Neotectonic Influence on Fluvial Capture in the Amazon Basin, State of Amazonas, Brazil

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Hailton IGREJA*, Elena FRANZINELLI* and Tammy REPOLHO**

Abstract This study deals with the influence of neotectonics on the processes of fluvial capture and its consequent effect on the biome in the valley of the Cuieiras River which is a tributary on the north bank of the Negro River. The Negro River represents one of the five principal structural strikes of the neotectonic model of the Amazon Basin. The fluvial capture was first determined after intensive study of data obtained by remote sensors, and in the second phase by analyses and studies in the field. The fluvial capture described does not fit the classic models mentioned in the bibliography. This is due to the translational and rotational neotectonic processes that have produced it. These processes have been verified on large and small scales. We consider this capture to be a result of the combined action of retrogression of headwaters and subterraneous deviation subordinate to a principal neotectonic origin.

Key words: neotectonics, fluvial capture, translational and rotational processes, Negro River region, neotectonic model

1. Introduction

The model (structural design) of neotectonics in the Negro River Basin (Franzinelli and Igreja, 1990) supplied some evidences for the establishment of the large "Neotectonic Transcurrent Dextral System" (SNTD), which can be applied to all the territory of the Amazon Basin.

New studies on the dextral strike-slip neotectonics of the Negro Basin indicate the occurrence of several processes of river capture, post-Tertiary in age, related to the movement of tectonic blocks, whose effects can be identified also through the occurrence of zones of ecological "stress", showing anomalous superposition of biomes with a mixture of original and invading species. We investigated a distinct river capture in the Cuieiras River Basin, a tributary on the north side of the Negro River, in the location where the Cuieiras River captured the medium and high flow of a river larger than the present day river called Tarumã Mirim.

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2. Geographic and Geologic Aspects

The area studied is located on the north continental section of the South-American Plate, in the Brazilian Amazon (Fig. 1). It is situated outside the city of Manaus on the left side of the Lower Negro River (Fig. 2).

The region has been subject to the Neotectonic Transcurrent Dextral System since 24 million years ago (Lower Miocene). As a result of the collisional and transcurrent tectonic forces coming from the west (Nazca Plate) and north (Carribean Plate), lateral and subsequent vertical movements were produced which were responsible for the genesis and extinction of the drainage network and its elements, *e.g.*, interior seas, mega-rivers, lakes and watersheds (Fig. 3).

The present neotectonic model of the Amazon Region can be simplified into five structural directions: the Amazonas Strike (WSW-ENE); the Solimões Strike (N60° W); the Rio Madeira Strike (N50°E); the Tarumã Strike (N10°E) and the Rio Negro

