent transgressive marine phases.

Eventually the correlation between the State of São Paulo southwest and northeast coastal plains stratigraphic columns would permit to study the possible tectonic influences during the last two marine transgressions.

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MARTIN,L. & SUGUIO, K., 1975. Cuaternario marino de la mitad sur del litoral del estado de São Paulo, Brasil. Utilizacion de sambaquis (kjokkenmodings) en la determinacion de antiguas lineas de costa. I Simposio del Cuaternario del Uruguay, Melo.

Le littoral pauliste présente des caractéristiques mixtes de côte d'émersion et de submersion. La région de l'ile de São Sebastião constituant la limite entre deux zones de comportement différent. Au nord, les dépôts marins quaternaires sont très peu développés, par contre au sul, il existe une série de plaines quaternaires caractérisées par la présence de très nombreux sambaquis. Jusqu'ici, seule la plus grande de ces plaines (Iguape-Cananéia) a été étudiée en détail. Il y existe des preuves indiscutables de niveaux marins holocènes supérieurs au niveau actuel. Un certain nombre de datations au ^{14}C et de caractèristiques morphologiques ont permis d'y établir l'ébauche d'une courbe de variation du niveau de la mer depuis 6000 ans. Confrontés à d'autres données les âges et les positions des sambaquis peuvent être d'une grande aide dans la determination de ces variations à condition d'être utilisés avec précaution.

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MARTIN,L. & SUGUIO,K., 1976. Quaternaire marin du littoral de l'État de São Paulo (Brésil). Schéma de l'évolution structurale de la zone littorale. III Congresso Latinoamericano de Geologia, México.

Le littoral de l'État de São-Paulo présente des caractéristiques morphologiques de submersion au nord et d'émersion au sud. Cette différenciation n'est pas brusque mais progressive ce qui écarte l'éventuelle existence d'une faille séparant deux blocs ayant joué différemment. Un mécanisme de flexure continentale différentielle semble pouvoir, em première analyse, expliquer cette différence de morphologie d'autant plus que la partie terrestre de la marge continentale est en élévation et la partie marine en subsidence depuis le Crétacé. La position différente de la ligne d'inflexion par rapport à la ligne de côte pourra entraîner la différence morphologique que l'on constate. La construction de courbes de variation du niveau rélatif de la mer en différentes parties du littoral, devrait permettre de verifier si ce mécanisme de flexure continentale s'est poursuivi au cours de l'Holocène.

MARTIN,L. & SUGUIO,K., 1976. Les variations du niveau de la mer au Quaternaire Récent dans le sud de l'état de São Paulo (Brésil). Utilisations des "sambaquis" (kjokkenmodings) dans la détermination des anciennes lignes de rivage holocènes. Actes du XLIe. Congrès Intern. des Américanistes, V. IX-A: 73-83, Paris.

Dans la plaine quaternaire d'Iguape-Cananéia(sud de l'état de São Paulo, Brésil), on rencontre des témoins indiscutables de niveaux marins holocènes supérieurs au niveau moyen actuel de la mer. Des datations sur les échantillons provenant de formations naturelles ont permis d'avoir une idée du sens des oscillations du niveau moyen de la mer depuis 6000 ans.

Des datations sur les coquilles de sambaquis (kjokkenmodings), très nombreux dans cette région, nous ont permis de préciser la position des maxima et des minima. Ainsi, semblerait que le niveau moyen de la mer soit passé par deux maxima. Le premier se serait produit vers 5000 ans B.P. à une époque où le niveau moyen de la mer était supérieur de 3 à 3,5m au niveau moyen actuel. Le second se serait produit vers 3200 ans B.P. à une époque où le niveau de la mer était supérieur de 3m au niveau moyen actuel. Entre ces deux maxima, il y aurait un minimum vers 3800 ans B.P. au cours duquel le niveau de la mer aurait été légèrement inférieur au niveau actuel.

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MARTIN,L. & SUGUIO,K., 1976. Étude préliminaire du Quaternaire marin: Comparaison du littoral de São Paulo et de Salvador de Bahia (Brésil).Cah. O.R.S.T.O.M., Sér. Géol., v. VIII(I):33-47, Paris.

In the southern section of the São Paulo littoral there is an emerged coastline landscape with definite evidence of Pleistocene and Holocene former sea-levels above present-day sea-level. Comparisons between the positions of these old shorelines and the shorelines in the northern section, where there has been submergence, shows that recent tectonic movements have played a not inconsiderable part in coastal

geomorphology.

