ARTICLE IN PRESS

Marine and Petroleum Geology xxx (2009) 1–7

Contents lists available at ScienceDirect

Marine and Petroleum Geology

journal homepage: www.elsevier.com/locate/marpetgeo

Review

Rift sequence stratigraphy

M.A. Martins-Neto [a,b,*], O. Catuneanu [c]

[a] Vale E&P, Av. Graça Aranha 26, ZIP 20020-900, Rio de Janeiro, Brazil
[b] Federal University of Ouro Preto, Geology Department, Ouro Preto/MG, Brazil
[c] University of Alberta, Dept. of Earth and Atmospheric Sciences, Edmonton, Alberta, Canada

ARTICLE INFO

Article history:
Received 4 August 2008
Received in revised form
27 July 2009
Accepted 3 August 2009
Available online xxx

Keywords:
Sequence stratigraphy
Sequence model
Rift basins

ABSTRACT

Conventional sequence stratigraphy has been developed primarily for passive-margin basins. Despite the conceptual advances within the last 30 years, a suitable model for rift basins has not yet been devised. Many authors have attempted to adapt the passive-margin model to all other tectonic settings, including rifts, despite the fundamental differences in terms of the mechanisms controlling the formation and evolution of these sedimentary basins. Passive margins have their stratigraphic framework controlled largely by cyclic sea-level fluctuations superimposed on long-term thermal subsidence. By contrast, rift basins have their accommodation history strongly related to their mechanical subsidence regime, with episodic pulses of extension that create space for sediment accumulation at very fast rates. Stages of rapid mechanical subsidence are typically followed by longer periods of tectonic quiescence, when sediment supply gradually consumes and fills the available accommodation. This cyclicity results in depositional sequences that display overall progradational trends and coarsening-upward vertical stacking patterns. Sequence boundaries are often marked by sharp flooding surfaces related to the transgression of lacustrine or marine systems in response to rapid tectonic subsidence and the consequent 'instantaneous' generation of accommodation. As such, a typical rift depositional sequence starts with a flooding surface overlain by a relatively thin transgressive systems tract and a much better developed highstand systems tract. A renewed subsidence pulse leads to the drowning of the previous deposits and the start of a new depositional sequence. The strong asymmetry of the base-level curve resembles the shape of glacio-eustatic cycles, with fast transgressions followed by longer term regressions, although at potentially different temporal scales.

1. Introduction

Classic sequence stratigraphy has been developed within the context of passive-margin settings, which are tectonically stable areas where accommodation may be primarily attributed to global sea-level fluctuations on a background of longer term thermal subsidence (Vail et al., 1977; Posamentier and Vail, 1988; Posamentier et al., 1988). This method is useful for understanding the organization of the stratigraphic framework of sedimentary basins. It is also a powerful exploration tool since it characterizes the spatial and temporal distribution of depositional systems, with a component of predictability with regards to the distribution and geometry of reservoir, source and seal facies.

Starting from the original model for passive margins, sequence stratigraphy continued to evolve during the last two decades (e.g., Weimer and Posamentier, 1993; Loucks and Sarg, 1993; Emery and Myers, 1996; Posamentier and Allen, 1999; Catuneanu, 2002, 2006; Catuneanu et al., 2009). However, despite the fundamental differences between the conditioning mechanisms of sequence development in tectonically stable versus tectonically active basins, many authors have attempted to apply the passive-margin model to all other tectonic settings. The variability of the sequence-stratigraphic model with the tectonic setting has not yet been captured in any summary papers or textbooks, and this is arguably one of the 'next frontiers' in sequence stratigraphy.

The purpose of this paper is to present a sequence-stratigraphic model for rift basins. The proposed model defines the dominant stratigraphic patterns that are commonly encountered in this tectonic setting, and it provides a framework for understanding the process–response relationship between the controls on accommodation and the resulting stratigraphic architecture of rift basins. This summary also provides a method for the definition of key surfaces for stratigraphic correlation in rift basins, and it highlights the predictive potential of the observed stratal stacking patterns in hydrocarbon exploration. The model proposed in this paper is based on case studies that include both marine and nonmarine

* Corresponding author. Vale E&P, Av. Graça Aranha 26, ZIP 20020-900, Rio de Janeiro, Brazil. Tel.: +55 21 2217 6810; fax: +55 21 2217 6884.
E-mail address: marcelo.martins@vale-ep.com (M.A. Martins-Neto).

0264-8172/$ – see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.marpetgeo.2009.08.001

