Extended Abstracts. L. Ortlieb & J. Macharé (Eds).
ORSTOM - CONCYTEC, Lima 1992, p. 207-212.

FLOOD EVENTS, EL NIÑO EVENTS, AND TECTONIC EVENTS

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Along the hyper-arid coast, the coastal geoarchaeological record of paleo-flood events exhibits episodes of exceptionally severe erosion and deposition that greatly exceed those produced by the 1925-26 and 1982-83 El Niño. Were the erosion and deposition strictly dependent on the amount of precipitation, then serious landscape modification should indicate extreme ENSO conditions or ancient "MEGA-NIÑO" phenomena. However, when these very strong ENSO events are proceded by major tectonic events, the synergistic consequences seem to lead to "Radical Environmental Alterations Cycles" (REAC's), which exacerbate both erosion and deposition. Investigations have been conducted in the Ilo region (17° S Lat), and at the Santa River mouth (9.9° S Lat) in an effort to find correlations in the geoarchaeological record for the synergistic consequences of prehistoric and historic flood, El Niño, and tectonic events that might represent pan-Andean horizon markers along the entire arid coast.

HYPOTHESES

Along the normally hyper-arid Andean coast, major floods are caused by significant rainfall that only occurs during El Niño-Southern Oscillation (ENSO) events. The coastal geoarchaeological record of paleo-flood events exhibits episodes of exceptionally severe erosion and deposition that greatly exceed the magnitude of El Niño inundations that transpired during 1925-26 or 1982-83. Episodes of particularly severe alteration may be explained by either of two hypotheses that need not be mutually exclusive. First, if scale of erosion and deposition were strictly proportional to quantity of precipitation alone, the extreme landscape modification would reflect extreme ENSO conditions and implicate ancient "MEGA-NIÑO" phenomena. Second, it has been hypothesized that when major tectonic events precedes El Niño events, the synergistic consequences lead to "Radical Environmental Alteration Cycles" (REAC's) with exacerbated scales of erosion and deposition (Moseley et al. 1981).

The REAC hypothesis purposes that strong tectonic events induced mass wasting and release abundant material which loosely reposes on the lower 40-50% of the normally rainless watershed. Later El Niño rainfall initiates abrupt transport of the tectonic debris. Flooding sweeps exorbitant quantities of material into streams and rivers. The drainages disgorge excessive sediment loads into the sea and this results in episodic coastal progradation (Fig. 1 A). With the resumption of normally strong long shore currents, the debris is reworked by marine processes and large aggregates of sand are deposited along the coast line (Fig. 1 B).

In turn, the new supply of sand is moved inland by strong daily winds off the ocean and results in episodic dune incursion (Fig. 1 C).
Demonstrating the validity that REACs are constrained by our limited abilities to document past tectonic events that preceded ENSO events. Here we summarize two case studies in support of the hypothesis.

