Nd and Pb isotope signatures on the Southeastern South American Upper Margin: Implications for sediment transport and source rocks

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ABSTRACT

Neodymium and lead isotope values in sediment samples were used to interpret sediment transport and source rocks on the Southeastern South American upper margin.

The sediments of the Argentinian margin exhibit an average ε_{Nd} value of -1.9, indicating the influence of the Andean rocks as sediment sources. Sediments from the Río de La Plata estuary show an average ε_{Nd} value of -9.6 which is similar to that of the Southern Brazilian Upper Margin. Finally, sediments of Southeastern Brazil, which are associated with the transport of the Brazil Current exhibit an average ε_{Nd} of –13.0.

The Pb isotope signatures also confirm the differentiation of source rocks in the sedimentation of the study area. In addition, Pb isotopes helped to establish the extent of the influence of the Río de La Plata on the sedimentation of the Southern Brazilian margin.

In terms of Pb isotopes the sediments from the Río de La Plata estuary and Southern Brazil are more radiogenic than those of Southeastern Brazil and the Argentinian margin.

INTRODUCTION

The occurrence of a northward transport of seawater, organisms and sediments along the Southern and Southeastern South American upper margin has been described in recent decades (Etchichury and Remiro, 1960, 1963, 1965; Potter, 1986; Boltovskoy et al., 1996, 2000). This seawater transport, which was previously described as extending as far north as 23°S, was originally attributed to the northward displacement of the Malvinas Current (Stevenson et al., 1998). On the other hand, due to its barotropic character, it seems that the Malvinas Current is unable to penetrate the shallow waters of the Brazilian shelf (Mahiques et al., 2004). More recently the analysis of hydrographic data has led to the more precise description of the shelf water masses involved in water transport which may be used as a reasonable explanation for this northward flow along the shelf (Piola et al., 2000; under review).

Despite the efficiency of this water transport mechanism in differentiating the characteristics of organic matter (Mahiques et al., 2004) as well as in establishing the relative differences in shelf sediment mineralogy (Rocha et al., 1975; Campos et al., under review) as between the sectors to the north and south of 25°S, its effectiveness in transporting sedimentary particles has not yet been adequately assessed.

Due to the rapid incorporation of the river-originated neodymium in the marine sediments (DePaolo, 1988), Nd isotopic composition may be used as a reliable tracer for sedimentary dynamics and sediment provenance and has already been so used in several studies (Vroon et al., 1995; Revel et al., 1996; Parra et al., 1997; Rutberg et al., 2000; Staubwasser & Sirocko, 2001; Ingram & Lin 2002; Weldeab, 2002a; Weldeab, 2002b; Bayon et al., 2003; Douglas et al., 2003; Kessarkar et al., 2003; Weldeab et al., 2003).

In South America, Nd isotope signatures, together with Sr, have been used for the recognition of the source rocks of dust and river sediments (Gaiero et al., 2007), as well as for Southern Ocean circulation (Walter et al., 2000).

Similarly, Pb isotopic composition is frequently used for the recognition of sediment sources, whether lithogenic (Farmer et al., 1993) or anthropogenic (Ferrand et al., 1999, Alleman et al., 2000; Chillrud et al., 2003; Di Lauro et al., 2004).

Despite its potential for studies of source rocks, the joint use of Nd and Pb isotope data is more limited than is the case with the separate use of these isotopes. These data were originally used in deep ocean studies (White et al. 1985; Ben Othman et al., 1989; Abouchami et al., 1999) but more recently have been incorporated into works dealing with continental margin sedimentation (Staubwasser & Sirocko, 2001; Fagel et al., 2002; Farmer et al., 2003).

The aim of this study is to evaluate neodymium and lead isotope signatures as a tool for the characterization of the sediment transport and their source rocks along the Southeastern South American upper margin, between the latitudes 55° and 20°S.

STUDY AREA

The study area constitutes a typical example of a passive margin, presenting one of the widest shelves in the world (Figure 1).

