VIII: Sea level and coastal stability

Neotectonics and Plio-Pleistocene sea level records in southern Peru

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The relationships between the subduction of the Nazca plate under the South American subcontinent and the recent vertical movements, registered along the Peruvian coast, are not yet well understood. During the Quaternary, a northern segment of the Peru coast has been emerging, a central segment has been apparently subsident, and the southern coast has been emerging, locally at very high rates. In this activity report on a cooperative work, associating several "old" members of the INQUA Neotectonics Commission, we shall focus on the southern segment of the Peruvian coast.

From lat 14°S southwards, the coastal region experienced Plio-Pleistocene uplift motions which are evidenced by staircased sequences of marine terraces. The spatial and geometrical distribution of these remnants of late Cenozoic high sea stands reflects altogether regional crustal movements and local deformations. Current correlation studies between well-developed series of terraces at Ilo (17°30'S), Chala (16°S) and San Juan Marcona (15°30'S) are aimed to characterize these regional and local tectonic controls.

In San Juan Marcona area, exceptional sequences of marine terraces are preserved. The terraces are abraded platforms, separated by steep seacliffs (mean height of the order of 20 m), locally veneered by thin coastal deposits and generally covered by deflated eolian sands. More than thirty steps may be distinguished. The highest terraces reach elevations of about +780 m and contain late Pliocene fauna (Devries *in* Macharé, 1987).

In spite of various intents of age determination on marine shells, the chronostratigraphy of the lower terraces is still debated. Isotopic stage 5e age assignments have been successively proposed for: the +148 m terrace (Hsu & Blom, 1985; Osmond, 1987), the +110 m terrace (Hsu & Wehmiller, 1987), the +90 m terrace (Macharé, 1987), and the +65 m terrace (Hsu, 1988; Hsu et al., 1989). Accordingly, the mean uplift rate estimates for a particular transect vary between 1140 and 470 mm/10^3y. Additional dating of the lower terraces is presently under way (at Geotop lab., UQAM, Montreal) and will hopefully yield determinant results.

The strong, and apparently continuous, vertical motions registered at San Juan Marcona are closely related to the subduction of the aseismic Nazca Ridge (Macharé et al., 1986; Macharé, 1987; Hsu, 1988; Macharé & Ortlieb, 1990). Deformations of the terraces around San Juan Marcona depict some recent faulting activity, reactivation of old faults, and block tilting. A detailed tectonic map of this key area, registering the most rapid and complete sequence of Plio-Pleistocene high sea stands of South America, is presently being prepared.

At Chala, a favorable embayment, controlled by several faults, also recorded a long sequence of high sea stands (up to 28 steps have been distinguished). In this case, the Pleistocene (and latest Pliocene ?) interglacial sea stands are registered as wave-cut surfaces on which lay marine deposits that were partially covered by alluvial fan units. The alluvial sediments, spread over almost each marine terrace of the sequence, appear to have been covered with the intervening glacial stages and cooler interstages (within interglacial episodes). The marine deposits vary in composition and thickness, two units consisting in several-metre-thick coastal sands (corresponding shoreline angles at +64 m and +180 m).

From geometrical considerations and stratigraphic relationships, it is interpreted that about ten transgressive cycles can be distinguished. For instance, the youngest pre-Holocene complete cycle shows three well-defined marine episodes (sea-stand maxima at +64 m, +44 m and +31 m), separated by two events of alluvial fan deposition; locally, at the southeastern boundary of the embayment, two additional, lower, marine benches were formed, probably as a result of local

deformations. If the major cycles correspond to interglacial periods, and the smaller sea level fluctuations to interstages, it may be inferred that the isotopic stage 5e high sea stand would be registered at +64 m in the Chala embayment.

The highest part of the sequence (above +250 m) is obliterated by thick sheets of alluvium. The highest observed marine sediments, lying on abrasion surfaces in Chala region (at +240 m), might be of earliest Pleistocene age, since they overlie Pliocene foreshored beds outcropping (at about +200 m) immediately north of the bay of Chala.

In spite of a strong tectonic control of the morphology of the Chala embayment, there is no evidence of major displacements of the marine terraces after their formation. The main local tectonic activity, that is attributed to slight readjustments of former fracture zones, is limited to landslides on the walls of the principal canyon crossing the embayment (Quebrada Chala). Though, immediately southeast of Chala, the coastal region experienced stronger deformations, evidenced by faulted Pleistocene terraces and by upwarped Holocene beach deposits.

The region of Ilo registered less spectacular series of marine terraces but offers probably the best developed sequence of Pleistocene high sea stands available in southernmost Peru. East of Ilo, staircased terraces are preserved at up to about +350 m, but those, which may be assigned a Pleistocene age, are lying at less than about +200 m. Along a 50 km-long coastal segment, north and south of Ilo, Middle and Late Pleistocene marine deposits, often associated to alluvial units, are generally observed at elevations increasing with their relative age. Aminostratigraphic and U-series analyses indicate that the isotopic stage 5e shoreline locally reaches a +25 m elevation, and suggest that several Middle (and Early?) Pleistocene high sea stands were preserved at about +40, +50, +80, +120 and +160 m (Ortlieb et al., in prep.)

South of Ilo, the marine terrace record is complicated by the existence of relatively thick coastal sediments and by some overlap of these Pleistocene units. Stratigraphic observations, supported by some preliminary aminostratigraphic data (Hsu, 1988; Hsu et al., 1989; Ortlieb et al., in prep.), show that marine and lagoonal beds, probably coeval with the last two (or three) interglacials, are locally superposed, in normal stratigraphic order. Some local tectonic motions and particularly paleogeographic conditions have been involved in the overlap disposition, but it is not interpreted that a true subsident regime was installed at the end of the Middle Pleistocene (as suggested by Hsu, 1988). At the mouth of Rio Locumba, south of Ilo, a relatively important Middle and Late Quaternary tectonic activity is evidenced by deformations of marine terraces and alluvial fans.

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