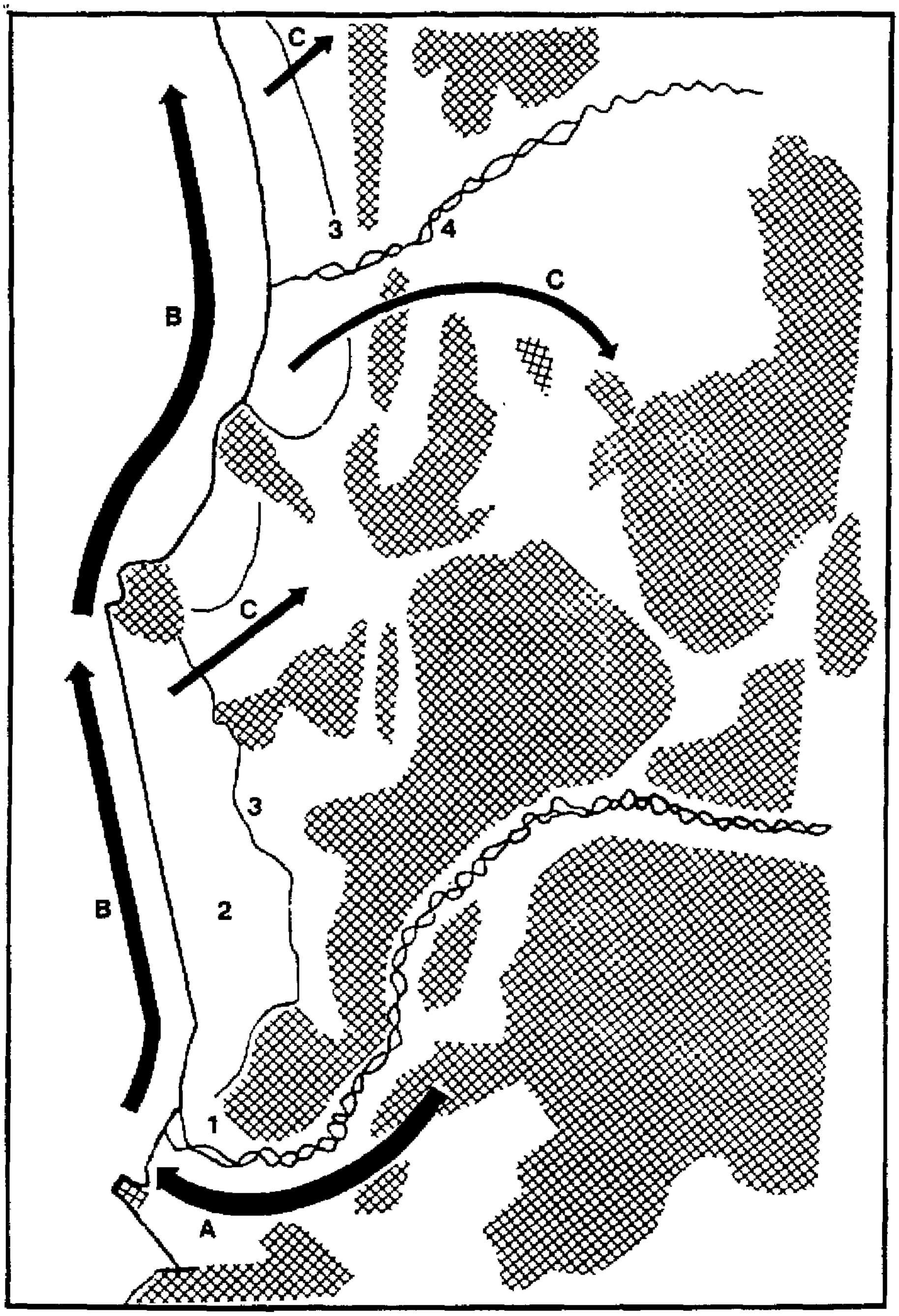

Figure 1

THE ILO PALEO-FLOOD SEQUENCE

In the Ilo region (17° S Lat.) the lower Osmore drainage and independent coastal quebradas leading to the sea received preliminary investigations of paleo-flood sequences in 1990. Our initial findings are summarized in the Figure 2 stratigraphic column. Mud flows from the 1982-83 El Niño are preceded by the far larger "Chuza" flood event which directly overlies volcanic ash from the February, A. D. 1600 eruption of the Huayna Putina volcano. Beneath the tephra, thicker flood deposits are associated the "Miraflores" event which interdicts prehistoric Chiribaya settlements dating after A. D. 1000. Lower in the column there is a "Basal Sequence" of multiple paleo-flood deposits that lack archaeological dates and extend into early Quaternary times.

The Chuza event is potentially the synergistic consequence of tectonic activity followed by ENSO activity, and may be the product of: a) the strong seismic shocks that accompanied the A. D. 1600 eruption of Huayna Putina; b) the major earthquake of November 1604 (Silgado 1974), and; c) the strong El Niño event of 1607 (Quinn et al. 1986). A tectonic component for the Miraflores event has yet to be demonstrated, but seismic shock cannot be ruled out. Although this flood event transpired during Chiribaya times, in several coastal localities Miraflores deposits directly overlie preceramic midden dating before 1500 B. C. Thus, the stratigraphic column only reflects two exceptionally severe episodes of landscape alteration during the last 3500 years. Past floods of a magnitude comparable with, or lesser than the 1982-83 El Niño mudflows have not been detected, and are apparently not preserved.

THE SANTA BEACH RIDGE FORMATION

The formation of nine major beach ridges inmediately north of the Santa River mouth (9.9° Lat S.; Fig. 1 #2) has attracted attention because the cobble-clad ridges are thought to have originated sequentially under rare but recurrent catastrophic circunstances (Sandweiss 1986). To monitor the origin of the most recent beach ridge to arise, high altitude imagery of the area was digitized and computer overlaid for 1944, 1955, 1961, 1972, 1982 aerial photographs, 1975 and 1978 LandSat MSS imagery, and 1984 Large Format Camera Space Shuttle photographs (Figure 2). Following a 1944-1955 incident of moderate progradation, the imagery indicates that a new beach ridge arose after 1970, and was in place by 1975, after which an episode of moderate progradation transpired at the mouth of the Rio Santa between 1982 and 1984. Table 1 summarizes ENSO and tectonic activity affecting the region during the 40 year time span of the digitized imagery. Formation of the most recent cobble ridge can be interpreted as the synergistic consequence of: a) the 7.7 seismic event of May, 1970; b) the strong El Niño of 1972-73 with; c) the very strong El Niño of 1982-83 contributing renewed progradation. The 1944-1955 incident of progradation may be attributed to the 1946 7.25 seismic shock and the moderate 1951 and 1953 ENSO events (Moseley at al. 1991).