Morphology

The Argentinian shelf, formerly denominated “bonaerense-patagónica”, is characterized by a gentle slope and the absence of conspicuous relief (Parker et al., 1997). It presents four terraces, located, respectively, at 25-30m (I), 85-95m (II), 110-120m (III) and 130-150m (IV) depths, which have been related to Plio-Pleistocene sea-level stands (Groeber, 1948). The shelf break is located at depths varying from 110 to 165 meters.

The morphology of the Brazilian shelf between the latitudes of 30°S and 35°S has been studied by Correa (1996), who identified nine breaks in the shelf slope and correlated them with periods of stable sea-level. Four of these events, at 130, 70-60, 45-32 and 25-20 meter depths were dated by him, respectively, 17,500, 11,000, 9,000 and 8,000 years B.P.

Sedimentology

According to Parker et al. (1997) the Argentinian shelf is mainly siliciclastic, covered by relict sediments which have been deposited in littoral, barrier and estuary environments and reworked during the several Cenozoic transgressive-regressive events. About 65% of the Argentinian shelf is covered by sands, corresponding mainly to well sorted fine sands, with subordinate very fine and medium fractions and variable gravel and mud content. Gravels and shells cover approximately 25% of the shelf surface. Their distribution is irregular, shells dominating the sector northward to the 43°S parallel and gravels the Southern sector. The shells are related to relicts of former coastlines presently submerged, lying more or less parallel to the present coast. Gravels form extensive sheets of unconsolidated material, probably of fluvio-glacial origin, and are distributed from the Patagonian river mouths oceanwards.

Mud, represented by clayey-silts, sometimes resuspended, covers an area of 8% of the surface. It is concentrated in the proximity of the Río de La Plata as well as in semi-enclosed areas close to the coast. A small amount is found on the outer shelf. Finally, outcrops of volcanic, metamorphic and sedimentary rocks are found, though not exceeding 2% of the surface area.

The mineralogical characteristics of the Argentinian shelf have been studied by various authors (Etchichury and Remiro, 1960; 1963; Cortelezzi et al., 1971; Gelós & Chaar, 1988), all of whom are in agreement as to the influence of the pyroclastic and volcanic sediments of Pampean-Patagonian origin in the sedimentary processes. These sediments are mainly of andesitic and basaltic origin, as well as being derived from rhiolites and porphyres. Less influence has been exercised by metamorphic and plutonic rocks.

Etchichury and Remiro (1960) recognized a sedimentary input from the Uruguay basement, reaching as far south as latitude 35°S, although some other studies suggest that this influence extends down to 43°S (Marcolini, 2003). The Pampean-Patagonian sediments which originated further south were considered to have been transported northward by the Malvinas Current, reaching the Río de La Plata estuary and even the Southern Brazilian shelf (Etchichury and Remiro, 1963; 1965).

A compilation of information taken from several authors (Pierce and Siegel, 1979; Gaiero et al., 2003; Isla and Cortizo, 2005) indicates that on the Patagonian coast only 3% of the sediment input to the shelf is from fluvial action, the most important contributors being coastal erosion and dust transport by the wind.

The Southern and Southeastern Brazilian shelf has been extensively studied since the 1970´s. As a rule, most of the papers published suggest that the sedimentary cover of the area is characterized by relict and palimpsest facies, with a limited modern contribution (Kowsmann & Costa, 1974; Milliman, 1975; Rocha et al., 1975). This interpretation is based mainly on the almost total absence of significant fluvial input between 22°S and 34°S. More recently, Mahiques et al. (1999; 2004) and Figueira et al. (2006) have, however, reassessed the importance of the modern sedimentation on the Southeastern Brazilian shelf.