This differentiation between submerged landscape in the north and emerged ones in south is not, it appears, due to block movements along fault lines perpendicular to the coast, as is the case in the Salvador (Bahia) region, but to warping along the continental flexure line. It seems that the line of warp passes over the land mass in the north, then becomes progressively further from the coast toward the south.

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MARTIN,L. & SUGUIO,K., 1976. O Quaternário Marinho do litoral do Estado de São Paulo. An. XXIX Congr. Bras. Geol., v. 1:281-293, Ouro Preto (MG).

The sedimentary coastal plains of the State of São Paulo are essentially formed of sandy marine deposits. These sediments were laid down in shallow marine environments throughout the two most important transgressive phases during the Pleistocene and Holocene. They are extensively distributed in the southern half of the "Paulista" littoral becoming less and less important northward. Detailed study of these Quaternary formations allows the establishment of a curve of relative mean sea-level changes for the last 6,000 years and suggests an active differential uplifting mechanism along the coastline during the Quaternary.

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MARTIN,L. & SUGUIO,K., 1978. Ilha Comprida: Um exemplo de ilha-barreira ligado às flutuações do nível marinho durante o Quaternário. An. XXX Congr. Bras. Geol., v. 2:905-912, Recife.

Previous works on the Cananéia-Iguape sedimentary plain have shown that Comprida island is predominantly formed of sandy deposits related to the last two marine transgressions.

The final part of the latest transgression (Santos transgression) has become very well known through radiocarbon

dating of about 55 samples which allow us to outline a sea-level change curve for the past 6,500 years. Thus, two periods of sea-levels higher than present, occurring about 5,100 and 3,500 years ago, have been detected.

Detailed mapping showed that Comprida island's south-western portion is made up of sands deposited during the second most recent transgression (Cananéia transgression) about 120,000 years B.P. The rest of the island is made up of beach ridges from the most recent Santos transgression. A 100m wide swampy belt is developed along practically the entire island and seems to divide two generations of Holocene beach ridges. After the first maximum level of the Santos transgression (5,100 years B.P.), the island "grew" northward in the direction of Iguape. Curved beach ridges easily visible on aerial photos confirm this mode of formation. As the island grew longer northeastwardly, it was widening by the addition of beach ridges parallel to the present strandline. During the minor transgression that took place prior to the second maximum (3,500 years B.P.), these beach ridges were partially eroded. In reality, the boundary of the sea during the second maximum is marked by a low-lying swampy zone found over the greater part of the island. A shell-midden found upon the first beach ridge has been dated at 3,220 $\pm$ 90 years B.P. (Bah-307) and 3,090 $\pm$ 110 years B.P. (Gif-3645), and, as it has abundant whale bones, probably was constructed near the strandline. This very nicely proves that the part of island between swampy belt and the ocean was formed after the second maximum (3,500 years B.P.).

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MARTIN,L. & SUGUIO,K., 1978. Excursion route along the coastline between the town of Cananéia(State of São Paulo) and Guaratiba outlet (State of Rio de Janeiro). Special Publ. nº 2, International Symposium on Coastal Evolution in the Quaternary: 95 pp., São Paulo.

The portion of the Brazilian coastline studied here is elongated in a NE-SW direction and is located between 44°

and 48°W longitude. It covers the entire extent of the State of São Paulo's coastline as well as the southern portion of the coast of State of Rio de Janeiro. This corresponds, in a straight line, to about 550km of the Brazilian coast. This portion of the coastline is included in the crystalline coastline of SILVEIRA's classification, which is characterized by the presence of the Serra do Mar.

The southern part is completely filled by Quaternary deposits, and the strandlines are practically straight. Northward, these plains are less and less filled, until finally, in the Ilha Grande bay area, only a few Quaternary marine deposits occur. Discounting the presence of the sedimentary deposits in the south, this coastline is rather uniform in its morphological characteristics. The morphological differentiation that is observable from north to south can be explained either by differences in the dynamics of sedimentation or by tectonic influences.

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MARTIN,L.; SUGUIO,K. & FLEXOR,J.M., 1979. Précautions sur l'utilisation des datations par radiocarbone pour la reconstruction des anciens niveaux marins (Additif et correctif à: Le Quaternaire marin du littoral brésilien entre Cananéia, SP et Barra de Guaratiba, RJ). Proceedings 1978 International Symposium on Coastal Evolution in the Quaternary: 332-342, São Paulo.

