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EROSION AND ACCRETION PROCESSES DURING EL NIÑO PHENOMENON OF 1982-83 AND ITS RELATION TO PREVIOUS EVENTS

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Summary: Erosion and accretion are the main processes of coastal line changes. During El Niño Phenomenon of 1982-83, a great climatological and oceanographic event, occurred important morphological processes, Piura river bed socavation was measured monthly, reaching five meters deep and ninety meters wide at the maximum river discharge. The sediments transport of Jequetepeque river increased in 1983 about twenty times the average of previous years, reaching more than thirthy millions of cubic meters. Probably it occurred the same in most rivers in Peruvian northern coast and it seems that it should exist a relation between these processes and the biggest El Niño events, like that of 1982-83 supplying the sediments which are forming the holocene beach ridges, north of Chira, Piura and Santa river mouths and in Colan.

Los procesos de erosión y acreción durante el fenómeno EN 1982-1983

Resumen: Los principales procesos de cambio de la línea de costa son la erosión y la acreción. Durante el Fenómeno El Niño de 1982-83, gran evento climatológico y oceanográfico, ocurrieron importantes procesos morfológicos. La socavación del cauce del río Piura se midió mensualmente alcanzando cinco metros de profundidad y noventa metros de ancho durante la máxima avenida del río. El transporte de sedimentos del río Jequetepeque aumentó en 1983 en casi veinte veces el promedio movilizado en años anteriores, llegando a más de treinta millones de metros cúbicos. Probablemente ocurrió algo similar en la mayoría de los ríos de la costa norte peruana y existiría una relación entre estos procesos y los mayores eventos de El Niño, como el de 1982-83, que han aportado los sedimentos que constituyen los cordones litorales holocénicos que se localizan al norte de las desembocaduras de los ríos Chira, Piura y Santa y en Colán.

INTRODUCTION

In the southeast Pacific region, El Niño Phenomenon may give at a limited scale, a good idea of global and regional climatological and oceanographic changes. This event shows the intrusion of warm and low salinity waters, heavy rains and flooding of rivers (Teves, 1990).

During El Niño events occur different kinds of processes such as river bed erosion, increase of transported fluvial sediments which reach the sea in great volumes accreting along the coastal line beaches (Teves, 1989).

EROSION AND SEDIMENTATION PROCESSES

Erosion in Piura river.-

Peruvian northern zone suffered in 1983, related to El Niño Phenomenon, high temperatures, big rains and flooding of rivers. The great increase of Piura river discharge produced strong erosion on river margins and socavation in river bed occurring gravity mass movements that produced damages or destroyed houses and civil engineering works.

The lithostratigraphic units that crops out in Piura area are Zapallal Formation from the Terciary and quaternary marine, fluvial and aeolian deposits. Zapallal Formation is made up of gray and green shales and siltstones, in the upper part there are fine grained sandstones cemented with salts being almost impermeable, while the lower interbedded sandstones are permeable and have been serving as aquifers.

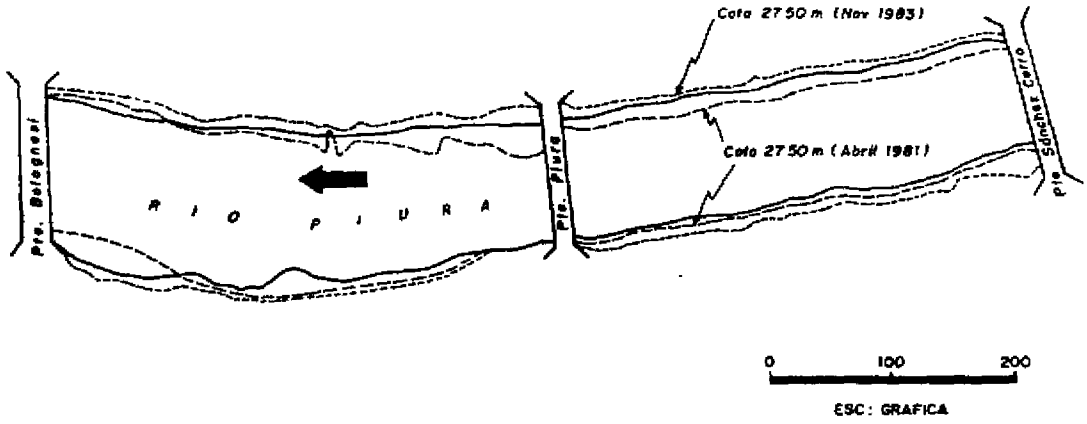
This formation has lateral facies changes with deltaic and shallow marine characteristics. The marine beds have great areal distribution and uniformity. Marine quaternary deposits are locally called Tablazos. Aeolian deposits are formed of very fine sands that cover superficially great areas in the plains. Fluvial deposits are not so thick due the Piura river has changed several times of channels abandoning the ancient ones; there are predominantly fine and very fine sands.

