6th International Symposium on Andean Geodynamics (ISAG 2005, Barcelona), Extended Abstracts: 246-249

Late Miocene coastal subsidence in Central Chile: Tectonic implications

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KEYWORDS: Miocene, Chile, subsidence, tectonic erosion, Quechua phase, magmatism

INTRODUCTION

Neogene strata crop out at different places located along the Chilean coastline (Cecioni, 1980) and have also been recognized in boreholes drilled in the continental platform (Mordojovich, 1981). The Navidad Formation (~32°30'-34°S) is the best studied among the units defined onshore being considered as the reference formation for the marine Neogene of Chile. Classical sedimentologic studies generally refer to this formation as a shallow marine deposit (Etchart, 1973; Cecioni, 1978), although foraminifera and ostracodes indicate bathyal depths (Osorio, 1978; Martínez-Pardo, 1979). New sedimentologic, paleontologic and tectonic studies, which were carried out mostly in the Navidad Formation, indicate that the coastal area of central and southern Chile was the subject of a major subsidence during the Late Miocene.

STRATIGRAPHY AND SEDIMENTOLOGY

The approximately 100-200 m thick basal member of the Navidad Formation overlies the Paleozoic granitic basement and Upper Cretaceous marine rocks of the Punta Topocalma Formation (Cecioni, 1978). It exhibits a basal conglomerate overlain by a succession of interbedded siltstone and sandstone, with minor conglomerate. The basal conglomerate is only a few meters thick and consists of a fossiliferous conglomerate or coquina.

Beds overlying the basal conglomerate comprise facies consisting of massive sandstone, interbedded siltstone and sandstone with Bouma cycles, synsedimentary breccia, slides, slumps and massive siltstones. These facies are interpreted as being generated by alternation of gravity flows with settling of fines deposited on the continental slope during rapid, major coastal subsidence. This interpretation is supported by the presence of benthic foraminifers indicative of deposition at a minimum depth of 1500 m, as well as the occurrence of abundant *Chondrites isp.* and *Zoophycos isp* in siltstones and fine-grained sandstones. This trace fossil association is typical for slope and apron settings (Buatois et al., 2002).

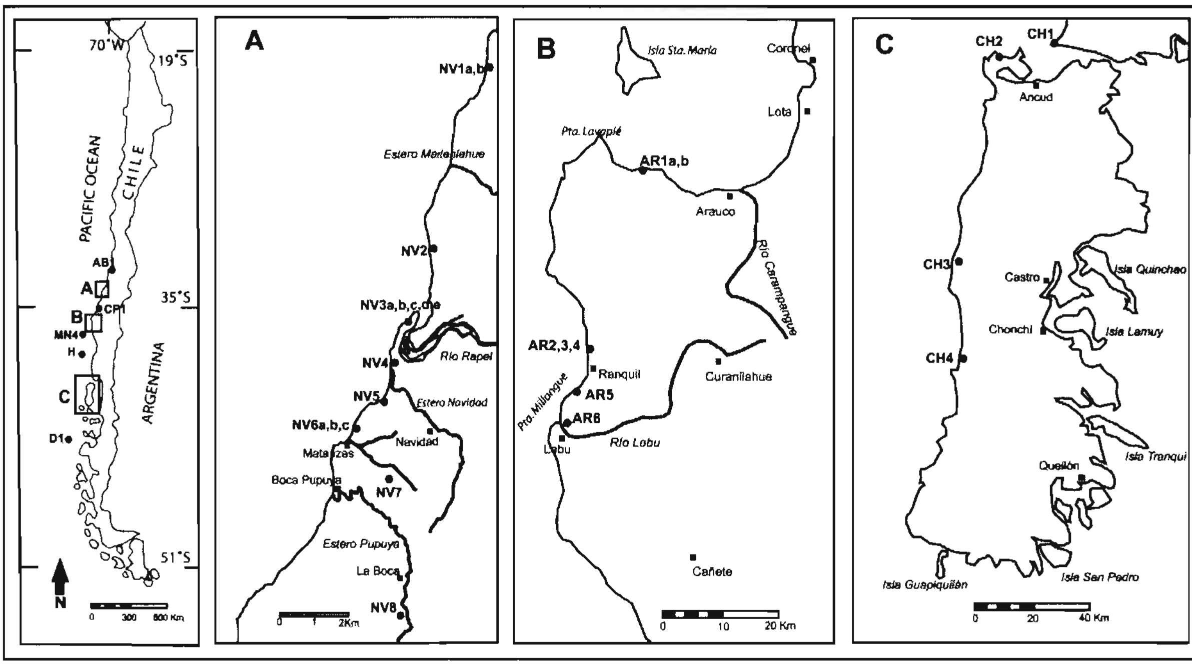

Figure 1: Location of foraminifer and ostracode samples collected from coastal outcrops and ENAP boreholes from the continental platform. A) Navidad area; B) Arauco area; C) Chiloé area.

