



Tectonics and sedimentation in the Curitiba Basin, south of Brazil

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Abstract

The Curitiba Basin, Paraná, lies parallel to the west side of the Serra do Mar range and is part of a continental rift near the Atlantic coast of southeastern Brazil. It bears unconsolidated and poorly consolidated sediments divided in two formations: the lower Guabirota Formation and the overlying Tinguis Formation, both developed over Precambrian basement. Field observations, water well drill cores, and interpretations of satellite images lead to the inference that regional tectonic processes were responsible for the origin of the Basin in the continental rift context and for morphotectonic evolution through block tilting, dissection, and erosion. The structural framework of the sediments and the basement is characterized by NE–SW-trending normal faults (extensional tectonic D_1 event) reactivated by NE–SW-trending strike–slip and reverse oblique faults (younger transtensional tectonic D_2 to transpressional tectonic D_2' event). This tectonic event, which started in the Paleogene and controlled the basin geometry, began as a halfgraben and was later reactivated as a pull-apart basin. D_2 is a neotectonic event that controls the current morphostructures. The Basin is connected to the structural rearrangement of the South American platform, which underwent a generalized extensional or transtensional process and, in late Oligocene, changed to a compressional to transpressional regime.

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Keywords: Sedimentary basin; Tertiary and Quaternary tectonics; Morphotectonics; Neotectonics

Resumo

A Bacia de Curitiba, localizada no Estado do Paraná, é paralela à face oeste da Serra do Mar, e faz parte de um rifte continental, próximo à costa atlântica do sudeste do Brasil. É preenchida por sedimentos pouco consolidados a inconsolidados e abrange as formações Guabirota, inferior, e Tinguis superior, posicionadas sobre o embasamento pré-cambriano. Com base em observações em campo e imagens de satélite, bem como perfis de sondagem, conclui-se que processos tectônicos regionais propiciaram a origem da Bacia de Curitiba, no contexto do rifte continental e, em um segundo momento, controlaram sua evolução morfotectônica através de basculamento de blocos, dissecação e erosão. Tanto os sedimentos quanto o embasamento são caracterizados por falhas normais de direção NE–SW (regime extensional D_1), posteriormente reativadas como direcionais e inversas oblíquas (regime transtensional D_2 a transpressional D_2'). Os eventos ocorreram a partir do Paleógeno e definiram a geometria da bacia, iniciada como halfgraben e reativada como bacia pull-apart. O evento D_2 também gerou morfoestruturas e caracteriza processos neotectônicos. A bacia está ligada ao rearranjo estrutural da Plataforma Sul-Americana, que sofria inicialmente generalizado processo extensional ou transtensional e passa, a partir do Oligoceno superior, a sofrer processos compressionais e transtensionais.

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Palavras chaves: Embasamento pré-cambriano; Plataforma Sul-Americana; Compressonais e transtensionais

1. Introduction

The Curitiba Sedimentary Basin, which comprises an area of approximately 3000 km², is situated in the central-southern portion of the Curitiba plateau, Paraná (Fig. 1). It

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✉ In Memoriam.

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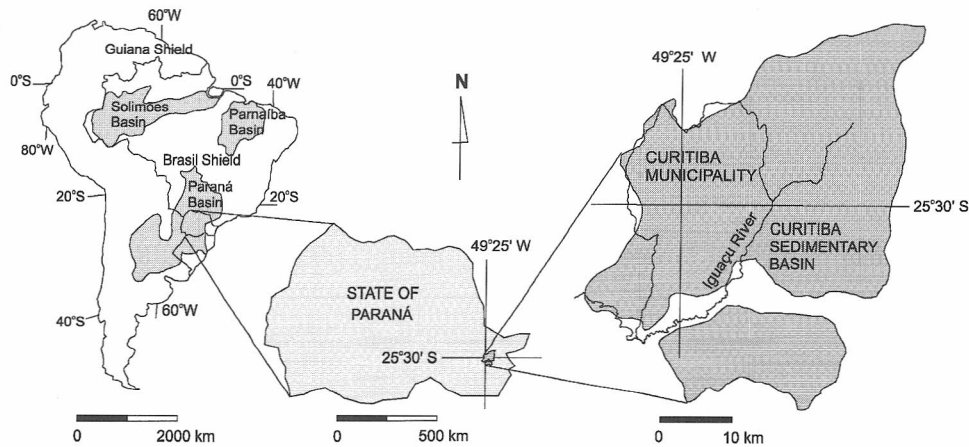


Fig. 1. Location of the Curitiba Sedimentary Basin.

belongs to a larger set of graben known as the continental rift of southeastern Brazil (Riccomini et al., 1989), which runs along the Serra do Mar range parallel to the Atlantic coast between Rio de Janeiro and Curitiba (Fig. 2).

The Basin is a NE–SW, elongated depression between the northern and central portions of the upper Iguazu River hydrographic basin with altitudes ranging between 870 and 960 m. It is completely surrounded by Precambrian rocks: the Serra do Mar range in the east and southeast margins and the Precambrian metasediments of the Açungui group in the west and northwest margins. The Basin strata are gently tilted toward the S–SW in the direction of the Iguazu River, which represents the regional base level.

Urban and industrial growth in the metropolitan region of Curitiba, as well as prospecting for nonmetallic minerals, has demanded comprehensive hydrological, geotechnical, and environmental studies. For these investigations, detailed lithological and structural information is required. This

paper presents such aspects and discusses the formation and evolution of the Curitiba Basin on the basis of the sedimentary filling, geomorphology, structures, tectonic kinematics, and paleostresses.

