NEOTECTONIC CONTROLS ON FAN-DELTA SEDIMENTATION, COASTAL NORTHERN CHILE: A RESPONSE TO ASEISMIC RIDGE SUBDUCTION

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Resumen

La estructura, el desarrollo geomorfológico y la respuesta sedimentaria del area costera entre Antofagasta en al sur y Arica en al norte sido investigados para evaluar la influencia de la subsidencia de la placa de Nazca sobree los cambios del nivel del mar durante el cuaternario y al reciente. Los datos obtenidos sugieren que las variaciones regionales de patrones del leventamiento del terreno lo largo de la costa norte de Chile están controlados por la subduccion de una dorsal aseísmica, la cual produce fluctuacimes eustaticas del nivel del mar.

Introduction

In the last decade the interdisciplinary science of basin analysis has produced advances in our understanding of the role of base level changes in controlling the stratigraphy and architecture of basin-fill successions. Both global eustacy and regional tectonic activity are known to have major affects on basin-fill characteristics and facies architecture. However, reliable distinction between the relative importance of tectonics and eustacy in controlling base level and thus architecture has not generally been made. In this paper we investigate the structure, landform development and sedimentary dynamics of the north Chilean Pacific margin to evaluate the influence of Nazca plate subduction processes on relative sea level changes over Quaternary to Recent times.

Regional Geology

The coastline of northern Chile is dominated by the Coastal Cordillera, a longitudinally continuous mountain range, over 2000 m high in places (Fig. 1). This range comprises Jurassic volcanic rocks and minor intercalated sediments of the La Negra Formation and has been traditionally interpreted as marking the position of the Jurassic Andean volcanic arc (Coira et. al., 1982). The La Negra Formation is overlain unconformably, locally by early Cretaceous basin-fills but mainly by transgressive marine sandstones and coquina limestones of the Miocene-Pliocene La Portada Formation (Ferrais & Dibase, 1978). The La Portada Formation is in turn overlain by Quaternary alluvial fan/fan-delta deposits.

Morphologically the coastline consists of a series of bays, headlands and distinctive terraces/wave-cut platforms. In this paper we describe the dynamic evolution of the Quaternary fan systems and integrate the field evidence with published marine geophysical and oceanographic data to elucidate the Quaternary-Recent relative sea level history of the Chilean

margin and possible driving mechanisms. A major feature in this region is the aridity of the climate. In the study area only one river, the Rio Loa, flows tthrough the Coastal Cordillera into the Pacific ocean (Fig. 1).

Sedimentology of the coastal fan/fan-delta systems

We summarise here the first detailed sedimentological studies of these sequences, fully described by Flint et al. (1989). The fans can conveniently be divided into three main groups on the basis of catchment size:
(1) Internal fans which have a catchment area comprising the immediate watershed of the Coastal Cordillera;
(2) External fans, which are much larger and have access to external drainage from within and occasionally right through the Cordillera (e.g. the Rio Loa fan; Fig. 1). Sixty percent of the feeder canyons (n=40) follow the trace of steep, east-west trending normal faults which cut the Coastal Cordillera.
(3) Side cones, which are small, steep scree cones with no true feeder canyon dominating the supply of sediment to the fan.

Out of 52 main locations studied between the mouth of the Rio Loa southwards to the Mejillones peninsula (Fig. 1) a total of 43 external and 79 internal fan systems were surveyed. However, many of the external systems are coalesced with subsidiary internal and side cone fans (Flint et al., 1989).

Chilean coastal dynamics

At Arica (Fig. 1) the coastal range is in net extension, characterised by extensional normal faulting and subsidence, in common with much of the Chilean margin. South of Arica uplift is recorded by spectacular canyon cutting, marine terrace development and incision of alluvial fan surfaces; uplift reaches a maximum south of Iquique. The northern boundary between the regions in net subsidence and net uplift is marked by north-facing neotectonic normal fault scarps (Mortimer, 1972; Mortimer & Sarie, 1972;).

Recently published tide gauge records for the west coast of South America for the 30 year period between 1940 and 1970 (Aubrey et al., 1988) provide an independent assessment of uplift at the Andean margin. Plotting of the uplift pattern and tide gauge readings on a map with Pacific bathymetric data reveals a good correlation between areas undergoing uplift and the intersection of aseismic ridges with the South American plate edge (Fig. 2). Thus the uplift (measurable over a 30 year period) in specific areas of Equador and Peru is coincident with the Carnegie and Nazca ridges and the Antofagasta-Iquique sector coincides with the ongoing subduction of an unnamed ridge (Fig. 2). Plate reconstructions indicate that aseismic ridge subduction has been an important component of the Tertiary Nazca plate history (Cross & Pilger, 1982; Pilger, 1984) and several authors have suggested that subduction of such ridges may, on a large scale and over periods of several million years, affect arc volcanism and structural evolution (Nur & Ben Avraham, 1981; Cross & Pilger, op cit.).

