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Marine influence in the Barreiras Formation, State of Alagoas, northeastern Brazil

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ABSTRACT

Tidal processes were important for deposition of the Barreiras Formation located in northern Brazil, while correlatable deposits in northeastern Brazil have been traditionally related to continental environments. Facies analysis in southern Alagoas revealed that the Barreiras Formation consists of cross-stratified conglomerates and sandstones (facies Sx and Cgx), compound cross-stratified sandstones (facies Cx), and heterolithic beddings (facies H). A significant portion of these deposits occurs within channel morphologies displaying fining and thinning upward successions. An abundance of sedimentary features is comparable to those from the northern Brazilian counterpart. These include: tidal bundles; herringbone cross-stratification; heterolithic beddings with sandstone and mudstone beds in sharp contacts; and ichnofossils mostly consisting of *Ophiomorpha nodosa*, *Skolithos* and *Planolites*. Altogether, these features point to a marginal marine depositional setting dominated by tidal processes, which are related to an estuarine system, an interpretation also provided for the Barreiras Formation in northern Brazil. The widespread occurrence of deposits with unambiguous evidence of tidal processes in the Barreiras Formation of northern Brazil, and now in the State of Alagoas, leads to argue that the early/middle Miocene worldwide marine transgression might have left a much more widespread sedimentary record along the Brazilian coast than currently regarded.

Key words: Miocene, marine transgression, tidal currents, sedimentary structures, northeastern Brazil.

INTRODUCTION

The early/middle Miocene is well known as a period for a worldwide transgression due to a sea level rise. The Barreiras Formation exposed in the States of Pará and Maranhão, northern Brazil, displays an excellent record of this event. In these areas, the Barreiras Formation consists of lower/middle Miocene deposits (Arai et al. 1988, 1994, Arai 1997, Leite 2004, Leite et al. 1997a, b, F.P.R. Leite, unpublished data) that are dominated by an abundance of sedimentary and ichnologic features derived under influence of tidal processes (Rossetti and Truckenbrodt 1989, Rossetti et al. 1990, Rossetti 2000, 2001, 2006a, b, Netto and Rossetti 2003, Rossetti and Santos Jr. 2004). Despite its occurrence in several geological contexts, including different sedimentary basins and platformal areas, the Barreiras Formation shows both faciological and stratigraphic organizations easily reproduced throughout northern Brazil (e.g., Rossetti 2004). Its sedimentary nature is compatible with deposition in a variety of environments linked to incised valley estuaries developed under the combined effect of eustasy and tectonics (Rossetti and Santos Jr. 2004, 2006).

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The Barreiras Formation is widespread along the Brazilian coast, occurring throughout the Northeast and Southeast Regions up to the State of Rio de Janeiro, being particularly well represented along numerous but discontinuous coastal cliffs. In contrast to more inland areas, the sedimentary structures have a higher preservation potential along these cliffs. This is due to the combined effect of wind, waves and tidal currents, which preclude vegetation growth and promote frequent sediment fall. The constant renewal of cliff face provides fresh exposures, which favor sedimentological investigation aiming the reconstruction of sedimentary processes.

There are several works dealing with the Barreiras Formation in northeastern Brazil (e.g., Mabesoone et al. 1972, Bigarella 1975, Suguio et al. 1986, Alheiros et al. 1988, Alheiros and Lima Filho 1991, Vilas Boas et al. 2001, C.C.U. Lima, unpublished data, Lima and Vilas Boas 2004, Araújo et al. 2006, Furrier et al. 2006, Lima et al. 2006). However, in contrast to northern Brazilian areas, these studies have recognized only continental, mostly fluvial and lacustrine deposits within this unit. If these interpretations are correct, then an intriguing question to be answered is why the Miocene transgression is well recorded only in northern Brazil, and not along its northeastern coast, where these deposits are well represented?

Perhaps, there is no need for one to seek answers for this question, as the recognition of marine features might have been under looked. Some authors (Suguio and Nogueira 1999, Arai 2006, Rossetti 2006b) commented that a marine transgression should be also reported in northeastern Brazil, though no data have been provided to sustain this claim. In addition, Salim et al. (1975) and Menezes et al. (1998) documented marine influenced deposits in the Barreiras Formation exposed in the eastern coast of the State of Rio Grande do Norte. Although to the present authors knowledge this represents the only report of this kind, it motivated to look for further evidence that could provide conclusive data for supporting a marine influence in northeastern Brazil.

The recognition of marine influence in deposits lacking fossil data, as in the Barreiras Formation, might be problematic. In this case, one must rely on detailed observation of physical sedimentary structures, which might be combined with the study of ichnofossils, in order to interpret the sedimentary processes.

This work aims to present the results of a sedimentological investigation undertaken along several cliffs distributed along the southern coast of the State of Alagoas (Fig. 1), where an abundance of sedimentary features in the Barreiras Formation could be characterized in great detail. Based on the data provided herein, it is possible to assure that tidal currents were responsible for the deposition of this unit.

GEOLOGICAL CONTEXT

The study area is located in the Sergipe-Alagoas Basin. This consists of a NNE/SSW elongated asymmetric structure formed along the Brazilian coast during the South Atlantic rifting, initiated in the late Jurassic to early Cretaceous. This basin reaches up to 13,000 km^2 onland and nearly 35,000 km^2 offshore. It separates from the Pernambuco-Paraíba Basin by the Maragoji High to the north, and from the Estância Platform and Jacuípe Basin by the Vaza-Barris Fault Zone to the south. The basin is internally sub-divided in two sub-basins by the Jaboatã-Penedo High (Aquino and Lana 1990).