2. Methods

A combination of field data and aerial photo interpretations was used. Structural data, such as fault planes and their kinematic indicators, were obtained from the basin sediments and, where possible, in sedimentary rocks and the surrounding basement rocks. Data from drill holes also were assembled to understand the three-dimensional architecture of the basin sedimentary sequences.

Surface data were grouped in different morphostructural domains that characterize homologous zones, defined by parameters such as fracture density and orientation and by

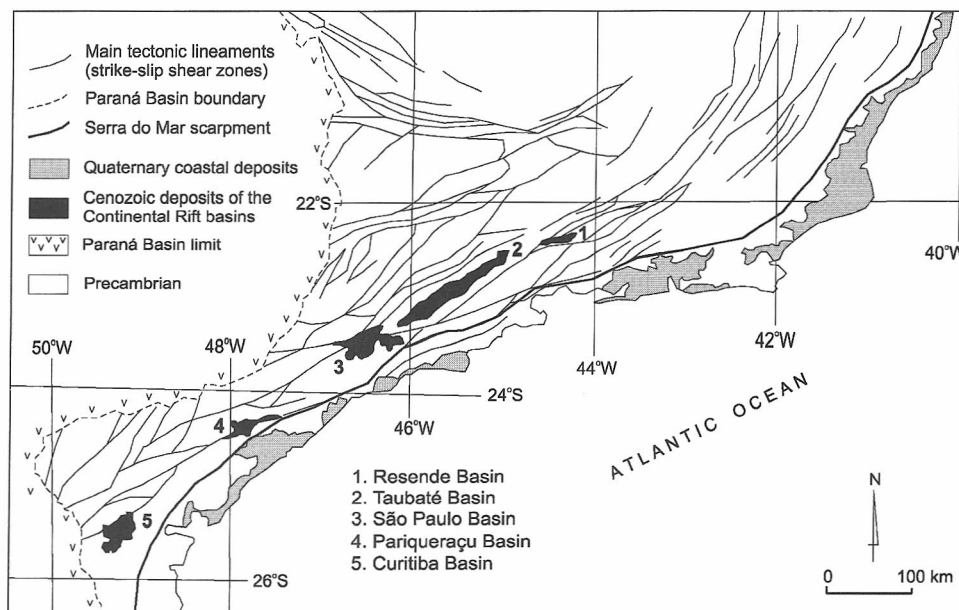


Fig. 2. Main Tertiary basins of the southeastern Brazilian continental rift. Simplified from Schobbenhaus et al. (1981).

morphological aspects such as drainage patterns and physiography. The structural analysis was used to define tectonic controls related to the formation of the Basin, its sedimentary filling, and subsequent deformation.

The structural analysis focused on the determination of principal paleostress axes through the method of right dihedral (Angelier, 1989, 1994) using fault planes and slickensides in each domain. To avoid ambiguous interpretations, the structural data were processed separately according to their occurrence along extensional or compressive/transpressive faults.

3. Geological setting and morphostructures

3.1. Basin lithostratigraphy and facies distribution

The stratigraphic column of the Curitiba Basin is presented in Table 1. The Guabirota Formation (Bigarella and Salamuni, 1962) is the most important unit. It rests unconformably over Precambrian metamorphic rocks of the Atuba complex (Siga et al., 1995) and is overlain by the Tinguis Formation (Becker, 1982) and younger colluvial and alluvial sediments of the Iguaçú River and its tributaries.

The Atuba complex consists of several lithotypes limited by NE–SW- to E–W-oriented, steeply to moderately dipping, ductile to brittle–ductile shear zones. The Atuba complex comprises metabasites and metaultrabasites, granitic gneisses, schists, quartzites, paragneisses, migmatites, granites, and granulites. These Paleoproterozoic lithotypes reveal Mesoproterozoic and Neoproterozoic reworking (Melo et al., 1985; Basei et al., 1992; Siga et al., 1995). The most conspicuous structure is an anastomosed NW-striking and, to the SE, steeply to moderately dipping gneissic foliation that records the last Neoproterozoic dextral strike–slip deformation.

Previous research on the Guabirota Formation has focused mainly on its sedimentary features, stratigraphy, and paleoenvironment. Its average thickness is 40 m, but it attains up to 80 m in some troughs in the central and central southeastern sectors. It overlies the basement in

a nonconforming pattern and consists of greenish clay and slightly lithified silty sediments that grade upward or laterally to coarser facies, depending on the local structural framework. Caliche, arkose, arkosic sand and quartz-dominated oligomictic gravel deposits form local intercalations. The main facies of the Guabirota Formation are as follows:

1. Massive pelitic facies (Pm) formed mainly of argillaceous and muddy deposits, thicker in the center of the Basin and less common on its borders, well compacted, massive, fine-grained, and gray-greenish with white stains or pink where lateritization is evident.
2. Psammitic facies (Am) formed of unconsolidated or weakly consolidated deposits of sand diamictos, arkoses, and arkosic sands with submillimetric to centimetric, angular and subangular, slightly reworked quartz, quartzite, and feldspar clasts in a silty–sandy, locally clayey, matrix. The sand layers show tabular and cross-stratification. The arkosic sands vary from medium- to fine-grained in the center and southwest of the Basin to coarse-grained in the eastern and northeastern portions. The matrix is generally argillaceous and gray.
3. Massive paraconglomeratic facies (Pm) composed of angular to subrounded polymictic gravels with a clay matrix. In the southwest and west of the Basin, the pebbles are mainly of quartz and quartzites, whereas to the northeast, east, and southeast, they are mainly composed of quartz, feldspar, granite, migmatite, and diabase.
4. Layered carbonatic facies (C) represented by tabular, massive, and discontinuous caliches in white–colored beds with meter-sized lateral extensions and centimeter-to meter-scale thickness scattered in the Guabirota Formation. Small fractures contain calcrete venules.

