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Seismic study of the southernmost Andes in the SW Atlantic Ocean: Main wrench faults and associated basin

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Introduction

The orientation of the main axis of the southernmost segment of the Andes, displays a change from N-S to almost E-W in the region of Tierra del Fuego and in its submerged continuity toward the E, in the region of the North Scotia Ridge to South Georgia Island. This change of orientation has been the object of diverse studies to obtain a model that could explain its formation and its relationship with the tectonic processes that have delineated of the boundaries of the current plates and the associated sedimentary basins. On the basis of interprect multichannel seismic of reflection profiles and their correlation with the geologic information that we have obtained and bibliographical data, we present novel results of the submerged sector of Tierra del Fuego, with a schematic synthesis of a segment of the fold-and-thrust-belt of the Fuegian Andes and a map of the marine bottom, with the distribution of the different geologic units and the main faults and associated basins.

Area of the Study

The present day tectonic architecture of the Tierra del Fuego margin (Fig. 1) is the result of the long and complex evolution of southernmost South America since the Early-Mesozoic (Dalziel and Elliot, 1973; Dalziel, 1982). Since the Middle Jurassic, the southern part of the continent underwent extension associated with the Gondwana break-up. At about 100 Ma, a general phase of compressional tectonics led to the closure of the Rocas Verdes basin and contemporaneous development of the Magallanes-Malvinas Basins as a foreland basin, with deposition of clastic sediments sourced in the Cordillera de los Andes (Natland et al., 1974). From late-Mesozoic through Tertiary, the Tierra del Fuego region underwent continentward propagation of the Magallanes fold-and-thrust-belt (Winslow, 1982; Biddle et al., 1986). This belt comprises thrusting of the Mesozoic units over early-Cenozoic deposits, and also many thrusts within the Mesozoic sequences of the Magallanes basin (Ramos, 1989). This tectonic event may have developed in conjunction with a strike slip shear zones which possibly accommodated the relative motion between South America and Antarctic continents since the Early-Cretaceous (Diraison et al., 2000).

Thus, the region may be divided into two sectors with structural and sedimentary different settings (Figs. 1 and 2): <u>undeformed zone</u> (the foreland platform and the foredeep) and <u>deformed zone</u> (inner and outer fold and thrust belt). The study area correspond to a segment of the deformed zone (the Magallanes fold-and-thrust belt), located developed adjacent to the northern flank of the southernmost Andes.

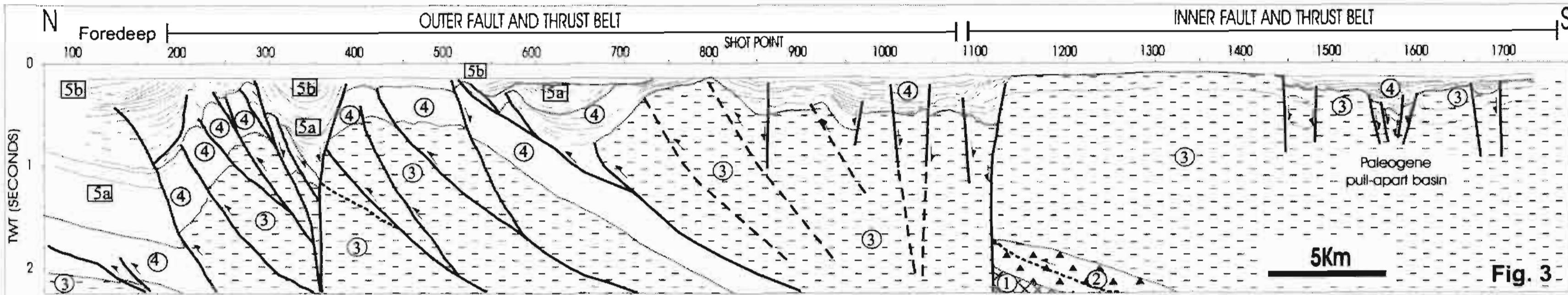

Fig.3: TM-08 seismic profile (acquired by the geophysical Project TESAC 1999) and interpretation (located in Fig. 2). The linedrawing shows the structural model of the external deformation front and the deformed sector (inner and outher fold and thrust belt). Numbers refer to the main seismostratigraphic units of the sedimentary infilling and basement. See text for further details.

