Etendeka volcanics in Namiba) as well as in the syn- to postrift magmatism across the conjugate margins of Brazil and Namibia-South Africa. The SDRs zone reaches its maximum expression, in both the South American and the West African branches, near the Rio Grande Rise and in the Abutment Plateau, respectively (Gladczenko *et al.*, 1998).

Regionally, the South Atlantic SDRs province seems to have evolved diachronously from south to north. The province accompanies the opening of the South Atlantic Ocean and the formation of the rifted basins of the conjugate margin (Rabinowitz, 1976). The "zipper style" of opening is interrupted by the major continental lineaments, controlling the magma distribution, shifting, and modifying the SDRs architecture (Soto *et al.*, 2011).

The continental lineaments have been interpreted as weakness zones of inherited basement fabrics, probably in connection to the modern oceanic fracture zones (Hinz *et al.*, 1999; Franke *et al.*, 2002, 2007). The lineaments divide the margins into elongated segments of 4000 km long and 50 to 100 km wide. The volcanic activity inside each segment appears to have developed temporally and volumetrically from south to north in a cone-shape distribution pattern (Hinz *et al.*, 1999; Franke *et al.*, 2002, 2007; Mohriak, 2001; Soto *et al.*, 2011) and is associated with oceanic propagators as defined by Hey, 2004. This mechanism repeats systematically in each segment, indicating an intermittent rifting propagation (Hinz *et al.*, 1999; Franke *et al.*, 2002, 2007). But in the proximity to the Rio Grande Rise and the Abutment Plateau, the conic shape distribution inverts, displaying an increase in magma volume from south to north (Gladczenko *et al.*, 1997, Stica *et al.*, 2013). The lithospheric stretching and adiabatic decompression is considered the main source of this voluminous magmatism (Hinz *et al.*, 1999; Franke *et al.*, 2002, 2007), except for the area under the influence of Tristão da Cunha plume, as observed in the magmatic distribution map of Pelotas basin (Fig. 4).

In the Torres Arch area, in southern Santos basin, the South American SDRs province is almost in physical continuity with the Paraná continental flood basalts province (Figs. 1, 2, and 4). In the area of study, the Pelotas volcanic province segment covers an area of 150,000 km^2 (Fig. 4). The magmatic activity in the Pelotas basin increases oceanward, as opposed to the landward increase in activity of the volcanic flows of the Paraná continental flood basalts. This change in thickness indicates a major tilting in the area of deposition of the lava flows. Although both provinces (Paraná and Pelotas) share geochemical affinities such as low and high TiO$_2$ tholeiitic suites (Lobo, 2007), the Pelotas volcanic province is younger than the main volcanic activity of the Paraná continental flood basalts (Fig. 3). This is also corroborated by seismic interpretation of the seaward-dipping reflector wedges which feather out towards the upper part of the syn-rift troughs along the continental margin.

The Pelotas Basin

The Pelotas basin is located between 29° to 36.5° of latitude south and 43.5° to 53.5° of longitude west, extending from the southern coast of Brazil to the northern coast of Uruguay (Fig. 2). The basin is separated from the Santos basin (Brazil) by the Florianópolis Fracture Zone to the north, and from the Punta del Este basin in the south by the Cabo Polonio High in Uruguay (Figs. 1 and 2). The basin is bounded to the west by the Paleozoic Paraná basin and by the Don Feliciano Precambrian onshore belt (G2 on Fig. 2). The basin covers an estimated area of about 226,000 km^2. It is characterized by a limited onshore area of sedimentary outcrop, but the majority of the basin is offshore, extending to water depths up to of 4600 meters beyond the continental-oceanic crust boundary (Fig. 2). The Pelotas basin can be sub-divided into the northern, central, and southern sub-basins based on geological variations in the width, along the strike, of the seaward dipping reflectors zone (Fig. 4); the proposed sub-basin boundaries are the Porto Alegre and the Chui fracture zones (Bassetto *et al.*, 2000; Vital Bueno *et al.*, 2007; Stica *et al.*, 2013).

The Pelotas basin exhibits distinctive geological features that allow its differentiation from the neighboring basins:

- The presence of a volumetrically significant synrift and postrift volcanism, including seaward dipping reflectors (SDRs);
- A subordinate presence of terrigenous Early Cretaceous synrift deposits, which infill narrow lacustrine troughs along the proximal continental margin;
- Scarcity of evaporite deposits, except for anhydrite in the northern region (*i.e.*, at the Florianópolis platform, Fig. 2);
- Important marine sediment accumulation, reaching maximum thickness in the Rio Grande Cone area, in the central to southern segments of the basin (Fig. 2), where a thick depocenter exceeding 4000 m in thickness formed in the Miocene (Saunders and Bowman, 2014).