The sparsely distributed Tinguis Formation is composed of arkosic and quartzose sands and a clay facies originated from the reworking of the Guabirota Formation. It shows incipient stratification of clay beds and, eventually, of beds composed of polymictic, angular pebbles, sometimes covered by a sequence of brownish or white sandy sediments.

Colluvial–alluvial deposits, 1–7 m thick, occur in the plains of the Iguaçú River and its main tributaries. They are immature sediments/sedimentary rocks composed of fine sandy and pebbly facies, with either a silty clay or silty sand matrix. The sandy rudaceous deposits are cross-bedded in the conglomeratic facies and interbedded with organic clay lenses with dark-colored peats. These sedimentary features are typical of fluvial meander deposits, as well as of marginal dike ruptures or floods.

The Guabirota Formation was deposited in two distinct stages of sedimentation. At the onset of sedimentation, the structural framework of the Basin enabled deposition of coarse-grained sediments, gravel, and arkose

Table 1
Stratigraphic units of the Curitiba sedimentary basin

Age	Stratigraphic units
Upper Quaternary–Holocene	Alluvial deposits and secondary colluvial deposits
Upper Quaternary–Holocene	Tinguis Formation
Lower Quaternary–Miocene–Pliocene	Guabirota Formation
Jurassic–Cretaceous	Serra Geral Formation (basic dykes)
Neoproterozoic	Açungui group (Capiru Formation)
Neoproterozoic–Archean	Atuba complex

lenses in the eastern part, close to the slopes of the Serra do Mar range. Outcrops of finer sediments, clays, and related sediments, in addition to fine-grained arkose, appear to the north, south and west and in the Curitiba urban area. During the second stage, in the Quaternary, sediments were more uniformly deposited on the surface, with coarser ones dominating in the marginal areas and finer sediments gradually increasing in quantity toward the center of the Basin.

Sedimentation processes varied in accordance with morphotectonic changes in the Curitiba plateau during the extensional tectonics that began in the upper Oligocene. The main phase of deposition of the Guabirota Formation occurred between the Oligocene and Miocene (Salamuni et al., 1999) in response to strong subsidence, as has been described in other basins along the Serra do Mar Rift System. Almeida (1976) reports an increase in subsidence of the Taubaté and Resende Basins and the generation of the São Paulo Basin during that time as well.

According to Bigarella and Salamuni (1962), the Guabirota Formation was deposited along extensive alluvial fans formed by intermittent channels. These fans, when entering the center of the Basin, gave way to a playa lake environment that filled the trough. The sedimentation was cyclic and laterally variable, probably from a viscous flow, which advanced or retreated in accordance with the geometry and was episodically controlled by successive tectonic pulses. Sharp climatic changes during the Upper Tertiary and the Lower Quaternary gave rise to recurrent debris-flow-type sedimentation drained in from intermediate parts through intermittent braided channels (Salamuni, 1998).

Advance or retreat of the fans into the Basin center was controlled by differential water volume, the nature of the sediments, the degree of rock alteration in the original sites, and, mainly, the continuous tectonic compression that uplifted marginal topographic highs. These factors created favorable conditions for the deposition of debris flows in distal parts of the source area. Lenticular deposits of arkosic sands or arkoses represent channel deposits found in intermediate positions between the fine- and coarse-grained facies of the alluvial fans. Some larger channels appear to have prograded into the lacustrine environment, thus enabling deposition of coarser sediments. The pelitic facies represent ephemeral playa lake environments with reasonable amplitudes and accumulations, which form massive beds several meters thick. The intermittent nature of the lakes and water saturation with carbonates enabled deposition of caliches. The interbedding of finer and coarser sediments reveals an episodic stratigraphic evolution in cycles of extension and subsidence due to periods of different degrees of tectonic activity (Salamuni et al., 1999).

3.2. Structural features

Observation of satellite images and aerial photographs reveals many lineaments, ranging from several tens of

meters to ten kilometers in length, that cut across the Basin and its surrounding basement. These lineaments correspond to faults and large fracture zones observed in loco.

The simplified geologic map (Fig. 3) shows the larger lineaments, where major drainage channels are located. Three major lineaments that influenced the original formation of the Basin now control its dissection: the Passaúna fault along the northwestern Curitiba Basin limit; the Eastern Serra do Mar fault along the southeastern to eastern limit; and the Alto Iguaçú fault, which is inferred to cross the Basin depocenter. These faults were initially high-angle normal faults that were subsequently reactivated as oblique strike-slip faults and that now control the rhombohedral architecture of the Basin.

Analysis of borehole loggings offers a good degree of certainty about the geometric model of the Curitiba Basin and the morphostructures of its basement. The surface trend enables researchers to delimitate, with a greater degree of confidence, the structural contour of the basement (Fig. 4) and intermediate structural heights, which were responsible for the presence of isolated and asymmetric depocenters.

The structural characterization of the Basin was more difficult to establish than that of the basement, because of the homogeneous nature of the sediments. Moreover, recent alluvial deposits cover some of the lineaments in the Basin, so the traces of these structural features are inferred in places. To characterize the structure of the Basin sediments, morphostructural criteria (e.g. the strong linear orientation of the main drainages, with several sectors where small scarps occur; anomalous sectors; the angularity and the alignment of the relief) were used to identify fracture traces in both the basement rocks and the sedimentary cover.