Les hypothèses pour que le méthode du radiocarbone soit valable sont: a) que le système soit resté "fermé" depuis la mort de l'organisme, c'est-à-dire, qu'il n'y ait pas eu d'apports et/ou de pertes ultérieures en carbone; b) que la radioactivité spécifique du CO_2 atmosphèrique soit restée constante dans le temps (LIBBY, 1952). La deuxième de ces hypothèses est vérifiée de façon approximative pour les dernières 7 000 années (SUESS, 1967), tandis que la première dépend de la nature même de l'échantillon et des conditions dans lesquelles il s'est trouvé depuis sa formation.

Il est donc évident qu'une seule datation obtenue pour une certaine région, sans la confronter à d'autres données

de nature géologique, peut entraîner des erreurs grossières. Nous montrons dans ce travail trois exemples dans lesquels des données complémentaires nous ont amenés à éliminer certaines datations.

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MARTIN,L.; SUGUIO,K. & FLEXOR,J.M., 1979. Le Quaternaire marin du littoral brésilien entre Cananéia (SP) et Barra de Guaratiba (RJ). Proceedings 1978 International Symposium on Coastal Evolution in the Quaternary: 296-331, São Paulo.

The portion of the Brazilian littoral zone here studied is situated along the crystalline coastline of south-eastern Brazil. It is characterized by the presence of an escarpment near the sea 900 to 2,000m - high that continues over 1,200 km thus forming the Serra do Mar(Coastal Ranges). From the morphological viewpoint, we can distinguish a southern littoral zone with emersion characteristics and a northern littoral zone presenting submersion characteristics, In the south the Quaternary marine deposits are very well developed which has allowed us to observe uncontestable geological records indicative of at least two transgressive phases (Cananéia and Santos transgressions). Northward, only few Quaternary marine deposits are observed above present sea-level, and these are related to the Santos transgression. The final part of this transgression has been studied in detail, utilizing more than 125 radiocarbon datings. From these datings and other data, we have outlined sea-level fluctuation curves for the last 8,000 years for several part of this coastline. The comparison of these curves reveals differences in their amplitudes, differences which suggests that the amplitude of the local phenomena related to sea-level fluctuations have not been the same along the entire coastline. However, if a continental inflection mechanism has been active in this region, the observed differences are hardly explainable solely by this mechanism. Thus, it is necessary to look for another mechanism which could be related to horizontal and/or vertical deformations of the geoid surface.

To the north, the portion of the coastline within the Guanabara graben seems to have had a different evolution, one suggestive of the erosion or sinking of records related to the Santos transgression.

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MARTIN,L.; SUGUIO,K. & FLEXOR,J.M. 1981/1982. Utilisation des amas coquilliers artificiels dans la reconstruction des anciennes lignes de rivage. Exemples brésiliens. Cah. O.R.S.T.O.M., Sér. Géol., XII(2):135-146, Paris.

The artificial shelly accumulations created by the former inhabitants of the coastal regions can be used as markers of old sea levels under certain conditions. They could be used only in the coastal region which were subject to a submergence followed by an emergence. In this case, if the former inhabitants are supposed to have settled near the harvesting site of mollusks, whose shells have been used, it will be possible to establish an horizontal relation between the geographical position of the site and a lagoon, an estuary or the sea. The values of the ratio $^{13}C/^{12}C$ expressed in the form of $\delta^{13}C$(PDB) of carbonate shelly accumulations will give very significant additional information.

On the Brazilian coastline, datings of "sambaquis" related to the value of $\delta^{13}C$(PDB) of carbonate shells were used appropriately in the plotting of curves of variation in the relative sea level over the last 7,000 years.

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MARTIN,L.; SUGUIO,K. & FLEXOR,J.M., 1984. Informações adicionais fornecidas pelos sambaquis na reconstrução de paleolinhas de praia quaternária: Exemplos da costa do Brasil. Revista Pré-História, USP, v. VI: 128-147, São Paulo.

MARTIN,L.; SUGUIO,K. & FLEXOR,J.M.,1985. Additional information derived from shell middens in Quaternary shoreline reconstruction: Examples from the coast of Brazil. In: Sea-Level Research. A manual for the collection and evaluation of data. O. Van de PLassche ed., Geo Books, Norwich.

Artificial accumulations of shells of brackish water and marine organisms built up by ancient inhabitants of the coastal regions, under some conditions, may be used as indicators of the past sea levels. This utilisation is particularly possible in coastal area submitted to a submergence followed by an emergence. Assuming that the ancient inhabitants have established their campsite near a place able to furnish sufficient mollusks and that high-tide level could not have above its substrate at the beginning of its construction, it is possible to establish a horizontal relationship between shell-midden sites and the ancient lagoonal, estuarine or marine environments. $^{13}C/^{12}C$ isotope ratios of mollusk shells from the shell-middens, represented by $\delta^{13}C(PDB)$, have derived very important complementary data.