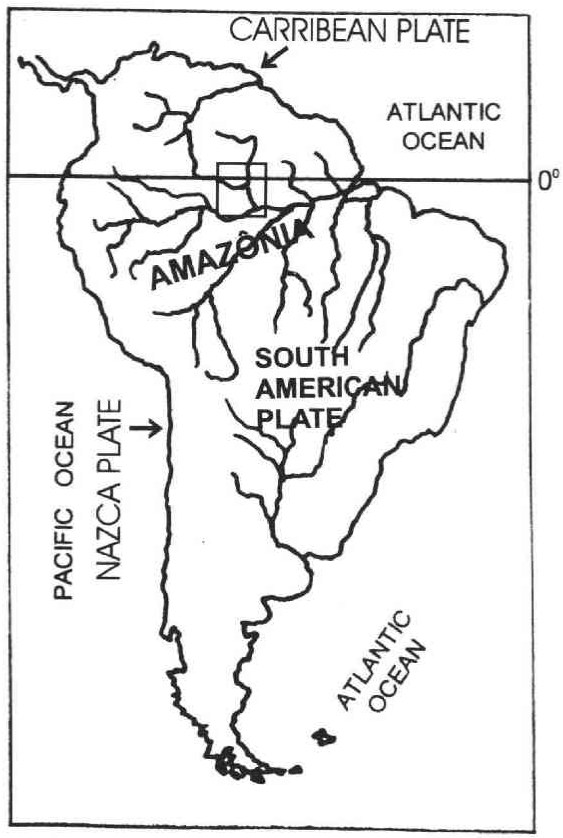

Fig. 1 Location map of the studied area

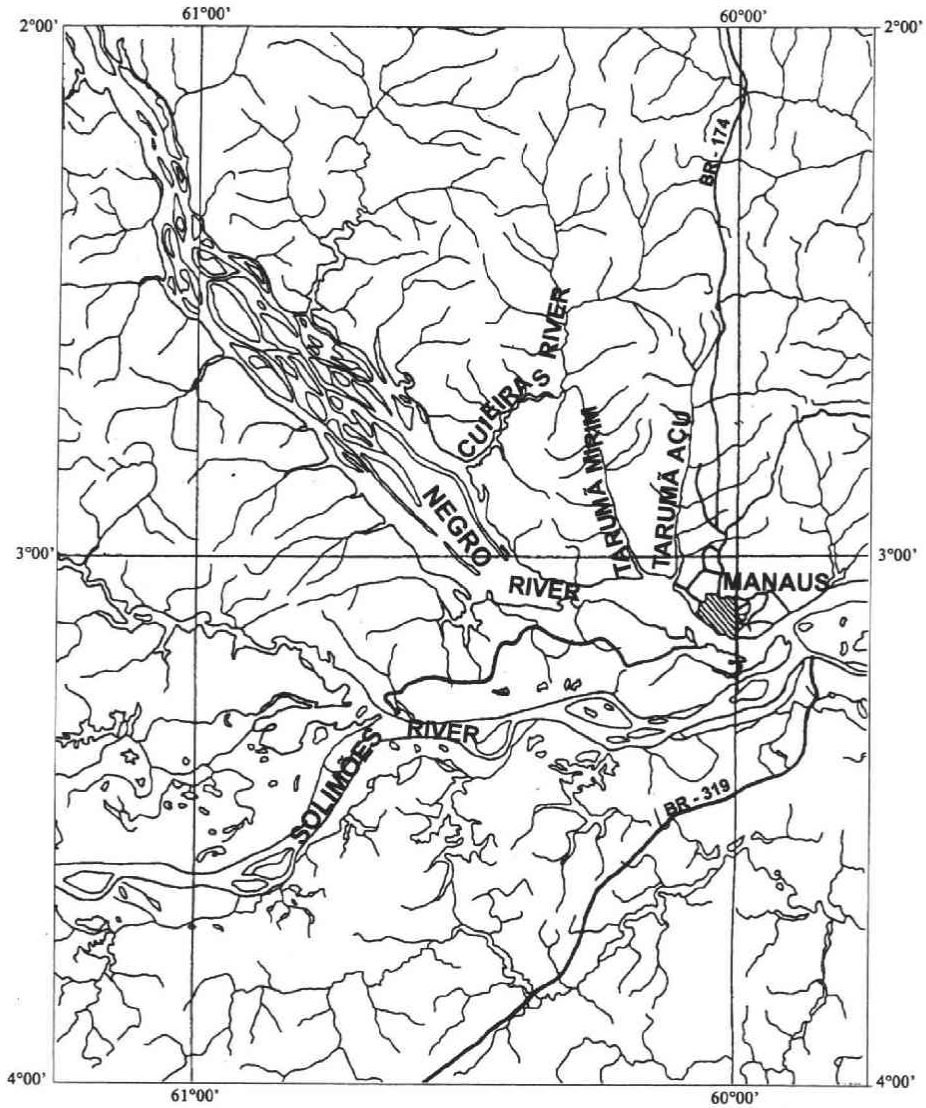

Fig. 2 Lower Negro River region drainage

Strike (N45°W) (Igreja, 1999). This last direction is the principal tension region and its extensional transversal effects are demonstrated in the Lower Negro River (parting fracture and transtensional dextral structures), and Cuieiras River (transfer fault and transpressional shear fault). The Lower Negro River is the main study area on the north side of the Amazon Model. The features found in this area occur throughout the northern part of the South American Plate (Fig. 4).

