

# SEQUENCES AND CORRELATIONS OF BRASILIAN LATE PALEOZOIC AND MESOZOIC DEPOSITS

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## ABSTRACT

Sedimentary sequences in the sense of packs of rocks limited above and below by widespread unconformities and their possible continental or worldwide extensions are here discussed based on the Brazilian Mesozoic sequences inasmuch as a great amount of information on the Brazilian Mesozoic rocks is available.

The conclusion reached herein is that even though there are widespread tectono-sedimentary events the resulted sequences are not worldwide except perhaps for a few examples. The Mesozoic fault tectonism responsible for the Brazilian rift-valleys started in the Northeast during Valanginian-Barremian times and migrated Northward and Southward, reaching the Middle North Coast during Albian and the North Coast (Amazonas Mouth Basin) during Late Cretaceous. The principal tectonism in the Southernmost Brazilian coast are Tertiary in age. The Middle North taphrogenesis reflected in the Parnaíba, São Francisco and Amazonas intracratonic basins. The Paraná intracratonic basin on the other hand, was not influenced by this tectonism; no sedimentary record of this interval of time is known (Albian-Santonian) so the tectonic-sedimentary events are not synchronous in the three intracratonic basins.

The Paleozoic-Mesozoic unconformity with an hiatus involving Early Triassic could however be a Brazilian example of unconformity fitting the world framework.

## RESUMO

Discutem-se aqui os problemas das seqüências sedimentares no sentido de agrupamentos de rochas em sucessões separadas por discordâncias de natureza regional na base e no topo e suas possíveis extensões em âmbito intercontinental ou mesmo mundial.

A tese aqui defendida é que, embora haja eventos tectono-sedimentares de grande amplitude geográfica, responsáveis pelo desenvolvimento de seqüências, elas não são de âmbito mundial excetuando-se, talvez, alguns poucos eventos.

As seqüências mesozóicas do Brasil são tomadas como exemplo, tendo em vista o grande volume de dados que já se possui. A migração do tectonismo de falhas, do NE para o N e para o S seria contrária à idéia de eventos tectono-sedimentares sincrônicos, premisa necessária à admissão de seqüências de grande amplitude geográfica. As sinéclises do Parnaíba e São Francisco sofreram reflexos do tectonismo costeiro do Meio Norte. A única seqüência mesozóica da Bacia do Amazonas estaria relacionada à seqüência albiana-santoniana da Bacia do Parnaíba.

No extremo norte do país, a Fossa do Tacutu das Guianas, avança pelo território brasileiro de Roraima, por área de cerca de 150 km por 150 km. A seqüência cretácea aí presente, é de idade purbeckiana-barremiana. A única seqüência mesozóica da Bacia da Foz do Amazonas não pode ser comparada às seqüências da Fossa de Barreirinhas e estas não podem ser comparadas às seqüências das fossas tectônicas do Nordeste.

## INTRODUCTION

Since 1964 several Brazilian geologists have tried a synthesis of the geological history of the Brazilian Phanerozoic through the establishment of sequences.

Mesner and Wooldridge (1964, p. 139) grouped the Parnaíba Basin Phanerozoic in three sequences: 1) Late Silurian-Mississippian; 2) Pennsylvanian-Triassic; 3) Cretaceous. A sequence, according to Mesner and Wooldridge would be a succession of deposits found in a definite climatic and tectonic framework. There would be indeed four sequences in the Parnaíba Basin even considering their concept; the second one could be split into two, that is, Pennsylvanian-Permian and Triassic.

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Gomes (1968) did the first effort to reach a nationwide Phanerozoic subdivision into sequences but his concept (as well as Mesner and Wooldridge's) is different from the present one. He proposed five sequences: 1) Silurian-Denovian; 2) Carboniferous-Permian; 3) Triassic-Early Cretaceous; 4) Late Cretaceous; 5) Cenozoic. He stated however that *his sequences would not be exactly time equivalents in the three intracratonic basins (Amazonas, Parnaíba and Paraná)*.

Almeida (1969) also proposed a nationwide subdivision of Phanerozoic sequences but again his concept of sequence was different from the present one. His subdivisions are: 1) Cambro-Ordovician; 2) Early Silurian-Mississippian; 3) Pennsylvanian-Triassic; 4) Late Jurassic-Early Cretaceous (pre-Aptian); 5) Early Cretaceous (post-Aptian)-Eocene; 6) post-Eocene.

The Brazilian geologists after 1970, have followed Krumbein, Sloss and Dapples' (1949) and Sloss' (1963) concept of sequences. Fulfaro (1971) accepted this concept and considered the following sequences in the Paraná Basin: 1) Denovian; 2) Pennsylvanian-Permian; 3) Late Jurassic-Early Cretaceous. Soares (1973) proposed, still for this basin: 1) Late Paleozoic; 2) pre-volcanic and volcanic Mesozoic; 3) Late Cretaceous.

Ghignone's (1972) sequences were based mainly on the Northeast of Brazil but he extended them to most of the Eastern Brazil. He proposed: 1) End of Precambrian-beginning of Cambrian; 2) Ordovician-Mississippian (Amazonas Basin), Devonian-Mississippian (Parnaíba Basin) and Denovian (Paraná Basin); 3) Pennsylvanian-Permian; 4a) Non-marine sediments associated with basaltic lavas and 4b) Late Jurassic-Early Cretaceous (pre-Aptian) (from the rift-valleys); 5) Aptian-Albian (post-tectonic); 6) Tertiary.

Sloss' ideas (1972) of correlations between continents, born from the comparisons of North-America and Russia cratons were stressed by Fulfaro and Landim (1973) who based on the Brazilian intracratonic basins inasmuch as the rift-valleys would be subjected to a more complicated tectonism.

They did a closer study of the Paraná Basin considering the stratigraphy of the Parnaíba and Amazonas Basins not sufficiently set. They proposed the following sequences: 1) Early-Denovian-Mississippian; 2) Pennsylvanian-Late Jurassic; 3) Late Jurassic-Paleocene; 4) post-Paleocene.