Analysis of structural features both in field (Fig. 5) and in satellite images shows that the most abundant and largest faults, cutting both basement and sediments, trend in a NE–SW direction. In the basement, these lineaments predominantly trend in a N40–60E direction with a subordinate N30–50W direction. In the sediments, however, these faults are expressed in both N50–70E and E–W orientations.

The segmented structure of the Basin is controlled by lineaments, present in the basement since the Precambrian, that were reactivated during and after the infilling of the Basin. The NW–SE-trending fractures, associated with the intrusion of Mesozoic dolerite dikes, appear to offset the NE–SW lineaments. The N–S-trending lineaments, possibly associated with the last tectonic pulse, are less significant in the basement than in the overlying sediments. Jackson et al. (1996) show that offsets in deep faults are expressed at the surface of the sedimentary cover through discontinuous and subtle fracture zones characterized by anomalous, aligned drainage patterns. These morphostructural characteristics are observed in the Curitiba Basin.

Medium-scale faults appear in all of the geologic units, from the basement through colluvial deposits even younger

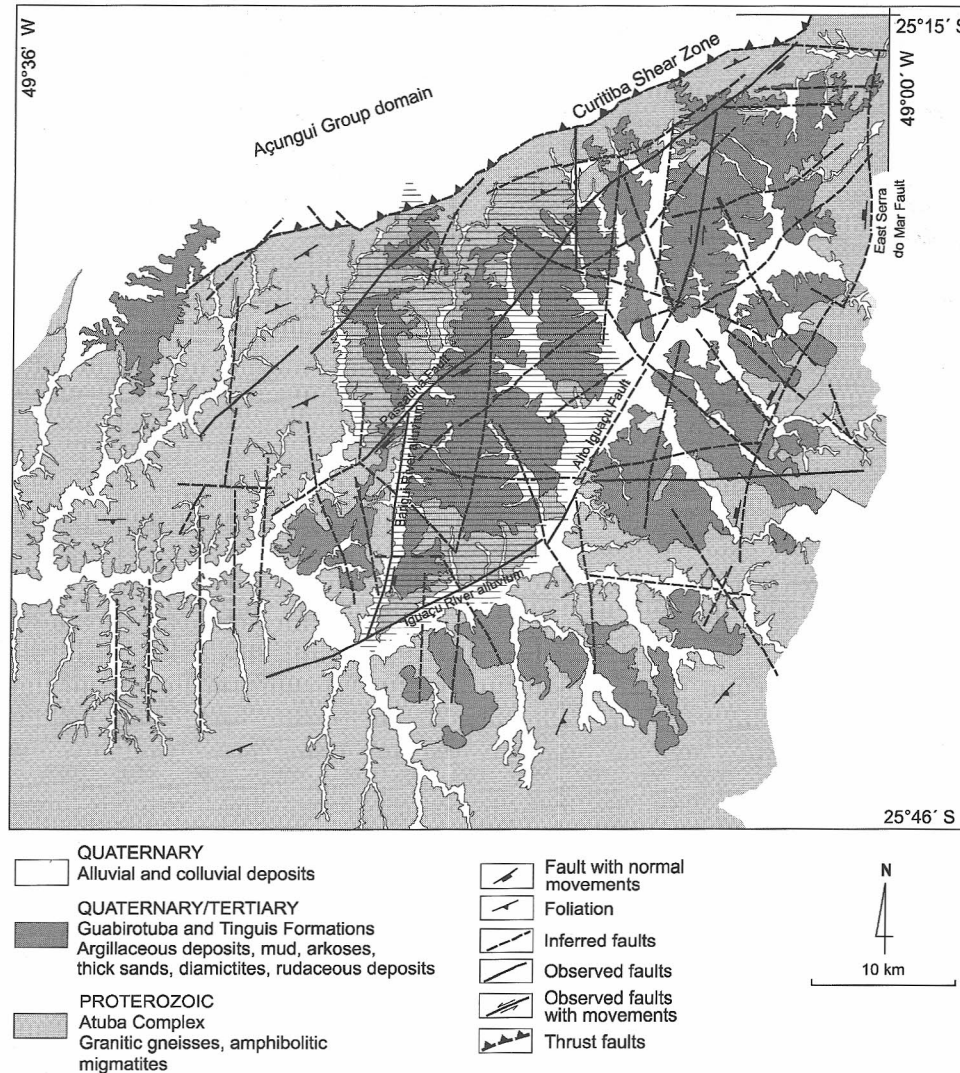


Fig. 3. Geological map of the Curitiba Sedimentary Basin and major lineaments.

than the Guabirotuba Formation. These faults display planar to irregular geometries, as a function of the local rheology, but are parallel to subparallel to the regional lineaments. In the basement rocks, these faults are normally conjugate with centimeter- to decimeter-sized extensions expressed as slickensides, dislocation of veins, gneissic foliation, and small dikes, as well as centimeter-sized cataclastic and protocataclastic bands.

In the sediments, the fault planes are centimeter- to meter-sized and characterized by the dislocation of sandy lenses, argillaceous strata, and caliche layers, in addition to offsets in the more lithified strata (Fig. 5).

Closed fractures of different dimensions are widespread in the sediments of Curitiba Basin. Some open fractures are filled with alteration products of kaolinic or argillaceous composition or by oxides. These fractures always occur in systems, but the degree of penetration is variable and depends on the local sediment compositions. They have predominant NE–SW, NW–SE, N–S, and E–W directions

and plunge with high to moderate angles. These features are interpreted, on the basis of Scheidegger's (1991, 1993) considerations, as fractures proximal to major fault planes generated in a local stress field.

