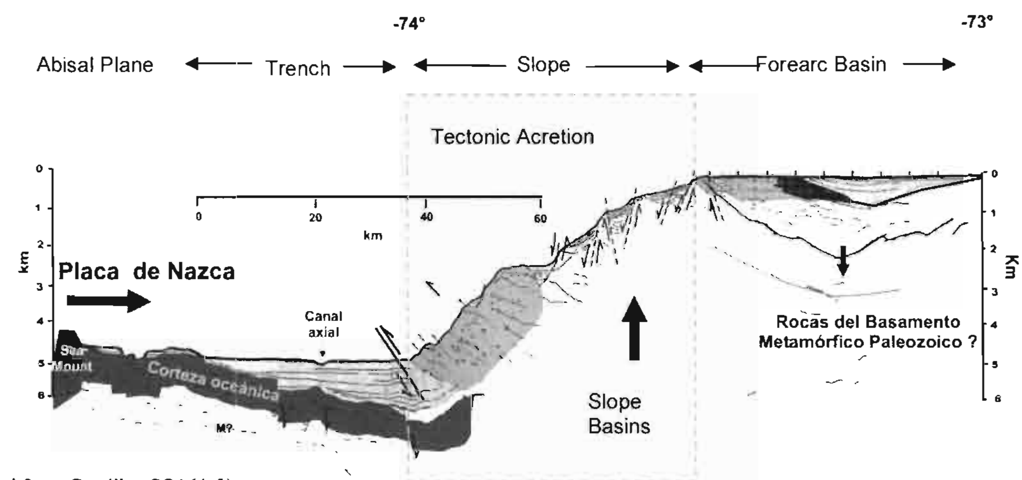
Architecture of the sedimentary basins in the medium and upper slope of the Chilean subduction margin (33°30'-36°s)

Ximena Contardo, José Cembrano, & Arturo Jensen

Departamento de Ciencias Geológicas, Universidad Católica del Norte. Av. Angamos 0610, Casilla 1280. Antofagasta, Chile; xcontardo@ucn.cl, jcembrano@ucn.cl, ajensen@ucn.cl

INTRODUCTION

The Chilean continental margin is a plate convergent boundary marked by the effects of active subduction since the Jurassic. The Chilean forearc exhibits end-members of the different mass transfer modes that occur at convergent margins: a purely tectonically erosive margin in the north (from Arica to Valparaiso) -adjacent to the Central Andean plateau- and an accretionary margin in the south, from Valparaiso -where the Juan Fernandez Ridge collides with the continental plate- to southernmost South America. Specific patterns and styles of deformation are related to these systems; furthermore, climatically controlled surface mass transport is also contrasting between these portions of the Chilean Margin (Lohrman *et al.*, 2001)

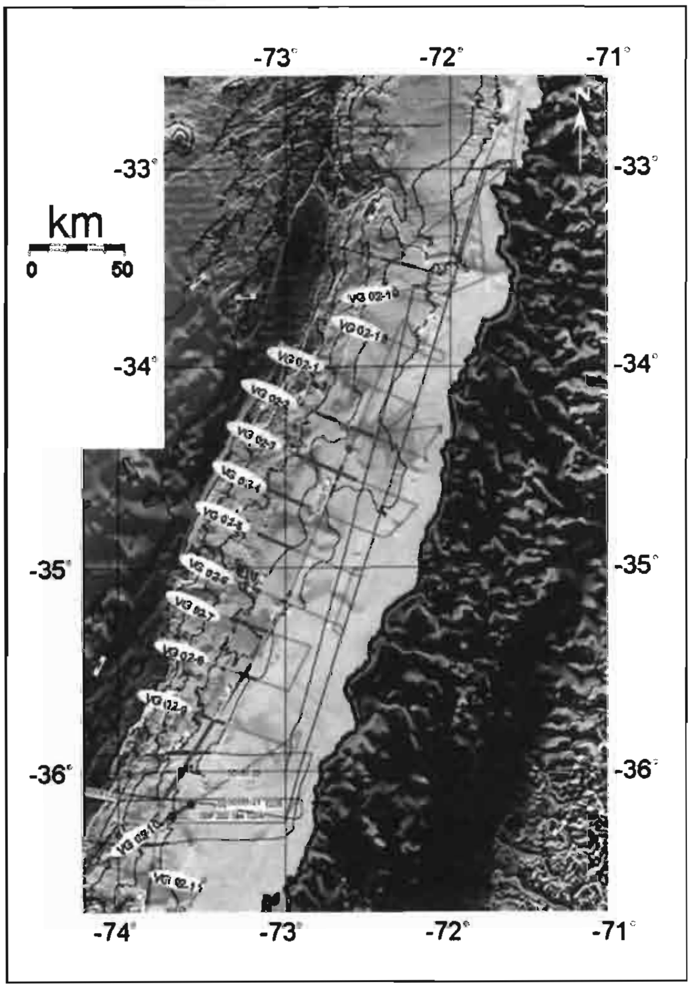


(Modified from Gaedike, SO161-3)
Fig.1. Interpretative section with the spatial the distribution of morphotectonic elements of the subduction zone (latitude 35°55'S). Platform basin, slope basins, and trench filled with sediments (Cruise Report R/V SO 161-5. SPOC. 2002).