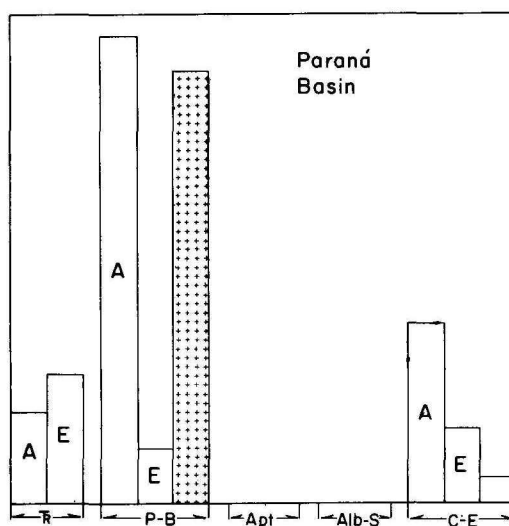


Fig. 1 - Paraná Basin.

Since Sloss' publication there is a rising conviction of worldwide tectono-sedimentary events and if this is true the geologists would have a precious tool for worldwide correlations.

The purpose of this paper is to try to demonstrate that even though some tectonic-sedimentary events may reach large portions of the Earth they cannot be taken as worldwide perhaps with a few exceptions. Would this synchronicity of events be true then record of the

Brazilian Ordovician, for instance, would be widespread as it does in the Northern hemisphere where a great subsidence occurred. The Brazilian Ordovician record however, is very meager and affossiliferous formed in molassic environments, the dying remnants of the Latest Precambrian geosynclinal episodes.

It is true that the intracratonic basins are submitted to tectonisms weaker than the rift-valleys but nevertheless they must be influenced by the rift-valley tectonisms either directly or indirectly by fluctuations of the base level.

The Brazilian Mesozoic is the best known of the Eras so the points of view here explained are mostly illustrated by the Mesozoic examples.

### LATE PALEOZOIC AND MESOZOIC SEQUENCES

Every above cited author who dealt with the problem of recognition of Brazilian sequences points out a Late Paleozoic one, started in the Pennsylvanian and closed in the Late Permian, Triassic or even Early Jurassic according to different authors. They all agree in the delimitation of the base of the sequence because the Pennsylvanian beds are richly fossiliferous with good index-fossils clearly distinguished from underlying Mississippian or Devonian fossils. The lack of unanimity in the definition of the top of the sequence is due to poor fossiliferous or even barren beds. The tectonic-sedimentary framework of the basins and the cycles of sedimentation become them of prime importance in the correlations of these barren or scarcely fossiliferous beds.

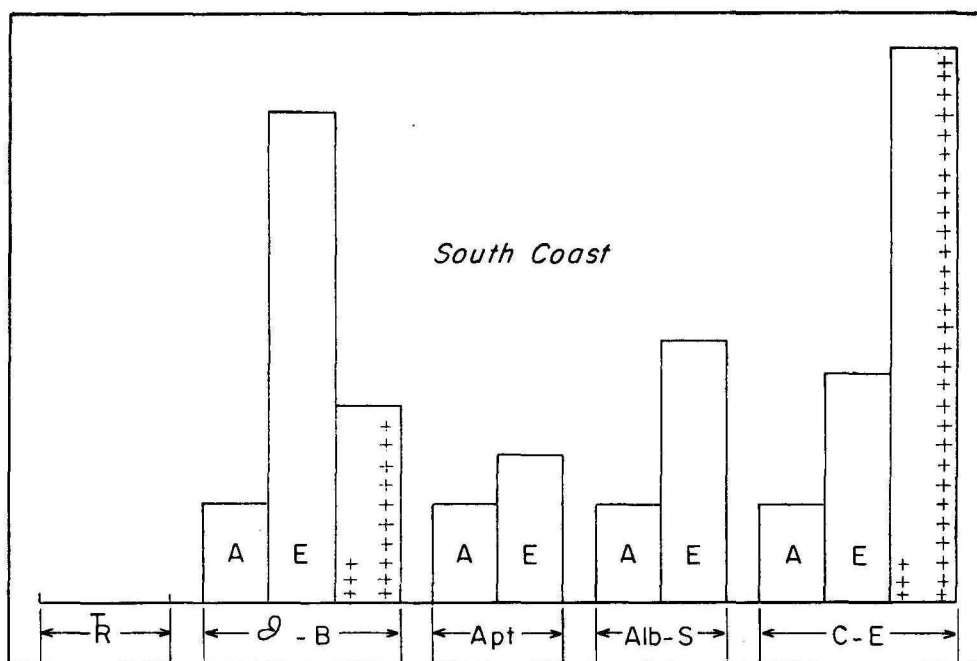


Fig. 2 - South Coast (Includes Santos, Campos and Espírito Santo basins).

The Late Paleozoic sequence is a transgressive-regressive cycle clearly seen in the Amazonas Basin. Its transgressive phase is made up by the Monte Alegre Formation and part of the Itaituba Formation. The first one, a sandstone with some gray shales and dolomite and limestone beds, were laid down in fluvio-lacustrine environments. Itaituba is a marine limestone and shale formation. Its regressive phase is made up by the upper part of the Itaituba, by the Nova Olinda Formation, when evaporites were laid down in restricted seas and closing with the non-marine Permian Andirá Formation. This cycle is characterized by a rather sudden

transgression with fluctuations and a slow regression. The culmination of the regressive phase resulted the emergence and erosion, the hiatus involving the Triassic, Jurassic and Early Cretaceous. Only in the Albian was the sedimentation resumed. This long time of no sedimentation characterized the whole Northern Brazil except an small area in the Acre Basin where some sediments containing evaporites are considered as Late Jurassic.

This Late Paleozoic transgressive-regressive cycle of the Amazonas Basin involved in a hot arid climate and so thick evaporitic successions were formed in the restricted regressive seas.