3.3. Morphostructural setting

The region of the Curitiba Basin and its surrounding basement is subdivided into the following morphological domains: (1) plains and alluvial terrains, (2) hilly zones with elongated and planar tops, (3) a mountain system, and (4) mound systems and karst topography. The occurrence of a structural low in its central portion is responsible for flooding areas.

Local hypsometric analysis reveals high and low blocks bounded by structural alignments that host the major drainages. This type of relief is marked by strong substituted escarpments due to the present Basin dissection, with topographic differences of up to 30 m.

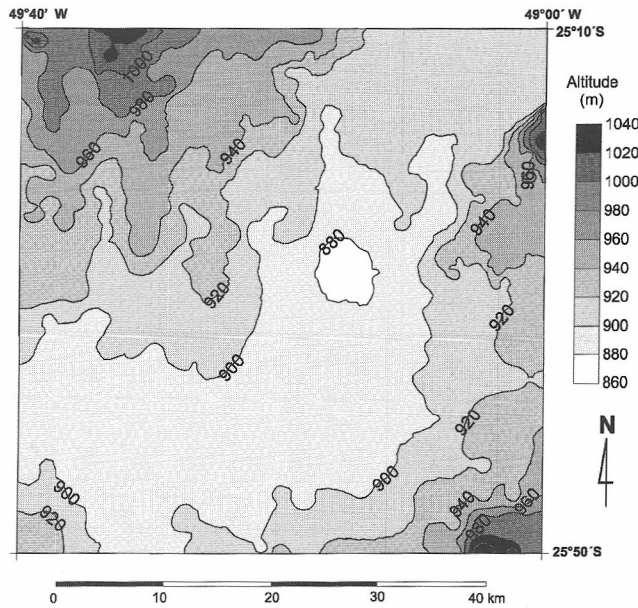


Fig. 4. Structural outline map of the basement of the Curitiba sedimentary basin (modified from Salamuni et al., 1998).

In the asymmetric hillside area, colluvial deposits along escarpments, alluvial terraces, altitude differences of beds, and outcrops of lateritic horizons are common. In addition, long stretches of straight valleys, which control the actual landscape, were observed, many of which limit sedimentary facies in the Basin.

The Basin is drained by the upper Iguaçú River and its first-, second-, and third-order tributaries, according to the classification of Strahler (1952). The drainage pattern tends to be subrectangular in the eastern part of the River, but in the western part, the pattern is subparallel and subrectangular. The older, second-order drainages show two principal orientations (N40–60W and N40–60E). The first-order drainages are primarily oriented N–S and secondarily

E–W, NE–SW, and NW–SE. These drainage patterns are tectonically controlled.

According to Ouchi (1985), the river morphologies and channel behavior reflect changes in neotectonic processes. By interpreting the upper Iguaçú River according to these criteria, uplift of its northern margin can be inferred. The consequent increase in the hydraulic gradient of the channel modifies its depositional pattern and the alluvial plain. The eastern part of the River meanders more than it does in the western areas. This pattern changes north of the Barigui River, which is controlled by a N–S fault that limits two tectonic blocks and dams the Iguaçú River. Uplift of the basement blocks during neotectonic processes generated this morphology.

4. Cenozoic tectonics and neotectonics of the Curitiba Basin

During the early opening of the Atlantic Ocean at the end of the South Atlantic tectonic reactivation (Schobbenhaus and Campos, 1984), reactivation of the older faults occurred in a brittle regime. Newly formed structures also appear in the basin sediments, created by present-day tectonic movements. Recent studies (Riccomini et al., 1989; Hasui, 1990; Saadi, 1993; Hasui et al., 1998) associate these reactivations of preexisting structures in Brazil with neotectonic processes.

The Curitiba Basin is geometrically characterized by tilted blocks bordered by faults that affect both the basement and the filling sediments. The brittle structures record the superposition of tectonic episodes that have influenced both the paleogeography and the sedimentary stratigraphic evolution of the Basin. There are two generations of tectonic discontinuities in the basement. The old discontinuities are Neoproterozoic brittle–ductile, NE–SW-, ENE–WSW-, and NW–SE-trending, strike–slip, and oblique faults.

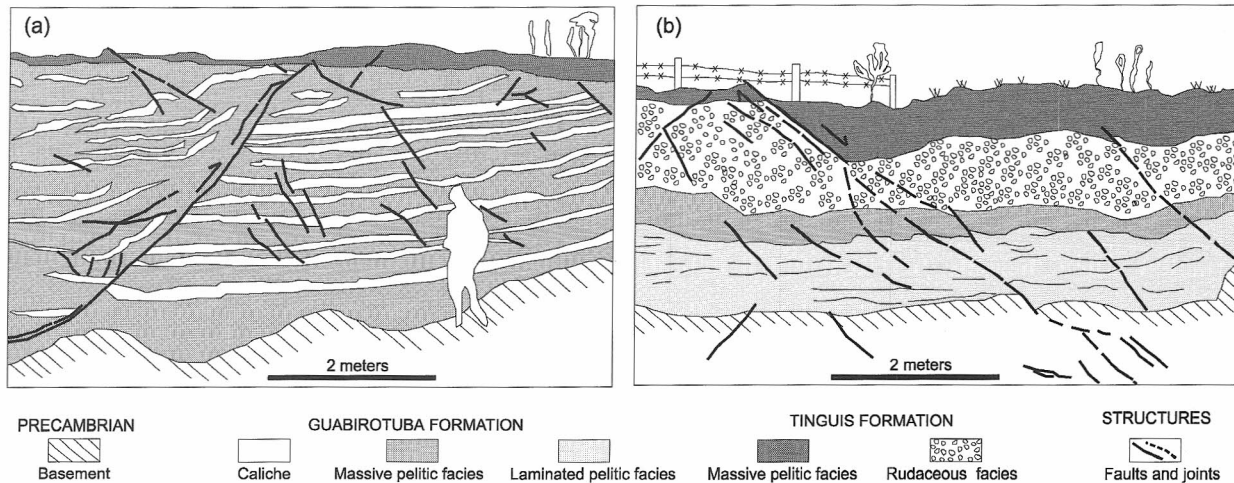


Fig. 5. Typical sedimentary associations generated by debris flow and lacustrine environment and faults. Outcrops at the southern (a) and northern (b) regions of the Curitiba basin.