The first order geodynamic elements that control the tectonic evolution of the margin are the subduction of the Nazca Plate underneath South America and the collision of oceanic ridges. Other, second order elements, are the nature and volume of sediments in the trench, and the pore fluid pressure (Hilde, 1983; Von Huene, 1997; Bangs & Cande, 1997; Lohrman *et al.*, 2001). The nature of the interaction between the factors that control the morphology of the margin and the evolution of the marine basins of the slope and continental platform, are not yet fully understood. A record of the interplay between the kinematics associated with the deformation induced by subduction and the basin formation can be found along the continental margin.

The objective of this work is to better understand the relationship between the convergence processes and the tectono-sedimentary development of marine basins in the continental slope. With this purpose, nine seismic sections (VGO2, from 4 to 12) have been analysed. The architecture of the basins was obtained through the analyses of seismic sections acquired offshore Chilean coast between V y X regions, by the FONDEF

D00I1104 Project: Hidratos de Metano: Una nueva fuente de energía para el siglo 21 (Figure 2). Some specific examples were selected to show the geological structures, deformational style, and the location of the BSR (Botton Simulator Reflection), and its implications for the structural development of the basins.



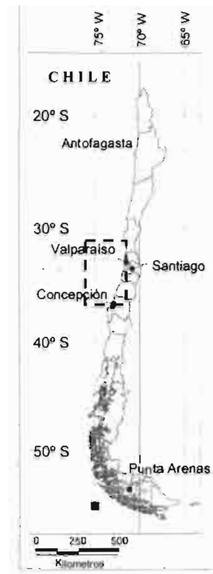


Fig.2. Study area with the distribution of the seismic reflection lines obtained on board to the Vidal Gormaz ship, for the Gas Hydrates FONDEF D00I1104 Project. Some segments of these profiles are analyzed in this work.

SOME KEY FEATURES OF THE SLOPE BASINS

The slope basins are receptacles of mass flow processes resulting from episodic destabilization of the shelf margin and the upper slope due to earthquakes, storms, or sea level falls, mixing their deposits with hemiplegics sediment (Emery and Myers, 1996). Previous works documents ages from Miocene and mainly Pliocene-Holocene for slope basins (Gonzalez, 1989; Laursen *et al.*, 2002; Cruise Report SO161-5.SPOC 2002). The lithology of the slope -obtained by dredge during scientific cruises- documents poorly to well-lithified sedimentary rocks with various degrees of deformation. This ranges from soft-sediment deformation (flame structures, convolute bedding) through brittle-ductile (claystone, sandstone) response of semiconsolidated material to entirely brittle processes such as fracturing, faulting and veining in highly lithified material (Cruise Report SO161-5.SPOC 2002).

The overall architecture of the slope is characterized by several adjacent half-graben basins, some of them hanging (Figure 3). The individual basins of the inner slope have between 2 and 15 km wide and 200 to 600 km. thick. In some cases, there is a large slope basin, composed by many small half-graben with BSR levels localized at their base (around 0,5 to 3,5 s). Possible expulsion vents of methane hydrates are observed.

