SBGf01499

Different styles of canyon infill related to gravity and bottom current processes : examples from the upper slope of the SE Brazilian margin.

Viana, A.R.; Almeida Jr., W.; Machado,L.C.,

PETROBRAS S/A, Brazil

Abstract

A series of modern submarine canyons were examined in the south-eastern Brazilian margin in order to identify the different styles of canyon filling and their relationship with sedimentary processes and sea-level changes. Such study should be considered as a predictive tool in order to estimate the presence of reservoir-like deposits. Four seismic facies related to intra-canyon depositional patterns were individualised in this study: clinoform prograding lateral accretion (Cp), cahotic fill (Ch), parallel-to-divergent aggradation (Pd) and horizontal strata (Pl). Relationship between these styles and sea-level changes was attempted and results indicate a complex interaction between hydrodynamic conditions, position of sediment source and sediment availability. Coriolis Effect seems to play a minor role in controlling the downcanyon flow/erosion processes. Lateral accretion is mainly related to the southward flowing Brazil Current. Aggradation and horizontal strata are related to a relative decrease in the Brazil Current action and to an increase in gravity flows activity.

INTRODUCTION

Submarine canyons may act as deep-sea conduits for sediments from shallow to deep-sea environments. The different styles of canyon fill are related to the whole set of sedimentary processes occurred during the canyon evolution and indicate changes in the behaviour of sediment supply. Processes involved in the sediment transport via canyon are mostly all related to gravity flows. However, processes involved in sediment supply to the canyon valley comprise both gravity flows and bottom-currents action. The signature of such processes in the modern continental margins is well recorded in seismic profiles. The analysis of a set of seismic profiles crossing several modern submarine canyons on Campos basin, along the south-eastern Brazilian margin, indicates different styles of canyon fill, both related to gravity and bottom currents.
In the recent years a series of papers has been published portraying the morphology and depositional styles of submarine canyons and related fan deposits. Among those papers we can cite that of Rasmussen (1994) on the offshore Gabon canyons which have several similarities with those we have studied in the opposite ocean margin. On the present study area, papers from Brehme (1984), Viana (1989, 1998), Miller et al. (1996) e Machado et al. (1998) report the general morphology and geometry of the canyons. Three major groups of canyons individualised by their geographic setting are depicted from these works (Fig. 1). The Northeast Group of canyons comprises the Camara, Tabajara, Grussaí, Itapemirim and São Tomé canyons. The Southeast Group of canyons, composed by 5 canyons comprises from the north to the south the Goitacá, Tupinambá, Temiminó, Tamoio and Tupiniquim canyons. To the southernmost portion of the Campos Basin continental slope, the Southeast-South group of canyons is composed by extremely immature canyons which excavate the canyons in a widely complex physiography of imbricate channels with no individualised canyon valleys resulting from several recurrent mass movements. Tabajara, Goitacá, Tupinambá, Temiminó, Tamoio and Tupiniquim are denominations here proposed for submarine features recognised by the mentioned previous works but up to now not yet linked to a formal name. These nomenclatures are related to the different original habitants of the east-southeast Brazilian coast.
Sediment erosion and deposition within submarine canyons are traditionally related to gravity-driven processes (McHargue and Web, 1986; Pratson et al., 1994). The action of bottom-currents inside canyon valleys firstly evoked by Shepard et al. (1973), has been observed in several canyons around the world and currently associated to the amplification of tidal oscillations. Transversal currents impinging on canyons have been reported by Serrane et al. (1992) and Rasmussen (1997). On the Brazilian margin, the impact of bottom-currents on canyon fill was observed by Viana (1998) along the Campos Basin margin, who associated the passage of the Brazil Current (BC), a strong surface western boundary current, to the development of prograding wedges transversally oriented to the thalweg.
The present study reports the analysis of several multi-channel seismic profiles in order to determine the different styles of the modern submarine canyons fill along Campos Basin margin and forecast the sedimentary deposits related to each determined seismic pattern.

