THE NEGRO'S FAN AND ITS PALEOENVIRONMENTAL CHANGES IN THE QUATERNARY, SOUTHEAST EDGE OF PANTANAL MATO-GROSSENSE (BRAZIL)

Paola Bueno QUIRINO[1]
Edna Maria FACINCANI[1]
Wanly Pereira ARANTES[1]
Raquel Magalhães dos SANTOS[1]
Bruna Medeiros CORDEIRO[2]

Abstract

The Negro river megafan is an expressive geomorphological feature in the Southeast edge of the Pantanal (MS) Basin. . It is characterised by depositional systems and sedimentary dynamics of complex evolution reflected in the composition of the vegetation cover. After the formation of the oldest lobe, an avulsion in the main channel took place, which began to flow to the southeast, originating the pre-current lobe at the distal portion of the system (Neo-pleistocene age) and in the Holcene the current lobe was formed. The methodological procedures were based on interpretation of satellite images, topographic maps, SRTM radar images, thematic maps, and field data. The neotectonic features were identified based on drainage and relief anomalies and the depositional system on the old, pre-current and current lobes, which are registered in its surface considering the standard of distributary drainage and indications of avulsion, showing neotectonic events in the Quaternary. The process of fluvial abandonment is registered in the pre-current lobe, by paleodrainage of NE-SW direction and by the vegetation cover along its course, around 50 km. This paleodrainage is marked in the landscape as a large ebb called Santa Clara.

Key-words: Paleoenvironmental changes. Avulsion. Negro Megafan and Pantanal.

Resumo

Megaleque do Negro e suas mudanças paleoambientais no quaternário, borda sudeste do Pantanal Mato-Grossense (Brasil)

O Megaleque Negro é uma feição geomorfológica expressiva na Borda Sudeste da Bacia do Pantanal (MS). Caracteriza-se por sistemas deposicionais de dinâmica sedimentar e de evolução complexa que se refletem na composição da cobertura vegetal. Após a formação do lobo mais antigo, ocorreu uma avulsão com o canal principal, que passou a fluir para sudeste, originando o lobo pré-atual na parte distal do sistema (idade neopleistocênica) e no Holoceno formou-se o lobo atual. Os procedimentos metodológicos fundamentaram-se na interpretação de imagem de satélite, cartas topográficas, imagem de radar SRTM, mapas temáticos e dados de campo. As feições neotectônicas foram identificadas baseadas nas anomalias de drenagem e relevo e o sistema deposicional pelos lobos antigo, pré-atual e atual que são registradas em sua superfície por padrão de drenagem distributária e indicações de avulsões, denunciando um palco de eventos neotectônicos no Quartenário. O processo de abandono fluvial está registrado no lobo pré-atual, por paleodrenagem de direção NE-SW e pela cobertura vegetal ao longo do curso, em torno de 50 Km. Essa paleodrenagem é marcada na paisagem como uma grande vazante denominada Santa Clara.

Palavras-chave: Mudanças paleoambientais. Avulsão. Megaleque Negro e Pantanal.

[1] Universidade Federal de Mato Grosso do Sul- UFMS, Av. Oscar Trindade de Barros, 740, 79200-000 Aquidauana-MS Brasil. E-mails: pa_facul2011@hotmail.com, edna.facincani@ufms.br, wanly@terra.com.br, magalhães.rms@gmail.com

[2] Universidade de São Paulo- USP, Instituto de Geociências, Rua do Lago, 562 -05508-080 - Cidade Universitária -SP, Brasil. E-mail: brunamc@usp.br

INTRODUCTION

The sedimentary Basin of Pantanal is the largest wetland in the world (JUNK; BROWN; CAMPBELL; FINLAYSON; GOPAL; RAMBERG; WARNER, 2006, p.68), it is located in the Center-West region of Brazil, in the parallels 15° and 20°S and the meridians 59º and 55°W. Coinciding with the area of Bacia do Alto Paraguai (BAP) it is surrounded by the plateaus of Maracaju-Campo Grande and Taquari-Itiquira to the East, Guimarães and Parecis to the North, Urucum-Amolar to the West and Bodoquena to the South, according to figure 1.

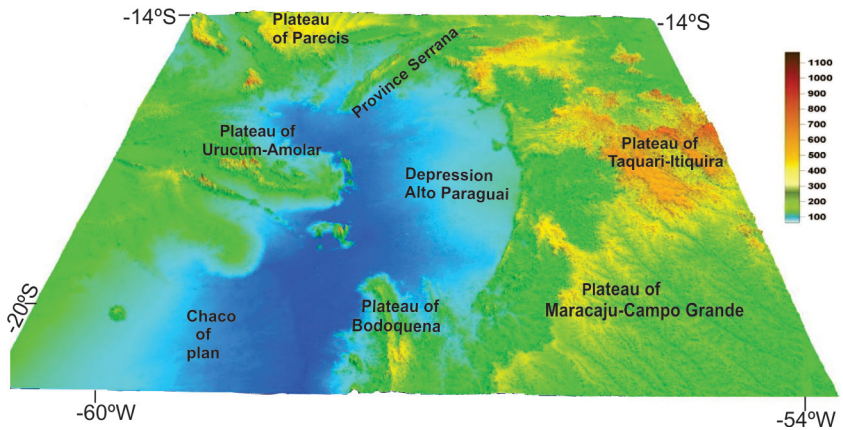

Figure 1 – Digital model of the elevation in the Depression region of Alto Paraguai, where the Sedimentary Basin of Pantanal Mato-Grossense is, surrounded by its plateaus. (ASSINE, 2010)

Pantanal is an active geotectonic entity of Cenozoic age, a subsident area, with active failures and epicenters of earthquake (ASSINE 2004, p.71); (FACINCANI, ASSUMPÇÃO, ASSINE, FRANÇA 2011, p.314). The resurgent tectonic (HASUI 1990, p.1) and its relations with the seismicity in the Middle-West region is marked by a lining bundle of medium direction of N45ºE, called *Lineamento Transbrasiliano*, (SCHOBBENHAUS, C. F. ; OGUINO, G. ; RIBEIRO, D. L. ; OLIVA, L. A. ; TAKANOHASHI, J. T., 1975, p.114). It is a sedimentary basin structured by failures, with an extension of about 400 km (North-South direction), 250 km width (East-West direction) and thickness superior to 400 m of Cenozoic sediments, constituting the biggest depression of Neotectonic in the State of Mato Grosso do Sul.