Along the Brazilian coast, in submergence until 5,100 years B.P., followed by an emergence with two short submergence periods, shell-midden's radiocarbon ages associated with $\delta^{13}C(PDB)$ of its mollusk shells have been used as complementary data in Quaternary relative sea-level reconstruction. Obviously, the mollusk shells-middens do not provide direct evidence for sea-level heights, however they can furnish valuable additional information (height, stratigraphy, fauna-environment, $\delta^{13}C$ content-environment, radiocarbon and archeological ages), and they must be used as part of the more encompassing shoreline-sea-level investigation.

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MARTIN,L.; SUGUIO,K.; FLEXOR,J.M.; BITTENCOURT,A.C.S.P. & VILAS BOAS,G.S., 1979/1980. Le Quaternaire marin brésilien (Littoral pauliste, sud fluminense et bahianais). Cah. O.R.S.T.O.M., Sér. Géol., XI(1): 95-124, Paris.

Along the coastline of the States of Bahia and São Paulo, there are some geological records which without any doubt result from the two last major transgressions. In the southern coastline of the State of Rio de Janeiro, there are only some geological records from the last transgression.

The age of the last-but-one transgression which reached a peak of +8 to +10m is not still known. But the dating of coral through U/Th method should give some precise details about it. No displacement is observed between the top of the terraces from the last-but-one transgression in the southern part of State of São Paulo and those of the State of Bahia. Numerous ^{14}C datings made it possible to know precisely the end portion of the last transgression. From these data, it was possible to draw several variation curves about the relative sea-level in several coastal areas. Those curves show fluctuations and displacements between each other which are too constant to be of a casual type. The best explanation for these fluctuations and displacements seems to lie in the variations of the geoid surface which occurred during Holocene. On this part of the Brazilian coastline, the variations in the relative sea-level were the main factor in the coastal sedimentation.

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MARTIN,L.; SUGUIO,K.; FLEXOR,J.M.; DOMINGUEZ,J.M.L. & AZEVEDO, A.E.G. de, 1984. Evolução da planície costeira do Rio Paraíba do Sul (RJ) durante o Quaternário: Influência das flutuações do nível do mar. An. XXXIII Congr. Bras. Geol., v. 1 (V Simpósio do Quaternário no Brasil): 84-97, Rio de Janeiro.

Previous works on the central portion of the Brazilian coastline indicated that the relative sea-level changes and the longshore currents have played an essential role in the construction of the coastal plains.

Detailed mapping and radiocarbon dating have allowed us to establish the different phases involved in the depositional history of the coastal plain situated at the Paraíba do Sul river mouth (State of Rio de Janeiro). Thus, it was possible to demonstrate that this coastal plain is partially of Pleistocene age (after 120,000 years B.P.) and partially of Holocene age (after 7,000 years B.P.).

A submergence period before 5,100 years B.P. has

been recorded by the formation of an extensive lagoon, within which the Paraíba do Sul river has constructed a huge delta. It was only after relative sea-level drop, followed by the partial desiccation of the lagoon, that the Paraíba do Sul river reached directly to the open ocean, thus contributing to the construction of the Holocene sandy terraces.

On the other hand, it was possible to demonstrate that the river sands are being dominantly deposited at the north of the river mouth. Meanwhile, the marine terraces covered by beach ridges, situated at the south of the river mouth, have been constructed by sands derived from the adjacent inner shelf. The relative sea-level drop propitiated the transference of sands from the shoreface to the beach, which are removed by the longshore currents and blocked by the Paraíba do Sul river flow.

Finally, evidence of Recent tectonic activities is represented by a subsidence area located at south of this coastal plain, affecting the Pleistocene marine terraces.

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MARTIN,L.; SUGUIO,K.; FLEXOR,J.M.; TESSLER,M.G. & EICHLER, B.B., 1984. Significado geológico das variações dos graus de arredondamento das areias holocênicas da planície costeira do Rio Paraíba do Sul (RJ). An. XXXIII Congr. Bras. Geol., v. I (V Simpósio do Quaternário no Brasil): 119-132, Rio de Janeiro.

MARTIN,L.; SUGUIO,K.; FLEXOR,J.M.; TESSLER,M.G. & EICHLER, B.B., 1985. Geological significance of variations in degrees of roundness in Holocene sands of the Paraíba do Sul river coastal plain, Rio de Janeiro, Brazil. Journal of Coastal Research, 1(4):343-351.