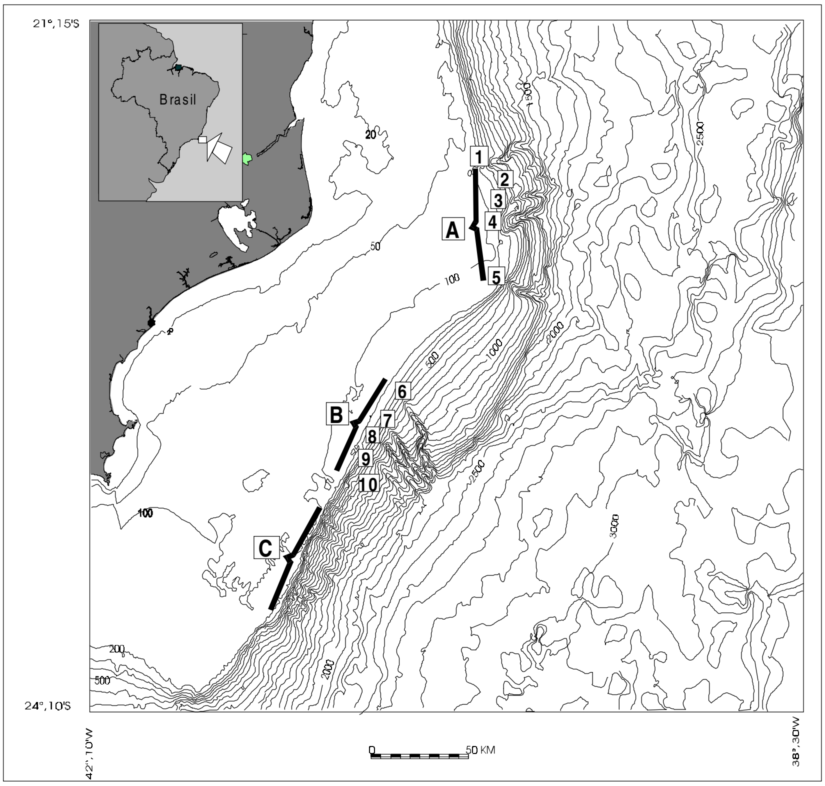

Figure 1: Bathymetric map with the location of the main features discussed in the text. A, B, and C are the Northeast, the Southeast and the Southeast-South Group of Canyons. Numbers represent the canyons: 1- Almirante Camara; 2- Tabajara; 3- Grussaí; 4- Itapemirim; 5- São Tomé; 6- Goitacá; 7- Tupinambá; 8- Temiminó; 9- Tamoio; 10- Tupiniquim. Contour intervals are expressed in meters.

SEISMIC FACIES

The analysis of transverse seismic sections indicate initial canyon excavation is associated to an unconformity of probable Upper Miocene age (Viana, 1989; Viana et al., 1990). Four different seismic facies have been individualised within the canyons.

Facies 1 (Cp) is characterised by a clinoform progradational pattern marked by oblique, high- to medium-amplitude reflectors (Fig. 2). Reflectors show good lateral continuity and each reflectors set thickens toward the thalweg. The reflectors dip up to 15°, in general towards the south. Reflectors offlap the thalweg and become parallel outside the canyon, towards the north. Frequent internal convergence is observed. Lower and upper boundary of each prograding set is marked by high-amplitude reflectors with good lateral continuity.
Facies 2 (Ch) is characterised by medium- to high-amplitude reflectors showing internal chaotic pattern (Fig. 2). This facies onlap both sides of the canyon and locally show lateral continuity to the downlapping termination of Facies Cp. Upper boundary is marked by a high-amplitude reflector, flat- to mounded-top. Lower boundary is erosive, truncating underlying layers.
Facies 3 (Pl) is characterised by low- to medium-amplitude reflectors showing parallel reflection pattern. It onlaps both canyon walls (Fig. 2).
Facies 4 (Pd) is characterised by low- to medium-amplitude reflectors with relatively good lateral continuity. It is marked by parallel-bending divergent reflectors with well defined upper and lower boundaries (Fig. 2).

Facies Cp is observed from the upper to the middle slope (300m to 800m water depth) and is often observed in the northern wall of the canyons. This facies thins-out downslope and becomes more parallel, draping the canyon wall. *Facies Ch* is the most frequent facies present all along the canyons valleys being sometimes recovered by *Facies Pl*. *Facies Pd* is observed in narrow and shallow canyons in the upper slope of the northern area and is stratigraphically followed by *Facies Ch* or *Pl*.

