

Contourite Terraces in the Middle-Slope of the Northern Scotia Sea and Southern Atlantic Ocean: Palaeoceanographic Implications

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Abstract: *The morphology of the continental margin off Tierra del Fuego is highly influenced by the presence of middle-slope contourite terraces. This area is dominated by the relatively strong flow associated to the northern Antarctic Circumpolar Current, with the North Scotia Ridge acting as an important morphological barrier. The flow includes portions of Upper Circumpolar Deep Water and recently formed Antarctic Intermediate Water that later flows northward reaching the Northern Hemisphere. The depth of the boundary between these water masses coincides with the regional occurrence of the terraces. Similar terraces have also been identified along the Argentine and Uruguayan margins, representing a major morphologic element in the South Atlantic Ocean with important oceanographic and palaeoceanographic implications.*

Key words: *Contourite Terraces, Antarctic Intermediate Water, Scotia Sea, Malvinas/Falkland Through, Morpho-stratigraphic analysis.*

INTRODUCTION

Conceptually, a terrace is “an isolated relatively flat horizontal or gently seaward inclined surface which is bounded by a steeper ascending slope on one side and by a steeper descending slope on the opposite side”. The contourite terraces have been genetically related to water mass interfaces (Preu et al., 2013). Although terraces have been globally identified (e.g. Harris et al., 2014) few studies have focussed in the contourite terraces and their oceanographic implications (e.g. Hernández-Molina et al., 2009; Preu et al., 2013). Several terraces are identified in the present work in the Scotia Sea-Atlantic Ocean transition through morpho-stratigraphic analysis based on single- and multi-channel seismic (SCS and MCS) surveys (Fig. 1A). The observation and implied genesis of these terraces suggest previously unknown oceanographic and palaeoceanographic processes of global relevance.

GEOLOGICAL SETTING

The study area is located offshore of Tierra del Fuego continental margin (Fig. 1A), including the northwestern Scotia Sea and the Malvinas/Falkland Depression. The E-W trending North Scotia Ridge (NSR) represents the eastward prolongation of the orogenic system emerged in Tierra del Fuego. The northern flank of the NSR is influenced by the active subduction of the South America plate beneath the Scotia plate (Fig. 1A), while the southern flank is mostly characterized by strike-slip structures (e.g. Lodolo et al., 2006).

OCEANOGRAPHIC CONTEXT

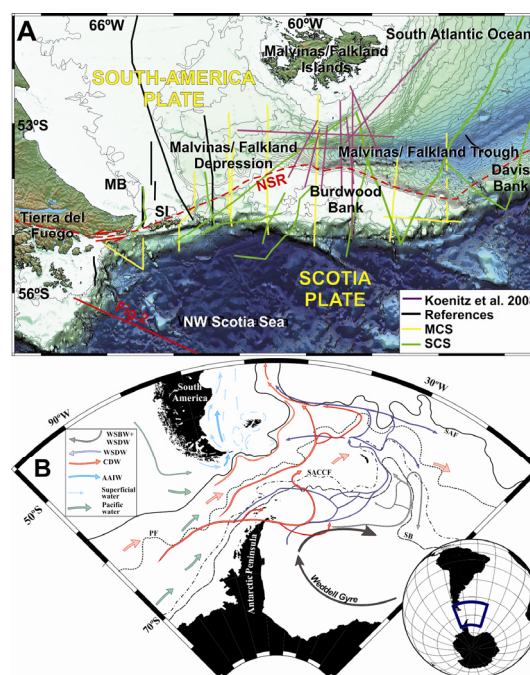


FIGURE 1. (A) Scotia Sea-Atlantic Ocean transition showing the location of seismic lines used in this study. MB, Malvinas Basin; NSR, North Scotia Ridge; SI, Los Estados Island. (B) Simplified sketch of the water masses circulation in the study area. Water masses defined in text. Fronts of the ACC: SAF, Sub-Antarctic Front; Pf, Polar Front; SACC; Southern ACC Front; SB, Southern Boundary of the ACC.