Sea-level changes during the Late Quaternary played a very important role in the construction of the extensive Paraíba do Sul river mouth coastal plain in the State of Rio de Janeiro.

Great volumes of sands have been transferred from the adjacent inner shelf to the coastal plain, as a consequence of continuous and gradual sea-level drop during the

last 5,000 years. On the other hand, longshore currents, dominantly trending south-to-north, have been very important in the definition of the asymmetrical pattern exhibited by the coastal plain at both sides of the Paraíba do Sul river mouth.

Variations in degrees of roundness showed by the beach sands at both sides of the river mouth, as well as by the Holocene beach ridges from northern and southern portions of this river, have been studied. Geological interpretation of these data have allowed us to evaluate the roles played by the sea-level and river discharge fluctuations through the time, as well as by the longshore currents, in the construction of this coastal plain.

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MARTIN,L.; VILAS BOAS,G.S.; BITTENCOURT,A.C.S.P. & FLEXOR,J. M., 1979/1980. Origine des sables et âges des dunes de la région de Salvador (Brésil): Conséquences paléoclimatiques. Cah. O.R.S.T.O.M., Sér. Geol., v. XI(1):125-132, Paris.

Sand dunes in Salvador region are composed of two types of sand. Grains in interior dunes get a degree of roundness similar to this of grains in a continental formation older than the last-but-one transgression. Grains in exterior dunes get a degree of roundness similar to this of sand grains in marine terraces of the last-but-one transgression. The relative position in relation to marine terraces shows that interior dunes appeared before the last-but-one transgression and exterior dunes appeared before the last transgression. This phenomenon shows that before the last-but-one transgression, the climate was markedly drier than currently. On the other hand, before the last transgression, the climate was only slightly drier than currently.

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SUGUIO,K. & MARTIN,L., 1976. Mecanismos de gênese das planícies sedimentares quaternárias do litoral do Estado de São Paulo. An. XXIX Congr. Bras. Geol., v.1:295-

305, Ouro Preto (MG).

The littoral of the State of São Paulo is characterized by a series of more or less extensive sedimentary plains separated from each other by headlands of crystalline basement that reach the sea. Changes in relative mean sea-level,associated with the last two great Quaternary glacio-eustatic transgressions played an important role in the origin of these plains. Recognition of several stages that characterize the evolution of these coastal plains is very important in understanding the mechanisms of their genesis.

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SUGUIO,K. & MARTIN,L., 1976. Presença de tubos fósseis de "Callianassa" nas formações quaternárias do litoral paulista e sua utilização na reconstrução paleoambiental. Bol. IG, Inst. Geoc., USP, v. 7:17-26, São Paulo.

The significance of the fossil Callianassid burrows occurrences for the paleoenvironmental reconstruction of the marine deposits has been fully emphasized in the literature.

For first time fossil burrows of these animals in the Cenozoic marine, probably Pleistocene, sediments from the State of São Paulo are discussed in some detail.

The comparison with the same area living forms galleries permitted to assume that the fossil burrows were built by Callianassa major and Callianassa guassutinga, and the first species was much more frequent than the second one, exactly as presently observed.

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SUGUIO,K. & MARTIN,L., 1976. Brazilian coastline Quaternary formations: The States of São Paulo and Bahia littoral zone evolutive schemes. An. Acad. Bras. Ciên., 48 (suplemento): 325-334, Rio de Janeiro.

The State of São Paulo coastline and part of the State of Bahia, Salvador area, may be compared as Brazilian

littoral evolutive scheme models during the Quaternary.

The Salvador coastal area, being a natural lengthening of the Recôncavo Sedimentary Basin, shows directly the tectonic behaviour of this "graben". Nevertheless, the presence of strong tectonic control evidences during the Quaternary, related to the continental inflection phenomenon, was verified in the State of São Paulo coastline.

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SUGUIO,K. & MARTIN,L., 1978. Mapas geológicos das formações quaternárias do litoral paulista e sul fluminense (1:100.000). Secretaria de Obras e do Meio Ambiente do Estado de São Paulo, Brasil.

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SUGUIO,K. & MARTIN,L., 1978. Formações quaternárias marinhas do litoral paulista e sul fluminense (Quaternary marine formations of the State of São Paulo and southern Rio de Janeiro). Special Publ. nº 1, 1978 International Symposium on Coastal Evolution in the Quaternary: 55 pp., São Paulo.

The portion of the Brazilian coastline here studied covers the entire extent of the State of São Paulo's coastline as well as the southern portion of the State of Rio de Janeiro. The lenght of this region is about 550 km.