FORAMINIFERS AND OSTRACODES

Samples were collected for Foraminifers and ostracodes from siltstones and fossiliferous lenses within sandstone and conglomerate in outcrops at Navidad, Concepción, Arauco, and Chiloé (Fig. 1). Core samples from exploratory boreholes drilled in the marine platform by ENAP near Valdivia (well H), on Mocha Island (well MN4) and between Chiloé and Taitao (well D1) were also studied (Fig. 1).

Most of the samples yielded assemblages of planktonic foraminifera with concurrent ranges indicating ages within the Tortonian (Late Miocene, N16) to Zanclean (Early Pliocene, N19) interval. Samples devoid of vital index species resulted in less precise age determinations that extended into this interval. Benthic foraminifers and ostracodes reveal downslope transport of sediments, as evidenced by their mixed association of littoral, neritic, and bathyal species, and deposition at lower middle bathyal (1000-1500 m) and lower bathyal (1500-2000 m) depths.

DISCUSSION

Sedimentologic and paleontologic studies carried out on Neogene exposures and offshore boreholes of central and southern Chile indicate that the Chilean forearc was subjected to major subsidence during the

Miocene. Recent studies in northern Chile (Gómez, 2003; Achurra, 2004) also indicate significant subsidence during the Miocene, although the timing and amount of vertical displacement can vary slightly compared to the successions of central and southern Chile. Subsidence also affected the present Central Valley and western slopes of the Andean Cordillera in some parts of Chile (Osorio and Elgueta, 1990). Evidence for major subsidence during the Miocene has been reported elsewhere around the Pacific, including New Zealand (Buret et al., 1997) Costa Rica (Vannucchi et al., 2001), Guatemala (Vannucchi et al., 2004) Japan (Von Huene et al., 1982) and Peru (Von Huene and Suess, 1988), suggesting a common cause. We ascribe tectonic erosion as the cause of this subsidence. Basal tectonic erosion would have subcrustally removed the underside of the upper plate causing upper plate thinning and subsidence of the margin.

Miocene subsidence is coeval with the most important tectonic period in the construction of the Andean Cordillera, known as the Quechua phase (Noblet et al., 1996). This tectonic phase has been related to increasing convergence rates (e.g. Pardo-Casas and Molnar, 1987). Major tectonic phases at 10 and 5 Ma, however, coincide with decreasing convergence rates making this correlation uncertain (Hartley et al., 2000). We suggest that global Miocene cooling could have been the cause of forearc tectonic erosion related to subsidence and major mountain building. Climatic cooling would have augmented the aridity along coastal Chile, by enhancement of the cold Peru-Chile current, diminishing continental erosion and trench sedimentation (Lamb and Davis, 2003). Starved trenches would have enhanced tectonic erosion and produced high shear stresses in the subduction zone, resulting in intense Andean tectonic activity.

During the Neogene an important eastward shifting of the volcanic front and changes in magma geochemistry also took place (Scheuber et al., 2000; Kay and Mpodozis, 2002). We attribute volcanic arc displacement to tectonic erosion. Magma changes related to crustal contamination and mineral deposit formation have usually been ascribed to crustal thickening and mountain uplift (Skewes and Holmgren, 1993). However, tectonic erosion could have played an important role in these processes (Stern, 1991). We suggest that major tectonic erosion, which was the cause of important subsidence of coastal Chile during the Neogene, generated variations in magma geochemistry and important mineral deposits.

Acknowledgments

Research was supported by Proyecto Fondecyt 1010691, Programa MECE Educación Superior UCH0010, Beca PG/50/02 of the Departamento de Postgrado y Postítulo-Universidad de Chile, a collaboration program between the "Institut de Recherche pour le Développement" (IRD-France) and the Universidad de Chile and by Program ECOS-Sud C00U01 that partly supported study and field work of A.L. (2003). We kindly thank ENAP (The National Petroleum Chilean Company) for their loan of microfossil slides and seismic lines.

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