

INTERNATIONAL GEOLOGICAL CORRELATION PROGRAMME

HOLOCENE SEA LEVEL CHANGES

(PROJECT 61)

Annotated bibliography (1960-1977) on Quaternary
shorelines and sea level changes in Brazil

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Contribution of the Instituto de Geociências of the University
of São Paulo for the Holocene Sea Level Changes Project (nº61).

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ANNOTATED BIBLIOGRAPHY (1960-1977) ON QUATERNARY SHORELINES
AND SEA-LEVEL CHANGES IN BRAZIL

by

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Studies on "Quaternary Shorelines and Sea-Level Changes" in Brazil are very scarce. It is important however that some one of the first recorded evidences of Holocene sea-level fluctuations, that is, beach rock, was described for the first time in the State of Pernambuco, Brazil, by CHARLES DARWIN in 1841. Moreover, one of the most complete and exhaustive studies on beach rock was done by BRANNER (1904) also in Brazil.

Probably the most significant developments in "Brazilian Quaternary Shorelines and Sea-Level Changes" studies have taken place since 1960, and particularly since the REMAC (Reconhecimento da Margem Continental) Project started in 1972. For this reason, we selected only those works published after 1960 for inclusion in this bibliography.

On the other hand, an increasing amount of research presently is being directed towards specific projects of the Coastal Laboratories, research principally concerned with selected localities, chiefly estuaries, coastal lagoons, and bays, for aquaculture and civil engineering projects.

The author wishes to express his thanks to Dr. Thomas R. Fairchild for careful revision of the English text.

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AB'SABER, A.N. (1965) - A Evolução Geomorfológica, in A Baixada Santista (Aspectos Geográficos), vol. I (As Bases Físicas) - Cap. 20 : 49-66, Editora da Univ. de São Paulo, São Paulo.

During the Flandrian transgression, the region of Santos, State of São Paulo, Brazil, formed a great paleo-archipelago. Sea-water ingressions were geologically very rapid, propitiating deposition of great masses of transgressive sands, which presently are known as the Cananéia Formation.

The author discusses in detail the role played by the Flandrian transgression in the formation of wave-built and wave-cut levels in this coastal plain.

ALMEIDA, F.F.M. (1961) - Geologia e Petrologia da Ilha de Trindade - DGM, Departamento Nacional da Produção Mineral, Monografia 18, Rio de Janeiro, RJ.

Includes brief mention of terraces and beach rock deposits about 3.5 m above present sea-level.

AMADOR, E.S., PONZI, V.R.A., NASCIMENTO, A.M. and CASTRO, M.I.B. (1975) - Fluvial-Marine Deposits of Baía da Guanabara Region - Bol. Paran. Geociênc. nº 33 : 47 (abstract), in press (Proceedings of the Intern. Symp. on the Quaternary, Curitiba, PR).

Upper Quaternary sedimentation along the periphery of the Baía da Guanabara is described. The marine deposits, named the Magé Formation, occur as far as 30km inland as testimony of a sea-level higher than the present. These marine sediments resulted from the reworking of fluvial sediments.

BANDEIRA, A.N., JR, PETRI, S. and SUGUIO, K. (1975) - Projeto Rio Doce-Relatório Final - Final Report of the Rio Doce Project (Petrobrás-Univ. de São Paulo Contract), Rio de Janeiro, RJ, 203 p.

Interest in the geological model suggested by this study is related to the great oil possibilities of the ancient delta systems (MORGAN, 1970).

The studied area lies between parallels 18° 30' and 20° 00' S and 38° 17' to 40° 15' W, with the emerged portion comprising 2,550 km². The underwater portion of the delta covers an area of at least 7,500 km².

The physical, chemical and biological parameters of the deposits forming the Rio Doce deltaic system were studied.

The origin both of several elongated lakes near the mouth of the Rio Doce tributary rivers as well as of the deltaic plain (beach ridges) are related to sea-level changes occurred during the Quaternary.

BANDEIRA, A.N., JR. and SUGUIO, K. - (1975) - Estudos Sedimentológicos do Delta do Rio Doce - Technical Report of the Rio Doce Project (Petrobrás-Univ. de São Paulo Contract), Rio de Janeiro, RJ, 151 p.

A geological model for the Rio Doce (State of Espírito Santo) deltaic system was described.

According to the classification of SCOTT and FISHER (1969) the Rio Doce delta is classified as a highly destructive, wave dominated type delta.

The evolution of the Rio Doce delta started at the end of the Flandrian transgression (Upper Pleistocene/Lower Holocene).

ne) and is still active in present days.

BARCELOS, J.H., SUGUIO, K. and COIMBRA, A.M. (1976) - Sedimentação e Subambientes Deposicionais da Ilha Comprida, São Paulo - Resumos dos Trabalhos of the XXIX Congresso Brasileiro de Geologia: 14 (abstract) - in press (Proceedings of the XXIX Brazilian Congress of Geology), Belo Horizonte, MG.

Comprida island, stretching from the mouth of the Ri beira de Iguape river and the Ararapira outlet, is a part of the Cananéia-Iguape lagoonal region at the boundary of the sta tes of São Paulo and Paraná. It is 70 km long, ranges from 2 to 5 km in width, and comprises a flat surface 2 to 4 m above the average present sea-level. Beach ridges are the dominant morphological features of the island's surface. A small hill (named Morrete), 42 m high and composed of alkaline rocks, is situated at the southwestern tip of Comprida island.

The field surveys were followed by conventional sedimentological research on grain size, heavy minerals, and sand grain surface textures in order to characterize the sedi ments and to make inferences as to their origin and depositio nal environments.

BIGARELLA, J.J. (1965) - Subsídios para o Estudo das Variações de Nível Oceânico no Quaternário Brasileiro - Anais Acad. Bras. Ciênc., vol. 37 (suplemento) : 263-278 , Rio de Janeiro, RJ.