The second generation of tectonic discontinuities, considered to be of Tertiary age, which dissect the oldest sedimentary strata of a possible protobasin (lower strata of the Guabirotuba Formation), is characterized by a set of NE–SW- and N–S-trending normal faults. The geometric distinction between the generations is difficult because of the reactivation of preexisting faults in the Brazilian shield (Hasui, 1990). In the study area, the fault planes show oblique displacements between blocks.

Because of geometric complications, the precise determination of the relative chronology of normal faults generated in different events is hampered. Offsets of blocks along preexistent faults can form new slickensides that overprint previous ones.

The vast majority of the fault planes observed in both the basement rocks and the overlying sediments display slickensides and striations, smooth surfaces, and centimeter- to decimeter-thick cataclasites. The analysis of basement fault planes and their striations, through an application of the normal dihedral method (Angelier and Mechler, 1977), indicates an extensional tectonic regime with a vertical maximum stress axis (σ_1) and NW–SE-trending minimum stress axis (σ_3) (Fig. 6(a)). This result is in agreement with the sets of fault planes and slickensides that characterize extension (Fig. 6(b)) of the sedimentary units. This syn-sedimentary extensional tectonic event (D_1) was accommodated by NE–SW-trending normal faults during the filling of the trough. The basement rocks show a stronger structural imprint than those of the Basin fill.

Solution of the stress fields for the reverse faults with oblique slips reveals two trends for the axis of maximum stress (σ_1). The first, mainly recognized in the basement, is

subhorizontal with a NNE–SSW trend (Fig. 6(c)). The second, better recorded in the Guabirotuba Formation, is horizontal with an E–W trend (Fig. 6(d)). Both are associated with distinct pulses of the same deformation event D_2 , during which the axis of maximum stress (σ_1) was rotated. In the sediments, the E–W-trending axis of maximum stress (σ_1) provided the reactivation of strike-slip faults in a transtensional (D_2) regime, whereas in the basement, the NNE–SSW-trending axis of maximum stress promoted the reactivation of strike-slip faults in a transpressive regime (D_2^p). In considering the orientation of the paleostress axes, we recognize the following chronology for the brittle tectonic events:

First event (D_1). Bulk extension was accommodated by NE–SW-trending normal, steeply to moderately dipping faults, possibly with listric geometry and striations with high or oblique rakes, along reactivated preexistent metamorphic foliation of the basement. This syn-sedimentary tectonic event affected the basement more and the overlying sediments less later. Tilting and rotating of the faulted blocks generated a halfgraben and were responsible for the formation and evolution of the Curitiba Basin.

Second event (D_2). Compression related to an E–W-trending maximum stress (σ_1) and N–S minimum stress (σ_3) was accommodated by NE–SW- to NNE–SSW-trending, dextral strike-slip faults, as well as secondarily by NW–SE-trending normal and strike-slip faults. Striations show low oblique rakes in accordance with the orientation of the reactivated older discontinuities. Data from faults and striations in the basement faults suggest that the progressive deformation caused rotation of the principal stress (σ_1) and a switch of the strike-slip faults from transtensive in the Basin to transpressive in its crystalline basement. As a consequence, the generation of reverse faults and the tectonic inversion of blocks occurred more intensely in the sediments than in the basement rocks.

Fig. 7 shows the orientation of the stress axes of compression (σ_1) and/or extension (σ_3) in each morphostructural subdomain, as well as of the initial extensional tectonics (Fig. 7(a)). These orientations were determined by the brittle structures of the basement, as were the subsequent compressional (or transpressional) regime (Fig. 7(b)), as were determined by the partially lithified cover sediments.

Until the end of the Paleogene, local geologic evolution was controlled by an extensional regime dominantly accommodated by normal faults. By the end of the Oligocene, the regional tectonic processes began to change significantly, as is indicated by the stress field modification. The σ_1 axis, vertical until then, was forced to change its orientation through the structural framework composed of blocks limited by strike-slip and secondary reverse faults. These kinematic changes were influenced by structural discontinuities of the Basin floor, mainly the NE–SW- and NW–SE-trending basement shear zones that acted as planes of weakness for reactivation. The initial deformation was marked by brittle shearing, which also occurred in

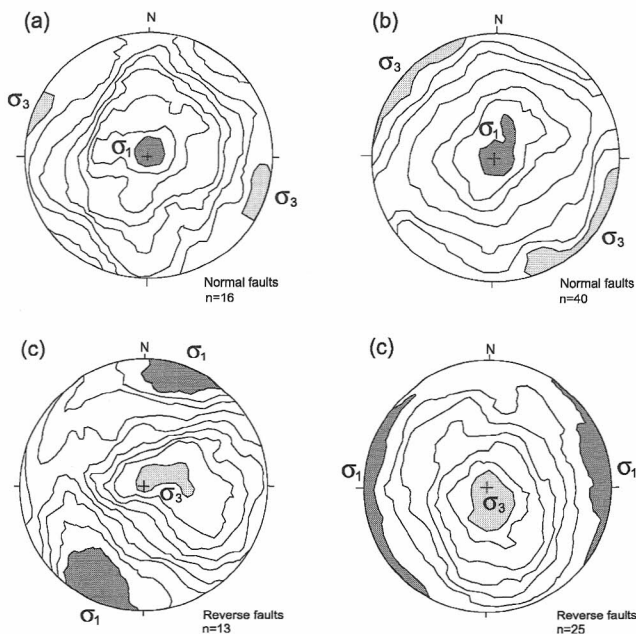


Fig. 6. σ_1 and σ_3 deduced from faults of the basement (a and c) and sediments (b and d) of the Curitiba basin.