The Pantanal Basin is dominated by systems of fluvial sedimentations which originate the Megafans, the stratigraphic succession shows textural thinning to the top and filling essentially siliciclastic. The treating of depositional systems is composed by an extensive fluvial plain meandering with marginal small lakes, which collects the water of several alluvial fans dominated by rivers. (ASSINE 2004, p.61).

The draining nets in the Negro Megafan are marked in the landscape by current and ancient features, where they are influenced mainly by neotectonic features and sedimentation. These processes have acted as an important agent modeler in the pantaneira landscape, changing the base levels and topographic gradients, which have mainly influenced the draining, with the developing of features called avulsion.

The term fluvial avulsion refers to the group of processes which cause evident changes in the river flow. Avulsion is initiated by the breaking of marginal dikes or by the

changing in the base level, caused by antropic action or natural phenomena, like tectonic events, flooding and sediment deposition in the channel, causing sediment accommodation in the spaces (Figure 2) according to Assine (2009, p.1036).

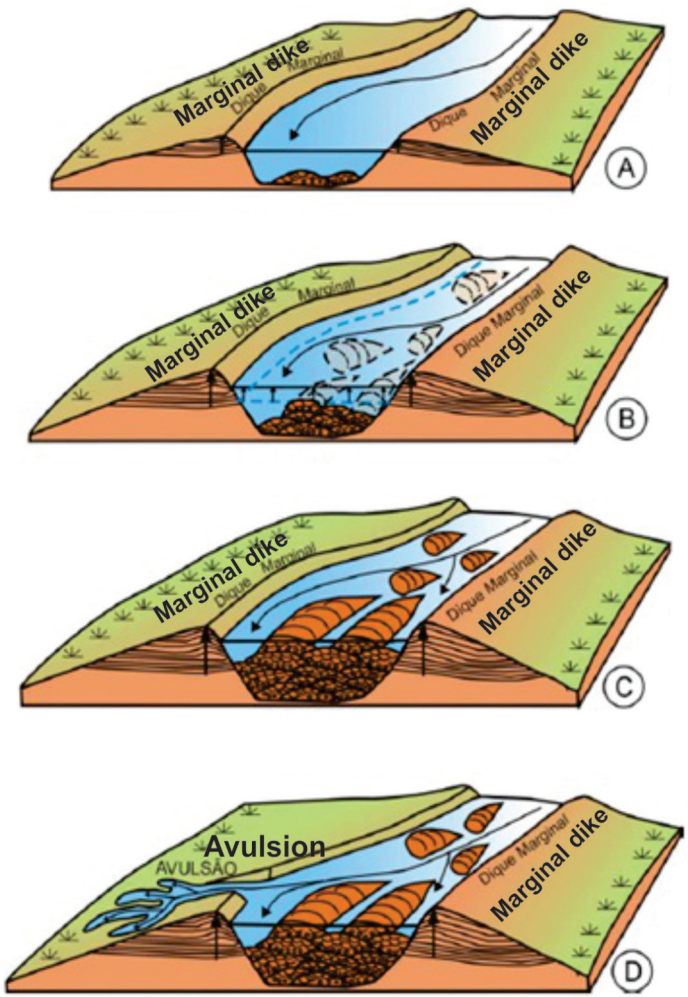

Figure 2 - diagram bloc representing the succession in the process that culminates with an avulsion of the channel: A) the channel is getting higher than the adjacent areas limited by the marginal dikes that are formed by the rivers during the flooding periods; B) deposition of sediments in the channel form subaqueous dunes and the bed is elevated by aggradation, like the marginal dikes; C) after the siltation of the channel, the bars are immersed even in the flooding period and the capacity of the channel to retain the water is more and more difficult; D) during the flooding the channel breaks the marginal dike, forming a fan of crevasse and causing inundation in the adjacent plain, what may cause changes in the river course, avulsion

In the distributing fluvial systems the evident developing of marginal dikes is very common. These dikes are broken in the period of big floods, when the process of avulsion takes place . Acoording to Stouthamer, (2001, p.75); Slingerland, R. & Smith, N. D. (2004, p.260) the process of avulsion can be classified in several forms: complete, partial, nodal, random, local, regional, instantaneous, gradual and non-avulsion. The process of avulsion occurs, mainly, in the rivers that are located in sites of active and pre-current sedimentation, marked by large features of paleochannels. The Negro Megafan is located in the

19º15'and 19º45'S and 55º00' and 56º00' W, surrounded by The Taquari Megafan to the West and the North, by The Taboco and the Aquidauana/Miranda Megafans to the South and by the Plateau of Maracaju-Campo Grande to the East, figure 3. Its access is possible by the road MS-419, regionally known as Taboco Road.