This paper revises the interpretation of the coastal morphology and associated sediments. Many of the erosional levels considered earlier to be marine are shown to be, in some places, continental deposits.

In the Paraná area the highest well identified ancient sea-level is 13 m higher than the present. Wave cut terraces are practically absent along crystalline rocky coasts due to rapid sea-level fluctuations during the Quaternary. A method for the determination of sea-level displacement based on wave built terraces (restingas) is proposed. These terraces reflect previous sea-levels 1 - 1.5m, 3m, and 7-8 m higher than the present.

BIGARELLA, J.J. and FREIRE, S.S. (1960) - Nota sobre a Ocorrência de Cascalheiro Marinho no Litoral do Paraná - Bol. Univ. Fed. Paraná, Geologia 3, Curitiba, PR.

A wave cut terrace about 13 m above sea-level is reported from near Matinho, Paraná, Brazil. The terrace level is tentatively correlated with one in the Fuego-Patagonia area of Argentina, described and discussed by AUER (1959); both terraces occur between eruptions 0₂ and 1 in AUER's system.

COSTA, M.P.A. (1974) - Cor dos Sedimentos Superficiais da Plataforma Continental Brasileira - Bol. nº 1 (Resumos das Comunicações) of the XXVIII Congresso Brasileiro de Geologia: 613-614; (abstract); Proceedings of the XXVIII Brazilian Congress of Geology (vol. 3) : 237-261, Porto Alegre, RS.

As a contribution to the evaluation of submerged Quaternary depositional environments, the ten color groups most indicative of modifications in sedimentary conditions were mapped. Groups A, B, C, D and F revealed yellowish oxidizing patterns; G, J and H neutral patterns; E and I dark reducing patterns.

The colors of the submerged Quaternary sediments, both modern and relict are probably due to the interaction between provenance and environmental conditions during deposition.

CUNHA, F.L.S. (1973) - Variação de Nível do Mar e Suas Implicações no Quaternário de Aracruz, ES (Abstract) - An. Acad. Bras. Ciênc. vol. 45 (3/4) : 668, RJ.

The evidences of ancient sea-levels higher than present, in the studied area, comprise wave-cut benches and burrows of sea-urchins near the level of the present high tide.

These features are observed on the lateritic rocks belonging to the Cenozoic Barreiras Formation. The burrows of sea-urchins are 1.5 m above their present life-level and the benches are at least 2.0 m above same reference level. The author correlated these evidences with that one observed and dated by C^{14} method in Recife area (State of Pernambuco, Brazil) by VAN ANDEL and LABOREL (1964), suggesting ages between 1,700 and 3,700 years B.P.

CUNHA, F.L.S. and ANDRADE, A.B. (1976) - Evidência Glácia-Eustática no Litoral de Niterói, RJ - Rev. DELFOS, 11/12, RJ.

The authors present the preliminary results of geolo

gical and mineralogical studies in the Niterói littoral (Praia das Flechas), State of Rio de Janeiro, Brazil. The investigated area shows evidences of ancient deposits 3-4 m above present sea-level and burrows of sea-urchins as far as 1.5 m above the intertidal zone along the gneiss cliff near of the beach. This event should represent the post-glacial optimum Flandrian transgression.

DELANEY, P.J.V. (1963) - Quaternary Geologic History of the Coastal Plain of Rio Grande do Sul, Brazil - Louisiana State Univ. Coastal Studies Series 7 : 63 p.

Pleistocene eustatic changes in sea-level produced a drowned river mouth coast in Rio Grande do Sul at the end of the Pleistocene. The large sand bar along the coast of Rio Grande do Sul was uplifted by Post-Pleistocene faulting which formed the Lagoa dos Patos. During the last glacial stage in the northern Hemisphere, the coastal plain was probably a low lying semi-arid, cold steppe, trenched by streams generally oriented in an east-southeast direction.

DELANEY, P.J.V. (1965) - Reef Rock on the Coastal Platform of Southern Brazil and Uruguay - Anais Acad. Bras. Ciênc. vol. 37 (Suplemento) : 306-310, Rio de Janeiro, RJ.

On the coastal platform of southern Brazil and Uruguay between 32° and 34° S latitude, 24 linear "reef-like" topographic structures have been found, occurring in water less than 20 m deep. They are never more than several tens of m long and 4 to 12 m wide and usually the strike of the reef is approximately parallel to the present shoreline.

The features studied along the coast of this area are lithologically similar to beach rock, and the author believes that the base of the reef is beach rock formed during a halt in the Recent rise of sea-level.

FAIRBRIDGE, R.W. (1976) - Shellfish-Eating Preceramic Indians in Coastal Brazil - Science Vol. 191 : 353-359.

Studies of the economy of the shellfish-eating Preceramic Indian residents of coastal Brazil have shed very important light on several apparently unrelated disciplines. These are geodesy or, more specifically, the history of mean sea-level and motions of the earth's crust, paleoclimatology and coastal geomorphology. Radiocarbon dating of shell middens discloses a relationship with Holocene sea-level oscillations.

FERREIRA, Y.A. (1969) - Recifes de Arenito de Salvador, Bahia - An. Acad. Bras. Ciênc., 41 (4) : 541-548, Rio de Janeiro, RJ.

There are stone "reefs" along the shoreline, particularly of the State of Bahia, that constitute elongated bodies of sandstones and conglomerates with thicknesses varying between 2 and 4 meters.

Observations on the stone "reef" of Rio Vermelho in Salvador indicate that these rocks partly represent former consolidated beach sands exhumed by a minor marine transgression of water about 1,5 m amplitude. The cement of these sandstones is calcium carbonate precipitated from water in lower layers of beach sands where the detrital particles were not influenced by sea water oscillations.