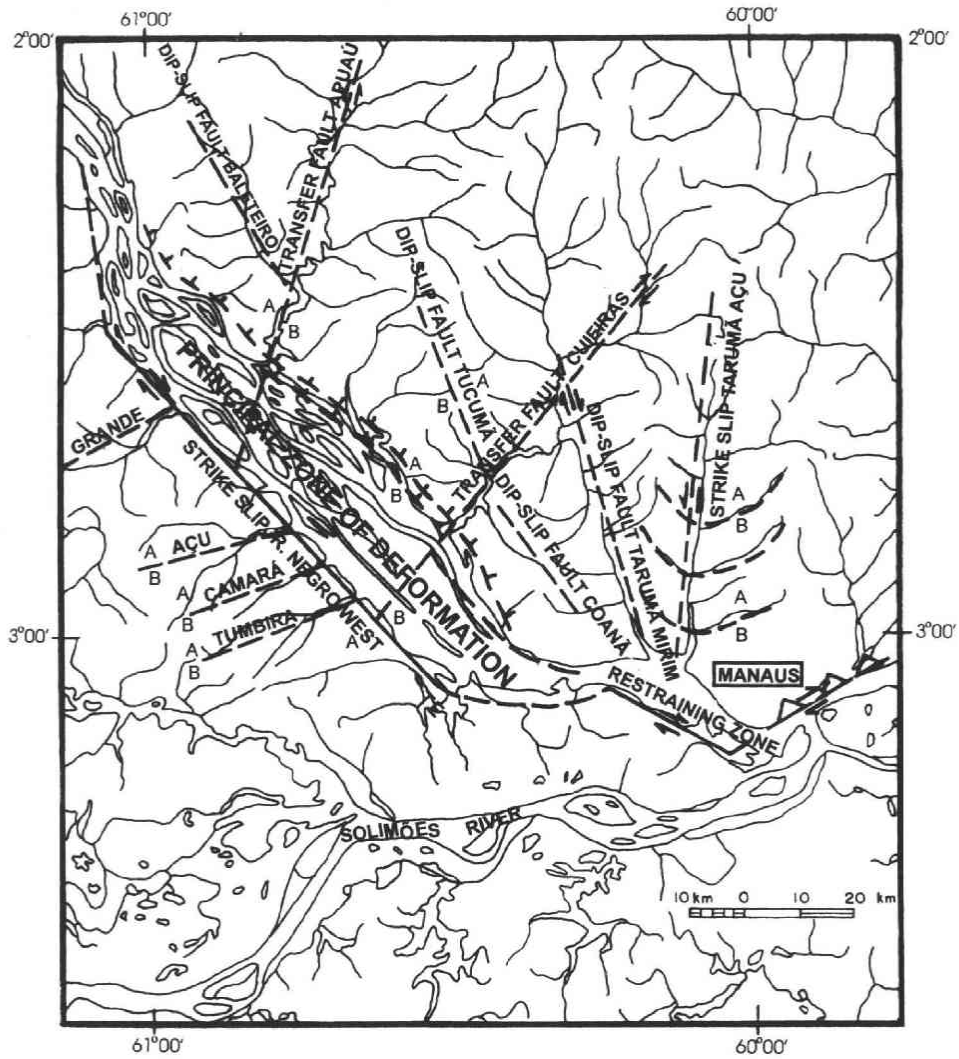

Fig. 3 Neotectonic model of Lower Negro River; Principal structural lineaments
A High Block, B Low Block, Strike-slip movements, VVV Significant reverse component, ⊥⊥⊥ Significant normal component (from Franzinelli and Igreja, 1990). This region is a small sub-system of the transcurrent Amazon mega-system.

