Fragmentation of Ecosystem Owing to Neotectonics in the Amazon Basin

Fragmentation of Ecosystem Owing to Neotectonics in the Amazon Basin

Elena FRANZINELLI*, Hailton IGREJA* and Tammy REPOLHO

Abstract The natural fragmentation of ecosystem is one response to the effects of neotectonics in the Amazon Basin. Present data suggest that the movements produced by neotectonics are much faster than what was supposed at the beginning of neotectonic studies. This condition has been verified in the Negro River Basin. Evidence for fragmentation was observed distinctly in the floristic and eventually in the faunal features of the Basin. Consequently, original and invading floristic species are aggregated in areas of tectonic movement showing ecological "stress". Rivers which are very wide in some reaches with shallow beds and without a definite channel are frequent in the studied area. In their large reaches these rivers show some tilted blocks with different altitudes and positions. Some blocks have subsided and have large dead tree trunks which are the remains of a dry land "*terra firme*" forest. Other blocks have a mixed "*igapó-terra firme*" forest. The higher blocks in the riverbed show only forest of the "*terra firme*" type. In the watershed regions, there are also ecosystem fragmentation areas, known in the literature as savanna remnants ("Refugia"; Haffner, 1982)

Key words: neotectonics, Amazon Basin, ecosystem, natrural fragmentation, biome, ecological stress

1. Introduction

The Amazon ecosystem is located in the north portion of the South American Plate. It is influenced by the tension originated by the collision of the Nazca Plate to the west and the Caribbean Plate to the north (Fig. 1). Translation and rotation of crustal blocks are developed, resulting from the effort in the direction E-W and N-S. Generally the borders of these blocks appear higher due to the incision of the great rivers of the Amazon Region. Thus, the fluvial Amazon System is the system that best shows the great geologic faults of this region, that generally delimit different biome. Geomorphological minor features, like lakes, small tributaries, waterfalls and floodplains also follow the general trends of the neotectonic lifted or lowered features.

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Science Reports of Tohoku University, 7th Series (Geography)
Vol. 49, No. 2 (Special Issue on GLOCOPH '98), December, 1999, 207-214

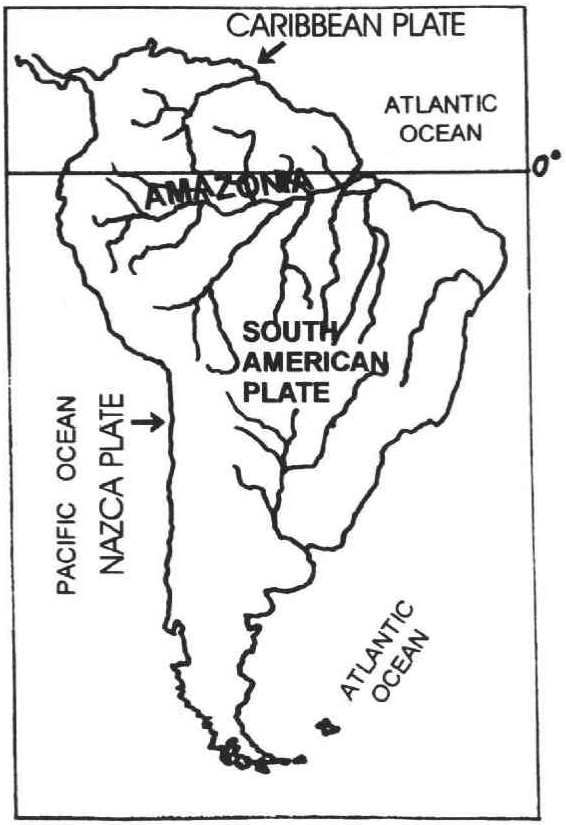

Fig. 1 Location Map

The biome that contain more terrestrial elements occur in the geotectonic directions NE-SW and NW-SE of the geomorphologic lifted regions, that is, morphotectonic units, like islands and almond-shaped terraces, sigmoidal plateaus and aligned or irregular headwaters.

The essentially aquatic biome shows a neotectonic lowered environment with subsided areas or inclined to flooding or to sedimentation. These morphotectonic units with negative relief show the sedimentological effects of the dualistic season changes, that is, in June the apex or the maximum of flooding and in October the apex or the low water level. If compared to the lifted areas these complex effect can be observed in the soils, paleosoils, lateritic horizons and large vegetal units.

These fluvial hierarchic orders generally obey the neotectonic order, with the tendency of a greater biomass concentration and block movements towards the principal zones of deformation Solimões-Amazonas, WSW-ESE (Igreja *et al.*, 1998) that contains the central axis of the fluvial Amazonian system. This system is the

largest discontinuity of the region and the major neotectonic transcurrent dextral continental system of the earth (Igreja, 1999). This huge zone of geologic faults shows a strctural importance over the cyclic reactivation of the ancient features in the north continental portion of the South American Plate.