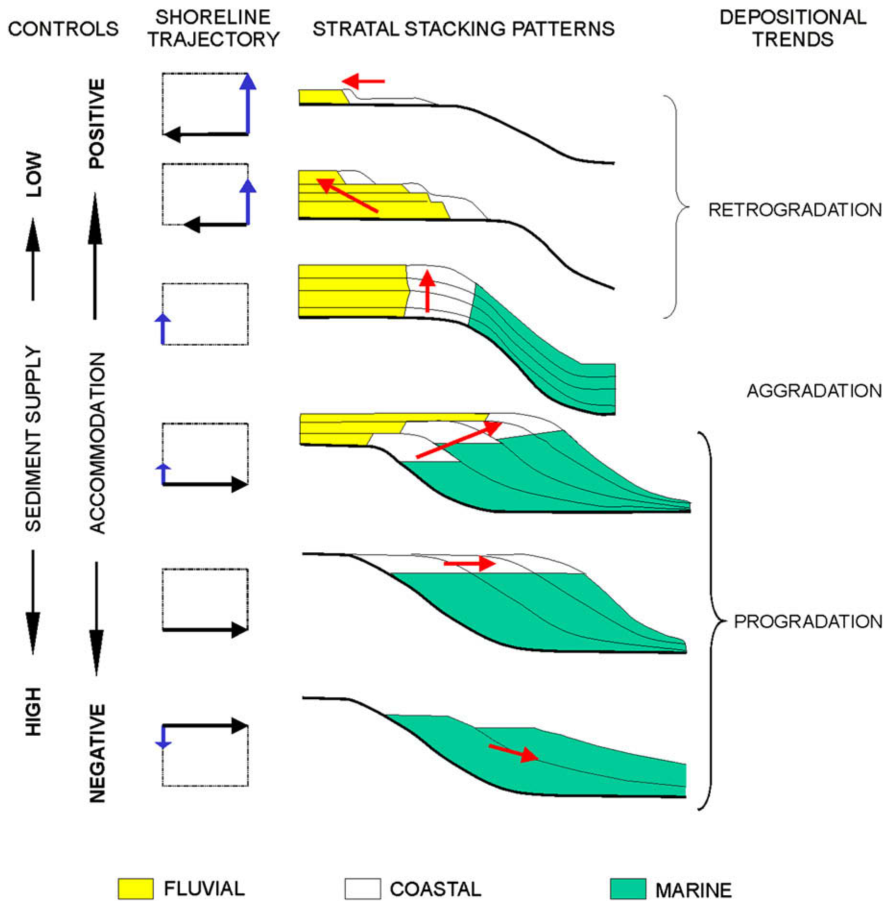

Fig. 1. Depositional trends (progradation, retrogradation, aggradation) as a response of the interplay of accommodation and sediment supply (modified from Van Wagoner et al., 1990). Black arrows represent the horizontal (progradational or retrogradational) component, blue arrows the aggradational component, and the red arrows the resultant shoreline trajectory. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

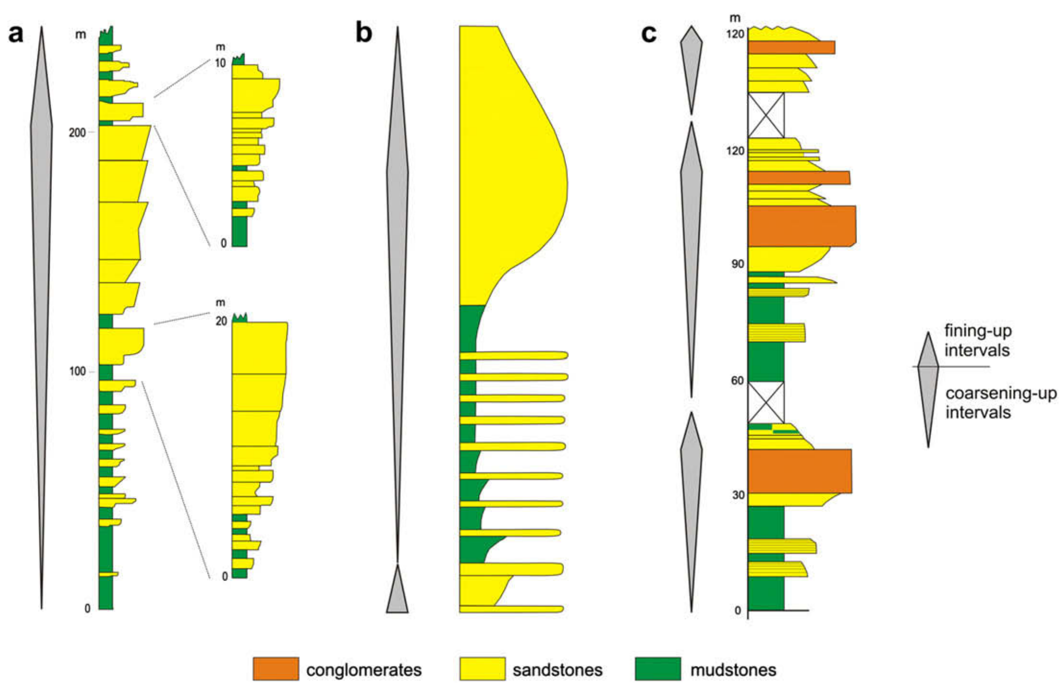

Fig. 2. Stratigraphic columns showing the coarsening-upward vertical stacking pattern that is typical of sequences accumulated in rift basins. Columns (a) and (b) are conceptual, whereas column (c) illustrates the Proterozoic, lacustrine-alluvial deposits of the Sopa-Brumadinho sequence (part of the syn-rift stage, Espinhaço Basin, Brazil). The fining-upward trends that are observed at the top of sequences may correspond to spans of time toward the end of each tectonic cycle when denudation of source areas, as well as the decrease in the differential relief between the source areas and the basin, combine to decrease the efficiency of sediment supply to the basin. References: (a) Frostick and Steel, 1993a; (b) Prosser, 1993; (c) Martins-Neto, 1993.