3. Methodology

The study of the river capture of the Tarumã by the Cuieiras River, follows from the careful interpretation of radar and satellite images, and aerial photos over a greater region. In a second stage, fault, fracture, joint and fold measurements and

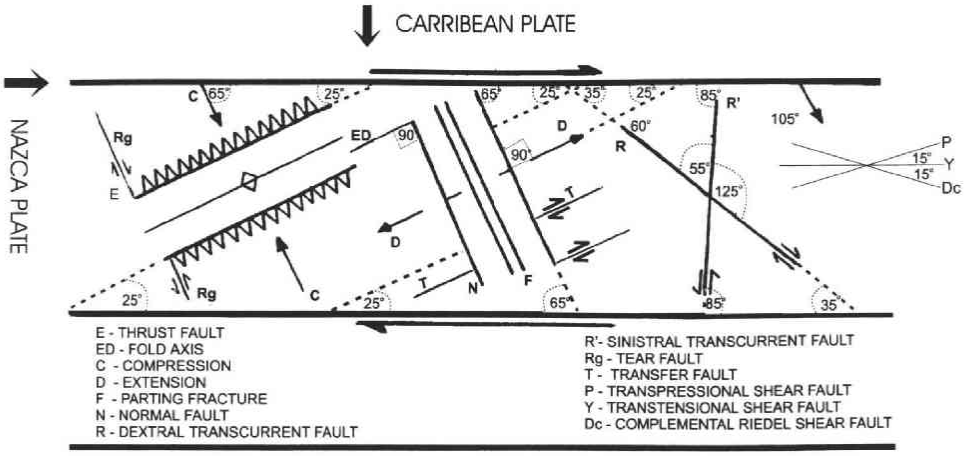

Fig. 4 General neotectonic model of the Amazonian region
The major compression is W-E (Nazca Plate) and the secondary compression is N-S (Carribean Plate), resulting in the principal component NW-SE.

analyses were performed in the field.

4. Neotectonic Processes and their Relative Effects

The most recent papers dealing with the Dextral Transcurrent Neotectonic System of the Amazon Basin (*e.g.*, Igreja, 1999) reinforce the importance of the geostructural control of its current physiography, which is one of the determinant components of the evolutionary history of its ecodynamics.

The interrelations among paleodrainage, actual hydrography, and the Amazonic neotectonic cycles are not well understood, though obvious. There is no effective space-time discrimination of cycles, owing to the superposition of the tectonic displacements, even along only one element (including the opposite direction). These tectonic displacements, associated with the past and current climatic and hydrological processes, make it difficult to obtain an evolutionally progressive sequence, which is complicated by a multiplicity of effects due to botanical and zoological elements particularly associated with post-Tertiary processes; that is, in the generation and extinction of rivers, lakes and marshes, common in the geological records of the last 25 Ky which are always related to neotectonic elements (faults, blocks and geocompartments) (Fig. 5).

One of the most spectacular effects of the Amazon neotectonic processes are the rotational effects, Holocene in age, where it is possible to examine the arrangement of rectilinear and curved lakes and also sigmoidal and elliptical islands dipositat along the

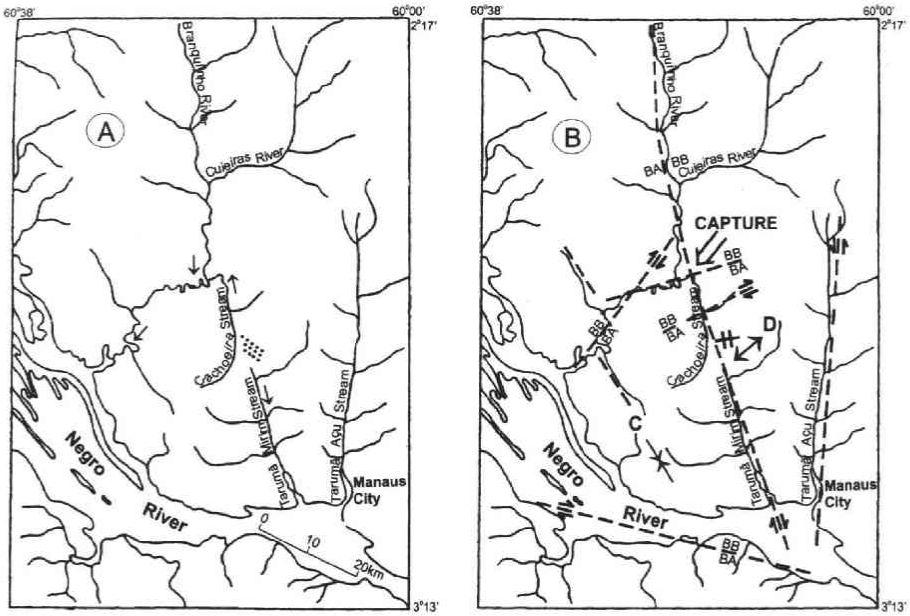

Fig. 5 Structural model of the river capture process in the Cuieiras River region, Amazonas, Brazil