The right margin of Piura river is made up by Zapallal Formation which is covered by wasted materials, in the nearsite of Piura city. These wasted materials are 4-5 m thick between Bolognesi and Sanchez Cerro bridges; the matrix is fine sand near the top, some muddy toward the bottom. Underlying this, a bank of clear gray fine sands, probably fluvial bed deposits, is resting over greenish gray shales and siltstones. The wasted materials in the left margin are 2-3 m thick.

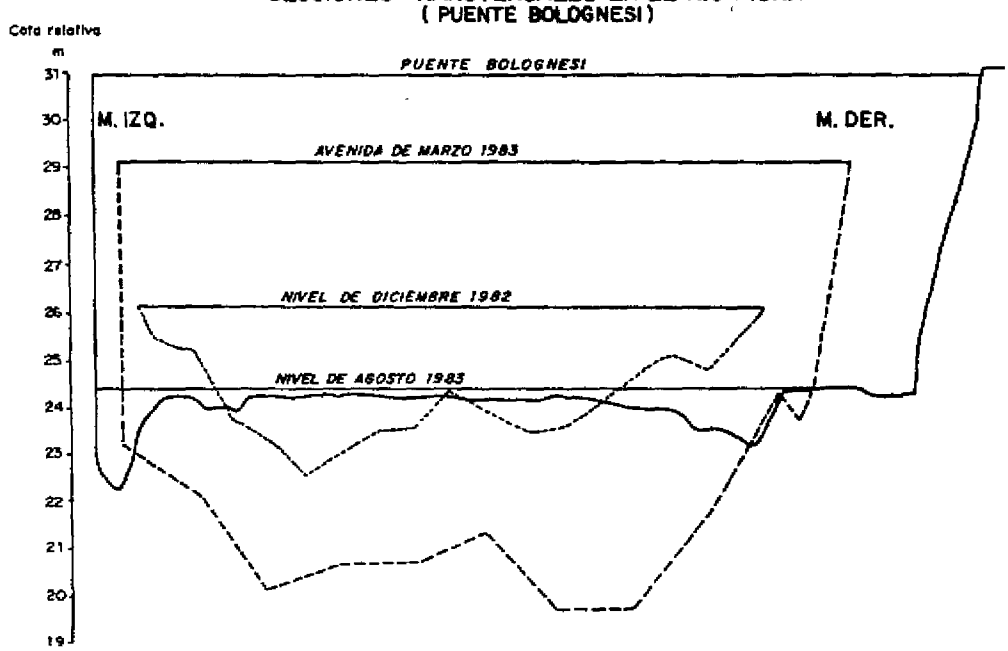
It was measured some cross profiles of Piura river bed, monthly, from December 1982 to August 1983 at Bolognesi bridge. It was evident the active socavation of the river bed with the increasing of river flow. In December 1982, the river eroded its bed to form two channels of two and one meters depth; in February 1983 the channels were 3 and 4.5 m depth respectively; in March reached 4 and 4.5 m depth; in April and May there was only one channel of five meters depth along all the wide of present river bed. This socavation probably saved Piura city from a catastrophic flood. In June 1983, with the diminishing of the river discharge, Piura river refilled again its bed and in August 1983, the river bed reached its normal level. The fluvial bed deposits are light gray fine sands with small brick fragments coming from the eroded margins. We assumed that the fluvial bed deposits have 4-4.5 m along the river bed upstream Bolognesi bridge based over drilling and geoelectric profiles data. If we estimate a 10 km socavation along Piura river bed, the volume of removed sediments would be enough to form a beach ridge of 15 km long.