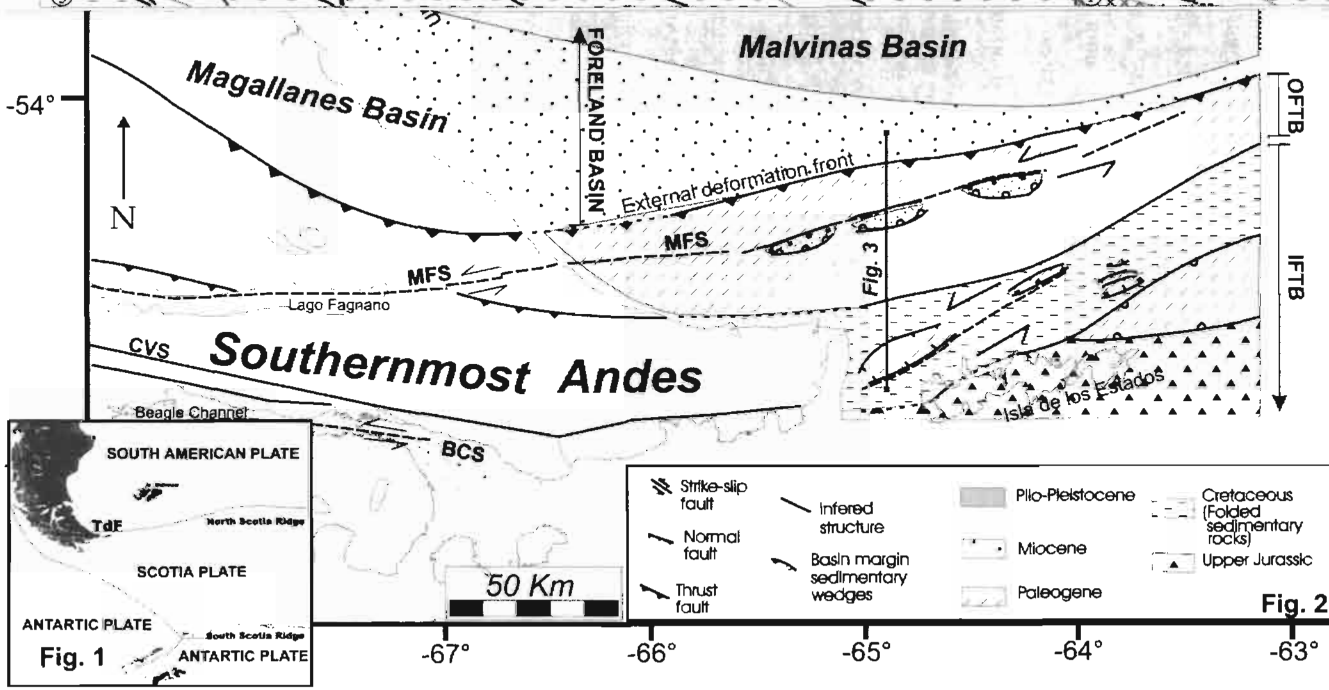

Fig.1: Regional tectonic map with the plate boundaries

Fig. 2: Simplified structural map of the southern deformed region of the Tierra del Fuego (Location in Fig. 1), with its offshore continuation and geological units of the sea bottom. OFTB: outer fold and thrust belt: IFTB: internal fold and thrust belt; CVS: Carabajal Valley fault system; MFS: Magallanes-Fagnano fault system, BCS: Beagle channel fault system. The northern border of the fold and thrust belt is also shown as well as the Magallanes-Fagnano Fault System which is the main segment of South America-Scotia plates boundary.