Please cite this article in press as: Martins-Neto, M.A., Catuneanu, O., Rift sequence stratigraphy, Marine and Petroleum Geology (2009), doi:10.1016/j.marpetgeo.2009.08.001

ARTICLE IN PRESS

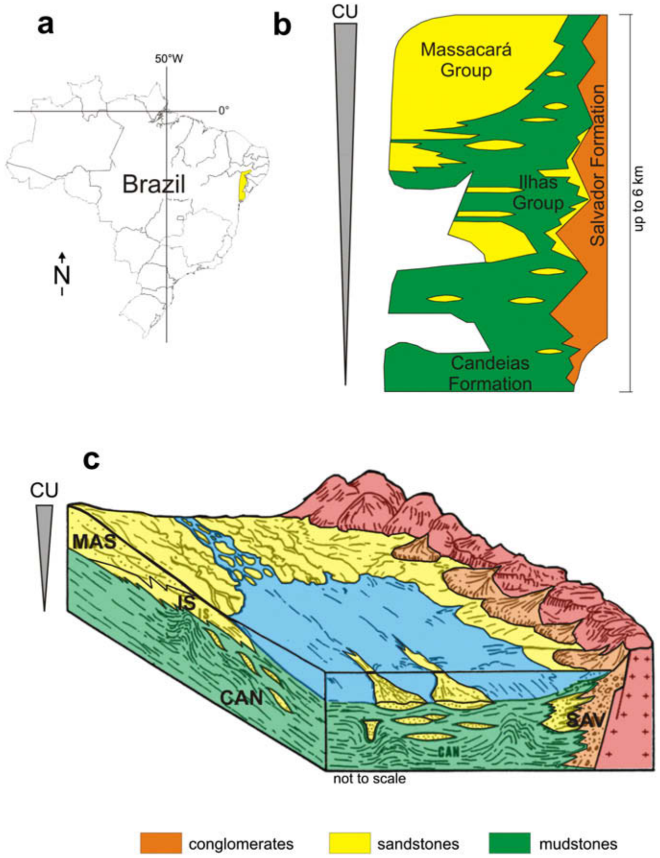

Fig. 3. a) Location of the Recôncavo-Tucano-Jatobá rift system (RTJ) in northeast Brazil. b) Simplified stratigraphic chart of the Recôncavo rift basin, the southern segment of the RTJ, showing the overall coarsening-upward vertical stacking pattern. c) Paleogeographic scenario for the Recôncavo rift basin (modified after Da Silva, 1993), showing the development of the coarsening-upward (CU) stacking pattern through the progradation of fluvial facies (Massacará Group – MAS) over the deltaic deposits of the Ilhas Group (IS), which in turn overlie the source-rock bearing lacustrine deposits of the Candeias Formation (CAN). Note turbidite intercalations in the distal/deep portion of the Candeias lake. SAV = Salvador Formation.

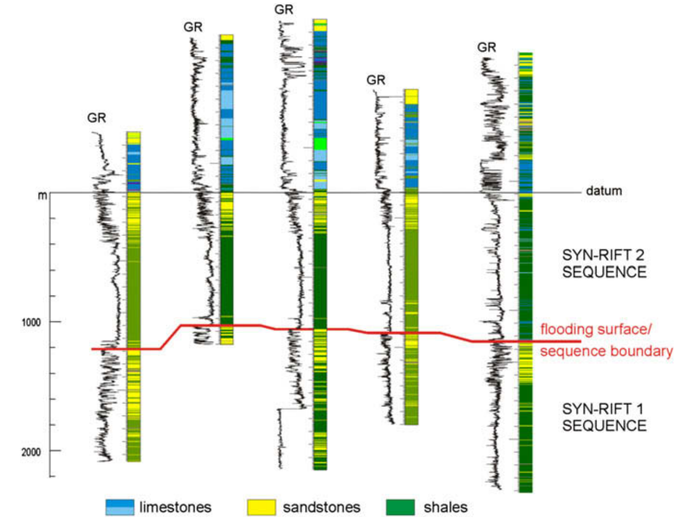

Fig. 5. Well-log cross-section of correlation in a Brazilian marginal, Cretaceous rift basin, showing two depositional sequences separated by a flooding surface (well data courtesy of Petrobras). The flooding surface is well defined in the lithologic and gamma-ray logs. Note the coarsening-upward stacking pattern of both sequences. The section is about 50 km long. Abbreviation: GR = gamma-ray.

depositional settings. However, whether the proposed model is general enough to apply to all rift basins still remains to be tested.

2. Fundamental concepts

Sequence stratigraphy improves our understanding of the evolution and infill architecture of sedimentary basins, thus providing a methodology for predictive exploration of natural resources. The method of sequence stratigraphy emphasizes changes in depositional trends (i.e., progradation, retrogradation, aggradation, erosion) and the resulting stratal stacking patterns through time, which are controlled by shifts in the balance between accommodation (space available for sediments to fill) and sediment supply (Fig. 1; Weimer and Posamentier, 1993; Emery and Myers, 1996; Posamentier and Allen, 1999; Catuneanu, 2002, 2006; Catuneanu et al., 2009).