In Piura river margin, it is recognized these fluvial bed deposits of very loose fine sands with transitional type ripples that indicate fast sedimentation of fine sands deposits of river bed which have had erosion and socavation during big flows occurring great lateral erosion. The river bed was wider and less deep. The present deepening of river bed is due to the presence of the bridges crossing the Piura river that are limiting the lateral erosion.

ZONA EROSIONADA EN LAS MARGENES DEL RIO PIURA



SECCIONES TRANSVERSALES EN EL RIO PIURA
(PUENTE BOLOGNESI)



Comparisons were made between two topographic maps of the river margins between the bridges prepared before and after the flood of 1983. The level curve of 27.50 m from April 1981 map compared with November 1983 map shows that in the right margin had occurred lateral erosion of 10-15 m in average.

Piura river maximum discharge of the century was measured in 1983 (2,947.3 m^3/sec in March 1983) eroding river bed to its maximum depth, but in the future, minor increase of river discharge could remove all the present river bed filling. This is the reason why any design for protecting the river margins should take in account this problem so there were not new socavations (Teves, 1983).

SEDIMENT TRANSPORT OF JEQUETEPEQUE RIVER

Coastal area in the Jequetepeque river basin has important quaternary fluvial and aeolian deposits. Lithostratigraphic units are 15 sedimentary formations and 5 volcanoclastic units; igneous rocks constitutes the coastal batolith and minor plutons. Volcanoclastic units are more susceptible to weathering and erosion.

Strong rains in 1983 removed great volumes of fluvial sediments in such exceptional quantities not considered in previous studies before the construction of Gallito Ciego dam. If the dam would have been finished, it could have retained a great part of the sediments diminishing the reservoir capacity.

The research study of the sedimentological impact dealt with this problem calculating the sediments transport in Jequetepeque river basin during 1983. This study considered 16 hydrological years (1968-1984) being the transport of suspended materials at Ventanilla's station of 45'474,515.90 m^3. The maximum annual transport was registered in 1982-1983 hydrological year with 22'057,141 m^3 and the minimum in 1977-1978 with 19,305.7 m^3.

The calculated volume of transported coarse sediments (size more than 20 mm) was 7'317,500 m^3 and of finer sediments (20-2 mm) was 1'945,000 m^3. The total volume of transported fluvial sediments, including suspended materials, was of 31'319,641 m^3 in 1982-1983 hydrological year (Teves, 1986).

COMPARISONS WITH PREVIOUS EL NIÑO EVENTS

The erosion and sedimentation processes of the northern coastal rivers were exceptional in occasion of a great event of El Niño Phenomenon, which has a recurrency of 300 yrs. The detail studies in Piura and Jequetepeque rivers in 1982-83 would let establish a relationship between these catastrophic events and the origin of the holocene beach ridges developed north of Chira, Piura and Santa river mouths and in Colan. The datings of the 8 ridges preserved in Colan determined ages from 3200 to 800 years B.P. Radiocarbon datings of shells and coal have given a relative chronology with lapses that vary from one to four centuries between the formation of each littoral ridge (Ortlieb *et al*, 1989).

The calculated volumes of eroded and transported sediments in Piura and Jequetepeque rivers let to establish the origin of the sediments that constitute the beach ridges and their relation with bigger El Niño events.

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EVIDENCIA DE EVENTOS "EL NIÑO-OSCILACION DEL SUR" (ENOS) MEDIANOS Y FUERTES : APARICION DE MOLUSCOS TROPICALES Y SUBTROPICALES EN BAHIAS DEL NORTE DE CHILE

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El autor postula que en el Norte de Chile, independientemente de la latitud, en las bahías cuya boca se abre hacia el Sur, en períodos posteriores a eventos ENOS de magnitud mediana o fuerte aparecen moluscos de origen tropical o subtropical, y que las bahías cuya boca se abre hacia el Norte alojan mayoritariamente especies de moluscos de origen templado.

