GEOMORPHOLOGY AND DEPOSITION EVENTS IN NHECOLANDIA PANTANAL WETLAND

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Abstract

The Pantanal wetland is an active sedimentary basin composed of a depositional tract system of alluvial fans and fluvial plains. The Taquari mega-fan is the largest one, with an area of 50,000km² and remarkably circular shape. The southern portion is known as Nhecolândia, where the most distinguished features are circular ponds, some of them known as *Salinas* because of its high salt concentration and pH around 9. The aim of this study is, using geo-technology techniques, to identify the features of surface and contextualize them with depositional developments in the southern portion of the Taquari mega-fan and also to use of geo-processing techniques for the readjustment of geomorphologic definitions in this area. In order to do that, we applied remote sensing data and techniques digitally processed in specific software. Results suggest that the area can be segmented in two parts when one considers the slope of the terrain. There is an evidence of a possible preterit dune field, which is larger than observable by remote sensing data, since these features are overlaid by subsequent depositional events. The use of advanced techniques, data from new sensor systems and computational tools of geo-processing enabled the obtainment of more reliable results, closer to reality, correcting previous geomorphologic concepts from this area.

Key words: Geomorphology. Geo-processing. Pantanal wetland.

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Resumo

Geomorfologia e eventos deposicionais no pantanal da Nhecolandia

O Pantanal é uma bacia sedimentar ativa preenchida por trato deposicional de leques e planícies fluviais. O megaleque fluvial do Taquari se destaca dentre os leques existentes pelo seu tamanho de aproximadamente 50.000km². A porção sul deste megaleque é conhecida por Nhecolândia, cuja característica principal é a presença de grande quantidade de lagoas, muitas destas conhecidas por salinas, pois apresentam elevada concentração de sais o que torna seu pH próximo a 9. Este trabalho objetivou identificar por meio de geotecnologias as diferentes formas do relevo da Nhecolândia a fim de contextualizá-las com a evolução deposicional da área estudada, bem como propor uma readequação de definições geomorfológicas utilizadas até então para esta área. Produtos de sensores remotos ativos e passivos foram processados digitalmente em *softwares* de geoprocessamento, permitindo compartimentar a área em duas unidades relacionadas à declividade do terreno. Os resultados apontam que o possível campo de dunas pretérito já foi maior do que pode ser revelado pelos sensores remotos, entretanto, parte das antigas feições se encontram obliteradas por eventos deposicionais recentes. A utilização de técnicas, sensores e ferramentas computacionais modernas de geoprocessamento possibilitaram obter resultados mais confiáveis e compatíveis com a realidade, corrigindo conceitos geomorfológicos da área.

Palavras-chave: Geomorfologia. Geoprocessamento; Pantanal.

INTRODUCTION

Located within the Upper Paraguay River Basin (BAP), the Brazilian Pantanal wetland has an area of approximately 138,183 km² (38,21% of BAP). Its area extends over the SW of the Mato Grosso State (48,865km²) and NW of the Mato Grosso do Sul State (89,318km²). The Paraguay is the trunk river of the basin; it runs for 1,683km in Brazilian territory (SILVA e ABDON, 1998; ANA *et al*, 2004).

The Pantanal wetland is an extensive surface of modern alluvial sediments undergoing a continuous sedimentation process. The area is affected by annual periodic flooding caused mainly by the relatively flat surface and by the low topographic gradient, with values between 0.3 and 0.5 m/Km in the North-South direction.

The relief of Pantanal wetland is shaped by successive depositional events; it is an active sedimentary basin, formed mainly by fluvial fans, the most notable of them is the Taquari (Figure 1). The Taquari fan presents altitudes between 85 and 190m and a topographic gradient of 36cm/Km. The large dimensions of this fan, with a diameter of approximately 250 Km and an area of 50,000Km^2, allows to classify it as a mega-fan (Assine, 2003). Its limits are established by the Maracaju-Campo Grande plateau and Negro River to the East, the Paraguay River to the West, the Piquiri and Itiquira rivers to the North and the Negro River to the South.

This mega-fan is divided by the Taquari River in two regions: Paiaguás to the North and Nhecolândia to the South. According to Franco & Pinheiro (1982) and Sakamoto et al. (1996) the Nhecolândia region presents distinctive morphologic features that receive regional nomenclature such as *Baías* (fresh water ponds), *Salinas* (salty water ponds), *Cordilheiras* (elevations sometimes surrounding *Baías* and *Salinas*), *Vazantes* and *Corixos* (both fluvial channels that drain basin waters).