FIGUEIREDO, A.G., JR. (1975) - Geologia dos Depósitos Calcários Biodetríticos da Plataforma Continental do Rio Grande do Sul - M.Sc. thesis (Instituto de Geociências/ Univ. Fed. Rio Grande do Sul), 72 p., Porto Alegre, RS (Unpublished).

This paper deals with studies of Molluscan ecology, in biodetrital deposits, associated beach rocks, C^{14} dates, submarine morphology, shallow structure, currents and sediment transportation on the continental shelf off the State of Rio Grande do Sul, Brazil.

The morphology of the inner continental shelf in the area is generally quite smooth. However, in some places it displays some sand bodies of Holocene age that are sometimes connected to the shoreline.

Elongated deposits of biodetrital material also occur on the shelf in association with those Holocene sandy bodies. These biodetrital deposits have been interpreted in the past as representing fossil shorelines. The author suggests that they may not represent fossil shorelines, but rather they have formed in response primarily to the hydrodynamics of the inner shelf.

FULFARO, V.J. and SUGUIO, K. (1974) - O Cenozóico Paulista - Gênese e Idade - Bol. nº 1: Resumos das Comunicações of the XXVIII Congresso Brasileiro de Geologia : 784-787 (abstract); Proceedings of the XXVIII Brazilian Congress of Geology (vol. 3) : 91-101, Porto Alegre, RS.

A Cenozoic stratigraphic column for southeastern Brazil has never been very well established. A tectonic framework of sedimentation seems to be the best tool for the stratigraphic division of Brazilian Cenozoic sedimentary deposits. In the State of São Paulo, the beginning of the Tertiary is marked by structureless sediments deposited in a fanglomerate shape around regional topographic highs thereby revealing a tectonic framework similar to that existing at the close of Mesozoic times (Bauru Formation).

In the Mesozoic and the beginning of the Tertiary, the coast in this area was uplifted during formation of the Serra do Mar. This region was the source of sediments for the Santos Basin; thus, the deposits in this basin can not be correlated with the proposed Cenozoic column. Only since about the Tertiary-Quaternary transition has the coastal area been the site of significant accumulation of sediments, represented by the marine Cananéia Formation and the continental Paríquera-Açu Formation.

FULFARO, V.J., SUGUIO, K. and PONÇANO, W.L. (1974) - A Gênese das Planícies Costeiras Paulistas - Bol. nº 1: Resumos das Comunicações of the XXVIII Congresso Brasileiro de Geologia: 792-794 (abstract); Proceedings of the XXVIII Brazilian Congress of Geology (vol.3) : 37-42, Porto Alegre, RS.

Coastal plains in the State of São Paulo show great similarities in their stratigraphic columns, thus demonstrating their similar geological evolution. Germorphologically, they can be divided into "compartments", the largest ones being situated south of the Santos-Bertioga area. To the north of this

natural limit only one "compartment", that of Caraguatatuba, occurs, and it is surrounded by rocks of the Crystalline Basement. The Santos-Bertioga region is the also limit between two types of coastline: a coast of emersion to the south and one of submersion to the north. Structural lines comprise the natural limits of São Paulo's coastal plains, for exemple, the Itatins fault system in the north of the Cananéia-Iguape region, the Cubatão and Paranapanema fault systems in the Santos - Itanhaém-Peruíbe area and the Camburu fault in the Caraguatatuba coastal plain. Strong Cenozoic fluviatile erosion, controlled by these fault systems, led to the formation of the present coastal plain areas, followed by subsequent marine ingressions.

FRANCISCONI, O., COSTA, M.P.A., COUTINHO, M.G.N. e VICALVI, M.A.

(1974) - Geologia Costeira e Sedimentos da Plataforma Continental Brasileira - Bol. nº 1 : Resumos das Comunicações of the XXVIII Congresso Brasileiro de Geologia : 636-637 (abstract); Proceeding of the XXVIII Brazilian Congress of Geology (vol. 3) : 305-321, Porto Alegre, RS.

This study is an effort to correlate the available data on Brazilian coastal geology with continental shelf sediments.

Three ancient shorelines were identified along certain sections of the shelf, reflecting sea-level stillstands near the present 110, 60 and 30 m bathymetric contours.

The different relationships between muddy sediments and the 60 m contourline along the São Paulo embayment and southern Rio Grande do Sul suggest a different age for the de-

position of the muds in these two areas.

JOST, H. - (1971) - O Quaternário da Planície Costeira do Rio Grande do Sul - I: A Região Norte - Bol. Esp. nº 1 : Resumos das Comunicações of the XXV Congresso Brasileiro de Geologia: 201-202 (abstract); Proceedings of the XXV Brazilian Congress of Geology (vol. 1) : 53-62, São Paulo, SP.

An effort was made to deduce the main events that occurred during Pleistocene/Holocene time in the area. The first unit following Miocene/Pliocene deposition, the Graxaim Formation, is made up of 250 m of continental deposits and has been traced from the present coastal plain eastward onto the continental shelf.

After the Graxaim Formation, a cyclic transgressive-regressive event took place which was responsible for the deposition of the Chuí Formation (shallow marine), Gauíba Formation (fluvial, deltaic and estuarine) and Itapoã Formation (coastal paleodunes). The last major event took place during the Upper Pleistocene and Lower/Middle Holocene.

JOST, H., PINTO, J.F. and LOSS, E.L. (1971) - Novas informações Estratigráficas sobre o Quaternário da Planície Costeira do Rio Grande do Sul, Brasil - Bol. Esp. nº 1 : Resumos das Comunicações of the XXV Congresso Brasileiro de Geologia: 206 (abstract); Proceedings of the XXV Brazilian Congress of Geology (vol. 1) : 49-52, São Paulo, SP.