Después del evento ENOS de 1971, la bahía de San Jorge (con boca abierta al Sur, ubicada en la latitud 23°27' S) se pobló de *Donax peruvianus, Bursa ventricosa y Aplysia spp.* y esa misma bahía después del evento ENOS 1982-83 fue colonizada por ejemplares de *Donax peruvianus, Atrina maura, Pteria sterna, Atrina* cf. *independencia y Aplysia* spp.

Sin embargo, en la bahía de Mejillones con boca abierta al Norte y ubicada 40 km al Norte de la de San Jorge, no se encontraron especies de moluscos de origen tropical, lo cual se puede deber al tipo de circulación de las aguas provocadas por los vientos tipos "paracas" que soplan desde tierra a mar y con dirección Sur-Norte, que impedirían la entrada de las aguas provenientes de Norte durante los eventos ENOS, por lo que no entrarían en ella las larvas de moluscos que vienen a la deriva en dichas aguas.

Por otro lado, los vientos provenientes de Sur-Oeste que soplan en la bahía de San Jorge internarían las larvas que vienen con las aguas del Norte durante los eventos ENOS, las que se asentarían en el fondo y desarrollándose posteriormente en adultos. La rapidez de su aparición dependerá de la estrategia de selección de cada especie en particular. Lo mismo ocurre en otras bahías más pequeñas hacia el Norte y Sur de estas dos bahías mayores.

Normalmente, las dos bahías mayores presentan diferencias de temperatura notorias (entre 1 y 2 °C), lo cual debe estar influyendo en la diferenciación de las poblaciones de una misma especie que viven en ambas bahías.

Se propone usar este modelo, en el estudio de conchales presentes en las plataformas costeras, con el fin de detectar los eventos ENOS medianos y fuertes que ocurrieron en el pasado reciente y analizar la distribución biogeográfica de las especies bajo esa nueva perspectiva.

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RECONSTRUCTING THE PALEO ENSO RECORDS FROM TROPICAL AND SUBTROPICAL ICE CORES

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Interannual variability in climate is a major feature of the climate system, particularly in subtropical and tropical regions. It is essential to know if the interannual variability signature in the climate record is affected by a change in the mean state of the climate system. This goal can be met only by analyzing long records of interannual climate variability throughout intervals in the past when climate was different from today (e.g. Little Ice Age, Medieval Warm, last glaciation). This task is especially important as man may be inadvertently altering the mean state of global climate.

With the exception of the annual cycle, ENSO is the dominant global climate signal on time scales of a few months to a few years. It is associated with major dislocations of rainfall regimes in the tropics. Whereas the northern coastal desert regions of Peru experienced abnormally high precipitation, the southern highlands of Peru, where Quelccaya is located, experienced drought. Annual variations in the amount and chemical composition of precipitation accumulating on both polar and alpine (high elevation) glaciers produce laminations which allow precise dating of these stratigraphic sequences. This paper examines the interannual climate variability in the Quelccaya ice core records; (1) over the last 150 years where a limited amount of documentary data exist by which the ice core data can be evaluated and (2) the longer record covering the last 1500 years where independent evaluation becomes more difficult. The Quelccaya precipitation records derived from the ice cores are compared to the early history of man in South America. There is archeological evidence that, when compared to the Quelccaya net balance record over the last 1500 years, suggests that periods of flourishing highland cultures appear during periods when the mountains are wetter than average and that coastal cultures fluorish when the mountains are drier than normal. These data suggest that there may exist longer period ocean/atmospheric links which yield "El Niño-like" precipitation responses on the longer term. Additional ice core evidence from the Dunde ice cap in China indicate that decadal net balance variations on the Qinghai-Tibetan Plateau are quite similar to those for the Quelccaya ice cores for the period 1600 to 1980 A.D. We know these two areas on opposite sides of the Pacific Ocean basin are statistically related through the Walker circulation on the short term and the ice core data suggest there may be longer term teleconnections between these areas of the earth.