The crystalline basement in the offshore Pelotas basin likely consists of the Precambrian Don Feliciano mobile belt from the Mantiqueira Province (Heilbron *et al.*, 2004). This basement crops out along the southeast Brazilian coast, from Santos to Pelotas basins, extending to the west and probably occurring underneath the eastern edge of the Paleozoic Paraná basin (G2 on Fig. 2). The Don Feliciano mobile belt comprises igneous and high grade metamorphic poly-orogenic rocks, developed from Neoproterozoic to Ordovician times (Heilbron *et al.*, 2004).

The South America and African breakup magnetic anomalies (EMAG2; Maus *et al*, 2009) are well delineated in the satellite magnetic map offshore southeast Brazil (Fig. 5). In this map, it is possible to define four linear magnetic anomalies that may correspond to anomalies LMA, M4, M2, and M0, with ages estimated around 133 Ma, 130 Ma, 127 Ma, and 126.7 Ma, respectively (Moulin *et al.*, 2010). The eastern boundary of the LMA anomaly coincides with the 'G anomaly' of Rabinowitz and Labrecque (1979), initially interpreted as the boundary between continental and oceanic crust. The LMA magnetic anomaly has more recently been interpreted to be related to the prebreakup basalts of the Paraná continental flood basalts (Moulin et al., 2010; Stica *et al.*, 2013), and the M4 to M0 anomalies have been used to demarcate the ocean crust boundary (Moulin *et al.*, 2010; Blaich et al., 2011).

In the sedimentary section of the Brazilian Atlantic rifted margin, four main tectonic-stratigraphic units are recognized (Chang *et al.*, 1992; Mohriak, 2003). They are known as prerift, rift, transitional, and postrift megasequences. The prerift megasequence is composed of Paleozoic and Mesozoic sedimentary and volcanic rocks from the Paraná basin. Outcrops from this megasequence are recognized in the Torres syncline area (Fig. 2). In this area, the Paleozoic section of the Paraná basin is covered by the Cenozoic sediments from the Pelotas basin (Dias *et al.*, 1994). The Neocomian-Barremian synrift megasequence is characterized by antithetic faults and half graben filled by siliciclastic deposits and lavas (Dias *et al.*, 1994). Towards the eastern margin of the basin, several wedges of seaward dipping reflectors occur from the platform to the ultradeep water province (Stica *et al.*, 2013). The transitional (evaporitic) megasequence exhibits a very restricted distribution, and is only found in the Florianópolis platform region (Fig. 2). This unit consists of anhydrite and it has been penetrated by a few exploratory wells that drilled trachyandesite layers underneath the evaporites (Dias *et al.*, 1994). The postrift megasequence consists of marine strata deposited from the Albian onwards.

The seismic volcano-stratigraphy of Pelotas basin

This study of the Pelotas basin volcanism is based on regional interpretation of seismic data and well records. Today, 20 boreholes have been drilled in the basin and some of them have sampled sills and lava flows (Figs. 2 and 8). The good quality deep crustal seismic sections available in the area allow the interpretation of ten volcanic units in the transition from the continental to the oceanic crust. The volcanic units identified are named as units "A," "B" to "F," "G1," "G2," "H," and "I" (Table 1), and additionally, three deep seismic facies are recognized and interpreted as the reflection Moho, the continental crust and the typical oceanic crust. The identification of the different volcanic units is based on the differences in the dips of the reflectors and in the onlap-offlap relationships among the reflectors packages.

The volcanic activity in the area of study has a geographical and temporal evolution that indicates a physical linkage between the Paraná continental flood basalts and the Pelotas volcanic province near the Torres syncline (Fig. 4). Volcanism in the Paraná basin (Paraná continental flood basalts) began during a prerift stage (Late Jurassic–Early Cretaceous). The deposits increase in thickness landwards (towards the intracratonic basin depocenter). Later, a major tilting changed the distribution of these volcanic deposits, probably due to the initiation of the Pelotas basin rifting process in the Early Cretaceous. The Paraná basin lavas (Serra Geral Formation) are covered by the first volcanic units of the Pelotas volcanic province (volcanic unit "A"), indicating a shifting of the depocenters from land to ocean. Subsequently, very pronounced wedges of SDRs have developed from shallow to deep waters as a consequence of the evolution of the rifting process (volcanic units "B" to "F"). Finally, the magmatic activity decreased with the deposition of the volcanic unit "H," which sealed the previous volcanic wedges, marking the late rift/post rift tectonic control of the volcanic distribution (Table 1, Fig. 4).