If beach ridge development was the exclusive product of El Niño conditions, then other sets of Andean beach ridges, such as the Chira formation, should have developed additional structures in concert with the Santa during the 1970-75 time frame; but we know of no evidence for this, nor is there evidence of coastal progradation in the Ilo region during this time frame. Similarly, there have been numerous strong and very strong ENSO events since the 4236 +/- 115 B. P. C-14 date on the earliest of the Santa beach ridge (Sandweiss 1986), but there are only nine major ridges.

Sequence of Events in the Ilo Valley

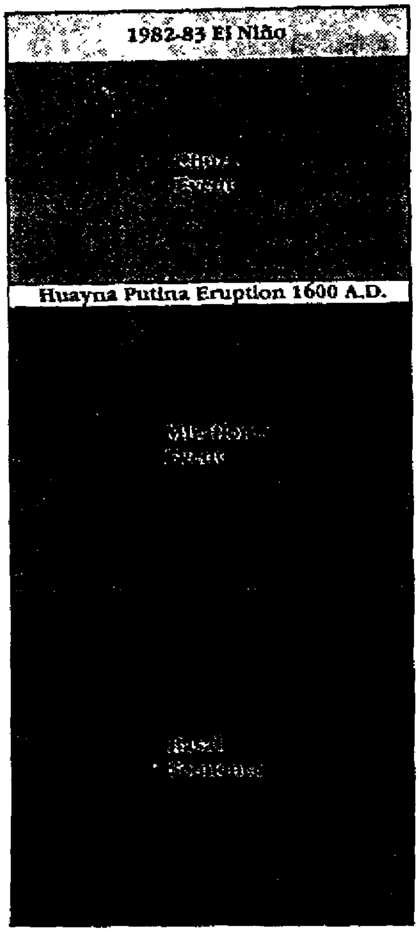

Figure 2

TABLE I

EL NIÑO AND SEISMIC EVENTS AFFECTING SANTA STUDY AREA

EVENT TYPE	DATE	MAGNITUDE
Niño	1940-41	S
"	1943	M+
Seismic	1946, Nov.	7.25
	8.3/77.8	
Niño	1951	NM
"	1953	M+
"	1957-58	S
"	1965-66	M+
Seismic	1962	6.75
	9.9/78.0	
"	1970, May	7.7
	9.2/78.8	
Niño	1972-73	S
"	1976-77	M
"	1982-83	VS

El Niño Magnitude ratings from Quinn et al. 1986: NM = Near Moderate, M = Moderate, S = Strong, VS = Very Strong. Seismic events from Ferro, 1978: Magnitude = Richter scale; approximate Epicenter = Lat. S/Lon. W