The sedimentary fill of the Sergipe-Alagoas Basin consists of four megasequences representative of the pre-rift, rift, transitional and post-rift phases (Mohriak et al. 1997), with a depocenter located in the Mosqueiro Low, south of Aracajú (SE). The pre-rift megasequence has Mesozoic and Paleozoic ages, and is represented by the Baixo São Francisco Group, which includes the Estância Formation (Precambrian), glacial deposits of the Batinga Formation (Carboniferous), sabkha deposits of the Aracaré Formation (Permian), and fluvio-lacustrine deposits of the Candeeiros, Bananeiras and Serraria formations (late Jurassic/early Cretaceous). The main rifting took place from Neocomian to Barremian, being represented by the Rio Pitanga, Penedo and Barra de Itiúba formations. The transitional megasequence, formed from Barremian to Aptian, consists of the Poção, Coqueiro Seco and Maceió formations, as well as transitional deposits of the Muribeca Formation (F.J. Feijó, unpublished data). The post-rift megasequence, formed during the Albian to Campanian, includes marine deposits of the Riachuelo Formation. Following the Campanian, the Sergipe-Alagoas Basin experienced a regres-

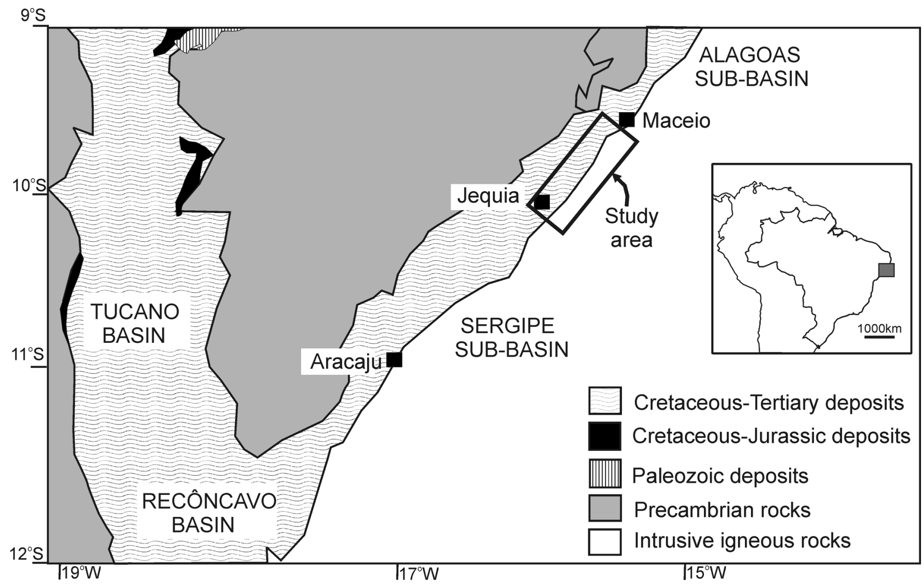

Fig. 1 – Location map of the study area containing exposures of the Barreiras Formation in the southern coast of the State of Alagoas, between the city of Maceió and the locality of Jequiá.

sion, which is represented by the Calumbi, Mosqueiro and Marituba formations.

The Barreiras Formation overlies the above described megasequences in the onland portion of the Sergipe-Alagoas Basin. This unit has not been dated in this study area yet, but studies of correlatable deposits in northern Brazil have indicated a Miocene age for these deposits (Arai et al. 1988, 1994, Arai 1997, F.P.R. Leite, unpublished data, Leite et al. 1997a, b).

THE BARREIRAS FORMATION IN THE STUDY AREA

Deposits of the Barreiras Formation studied herein occur in several cliffs along the southern coast of the State of Alagoas, particularly between the city of Maceió and the locality of Jequiá (Fig. 1). Cliffs are up to 25 m high, several hundreds of meters long (Fig. 2A), and display strata with a variety of well preserved sedimentary features that can be used for the reconstruction of the depositional processes. Likewise many other places in northeastern Brazil, the Barreiras Formation in this study area consists of quartzose conglomerates, fine to coarse-grained sandstones, heterolithic deposits and mudstones. These lithologies display a wide range of colors, varying from red, yellow, pink, white to purple, as typical for this unit.

In general, the base of the Barreiras Formation is not exposed in the study area, but in a few places, it is marked by a discontinuity surface mantled by an iron-cemented conglomeratic lag (Fig. 2B) displaying abundant root marks (Fig. 2C). In addition, this unit is distinguished from overlying sandy deposits, which are herein designated informally as the Post-Barreiras Sediments (*sense* Rossetti 2001), with basis on the presence of an unconformity. This unconformity, observed even on remote sensing image (Fig. 2D), is similar to the unconformity that occurs at the top of the Barreiras Formation in northern Brazil. Likewise that region, the unconformity atop the Barreiras Formation in the study area is characterized by an irregular, erosional discontinuity surface. This is marked by a lateritic paleosol presenting a ferruginous concretionary horizon up to 3 m thick (Fig. 2D-E). The thickness of the Barreiras Formation below this unconformity averages 15 m along the studied cliffs.

Analysis of the studied exposures revealed an abundance of strata with channel morphologies characterized by shallow (3 to 5 m thick), but laterally widespread (several tens of meters long), concave up features (Fig. 3A-C). The bulk of the channels are lithologically represented by well sorted, cross-stratified sandstones.