Based on regional mapping of the northern part (29° 15' to 31° 00' S) of the Rio Grande do Sul coastal plain, Brazil, the authors present new stratigraphical data and suggest modifications in the column presented by DELANEY (1965). A new column is not presented as the mapped area comprises only 1/3 of the total coastal plain in this State.

JOST, H. (1975) - Cenozoic Stratigraphy of the Rio Grande do Sul Coastal Province, SE Brazil - Bol. Paran. Geocienc. nº 33 : 54-55 (abstract); in press
(Proceedings of the International Symposium on the Quaternary, Curitiba, PR).

New data and revision of the older literature on Tertiary and Quaternary deposits of the Rio Grande do Sul, SE Brazil, coastal province are summarized.

The lithostratigraphic units of the area comprise the Patos Group whose age ranges from Pliocene to Holocene. This group may be divided into two main sedimentary formations and five members. The Graxaim Formation, consisting of a coarse-grained continental sedimentary sequence deposited as alluvial fans, can be divided into the Pelotas and Gravataí Members. The Chuí Formation is made up of fine-to-medium grained, yellowish and greenish sands, peat bogs and other related fine sediments which originated during the Pleistocene positive glacio-eustatic fluctuations of the sea-level. Three members are recognized in the Chuí Formation: the Taim, Itapoã and Capivari Members, represented respectively by nearshore and shore deposits, eolian sands and lagoonal sediments. The Cassino Formation includes all the sediments that

originated during the Holocene by various sedimentary environments in this coastal area.

JOST, H. and GODOLPHIM, M. (1975) - Holocene Sea-Level Fluctuations in the Rio Grande do Sul Coastal Province - Bol. Paran. Geociênc. nº 33 : 55 (abstract); in press (Proceedings of the International Symposium on the Quaternary, Curitiba, PR).

The first results of research on the coastal Holocene of Rio Grande do Sul, SE Brazil, are presented.

Aerial photographic interpretation favored the recognition of a regionally expressed positive sea-level fluctuation during Holocene time in this area. This transgression is named by the authors as the "Quinta Transgression" and its relation to the Flandrian Transgression is presently under study. Seven sea-level oscillations are proposed since the time of maximum transgressive level (\pm 6 m above sea-level) until the present.

JOST, H. and HERZ, R. (1975) - Use of Skylab Imagery for Quaternary Geology of SE Brazil Coastal Areas - Bol. Paran. Geociênc. nº 33 : 60-61 (abstract); in press (Proceedings of the International Symposium on the Quaternary, Curitiba, PR).

The authors used multispectral imagery obtained by the SKYLAB mission of September 1973 over the Rio Grande do Sul Coastal Province in order to establish the resolution capacity of such imagery for coastal Quaternary studies.

From this study it was possible to identify all known lithostratigraphic units, as well as morphologic units of the area. Important unknown depositional features not identifiable on conventional aerial photographs could be

recognized on the imagery.

The authors conclude that satellite multispectral images are an outstanding tool in Quaternary geological and geomorphological reconnaissance mapping.

KOWSMANN, R.O. and COSTA, M.P.A. (1974a) - Paleolinhas de Costa na Plataforma Continental das Regiões Sul e Norte Brasileira - Rev. Bras. Geociênc. 4(4) : 215-222, São Paulo, SP.

Three zones rich in terrigenous sand sized material, revealed in an analysis of surface sediments on the broad, northern and southern Brazilian shelf, are markers of sea-level stillstands that interrupted the Late Quaternary eustatic fluctuations.

The outer zone is located along the 170 m depth contour, the intermediate zone along the 100-110 m contour, and the inner zone extends from 60 m contour line to the shore.

Two age interpretations are given for the two zones but the authors conclude that C^{14} dates determinations are needed to resolve the issue.

KOWSMANN, R.O. and COSTA, M.P.A. (1974b) - Interpretação de Testemunhos Coletados na Margem Continental Sul Brasileira durante a Operação GEOMAR VI - Bol. nº 1 : Resumos das Comunicações of the XXVIII Congresso Brasileiro de Geologia : 617-619 (abstracts); Proceedings of the XXVIII Brazilian Congress of Geology (vol.3) : 297-304, Porto Alegre, RS.

Fourteen short cores taken along the continental shelf and slope off Rio Grande do Sul during Geomar VI Expedition were studied in order to understand the facies relationships of Quaternary sediments present in the area. The shelf is presently non-depositional and is covered by relict sediments.

In general the cores here studied were too short to reveal stratigraphic relationships and to make paleogeographic reconstruction of the Quaternary, which depends essentially on obtaining longer cores and on C^{14} dating. However, in one predominantly muddy and locally sandy core taken along the continental slope, the first 15 cm is rich in planktonic foraminífera which practically disappear downward giving way to muds with few benthic species. This faunal boundary is believed to represent the Holocene/Pleistocene contact.

KOWSMANN, R.O., COSTA, M.P.A. e GAMBOA, L.A.P. (1976) - Evidências de Estabilizações Holocénicas do Nível do Mar na Plataforma Continental do Rio Grande do Sul - Resumos dos Trabalhos of the XXIX Congresso Brasileiro de Geologia : 116 (abstract); in press (Proceedings of the Congress; Preprint of the paper presented at XXIX Brazilian Congress of Geology, Belo Horizonte, MG, 1976).

A sub-bottom penetrating echosounder survey along the continental shelf of Rio Grande do Sul, Brazil, revealed the existence of two continuous scarps, approximately following the present 60 and 110 m isobaths. Radiocarbon dating of cores taken in the area, and the comparison of these dates with published eustatic curves suggest that the -110 and -60 m

scarp delineate the shorelines 13,000 and 11,000 years ago , respectively.

KOWSMANN, R.O., COSTA, M.P.A., VICALVI, M.A., COUTINHO, M.G.N. and GAMBOA, L.A.P. (1976) - Modelo de Sedimentação Holocênica na Plataforma Continental Sul Brasileira - Preprint of the paper presented at XXIX Congresso Brasileiro de Geologia, Belo Horizonte, MG, 1976.

