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New insights into the tectono-stratigraphic evolution of the Malvinas Basin, offshore of the southernmost Argentinean continental margin

N. Baristeas [a,*], Z. Anka [a], R. di Primio [a], J.F. Rodriguez [b], D. Marchal [b], F. Dominguez [b]

[a] Helmholtz-Centre Potsdam - GFZ German Research Centre for Geosciences, Potsdam, Germany
[b] Petrobras Argentina S.A., Buenos Aires, Argentina

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ABSTRACT

A detailed tectono-stratigraphic analysis of the Malvinas Basin was achieved by the interpretation of around 65,000 km of 2D seismic reflection profiles. Five main seismo-stratigraphic units and their sub-units, informally named units U1 to U5 a/b, bound by major unconformities were identified and correlated with the Mesozoic to Cenozoic main tectonic phases of the basin. Unit U1 (Pre-168 Ma) represents the seismic basement. Unit U2 (168–150.5 Ma, syn rift phase) thickens and deepens southwards. Units U1 and U2 are affected by several syn-rift normal faults that exhibit a main NE–SW strike direction in the south of the basin and a NW–SE strike direction in the centre of the basin. This suggests that the Malvinas Basin may have developed initially as a rift basin with two different extensional directions: (1) a NW–SE directed extension probably linked with the opening of the Weddell Sea (Early Mid-Jurassic), and (2) a NE–SW directed extension most likely linked with the Jurassic back-arc extension of Gondwana and probably later with the onset of the opening of the South Atlantic during Late Jurassic to Early Cretaceous time. Unit U3 (150.5–68 Ma, sag phase) is mainly an aggradational wedge-shaped unit. Unit U4 (68–42.5 Ma, transtensional foredeep phase) overlies unconformable unit U3. It deepens in the south because of an N–S/NW–SE directed extensional regime. Accumulation rates decrease during units U2, U3, and U4 from 4.84, to 1.23 to 0.8 $km^3/Ma \times 10^3$. Units U5a and U5b (42.5–5.5 and 5.5–0 Ma, transpressional foredeep phase) finally represent a change from aggradation to progradation sedimentary pattern and to a left-lateral transpressional regime in the south. The sediment supply was considerably higher than before and a thick sedimentary wedge has been deposited until today. Accumulations rates increased in units U5a and U5b from 2.28 to 8.91 $km^3/Ma \times 10^3$.

1. Introduction

The Malvinas Basin is located east of Tierra del Fuego offshore on the southernmost continental margin of South America (Fig. 1A, B). It was first described by Ludwig et al. (1968), and has been investigated by several authors since (e.g. Galeazzi, 1996, 1998; Ghiglione et al., 2010; Ludwig et al., 1978; Tassone et al., 2008; Uliana et al., 1989; Urien et al., 1995; Yrigoyen, 1989; Zambrano and Urien, 1970).

The Malvinas Basin has been the target of several seismic exploration and drilling campaigns since the 70's, but up to now, only five wells reported non-commercial hydrocarbon accumulations. This contrasts the neighbouring Austral–Magallanes Basin, where first petroleum discoveries were already made in 1949 (Thomas, 1949) or in the North Falkland Basin, where recent exploration and drilling campaigns discovered commercial hydrocarbon accumulations (Falkland Islands Government, Department of Mineral Resources, 2012).

Although the basin's history is complex and it underwent multiple deformation phases due to the changing tectonic setting through time, the evolution of the Malvinas Basin is relatively well understood. The basin evolution can be summarised as following (after Galeazzi, 1996, 1998; Ghiglione et al., 2010; Tassone et al., 2008): The Malvinas Basin was initiated by Middle to Late Jurassic rifting and deepened during a following phase of thermal subsidence in the Cretaceous. After a short transitional extensional Palaeocene-Early Eocene phase, the tectonic regime changed to compression due to the Late Cretaceous-Palaeogene Andean orogenesis, and later to wrench deformation from the Oligocene until today. In response to this tectonic history unconformity bounded sedimentary units were deposited in the basin, forming a thick Jurassic to Holocene wedge-shaped sedimentary succession that consists predominantly of marine siliciclastic deposits. These sediments reach a thickness up to over 7000 m. However, previous studies were limited primarily due to the availability of data or by the limited focus of the work. This study aims to add a refined view and new insights into the tectono-stratigraphic evolution of the basin based on the detailed interpretation of a dense grid of almost 65,000 km 2D seismic reflection data (Fig. 2). The seismic grid of this study covers almost the entire Malvinas Basin and is therefore predestined to analyse the basin as a whole. Thus, this contribution presents a basin-wide and yet detailed view of the Malvinas Basin evolution and its implications with respect to the petroleum potential.

* Corresponding author presently at: RWE Dea AG, Überseering 40, 22297 Hamburg, Germany. Tel.: +49 331 288 1781.
E-mail address: baristeas@yahoo.com (N. Baristeas).