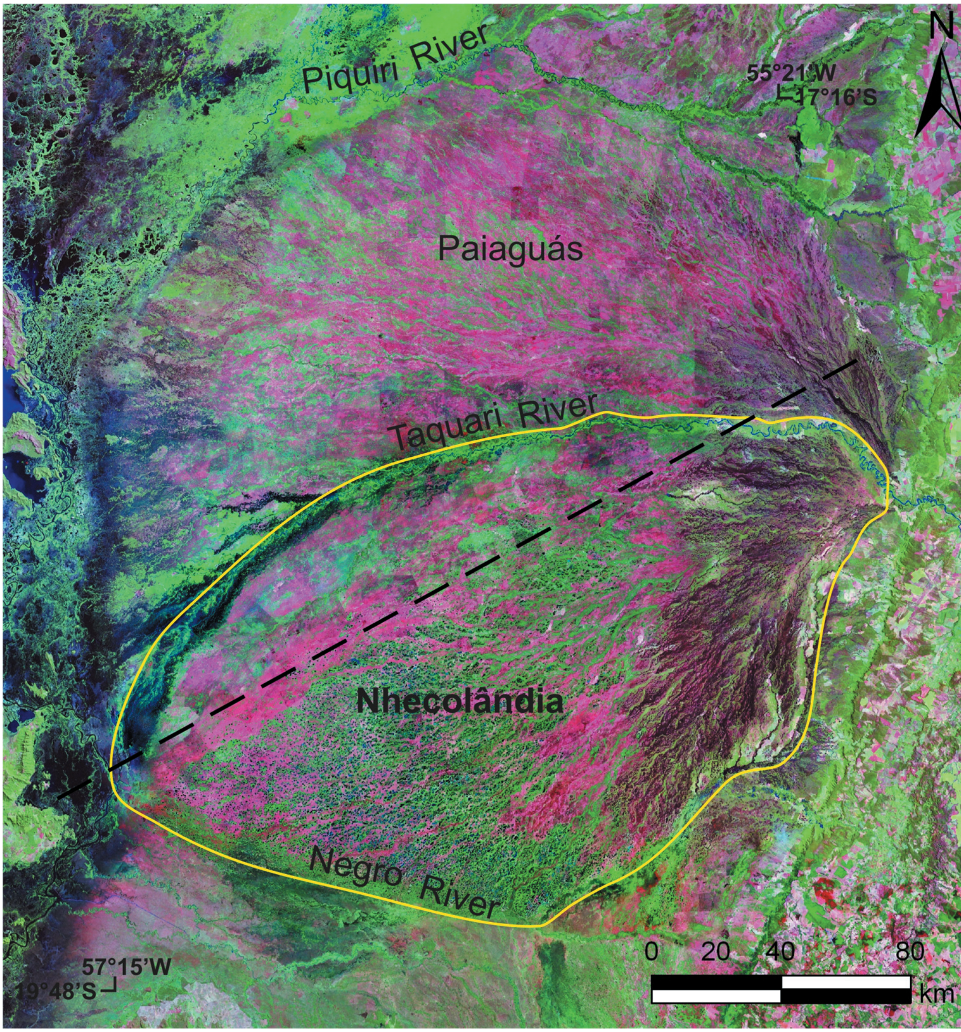


Figure 1 – Area under study. In yellow: Nhecolândia Pantanal Wetland, southern part of Taquari Mega-fan. Transbrasiliano Lineament represented by the dashed line in black. Image from Geocover/NASA, composition RGB 742, Available at https://zulu.ssc.nasa.gov/mrsid/

The origin of *Salinas* and *Cordilheiras* is still a question that has not been elucidated. One of the hypotheses suggests that these features are past records of a dune field, i.e. the ponds are old inter-dune depressions formed by a deflation process that happened probably during the Last Glacial Maximum (~20,000 BP) due to a reduction of rain levels and, as a consequence, lowering of the groundwater table (ASSINE; SOARES, 2004). The granulometric characteristics of sands also provide an evidence of this hypothesis. The sediments in distal portions are fine and better selected, forming a very distinctive group from the sediment in proximal portions, which presents a greater average diameter (SOARES et al., 2003). Structures directed to NE and drainage anomalies in Nhecolândia are related to the neo-tectonic control of the Transbrasiliano Lineament (ZANI et al., 2006).

In entire Nhecolândia, certain homogeneity features are observed, with sandy elevations (*Cordilheiras*), depressions (ponds and fluvial channels), and plains. In all Nhecolândia, elevations are denominated *Cordilheiras*, but they present differences in form, and have probably dual genesis, which allows the compartmentalization of these elements and the establishment of relationships between the different sedimentary processes.