From a morphological viewpoint, we can distinguish two parts, each characterized by different features. In fact, in the north, the crystalline basement reaches the sea almost continuously, except along small plains made up of continental deposits inland and marine sediments seaward. In the south are found very extensive sedimentary plains, mostly representing Quaternary marine and fluviatile-lagoonal deposits, separated from each other by narrow headlands of crystalline Precambrian rocks. The transition between these two portions is not abrupt but rather gradual. This seemingly eliminates the possibility of tectonic interaction between blocks that are separated by discontinuities normal to the

coastline. Thus, it is necessary to look for a differential continental inflection mechanism to explain these differences.

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SUGUIO,K. & MARTIN,L., 1980. Estudos sobre as oscilações do nível marinho quaternário ao longo do litoral brasileiro. Simpósio sobre Problemas Geológicos del Litoral Atlântico Bonaerense: 281-298, Mar del Plata, Argentina.

Pesquisas geológicas sobre o Quaternário e especialmente sobre as oscilações do nível marinho neste período, executadas antes da década de 60, são muito raras no Brasil.

Provavelmente, foi o Projeto REMAC (Reconhecimento Global da Margem Continental Brasileira), iniciado em 1972 e atualmente já concluído, que trouxe o maior número de subsídios para o conhecimento dos níveis marinhos abaixo do atual. Esses eventos ficaram registrados por intermédio de terraços de abrasão marinha ou de linhas de arenitos de praia (beach rocks), existentes sobre a plataforma continental. Este projeto foi executado sob os auspícios de órgãos governamentais como a Petrobrás, DNPM, DHN e CNPq.

As oscilações do nível marinho ocorridas nos últimos 7.000 anos têm sido objeto de estudo de grupos de pesquisadores da Universidade de São Paulo, Universidade Federal da Bahia e ORSTOM (França). Este grupo concluiu até agora os trabalhos de mapeamento em escalas 1:100.000 e 1:250.000 das planícies costeiras dos Estados de São Paulo e Bahia, respectivamente.

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SUGUIO,K. & MARTIN,L., 1981. Progress in research on Quaternary sea level changes and coastal evolution in Brazil. Holocene Sea Level Fluctuations, Magnitude and Causes, Columbia, SC: 166-181.

The main purpose of this paper is to give an idea about the state of knowledge on Quaternary sea-level changes

and coastal evolution in Brazil.

The REMAC project, active from 1972 through June 1978, was responsible for the largest geologic research program on the submerged areas of the Brazilian territory.

The studies of the fluctuations of sea-level occurring during the last 7,000 years are emphasized in the present paper.

In another vein, an increasing amount of research presently is being directed toward specific projects of the Coastal Laboratories, research mainly concerned with selected localities, chiefly estuaries, coastal lagoons, and bays, for aquaculture and civil engineering projects (harbors, navigation channels, etc.).

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SUGUIO,K. & MARTIN,L., 1981. Significance of Quaternary sea level fluctuations for delta construction along the Brazilian coast. Geo-Marine Letters, 1(3/4): 181-185, Estados Unidos.

Many important areas of Quaternary deltaic sedimentation along the Brazilian coast are practically unknown in the geologic literature, especially outside Brazil. Our studies show that these areas, previously considered as highly destructive wave-dominated deltas of Holocene age, were affected by a wave-dominated phase during the Pleistocene, succeeded by highly constructive, intralagoonal stage in the Holocene, in turn followed by wave-dominated deltaic sedimentation that continues until today. The geologic evolution of these coastal plains is exemplified here by the Doce River mouth area, State of Espírito Santo, where relative sea-level fluctuations during the Quaternary played an important role in the construction of the deltaic complex.

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SUGUIO,K.; MARTIN,L.; BITTENCOURT,A.C.S.P.; DOMINGUEZ, J.M. L. & FLEXOR,J.M., 1984. Quaternary emergent and

submergent coasts: Comparison of the Holocene sedimentation in Brazil and southeastern United States. An. Acad. Bras. Ciênc. 56(2): 163-167, Rio de Janeiro. Presented to the International Symposium on Coastal Evolution in the Holocene, Tokyo, Japan.

Very distinctive relative sea-level fluctuations occurred during the past 7,000 years along the coasts of Brazil and the southeastern United States. The Brazilian coast was subjected to submergence until about 5,100 years B.P., followed by emergence. The Atlantic and Gulf coasts of the United States, on the other hand, have been in submergence constinuously. Consequently, great differences are evident in the respective patterns of coastal deposition during the Holocene. Before 5,100 years B.P. the Brazilian coast was probably quite similar to that of the present southeastern United States.