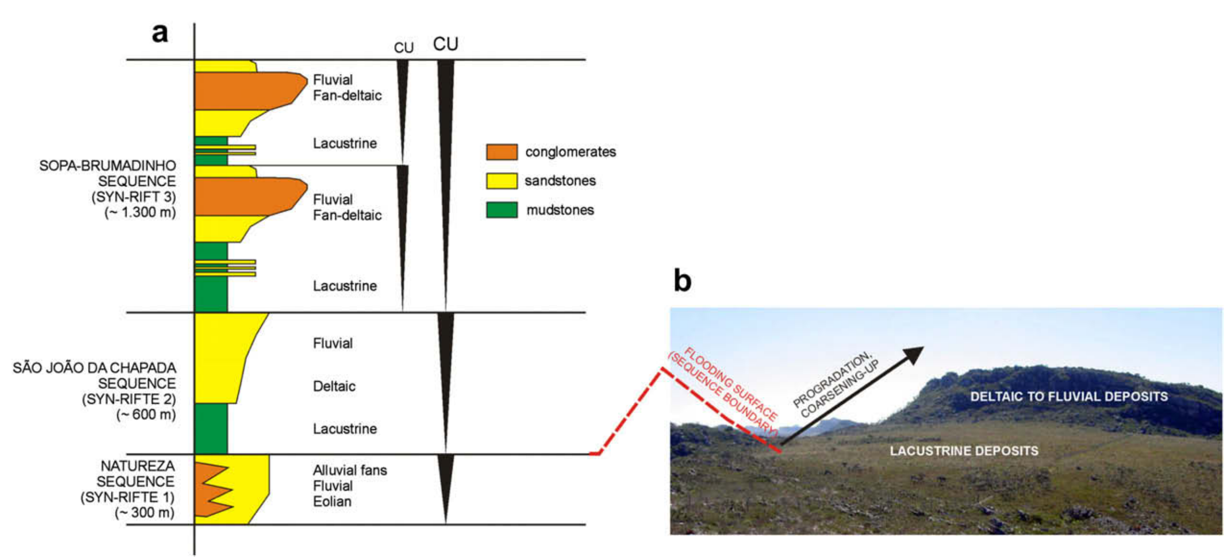

Fig. 4. (a) Schematic stratigraphic column of the rift succession of the Proterozoic Espinhaço basin, southeastern Brazil, showing dominantly coarsening-upward depositional sequences. Note the recognition of sequences of different hierarchical orders in the Sopa-Brumadinho syn-rift 3 sequence. See text for details. (b) Panoramic view of the São João da Chapada sequence (syn-rift 2), Espinhaço basin, southeastern Brazil, showing the position of its basal flooding surface and the coarsening-upward stacking pattern.

Please cite this article in press as: Martins-Neto, M.A., Catuneanu, O., Rift sequence stratigraphy, Marine and Petroleum Geology (2009), doi:10.1016/j.marpetgeo.2009.08.001

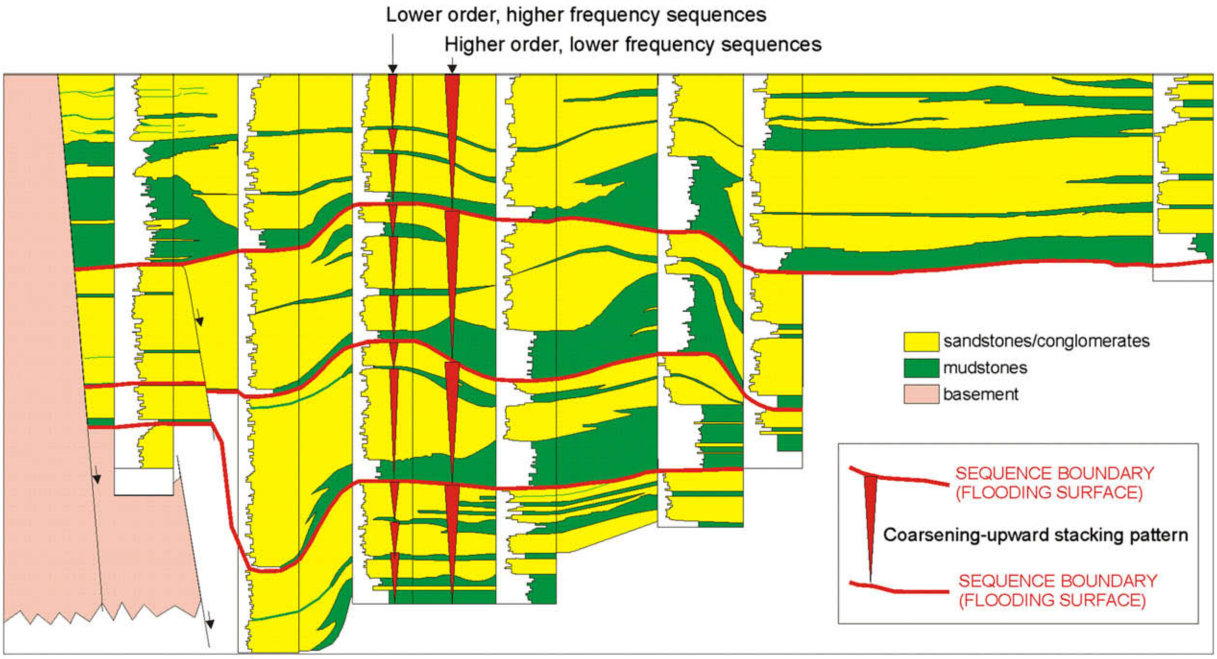

Fig. 6. Well-log cross-section of correlation in the Viking graben, North-Sea rift (modified after Frostick and Steel, 1993b), where four coarsening-upward depositional sequences, bounded by flooding surfaces, can be recognized. The sharp basal contacts of the deep-marine shales define flooding surfaces (sequence boundaries). The axial progradation of sandstones and conglomerates generates overall coarsening-upward stacking patterns. Note the recognition of lower order (higher frequency) sequences, which are bounded by lower order flooding surfaces.