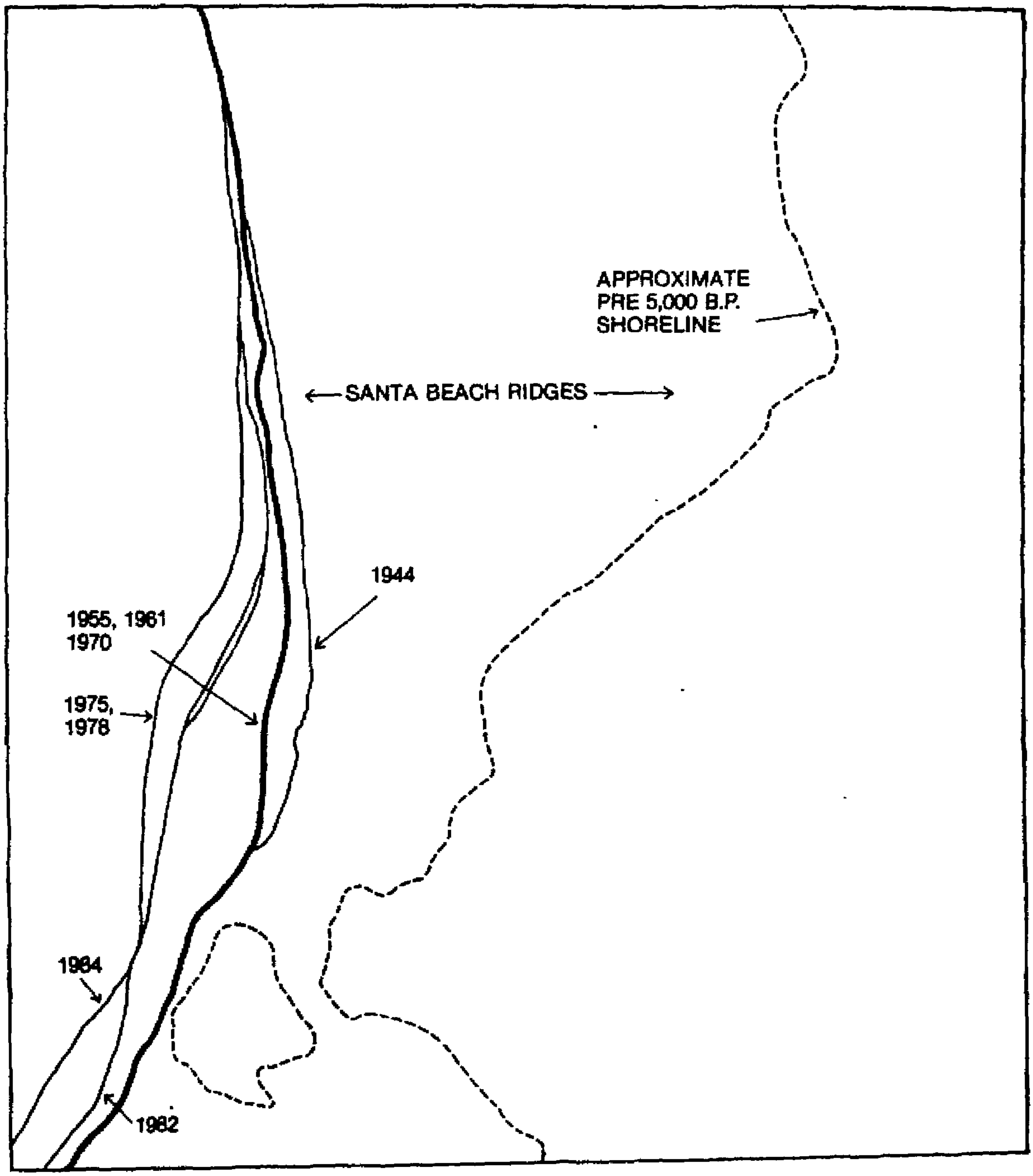

Figure 3

DISCUSSION

Proxy records of past Andean El Niño perturbations include historical accounts, Quelccaya glacial ice cores, and paleo-floods. The first two document numerous ENSO events, and where the historical and glacial records overlap in time there is substantial match in the events they document. If the paleo-flood record was the exclusive product of El Niño precipitation, then it too should register matching events. Yet, for the historic times, extremely few flood deposits have been identified, and while ice cores reflect many events during the last 1500 years the geoarchaeological record registers fewer events, but ones often assocated with dramatic landscape alteration. If severe episodes of erosion and deposition were driven by "MEGA-NIÑO" conditions, then flood episodes might be expected to represent pan-Andean horizon markers along the entire arid coast. Yet, the Chuza event has not been identified on the north coast. In the north, an A.D. 1100 episode of severe flood alteration identified in the Moche Valley (Nials et al. 1979) has been independently documented at archaeological sites in the Jequetepeque, Lambayeque, and La Leche drainages and cross correlated with an A.D. 1100 glacial ice core anomaly (Moseley 1990). Yet, this event is reputedly absent in the Casma drainage (Wells 1988). Such inconsistencies would have to be methodological by-products of different investigators pursuing different flood detection and dating techniques for the "MEGA-NIÑO" hypothesis to hold true. Alternatively, regional variation in paleo-flood sequences is predicted by the tectonic component of the REAC hypothesis.

IMPLICATIONS

The paleo-floods record may well reflect events produced exclusively by ENSO precipitation, but the REAC hypothesis allows the long term human consequences of El Niño events that follow tectonic events to be predicted relative to regional movement of sediment by water and wind. For example, the Chavimochic Canal is being built to carry Santa run off to the Rio Chao (Fig. 1 #4) and beyond, and the canal course crosses the trajectory of dune fields sourced by Rio Santa sediment (Fig. 1 C). The last component of a REAC to run its course is episodic dune incursion. If long shore currents are still depositing sand from the 1982-1984 incident of coastal progradation or the 1970-1975 era of beach ridge formation, then dune development is still active. Therefore, unanticipated stress from saltating sands could exceed canal design expectations and diminish planned agrarian performance.