Volcanic unit "A"

Volcanic Unit "A," also known as the Imbituba Formation in the formal stratigraphic column of the Pelotas basin (Vital Bueno *et al.*, 2007), has been sampled and cored by the exploratory well 1-RSS-3RS, which drilled 810 meters of amygdaloidal basalt (Table 1). The unit is located in the western part of the basin and is believed to correspond to subaerial lava flows, according to cutting and well core descriptions (Figs. 2 and 6 to 9). This unit exhibits a maximum seismic thickness of 345 msec (approximately 600 m using the well log velocity) and a map view distribution highlighted by the blue polygon in Figure 4, extending from the southern Santos basin to the boundary with the Punta del Este basin offshore Uruguay. The depositional style of the volcanic unit "A" is characterized by sheet drape external form having parallel to sub-parallel reflector patterns. But locally, this unit displays wedges with divergent seismic patterns in half-grabens, which are bounded by a counter- regional normal fault system, indicating the initiation of the rift phase by extensional faults that mainly dipped landwards (Figs. 6 and 7).

The gamma ray and sonic logs of well 1-RSS-3RS display important alternations of high and low log values that may be interpreted as compositional changes or differential weathering affecting the basalt layers. For example, the sonic velocity log exhibits interval changes that range from 3900 to 5900 m/s (Fig. 9 and Table 1).

Geochemical and geochronological analysis performed in the 1-RSS-3RS lower cored section (at 3800-3907 m) indicates ages of 125.3± 0.7 Ma (^{40}Ar/^{39}Ar) and 124± 8.6 Ma (^{39}K/^{40}Ar) (Mizusaki, 1990; and Lobo, 2000). Compositionally, this unit has an alkaline affinity and high TiO_2 content (Lobo, 2000 and 2007). Recently, this unit has been considered an equivalent of the Paraná continental flood basalts (Stica *et al.*, 2013), but the geochronological record (Fig. 3), and in addition, the shift in the distribution of the lava flow depocenters, do not allow this correlation (Misuzaki and Saracchine, 1990; Lobo, 2007).

Volcanic units "B"-"F"

The volcanic units "B" to "F" comprise sets of volcanic wedges in the Pelotas basin which have an internal divergent reflection patterns that dip seawards (Figs. 6, 7, and 9). The wedges progressively become younger to the east and have been interpreted as seaward dipping reflectors (SDRs) by Fontana (1996), Abreu (1998), and Talwani and Abreu (2000). The differences in structural dips and reflection terminations, among the wedges, allowed the subdivision of the main SDRs package into Units "B" to "F" (Fig. 6 and Table 1). The Units "B" to "F" are not affected by the initial rift tectonism, but the change in the reflector dips and the onlap relationship reflects different structural stages during the deposition of the flows. These units are likely to have been deposited in subaerial to submarine environments during the last rifting phase.

Approximately 300 meters of Unit "C" have been drilled by the exploratory borehole 2-BPS-6BP, corresponding to amygdaloidal (at the top of the layer) and microcrystalline basalts (Fig. 9). Geochemically, the tholeiitic basalts have high TiO_2 contents (Lobo, 2007).

The radiometric age reported by Lobo (2007) does not agree with the seismic stratigraphy analysis. The averages of 16 fractions of 40Ar/39Ar of well 2-BPS-6-BP (sampled at 6161 m) indicate an age of 75 ± 0.8 Ma, much younger than expected. The last two fraction analyses indicate an age of 138±5 Ma, and Lobo (2007) believed this calculated age is representative of this volcanism, considering it equivalent with the Paraná continental flood basalts main tholeiitic flows of the Serra Geral Formation (139 to 127 Ma; Gibson *et al.*, 2006). In our opinion, this age is not consistent with the seismic stratigraphy relationship observed in the area. The clear onlap relationship of the SDRs wedges of volcanic units "B" to "F" onto the older Unit "A" (125.3± 0.7 and 124± 8.6 Ma) observed in the seismic record does not allow this temporal assignment. These inconsistencies, in addition to the analytical problems, lead us not to consider the radiometric age reported by Lobo (2007) as representative of the SDR wedge drilled by the well 2-BPS-6-BP, which we interpreted bottomed at volcanic unit "C" (Fig. 9).

The sonic log velocity of unit "C" recorded alternation of low/high velocities layers (3900 to 5900 m/sec, Fig. 9 and Table 1). The seismic reflection analysis indicates a variation in thickness of the individual units from about 500 to 1400 msec (approximately from 2 to 3.5 km considering refractions velocities). The SDRs display a lateral-shift stacking depositional pattern and an increase in the magmatic volume from south to north (Figs. 4, 6, and 7; Stica *et al.*, 2013), which differs from the general behavior observed in the southern South Atlantic SDRs province. The SDRs wedges mapped along the coast of Argentina and Uruguay decrease in magmatic volume from south to north, in an opposite