The geologic history of the continental shelf of southern Brazil during the Holocene marine transgression is studied. Two former lines of beach ridges, morphologically identified as scarps in the sandy substrate, were detected along the Rio Grande do Sul shelf at the present 60 and 110 m isobaths. This study is based on the analysis of all 3.5 KHz records available, on the lithologic-micropaleontologic description and radiocarbon dating of twenty piston cores, and on their correlation with previously published surface sedimentary facies maps.

LABOREL, J. (1965) - Note Préliminaire sur les Récifs de Grès et Récifs de Coraux dans le Nord-Est Brésilien - Rec. Trav. St. Mar. End. Bull 37, Fasc. 53 : 341-344, France.

After the papers of HARTT and BRANNER during the last century and beginning of this century, Brazilian reefs were studied only many years later (TRICART, 1959, OTTMANN, 1960, etc.).

Fraom the State of Paraíba southward toward Bahia , stone and coral reefs are associated with each other and are parallel to the coastline, thus playing an important role in

littoral morphology.

The origin of the stone reefs can be related to a very recent time, when the average sea-level was about 2.60 m higher than present.

LABOREL, J. et DELIBRIAS, G. (1976) - Niveaux Marins Récents
a Vermetidae du Litoral Ouest Africain
(Description, datation et comparaison avec les
niveaux homologues des côtes du Brésil) - Ass. Sénégal. Et. Quaternaire Afr. Bull Liaison, n° 47 : 97-110, Senegal.

Nine samples of fossil Vermetidae shells have been collected at several localities along the coast of West Africa, and their absolute ages have been measured by the C^{14} technique. The results are indicative of two different high sea-level stands in the last 2,000 years; they are compared with those recently obtained by the authors along the coast of Brazil.

MABESOONE, J.M. (1964) - Origin and Age of the Sandstone Reefs of Pernambuco (Northeastern Brazil) - Jour. Sed. Petrol. 34(4) : 1-7.

Several lines of sandstone reefs occur along the NE coast of Brazil. These sandstones were submitted to grain size, morphometrical and morphoscopical studies. The grain size is characteristic of an offshore origin; however the megascopic character is typically that of beach rock. Thus, the presumed origin of the sandstones is related to the beach, but suffered later changes in grain size frequency by addition of

finer material. Their age is Recent and they resulted from the Holocene sea-level rise, with every line representing a temporary stillstand.

MABESOONE, J.M. and COUTINHO, P.N. (1970) - Littoral and Shallow Marine Geology of Northern and Northeastern Brazil - Trab. do Instituto Oceanográfico da Univ. Fed. de Pernambuco, Recife, nº 12, : 214 p.

This monograph summarizes the knowledge of the littoral and shallow marine geology of northern and northeastern Brazil, an area still little known.

In Chapter 6 (Recent Lime and Sandstones), the problem of the origin of beach rocks is discussed.

MARTIN, L. and SUGUIO, K. (1975) - The State of São Paulo Coastal Marine Quaternary Geology - The Ancient Strandlines - Bol. Paran. Geociênc. nº 33 : 18 (abstract); in press (Proceedings of the International Symposium on the Quaternary, Curitiba, PR).

The coast of the State of São Paulo shows two different aspects limited by the Bertioga region. The southwestern half shows emergent characteristics and is formed by well developed Quaternary marine formations. By the contrary the northeastern half is characterized by submergent features. This coast, which is not absolutely stable, was probably tectonically active during most of the Quaternary, but a tectonic influence has been minor in recent Quaternary sedimentation.

MARTIN, L. and SUGUIO, K. (1976a) - Les Variations du Niveau de la Mer au Quaternaire dans le Sud de l'Etat de São Paulo (Brésil). Utilisations des "sambaquis" (kjokkenmodings) dans la Détermination des Anciennes Lignes de Rivage Holocènes - Presented at XLII Congrès International des Américanistes, Paris (France) - September 2-9/1976, in press (Proceedings of the Congress).

In the Iguape-Cananéia area (southernmost part of the State of São Paulo, Brazil), incontestable records indicating sea-levels higher than present during the Holocene are observed. Radiocarbon datings of the geological samples permitted the establishment of scheme of sea-level fluctuations for the past 6,000 years in the area.

The interpretation of radiocarbon datings of samples from "sambaquis" (shell mounds) of the area was a valuable tool for better delineating the sea-level fluctuation curve.

MARTIN, L. and SUGUIO, K. (1976b) - O Quaternário Marinho do Litoral do Estado de São Paulo - Resumos dos Trabalhos of the XXIX Congresso Brasileiro de Geologia : 135 (abstracts); in press (Proceedings of the XXIX Brazilian Congress of Geology, Preprint of the paper presented at XXIX Congress, Belo Horizonte, MG, 1976).

The sedimentary coastal plains of the State of São Paulo are essentially formed by sandy marine deposits. These sediments were laid down in shallow marine environments

throughout the two most important transgressive phases of the Pleistocene and Holocene. They are extensively distributed in the southern half of the São Paulo's 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.

MONTEIRO, M.F. and SILVA, T.C. (1970) - Comentário da Carta de Geomorfologia do Litoral de Salvador - Bol. Baiano de Geografia 10(15/16/17): 49-66, Salvador, BA.

Occurrences of conglomerates and shelly sandstones dipping oceanward are described from Barra to Rio Vermelho, Salvador, State of Bahia, Brazil. These rocks have calcium-carbonate-cement and indicate an ancient littoral geomorphology slightly different from the present.

MORAIS, J.O. (1967) - Contribuição ao Estudo dos "Beach-Rocks" do Nordeste do Brasil - Trab. Oceanogr. Univ. Fed. Pernambuco, 9/11 : 79-94, Recife, PE.