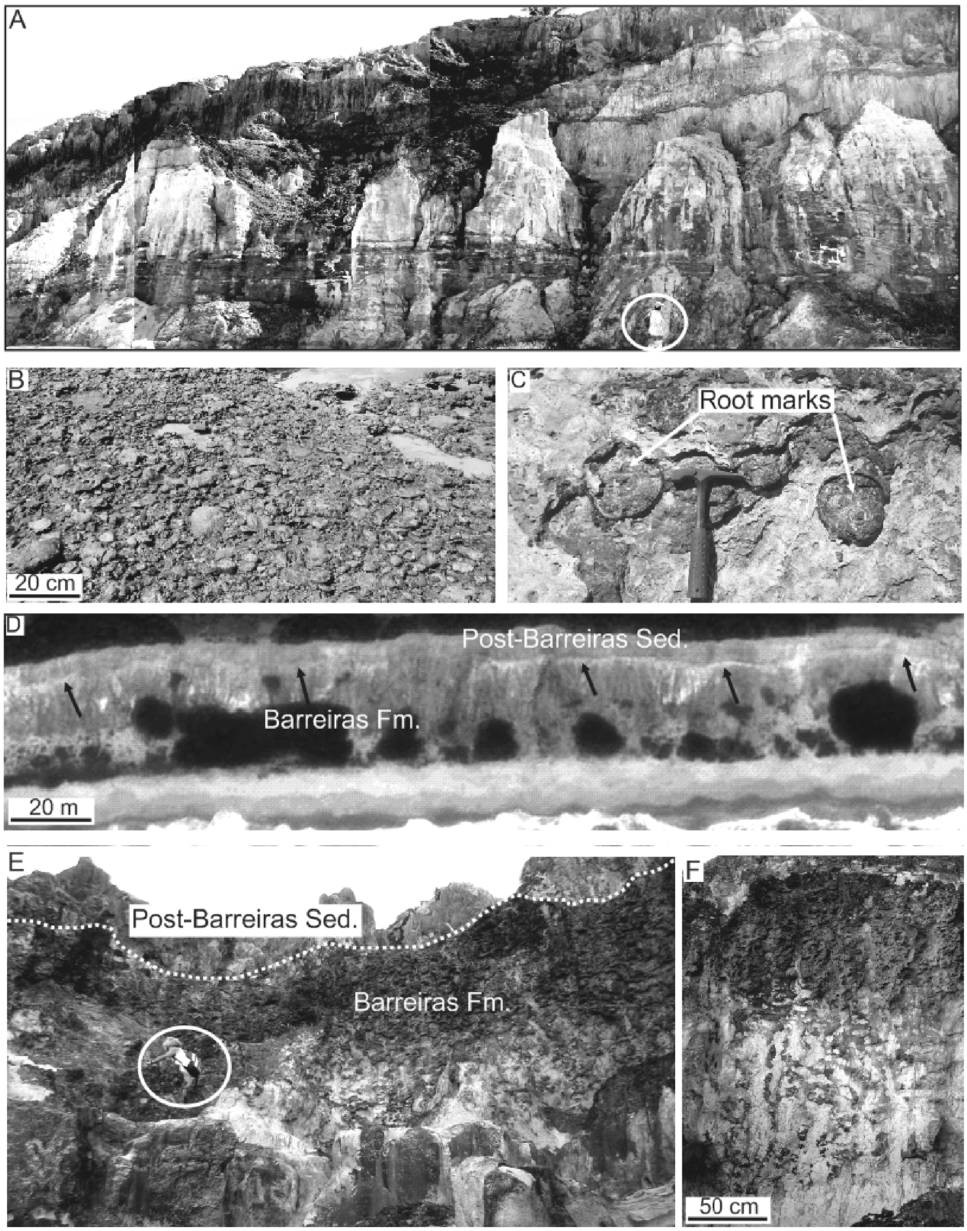

Fig. 2 – A) General view of a cliff consisting of exposures of the Barreiras Formation (person for scale indicated in the inside circle is 1.75 m tall). B-E) Characterization of discontinuity surfaces that bound the Barreiras Formation, illustrating: the iron-cemented conglomeratic lag (B) and the root marks (C) associated with the basal discontinuity surface; a spatial view of the upper unconformity, which separates the Barreiras Formation from the overlying Post-Barreiras Sediments (D; *Image 2007-Digital Globe*); general view of the upper unconformity, which is marked by lateritic paleosol (E; person for scale indicated in the inside circle is 1.75 m tall); and a close-up of the concretionary horizon of this paleosol (F).

However, the sandstones might grade both laterally and downward into conglomerates. Additionally, channel fills dominated by heterolithic deposits are also common. Channel deposits are amalgamated (Fig. 3B) or cut down into thick, laterally continuous, flat lying, heterolithic and muddy deposits (Fig. 3C). Both, i.e., the channel and the flat lying deposits, are internally organized into fining and thinning upward successions.

In the following, a detailed facies description of the studied deposits is provided in order to discuss the sedimentary processes responsible for the genesis of the channel deposits, as well as of the adjacent strata.