Accommodation is generated, or lost, primarily as a result of the interplay between tectonism (i.e., subsidence or uplift) and eustatic sea-level fluctuations (rise or fall). At the same time, sedimentation consumes available accommodation at rates that may or may not match the rates in which accommodation is created. The balance between the rates of accommodation change and the rates of sedimentation controls the manifestation of transgressions (coastal retrogradation) and regressions (coastal progradation) (Posamentier and Allen, 1999; Catuneanu, 2006; Fig. 1). In terms of vertical stacking patterns, progradation implies a facies succession where proximal facies gradually replace distal facies with time, generating a coarsening-upward succession in a shallow-water setting. Retrogradation results in a facies succession that displays proximal facies at the base, which grade upward to distal facies at the top (fining-upward trend in a shallow-water setting; Van Wagoner et al., 1990).

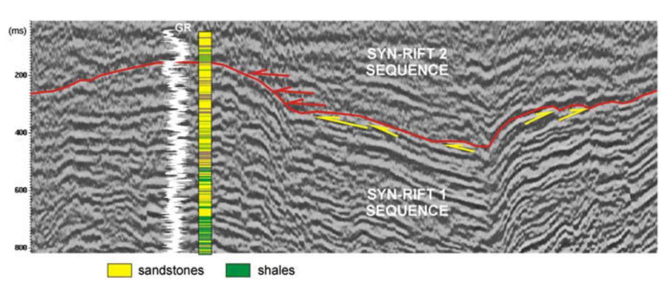

Fig. 7. Seismic section calibrated with borehole data, showing a rift-propagation unconformity (red horizon) characterized by erosional truncation at the top of syn-rift sequence 1 (yellow arrows) and onlap at the base of syn-rift sequence 2 (red arrows) (Brazilian marginal, Cretaceous rift basin; seismic data courtesy of Petrobras). The borehole data indicate that the unconformity (sequence boundary) is marked by a flooding surface. Abbreviations: GR = gamma-ray; ms = milliseconds (two-way travel time). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

Temporal variations in sediment supply depend on a number of variables including climate, rock types available for weathering and erosion in the source areas, and the evolution of the differential relief between the source areas and the basin. Among these controls, the latter can be predictably linked to the tectonic evolution of a sedimentary basin, and hence to the change in accommodation that can be attributed to tectonic mechanisms. The role of tectonism as a control on accommodation is more significant in the case of tectonically active basins, such as rifts, while the role of eustasy is increasingly dominant in the case of tectonically stable basins such as the divergent continental ('passive') margins.

The ability of fluvial systems to transport sediment to the basin is proportional to the landscape gradients, which are affected both by the basin subsidence and by the source area tectonism. During times of base-level fall, a steepening of the fluvial gradient downstream leads to a negative adjustment of the graded profile (negative accommodation), resulting in an increase in sediment supply to the marine portion of the basin. By contrast, a positive adjustment during base-level rise causes sediment retention closer to the basin margin, within the fluvial portion of the sedimentary basin. In turn, this may lead to a decrease of sediment flux into the basin, and consequently to a decrease in the deposition of marine reservoir facies.

Passive-margin basins have their accommodation history and, consequently, their stratigraphic framework controlled mainly by sea-level fluctuations at different hierarchical scales (Posamentier and Vail, 1988; Posamentier et al., 1988; Posamentier and Allen, 1999). Depositional sequences on passive margins begin and end with stages of base-level fall that cause subaerial exposure, erosion and clastic bypass of the continental shelf (sequence boundary) at the same time with the deposition of 'lowstand fans' (i.e., forced regressive deposits) in the deep-water setting. Following this, a shift in the balance between the rates of positive accommodation and sediment supply leads to the classic arrangement of the

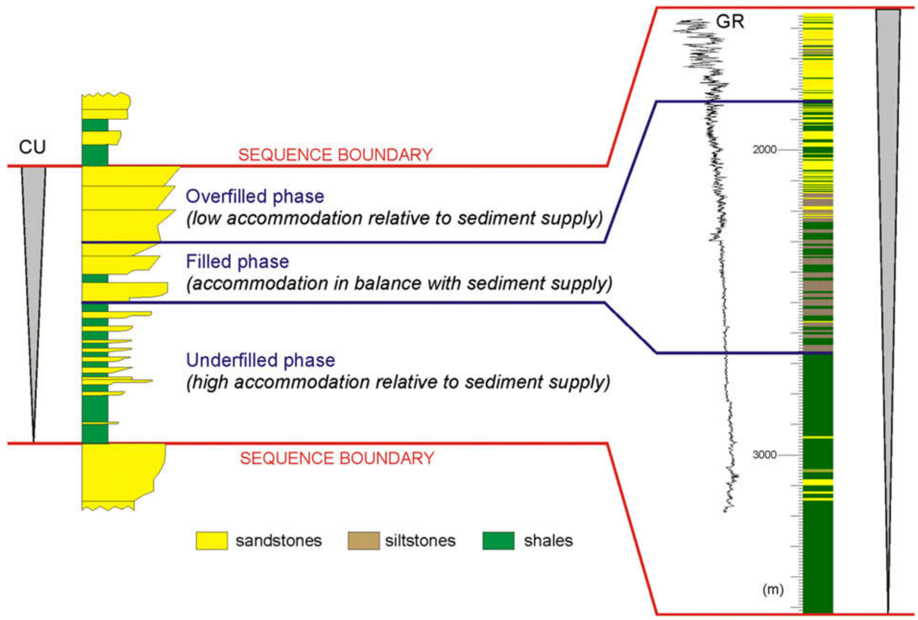

Fig. 8. Internal architecture of a complete (ideal) rift sequence, showing the overall coarsening-upward (CU) vertical stacking pattern, as well as the shift from underfilled to filled and overfilled conditions during the accumulation of the sequence. The conceptual column to the left is correlated with a well log in a rift basin (GR = gamma-ray).

stratigraphic record into lowstand normal regressive wedges, transgressive and highstand systems tracts.