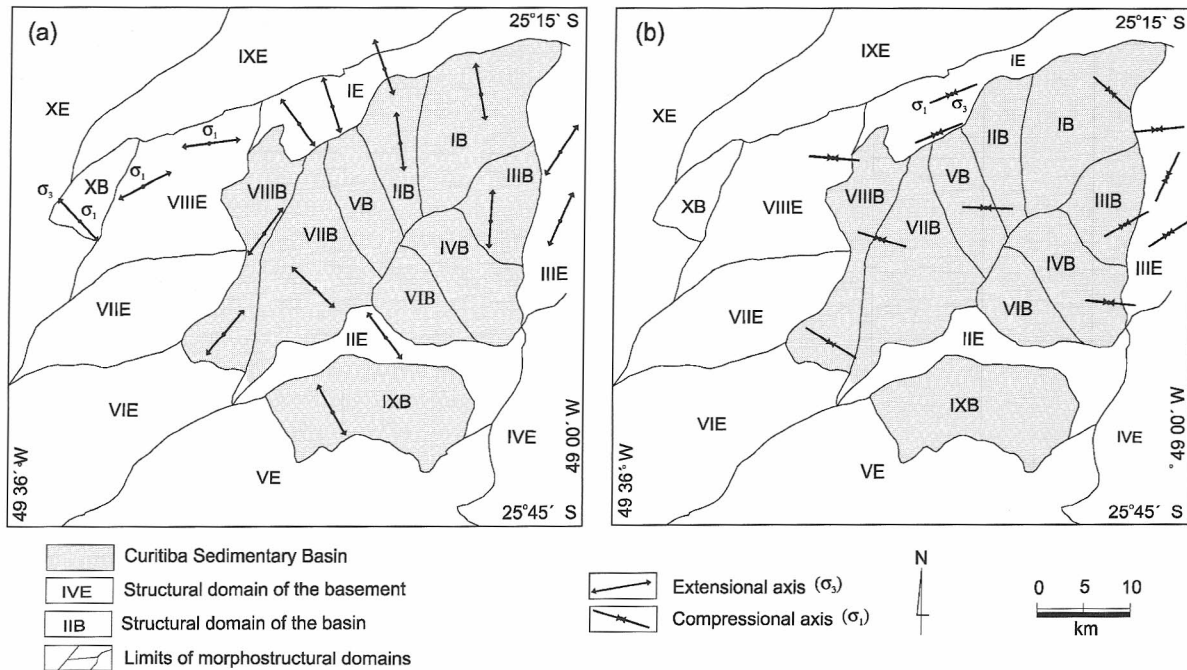


Fig. 7. Orientation of stress axis in the different morphostructural domains of the Curitiba basin: (a) extensional regime (Paleogene) and (b) strike-slip regime (Neogene–Quaternary).

the sedimentary beds, recorded as decimeter- to kilometer-sized fractures with variable strike NE–SW, N–S, E–W, and NW–SE and steep to moderate dip (Fig. 3). The N–S-striking faults are younger brittle shear zones, whereas the NE–SW- and ENE–WSW-trending lineaments correspond to Riedel shears (Riedel, 1929), compatible with dextral strike-slip. The extensional fractures are represented by E–W-trending lineaments, and the NW–SE ones represent the conjugate Riedel (R') or antithetic shear of Wilcox et al. (1973).

The deformation age of this neotectonic event is not well constrained. Bigarella and Salamuni (1962) suggest a Pliocene–Pleistocene age for the sediments, but considering that the evolution of the trough responsible for the deposition of the Guabirotuba Formation started between the end of the Oligocene and the beginning of the Miocene, it is plausible to consider this age as the onset of the deposition. Fossil pollen found in pelitic facies of the unit indicate a Miocene age (Salamuni et al., 1999), similar to that of Itaquaquecetuba Formation (Arai and Yamamoto, 1995) of the São Paulo Basin. A comparison between local structural data and data of a more regional nature indicates that the tectonic evolution of the Curitiba Basin is similar to correlative basins in the continental rift system of southeastern Brazil, which is associated with Miocene and Oligocene tectonic events. These data also reveal a better coherence among the beginning of sedimentation, the local tectonic stresses, and important geotectonic changes of the South American plate during the Oligocene, as reported by Frutos (1981) and Hoorn et al. (1995).

The initial basin geometry as a halfgraben with subsidence in the western part and evolution to a graben yielded the deposition of the Guabirotuba Formation. The final Basin evolution took place through a transtensional/transpressional tectonic regime, with rhombohedral geometry (pull-apart) and the deposition of the Tinguis Formation.

The extensional Basin evolution is shown in Fig. 8. The subsidence may have developed in different episodes due to the reactivation of marginal faults that produced higher slips in the eastern than in the western part of the Basin and the final evolutionary stage, which was a transtensional/transpressional tectonic event. The surface facies distribution was controlled by master faults, presently not revealed or exposed in outcrops and limited to the Basin border.