References

Moseley, M. E. 1990 Structure and History in the Dynastic Lore of Chimor. In: M. Moseley & A. Cordy-Collins, eds., The Northern Dynasties: Kingship and Statecraft in Chimor, pp. 1-42. Dumbarton Oaks, Washington D. C.

Moseley, M. E., Feldman, R. A., and Ortloff, C. R. (1981). Living with Crises: Human Perception of Process and time. In: M. Nietcki ed., Biotic Crises in Ecological and Evolutionary Time, pp. 321-367. Academic Press, New York.

Moseley, M. E., Wagner, D., and Richardson III, J. B. (1991). Space Shuttle Imagery of Recent Catastrophic Change Along the Arid Andean Coast. In: L. Lewis Johnson, ed, The Archaeology of Paleo-Shore Lines, in press, Tylford Press, New York.

Nials, F. L., Deeds, E. R., Moseley, M. E., Pozorski, S. G., Pozorski, T., and Feldman, R. A. (1979). El Niño: The Catastrophic Flooding of Coastal Peru. Field Museum of Natural History Bulletin. 50:4 (Part 1), 50:4 (Part II).

Quinn W. H., Neal V. T., and Antunez de Mayolo S. E. (1986). Preliminary Report on El Niño Ocurrences over the Past Four and a Half Centuries. Oregon State University.

Sandweiss, D. H. (1986). The Beach Ridges at Santa, Peru: El Niño, Uplift, and Prehistory. Geoarchaeology: An International Journal, 1:17.

Silgado Ferro, E. (1978). Historia de los Sismos más Notables Ocurridos en el Peru. Instituto de Geología y Minería.

Wells, L. E. (1988). Holocene Fluvial and Shoreline History as a Function of Human and Geologic Factors in Arid Northern Peru. Ph. D Dissertation, Department of Geology, Stanford University.

Extended Abstracts, L. Ortlieb & J. Macharé (Eds.),
ORSTOM - CONCYTEC, Lima 1992, p. 213.

LAS NEVADAS EN MENDOZA (ARGENTINA) Y SU TELECONEXION CON EL FENOMENO EL NIÑO

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En este trabajo se analizan las condiciones sinópticas y climatológicas determinantes de una nevada de envergadura que afectó a la región precordillerana del oeste y noroeste de la República Argentina. Una acumulación significativa de nieve (entre 20 y 30 centímetros) se registró en las ciudades capitales de la Provincias de Mendoza y San Juan entre el 31 de Mayo y el 2 de Junio de 1983.

Se observa que condiciones semejantes se registraron en forma débil en aquellos años previos a la ocurrencia del fenómeno El Niño y en forma más intensa en los años en que éste estaba en plena actividad.

Tales son los casos correspondientes a 1972, 1975 y 1982 (con nevadas débiles) y los registrados en 1973 y 1976 (con nevadas bien definidas). Sin embargo, se muestra también que las nevadas no ocurren solamente en estas circunstancias pudiendo ocurrir en otras épocas, por lo que El Niño es condición suficiente pero no necesaria de acuerdo a este estudio.

En particular, el 11 de Julio de 1991 hubo una situación nivea débil pudiendo coincidir con un año previo al evento oceánico cálido. En esa oportunidad una zona depresionaria se instaló en la República del Uruguay y provocó fuerte sudestada en la costa bonaerense, asociada a un anticiclón bastante intenso en la Patagonia.

Los elementos comunes a estas situaciones se pueden resumir en lo siguiente:
i) Presencia de un anticiclón de bloqueo en la región patagónica que se extiende hasta la alta tropósfera.
ii) Pasaje sucesivo de centros de baja presión o ciclónicos en latitudes más bajas que la trayectoria media habitual (entre los 30 y 40 grados de latitud sur).
iii) Desarrollo de una ciclogénesis en el Río de la Plata y vientos fuertes del sudeste con inundaciones y marejadas en la costa argentina.
iv) En todos los casos, una vez finalizada la tormenta se observa un enfriamiento pronunciado en los valles cordilleranos interiores y en altura en la atmósfera libre.

Se concluye que las condiciones favorables a nevadas, cuando éstas no son intensas, pueden ser tomadas como otro elemento predictor del evento, así como la ocurrencia de temporales de nieve intensos en la alta cordillera argentino-chilena, fenómeno que también es considerado como elemento predictor por investigadores argentinos.