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SUGUIO,K.; MARTIN,L. & DOMINGUEZ,J.M.L., 1982. Evolução da planície costeira do Rio Doce (ES) durante o Quaternário: Influência das flutuações do nível do mar. Atas IV Simpósio do Quaternário no Brasil: 93-116, Rio de Janeiro.

The prograding area neighboring the mouth of the Doce River (State of Espírito Santo, Brazil) was studied focusing upon the phenomena related to Quaternary sea-level fluctuations.

Supported by previous research in the Quaternary coastal plains of the States of São Paulo and Bahia, detailed mapping allowed us to recognize the existence of two sandy terraces related to the last two transgressive episodes when the sea-level was higher than at present. The sedimentary deposits of the next-to-the-last transgression, whose maximum occurred about 120,000 years B.P., were laid down at the foot of the Tertiary Barreiras cliffs. The sedimentary deposits related to the end of the last transgression, whose zero line was crossed about 7,000 years ago, are frequently separated from the Pleistocene terrace by an old lagoonal area. Within

this lagoon the Doce River built a typical delta characterized by several distributaries. Radiocarbon ages showed that the lagoonal area, probably isolated from the open ocean by a barrier island, had already formed by about 5,500 years B.P., that is, a little before the 5,100 years B.P. transgressive maximum. During the lagoonal phase the Doce River sediments were trapped within the lagoon and could not contribute to the formation of the Holocene beach ridges, which resulted mostly from prograding barrier islands. The fluctuations of sea-level after 5,000 years B.P. are indicated by the occurrence of several generations of beach ridges and phases of lagoonal expansion.

The great dimensions of the Holocene prograding zone in this coastal plain can not be explained merely by the accumulation of sediments presently transported by the Doce River. Thus, it seems that sea-level lowering of about 4 to 5m, during the last 5,000 years, was one of the most important factors in the construction of the Doce River coastal plain.

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SUGUIO,K.; MARTIN,L. & FLEXOR,J.M., 1976. Les variations rélatives du niveau moyen de la mer au Quaternaire Récent dans la région de Cananéia-Iguape. Bol. IG, Inst. Geociências, USP, v. 7:113-129, São Paulo.

Il existe, le long du littoral de l'état de São Paulo, des témoins indiscutables de formations marines liées aux variations rélatives du niveau moyen de la mer au Quaternaire Récent.

Des datations au carbone 14 effectuées sur des coquilles ou de morceaux de bois provenant de formations géologiques, mais également des datations sur des coquilles de "sambaquis" (kjokkenmodings), après interprétation de la position géographique de ceux-ci, nous ont permis de construire une courbe de variations rélatives du niveau de la mer depuis 6 000 ans.

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SUGUIO,K.; MARTIN,L. & FLEXOR,J.M., 1979. Sea-level fluctuations during the past 6,000 years along the coast of the State of São Paulo, Brazil. In: Earth Rheology, Isostasy and Eustasy (N.A. Mörner, ed.): 471-486, John Wiley & Sons Ltd., Publ., England.

Uncontestable geological records indicative of Holocene sea-levels higher than present are observed along the State of São Paulo's coastal plain. During the past 6,000 years the relative sea-level was subjected to two maxima about 5,000 and 3,300 years B.P. and to minimum about 3,800 years B.P. The comparison of sea-level change curves established for several parts along this coastal plain showed that the maxima have different amplitudes. At present stage of our knowledge about this problem, the mechanism of the vertical deformation of the geoid surface furnishes the best explanation to the amplitude differences.

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SUGUIO,K.; MARTIN,L.; FLEXOR,J.M.; TESSLER,M.G. & EICHLER,B. B., 1984. Depositional mechanisms active during the Late Quaternary at the Paraíba do Sul River mouth area, State of Rio de Janeiro, Brazil. International Symposium on Late Quaternary Sea Level Changes and Coastal Evolution: pp. 95, Mar del Plata, Argentina.

Wave-induced longshore currents and sea-level changes during the last 7,000 years played an important role in the construction of the Quaternary coastal plains adjacent to the present Paraíba do Sul River mouth.