Lithological, chemical and mineralogical compositions of the beach rocks of the State of Ceará are here studied.

Two megascopically distinct facies, that is, calcium-carbonate and iron-oxide-cemented sandstones, have been divided into three microfacies:

- a) Ferruginous sandstones;
- b) Conglomeratic ferruginous sandstones, and

c) Iron-oxide and calcium-carbonate cemented sandstones.

The origin of beach rocks and their significance to the study of sea-level changes during the Quaternary are discussed.

OTTMANN, F. (1960) - Une Hypothèse sur L'Origine des "Arrecifes" du Nordeste Brésilien - Extrait du C.R. Sommaire des Séances de la Société Géologique de France n° 7 : 175-176, France.

One of most remarkable aspects in the littoral morphology of Northeastern Brazil is the presence of several stone-reef lines parallel to the coastline.

The composition and the origin of these stone-reefs are discussed in summary.

OTTMANN, F. (1962) - L'Atol das Rocas dans l'Atlantique Subtropical - Revue Géogr. Physique et Géologie Dynamique 5 (2) : 101-106, France.

This island (4° S and 34° W) is not an atoll, but is made of debris, though algae live on its edge. Like the island of Itamaracá and Cape of Santo Agostinho, it shows signs of sea-level changes.

PETRI, S. and FULFARO, V.J. (1970) - Nota sobre a Geologia e Terraços Marinhos da Ilha do Cardoso, SP - Not. Geomorfol., Campinas, 10(20) : 21-31, Campinas, SP.

Evidence of sea-level fluctuations during the Quaternary at the southernmost part of the State of São Paulo, Brazil, are discussed in this paper.

Wave cut benches are clearly demonstrated along the coast of the island of Cardoso: 6, 2 and 0.5 m above the low-tide present sea-level. The three benches indicate an emergent coast with standstill phases.

PETRI, S. and SUGUIO, K. (1971a) - Some Aspects of the Neocene zoic Sedimentation in the Cananéia-Iguape Lagoonal Region, São Paulo, Brasil. Est. Sedimentol., Natal, 1 (1) : 25-33, Natal, RN.

This paper deals with the description of the Neocene zoic sedimentation sequence that occurs in the Cananéia-Iguape lagoonal region, State of São Paulo, Brazil; concomitantly a reconstruction of the geologic history of this record is attempted.

There are also discussions of the main problems related to the age and origin of the Pariquera-Açu Formation. An intimate association between its origin with events that occurred in the proximities of the mouth of the Ribeira river is recognized.

PETRI, S. and SUGUIO, K. (1971b) - Example of Activity of the Sea in the Southern Littoral of Brazil - Révue Photo-Interprétation, Editions TECHNIP, Fascicule V (4er. tr.), France (with French and Portuguese text).

A stereoscopic pair of air photos from the Cananéia region was chosen to demonstrate a remarkable feature of the

Southeastern Brazilian coast, that is, its great instability. Even though this coast tends to grow at the expense of the sea, smoothing out irregularities, locally the dominant winds and tidal currents can erode significant portions of the strandline in short time.

PETRI, S. and SUGUIO, K. (1973) - Stratigraphy of the Iguape-Cananéia Lagoonal Region Sedimentary Deposits, São Paulo State, Brazil - Part II: Heavy Minerals Studies, Micro-organisms Inventories and Stratigraphical Interpretations - Bol. IG, Instituto de Geociências, USP, vol. 4:71-85, São Paulo, SP.

The micro-organisms from subsurface samples and from different modern environments were compared. As a result, a useful tool was acquired for the reconstruction of the areal sedimentation history. The heavy mineral assemblages gave indications of the source rocks of the sediments, mostly with respect to the blanket sand deposits (Cananéia Formation).

PIAZZA, H. DELLA, ARAÚJO, M.B. and BANDEIRA, A.N., JR. (1974) - Litoestratigrafia do Quaternário do Espírito Santo - Bol. nº 1 : Resumos das Comunicações of the XXVIII Congresso Brasileiro de Geologia: 788-789 (abstract); Proceedings of the XXVIII Brazilian Congress of Geology (vol. 3) : 159-171, Porto Alegre, RS.

Detailed study of Quaternary sediments of the Espírito Santo coastal plain, between parallels 18° 30' and 20° 30', performed as part of the RIO DOCE PROJECT, allowed the recognition of a sedimentary sequence with two well defined li-

thostratigraphic units. The lower unit has uniform lithology, being composed of marine clays with abundant foraminifera. The upper unit presents a varied lithology and is divided into two distinct subunits. The lower subunit is represented almost exclusively by coarse, conglomeratic, quartzose sands, and the upper one is composed of clays, silts and fine to coarse sands. The authors propose the names Monsarás Formation and Linhares Formation for the two lithostratigraphic units. For the subunits of the Linhares Formation the authors propose the names Povoação and Barro Novo Member.

PONÇANO, W.L. (1976) - Sedimentação Atual na Baía de Sepetiba, Estado do Rio de Janeiro (Um Estudo para a Avaliação da Viabilidade Geotécnica da Implantação de um Porto) - M.Sc. thesis (Instituto de Geociências/Univ. de São Paulo): two volumes, 42 p., 28 figs., São Paulo (Unpublished).

The studied area is limited by latitude 22° 51' and 23° 15'S and longitude 43° 33' and 44° 10' W, State of Rio de Janeiro, Brazil.

A pre-Würm transgressive sequence is described for the Cenozoic stratigraphic column of the Sepetiba area that has, from bottom to top, freshwater deposits overlain by transitional and marine sediments. This sequence was subsequently incised during the last glacial period when sea-level was more than 100 m below its present level.

The landscape observed today in the area is inherited from the Flandrian transgressive time.