Ⓐ: identification of fluvial capture according to Projeto Radambrasil, 1978

Ⓑ: geokinematic identification of the Neotectonic processes that caused the capture of the (stream) Tarumã Mirim by the Cuieiras River.

→ Streams Flow; ∴ Dead Valley; ⟸ Capture; ⫩ Elena Waterfall; -⇌- Tectonics Dextral Lineament; — — $\frac{BA}{BB}$ — — Secondary Fault, (BA=High Block and BB=Low Block); **C** →← Principal Axis of Local Tectonic Stress; **D** ↔ Principal Axis of Local Tectonic Dilatation.

direction of current tectonic neostructural shear lines. When more complex assemblages appear in the context of the model, they can be determined by the simple combinations of lakes and streams, lakes and islands, islands and streams, in addition to identical physiographic elements (islands and islands). The islands of Careiro (elliptical) and Risco (sigmoidal) are examples of rotational processes ($\pm 16°$ clockwise) along the Principal Zone of Displacement (Deformation) of the System (Solimões-Amazonas, Igreja, 1999). The lakes and islands at Itacoatiara and also in the Manaus region line up with the neostructural "trends".

It is very important that the geologic phenomena can be confirmed by small scale features in outcrops, that is, the dimensions of the minor discontinuities such as: microfissures, fractures, joints, and small folds, which in this case control springs, gullies, and the capture of run off. These small features represent the primordial stages of established processes that are prominent on the scale of rivers, side channels, watersheds, waterfalls and large lakes (Fig. 6).

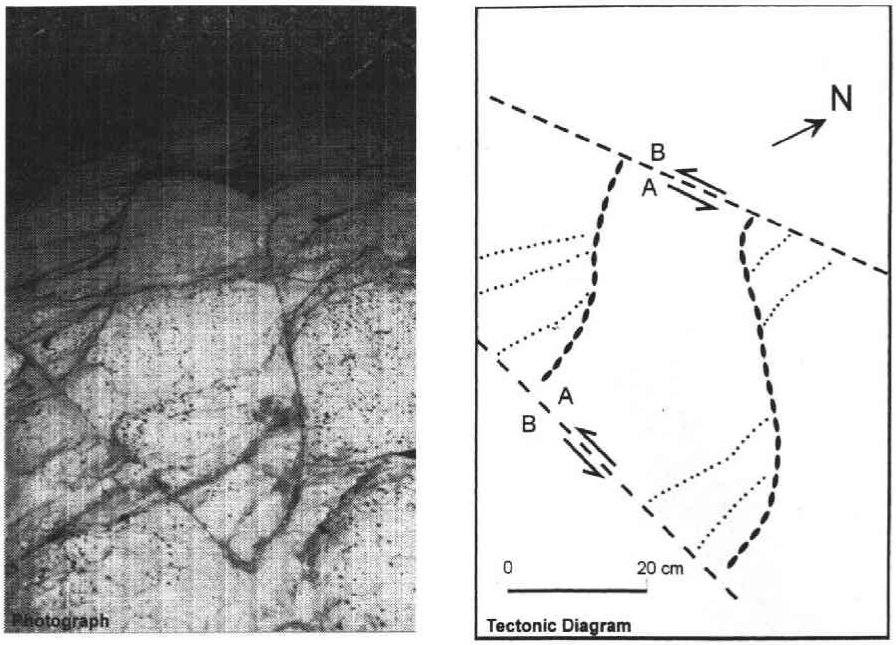

Fig. 6 Meso neotectonic structure on the sandstone of the Alter do Chão Formation, forming the bed of the Água Amarela waterfall in the region of the Cuieiras River capture (Photograph).
A=High Block ; B=Low Block ; Strike-slip movements (Tectonic diagram).