2. The Fragmentation Examples

Some researches showed examples of environmental fragmentation in Amazonia. The clear separation between the "*terra firme*" and the floodplain was documented by Sternberg (1950). More detailed modern studies (Projecto Radambrasil, 1978) indicate that these regional terms incorporate criteria of seasoning, type of soil, altitude, vegetation, topography, tectonic stability and specific fauna. From these points of view, the "*terra firme*" biome shows different and also conflicting characteristics with the floodplain biome. In fact, the "*terra firme*", is elevated about 20 meters above river level and is stable, less erodible, more compact with very scarce deposition, with large trees and older geologic backgrounds. On the contrary, the floodplain biome is unstable, friable, situated in low altitudes less than 20 meters above river level, friable, with very intense sedimentation, young geological background, immature soil and low and pioneer vegetation. The transition zone between the "*terra firme*" and the floodplain can be either abrupt or gradual. An abrupt transition zone coincides with a fault plane showing the topographic neotectonic gradient and the interrelation between the two blocks. It may be only a few meters in width. In contrast, a gradual transition zone may be kilometers in width along the gently sloping block. The "*terra firme*" indicates the high block and the floodplain the low block of the fault. It seems that the more modern neotectonic movement originates also in the fragmentation of the biome in the floodplain. Presently, the older fragmentation of the "*terra firme*" shows an anomalous concentration of vegetal species, refleting stages of different evolution when localized in distinct topographic levels in the transition zone, between high and low blocks of the fault. The cyclic continuous advance of the biome "*igapó*" on the floodplain in the neotectonic subsident blocks is common along the principal zone of deformation Solimões-Amazonas ; on the contrary, a very complex, less characterized, fragmented "*terra firme*" floodplain mixed biome occurs. One interesting example of this situation is shown in the Anavilhanas Islands, situated in the Lower Negro River, upstream of the Cuieiras River mouth (Fig. 2) where the big trees that grow in the central part of the island push couch-grasses to the shores and to the aquatic environment, compelling them to a hydroponic alimentation. In the Anavilhanas Islands, the stages of the fragmentation are shown from the geomorphological point of view, by the braided aspects of these islands and their aligned associated banks, that develop in the highest borders of the neotectonic rolled blocks or in the