In Southern Brazil the inner shelf sediments are composed mainly of sand and gravel, which together usually constitute more than 50% of the sediment. Silts and clays are predominant on the middle shelf, between the 50 and 100 meter isobaths. An increase in sand and gravel is seen on the outer shelf, sometimes accounting for more than 75% of the sediment distribution. The calcium carbonate content presents a northward trend of increasing values, especially on the outer shelf (Rocha et al., 1975). The organic matter shows a clear differentiation as between the sediments sampled northward and southward of latitude 25°S, due to the extent of the northward penetration of cold, less saline waters from the Río de La Plata and the Southern Brazilian lagoons on to the Southeastern Brazilian shelf (Piola et al., 2000; Mahiques et al., 2004).

The Río de La Plata estuary

The Río de La Plata constitutes the final outlet of the second largest river system in South America, covering an area of about 3,200,000 km^2. Two main basins, the Uruguay and the Paraná, this later

composed of the Paraguay and the Upper Paraná subbasins, contribute with almost 100% of the water discharge to the estuary (Henry et al., 1996, López Laborde, 1997). The Uruguay basin is the smallest in area, covering an area of 8% of the total drainage area, consisting mainly of tholeitic basalts, sedimentary rocks and alluvial sediments, and accounting for 22% of the mean water discharge to the estuary. The Paraguay subbasin (35% of the area and 16% of the water discharge) drains several types of rocks, from Precambrian metamorphic to Quaternary sediments, including Paleozoic and Mesozoic sedimentary rocks. Attention should be given to the Bermejo river, one of the Paraguay's tributaries, which covers an area equivalent to less than 5% of the total drainage area but responsible for more than 40% of the suspended load discharge to the Río de La Plata estuary. Finally, the Paraná subbasin (27% of the area and 56% of the river discharge), drains Paleozoic-Mesozoic sedimentary rocks, with intercalated basalts, and supported by crystalline rocks on the boundaries of the Paraná Sedimentary Basin. The fine sediment distribution in the estuary is confined to its upper and middle sectors, sands occurring in the outer estuary and on the adjacent shelf. A mixed facies extends towards the north, separating the muddy and sandy facies and correlating to the former river valley (López Laborde, 1997).

Values of river discharge and present sediment load have been summarized by Nagy et al. (1997) and present an average water volume discharge of 25,000 $m^3.s^{-1}$ and a suspended sediment load varying from 40 to 225 $mg.l^{-1}$. The same authors report the ocurrence of northward outflows of very turbid waters along the Uruguayan coast, associated with low salinity plumes, and related to violent flooding occurring in the catchment basins.

MATERIALS AND METHODS.

Fifty-three surface sediment samples from the south-eastern South-American upper margin, ranging from the Argentinian shelf, from as far south as 46°S, up to Southeastern Brazil, as far north as 22°S, were used for the analysis of neodymium isotopes (Figure 1, Table 1). Samples from the Río de La Plata estuary were also included in this study. We also incorporated the Nd isotope results of six samples reported by Basile et al. (1997), five being from the Argentinian Shelf and one from the Río de La Plata estuary, leading us to extend the study area to as far south as 55°S. Twenty-eight sediment samples from the same latitudinal ranges were used for the characterization of the lead isotopic values.

The samples were separated into four main groups, i.e. Argentina, the Río de La Plata Estuary, Southern Brazil and Southeastern Brazil. The limit between Southern and Southeastern Brazil was set at 25°S, based on previous geochemical studies (Mahiques et al., 2004; Figueira et al., 2006).

The Nd and Pb isotopic analyses of the bulk lithogenic fraction were carried out at the Geochronological Research Center of the University of São Paulo, Brazil. The Nd analyses, referred to as ε_{Nd}, were prepared by standard methods in accordance with the analytical procedures described by Sato et al. (1995), involving the removal of calcium carbonate, HF-HNO_3 dissolution plus HCl cation exchange, using a Teflon Powder column to separate ETR. No visible solid residues were observed after dissolution. Samples with incomplete dissolution were discarded. Nd ratios were normalized to a $^{146}Nd/^{144}Nd = 0.72190$. The averages of $^{143}Nd/^{144}Nd$ for La Jolla and BCR-1 standards were 0.511847 ± 0.00005 (2σ) and 0.512662 ± 0.00005 (2σ), respectively. The blanks indicate less than 0.03 ng. Nd isotopic analyses were carried out with a multicollector Finnigan-MAT 262 mass spectrometer.