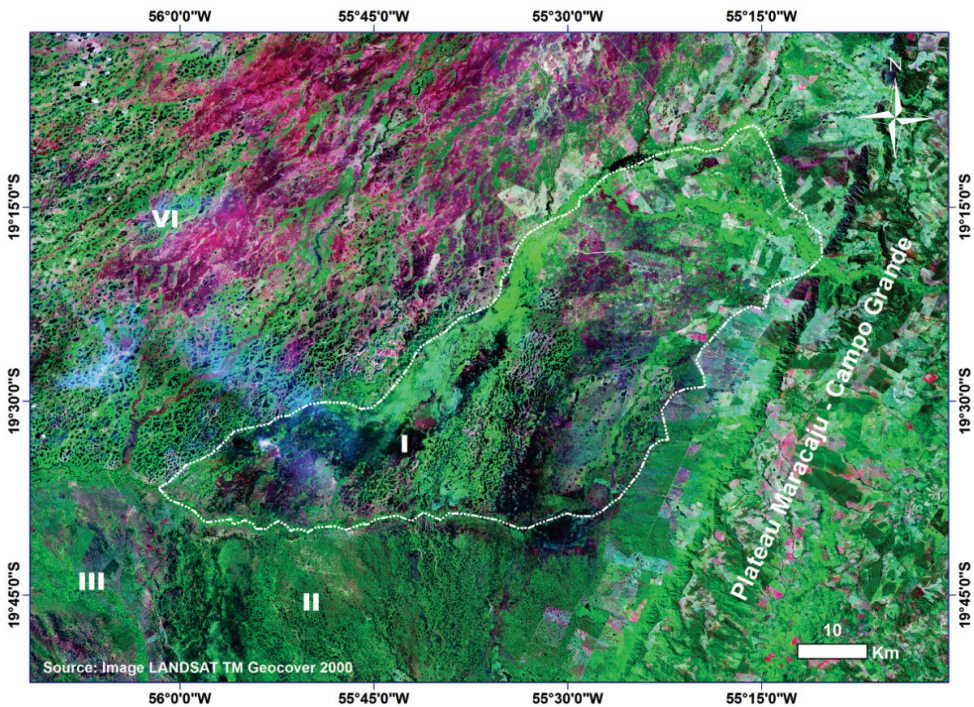

Figure 3 - Negro Megafan (I) with the indication of the coalescent megafans: Taboco (II), Aquidauana (III) e Taquari (VI). (Landsat image 7 ETM+, Geocover circa 2000, composition RGB, NASA, (https://zulu.ssc.nasa.gov/mrsid), according to Cordeiro, Facincani, Filho, Bacani, Assine. (2010, p.176). The line traced in white indicates the delimitation of the Negro Megafan

OBJECTIVES

This paper which deals with fluvial dynamics aims to identify, characterize and analyze the paleo-environmental changes in neotectonic activities in the Negro Megafan registered by current and old draining in three of its depositional lobes, focusing on the

processes of avulsion marked in the landscape by the Santa Clara ebb in the pre-current lobe, and shows the differences of the vegetation cover as part of the biological system associated to the depositional and hydrogeological systems in the paleo-environmental changes of the Quaternary.

MATERIAL AND METHODS

The steps of photo-reading, photo-analysis and photo-interpretation were followed in the elaboration of the geomorphological map. Photo-reading comprehends the recognition and the identification of the compartmentalized image elements, photo-analysis integrates the image study associating its elements to every repartition, and photo-interpretation joins all the previous analyzes, trying to demonstrate results using deductive, inductive and comparative methods, Soares e Fiori (1976 p.71). The techniques were applied to the present features in the old, pre-current and current lobes, marked by standard of channels and paleochannels. The spatial data were topographic cards in the scale of 1:100.000, satellite LANDSAT 7, sensor ETM+, ortoretified in colorful composition R7 G4 B3 (https://zulu.ssc.nasa.gov/mrsid), radar images SRTM (Shuttle Radar Topography Mission) provided by Companhia de Pesquisa e Recursos Minerais (CPRM), manual vectorizing of the features in the software Arcgis10.0 and field data collecting obtained on June 26th of 2012, in the form of transect in the direction E-W, with a total of 28 points shown , from Aquidauana towards Rio Negro city by the road MS-419 (Taboco Road), towards Campo Lurdes Farm, direction East/West covering about 111 km, as shown in figure 4. In this route the characterization of the vegetation dynamics was carried out checking *in loco* and sampling vegetal material to subsequent recognition of the main species in the areas with homogeneous physiognomies.

The characterization of the current lobe avulsion process was based on the methodological procedures according to Slingerland, R. & Smith, N. D. (2004, p.260), who focused on the avulsion concept, forming factors and their partial, nodal, local, complete, random and regional architectures; including the resurgent tectonics (HASUI 1990, p.1). The results were obtained from the analysis and comparison of the process among the registers of paleo-drainage, its correlative deposits and vegetal covering.

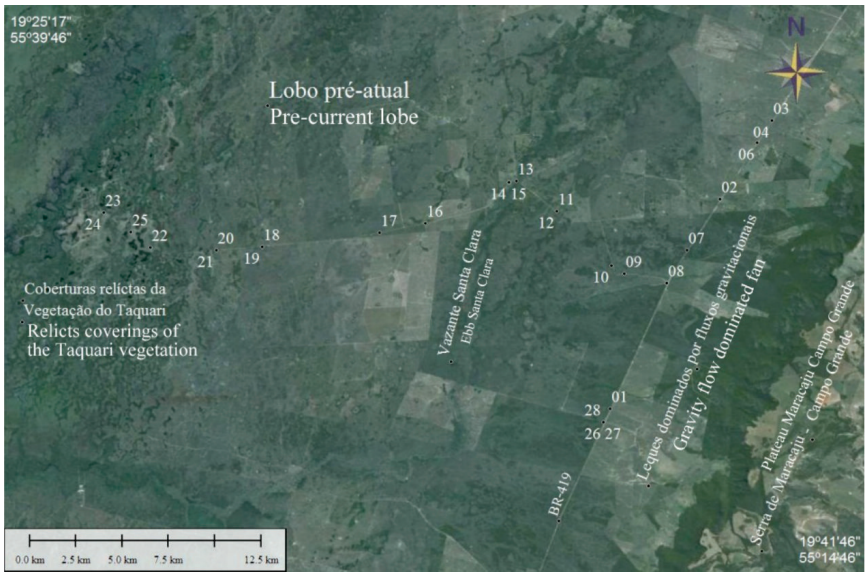

Figure 4 - Transect of the field data carried out on June 26th, 2012, in the direction East/West in the pre-current lobe and relicts deposits of Taquari (IV). Totalizing 28 points in sequential form

RESULTS AND DISCUSSION

The Negro Megafan constitutes an active geomorphological feature in the Eastern Edge of the Sedimentary Basin of Pantanal, formed by Negro river from the end of the epicenter to the current days. The Megafan has been formed in the plain of Pantanal and elongates towards NE-SW, with an area of around 2.350 km². Its west limit is given by the occurrence of fluvial and laky deposits of Baixa Nhecolândia, connected to the Taquari Megafan. Its South limit, with the Taboco and Aquidauana Megafans is defined by Santa Clara ebb and by the Negro river itself, where it empties to the west and its flux goes through a plain of meanders. The East limit of the Megafan is approximately parallel to the plateau scarp, it is separated from it by a ramp of deposits seen as colluvials. These deposits are understood as deposits of detritus flux, formed by alluvial fans kept by gravity flux. The Negro Megafan is marked by large structural discontinuities registered in the relief and by draining of directions NE-SW (Serra Maracaju-Campo Grande), E-W (Rio Negro), forming a big structure of sigmoidal type and thus conditioning the sedimentation of this unity geomorphology , possibly influenced by the shear zone of the Transbrasiliano, figure 5.