OBJECTIVES

The aim of this paper is to identify relief forms using geo-technology and to contextualize them within the evolution of deposition at the southern portion of the Taquari fluvial mega-fan (Nhecolândia). Additionally geo-processing techniques were used to readjust the geomorphologic definitions utilized so far in the Pantanal wetland region.

MATERIALS AND METHODS

To identify relief forms and to recognize deposition events that characterize the geomorphology of Nhecolândia, a digital elevation model (DEM) developed by the Shuttle Radar and Topography Mission (SRTM) was used. The SRTM generated a global DEM, with a resolution of approximately 90 m, and it constitutes the main data source for relief analysis (SMITH; PAIN, 2009). More information about this mission and technical specifications of data are available at Van Zyl (2001).

The DEM-SRTM presents a resolution of 3 second per arch (i.e. 90 m in 0 degree latitude). This product is compatible with the 1:100,000 scale, with level "A" in the Standard of Cartographic Precision (PEC) from IBGE. Even though DEM-SRTM presents a re-sampled pixel size of 90 m, its vertical absolute precision is above 16 m (FARR et al., 2007). In surfaces with low relief amplitude and little vegetation dominance, as in the Nhecolândia Pantanal wetland, this precision may reach 5m, considering a 90% confidence interval (RODRIGUEZ et al., 2006). So features with heights above this limit (i.e. 5m) could be discriminated satisfactorily using the DEM-SRTM. The analysis of the visual product generated, together with fieldwork observations, confirms the results of the procedure adopted.

The detailed analysis of the DEM-SRTM was performed with the software Mapper 9.0 and ArcGIS 9.2. Personalized color pallets were created in order to highlight relevant morphologic features, which might show sedimentation environments representative of the Quaternary deposition dynamics.

Finally, the visual analysis of the generated products was carried out, after the compartments of interest were identified and represented in vectors. Despite the simplicity of the applied procedures, various recent studies (e.g. ROSSETTI; VALERIANO, 2007; MANTELLI et al., 2009; ZANI et al., 2009; HAYAKAWA et al., 2010) have shown the efficacy of this technique for the characterization of morphology associated to Quaternary deposition systems.

RESULTS AND DISCUSSION

Relating the declivity and irregularity of the terrain (difference between depression and elevation points), two compartments (I and II) were identified with the level curve tracing (Figure 2). Compartment I is limited to the East by altitudes above 120m, to the South by the Negro River, to the North by the Transbrasiliano Lineament (Figure 1), and to the West by the Taquari River, where ponds are predominant. Compartment II is all the remaining part of Nhecolândia. The difference among these compartments is very well delineated by the larger relief irregularity of Compartment I, evidenced by the proximity and rise of the level curve.

Another area (A) within Compartment II adjacent to Compartment I presents an irregularity that is similar to that of Compartment I, but it presents a declivity close to that of Compartment II, which indicates that this area represents a transition between both Compartments. The lower intensity of irregularities in this section is due to the fact that the number of ponds there is less than at Compartment I, whereas in Compartment II they barely exist.

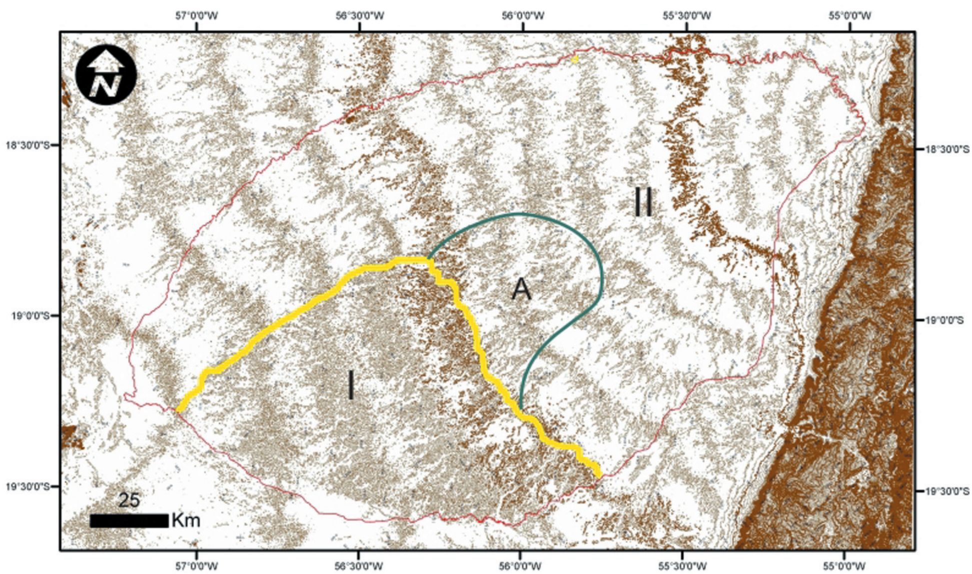


Figure 2 – Nhecolândia compartments. Limits of Nhecolândia in red, limit of compartments I and II in yellow and limits of the portion A in green. Level curve with equidistance of 8m