Hydrogeoenviromental characteristics of various elements, including geobotanical ones, are peculiar to "neotectonic environments". There is a tendency towards deep and still black waters in regions of transtension, and towards shallow, turbulent, and muddy waters in regions of transpression.

When there exists a combination of neostructural and dominant directional shear, there occurs a highly complex complement of distinct elements (black water streams and white water lakes), that clearly confirm the angular, geometric, and geodynamic components of the established model. The repetition of translational and rotational processes over geologic time may result in stream "clones" on one component of the shear while islands and/or lakes develop on the other component (conjugate) (Fig. 7).

5. Fluvial Capture Processes and the Capture of the Cuieiras River

The natural deviation of water from one hydrographic basin to another, producing the development of a new drainage system with negative effects on the captured basin, that is, fluvial or river capture, can be explained according to the following processes :

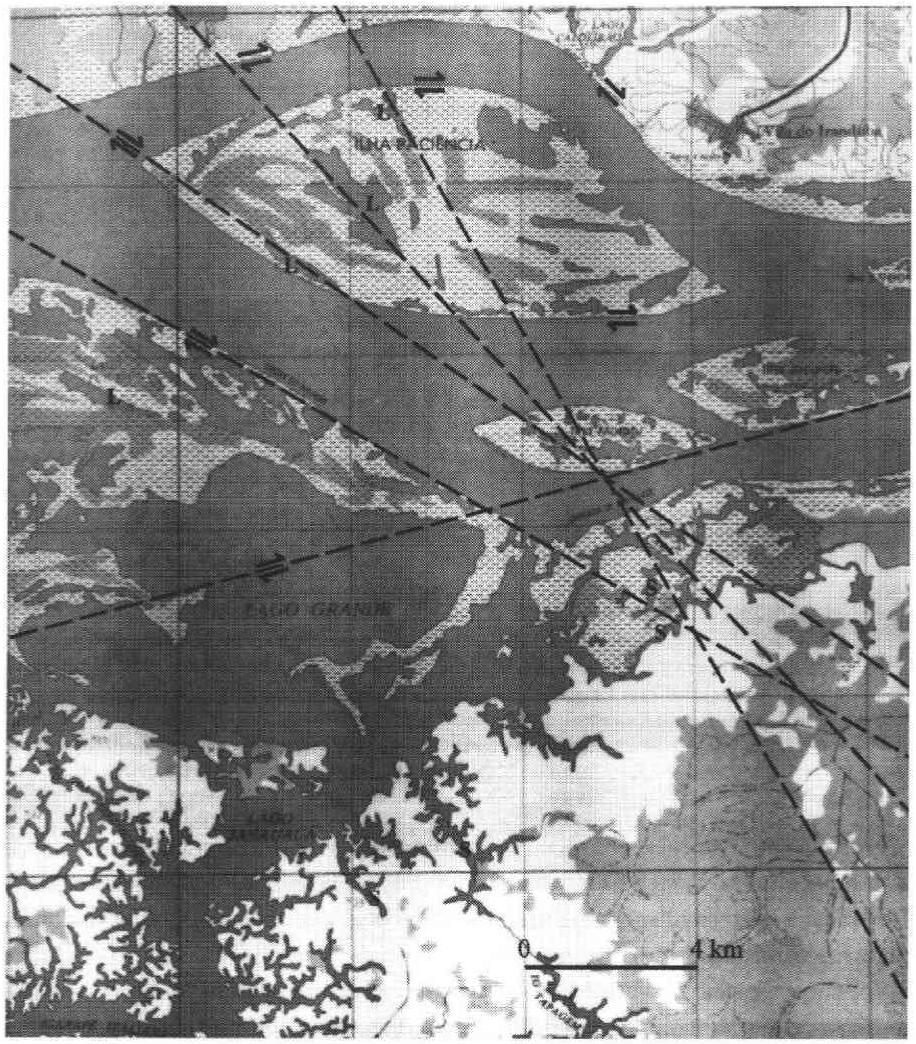

Fig. 7 Conjugate system in the genesis of stream (S) and lake (L) "clones"