A gradual sea-level drop during the Late Quaternary furnished an over-supply of sands to the coastal area. The river acted as a hydraulic groin, retaining the longshore drift sands on its updrift side. As a consequence the updrift side prograded much more rapidly than the downdrift side, which is supplied mostly by river-carried sediments. The southern margin (updrift side) prograded through the addition of succesive beach ridges forming a continuous sand-sheets, whereas at the downdrift side progradation was promoted by the incorporation of sandy islands backed by mangrove swamps. An asymmetric profile in sedimentary facies distribution is

thus established. Differences in degrees of roundness of sand samples collected in both sides of the river mouth agree with the proposed model.

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VILAS BOAS,G.S.; BITTENCOURT,A.C.S.P. & MARTIN, L., 1981. Leques aluviais pleistocênicos da região costeira do Estado da Bahia: Conseqüências paleoclimáticas. 33ª Reunião Anual da Soc. Bras. Progr. Ciênc., Salvador.

Ao longo da região costeira do Estado da Bahia são encontrados no sopé de elevações ou em encostas de vales, depósitos arenosos pleistocênicos, de cor branca a cinza, contendo algumas vezes grande porcentagem de cascalho, lama ou de ambos. Esses sedimentos são de origem continental e constituem depósitos de leques aluviais cujas características indicam uma deposição por processos do tipo fluxo de detritos, em condições de clima árido ou semi-árido bem distintas das atuais. Do ponto de vista paleoclimático eles constituem um marco importante representativo do último grande período de clima seco que afetou essa faixa do litoral brasileiro durante o Quaternário.

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VILAS BOAS,G.S.; FLEXOR,J.M.; BITTENCOURT,A.C.S.P. & MARTIN, L., 1980. Les grandes lignes des variations climatiques quaternaires sur le littoral de l'état de Bahia (Brésil). 26e. Congr. Géol. Intern., v. II (Sections 6 a 12): pp. 698, Paris.

Actuellement, le climat de la région littorale de l'état de Bahia est chaud et humid. On peut toutefois tracer une petite frontière climatique a la hauteur de Salvador séparant un littoral sud légèrement plus humide (région de cacao) d'un littoral nord légèrement plus sec. Après la mise en place, à la fin du Tertiaire, des sédiments de la Formation Barreiras, sous un climat semi-aride et à une époque de bas niveau marin, le climat est redevenu humide. Ce retour à un climat humide a marqué la fin du dépôt de la Formation Barreiras. A partir de cette époque, nous connaissons des té-

moins de trois grands épisodes transgressifs dont les deux derniers sont assez bien définis. Entre les deux transgressions les plus anciennes, le climat est redevenu du type semi-aride ce qui s'este traduit par la mise en place d'une seconde formation continentale comparable à la Formation Barreiras mais toutefois moins développée. Lors du maximum de l'avant dernière transgression, le climat était redevenu humide. Entre les deux dernières transgressions le climat n'a pas connu de variations radicales mais des oscillations n'ayant pas entrainé, dans la moitié sud du littoral, la disparition du couvert végétal. Depuis le maximum de la dernière transgression le climat a très peu varié.

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VILAS-BOAS,G.S.; MARTIN,L.; BITTENCOURT,A.C.S.P. & FLEXOR,J. M., 1979. Paleogeographic and paleoclimatic evolution during the Quaternary in the northern half of the coast of the State of Bahia, Brazil. Proceedings of the 1978 International Symposium on Coastal Evolution in the Quaternary: 254-263, São Paulo.

After the deposition of the sediments of the Barreiras Formation under a semi-arid climate, in an epoch during which the sea level was lower than today's the climate changed to humid. It is probable that this change marked the end, in a strict sense, of the deposition of those sediments. A transgression occurred which eroded a part of the Barreiras Formation. The limit reached by the sea is marked in some places by a line of old coastal cliffs. After this transgressive event the climate became drier while sandy braided river deposits formed at the base of these cliffs. The climate became humid again during the penultimate transgression (120,000 years B.P.), while the sea eroded part or locally all of these continental deposits. In the last phase of this transgression, terraces 6 to 8m higher than today's mean sea-level were formed. From this time on, the region south of Salvador no longer suffered climatic variations of the types mentioned above, as is demonstrated by the preservation of the crests of beach ridges built up during the terminal phase of the penultimate transgression. On the other hand,

north of Salvador the climate would have been dryer (like it is today) since the sand deposits, both continental and marine, have been slightly reworked by the wind.

Between 120,000 and 7,000 years B.P., the sea-level remained below today's mean level. Later it oscillated above and below it. If, in fact, the climate did not vary appreciably after 120 000 years B.P., it is probable that small oscillations occurred. For instance, the formations of the dune north of Salvador and the deposition of sandy sediments (with the age of 13 000 years B.P.) in the small valleys imply a climate slightly drier than today's.

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