Clean and well sorted sands in the deep Argentine Basin (SW Atlantic): the role of the Antarctic Bottom Water

Graziella Bozzano[1], Roberto A. Violante[1] and José Luis Cavallotto[1]

1 Servicio de Hidrografía Naval, Sección Geologia Marina, C1270ABV Buenos Aires, Argentina. gbozzano@hidro.gov.ar

Abstract: *A thick deposit of clean and well sorted quartz-rich sand found in the Argentine Basin (SW Atlantic) at about 5300m water depth is interpreted as a contourite drift. A set of cores from the Argentine basin, continental rise and slope have been studied to reconstruct the source-to-sink route of these sediments. The region of Bahia Blanca is proposed as the probable source area. Sediments were transferred to the continental rise within downslope gravity flows, captured by the Antarctic Bottom Current and transported to the deep basin. The fine components of the sediment were removed by bottom flows acting in the deep basin, leaving a lag of sand.*

Key words: *SW Atlantic, Argentine Basin, deep sands, AABW.*

INTRODUCTION

The occurrence of extensive, several meters thick deposits of clean and well sorted sand have been observed recently at the deep oceans (Rebesco et al., 2014). In the Argentine Basin, at ~ 5300m water depth, accumulation of sand were first identified in the seventies and interpreted as turbidites associated with the downslope processes of the adjacent margin (Ewing and Lonardi, 1971). Now, we revisited this interpretation on the basis of (1) current knowledge on contouritic processes acting at the Argentine margin (e.g. Hernandez-Molina et al., 2009), (2) increased understanding of the sediment facies draping this margin (e.g. Bozzano et al., 2011), and (3) an integrated view of the role of bottom currents and benthic storms in altering the sedimentary processes. The objective of the study is to identify the source area of the sands lying on the deep basin and to reconstruct their source-to-sink route.

STUDY AREA

This study is focused on the Argentine margin and basin, between Bahia Blanca (BB) and Mar del Plata (MdP) locations. Here, the shelf is 350-400km wide; the slope is dissected by the Mar del Plata and Bahía Blanca canyon systems; the continental rise ranges from 4000 to 5000m and the Argentine Basin depths exceed 5000m (Fig. 1). The margin is swept by south-originated waters (Malvinas current, Antarctic Intermediate and Bottom Waters), flowing toward the north and by the Brazilian current and North Atlantic Deep Water that flow to the south. The basin is between the mean frontal positions of the Brazil and Malvinas Current Extensions (40°S), where both currents flow to the east (Reid et al., 1977).

MATERIAL & METHODS

Four cores were collected by the Argentine Navy Hydrographic Survey (SHN): one in the deep basin (C5, at 5283m), one in the BB continental rise (C9, at 4534m), and two in the BB lower slope (T407, at 1960m and T409, at 2638m). The lithological information stored at GeoMapApp (http://www.geomapapp.org) on several other cores located in the same area was also used (Fig. 1). Grain-size analyses were performed on discrete samples from SHN cores with a CILAS laser particle size analyzer at the University of Buenos Aires and sand fraction composition was determined under a binocular. The surface of 10-20 quartz grains from selected samples will be investigated under a Scanning Electron Microscopy at the University of La Plata. Other cores from BB slope and rise hopefully will be obtained in an oceanographic cruise planned for June-July 2014.

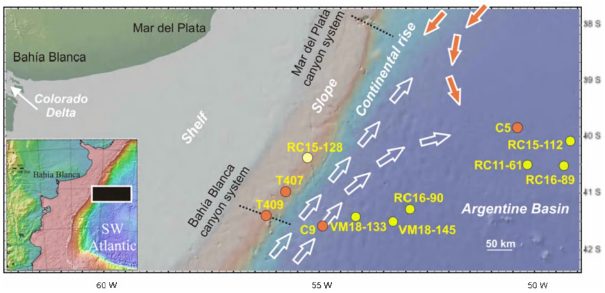

FIGURE 1. The study area with location of SHN cores (red dots) and other cores (yellow dots). Surface circulation is shown by white (Malvinas Current) and red (Brazilian Current) arrows.

RESULTS

Deep basin. Core C5 is formed by clean and well-sorted fine sand dominated by quartz grains. Medium and coarse sand proportions increase from top to bottom (10-40% respectively). Among other cores located nearby, we found that core RC11-61 displays medium to coarse grained quartz and that cores RC15-112 and RC16-89 also contain sand with thickness of up to 7 meters in core RC15-112.

Bahia Blanca continental rise. Core C9 is dominated by fine sediments with a lens of fine sand at 256-273cm as the only exception. Core RC16-90 contains 185cm of moist and unconsolidated sand, consisting mainly of abundant sub-rounded to rounded quartz grains, frequent rounded dark minerals and occasional igneous rock fragments. Also, sorted and rounded medium to coarse grained quartz-feldspathic sand occurs as layers of variable thickness in cores VM18-145 and VM18-133.