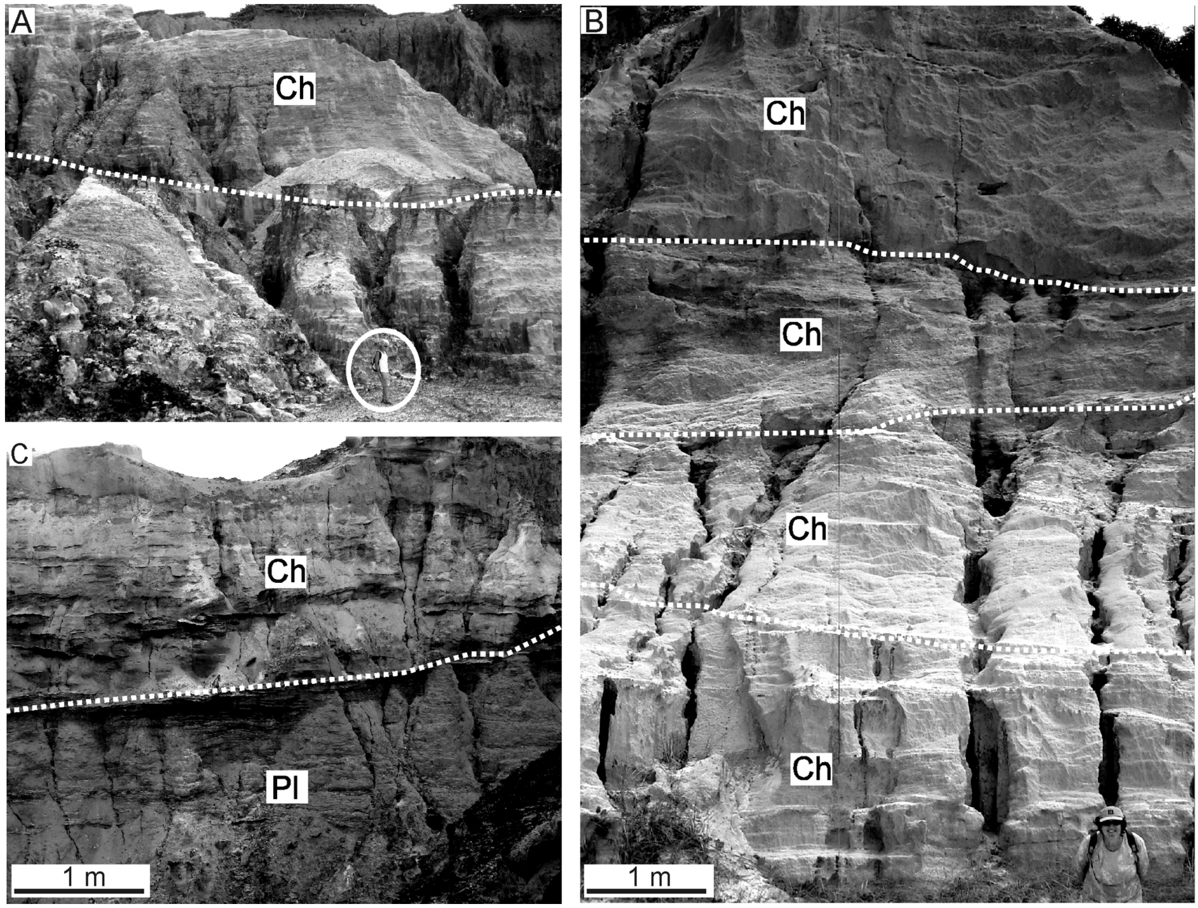

Fig. 3 – Typical channel morphologies of the Barreiras Formation. A) General view of a channel shape (person for scale indicated by inside circle is 1.65 m tall). B) Amalgamation of several channel deposits (Ch) that cut down into each other. C) A channel deposit (Ch) that cut down into laterally continuous flat lying heterolithic deposits (Pl).

FACIES DESCRIPTION

For the purpose of this work, the studied deposits can be described in terms of four main sedimentary facies: cross-stratified conglomerates (facies Cgx), cross-stratified sandstones (facies Sx), compound cross-stratified sandstone (facies SCx), and heterolithic deposits (H).

Cross-stratified Conglomerate (Facies CGX)

This facies (Fig. 4A-D) consists of poorly- to moderately-sorted, sub-rounded to rounded pebbles of quartz and intraformational mudstones, which are bounded by a matrix of coarse- to medium-grained sandstones. The mud clasts occur in sizes commonly larger than the quartz pebbles, reaching up to 10 cm. Facies Cgx is crudely to well stratified, with dominance of medium to large scale, opposed dipping, trough, and less commonly, tabular cross-stratifications. Despite the coarse-grained nature, thin mud drapes highlight internal reactivation surfaces (Fig. 4). Laminated mud layers averaging 5 cm thick are also present along set boundaries. These overly deposits topped by either symmetric or asymmetric ripple marks. A striking feature of this sedimentary facies is the abundance of trace fossils dominated by *Ophiomorpha* and *Skolithos* (Fig. 4B-D).

Cross-stratified Sandstone (Facies SX)

Cross-stratified sandstones (Fig. 5A-H) show, in general, poorly- to well-sorted, fine- to coarse-grain sizes and small to medium scale, tabular and trough cross-stratifications. Not rarely, large scale cross-stratification is also present, with individual sets reaching locally up to 3 m thick. As observed in facies Cgx, opposed-dipping cross strata are widespread in this facies, locally

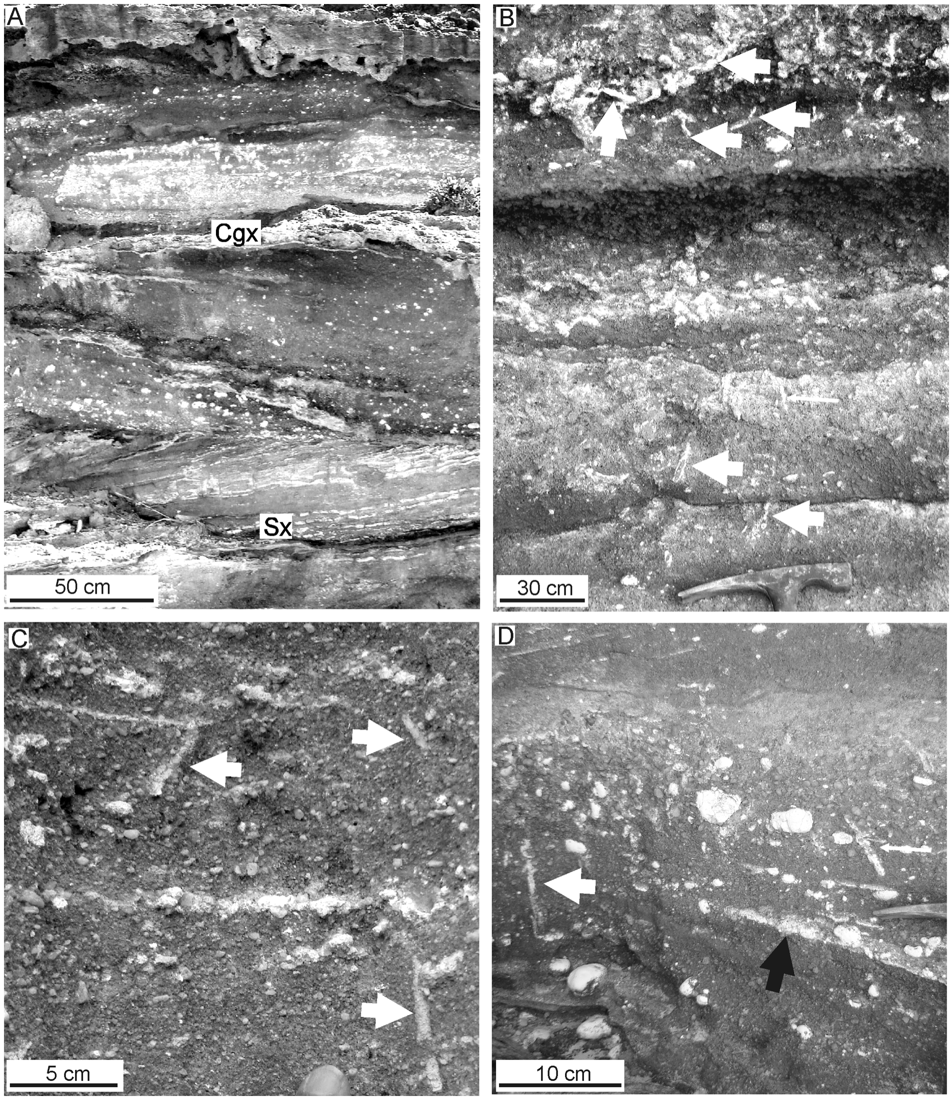

Fig. 4 – Cross-stratified conglomerates (facies Cgx). A) General view of several sets of cross-stratified conglomerates that grade downward into cross-stratified sandstones (facies Sx). B-D) Details of the cross sets with abundant (B) and disperse trace fossils (C-D) (white arrows), mostly consisting of *Ophiomorpha* and *Skolithos*. The white rounded clasts in all figures are mudstone intraclasts.