The standards of draining and the vegetal covering allow compartmentalizing the surface of the Megafan (Figure 6), since it testifies the depositional and geomorphological changes of the Quaternary. This occurs because the vegetal composition is attributed to different factors (physical, chemical and biological) which are strongly associated to variation in the vegetal coverage in the region. The succession of vegetal covering of the Negro Megafan indicates, in this way, a correlation with the sedimentation (depositional system treat) in the Holocene.

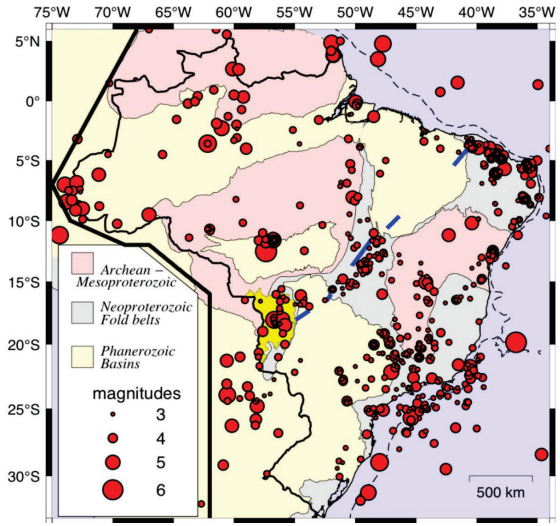

Figure 5 - Epicenters known in Brazil (Source: Boletim Sísmico Brasileiro, period from 1767 to 2010) and the principal geological provinces of the country. The total area of the Pantanal Basin is indicated in strong yellow color. The blue line shows the stronger traces of Transbrasiliano lining

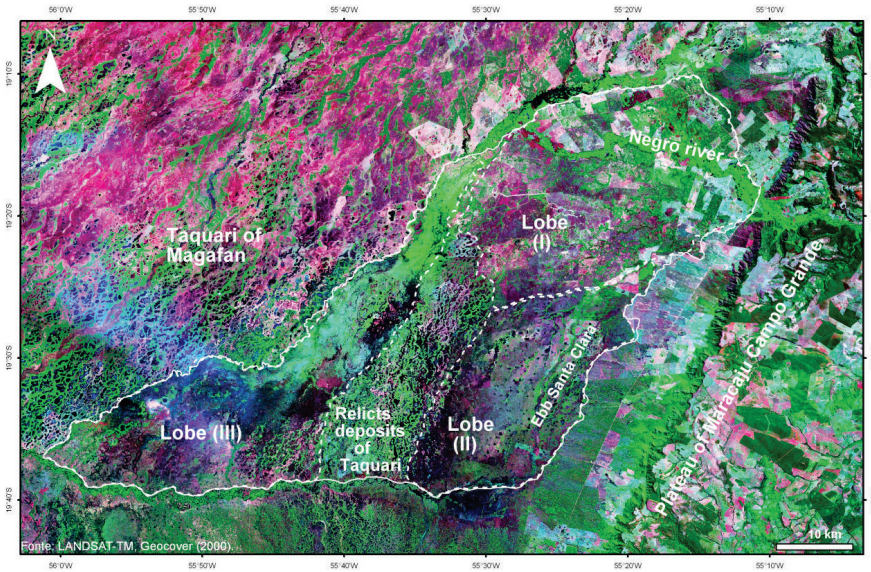

Figure 6 - Geomorphological compartmentalizing of the Negro Megafan, focusing the lobes: old (I), pre-current (II) and current (III). I must be noted to South-East the abandon the Santa Clara Ebb. Image Landsat 7 ETM+, Geocover circa 2000, composition RGB, NASA, (https://zulu.ssc.nasa.gov/mrsid). Adapted from (CORDEIRO, FACINCANI, FILHO, BACANI, ASSINE. 2010, p.179)

The Negro Megafan was the stage of three events: 1) the formation of the old lobe characterized by paleo-channels and the presence of *crevasses splays*, it does not present any process of current deposition; 2) the formation of a pre-current lobe with distributary paleo-drainage; 3) the formation of the current lobe is connected to the abasement of the equilibrium profile that caused the incision of the Megafan surface, originating in its subsequent portion an incisive plateau entrenched in deposits of the oldest lobe. The Dissecation also occurred in the distal portion with partial disintegration of the lake landscapes of Nhecolândia, registered in the succession of the vegetal covering with replacing of the arboreal and herbal covering. Ancient fragments of the Taquari vegetation (IV) have currently been verified in satellite images and in the fields, The lobes are morphological features that occur in the depositional systems where the river begins to present bifurcations and the system of draining becomes distributary because of the avulsion processes.

The change in the direction of the draining made the development in the old lobe possible with entrenching in the pleiscocenic sediments, thus creating, a plain of holocenic age in its subsequent part, possibly caused by the change in base profile and/or by the sedimentation reworking processes and by hydrogeological events which led to the aggradation of the Negro River bed and created the belts of meanders in the superior parts of the old lobe, figure 7.