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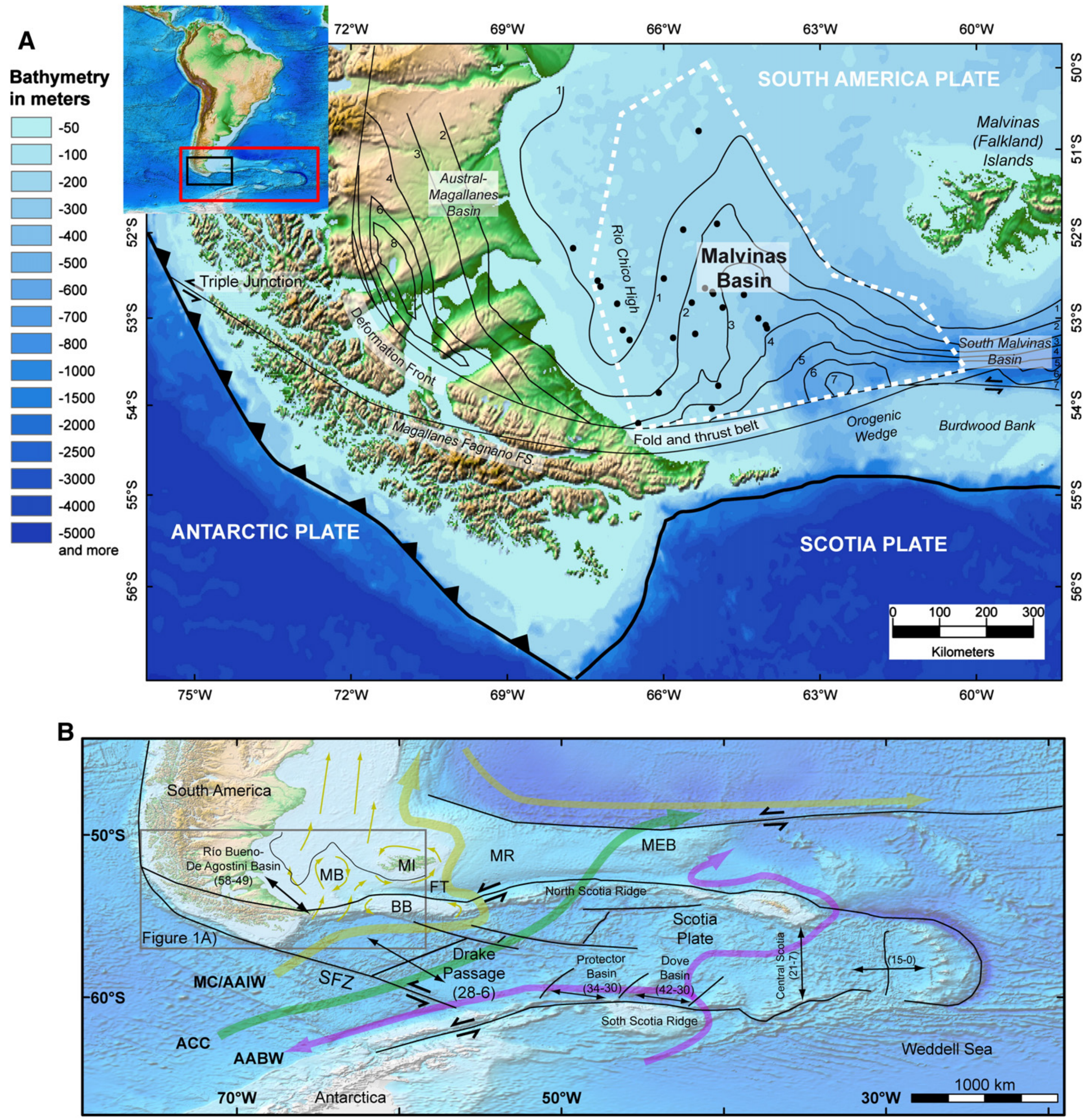

Fig. 1. A) Location of the Malvinas Basin, major tectonic elements, the study area (white dash-lined polygon), and wells (black dots). (Location area see black box upper left). Contours represent the sediment thickness (km) of the undeformed foreland basins. *FS* = fault system. Bathymetric data from Amante and Eakins (2009). B) Main surrounding plate tectonic elements of the Malvinas Basin (modified from Eagles et al., 2006; Ghiglione et al., 2008, 2010). (Location area see red box upper left). Numbers within parenthesis indicate start and end of seafloor spreading and tectonic activity in Ma. Coloured arrows show the simplified circulation of surface- and deep-water masses (modified from Hernández-Molina et al., 2010, and references therein). MB = Malvinas Basin, MI = Malvinas (Falkland) Islands, MR = Malvinas (Falkland) Ridge, MEB = Maurice Ewing Bank, BB = Burdwood Bank, MC/AAIW = Malvinas Current/Antarctic Intermediate Water, ACC = Antarctic Circumpolar Current, AABW = Antarctic Bottom Water.

2. Geological setting

2.1. Tectonic evolution and regional setting

The Malvinas Basin formed during the Late Triassic-Jurassic break-up of SW Gondwana (Uliana et al., 1989; Urien et al., 1995). The basin is located between a western elevated basement block, the Rio Chico High, and the Malvinas (Falkland) Islands in the east (Fig. 1). It has a triangular shape with a NNW–SSE oriented central axis and is connected in its southwest with the Austral–Magallanes Basin, and in the southeast with the South Malvinas Basin (Fig. 1A). The basins are bounded by a major W–E left-lateral transpressional transform fault in the south. This fault is the result of the transcurrent deformation between the southern oceanic Scotia Plate and the