forming herringbone cross sets (Fig. 5A). The dominant type is tabular cross-stratification, which is usually highly tangential to set bottoms (Fig. 5C-D). Sigmoidal cross-stratication was also observed locally. A particular feature of this lithofacies is the presence of abundant reactivation surfaces and mud drapes (Fig. 5B-D) locally organized into laterally alternating thicker/thinner successions of foreset packages, which vary from only a few centimeters up to 30 cm thick (Fig. 5E). Mud clasts are abundant throughout these deposits. Some of them have barely been displaced from the mud drapes that separate the foreset packages. In addition, trace fossils are pervasive in this facies, mostly consisting of *Ophiomorpha nodosa* (Fig. 5F-G) and, subordinately, *Skolithos* and *Planolites*. The first occurs in large sizes, i.e., burrow galleries averaging 10 cm in diameter and up to 40 cm, and locally forms monospecific ichnofabric. In places, bioturbation is so intense that the primary sedimentary structures have been almost completely obliterated (Fig. H).

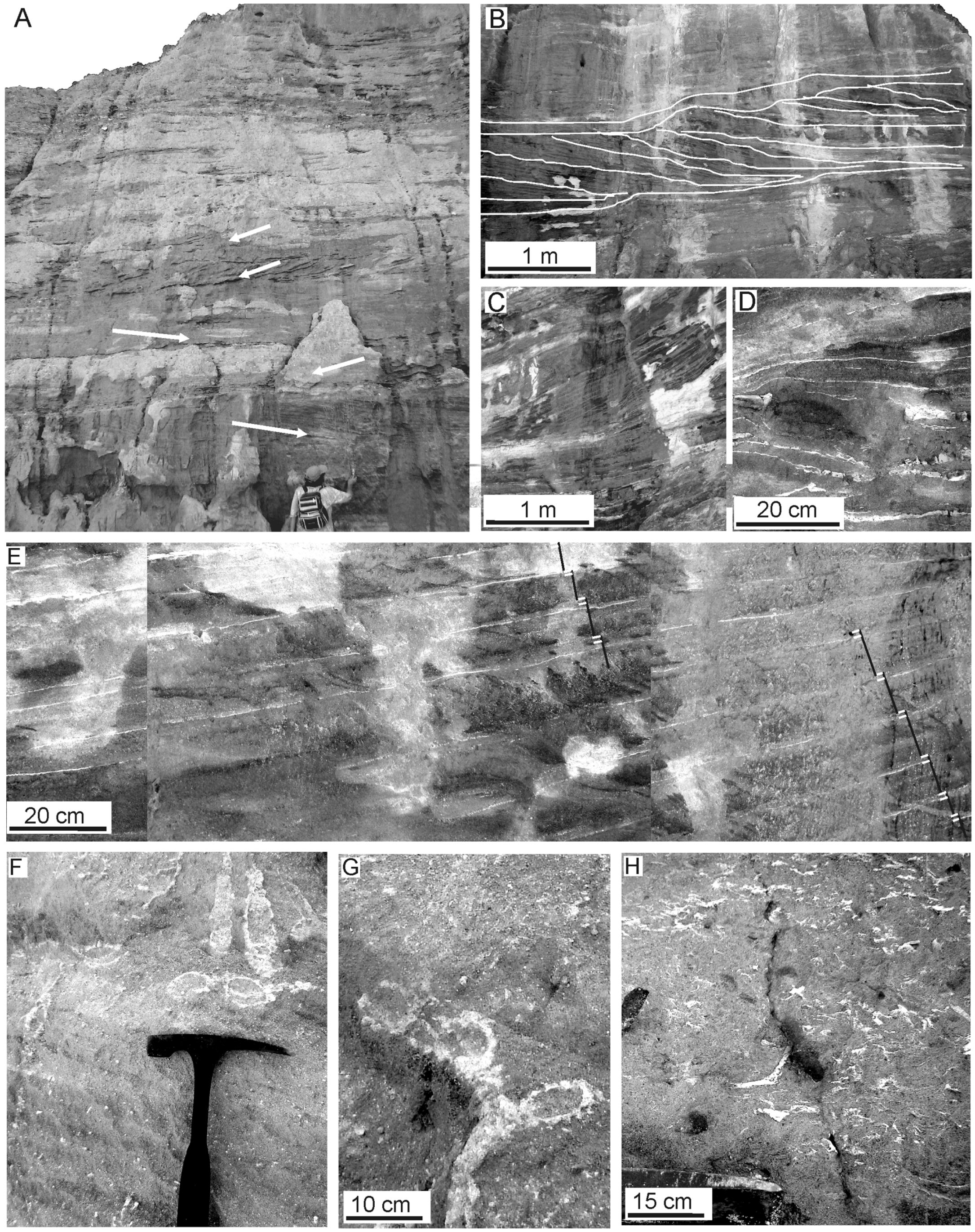

Fig. 5 – Cross-stratified sandstones (facies Sx). A) General view of several sets of cross-stratified sandstones displaying opposed foresets. B and C) Large scale cross sets with packages of foresets marked by reactivation surfaces and/or mud drapes, highlighted by white lines in B and white mud drapes in C. D) Close up of the cross-stratified sets with abundant, either continuous or discontinuous, mud drapes (white color). E) Detail of a cross set with abundant, alternating thicker and thinner foreset packages (black lines), defined by mud couplets (white lines), a feature related to ebb/flood tidal cycles. F) The trace fossil *Ophiomorpha nodosa*, which is abundant in this facies. G) Detail of a large, branched *Ophiomorpha nodosa*. H) Highly bioturbated sandstones where primary sedimentary structures became almost totally obliterated by the activity of organisms. Note the chaotic mud chips, resulting from disturbance of once continuous drapes.