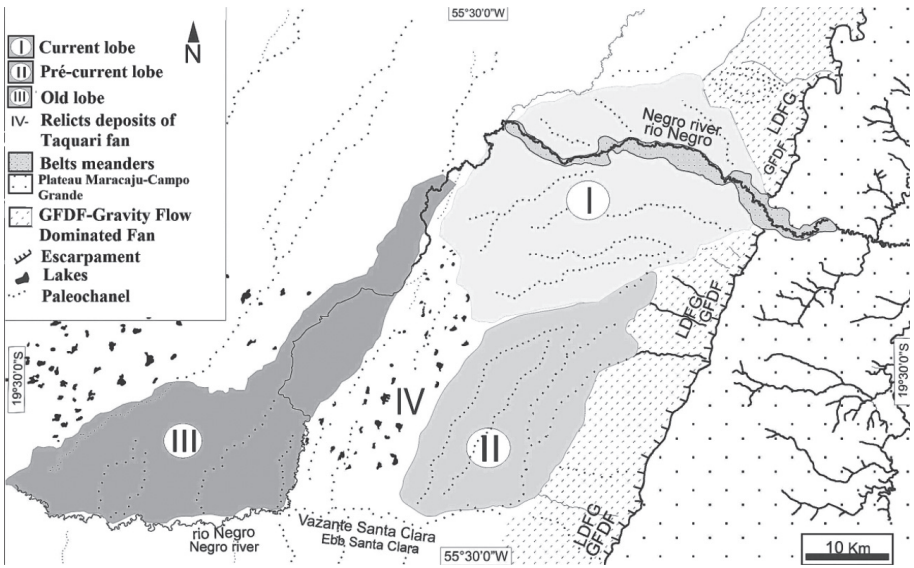

Figure 7- Geomorphological compartment of Negro Megafan, Old (I), pre-current (II) and current lobe (III) of Negro Megafan and relicts deposits of Taquari (IV). Adapted from CORDEIRO, FACINCANI, FILHO, BACANI, ASSINE. 2010, p.179

The process of fluvial avulsion, of the partial type and its abandonment in the Negro Megafan are registered in the pre-current and current lobes (Figures 8A and B), by paleo-draining of direction NE-SW and by vegetal coverage following the course, around 50 km, currently called Santa Clara Ebb, according to figures 9A and B.

The transection carried out was satisfactory to the characterization of the vegetal physiognomy, since the texture of satellite images registered two compartments: pre-current lobes and deposits of the Taquari, enabling the correlation of the sedimentary deposit

with modification of the vegetal coverage. Going to the West and North Edge, the dominant presence of native grass and species tolerant to flooding soils are observed, typical of the *cerrado* field, with the presence of humid areas. In the ebb areas, the most frequent macrophytes were *água-pé* (*Eichhornia azurea* Sw. Kunth); and *lanceiro* (*Pontederia parviflora* Alexander), samples shown in the lobes (II) and (IV). The *piri* (*Cyperus giganteus* Vahl), the *trevo* (*Marsilia deflexa* A. Braun) and the *caninha do brejo* (*Canna sp*) ocurred only in the lobe (IV). Concerning the lobe (II) big and dense species were verified in some points, with the presence of *angicos* (*Anadenanthera falcata* Benth. Speg.), *jatobás* (*Hymenaea courbaril*), *ximbaúva* (*Enterolobium contortisiliquum* Vell. Morong), among others, and also species that are typical of transition areas between the *cerrado sensu stricto* and the *cerrado* field, in well drained soils, table 1.

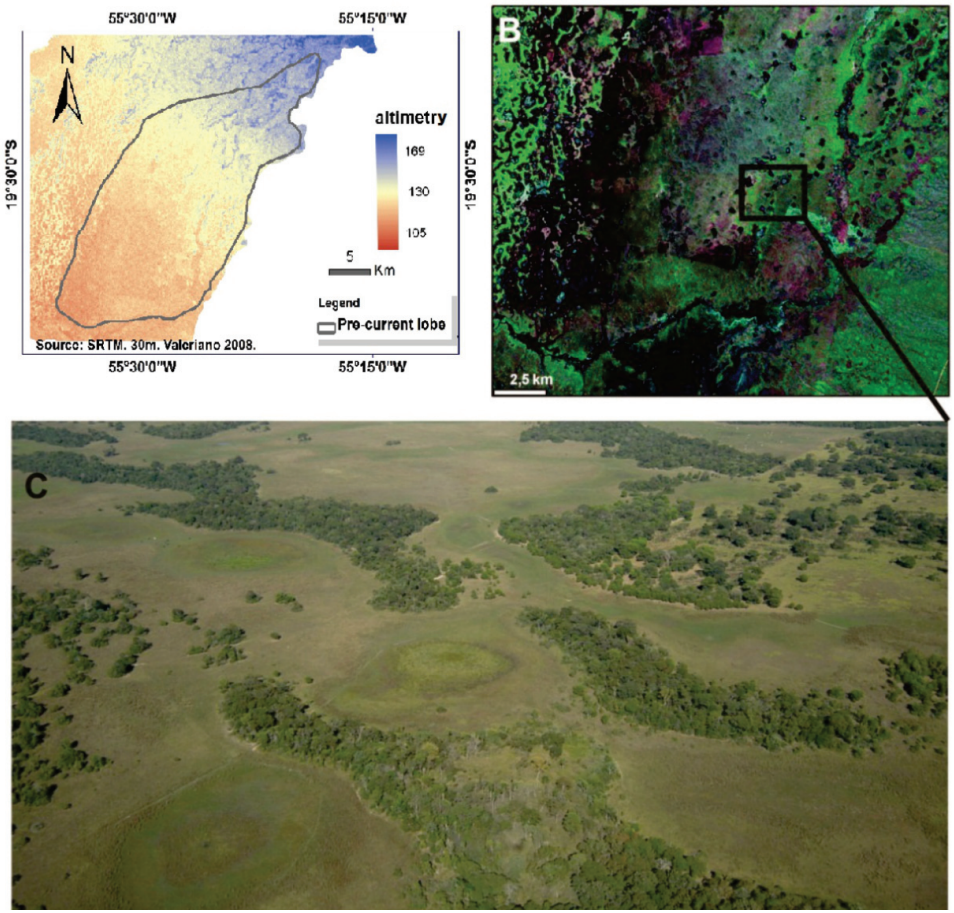

Figure 8A- Distributary pre-current Lobe. A) altimetry; B) distal part of the lobe in contact with surface of a lake in Nhecolândia (west), coalescent in the sops of the scarps (East), tributary channel connected to Santa Clara Ebb (East and South), C) surface in phase of dissection, with fragments of herbal vegetation, surrounded by grass (CORDEIRO, B. M. 2010. p.31)