In a broader sequence stratigraphic approach, which could be generalized for all tectonic settings, a depositional sequence corresponds to a complete stratigraphic cycle of changing depositional trends and stratal stacking patterns, generated by the interplay between the rates of creation/destruction of accommodation and sediment supply (Jervey, 1988; Posamentier and Allen, 1999; Catuneanu, 2002, 2006; Catuneanu et al., 2009).

3. Controls on the stratigraphic architecture of rift basins

Although climate-driven eustatic fluctuations may operate at a high-frequency level as a control on stratigraphic cyclicity in rifts, accommodation in these basins is generated mainly by tectonic subsidence. Rift basins are characterized by episodic subsidence with short stages of rapid creation of accommodation in response to pulses of extension and fault reactivation, commonly followed by longer periods of time of tectonic quiescence. During the latter stages, no new accommodation is generated and sediment supply gradually consumes the available space leading to a change from an underfilled to a filled or even overfilled basin. Typically, sediment supply increases soon after a tectonic pulse, when the newly created differential relief between the source area and the basin allows for a more efficient delivery of sediment to the basin.

The stratigraphic cycles observed in rift basins are dominated by progradational depositional trends, which describe coarsening-upward successions, as sediment supply fills the available accommodation after each stage of extensional subsidence (Fig. 2). A full cycle tends to include a short retrogradational portion (transgressive systems tract), which corresponds to the tectonic pulse of extensional subsidence, followed by a longer stage of progradation during tectonic quiescence (highstand systems tract). This stratal stacking pattern can be observed at different hierarchical levels. The first-order stratigraphic framework of the Early Cretaceous Recôncavo rift basin in northeast Brazil (Fig. 3), which is an aborted arm of the South Atlantic rift system, exemplifies the development of a coarsening-upward basin fill through the progradation of fluvial facies (Massacará Group) over the deltaic deposits of the Ilhas Group, which in turn overlie the source-rock lacustrine deposits of the Candeias Formation.

Another example of this stratigraphic pattern can be seen in the Proterozoic Espinhaço rift basin of southeastern Brazil (Martins-Neto, 2000, 2007, 2009; Fig. 4). Two angular rift-propagation unconformities separate three syn-rift sequences within the rift succession. Flooding surfaces, reworking the unconformities, are overlain by lacustrine deposits, and define sequence boundaries. Each syn-rift sequence shows a stacking pattern of coarsening-upward, developed by the progradation of alluvial, fluvial, and deltaic depositional systems on top of the lacustrine system. Higher frequency sequences, interpreted to be the product of higher frequency faulting pulses, can be recognized in the Sopa-Brumadinho third syn-rift sequence (Figs. 2c, 4), and display the same internal architecture as the higher rank (lower frequency) sequences.

Owing to the specific subsidence patterns of rifts, sequence boundaries tend, therefore, to be marked by flooding surfaces, as rapid creation of accommodation leads to transgression in an underfilled (lacustrine or marine) setting. Flooding surfaces of different hierarchical orders can be identified in well logs and outcrops within rift basins, providing a powerful tool for stratigraphic correlation (Figs. 5 and 6).

The well-log cross-section of correlation in Fig. 5 exemplifies how flooding surfaces can be used as the key surfaces for stratigraphic correlation. The sequence boundary in Fig. 5 separates two syn-rift sequences, each of them displaying a coarsening-upward stacking pattern, which can be recognized both in the lithologic and gamma-ray logs. Similarly, the well-log cross-section in Fig. 6 shows a stratigraphic organization that supports the framework presented here, where syn-rift depositional sequences bounded by flooding surfaces can be recognized at different hierarchical levels.

Fig. 7 illustrates a seismic section calibrated with well-log data, where a rift-propagation unconformity can be recognized using seismic-stratigraphic criteria (truncation at the top of syn-rift sequence 1 and onlap at the base of syn-rift sequence 2). The flooding surface at the base of syn-rift sequence 2 marks the sequence boundary, as documented by the well-log data.

Please cite this article in press as: Martins-Neto, M.A., Catuneanu, O., Rift sequence stratigraphy, Marine and Petroleum Geology (2009), doi:10.1016/j.marpetgeo.2009.08.001