The Parnaíba Basin exhibits also a Late Paleozoic cycle enclosing the Piauí, Pedra de Fogo, Motuca and Sambaíba Formations. The transgressive phase is short-lived and the regressive phase is long-lived similar to the Amazonas Basin. The transition from the transgressive to the regressive phase occurred within the Piauí Formation. This formation has a marine and a non-marine facies. The regressive Pedra de Fogo Formation constitutes a succession of repetitive flood plains and lacustrine deposits. The landscape might be a flat lowland with a great number of lakes. The following Motuca Formation might have been laid down in a hot lowland environment perhaps with some salty water influence and so some anhydrite beds were formed. The following Sambaíba Formation has a more continental flavor and its lithology is afossiliferous red and pink sandstone predominantly cross-bedded. According to Aguiar (1971) the Motuca Formation passes gradually to the Sambaíba and this is covered unconformably by basaltic rocks. The Pastos Bons Formation which is supposed to be younger than the basalts has good index fossils of the Late Triassic. On the other hand, according to Silva *et alii* (1974) the Sambaíba Formation would have Juro-Triassic sporomorphs and would lay unconformably on Pedra de Fogo Formation (which includes the Motuca Formation in their concept).

The stratigraphical position of the Sambaíba Formation as well as its lithological characteristics which would naturally place it at the top of the regressive phase of the Late Paleozoic transgressive-regressive cycle are reasons for considering it as Late Permian corresponding to the Andirá Formation of the Amazonas Basin. The unconformity pointed out by Silva *et alii* could eventually be diastems so common in formations that close regressive phases. Another possibility would be the consideration of the sporomorphs as soundly dated and so the formation would be Juro-Triassic in age. No Early Triassic sediments are known in the Parnaíba Basin anyway and the first Triassic sediments in the basin is the Late Triassic Pastos Bons Formation (the field relationships between Sambaíba and Pastos Bons are unknown).

The Pennsylvanian-Permian transgressive-regressive cycle with the same property of a swift transgressive and a slow regressive phase with fluctuations is also recognized in the Paraná Basin. The glacial climate during the transgressive phase however propitiated the deposition of many tillite and drift bodies that blurred much of the marine characteristics of the sediments. However many outcrops of marine fossiliferous sediments are known. The regressive phase kept pace with an amelioration of the climate.

The transgressive Itararé Formation of the Tubarão Group reaches 1,300 m due to the high rate of sedimentation. The regressive phase is constituted by the Rio Bonito and Palermo Formations of the Tubarão Group and by the Irati-Serra Alta, Estrada Nova and Rio do Rastro Formations of the Passa Dois Group. The post-glacial Tubarão is 200m thick and the Passa Dois Group is 1,700 m thick.

The Paraná Basin region after the glaciation was a lowland with lakes chaotically disposed bespeaking a Finnish landscape. The Rio Bonito Formation were at least partly deposited in deltaic environments. Irati and Serra Alta are lacustrine or lagoonal facies of the same formation, laid down respectively under strong and mild reducing conditions. The gradual prograding of the lakes resulted the Estrada Nova Formation and the establishment of more and more subaerial conditions resulted in the deposition of the fluvial Rio do Rastro Formation. This formation therefore is the culmination of a long slow regressive tendency of the Paraná Basin during the latest times of the Paleozoic and could therefore be correlated to the Andirá and Sambaíba Formations of the Amazonas and Parnaíba Basins. The continuation of the regressive trend resulted in the inception of erosive conditions in the beginning of the Triassic.

The Late Triassic Rosário do Sul Formation of the State of Rio Grande do Sul is the oldest Mesozoic Formation of the Paraná Basin. The Pirambóia Formation of the State of São



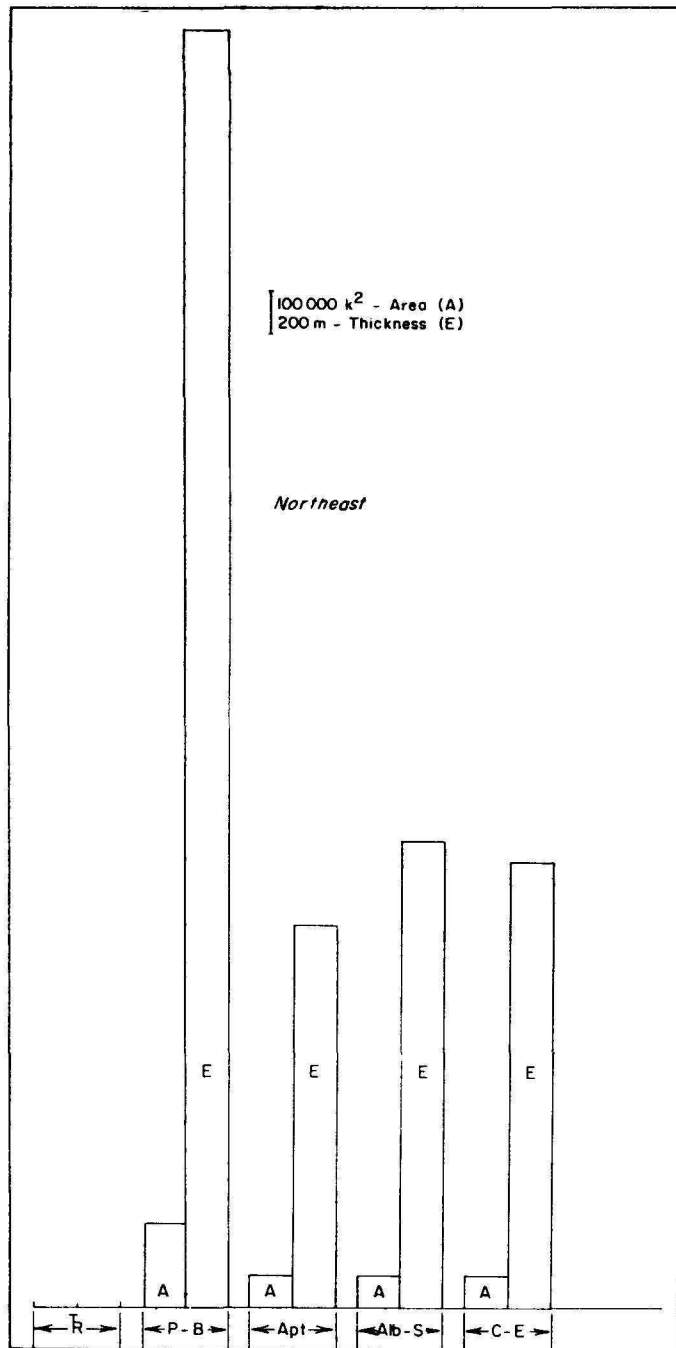


Fig. 3 - Northeast (Includes Jequitinhonha, Recôncavo, Tucano and Jatobá, and Sergipe-Alagoas basins).