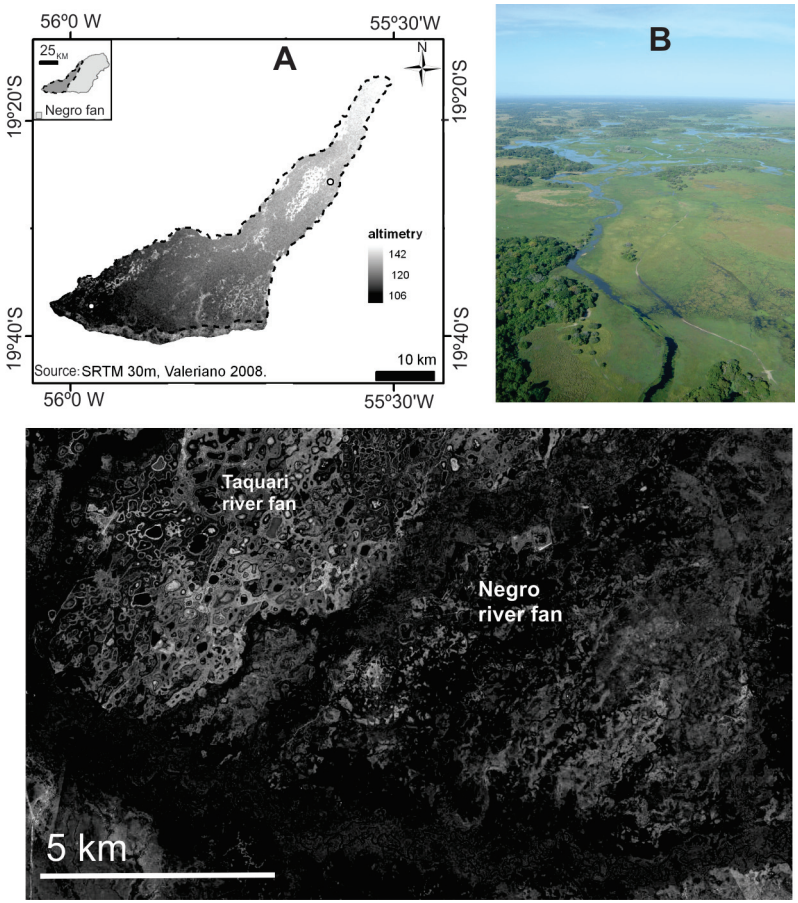

Figure 8B - Distributary pre-current lobe: A) Altimetry; B) distributary channel in the apex in oblique aerial photo; C) fringe of the megafan in contact with Taquari Megafan (West) and Rio Negro (South) (CORDEIRO, FACINCANI, FILHO, BACANI, ASSINE. 2010, p.181)

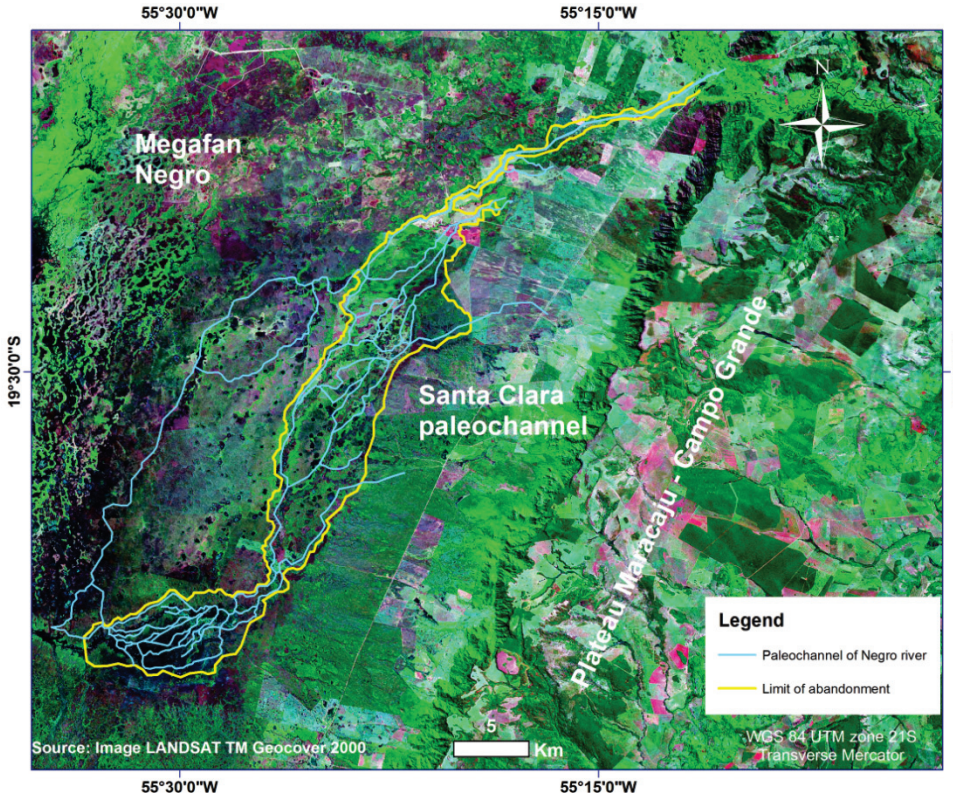

Figure 9A- Stretch of fluvial abandon (Santa Clara Ebb), with extension about 50 km of direction NE-SW, in the pre-current lobe (II) in the Negro Megafan. (Mosaic of the image Landsat ETM). Presence of the vegetation of macrophytes and flooded fields

Table 1 - List of families and botanic species shown in the lobo pre-current areas (II) and deposits of Taquari (IV) of Negro Megafan, Aquidauana City, MS State