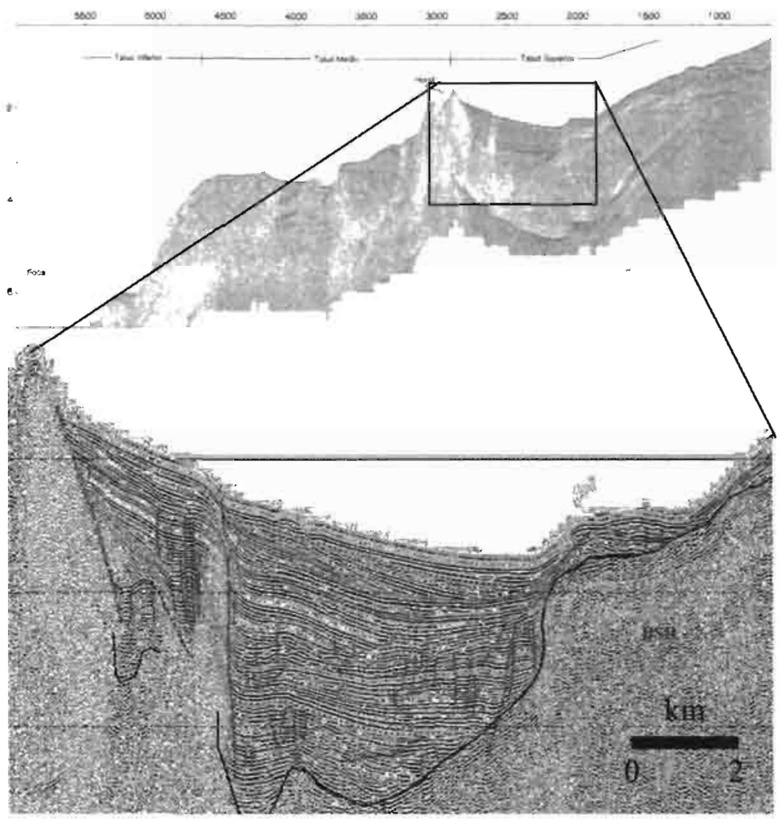


Fig.3. Section of the slope corresponding to the seismic section VGO2-8, showing the geometry of a slope basin. The accommodation space is controlled by tectonic processes that allow the syn-kinematic deposition of thick sequences and post kinematics deposition. On the top of sequences more homogeneous deposition suggests a period when deposition was more significant than tectonic deformation. An incipient post kinematic deformation of the upper sequence suggests the beginning of a younger tectonic disturbance.

Fig.4. Section of the seismic reflection profile VGO2-5. It show a large slope basin composed by many hemigraben basins. The BSR level is located at the base of these hemigraben. This section also exposes the different episodes of deformation (pre, syn and post kinematics).

The geometry of deposition on each hemigraben basin (wedge-shaped) suggests differential subsidence, synkinematic with deposition (growth strata) (Figures 3 and 4). Examination of the different seismic lines shows different episodes of deposition; pre-kinematic, syn-kinematic, and post-kinematic. The synkinematic deposition has allowed the development of growth strata and deposition of thick sedimentary sequences, whose depocenter are controlled by differential tectonic displacements on flanking faults. In these time periods tectonic displacement on flanking faults seems to occur at higher rates than deposition. To the top, the geometry of the sequences show that the basins tend to be filled by sediment under a period of apparent stability, represented by homogenous deposition of the upper sequence, showing lateral continuity of sediments thickness that covers most of the slope. Finally, an incipient late deformation of the upper strata may indicate a reactivation of tectonic processes.

CONCLUSIONS

Preliminary analyses of seismic lines obtained by FONDEF Project D00I1104 allowed us to identify key features of the continental slope offshore Central Chile between 33°30' and 36°S. The architecture of the slope is characterized by many half-graben basins, controlled by differential uplift and/or warping of the accreted margin. Examination of the different seismic lines shows different episodes of deposition; pre-kinematic, syn-kinematic and post- kinematic. The sequence record suggests periods of intense tectonic deformation that modify and control the morphology of the slope and consequently the accommodation space. A later period shows important sedimentation and a relative decrease in tectonic activity. At the top of all slope sedimentary sequences more homogeneous deposition took place, indicating a period of time when the deposition rates were more important than tectonics. BSR (Botton Simulator Reflection) levels are localized at the base of the big slope basin composed by many small hemigrabens.

Acknowledgments

We wish to thank at Juan Diaz Naveas coordinator of the FONDEF Project D00I1104 by its excellent disposition providing valuable information of the seismic reflection profiles analyzed in this work.

References

Bangs & Cande, 1997. Episodioc Development of a Convergent Margin Inferred From Structures and Processes Along the Southern Chile Margin. Tectonics, Vol.16, No.3, Pages. 489-503, June 1997.

Cruise Report R/V SO 161-5, SPOC, 2002. (Subduction Processes Off Chile) Geology - Geochemistry – Heatflow. Valparaiso 24.12.2001-26.01.2002. 221 pages. BGR, Hannover. März.

Emery & Myers, 1996. Sequence Stratigraphy. 297 p

Gonzalez. 1990. Hydrocarbon Resources in the Coastal Zone of Chile, in Geology of the Andes and its relation to hydrocarbon and mineral resources, Earth Science Series, v.11, 383-404. Circum-Pacific Council for Energy and Mineral Resources. Houston, Texas,.

Hilde. 1983. Sediment Subduction versus Accretion around the Pacific. Tectonophysics, 99, 381-397.

Laursen, Sholl, & Von Huene. 2002. Neotectonic deformation of the central Chile margin: Deepwather forearc basin formation in response to hot spot ridge and seamount subduction. Tectonics. Vol21, No.5. 15pp.

Lohrman, Kukowsky & Oncken. 2001. Erosive and accretive mass transfer modes and related deformation at the Chilean forearc – results of 2D scaled sandbox experiments. I. Scientific report for research period 1999-2001. Collaborative Research Center SFB 267. Berlin, Postdam p. 395-421.

Von Huene. 1997. Chilean Margin Tectonics, Iquique to Isla Chiloé. VIII Congreso Geológico Chileno. Departamento de Cs. Geológicas Univ. De Antofagasta. Actas, Vol III. Simposio Geología Marina de Chile. Págs. 1859.