For the Pb isotopic analyses, each sample was washed ultrasonically in triple distilled water before chemical attack. The sediment was totally dissolved using 3 ml of 6N HCl plus 2 ml of HNO_3 with Parr type pumps and then dissolved in 2 ml of 0.7N HBr. Afterwards the sample was passed through an ion exchange column holding Dowex 1X8 AG anion exchange resin. After the treatment of the column the solutions were brought to dryness and the residues dissolved in 0.7N HBr and passed again through the same (Dowex 1X8 AG) ion exchange column described above. Pb was separated using HBr + HCl chemistry in Dowex 1X8 AG ion exchange resin. Lead was loaded onto a Re ribbon, using silica gel plus H_3PO_4 and analyzed by a fully automatized VG 354 Micromass multicollector thermal ionization mass spectrometer. Analyses of the "National Bureau of Standards" standard NBS 981 yielded mass

discrimination and fractionation corrections of 1.0024 ($^{206}Pb/^{204}Pb$), 1.0038 ($^{207}Pb/^{204}Pb$) and 1.0051 ($^{208}Pb/^{204}Pb$); the combination of these uncertainties and within-run uncertainties are typically 0.15% - 0.48% for $^{206}Pb/^{204}Pb$, 0.13% - 1.07% for $^{207}Pb/^{204}Pb$ and 0.10% - 0.45% for $^{208}Pb/^{204}Pb$, all at the 2σ (95%) confidence level. The total Pb blank contribution, < 1 ng, is negligible.
Replicates of Nd and Pb analyses were carried out on selected samples.
Grain size was determined from decarbonated samples in a Malvern Mastersizer 2000 analyzer.

RESULTS AND DISCUSSION

The Nd and Pb isotopic compositions are presented in Table 1.

Latitudinal variations

There are conspicuous latitudinal variations in the Nd isotopic signatures in the study area (Figure 2). In the Argentinian sector ε_{Nd} values, calculated to the present day, vary from -0.1 to -4.0 (mean = -1.9, σ = 1.2, n = 11), with a slightly increasing trend in values towards the North. The Río de La Plata estuarine sediments exhibit ε_{Nd} values ranging from -8.2 to -10.3 (mean = -9.6, σ = 0.7, n = 12) and similar behaviour is observed in the sediments from Southern Brazil (mean = -9.3, σ = 0.9, n = 18). In the northernmost sector of the study area, the sediments from Southeastern Brazil show a sharp northward decrease in ε_{Nd} values, ranging from -9.9 to -17.1 (mean = -13.0, σ = 2.1, n = 18). There is an apparent gradient in the ε_{Nd} values, which increase towards the South. This trend indicates different sources for the sediments, with the northernmost source-rocks exhibiting more negative ε_{Nd} values.
Despite their being less conspicuous, the Pb isotope data (Figures 3 to 5) also present some differentiations between the sectors considered in this study. Samples from Southern Brazil, the Río de La Plata estuary and Argentina present very homogeneous Pb isotopic compositions. Samples from Southern Brazil exhibit slightly more radiogenic average values ($^{206}Pb/^{204}Pb$ = 18.643±0.079, $^{207}Pb/^{204}Pb$ = 15.677±0.044, $^{208}Pb/^{204}Pb$ = 38.782±0.163, n = 15), followed by sediments from the Río de La Plata Estuary ($^{206}Pb/^{204}Pb$ = 18.667±0.058, $^{207}Pb/^{204}Pb$ = 15.645±0.010, $^{208}Pb/^{204}Pb$ = 38.700±0.078, n = 3), Argentina ($^{206}Pb/^{204}Pb$ = 18.620±0.104, $^{207}Pb/^{204}Pb$ = 15.615±0.016, $^{208}Pb/^{204}Pb$ = 38.520±0.149, n = 5). Samples from Southeastern Brazil show the least radiogenic signatures of the whole data set ($^{206}Pb/^{204}Pb$ = 18.389±0.230, $^{207}Pb/^{204}Pb$ = 15.606±0.009, $^{208}Pb/^{204}Pb$ = 38.407±0.255, n = 5). As distinctive features we may observe the displacement of the Pb isotopes of the samples from S Brazil, between 27°S and 25°S, towards more radiogenic values; at 25°S we observe a break in the Pb isotope trends. Thus, the possibility of mixing populations as between Southern and Southeastern Brazil may be discarded but, on the other hand, there seems to be a mixture of sources for the Southern Brazil sediments, from the Río La Plata estuary up to 27°S.