COMPOUND CROSS-STRATIFIED SANDSTONE (FACIES SCX)

Compound cross-stratified sandstones (Fig. 6) are characterized by low angle (< 15°) dipping, large scale (up to 5 m thick) cross sets internally showing superimposed, medium scale, either tabular or trough cross beds. Sand grain sizes vary from fine to coarse, and the sorting is usually moderate. Mud clasts are disperse throughout these beds, particularly in association with coarser grain sizes. The superimposed cross sets usually ascend (climb) upon the large scale foresets, though descending cross sets are also present. Foresets within the superimposed cross sets also dip at low angle (< 20°, on average). Facies SCx is most common at the base of channel deposits, or it can fill up the entire channel. Likewise facies Sx, climbing cross sets display abundant reactivation surfaces, but mud drapes are rare. Master beddings, however, are marked by mud layers. Trace fossils similar to those found in facies Sx are disperse throughout these deposits, though they are much less abundant than in that facies.

HETEROLITHIC DEPOSITS (H)

This facies (Fig. 7A-D) consists of interbedded sandstones and mudstones with layers in sharp contacts. The proportion between these lithologies varies, resulting in several types of heterolithic beddings. Thinly-laminated (pinstripe) beddings are formed where mudstones are dominant, with only minor sandstone stripes forming thin lenses or continuous laminae less than 1 mm thick. Lenticular/wavy bedding is characterized by alternating sandstone and mudstone layers commonly 1-2 cm thick (Fig. 7A). Flaser bedding consists of sandstone layers internally displaying discontinuous mud laminae. Additional features are vertically accreting sandstone units up to 5 cm thick that are separated by either planar or slightly undulatory, laterally continuous mudstone layers a few mm thick (Fig. 7B). Sandstone layers are mainly parallel laminated and, less commonly, cross laminated. Interestingly is the internal organization of these lithologies, which form alternating thicker/thinner successions of sandstones separated by mud couplets (Fig. 7C-D), as observed in facies Sx. Similarly to the other sedimentary facies described herein, the heterolithic deposits display abundant trace fossils, particularly within the sandy components. In addition to the types of traces described above, there are several smaller-scale, undetermined burrows.

INTERPRETATION OF SEDIMENTARY PROCESSES

In the lack of fossil bodies, the best criteria to recognize deposits formed under influence of marine flows in the sedimentary record are based on the presence of sedimentary structures diagnostic of tidal processes. The sedimentological imprint of tidal currents relies chiefly on their cyclic nature, which results from diurnal/semidiurnal ebb and flood tide and monthly neap and spring tide fluctuations. Earlier workers focusing on the recognition of tidal deposits had to rely their interpretation basically on the presence of bipolar or bidirectional herringbone cross-stratification (Yagishita 1997). However, the action of tidal currents on sediments does not necessarily produce this structure. This is because many tidal settings display asymmetrical tidal currents, when reduced deposition or even no deposition is expected during weak, subordinate tides (Kreisa and Moiola 1986), as observed in many ancient and modern settings (Dalrymple et al. 1978, de Boer et al. 1989, Nio and Yang 1991).

The advance of studies on tidal settings resulted in several additional criteria that can be used to identify tidal rhythmites (see Nio and Yang 1991 for a review). These are imprinted in the sedimentary deposits as tidal beddings (Reineck and Wunderlich 1968, Visser 1980, Terwindt 1981). Tidal bundles were first identified by Boersma (1969) as being deposited by dominant tidal currents, and thin mud layer were ascribed by Terwindt (1971) to slack water deposition during tidal reversals. The thickness variation of tidal bundles was shown to correspond to neap/spring tidal cycles by Visser (1980). Based on these works, many deposits previously ascribed as entirely continental in origin were reinterpreted as primarily formed by tidal processes.

The main feature diagnostic of tidal bundles is the repetitive thick-thin pairing of strata marked by reactivation surfaces and/or mud drapes, which are related to ebb/flood tidal periodicities (e.g., Mowbray and Visser 1984, Yang and Nio 1985, Kreisa and Moiola 1986, Chakraborty and Bose 1990, Leckie and Singh 1991, Simpson and Eriksson 1991, Shanley et al. 1992).