SALAMUNI, R. and BIGARELLA, J.J. (1962) - Notas Complementares à Planta Geológica Provisória da Baía de Guaratuba - (Estado do Paraná) - Bol. Univ. Fed. Paraná, Geol. 8 : 1-6, Curitiba, PR.

Described in this short note are wave-built beaches between 3.5 and 10 m above present sea-level and the remains of rock pediments, between 50 m and 220 m above present sea-level, which developed during arid conditions in the Pleistocene.

SANTOS, M.E.C.M. (1972) - Paleogeografia do Quaternário Superior da Plataforma Continental Norte Brasileira - Bol. nº 2: Resumos das Comunicações (Simpósios) : 58-59 (abstract); Proceedings of the XXVI Brazilian Congress of Geology (vol. 2) : 267-288, Belém, PA.

Studying the carbonate fraction and its relationship to other parameters determining the sedimentary facies, the author recognized several constituents as being mixtures of modern and relict sediments.

There is a large control by shelf morphology, representing stratigraphic model interpretable in terms of shifting environments through time.

The relationship between the studied elements and the submarine morphology made possible to suggest a paleogeographic evolutionary scheme to the interval Late Wisconsin to Recent.

SILVA, T.C. (1970) - Aspectos da Geomorfologia do Litoral de Ilhéus - Bol. Baiano de Geografia, 10 (15/16/17) : 79-102, Salvador, BA.

Wave cut terraces in crystalline rocks, 4 to 6 m above the present beach, are described at Olivença south of Ilhéus, State of Bahia, Brazil.

The position of leavy-mineral-rich, shelly sandstone banks dipping oceanward is related to a sea-level 1 to 1,5 m above the present. These banks occur at Pontal and other places in the southern part of Ilhéus.

SILVA, J.X. and COELHO, M.C.N. (1975) - Investigaçāo Morfométrica sobre os Feixes de Restingas Associadas ao Delta do Rio Paraíba do Sul - Bol. Paran. Geociênc. nº 33:56-57 (abstract); in press (Proceedings of the International Symposium on the Quaternary, Curitiba, PR).

This paper is a study of the progradational sequence associated with the mouth of the Paraíba do Sul river, State of Rio de Janeiro, Brazil.

On the basis of air photos and topographic maps, individual beach ridge sets were identified and their main morphometric features measured, such as: area, topographic gradients and frequency of beach ridges in each set. Statistical treatment of these parameters indicates that:

- a) There is no significant difference between corresponding beach ridge sets situated on opposite sides of the river.
- b) There are significant differences among sets, and, whether meaningful or not, differences were also found within

each set as a function of increasing distance from the present bank of the river.

SUGUIO, K. and BARCELOS, J.H. (1977) - Quaternary Sedimentary Environments in Comprida Island, State of São Paulo, Brazil - To be presented during X INQUA International Congress, Birmingham, England.

The coastal plain between the towns of Cananéia and Iguape is very important as it contains the most extensive Quaternary coastal sedimentation in the State of São Paulo, Brazil.

Comprida island, the most prominent physiographic feature in this geological setting, is formed essentially of shallow marine sands. It is 70 km long and 3 to 5 km wide. The lowland of this island is interrupted only by a little hill (Morrete), situated at its southern tip, composed of alkalic intrusive rocks (quartz-syenite). The "Morrete" is 42 m high, but the rest of the island averages only 3 m above mean sea-level.

Sedimentological analysis and inventories of micro-organisms were made in order to characterize the different environments of Comprida island.

SUGUIO, K. and KUTNER, M.B. (1974) - Sedimentação na Área de Itanhaém, SP - Bol. nº 1: Resumos das Comunicações of the XXVIII Congresso Brasileiro de Geologia: 44-46 (abstract); Proceedings of the XXVIII Brazilian Congress of Geology (vol. 2) : 95-106, Porto Alegre, RS.

This area with Neocenozoic sedimentation is situated in the Itanhaém-Peruíbe geomorphological "compartment" that belongs to the Baixada Santista region of the State of São Paulo coastal plain.

Sedimentological and micro-organismal studies (diatoms), together with the stratigraphical relationships and lithological nature of the drilled beds, have made it possible to determine the environments in which sedimentation occurred.

SUGUIO, K. and MARTIN, L. (1975) - Cuaternario Marino de la Mitad Sur del Litoral del Estado de São Paulo (Brasil) - Utilización de Sambaquis (Kjokkenmodings) en la Determinación de Antiguas Líneas de Costa - Presented at I Simpósio del Cuaternario del Uruguay , Melo; in press (Proceedings of the Symposium).

The State of São Paulo (Brazil) southern littoral is very rich in "sambaquis" or shell mounds, pre-historical artificial accumulations mainly made up of molluscan shells. Generalities about the Quaternary geology and the application of the "sambaquis" to the definition of the ancient strandlines in this region are discussed here.

SUGUIO, K. and MARTIN, L. (1976a) - Brazilian Coastline Quaternary Formations - The States of São Paulo and Bahia Littoral Zone Evolutive Schemes - An. Acad. Bras. Ciênc. vol. 48 (suplemento): 352-334, Rio de Janeiro, RJ.

The coastline of the State of São Paulo and that of the State of Bahia, Salvador area, may be compared as models for an evolutionary scheme of littoral sedimentation in Brazil, during the Quaternary.

The Salvador coastal area, being a natural lengthening of the Recôncavo Sedimentary Basin, directly shows the tectonic behaviour of this "graben" oriented perpendicular to the coast. On the other hand, for the Quaternary a strong tectonic control, paralleling the coast and related to continental inflection is evident for the coastline of the State of São Paulo.

SUGUIO, K. and MARTIN, L. (1976b) - Presença de Tubos Fósseis de "Callianassa" nas Formações Quaternárias do Litoral Paulista e sua Utilização na Reconstrução Paleoambiental - Bol. IG, Instituto de Geociências, USP, vol. 7: 17-26, São Paulo, SP.