Bathymetry and grain-size relationships

Plots of isotope values versus water depth (Figure 6) indicate the lack of bathymetric control over the isotope distribution, meaning either that this water transport model is valid up to the upper slope or that the cross-shelf processes are effective throughout the study area.
With the exception of a few samples in the Argentinian and SE Brazil sectors and half of the samples from S Brazil, most of the material analysed in this study is composed of silts. The amount of clay varies from less than 1.0% in samples from S and SE Brazil to around 20.0% in the sediments from the Rio de La Plata estuary. Differently from what was observed by Innocent et al. (2000), we did not find statistically significant correlations between grain size parameters and isotopic values in any of the sectors considered, as exemplified in the plots of clay content versus ε_{Nd} and Pb isotopes (Figure 7), although we may recognise a slight trend in increasing values of $^{206}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$, coincident with finer sediments.

Source Rocks

Nd versus Pb binary plots (Figure 8) allowed us to recognize different sources from the sediments in the study area. The present day ε_{Nd} values of around -1.9, calculated for the sediments from the

Argentinian area, suggest the younger Andean volcanic rocks as the main source for the sediments analysed. Assuming that there is no contribution of neodymium from the Pacific Ocean to the Atlantic Ocean through the Drake Passage (Piepgras and Wasserburg, 1982), we recognize that the wind regime or even the rivers of Southern Argentina may act as important contributors of sediments from terrains essentially different than those of the Río de La Plata basin, as originally stated by Potter (1986). A comparison of our ε_{Nd} data with those of the Patagonian materials reported by Basile et al. (1997) and Gaiero et al. (2007) allows the establishment of such a correlation, despite the fact that the loess Nd isotope signatures presented in Basile´s work may be significantly higher than our data for the Argentinian upper margin. On the other hand, the Patagonian river bed sediment Nd signatures reported by Gaiero et al. (2007) are consistent with the values obtained in this study. Based on Nd and Sr isotopic data, these later authors suggest that there may e a relative uniformity in the dust exported from Patagonia, by virtue of the efficacy of the westerly wind regime in redistributing fine fractions. Our data indicate that, despite slight isotopic differences between dust and coarser sediments (dust being more radiogenic), this signature uniformity may be extended to the sediments of the Argentinian upper margin, from 55°S to 37°S, suggesting that an effective hydrodynamic system may also be active in sediment redistribution.

Henry et al. (1996) analysed Nd and Sr isotopes in the dissolved and suspended loads of the Uruguay and Paraná rivers, leading to significantly different signatures between the two basins. In terms of the ε_{Nd} of the suspended load, the authors discovered values ranging from -6.0 to -6.7 in the Uruguay's waters and from -10.3 to -11.0 in the Paraná's waters. This difference between more and less radiogenic values has been attributed to the influence of the tholeitic basalts, in the Uruguay basin, and to Paleozoic rocks, in the Paraná basin.