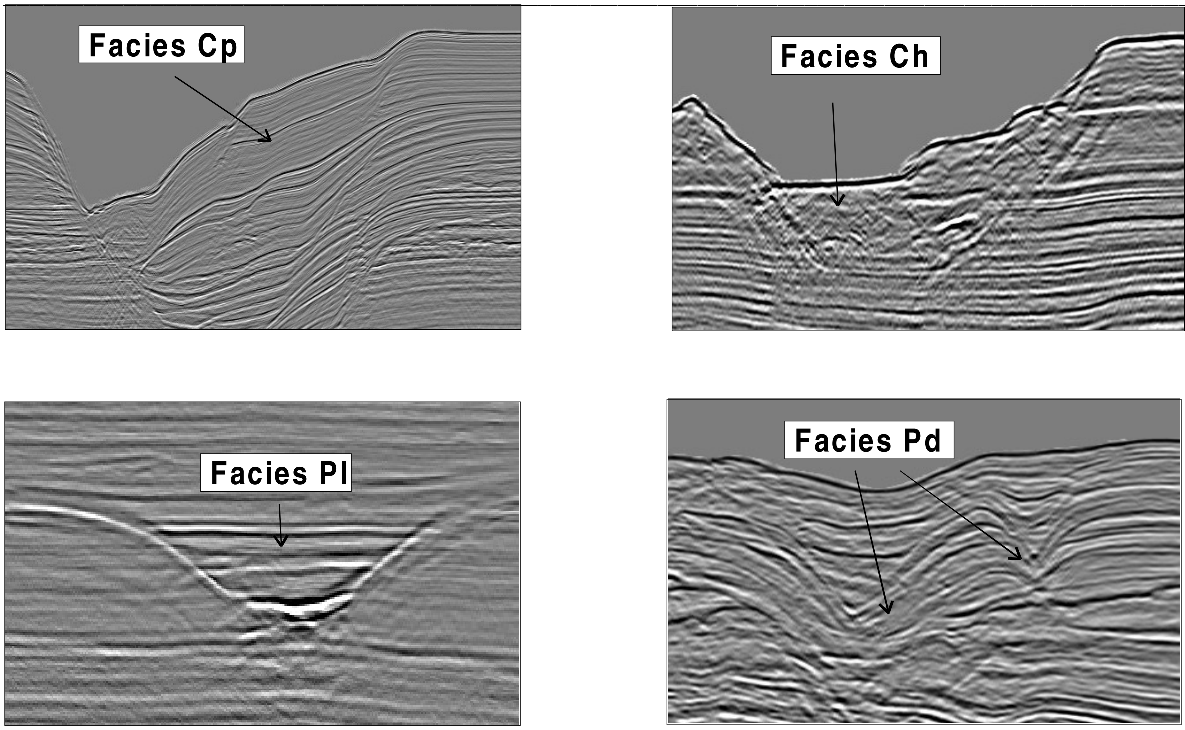

Figure 2: Cross sections showing the seismic facies discussed in the text.

SEDIMENTOLOGICAL AND STRATIGRAPHICAL IMPLICATIONS

The formation of submarine canyons is generally related to slope failure occurring during sea-level fall resulting from different processes such as phase changing of gas-hydrates, impact of storm waves, action of bottom currents, river connection of pre-existent slope transverse features. The progradational pattern of *Facies Cp* is here related to the alongslope transport of sediments related to the passage of geostrophic currents. The most frequent trend of prograding clinoforms of the *Facies Cp* is towards the south. It is very well preserved in the Southeast Group of canyons, specially on the northern flank of the Goitacá canyon. Such progradation direction associated to the bathymetric confinement to the upper slope and uppermost middle slope of *Facies Cp* indicates that the Brazil Current controls the deposition of that facies. As suggested by Viana (1998) the Brazil Current has been active at least during all Neogene and Quaternary, with its intensity changing in accordance with glacio-eustatic oscillations. Periods of greater intensity of the current occurs from the Glacia Maxima to highstand periods specially accentuated during the Quaternary (1.65 My to present). During the sea-level lowering, the BC had its intensity decreased but it was still active in order to redistribute southward the suspended plume of river-driven continental-derived sediments. These periods are related to high sedimentation rates, and deposits are essentially fine-grained, marked by well-continuous, low-amplitude/high-frequency reflectors. Periods of greater activity of the BC may be related to the high-amplitude boundaries of each prograding set and may correspond to coarser deposits (very-fine to medium-sand). Tying seismic reflections to well data, we observe that the major development of the progradational sets are related to the Quaternary and we estimate that each sequence corresponds to a 100ky Milankovitch-cycle (Fig. 3). *Facies Ch* is related to deposits of the canyon floor. Sometimes it corresponds to the inside-canyon termination of the clinoforms. It is related to gravity flow deposits occurred during the sea-level fall (slumping of southern walls of the canyons or upslope-originated mass movements/turbidity flows). Sediments associated to this facies can comprise fine-grained debrites (medium-amplitude, highly chaotic reflection pattern) and coarse-grained turbidites (high-amplitude, chaotic to transparent reflection pattern). *Facies Pl* is related to the abandonment of the canyon by gravity-driven currents and seems to define zones below the influence of geostrophic currents. Sediments are fine-grained hemipelagites and pelagites. *Facies Pd* is related to rapid canyon filling by the deposition of gravity-flow-originated suspended sediments (typically associated to overbank deposits of turbidity currents). It is well observed in the Northeast Group of canyons.