Paulo may be of the same age. As no Triassic sediments are present in the rift-valleys so *the beginning of the Triassic was a time of generalized emergence of the Brazilian craton and lack of sedimentary record and erosion were ubiquitous in consonance with a worldwide trend during the dawn of the Mesozoic.*

The Earliest Triassic generalized emergence was not the result of an uniform

epirogenic uplift at least as far as the Parnaíba Basin is concerned. This basin was a symmetrical one during the Late Paleozoic with the most subsident area located in the middle of the basin. During the Triassic, on the other hand, the basin tilted Westward (Mesner and Wooldridge, 1964).

The Brazilian Triassic sedimentary record is restricted to the Paraná and Parnaíba Basins and always laid down under fluvio-lacustrine environments. A succession of cycles of channel and overbank deposits characterizes the Pirambóia Formation. Its isopach map

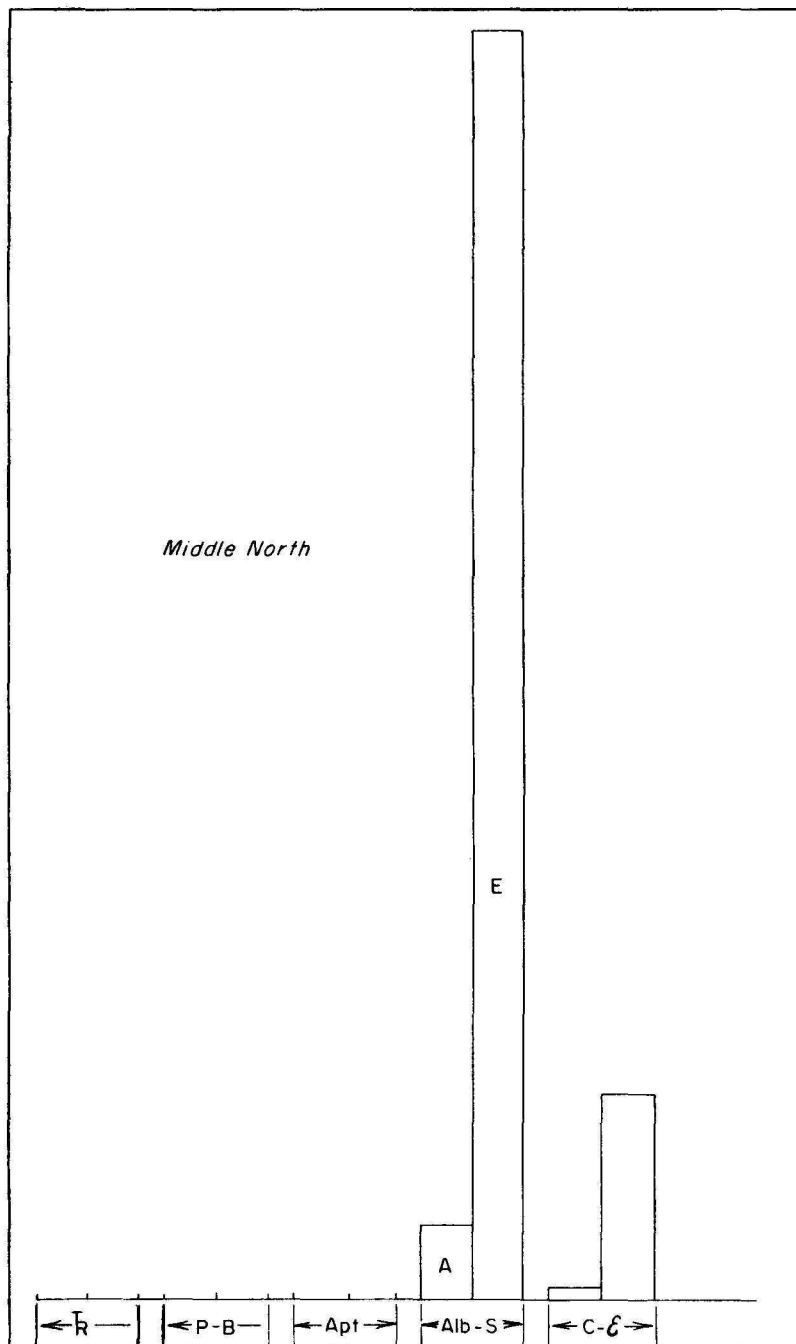


Fig. 4 - Parnaíba-S. Francisco basins.

suggests a Northwest drainage toward the junction of the Grande and Paranaíba rivers (Soares, 1973). The continuation of the drainage beyond that point is unknown. Sandstones believed to belong to the Uppermost Jurassic Botucatu Formation spread over the lowlands about the Paraná river, covered by younger beds. Part of these sandstones might belong to the Pirambóia and if so an inflexion of the Triassic drainage South of junction Grande-Paranaíba would be warranted. Environments similar to the Pirambóia ones might have occurred during the deposition of the Rosário do Sul but with an important fluvio-lacustrine intercalation, where sediments famous for their fossils were deposited (Santa Maria). The areas of occurrence of these two formations suggest that they belong to two branches of a drainage basically directed toward the South. A Southern trend of the drainage similar to the present one would therefore be present as early as the Triassic, lately disrupted by the Botucatu aridness and the basaltic flows. The reorganization of the present drainage took place during the times of deposition of the Bauru Formation. The Paranaíba Basin, Pastos Bons and Corda Formations constitute also a fluvio-lacustrine cycle of sedimentation more humid during Pastos Bons times and drier during Corda times.