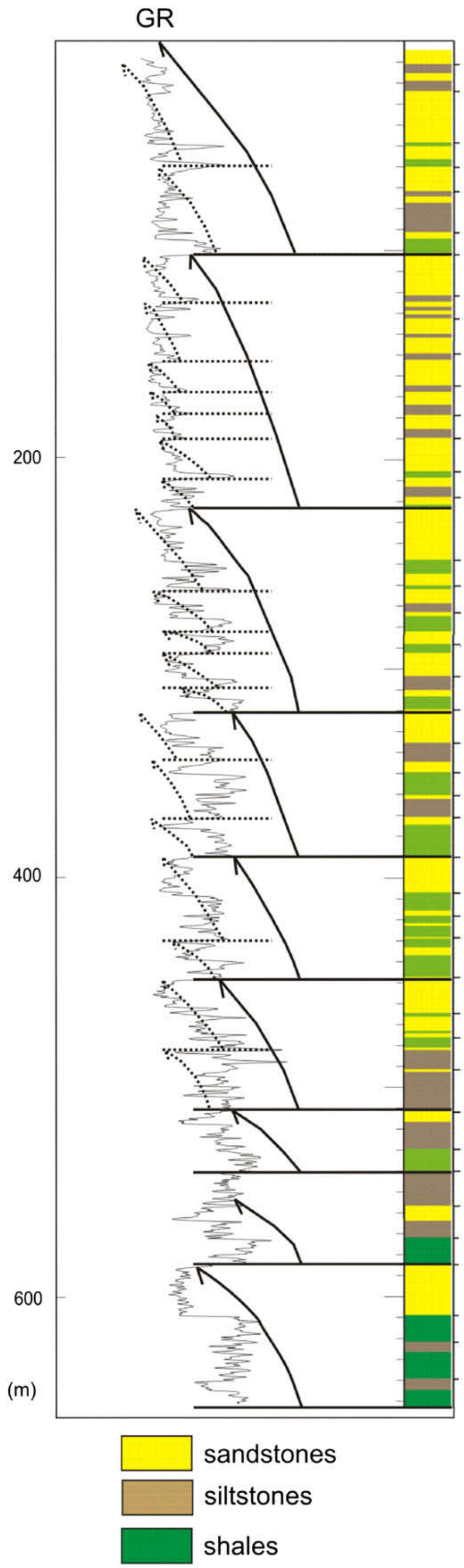

Fig. 9. Well log (GR = gamma-ray) showing rift sequences of two hierarchical orders (solid arrows for higher order and dotted arrows for lower order). Regardless of their order of cyclicity, sequences are bounded by sharp flooding surfaces and display overall coarsening-upward vertical stacking patterns.

4. Discussion and conclusions: a sequence-stratigraphic model for rift basins

A typical rift sequence tends to start with relatively deeper water deposits at the base, overlying a flooding surface, which are the product of rapid subsidence and consequent transgression (Figs. 2–8). A basal sandy interval can occur in some basins, below the initial flooding surface, representing the early stage of rift initiation, when accommodation is still limited (Prosser, 1993). Intercalations of turbidite facies within the basal fine-grained succession that overlies the first flooding surface may indicate the onset of progradation. The shale/turbidite package characterizes the underfilled phase in the evolution of the basin. With progradation, the succession passes upwards to shallow-water and coastal systems (filled phase), which grade to alluvial facies at the top (overfilled phase). The general change from underfilled to overfilled conditions is attributed to a shift in the balance between accommodation and the ability of sedimentary systems to fill the available space.

A typical rift sequence consists of transgressive and highstand systems tracts. The transgressive systems tract includes the retrogradational facies that accumulate during the tectonically-driven pulse of subsidence and flooding. The highstand systems tract forms the bulk of the sequence, and includes the progradational coarsening-upward succession that overlies the maximum flooding surface. Due to the strongly asymmetrical shape of the base-level (accommodation) curve, with fast rise (pulse of tectonic subsidence) followed by prolonged stillstand (tectonic quiescence), the lowstand systems tract tends to be poorly developed or absent. This marks a significant difference between rifts and tectonically stable basins such as those represented by continental shelves in passive-margin settings.

The tectonically-controlled stratigraphic framework of rift depositional sequences bounded by flooding surfaces and arranged internally in dominantly coarsening-upward successions characterizes the architecture of sequences that develop at different hierarchical levels (Figs. 2, 4, 6). Higher frequency sequences can be recognized in well logs, as shown in Fig. 9, where two smaller scale sequences display the same coarsening-upward character, with sequence boundaries marked by sharp flooding surfaces. Such higher frequency sequences (e.g., at third-order level) are attributed to smaller scale tectonic pulses of fault reactivation that occur between the higher magnitude (e.g., second-order) tectonic events, during a time of long-term (e.g., second-order) tectonic quiescence. A renewed subsidence pulse leads to the drowning of the previous deposits and the start of a new depositional sequence. The relative importance of sequences (e.g., based on thickness, or temporal scale) can be used to develop a hierarchy system for each rift basin fill. The entire basin fill of a rift can be taken as a first-order sequence, which represents the starting point for developing a hierarchy system for that basin (Catuneanu et al., 2005; Catuneanu, 2006).

Variations from the 'typical sequence' can occur due to several factors such as the overprint of climate-driven sea/lake-level fluctuations, stretching rates during the evolution of the rift system, differences in the subsidence history between the various sub-basins of a rift system, and the location of the depocenters relative to the source areas and the sediment entry points into the basin.

Acknowledgments

We thank Luiz Fernando Ev, Mariangela G.P. Leite (Federal University of Ouro Preto) and Frank Falkenhein (Petrobras) for their comments on earlier versions of this paper. The research has been funded by grants from CNPq (Brazilian National Research Council) and NSERC (Natural Sciences and Engineering Research Council of Canada). We thank Petrobras for providing data and feedback during a long-term collaboration that resulted, in part, in the publication of this paper. We also express our thanks to the JMPG referees for their comments and suggestions.

References

Catuneanu, O., 2002. Sequence stratigraphy of clastic systems: concepts, merits and pitfalls. Journal of African Earth Sciences 35, 1–43.