Neotectonic adjustments of the blocks tilted from northwest to southeast, mainly related to the D_2'' event, enabled the establishment of the present drainage network and the development of the upper Iguaçú River hydrographic basin. The channels contributed to the exposure of the deeper basin horizons, forming an older alluvial blanket deposited in the first formed valleys. The morphological outline and large drainage systems also have been controlled by neotectonics, which allowed the formation of escarpments. Alluvial deposits are laterally displaced relative to the channels; there are topographic asymmetries and anomalies in the drainage subbasins, as well as a damming that resulted in the spreading out and consequent generation of new alluvial deposits. The neotectonic processes are also

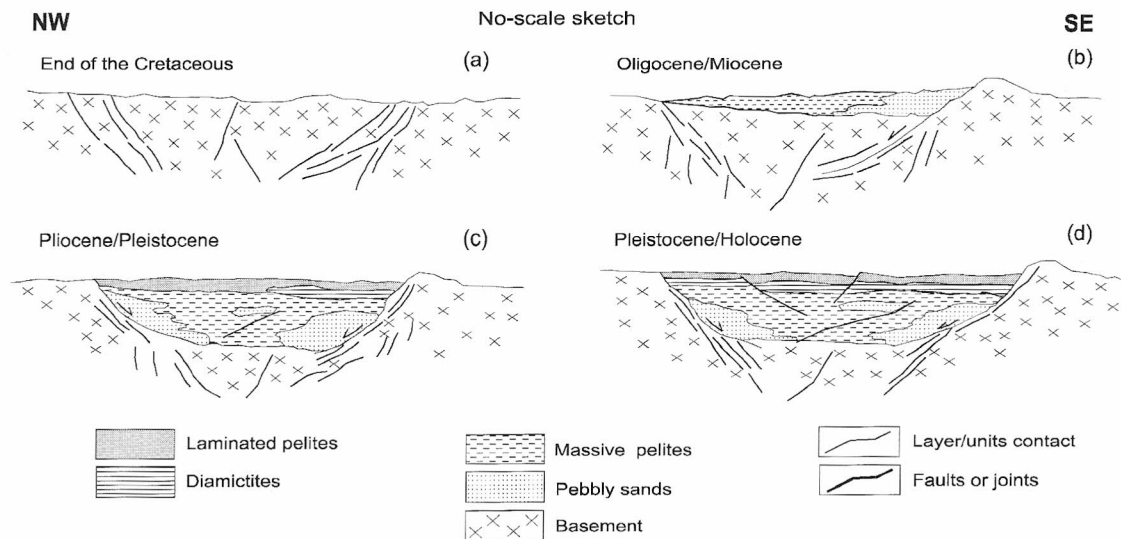


Fig. 8. Model of tectonic/sedimentary evolution of the Curitiba sedimentary basin.

responsible for the meandering pattern of the Iguazu River in the south and southeastern portions of the sedimentary Basin.

5. Conclusions

Fieldwork and morphostructural models of the basement and Basin show that the structural framework, stratigraphy, distribution of lithologies, and geologic evolution of the Curitiba Basin are tied to reactivation of Precambrian tectonic structures. Specifically, these structures are, ductile–brittle Proterozoic structures that were reactivated at the end of the Cretaceous and beginning of the Tertiary and served as master faults for Basin development.

In relation to the structural framework of the Basin, the presence of the coarser grained sediments in the E–NE portion and finer sediments in the remaining parts of the Basin are characteristic of a halfgraben generated in an extensional regime. Following the initiation of this halfgraben structure, a strike–slip tectonic regime changed the sediment facies distribution. At that time, the coarser grained sediments were deposited evenly around the Basin perimeter, and finer grained sediments were deposited in the central portion. This framework is consistent with a rhombohedral basin controlled by transtension.

Through direct and indirect evidence and observations mentioned herein, we conclude that the regional Middle Tertiary to Quaternary tectonic processes responsible for the structural rearrangement of the South American platform (Frutos, 1981) controlled the formation and evolution of the Curitiba Basin.

This study concludes that the neotectonic process of the latest evolution of the Curitiba Basin is certainly of low intensity when compared with the active margins of South America. The evolution of this Basin is best understood in

the context of the regional tectonic framework at the end of the Cretaceous. At that time, the Serra do Mar and Serra da Mantiqueira mountain ranges were uplifted by regional intraplate extensional tectonics (Almeida and Carneiro, 1989).

The geologic characteristics reveal that regional tectonic processes were controlled by E–W-trending σ_1 (initial extension from the Cretaceous to the Paleogene, followed by compression since the Neogene), as have been characterized by Assumpção (1992) and Lima et al. (1997). In the basin, E–W and WNW–ESE extensions formed normal faults and correspond to the D_1 tectonic event. During the Miocene, there was an important change in the regional tectonic regime, and the stress system changed from extensional to compressional in the same E–W and NW–SE direction. This change was responsible for the generation or reactivation of strike–slip faults and characterizes the neotectonic events $D_{2'}$ and $D_{2''}$.

The morphostructural characteristics of the Curitiba Basin indicate that the current drainage network is structurally controlled. It appears that this drainage pattern was initiated during $D_{2'}$ and $D_{2''}$, when compression promoted uplift and the subsequent erosion of unconsolidated sediments of the Guabirotuba Formation. These deformational processes observed in the Curitiba Basin are attenuated relative to the other basins in the northeast of the continental rift of southeastern Brazil, such as the São Paulo, Taubaté, and Resende Basins.

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