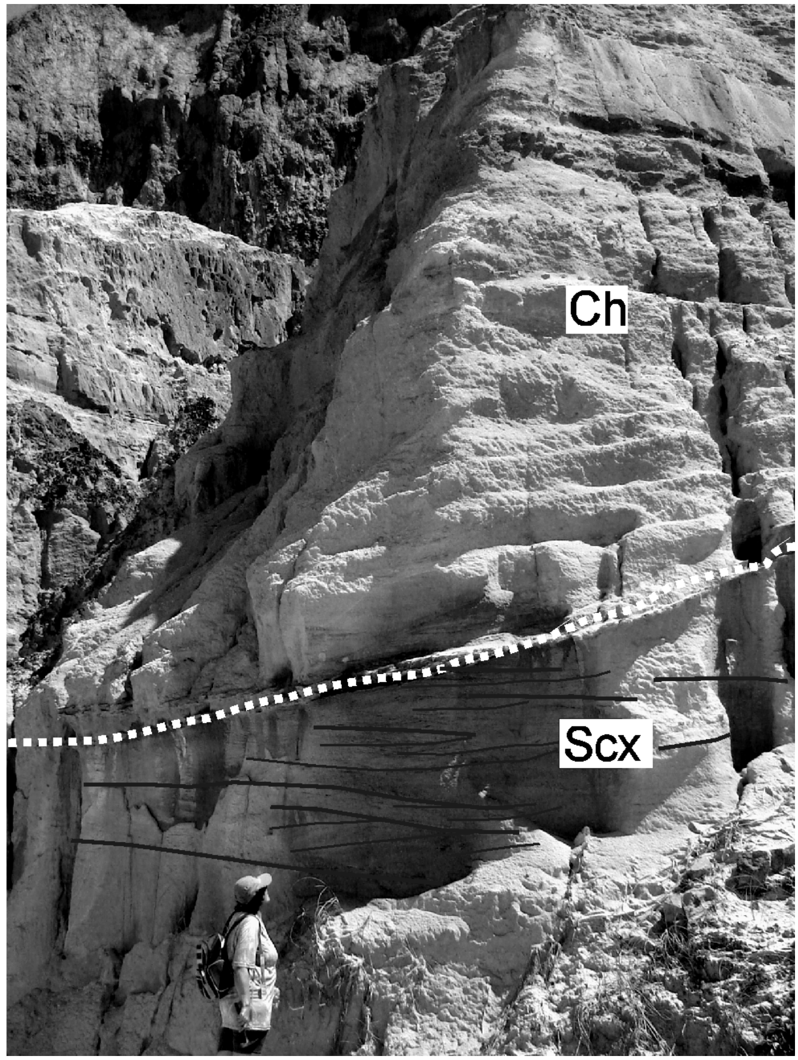

Fig. 6 – Compound cross-stratified sandstone (facies SCx) with large scale cross sets defined by low angle dipping master bedding separating internal, medium scale, ascending cross sets. Note that this facies is sharply overlain by a concave up deposit related to a tidal channel (Ch) (the dotted white line highlights the base of the channel deposit).

In the study area, there are several features assuring that deposition took place chiefly in a marine influenced setting under the action of tidal currents. The common occurrence of opposed dipping cross sets forming herringbone cross-stratification is consistent with highly fluctuating flow conditions, as occurs in marine settings. However, the most convincing evidence is the abundance of sedimentary structures diagnostic of tidal periodicities. This is particularly indicated in facies Sx by the laterally alternating thick-thin pairing marked by double mud couplets, which is similar to many others recorded in both modern and ancient tidal-generated deposits (e.g., Visser 1980, Allen 1981a, b, Boersma and Terwindt 1981, Nio et al. 1983, Allen and Homewood 1984, Mowbray and Visser 1984, Tessier and Gigot 1989, Nio and Yang 1991, Archer et al. 1995, Shanley et al. 1992). Sandstones with lateral successions of tidal bundles are related to megaripple migration under fluctuating asymmetric flood and ebb tides. The thicker and thinner sand beds that compose the pairs are formed during dominant and subordinate tides, respectively. The mud couplets record the two moments

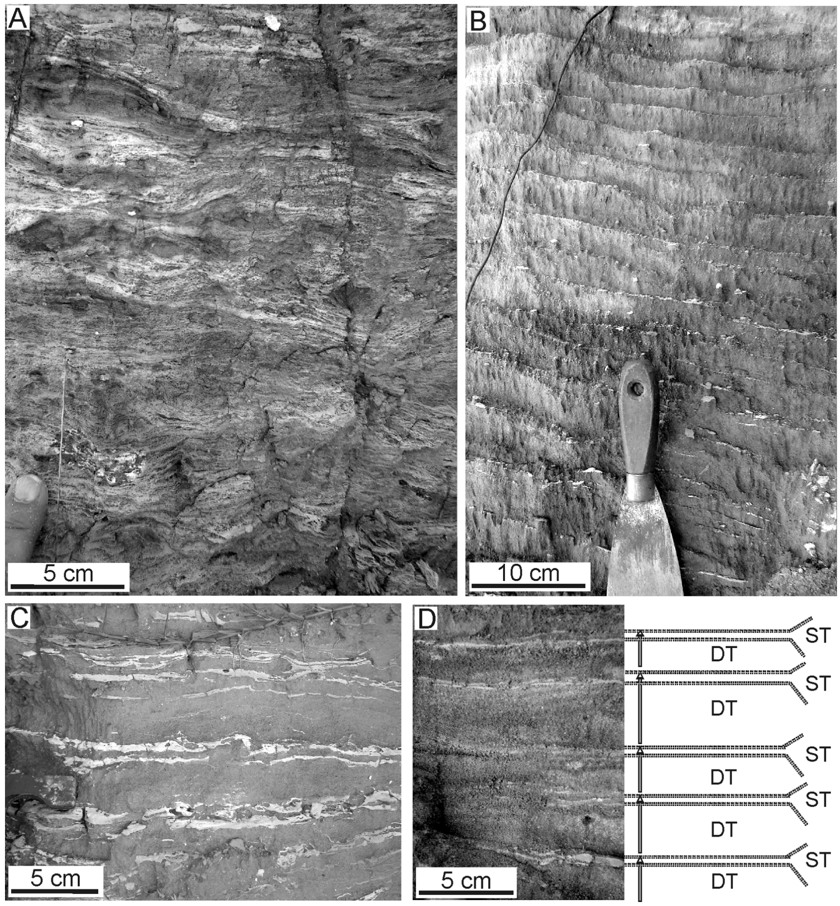

Fig. 7 – Heterolithic bedding (facies H). A) Lenticular/wavy heterolithic bedding. B) Heterolithic bedding consisting of vertically accreting sandstone packages defined by either planar or slightly undulating, laterally continuous mudstone layers. C-D) Internal organization of the vertically accreting sandstones, forming alternating thicker/thinner successions separated by mud couplets related to dominant (DT)/subordinated (ST) daily tidal cycles.

of slack water that occur just before flow inversions. The sigmoidal cross strata present in facies Sx are also attributed to tidal processes, as similar structures have been recorded in many tidal-influenced settings (e.g., Kreisa and Moiola 1986, Nio and Yang 1991). Sigmoidal beddings reflect progressive acceleration from full vortex to deceleration flow conditions within a single ebb-flood tide (Boersma and Terwindt 1981, Allen and Homewood 1984, Uhlir et al. 1988).

Facies H is also related to tidal processes, as revealed by several lines of evidence. First, this facies is commonly intergraded with facies Sx. Second, the abundance of heterolithic facies is, in itself, suggestive of fluctuating tidal velocities, since frequent alternations of traction and suspended-load deposition are naturally favored under the time velocity asymmetry of tidal currents (e.g., Reineck and Wunderlich 1968, Reineck and Singh 1986, Terwindt 1971, Terwindt and Breusers 1972, Howley 1981, Mowbray 1983). Third, the sharp contacts between sandstone and mudstone layers, though not exclusive, are typical of tidal processes, indicating rapid changes between periods of quiescence (mud settling) and periods with relative increase in flow strength (sand deposition). Finally, the tidal influence on the genesis of facies H is particularly shown by the vertically accreting sandstone beds that are separated by either planar or slightly undulatory, laterally continuous mud couplets. This feature is equivalent to the thicker/thinner pairing observed in facies Sx. However, instead of related to lateral bedform migration, this structure reflects periodic vertical sand accumulation due to tidal currents affecting flat areas (tidal flats and shoals) with high sediment rates. Shallow waters under this environmental condition would have momentaneously enhanced tidal flows, promoting upper flow regime sand deposition, as recorded by the abundance of parallel laminated sandstones.