Family	Gender/Specie	Popular Name	Occurance
01. Anacardiaceae	Astronium fraxinifolium Schott	Gonçalo	Da–(II)
02. Annonaceae	*Xylopia aromatica* (Lam.) Mart.	Pimenta de macaco	Da–(II)
03. Annonaceae	*Rollinia dioica* St.Hil.	Araticum	Da -(II)
04. Arecaceae	*Orbignya oleifera* Bur	Babaçu	Hu -(II)
05. Arecaceae	*Copernicia alba* Morong	Carandá	Hu -(II)
06. Arecaceae	*Scheelea phalerata* (Mart) Bur	Acuri	Hu –(IV),(II)
07. Arecaceae	*Bactris glaucescens* Drude	Tucum	Hu -(II)
08. Bignoniaceae	*Tabebuia heptaphylla* (Vell.)Toledo	Ipê-rosa	Da -(II)
09. Bignoniaceae	*Tabebuia aurea* (Manso) Benth.	Paratudo	Da -(II)
10. Boraginaceae	*Cordia glabrata. (Mart.)A. DC.*	Louro branco	Da -(II)
11. Bromeliaceae	*Bromelia balansae* Mez	Caraguatá	Da - (II)
12. Cactaceae	*Cereus peruvianus* Mill	Cacto	Da -(II)
13. Caryocaraceae	*Caryocar brasiliense* Camb	Pequi	Da -(II)
14. Cecropiaceae	*Cecropia pachystachya* Trec	Embaúba	Da -(II)
15. Compositae	*Vernonia sp*	Assa-peixe	Da -(II)
16. Cyperaceae	*Cyperus digitatus* Roxb	Piri	Hu -(II)
17. Dilleniaceae	*Curatella americana L.*	Lixeira	Da -(II)
18. Erythroxylaceae	*Erythroxilum suberosum* St. Hill.	Sombra de touro	Da -(II)
19. Euphorbiaceae	*Sapium sp*	Leitero	Da -(II)
20. Fabaceae	*Dimorphandra mollis* Benth	Faveira	Da -(II)
21. Fabaceae	*Dipteryx alata* Vog	Cumbaru	Da -(II)
22. Fabaceae	*Enterolobium contortissiliquum*(Vell)	Ximbauva	Da -(IV)
23. Fabaceae	*Indigofera hirsuta* L.	Indigo	Da - (II)
24. Fabaceae	*Prosopis rubriflora* Hassl	Barreiro	Hu - (II)
25. Fabaceae	*Hymenaea courbaril* (Hayne) Y.T.Lee e Langenh	Jatobá	Da -(II)
26. Fabaceae	*Albizia polycephala* (Benth.) Killip. ex Record	Angico branco	Da -(IV)
27. Flacourtiaceae	Casearia sylvestris SW.	Chá de bugre	Da - (II)
28. Malpighiaceae	*Byrsonima* sp		Da - (II)
29. Marsiliaceae	*Marsilea* sp	Trevo	Hu - (II)
30. Melastomataceae	*Miconia* sp		Da - (IV) e (II)
31. Moraceae	*Ficus* sp	Figueira	Hu -(II)
32. Myrtaceae	*Psidium guineense* SW	Araçá	Da/Hu -(II)
33. Myrtaceae	*Myrcia sp*		Da - (IV) e (II)
34. Onagraceae	*Ludwigia* sp	Cruz de Malta	Hu - (IV) e (II)
35. Pontederiaceae	*Eichhornia azurea* (Sw.) Kunth	Agua-pé	Hu - (IV) e (II)
36. Pontederiaceae	*Ponderia parviflora* Alexander	Lanceiro	Hu - (IV)e (II)
37. Rubiaceae	*Genipa americana* L.	Jenipapo	Hu -(IV)
38. Rubiaceae	*Alibertia edulis* (Rich.) A. Rich ex DC.	Marmelo	Da -(II)
39. Salviniaceae	*Salvinia* sp	Orelha de onça	Hu - (IV) e (II)
40. Solonaceae	*Solanum viarum* Dun.	Juá	Da/Hu - (II)
41. Vitaceae	*Cissus erosa* L.C.Rich	Uvinha	Hu – (II) e (IV)
42. Vochysiaceae	*Vochysia divergens* Pohl	Cambará	Da/Hu – (II)
43. Zingiberaceae	*Costus* sp	Caninha do brejo	Hu – (IV)

Label: **Da** – dry area. **Hu** – humid area. **Pre-current Lobe** (II), **Deposits of Taquari** (IV).

The successive avulsions caused some adjustments in consequence of some events that occurred creating a stage of active sedimentation (current lobe III) over the distal portion of the Taquari Megafan in the current lobe (Figures A and 10). Thus, the avulsion processes were predominant in the distributary lobes as a consequence of abrupt changes of the paleo-draining in the Megafan.

Figure 9B – Santa Clara Ebb located in the pre-current lobe (II) in the Negro Megafan, caused by a process of partial avulsion. Flood fields, macrophyts presence. Location -55° 24′ 23′′W e -19° 30′ 21′′S. Source: Quirino, 2012

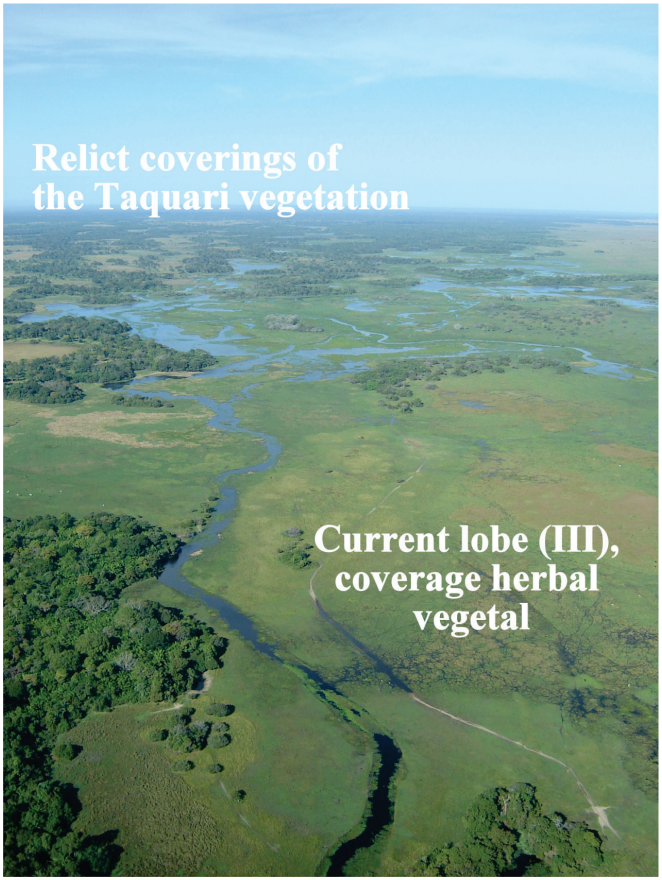

Figure 10 - Current lobe (III), avulsion phenomenon of the Rio Negro channel, presenting distributary system in the distal part of the Negro Megafan, to the left the presence of relict coverings of the Taquari vegetation (IV), according to the compartment of the picture 3. (CORDEIRO, FACINCANI, FILHO, BACANI, ASSINE. 2010, p.181). Source: Cordeiro, 2010