Bahia Blanca Slope. Cores T409 and T407 display up to 1.5m of fine sand. This consists in abundant sub-angular to sub-rounded quartz and feldspars grains, frequent dark minerals, glauconite, and foraminifera in core T407. Core RC15-128, located northward at 2041 m water depth, is made of 630cm of pure sand with sub to rounded quartz grains, igneous rock fragments and granules, gravel and pebbles of sedimentary rock.

DISCUSSION

The finding of medium to coarse -grained and well-sorted sands at deep depths implies the persistence of strong and stable bottom currents, entailing large amount of resuspended sediments (Hollister and McCave, 1984). In the Argentine continental rise, plausible mechanisms for sediment entrainment in deep contourites involve the reworking of downslope gravity- turbiditic and debris-flows and the resuspension from benthic storms.

Downslope gravity flows characterize the entire margin. Turbiditic deposits are associated with the MdP and BB canyons; evidences of debris flows have been found in the BB (unpublished data) and MdP (e.g. Krastel et al., 2011) slopes; mixed turbiditic-contouritic deposits have been described for BB continental rise (Hernandez-Molina et al., 2009). Thus, a large amount of sediments is available for being reworked by bottom currents. Resuspension from abyssal storms in general occur where high surface eddy kinetic energy (EKE) and strong near-bottom mean flow coexist (Hollister and McCave, 1984). Both conditions are fulfilled in the study area. The region has unusual high levels of both surface and abyssal EKE (Weatherly, 1993). The good size sorting observed in the sands is probably achieved along repeated benthic storms with periodic resuspension-transport-deposition events. In the basin, average values of current speed of 16 $cm.sec^{-1}$, with a few peak values > 30 $cm.sec^{-1}$, have been reported at 5415m water depth (Richardson et al., 1993); this current speed allows fine components to be removed from the drift (Hollister and McCave, 1984).

As for the source area of the abyssal sands, likely candidates are MdP and BB regions. Sediments from MdP margin consist in muds with very fine sands as the coarsest size; dark minerals and angular grains of feldspar are abundant, with less quartz (Bozzano et al., 2011). Both grain-size and composition make MdP sediments dissimilar to those found in the deep basin. The margin off BB seems a more plausible source area. Today, BB coastal region is covered by dunes and mantles of loess and sands of volcano-pyroclastic mineralogical composition (Zarate and Blasi, 1993). The Colorado River formed a large deltaic system that was very active when sea level was 130m lower than today (e.g. during glacials). Huge amount of coarse materials was probably accumulated at the shelf where they underwent successive cycles of erosion and deposition until they reached the present shelf-slope transition. Afterward, debris and turbiditic flows transferred these sediments downslope where were captured by bottom currents flowing northward along the continental rise.

CONCLUSIONS

- Clean and well sorted sands found in the Argentine Basin are part of a large contourite drift.
- Bahia Blanca region is proposed as a plausible source area for these deep sands.
- Along its source-to-sink route, sediment size-sorting was achieved by repeated resuspension, transport and deposition events favoured by benthic storms.
- In the Argentine Basin both magnitude and direction of bottom flows allow to remove the fine components of the sediment, leaving a lag of sand.

REFERENCES

Bozzano, G., Violante, R., Cerredo, M.E., 2011. Middle slope contourite deposits and associated sedimentary facies off NE Argentina. Geo-Marine Letters 31, 495-507.

Ewing, M., Lonardi, A.G., 1971. Sediment transport and distribution in the Argentine Basin. Sedimentary structure of the Argentine margin, basin, and related provinces. In Ahrens, L.H. et al., (Eds.) Physics and Chemistry of the Earth 8, pp. 125-251.

Hernández-Molina, J., Paterlini, M., et al., 2009. Contourite depositional system on the Argentine Slope: An exceptional record of the influence of Antarctic water masses. Geology 37, 507–510.

Hollister, C.D., McCave, I.N., 1984. Sedimentation under deep-sea storms. Nature 309, 220-225.

Krastel, S., Wefer, G., et al., 2011. Sediment dynamics and geohazards off Uruguay and the de la Plata River region (northern Argentina and Uruguay). Geo-Marine Letters 31, 271-283.

Rebesco, M., Hernández-Molina, F.J., Van Rooij, D., Wåhlin, A., 2014. Contourites and associated sediments controlled by deep-water circulation. Processes: state of the art and future considerations. Marine Geology. In press

Reid J.L., Nowlin Jr., W.D., Patzert, W.C., 1977. On the characteristics and circulation of the southwestern Atlantic Ocean. Journal of Physical Oceanography 7, 62-91.

Richardson, M.J., Weatherly, G.L., Gardner, W.D., 1993. Benthic storms in the Argentine Basin. Deep-Sea Research II 40, 975-987.

Weatherly, G.L., 1993. On deep-current and hydrographic observations from a mud-wave region and elsewhere in the Argentine Basin, Deep Sea Res., Part II 40, 939-961.

Zarate, M., Blasi, A., 1993. Late Pleistocene-Holocene eolian deposits of the Southern Buenos Aires Province, Argentina: A preliminary model. Quaternary International 17, 15-20.