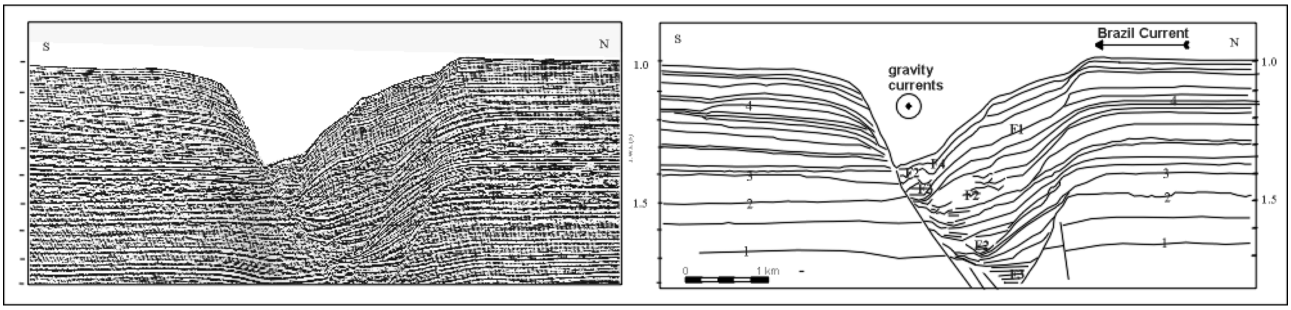

Figure 3: Cross section and interpretation of the Goitacá canyon. 1, 2, 3 and 4 are guidelines for tying both sides of the canyon. F1, F2, F3 and F4 correspond respectively to facies Cp, Ch, Pl and Pd. Reflector 1 corresponds to the upper Miocene unconformity (Gray Marker, Viana et al., 1990), Reflector 2 corresponds to the base of Pleistocene unconformity (1.65 Ma). Reflectors within the Quaternary section correspond to major prograding sets development. Cycles fit with 100 ky-orbital oscillations.

CONCLUSIONS

From the analysis of the available data set we can conclude that canyons from the northern area were more subjected to turbidity currents than those situated to the south, more influenced by the action of the geostrophic currents. Such difference is attributed to the grain size of the available sediments from the upper slope (coarser to the north and finer to the south). Forecasting the development of coarse grained submarine fans associated to each seismic facies can be done based on the processes responsible for their deposition. Canyons where prevails Facies Cp and medium-amplitude, chaotic Facies Ch seem to be conduits for fine-grained disturbed deposits (disintegrative mass flows). Canyons filled by Facies Ch high-amplitude, transparent reflection pattern and by Facies Pd are suspected to have been worked as conduits of coarse-grained turbidites. Facies Pl mark the abandonment of the canyon by both gravity- and current-driven processes.

REFERENCES

Machado, L.C.R., Kowsmann, R.O., Almeida Jr., W., Murakami, C.Y., Schreiner, S., Miller, D.J., and Piauilino, P.O., 1998. Modern Turbidite System in the Campos Basin: Key to Reservoir Heterogeneities. AAPG Int. Conference and Exhibition, Extended Abstracts, Rio de Janeiro, Vol., p:408-409.

McHargue ,T.R. and Webb, J.E., 1986. Internal geometry , seismic facies, and petroleum potential of canyons and inner fan channels of the Indus Submarine Fan. AAPG Bull., v.70 (2): 161-180.

Miller, D.J., Kowsmann, R.O., and Rizzo, J.G., 1996. Feições fisiográficas da Bacia de Campos à luz de novos dados batimétricos. In : Congr. Bras. Geologia, 39. Annales. Salvador, SBG, v. 3, p. 397-398

Rasmussen, E.S., 1994. The relationship between canyon fill and sea-level change: an example from Middle Miocene offshore Gabon, West Africa. Sedimentary Geology, 90: 61-75

Serrane, M., Seguret, M. and Fauchier, M., 1992. Seimi super-units and post-rift evolution of the continental passive margin of southern Gabon. Societé Géologique de France, Bulletin, v.163:135-146.

Shepard, F. and Marshall, N.F., 1973. Currents along floors of submarine canyons. AAPG Bull., v.57:244-264.

Viana, A.R., 1989, Canyon São Tomé, um exemplo de canion submarino em margem atlântica passiva. Annals of the 3rd Southeast Brazilian Geological Congress

Viana, A.R., 1998, Le rôle et l'enregistrement des courants océanique dans les dépôts des marges continentales: le bassin sud-est brésilien. PhD Thesis, Université Bordeaux I.

Viana, A.R., Kowsmann, R.O. et Castro, D.D., 1990. A discordância do Mioceno médio / superior, Um marco regional na Bacia de Campos. 36ème Cong. Bras. Geol., Natal, Brazil. 1: 313-323.

ACKNOWLEDGMENTS

Authors are grateful to Petrobras for granting the publication of this article. Discussions with J.-C. Faugères and R. O. Kowsmann were of great help in understanding the processes of canyon working.