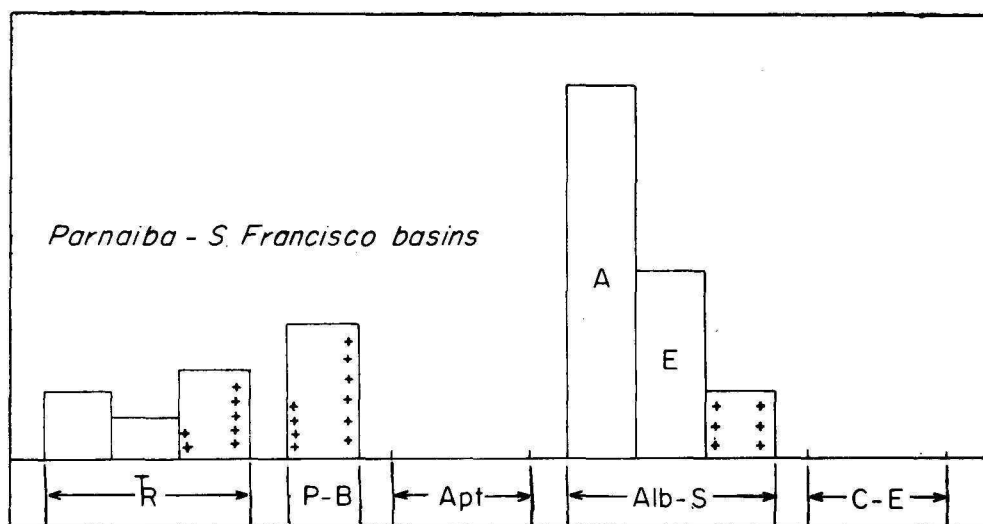


Fig. 5 - Middle North (based mainly on Barreirinhas Basin but might include Recife-João Pessoa, Potiguar, S. Luiz and Bragança-Vizeu basins).

The above mentioned formations are the only sedimentary record of the Brazilian Triassic. *This record is therefore relatively poor and no marine beds are known.*

Similar to the Triassic there is no sedimentary record of the beginning of the Jurassic. *The whole sedimentation supposed to be Jurassic is poorly fossiliferous, considered to be Purbeckian and in the rift-valleys passing upward gradually to Early Cretaceous beds. No Jurassic marine beds are known in Brazil. This is in sharp contradiction to what happened in the world where subsidence prevailed in widespread regions during great part of the period.*

The Late Jurassic in the Paraná Basin was dominated by deserts where the Botucatu sands were formed. Interfingering of the first basaltic flows and the last Botucatu sands and the presence of basaltic particles in the sands of the top of the Botucatu attest that the desert sands were still accumulating when the first basaltic flows poured over the geoclasts opened in the desert. Other evidences of contemporaneity are basaltic blocks enclosed in the sands formed either through volcanic explosions (Leinz, 1949) or through the development of talus deposits where the blocks were rolled down (Mendes and Frakes, 1964) and dune surfaces covered by basaltic flows (Almeida, 1964). As the radiometric ages of the basalts are Latest Jurassic-Early Cretaceous, a Purbeckian-Barremian sequence or Dom João-Alagoas, after Schaller (1969) and Vianna *et alii* (1971) can be figured out for the Paraná Basin, starting with a sedimentary phase and closing with a volcanic phase. Large flows of basaltic lavas which seem to be of the same age, are known in Santos Coastal basin.

This sequence is very incompletely developed in the Parnaíba Basin, where basalts were present but thinner and extending through a smaller area in comparison with the basalts of the Paraná Basin. This sequence is not present in the Amazonas Basin and only in the Acre it is represented by red beds of Juruá Mirim thought to be Purbeckian in age, occupying a restricted area. North of the Amazonas Basin it occurs at the Takutu rift-valley going from the Guianas, to the Roraima Territory. The total thickness of the sediments filling this rift-valley, which may include Tertiary beds, is 3,300 m.

The Northeastern rift-valleys on the other hand, contain huge representations of this sequence with enormous thicknesses syntectonically deposited. The first sediments of this sequence are equivalent in time with Botucatu Formation. Anhydrite and halite are developed in the Southern Recôncavo Basin in the lower part of the Aliança Formation suggesting ample development of dry climates in those being present in regions as far apart as Recôncavo, Paraná and Acre.

The upper part of the Aliança Formation is made up of coarse and fine clastics with sedimentary structures bespeaking deposition in flood plain environments full of ponds and oxbow lakes. Red clay beds are common in the lower section suggesting red soils sources. The overbank and pond deposits exhibit oxidizing conditions but greater lake deposits exhibit reducing conditions.

Sand intercalations with red hues are more and more frequent toward the top suggesting that the soil cover of the source areas were gradually razed with increased erosion of fresh rocks.

The following Sergi and equivalent formations reflect the continuation of the denudation of the source areas resulting in a sandy succession with some clay beds in the lower section. Crossbeddings are frequent developed even in conglomeratic beds bespeaking torrential flows. Silicified conifer trunks lay down along bedding planes suggesting current action. The climates therefore became wetter perhaps with rainy and dried seasons.

The Recôncavo and Tucano Latest Jurassic scenery was that of a tectonic valley drained toward the South. Jatobá, Mirandiba, São João do Belmonte and Araripe regions probably belonged to the same river system. They were probably parts of only one basin broken by subsequent erosion. The thicknesses of the formations increase gradually Southward and the coarsenesses of the sandstones, contrarily, decrease. The most negative area was Southern Recôncavo and to it the old rivers might converge.

The Recôncavo-Tucano Latest Jurassic valley persisted during Valanginian to Barremian times but the headwaters changed from Mirandiba-São José do Belmonte-Araripe to Rio do Peixe, Iguatu, Malhada Vermelha, Lima Campos, Icó, São Miguel and Pau dos Ferros.

The sedimentation in the headwaters is best shown in the Rio do Peixe Basin where shales with some marls (Souza Member) is located between lower Antenor Navarro Sands and Upper Piranha Sands. The lithologies, fossils and sedimentary structures suggest a fluvial environment evolving to a lacustrine one (Souza Member). The gradual prograding of this lake formed the flood plain deposits known as Piranha Member.

At Iguatu, clay and marl thin beds form a lithology that alternates with sandy beds, suggesting the presence of lakes passing laterally to flood plains. The contact between these two facies changes constantly suggesting great fluctuations with time of the geographical distributions of the two environments.