Tectonostratigraphic evolution of the Tierra del Fuego Atlantic off-shore

Five main seismostratigraphic units have been identified which document different periods with particular geodynamic characteristics during the evolution and building of the Fuegian continental margin. This was achieved by correlating these main seismic units with well data and the results obtained by Galeazzi (1996), Biddle et al. (1986), Yrigoyen (1989), Robiano et al., (1996), Richards et al. (1996) and others for the undeformed zone (Magallanes and Malvinas foreland basin) and the outer deformed sector (Tassone et al., 2001; Tassone et al., 2003; Lodolo et al., 2002; Lodolo et al., 2003; Yagupsky et al., 2003; Yagupsky et al., 2004). In the internal deformed sector, made up by the inverted infill of the Rocas Verdes marginal basin, the seismic units and main faults found offshore were correlated with the geological units and master fault systems of the Tierra del Fuego onshore. The five recognized units are: Unit 1- Pre-Jurassic basement; Unit 2- Rift phase (Lower Jurassic - Upper Jurassic); Unit 3-Sag phase (Upper Jurassic – Upper Cretaceous); Unit 4- Foredeep transition phase (Upper Cretaceous – Middle Eocene); Unit 5- Foreland phase (Middle Eocene – Pleistocene). Each of the seismostratigraphic units represents a particular tectonic stage during the evolution of the region characterized by distinct tectonic and sedimentary features.

During the Tertiary, the Magallanes fold- and thrust belt was formed as a result of the compressive stress propagation to the foreland. In the Malvinas basin the foredeep delineated in the Early Tertiary (Fig. 2) and its function as foreland basin *sensu stricto* dates from the Middle Eocene (Fig. 2). The diachronism between both basins is due to the eastward propagation of the transpressive stresses in the extreme south of the continent over the North Scotia Ridge. The strike-slip tectonic regime in this region may have been active since around 100 Ma, associated with the counterclockwise movement between the Antartic Peninsula and South America. The later formation of the Scotia plate and the opening of the Drake Passage during the late Eocene - Oligocene overlapped transpressive and transtensional features over the structures previously formed.

One small segment of the foredeep sector of the Magallanes basin is represented in the geophysic section (Fig. 3). The subsidence probably accentuated the activity of the transtensional structures generated during the Paleocene in the foredeep region, where a significant lowering of the Middle Eocene unconformity (lower boundary of the Subunit 5a) is observed, severely modifying the geometry of the basin (Yagupsky et al., 2003).

The positive flower structural patterns result from strike-slip movements, with transtensive and transpressive structures of E-W strike, which affected the southern sector of the basins of this sector of the Fuegian continental margin during the early Cenozoic, as was recognized by Robiano et al. (1996) in the Austral (Magallanes) marine basin and by Yrigoyen (1989) and Galeazzi (1996) in the Malvinas basin. The interpreted profile (Fig. 3) shows the orogenic front, formed by a deep positive flower structure suggesting a transpressive strain dynamics. This structure forms an anticline with Eocene-Oligocene wedge top deposits over its dorsal limb. A series of folds of kilometric scale are observed, likely transported by blind thrust faults, slightly deforming the overlaying Miocene strata (Subunit 5b; Fig. 3).

The rise of the Andean Orocline in this region gave also a new sedimentary source in the meridional margin. This transtensional regime was also registered during the Paleogene in the inner sector of the fold- and thrust belt (Fig. 3). Thus, it should be underlined the two stages (Paleogene and Neogene) of strike-slip tectonics above mentioned. The first generated wrench basins in the inner sector of the fold and thrust belt, and the second is represented by the transtensive system that crosses through the outer fold and thrust belt and delineates the actual

South America-Scotia plate boundary, producing a chain of pull-apart basins along its strike (Tassone et al., 2002; Lodolo et al., 2002; Lodolo et al., 2003; Tassone et al., 2004).

The inner fold and thrust belt seen in the southern part of the map of Fig. 2 shows Cretaceous (units 3) outcrops over the sea floor (Fig. 3, seismic profile).

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