In view of the river discharge contribution from each of the basins to the Río de La Plata estuary we may consider that our values represent the weighted contribution of each of the sources to the isotopic signature. The authors also estimated a ε_{Nd} mean value of -10.2 at the entrance and -8.3 at the exit of the estuary to the ocean. Concerning this aspect, our results of $\varepsilon_{Nd\ in}$ in the lower estuary, ranging from -8.2 to -10.3 (mean of -9.6), as well as the lack of any geographical gradient along the estuary, suggest that the Nd isotopic enrichment along the estuary is not as effective as the authors quoted supposed.

Sediments from the Southern Brazil sector exhibit a mixture of sediment materials originating in the Río de La Plata estuary with older, UCC rocks. This may be confirmed by the intermediate ε_{Nd} and high Pb radiogenic values, comparable to the UCC values reported by Millot et al. (2004).

Finally, sediments from the Southeastern Brazil sector exhibit a lesser radiogenic Nd isotopic composition, as is typical of sediments derived from Upper Continental Crust associated rocks and/or rocks with longer crustal residence life.

In another approach to the interpretation of our data as regards potential source rocks we compared them with the lead isotopic compositions available for: fluvial sediments and pre-cambrian galenas from Southern Brazil, located approximately at 25°S – 48°W (Tassinari et al., 1990; Daitx et al., 1996; Moraes, 1997), sedimentary and igneous rocks from the central Peruvian Andes (Gunnesch et al., 1990), South American and African Upper Continental Crust-originated river sediments (Millot et al., 2004), mantle-derived low-TiO_2 flood basalts of the Paraná Magmatic Province (Marques et al., 1999), and a pelagic clay sample collected on the Rio Grande Rise (Ben Othman et al., 1989). Our data were also compared with the Pb isotopic evolution curves of the Plumbotectonics Model (Zartman and Doe, 1981) (Figure 9).

In the uranogenic $^{207}Pb/^{204}Pb$ versus $^{206}P/^{204}P$ diagram (Figure 8a), all of the Pb isotopic compositions plot above the orogenic curve, indicating an upper crustal composition for all of the sediment sources. Moreover, the sediments from the S Brazil sector present the most radiogenic isotopic composition, as regards the $^{207}Pb/^{204}Pb$, being located above the Upper Continental Crust curve of the Plumbotectonics Model. The Pb isotopic trend of the Río de La Plata estuary and S Brazil represents a mixed line between at least two end-members, both with UCC characteristics.

In the thoriogenic diagram (Figure 8b), all of the samples plot above the orogenic curve, and closer to the basalt field, which suggests that the continental sources present slightly higher Th/Pb ratios than the Th/Pb Upper Crustal average values.
Marques et al. (1999), on the basis of several element and isotopic data, recognized a mantle source for the basalts of the Paraná Magmatic Province. Our data indicate that of the four main types of basalt reported by the authors, the Low-Titanium Basalt of the Southern Paraná Magmatic Province may be considered as a potential source for the sediments of the Río de La Plata Estuary as well as for the Southern Brazil sector as far north as 28°S. In fact, most of the Río de La Plata system, especially the Paraná River, drains the rocks of the Southern Paraná Magmatic Province.
Sediments of the Southern Brazil sector exhibit a mixture of sediment materials originating from the Río de La Plata Estuary with older, Upper Continental Crust (UCC) rocks. This may be confirmed by the intermediate ε_{Nd} and higher radiogenic Pb values, comparable to the UCC values reported by Millot et al. (2004), as well as to the UCC curve presented in the $^{207}Pb/^{204}Pb$ vs. $^{206}Pb/^{204}Pb$ diagram of the Plumbotectonic model by Zartman and Doe (1981). Finally, the sediments of the Southeastern Brazil sector exhibit the lowest ε_{Nd} and least radiogenic Pb isotope values, leading us to recognize a contribution of U-depleted granulitic rocks from deeper crustal levels as source rocks for the sediments of this sector, possibly resulting from the transport of sediments originating in the erosion of the Brazilian Shield.