A) absorption; B) retrogression of headwater; C) lateral levelling; D) overflowing, and E) subterraneous deviation (Houaiss, 1980). The operation of these processes is based on essentially erosional-geochemical (B, C, E) and depositional-geophysical (A, D) principles (Fig. 8). We think that in the studied region a combined action between retrogression of headwaters and subterraneous deviation occurred, subordinated to a principal neotectonic origin, similar to the processes identified in the plain of the Paraiba River above the Tiete River in Southern Brazil, (Ab'Saber, 1957, in Houaiss, 1980).

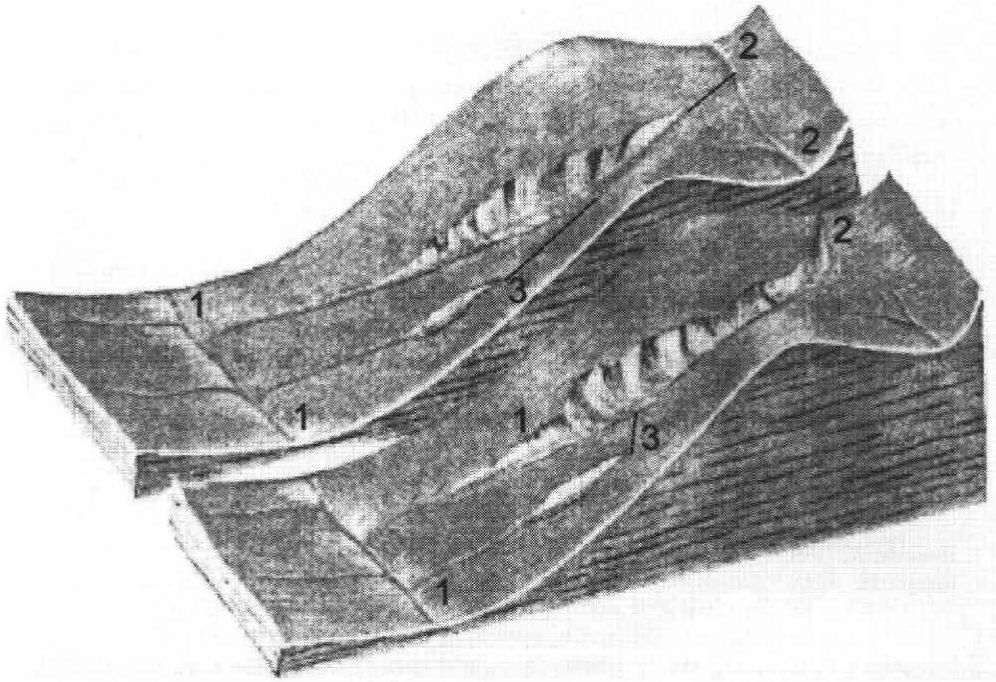

Fig. 8 Theoretical processes of fluvial capture
1 : Incision or elimination of the watersheds between streams with different altitude.
2 : Incision or elimination of the watersheds owing to the progress of the headwater (Retrogression of the headwater).
3 : Incision or elimination of the watershed by headwaters of a stream that absorbed the headwaters of an adjoining stream (Modified from Accordi and Lupia, 1991)

The erosion process in subsiding blocks stretched in an NW-SE trend recently studied in the extreme west of the Amazon Basin (Acre State, Latrubesse and Rancy, 1999) and first order rivers blocked due to a fault scarp in the extreme east of the Amazon region (Pará State ; Costa *et al.*, 1991) support the regional neotectonic model.

6. Conclusions

The movements of the present transcurrent neotectonic Amazonian system appear to be the principal agents that produce the processes of fluvial capture in this region. Studies of geometry and geokinematics are essential to understand past events and to foresee future events in this actively evolving river basin.

Acknowledgments

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