The conglomeratic sands that predominate at Icó, Lavras de Mangabeira, Lima Campos and Pau dos Ferros suggest the predominance of channel river environments.

The Tucano and Recôncavo were occupied during Early Cretaceous times by great lakes passing laterally to flood plains. Shales, some bituminous, siltites, dolomites, and limestones were formed in these lakes while massive sandstones with clay galls often with slump structures were formed in the flood plains (Itaparica and Candeias Formations). The realms of the two sub-environments changed with time.

During the deposition of the Candeias Formation the increased fault tectonism caused deposition up thick coarse clastics, bad sorted, immature and with high rate of unstable minerals. Their thicknesses and coarsenesses decrease abruptly away from the fault slopes passing gradually to sandstones and shales.

The fluvio-lacustrine environments persisted for long time with fluctuations between

the lakes and flood plains. This fluvial cycle ended with the prograding of the fluvial valleys by the S. Sebastião Formation sediments and finally erosion installed on the area.

This sequence corresponds to Ghignone's n. IV (Ghignone, 1972). According to this author its deposits would cover all the land from Northern coast to the Recôncavo including the Sergipe-Alagoas area. It must be reminded however that they are fluvio-lacustrine deposits and so a linear disposition of its sediments would be expected along an old drainage. There are no evidences that the Recôncavo-Tucano fluvial system went as far North as the Northern coast and the deposits of the Sergipe-Alagoas Basin, though similar in lithology, could be accumulated in independent fluvial systems.

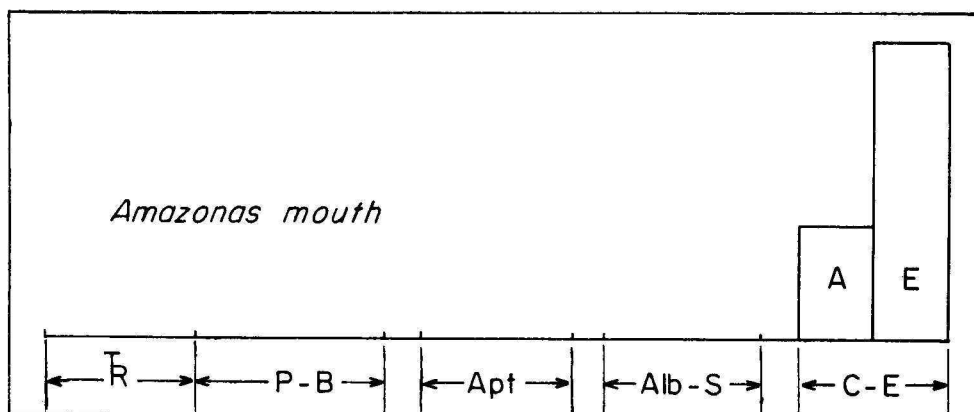


Fig. 6 - Acre Basin.

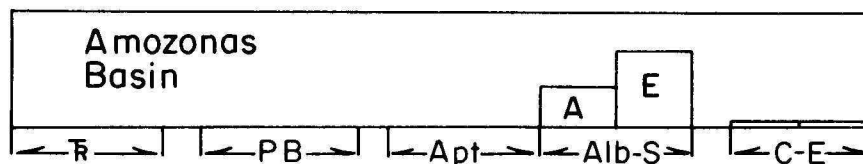


Fig. 7 - Amazonas intracratonic Basin.

The unconformity between pre-Aptian and Aptian sediments involved deep structural rearrangement in the Northeastern and Eastern rift-valleys. The Purbeckian-Barremian sediments are intensively faulted commonly with dips toward the continent while the younger sediments are less disturbed and with dips toward the ocean.

An unconformity between Early and Late Aptian is widespread in spite of the short-lived hiatus. Dry climates prevailed in the Northeast and East during Aptian times with evaporites beds among the regressive sediments of the coastal basins. The Aptian Marizal Formation of Recôncavo, Tucano and Jatobá has a different lithology because of the non-marine environment of deposition. Contrary to the other formations, it thickens irregularly Northward. Its lithologies, the distribution in isolated spots associated to rising fault blocks and the irregularity of thicknesses suggest local sources and torrential currents or even mud flows near the slopes and slower flows away from the slopes. Even though evaporites are unknown the climate could be dry with endorreic drainage at least during certain times.

The area of distribution of the Marizal is smaller than the areas of previous formations which indicate already a trend to the consolidation of these basins to the F.razilian craton.

The following transgressive-regressive sequence is Late Aptian-Santonian in age. The advancing seas reached its farthest front in the Northeast and Middle North regions, during Middle Albian times being present in the Parnaíba and Araripe Basins. Ghignone (1972) called this sequence V, stating that the Albian sediments covered at least half of the Brazilian territory. This surely is the most important Mesozoic transgression in Brazil but it is herein

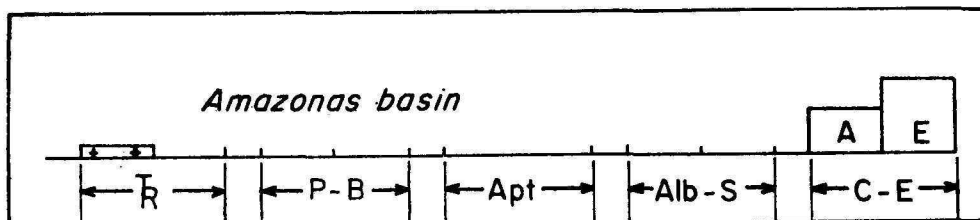


Fig. 8 - Amazonas Mouth Basin.