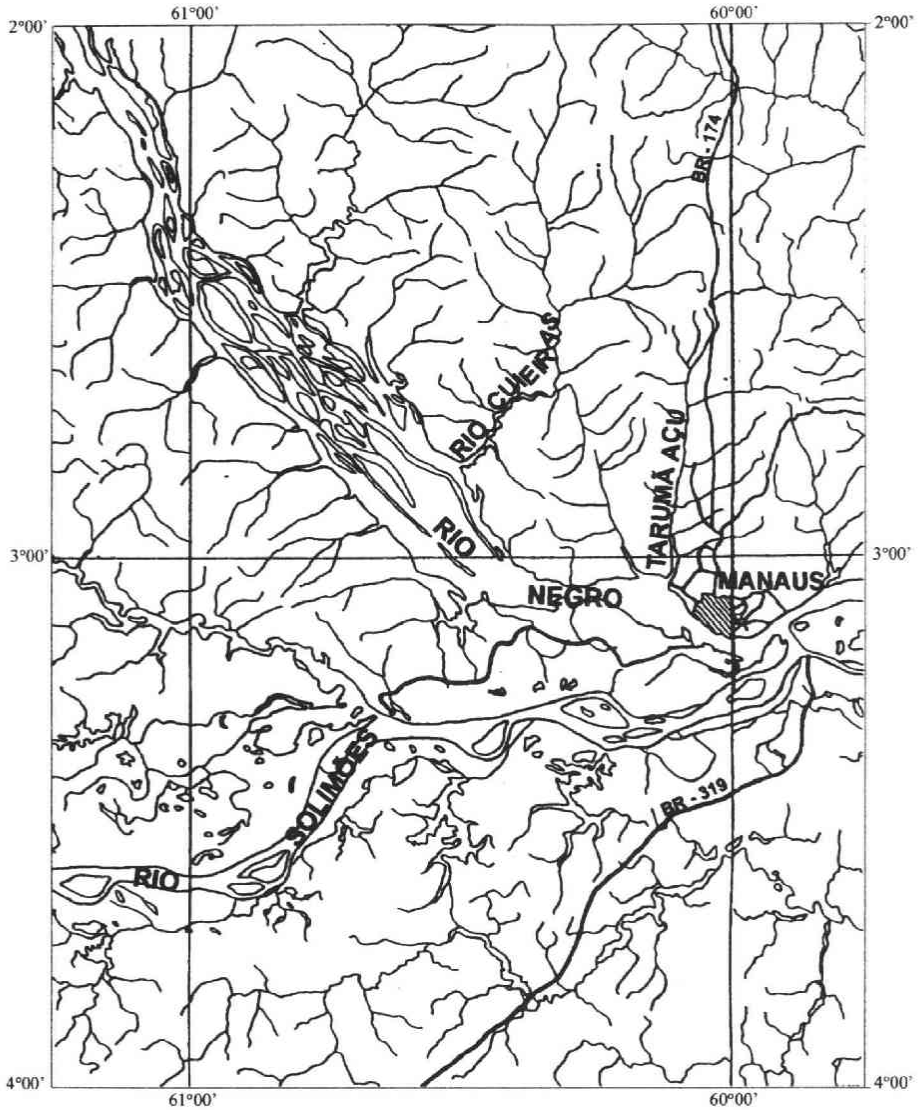

Fig. 2 Lower Negro River region drainage

tilting blocks in the southeast direction by the transtensional dextral neotectonic processes in the Lower Negro River region.

Another common example of fragmentation is found in the Itacoatiara region, about 200 km downstream from Manaus. This area is considered the geocentric portion of the geotectonic system. In this region there are permanent lakes that divide the floodplain biome along the Amazon River. The youngest faults of the

neotectonic system clearly delimit the lakes during the dry season, but during the wet season, these limits do not exist due to the high water level, although they can cause a selective action in the aspects associated with the sedimentation in the fluvial system. As a result, a sedimentary and vegetal zonation is settled in the Amazon floodplain in the lakes, in the transitional area between the lake and the area of division and between the area of division and the Solimões-Amazonas River. These zones have the function of neotectonofacies in the Amazon neotectonic system whose erosional, depositional, climatic and biological processes are important, but subordinate to the deformational, transitional and or rotational neotectonic evolution that promote (cause) the fragmentation of the biome and that is repeated according to the generation of new delimiting faults.

Some assessments about the environmental divisions relating to major events of the west border of the South American Plate, documented by the occurrence of fossil of fishers, crocodiles, primates, birds and others, were shown by Latrubesse *et al.* (1997). Some examples of environmental fragmentation of the "*terra firme*" forest, producing at the same time "*igapó*" forest are very clear and didatic in the aspect concerning the separation of the neotectonic blocks. In the Cuieiras River, a tributary of the Negro River, the "*igapó*" forest developed in a very wide part of this river, called Jarada Lake (Fig. 3), shows an abrupt change of the "*terra firme*" forest in a high

Fig. 3 Jarada Lake (Cuieiras River) tree trunks submerged on the bottom of the lake due to the movement between the low block (*igapó*) and the high block (*terra firme*).

topographic difference in level, that corresponds to the high block of the fault. The intermediate zones at different levels show forest of mixed vegetation; on the low block the forest of "*terra firme*" shows stanted, ill-grown and dwarf species due to the strong effects of climatological and seasonal fluviatile influences, in opposition to the well developed and adapted tall vegetation of the high block. In this area an important process of river capture occurred, where the Cuieiras River "absorbed" the medium and low channels of the Tarumã Mirim River (Igreja *et al.*, 1998). The occurrence of ancient, probably Pleistocenic biome, originated when the amazon climatic and environmental condition helped the predominance of the savanna, is characterized by the lack of lateritic beds and paleosoils, in opposition to the adjacent biome, that shows thick beds of these elements. The modern climatic conditions, favourable to the development of the tropical rain forest, are causing the disappearance of a remaining nucleus of savanna with couch-grass that grows with some species characteristic of the floodplain and of the "*terra firme*" in the lowest levels of the transitional interface of the biome. One of these ancient nuclei, called "refugia" according to Haffner (1982), in the Cuieiras River region, occupies a neotectonic "sigmoidal-romhorste"-shaped area, with the typical vegetation of the savanna. In this last example of environmental fragmentation of the "*terra firme*", some geochemical and geobotanic phenomena are characterized by species of palms in different adaptative situation: dwarf shapes are well spreaded, the absence of weathered soil and paleofauna, showing an area lifted by neotectonics and a biome with strong ecological "stress" (Fig. 4).