Ocean circulation and isotope signatures
The binary Nd-Pb plots (Figure 7) may also be used for the reconaissance of three different isotopic populations and their relationship with the main hydrographic systems acting over the study area. The Subantarctic Shelf Water (SASW) is a cold, fresh water mass arising from the dilution of the Subantarctic Water in the Southeastern Pacific which encounters the Argentinian shelf around 55°S (Piola et al., 2000). Our εNd data suggest that this water mass acts at least up to 38°S and indicate that the sediment samples from the Argentinian sector constitute a population essentially different from that located further north, which reinforces the conclusion that, as stated by Piola et al. (op.cit.), there is no mixing of this water mass with that of the Subtropical Shelf Water (STSW).
From the Río de La Plata Estuary a low-salinity tongue, called Plata Plume Water (PPW), extends northward, with its limits clearly determined by the wind regime (Möller Jr. et al., under review). Both the STSW and PPW may be considered responsible for the Pb and Nd isotopic characteristics of the Southern Brazil sediments. The similarity of the Río de La Plata sediments to those of Southern Brazil located southward of 28°S is a clear indication of the influence of this low salinity plume. There is a recognizable sediment mixture, from this latitude up to 25°S, and this may be taken to represent the transition between the PPW and the STSW.
Frenz et al. (2003), analyzing sediment chemistry and establishing an end-member model of grain-size, in samples from the continental slope off the study area, recognized a clear division of coarse-grained and carbonate-depleted sediments in the south and finer-grained and carbonate-rich sediments in the north. Those authors demonstrated a terrigenous influence of the Río de La Plata as far northward as 32°S, corresponding to the present position of the Brazil Malvinas Confluence. Our data indicate that, at least for the shelf and upper slope (up to 500 meters depth), the limit between the Tropical and Subtropical domains, as well as the extension of the Río de La Plata flow, may be considered to lie farther north than was suggested by the authors quoted.
Northward from 25°S another break in both Nd and Pb isotopic signatures marks the limits of the sector dominated by the southward flow of the Brazil Current, transporting Tropical Water and South Atlantic Central Water (Castro Filho et al., 1987).

CONCLUSIONS

The neodymium and lead isotopic compositions of the surface sediments of the Southeastern South American upper margin have here been used as reliable proxies for the identification of source rocks and sediment transport.

The sediments of the Argentinian shelf exhibit high values of ε_{Nd}, ranging from -0.1 to -4.0, with an average value of -1.9. These, together with Pb isotope data, may be interpreted as showing that the Andean rocks may be considered as source rocks for this area, as stated by previous works. The relative homogeneity of the isotopic signatures of this area may be an indication of the effectiveness of the Subantarctic Shelf Water in sediment redistribution. For finer sediments, this homogeneity was attributed to the effectiveness of the westerly winds in transporting dust from the Andean chain to the South Atlantic. There is no mixing of sediments as between those in this area and those located further northwards.

Sediments from the Río de La Plata estuary show an average ε_{Nd} value of -9.6 which is similar to that of those of the Southern Brazil sector (-9.3). Nevertheless, our Pb isotope data suggest that this similarity can be traced only up to 28°S, the sediments located further north exhibiting more radiogenic Pb values. Basalts from the Paraná Magmatic Province may be identified as potential partial source rocks for the sediments from the Río de La Plata as well as from the Southern Brazil sector located southward to 28°S. Thus we may use the Pb isotope signatures to establish the northward limit of the Plata Plume Water (PPW). Between 28°S and 25°S, Nd and Pb isotopes suggest that the sediments are derived from older, upper crustal rocks.

Finally, sediments from Southeastern Brazil exhibit the lowest average ε_{Nd} (-13.0) and the least Pb radiogenic values in the study area. These sediments possibly originated in the erosion of the Brazilian Shield and are carried by the southward flow of the Brazil Current, which transports the Tropical Water and South Atlantic Shelf Water.

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