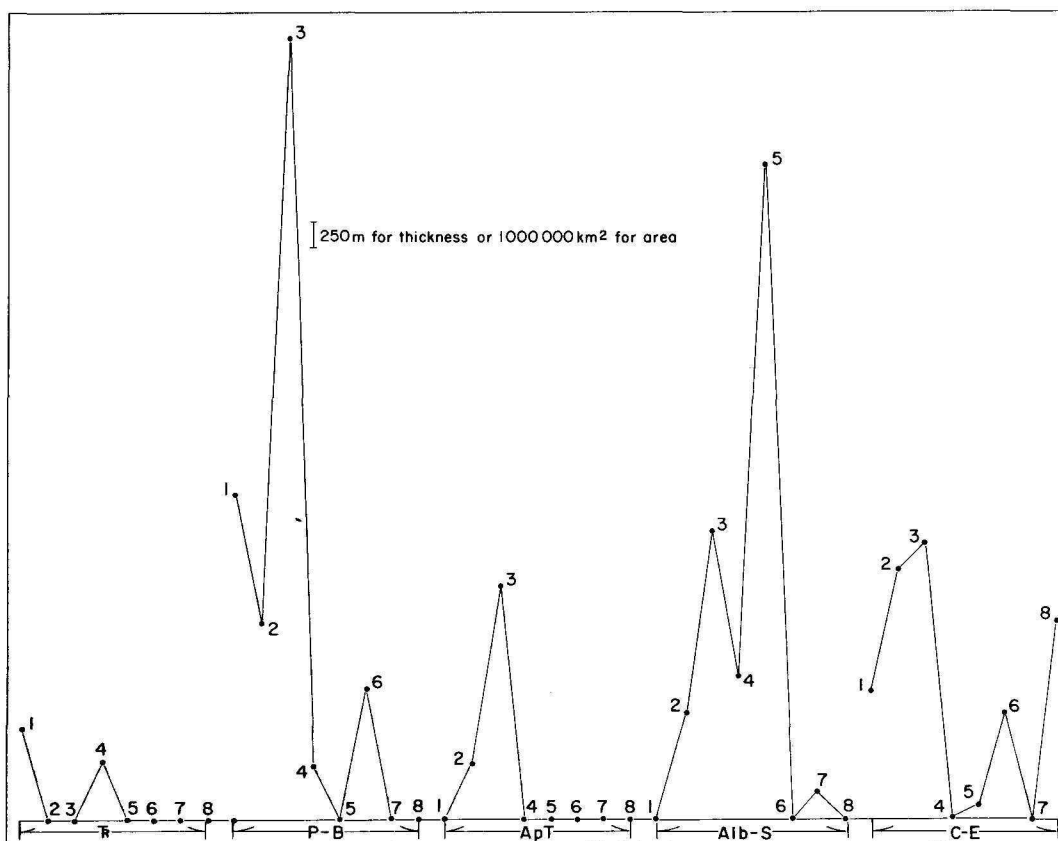


Fig. 9 - Combination of the preceding figures.

1 - Paraná Basin; 2 - South Coast; 3 - Northeast; 4 - Parnaíba and S. Francisco; 5 - Middle North; 6 - Acre; 7 - Amazonas intracratonic Basin; 8 - Amazonas Mouth.

The peaks of the curves represent maximum developments of the sequences per region as specified above. Same legend of the other figures.

believed that its sequence didn't cover half Brazil. It is important and can be considered an unity only in Center-East Brazil, including the Middle North Basins (Barreirinhas and S. Luiz) Parnaíba and S. Francisco Basins. In the Northeast and East regions a Cenomanian hiatus breaks the succession into two sequences, Late Aptian to Albian and Turonian to Santonian.

The Center-East Brazil, from S. Francisco Basin Northward, was submitted to a tectono-sedimentary development dependent on the taphrogenesis of the Middle North rift-valleys that occurred later than the Northeastern main taphrogenesis the peak being in the Albian. This sequence is represented in the Parnaíba Basin by the Grajaú-Codó-Itapecuru Formations.

The Grajaú sediments accumulated in subsident flood plains so marine influences



were gradually established with the deposition of the Codó Formation though open marine conditions never occurred. Anhydrite and oyster banks attest the presence of restricted seas. Non-marine ostracodes and fishes are also present in this formation. These flood plains and restricted seas extended to Chapada do Araripe, being represented respectively by Crato and Santana Formations.

A great river, ancestor of the present S. Francisco, extended from South to North with its headwaters in Center-West Minas Gerais, about the present 20° latitude and going to Maranhão Continental shelf to present latitudes below 2°, during the Albian-Santonian interval of time. While the Codó Formation was in process of accumulation in the Parnaíba Basin, the Areado Formation was being deposited in Minas Gerais and Bahia. Piedmont coarse sediments were being formed near Alto Parnaíba Arch grading away to fluvio-lacustrine finer sediments.

The regressive phase of the Aptian-Santonian sequence started in the Parnaíba Basin in the middle of the Codó and continued above by the red beds of the Itapecuru Formation. The emergence of the basin in the Santonian closed the cycle. The Alcântara of the S. Luiz Basin might belong to the Itapecuru and supposed unconformity between these two formations might be one of the diastems which are so common in the regressive formations. The correspondent regressive formation of the Chapada do Araripe is known as Exu.

The basal sediments of the Albian-Santonian sequence in the Barreirinhas are characterized by fanglomerates near rising fault slopes grading laterally to flood plains and lacustrine deposits. The fluvial deposits grade to deltaic plain deposits and then to prodeltaic ones. The succession of facies and absence of destructive phases suggest a constructive delta. This delta probably resulted from the work of many rivers converging to the area because of its high subsidence rate. The most important river however was probably the ancestor of the S. Francisco. Only a great river could be responsible for such an enormous thickness of sediments, up to 5,000 m, accumulated in a short geological time, only in the Albian. The present S. Francisco doesn't go all the way Northward but deviates Eastward along Pernambuco-Bahia and Alagoas-Sergipe borders. Perhaps the cause of this deviation is the Late Cretaceous reactivation of the Pernambuco lineament.

It is possible that the fluvial-lacustrine system responsible for the fluvio-lacustrine Alter do Chão Formation of the Amazonas intracratonic Basin drained toward this deltaic region, as suggested by Roberto F. Daemon, inasmuch as no correlative deposits are present in the Amazonas Mouth region.

As the regressive deposition of the Itapecuru Formation and of the deltaic deposits kept on in the Parnaíba, S. Luiz and Barreirinhas basins, the intensification of the rising movements along the areas near the Alto Parnaíba propitiated the development of volcanoes aligned Northwestward from which alkaline and ultrabasic lavas poured out and hipoabisal rocks were formed. The lavas and volcanic tuffs grade laterally to cross-bedded tuffaceous sandstones and conglomerates and these to argillaceous sandstones with a montmorillonite cement derived from volcanic sources. These volcanic derived sediments are known as Mata da Corda Formation.