The role of aseismic ridge subduction in producing ***recent and ongoing*** *local* distributed uplift was first suggested by Aubrey et al. (op cit.). Our data further support the thesis that ridge irregularities or a series of seamounts/ridges may have been responsible for driving the high frequency pattern of relative sea level changes throughout the Late Tertiary/Quaternary in northern Chile.

The subsidence and extensional tectonic regime in inter-ridge areas such as Arica (Fig. 1) is well documented (Katz, 1971), despite continuous subduction at the Andean margin since Jurassic times (Coira et al., 1982). This forearc extension may be a result of subduction roll-back (Hartley et al., 1988), typical for the "cordilleran margin" type of Aubouin (1989) and is marked in the study area by oblique NE-SW and N-S trending normal faults in the Coastal Cordillera (Fig. 1) and many neotectonic fault scarps in the Central Depression.

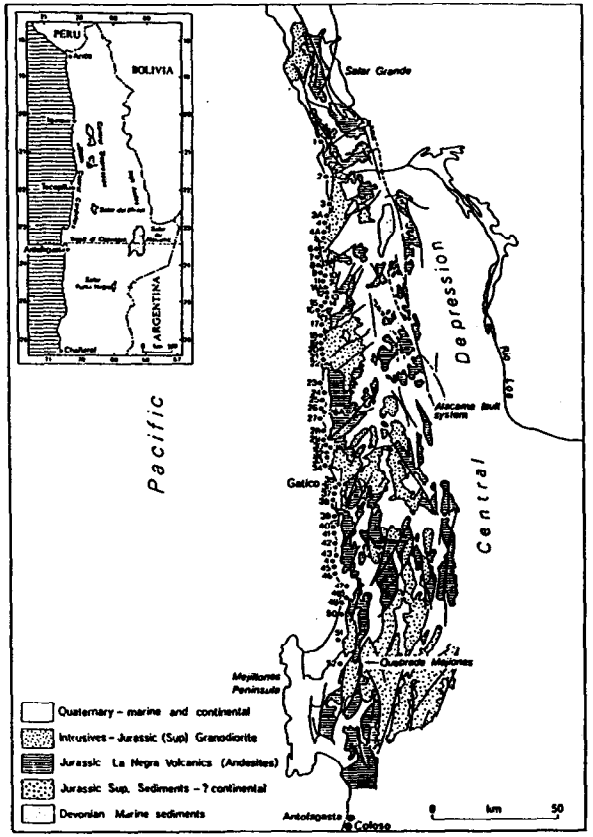

Figure 1: The Andean margin of northern Chile showing main morphotectonic divisions (inset) & locations of the studied fan systems (numbered). Note the intense pattern of extensional normal faulting in the Coastal Cordillera.

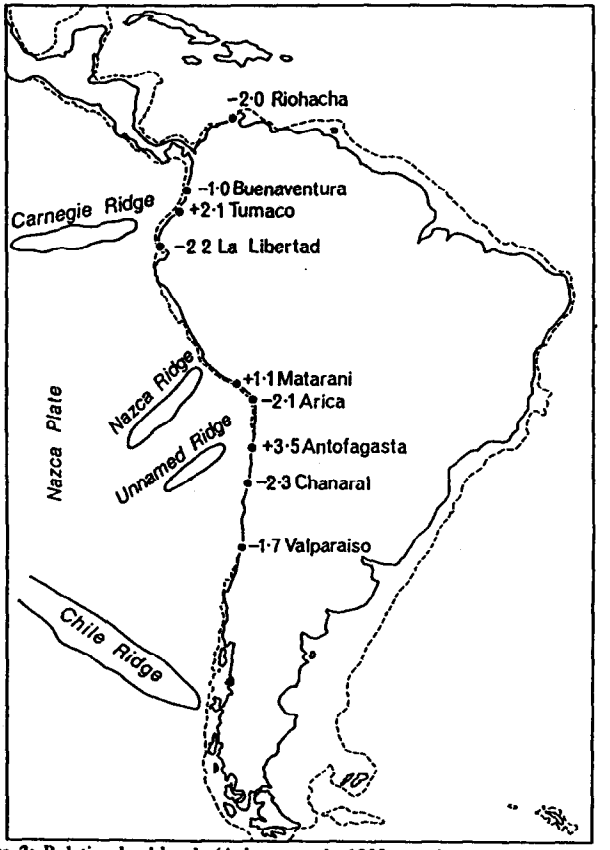

Figure 2: Relative land levels (Aubrey et. al., 1988; + values = land rising, - values = subsidence, in mm/yr) show that the Andean margin is currently in extension/subsidence except for areas coincident with ridges, where active uplift is recorded over a recent 30 year period.

Conclusion

Our data suggest that regionally variable patterns of Quaternary coastal uplift along the north Chilean coast are controlled by the subduction of an aseismic ridge, which overprints the effects of eustatic sea level fluctuations. Thus, subduction of oceanic plate heterogeneities may provide a mechanism for producing cyclicity in sedimentary sequences at a frequency equal to or higher than glacio-eustacy in fore-arc and possibly back-arc sedimentary basins. These sequences will be neither of global extent nor global synchroneity.

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