The deepest water mass in the northwest Scotia Sea is the Southeast Pacific Deep Water (SPDW), which flows to the north of the Southern Antarctic Circumpolar Current Front (SACC). Above the

SPDW, the Circumpolar Deep Water (CDW) flows eastward as the deepest fraction of the Antarctic Circumpolar Current (ACC). CDW is divided into an Upper (UCDW) and Lower (LCDW) fractions, separated by the Southeast Pacific Deep Slope Water (SPDSW, Well et al., 2003). Above the CDW the Antarctic Intermediate Water (AAIW) and the Antarctic Surface Water (AASW) are found. AAIW and UCDW contribute to the Malvinas/Falkland Current. Water depths along the crest of NSR range from 200 to 2000m. As result, the ridge forms a huge barrier to ACC northward flow deeper components (Fig. 1B; Naveira-Garabato et al., 2003).

RESULTS

A well-developed terrace is identified in the middle continental slopes of both northwest Scotia Sea and around the Malvinas/Falkland Depression. In the northwest Scotia Sea the terrace is located between 900 and 1100m water depth (wd) being around 10km wide (Fig. 2). A similar terrace is evident in the northern slope of the Malvinas/Falkland Depression at between 400 and 600m wd, where it widens to 6km. Laterally, eastward this terrace is well-developed in the southern slope of the Malvinas/Falkland Islands where it exceeds 10km wide based on the data from Koenitz et al. (2008).

DISCUSSION AND CONCLUSIONS

11.6% of the global continental slopes are shaped by terraces (Harris et al., 2014). Only those genetically related to bottom currents can be considered as contourite terraces (e.g. Preu et al., 2013). In the Scotia Sea-Atlantic Ocean transition, the water depth of the regional interfaces between water masses matches with the occurrence of terraces along the middle-slope (Fig. 2). The largest contourite terrace is located in correspondence with the lower boundary of the AAIW mass, which has been considered in this study area between 200 and 1100m wd (Naveira-Garabato et al., 2003). AAIW is formed by surface water mixing and northward subduction at the Antarctic Convergence Zone/Antarctic Polar Front (Naveira-Garabato et al., 2003). This water mass flows to the north within the Malvinas/Falkland Current, above the UCDW and farther north above North Atlantic Deep Water (NADW), and contributes to the formation of other equivalent terrace identified in the Southern Hemisphere: the Perito Moreno (~1000m) and the Ewing (~1500m) terraces defined in both the Argentinian and Uruguayan margins (Hernández-Molina et al., 2009; Preu et al., 2013). Therefore, the genesis of these terraces can be associated with the northward circulation of the AAIW and the dynamics of its lower boundary. Also the depths of these terraces are indicative of a slight northward deepening of the AAIW layer. The seismic analysis allows us to identify the occurrence of these terraces since the emplacement of the Horizon-c (Fig. 2). According to other regional studies, the age of this reflection corresponds to middle Miocene (Maldonado et al., 2006), the same period in which the lower boundary of AAIW started to generate

the Perito Moreno and the Ewing terraces (Hernández-Molina et al., 2009; Preu et al., 2013). Consequently, we can establish the middle Miocene as the age of the AAIW/UCDW emplacement and the onset of the northward AAIW widespread flow.

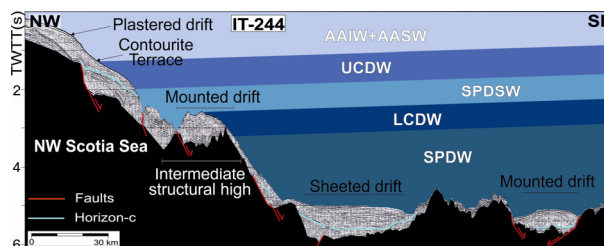


FIGURE 2. Multichannel seismic line (Lodolo et al., 2006; Location in Fig. 1) with seismo-stratigraphic interpretation and tentative outline of the water masses distribution in the northwestern Scotia Sea.

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