CONCLUSIONS

The Negro Megafan represents an active geomorphological feature in the *pantaneira* plain, in the Southeast Edge of the Sedimentar Basin of Pantanal, besides expressive correlations in the vegetal coverage with the process of sedimentation. Different geomorphological features of three compartments are registered in its surface by several paleochannels and active channels, besides indications of avulsions and fluvial changes that testify a stage of events, with level variations of the base due to the neotectonics processes since the end of the Pleistoceno, creating a typical mutant landscape in Pantanal. It can be said that the vegetation that follows the Rio Negro Megafan has gradually been

replaced. In the shrubby-herbal extract the *ipês* (*Tabebuia* sp) are initially the predominant ones, followed by the *lixeira* (*Curatella americana* L.) as the dominant species and then by, the *cambará* (*Vochysia divergens* Pohl) in the humid areas. The establishment of this succession of events was only possible thanks to the application of geotechnologies, which permits the identification of the Negro Megafan and its geomorphological compartment. It is also noteworthy that the comprehension of the sedimentary processes and of the deposits of the fluvial megafans, such as the Negro one, is of extreme importance to understand the origin and evolution of the *pantaneira* landscape. Finally, it is important to emphasize that the chronology related to events herein , constitutes the base for future work of characterization and dating of the deposits, which are necessary for a more precise reconstitution of the events that occurred in Southeast Edge of Pantanal, from the Pleistocen to the present.

REFERENCES

ASSINE, M. L. **Sedimentação na Bacia do Pantanal Mato-Grossense, Centro-Oeste do Brasil.** 2003. Tese (Livre Docência) - Instituto de Geociências e Ciências exatas, Universidade Estadual Paulista, Rio Claro, 2003.

ASSINE, M.L. A bacia sedimentar do pantanal Mato-Grossense. In: MANTESO-NETO, V. BARTORELLI, A. CARNEIRO, C. D. R e NEVES, B. B. B (Org.) **Geologia do continente Sul-Americano:** evolução da obra de Fernando Flávio Marques de Almeida. São Paulo: Beca, 2004. Cap. IV. p. 61-74.

ASSINE, M. L. Taquari: um rio mutante**.** In: SIMPÓSIO DE GEOTECNOLOGIAS NO PANTANAL, 2., Corumbá-MS 7-11 novembro 2009, **2º Geopantanal. Embrapa Informática Agropecuária/INPE**, 2009. p.1034-1040.

ASSINE, M. L. Pantanal Mato-Grossense: Uma paisagem de exceção. In: MODENESI-GAUTTIERI, M. C.; BARTORELLI, A.; MANTESSO-NETO, V. CARNEIRO, C. D. R.; LISBOA, M. B. A. L. (Org.) **A Obra de Aziz Nacib Ab' Saber**. São Paulo: Beca-Ball, 2010. 25, p. 464-489.

CORDEIRO, B. M. FACINCANI, E. M. FILHO, A. C. P. BACANI, V .M. ASSINE, M. L. Compartimentação geomorfológica do leque fluvial do Rio Negro Borda Sudeste da Bacia do Pantanal (MS), **Revista Brasileira de Geociências**, v. 40, n.2, p.175-183,2010.

CORDEIRO, B. M. **Caracterização geomorfológica do leque fluvial do Rio Negro, Borda Sudeste da Bacia do Pantanal (MS)**. Monografia (Bacharel em Geografia), Universidade Federal de Mato Grosso do Sul, Campus de Aquidauana, 6/12/2010.

FACINCANI, E. M. ASSUMPÇÃO, M. ASSINE, M.L. FRANÇA, G. Sismicidade da Bacia do Pantanal Mato-Grossense. In: SIMPÓSIO DE ESTUDOS TECTÔNICOS, 13., Campinas-SP, 15-19 Maio 2011. **SNET VII International Symposium on tectonics**. Campinas-SP,2011. p.314-317.

HASUI, Y. Neotectônica e aspectos fundamentais da tectônica ressurgente no Brasil. In: WORKSHOP SOBRE TECTÔNICA E SEDIMENTAÇÃO CENOZÓICA CONTINENTAL NO SUDESTE BRASILEIRO,1. **Anais...** Belo Horizonte. Belo Horizonte: SBG-MG, 1990. p.1 –31.

JUNK, W. J.; BROWN, M.; CAMPBELL, I. C.; FINLAYSON, M.; GOPAL, B.; RAMBERG, L.; WARNER, B. G.**.** The comparative biodiversity of seven globally important wetlands: a synthesis. **Aquatic Sciences**, Amsterdam. v. 68, n. 3, p. 400-414, 2006.

SLINGERLAND, R.; SMITH, N. D. River avulsions and their deposits**. Annual. Review of Earth and Planetary Sciences**. v. 32, p.257–285, 2004.

STOUTHAMER, E. Sedimentary products of avulsions in the Holocene Rhine-Meuse delta, The Netherlands. **Sedimentary Geology**. Elsevier. v. 145, p. 73–92, 2001.

SOARES, C.P; FIORI, A.P. Lógica e sistemática na análise e interpretação de fotografias aéreas em Geologia. **Not. Geomorfologia**, Campinas-SP, v.16. n.32.p. 71-104.1976

SCHOBBENHAUS, C. F.; OGUINO, G.; RIBEIRO, D. L.; OLIVA, L. A.; TAKANOHASHI, J. T.; Carta Geológica do Brasil ao Milionésimo. **Folha de Goiás** (SD.22). Brasília: MME/DGM/DNPM. p. 114. 1975.