Catuneanu, O., 2006. Principles of Sequence Stratigraphy. Elsevier, Amsterdam, p. 375.

Catuneanu, O., Martins-Neto, M., Eriksson, P.G., 2005. Precambrian sequence stratigraphy. Sedimentary Geology 176 (1–2), 67–95.

Catuneanu, O., Abreu, V., Bhattacharya, J.P., Blum, M.D., Dalrymple, R.W., Eriksson, P.G., Fielding, C.R., Fisher, W.L., Galloway, W.E., Gibling, M.R., Giles, K.A., Holbrook, J.M., Jordan, R., Kendall, C.G.St.C., Macurda, B., Martinsen, O.J., Miall, A.D., Neal, J.E., Nummedal, D., pomar, L., Posamentier, H.W., Pratt, B.R., Sarg, J.F., Shanley, K.W., Steel, R.J., Strasser, A., Tucker, M.E., Winker, C., 2009. Towards the standardization of sequence stratigraphy. Earth-Science Reviews 92, 1–33.

Da Silva, H.T.F., 1993. Flooding surfaces, depositional elements, and accumulation rates – characteristics of the Lower Cretaceous Tectonosequence in the Recôncavo Basin, northeast Brazil. Unpublished Ph.D. thesis, University of Texas, p. 312.

Emery, D., Myers, K.J., 1996. Sequence Stratigraphy. Blackwell, Oxford, p. 297.

Frostick, L.E., Steel, R.J., 1993a. Tectonic signatures in sedimentary basin fills: an overview. Special Publication of the International Association of Sedimentologists 20, 1–9.

Frostick, L.E., Steel, R.J., 1993b. Sedimentation in divergent plate-margin basins. Special Publication of the International Association of Sedimentologists 20, 111–128.

Jervey, M.T., 1988. Quantitative geological modeling of siliciclastic rock sequences and their seismic expression. In: Wilgus, C.K., Hastings, B.S., Kendall, C.G., Posamentier, H.W., Ross, C.A., Van Wagoner, J.C. (Eds.), Sea Level Changes – an Integrated Approach, vol 42. SEPM Spec. Publ., pp. 47–69.

Loucks, R.G., Sarg, J.F. (Eds.), 1993. Carbonate Sequence Stratigraphy. AAPG Memoir 57, p. 545.

Martins-Neto, M.A., 1993. The Sedimentary Evolution of a Proterozoic Rift Basin: the Basal Espinhaço Supergroup, Southern Serra do Espinhaço, Brazil. Freiburger Geowissenschaftliche Beiträge, Germany, p. 155.

Martins-Neto, M.A., 2000. Tectonics and sedimentation in a Paleo/Mesoproterozoic rift-sag basin (Espinhaço Basin, southeastern Brazil). Precambrian Research 103, 147–173.

Martins-Neto, M.A., 2007. Proterozoic first-order sedimentary successions of the São Francisco basin in eastern Brazil. Zeitschrift der Deutschen Gesellschaft für Geowissenschaften 158, 117–129.

Martins-Neto, M.A., 2009. Sequence stratigraphic framework of Proterozoic successions in eastern Brazil. Marine and Petroleum Geology 26, 163–176.

Posamentier, H.W., Allen, G.P., 1999. Siliciclastic sequence stratigraphy: concepts and applications. SEPM Concepts in Sedimentology and Paleontology 7, 210.

Posamentier, H.W., Vail, G.P., 1988. Eustatic controls on clastic deposition II – sequence and systems tract models. In: Wilgus, C.K., Hastings, B.S., Kendall, C.G., Posamentier, H.W., Ross, C.A., Van Wagoner, J.C. (Eds.), Sea Level Changes – an Integrated Approach, vol. 42. SEPM Spec. Publ., pp. 125–154.

Posamentier, H.W., Jervey, M.T., Vail, P.R., 1988. Eustatic controls on clastic deposition I – conceptual framework. In: Wilgus, C.K., Hastings, B.S., Kendall, C.G., Posamentier, H.W., Ross, C.A., Van Wagoner, J.C. (Eds.), Sea Level Changes – an Integrated Approach, vol. 42. SEPM Spec. Publ., pp. 109–124.

Prosser, S., 1993. Rift-related linked depositional systems and their seismic expression. Geological Society Special Publication 71, 35–66.

Vail, P.R., Mitchum Jr., R.M., Todd, R.G., Widmier, J.M., Thompson III, S., Sangree, J.B., Bubb, J.N., Hatlelid, W.G., 1977. Seismic stratigraphy and global changes of sea-level. In: Payton, C.E. (Ed.), Seismic Stratigraphy – Applications to Hydrocarbon Exploration. AAPG Memoir 26, pp. 49–212.

Van Wagoner, J.C., Mitchum Jr., R.M., Campion, K.M., Rahmanian, V.D., 1990. Siliciclastic Sequence Stratigraphy in Well Logs, Core, and Outcrops: Concepts for High-Resolution Correlation of Time and Facies. In: American Association of Petroleum Geologists, Methods in Exploration Series 7, p. 55.

Weimer, P., Posamentier, H.W. (Eds.), 1993. Siliciclastic Sequence Stratigraphy. AAPG Memoir 8, p. 292.

Please cite this article in press as: Martins-Neto, M.A., Catuneanu, O., Rift sequence stratigraphy, Marine and Petroleum Geology (2009), doi:10.1016/j.marpetgeo.2009.08.001