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

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

Comparison with galleries of the living forms from the same area suggest that the fossil burrows were built by Callianassa major and Callianassa guassutinga, and that the former species was more frequent than the latter, in a manner exactly as presently is observed.

SUGUIO, K. and MARTIN, L. (1976c) - Mecanismos de Gênese das Planícies Sedimentares Quaternárias do Litoral do Estado de São Paulo - Resumos do Trabalhos of the XXIX Congresso Brasileiro de Geologia: 136-137 (abstract); in press (Proceedings of the XXIX Brazilian Congress of Geology), Preprint of the paper presented at the Congress, Belo Horizonte, 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 the coastal plains is very important in understanding the mechanisms of their genesis.

SUGUIO, K., MARTIN, L. and FLEXOR, J.M. (1976) - Les Variations Relatives du Niveau Moyen de la Mer au Quaternaire Récent dans la Région de Cananéia-Iguape (São Paulo) - Presented at the IGCP-Project 61 Meeting - Rio de Janeiro (May 26-27/1976); Bol. IG, Instituto de Geociências, USP, vol. 7 : 113-129, São Paulo, SP.

The mean relative sea-level changes during the recent Quaternary in the Cananéia-Iguape region (São Paulo) are suggested by several geological records certainly related to these events.

An adequate interpretation of the radiocarbon dating

of the samples collected from the geological formations, in addition to the informations obtained from the "sambaquis" (shell mounds), furnished valuable data for delineation of the mean sea-level change curve for the last 6,000 years in the studied area.

SUGUIO, K. and MARTIN, L. - (1977) - Sea-Level Fluctuations during the Past 6,000 years at the Coast of the State of São Paulo, Brazil - To be presented during X INQUA International Congress, Birmingham, England.

Incontestable geological records, indicative of Holocene sea-levels higher than present, are observed on the State of São Paulo coastal plain. From the interpretation of radio-carbon datings, in a geological context, a relative sea-level change curve for the past 6,000 years was established. The average sea-level was subjected to several oscillations during this period. The sea-level at 6,200 years was near the present one. The first maximum occurred at 5,000 years B.P., when the average sea-level was, in some places, 4.5 m higher than present. This first maximum was followed at 3,800 years B.P. by a minimum when the sea-level was a little lower than present. At 3,200 years B.P. a second maximum occurred when the sea-level was 3 m higher than present. Finally, it appears likely that a relative sea-level near the present was attained about 1,800 years ago.

SUGUIO, K. and PETRI, S. (1973) - Stratigraphy of the Iguape-Cananéia Lagoonal Region Sedimentary Deposits, São Paulo State, Brazil - Part I: Field Observations and Grain Size Analysis-Bol. IG, Instituto de Geociências, USP, vol. 4: 1-20, São Paulo, SP.

The geological history of the Quaternary events of the coastal plain of southern São Paulo State, in the area known as Iguape-Cananéia lagoonal region, is here presented.

Grain size characteristics of the sediments from the present environments were also compared with the grain size characteristics of the sediments from the ancient environments, allowing the recognition of the depositional mechanisms for the ancient sediments.

Transgressive and regressive sequences were widely recognized during examination of the cores from stratigraphic wells drilled by the "Instituto Geográfico e Geológico".

SUGUIO, K., VIEIRA, E.M., BARCELOS, J.H. and SILVA, M.S.

(1976) - Paleoambientes da Sedimentação Holocênica na Área de Itanhaém, SP - Resumos dos Trabalhos of the XXIX Congresso Brasileiro de Geologia : 117 (abstract); in press (Proceedings of the XXIX Brazilian Congress of Geology, Belo Horizonte, MG, 1976).

Eighteen drillings were made in the study area, near the town of Itanhaém, within the Santos-Itanhaém-Peruíbe geomorphological "compartment", State of São Paulo, Brazil.

Studies of sedimentology and micro-organisms (foraminiferans, diatoms and thecamoebans), together with stratigraphical relationships and the lithologies determined by drillings, made it possible to define depositional environments that prevailed during the Neocenozoic sedimentation in the area.

TRICART, J. and SILVA, T.C. (1968) - Estudos de Geomorfologia da Bahia e Sergipe - Fundação para o Desenvolvimento da Ciências na Bahia, 167 p., Salvador, BA.

The beach rocks that are calcium-carbonate-cemented sandstones are presently being destroyed, indicating that different conditions occur now than during their origin. The distribution of the beach rocks indicates a former sea-level higher than the present one.

VAN ANDEL, T.H. and LOBOREL, J. (1964) - Recent High Relative Sea-level Stand near Recife, Brazil - Science, 145 : 580-581.

Radiocarbon dates on Vermetidae limestone from the edge of the Brazilian Shield at Cape Santo Agostinho, Brazil, indicate sea-level stands of up to 2.6 m above the present positions, 3,600, 2,790 and 1,190 years ago. Accurate determination of relative sea-level is possible because of the well-defined habitat of the fossil organisms dated.

VILLWOCK, J.A. (1972) - Contribuição à Geologia do Holoceno da Província Costeira do Rio Grande do Sul, Brasil - M.Sc. thesis (Instituto de Geociências/Univ. Fed. do Rio Grande do Sul), 133 p., 16 figs., Porto Alegre, RS (Unpublished).

The Holocene sedimentary sequence, which accumulated upon the Pelotas Basin deposits, consists of a transgressive bed whose upper portion is exposed on the sandy coastal plain.

The accumulation of large quantities of sand throughout this time, without any tectonic activity in the area, caused the progradation of the coast (depositional regression).

Eustatic oscillation data obtained by means of geomor-
phological interpretations are correlated with FAIRBRIDGE's
sea-level eustatic variations curve for the last 6,000 years.