3. The Biome in the Structures of the Neotectonic Amazon Model

The biome, in the Amazon Basin, are directed by cyclic hydrological, climatic, environmental, erosional and depositional, and topographic-tectonic factors. These topographic-tectonic factors control the principal strikes. The modern neostructural directions of the Amazon transcurrent system can be sumarized in this way: 1) Solimões River: N60W; 2) Negro River: N45W; 3) Amazon River: N80E; 4) Madeira River: N50E; 5) Tarumã River: N10E. The configurations of the different biomes result from the interrelations among these neotectonic directions. One can observe that modern biosomatic characteristics are different from those of the Pleistocene age, but in some places ancient nuclei occur. These geological elements allow the explanation of the geokinematic paleoclimatology and the evolutional models that are represented by paleosoils, fossiliferous niches and paleogeographic units that are anomalous in the actual situation. But it is probable that similar processes had occurred in areas outside the actual Amazon ecosystem, under the more active influence of one of the above quoted factors, and not of the topographic-

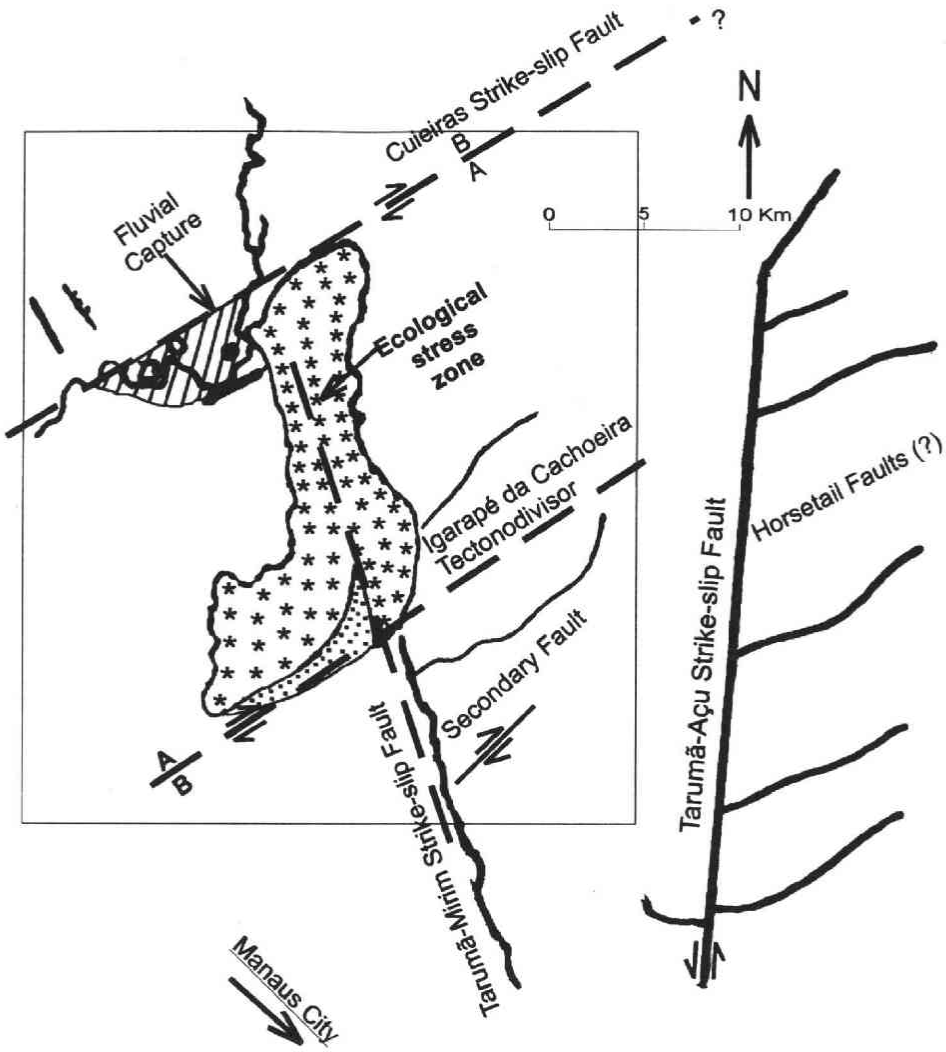

Fig. 4 Neotectonic sketch of the Igarapé da Cachoeira and Cuieiras region obtained by the interpretation of radar images, 1 : 250.000 scale.
The evidence for fragmentation was revealed by the sigmoidal shape of the ecological stress zone which shows a bifurcation in the south neotectonic border-Igarapé da Cachoeira tectonodivisor (Rainferest-blank area), defining an area of geobotanical drag (dotted area-Clockwised of 20°). The north border also is a tectonic fault. Here a wide area of geoecological collapse and fluvial capture occurs, defined by "*igapó*" forest.
A=High Block ; B=Low Block ; Allows indicate Strike-slip movements.

neotectonic factors. In the same way, the modern and ancient shapes of the Amazon biome preserve the directional characteristic of the neotectonic system, and the lozenged, sigmoidal Z, triangular and elliptic shapes are preserved and can be distinguished. Their component of vertical tension controls the subsident or lifting behaviour in the roto-translation process of neotectonic activity.

4. Conclusions

Neotectonic processes are the determining factors for the fragmentation of the ecosystem in Amazonia. Presently our study is limited to the large layouts booked by the neotectonic features, but in the future this study will be directed towards the confirmation of the botanic, pedologic and vegetational fields.

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