Alkaline volcanic manifestations resumed in the upper section of the Paraná Basin and nearby Precambrian during Uppermost Cretaceous going up to Lowermost Tertiary, extruded from volcanic edifices.

The last important unconformity in the Brazilian Cretaceous is found between Santonian and Campanian. The last Cretaceous sequence going up to the Eocene is present in most of the Southern and Northeastern rift-valleys; however, it is restricted to the continental shelf in the Middle North, it starts in the Cenomanian in the North and it is lacking in the Parnaíba intracratonic Basin. This sequence is restricted to the upper section of the Paraná Basin, being present in the States of São Paulo, Minas Gerais (Triângulo Mineiro), Goiás and Mato Grosso. The sequence in the Upper Paraná sub-basin starts with the Uberaba Formation, made up of tuffaceous sandstones and conglomerates, grading laterally and vertically to the sediments of the Bauru Formation, predominantly arenaceous, some with calcitic cement accumulated in conditions of high viscosity and low energy fluvio-lacustrine environments.

The Alto Parnaíba Arch behaved then as a more positive feature than the Ponta Grossa Arch and so the Bauru paleoslope dips Southwestward from this Arch. The drainage of the fluvial system responsible for the Bauru deposition parallels approximately that of the

present Paraná river system. It looks that the Paraná river basin in their general trend of the drainage direction was Maestrichtian, resulting of the Upper Cretaceous rearrangement of the drainages disrupted by the basaltic volcanism and Botucatu endorreism and general aridity that prevailed during Aptian times.

Really the Mesozoic sequences in different Brazilian tectono-sedimentary regions must be conceived according to Table 1.

**TABLE 1**  
**Brazilian Mesozoic Sequences According to the Geological Regions**

ACRE	TAKUTU	AMAZONAS MOUTH	AMAZONAS	MIDDLE NORTH and CENTER EAST	NORTHEASTERN RIFT-VALLEYS	PARANÁ BASIN	SOUTHERN RIFT-VALLEYS
Neocomian-Eocene		Neocomian-Eocene		Campanian-Eocene (only in continental shel)	Campanian-Eocene	Volcanics Maestrichtian	Campanian-Eocene
			Late Aptian-Santonian	Late Aptian-Santonian	Turonian-Coniacian		Late Aptian-Santonian (?)
					Late Aptian-Albian		Early Aptian
					Early Aptian		
Purbeckian	Purbeckian-Barremian			Volcanics	Purbeckian-Barremian	Purbeckian-Barremian (sediments and volcanics)	Purbeckian-Barremian (sediments and volcanics)
				Middle and Late Triassic		Middle and Late Triassic	

A synthesis of the Brazilian Mesozoic sequences might be tried taking into account the data of the Table 1, bearing in mind that they are not ubiquitous over the whole territory of the Nation.

- 1 - Campanian-Eocene
- 2 - Late Aptian-Santonian
- 3 - Early Aptian
- 4 - Purbeckian-Barremian
- 5 - Middle and Late Triassic

The relative importance of these sequences change according to the tectonic history of the region considered. In the Eastern Northeast, the most important one is the Purbeckian-Barremian. In the Eastern and Northern Brazil, from Maranhão and São Francisco basins to Amazonas Basin, the most important one is the Late Aptian-Santonian and in the Amazonas Mouth Basin the most important one is Neocomian (Campanian)-Eocene.

Figures 1 to 8 represent the relative importances of the referred sequences at the different regions. The intracratonic basins were considered separately except Parnaíba and S. Francisco which were grouped together, the S. Francisco Basin being considered a continuation of the Parnaíba one. The South coastal basins were grouped together and so the Northeastern ones and the Middle-Northern ones. The Takutu rift-valley was not illustrated because of the lack of informations about the thicknesses and distributions of its formations.

Figure 9 represents the combination of data from Figures 1 to 8.

As tectonism and sedimentary sequences are closely related it is herein not believed that all the recognized sequences in the intracratonic basins are of world amplitude even though some unconformities are so ample that might eventually be very near to the ideal world extension. The Permian-Triassic unconformity might be one example of this kind.

The Brazilian territory could be split into four tectono-sedimentary regions according to the Mesozoic sequences present and their importances: 1) South; 2) Northeast; 3) Center-

East and Middle North and 4) Amazonian region.

The South would include the Paraná Basin and the coastal basins up to Espírito Santo. It has the following characteristics: 1) Purbeckian-Barremian sequence present with great volcanic manifestations; 2) Aptian evaporites in the coastal basins; 3) Campanian-Eocene sequence with volcanic manifestations.

The Northeast has the following characteristics: 1) Syntectonic Purbeckian-Barremian sequence of prime importance; 2) Aptian evaporites in the coastal basins; 3) Late Aptian-Santonian sequence not present. It is split into two sequences, Late Aptian-Albian and Turonian-Coniacian, separated by a Cenomanian unconformity.

The Center-East and Middle North region would include the S. Francisco, Parnaíba, Potiguar, Barreirinhas, São Luiz, Bragança-Vizeu and Chapada do Araripe basins. It has the following characteristics: 1) Syntectonic Late Aptian-Santonian sequence of prime importance; the most important phase of sedimentation, principally in the Barreirinhas Basin, is Albian in age; 2) evaporites when present are of secondary importance; 3) Campanian-Eocene sediments restricted to the continental shelf.

The Amazonas region is characterized by a long-lived unconformity spanning the whole Triassic and most the Jurassic with restricted beds belonging to the Purbeckian-Barremian sequence in Acre and Tukutu rift-valley.

The pre-wealdian hiatus in the Southern and Northeastern rift-valleys involves the whole Triassic and pre-Purbeckian Jurassic. In the Middle North rift-valleys, it goes up to the Aptian and in the Amazonas Month rift-valley, up to the Cenomanian. There is therefore a gradual increase of the time of no record from South and Northeast to the North due to the migration of the principal tectonism, which speaks against the exact contemporaneity of the sequences.

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