The high volume of features characteristical of tidal bundles in facies Sx and H is consistent with formation of tidal bundles under subtidal conditions. The preservation of subordinate, slack water mud drapes is not favored in the intertidal zone (Clifton 1983, Terwindt 1988, Nio and Yang 1991).

Given the genetic relationship of facies Sx and H, the compound cross-stratified sandstones are related to migration of large-scale bedforms, mostly within channels, during alternating dominant and subordinate tidal currents (e.g., Houbodt 1968, Allen 1980, Dalrymple 1984, Mowbray and Visser 1984, Chakraborty and Bose 1990, Simpson and Eriksson 1991). The large scale bedforms were superimposed by smaller scale bedforms that migrated mostly upstream during subordinate tides, producing the ascending cross sets. Deeper waters within tidal channel settings would have favored the development of this facies, as indicated by its frequent occurrence within channelized deposits.

Facies Cgx was also formed by tidal currents, as indicated by its transition to facies Sx. The coarse-grained nature of these deposits, added to the abundance of large mud clasts, record high energy tidal flow conditions. However, the reactivation surfaces with mud drapes record punctuated episodes of low flow conditions, which are naturally developed in tidal settings.

In addition to the abundance of sedimentary structures diagnostical and/or suggestive of tidal processes, the types of trace fossils recorded in the studied strata support deposition in marginal marine settings. A further specific ichnological investigation is still needed in order to fully characterize the entire assemblage of trace fossils present in these deposits. However, the overall prevalence of *Ophiomorpha nodosa* and *Skolithos*, with subordinate occurrence of *Planolites*, attests a low diversified community of benthic opportunistic organisms, which is typical of stressed settings undergone to fluctuating salinity (Pemberton and Wightman 1992). *Ophiomorpha nodosa* records dwelling/feeding activity of organisms reworking marine settings. Its occurrence as large burrows forming monospecific ichnofabric reflects an opportunistic behavior of marine organisms, which was also recorded frequently in the Barreiras Formation in northern Brazil (Netto and Rossetti 2003). *Skolithos* is a dwelling trace that occurs in marginal marine, brackish and freshwater environments undergone to highly fluctuating flow energy, being particularly common in tidal settings (Bromley and Asgaard 1979, Pemberton et al. 1992a, b, Buatois et al. 1998, Pattison 1992, Gibert and Martinell 1998). *Planolites* is a feeding structure that occurs in a variety of depositional settings (Pemberton and Frey, 1982). Together, these traces characterize the *Skolithos* ichnofacies developed in high energy marine influenced settings.

CONCLUSION

This work records the first unequivocal evidence of marine influence in the Barreiras Formation of northeastern Brazil. Combination of sedimentary structures and ichnological data led to the conclusion that the Barreiras Formation that occurs in the southern coast of the State of Alagoas is definitely related to sediment deposition in a marine, tidal dominated depositional setting.

The studied deposits display a variety of sedimentary features that resemble those documented in estuarine deposits of the Barreiras Formation located in northern Brazil. In particular, the dominance of tidal signature, though not exclusive to, is typical of estuarine settings. The complex sedimentary record consisting of an abundance of channel fills, characterized by wide and extensive concave up deposits with fining/thinning upward successions, is common in estuarine successions, as are heterolithic beddings. This environmental context is further sustained by the ichnological assemblage suggestive of stressed waters with constant salinity fluctuations. However, future detailed facies mapping should be undertaken in this area in order to determine the spatial (i.e., lateral and vertical) distribution of facies associations, which is crucial to reconstruct the paleoenvironments and better characterize the depositional system.

Based on data presented herein, it is recommended to search further evidence of tidal sedimentation in the Barreiras Formation that occurs in other coastal areas of northeastern Brazil. The pervasive occurrence of deposits with unambiguous evidence of tidal processes in the Barreiras Formation of northern Brazil, and now in the State of Alagoas, leads to argue that the early/middle Miocene period of worldwide marine transgression might have left a much more widespread sedimentary record along the Brazilian coast than currently regarded.

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RESUMO

Processos de maré foram importantes na deposição da Formação Barreiras localizada no norte do Brasil, enquanto depósitos correlatos do nordeste brasileiro têm sido tradicionalmente relacionados a ambientes continentais. Análise de fácies no sul de Alagoas revelou que a Formação Barreiras consiste em conglomerados e arenitos com estratificações cruzadas (facies Sx e Cgx), arenitos com estratificação cruzada composta (facies Cx), e acamamentos heterolíticos (facies H). Uma porção significativa desses depósitos ocorre inserida em morfologias de canal, internamente contendo sucessões de granocrescência e adelgaçamento ascendentes. A abundância de feições sedimentares é comparável àquelas documentadas em depósitos correlatos do norte do Brasil. Estas incluem: bandamentos de maré; estratificações cruzadas espinha-de-peixe; acamamentos heterolíticos contendo camadas de arenitos e argilitos em contato brusco; e icnofósseis consistindo principalmente em *Ophiomorpha nodosa*, *Skolithos* e *Planolites*. Estas feições apontam para ambiente deposicional marinho marginal dominado por processos de maré, possivelmente relacionado a sistema estuarino. Esta interpretação é similar à atribuída para a Formação Barreiras no norte do Brasil. A ampla ocorrência de depósitos contendo evidência inequívoca de processos de maré na Formação Barreiras no norte do Brasil, e agora também no Estado de Alagoas, leva a propor que o período de transgressão marinha registrada globalmente no eo/meso Mioceno pode ter deixado um registro sedimentar muito mais amplo ao longo da costa brasileira do que até então considerado.

Palavras-chave: Mioceno, transgressão marinha, correntes de maré, estruturas sedimentares, nordeste do Brasil.

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