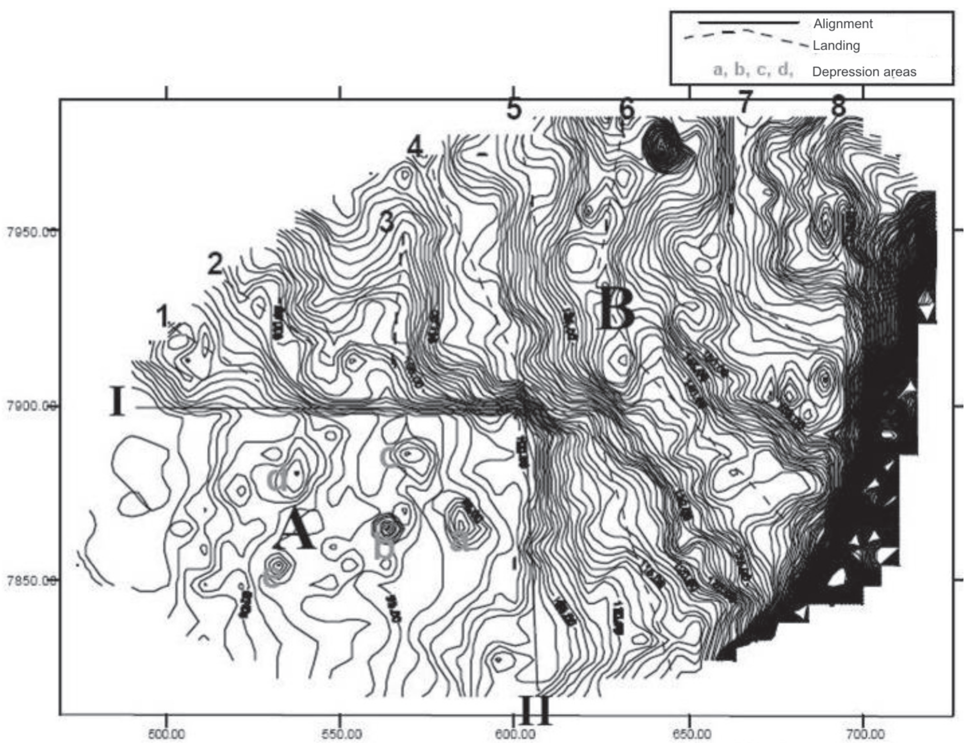
The results obtained in this study differ partially from those obtained by Fernandes (2000) who, using a digital terrain model (Figure 3) built with points recorded on topographic maps of the DSG, indentified two compartments in similar areas. This model did not highlight surface irregularities and presents the northern limit to Compartment I in another position, different from what was achieved in this study.

This occurred because accentuated irregularities cannot be obtained with data from topographic maps of DSG, which present less details, because the equidistance of the level curves is 40m. Another difference which also can be pointed out might be related to the fact that the source of the data is the height value that divides the two compartments (Table 1).

A third difference, but which is not related to the source of data, is the northern limit of Compartment I. This Compartment is related to the area controlled by the Transbrasiliano Lineament (SW-NE direction), whereas in Fernandes (2000), this limit is not related to the Lineament because it occurs in E-W direction.

Table 1 – Comparison among the results obtained by Fernandes (2000) and results from this study

Attribute	Fernandes (2000)	In this study
Altimetric value of the limit between the compartments	100m	120m
Northern limit compartment I	E-W	SW-NE
Irregularity represented in the compartment I	No	Yes



Source: SGE, 1969 (mod.)

Figure 3 – Height partition of Pantanal Nhecolândia Wetland according to Fernandes (2000)

The declivity difference among both compartments is even more remarkable with the calculation of it. In Compartment I, declivity is 0.33m/km with values which increases in S-N direction, whereas in Compartment II declivity raises to 0.56m/km in the same direction.

Using the deposition lobes identified by Zani et al. (2006) as a reference (Figure 4), the declivity for each lobe was calculated. The results show that they all are smooth up to the 120 m height, in lobe 4 it is 0.32m/km and 0.31 m/km in lobe 1. Above 120m the declivity rises in all lobes, but keeps values that are very close among themselves.

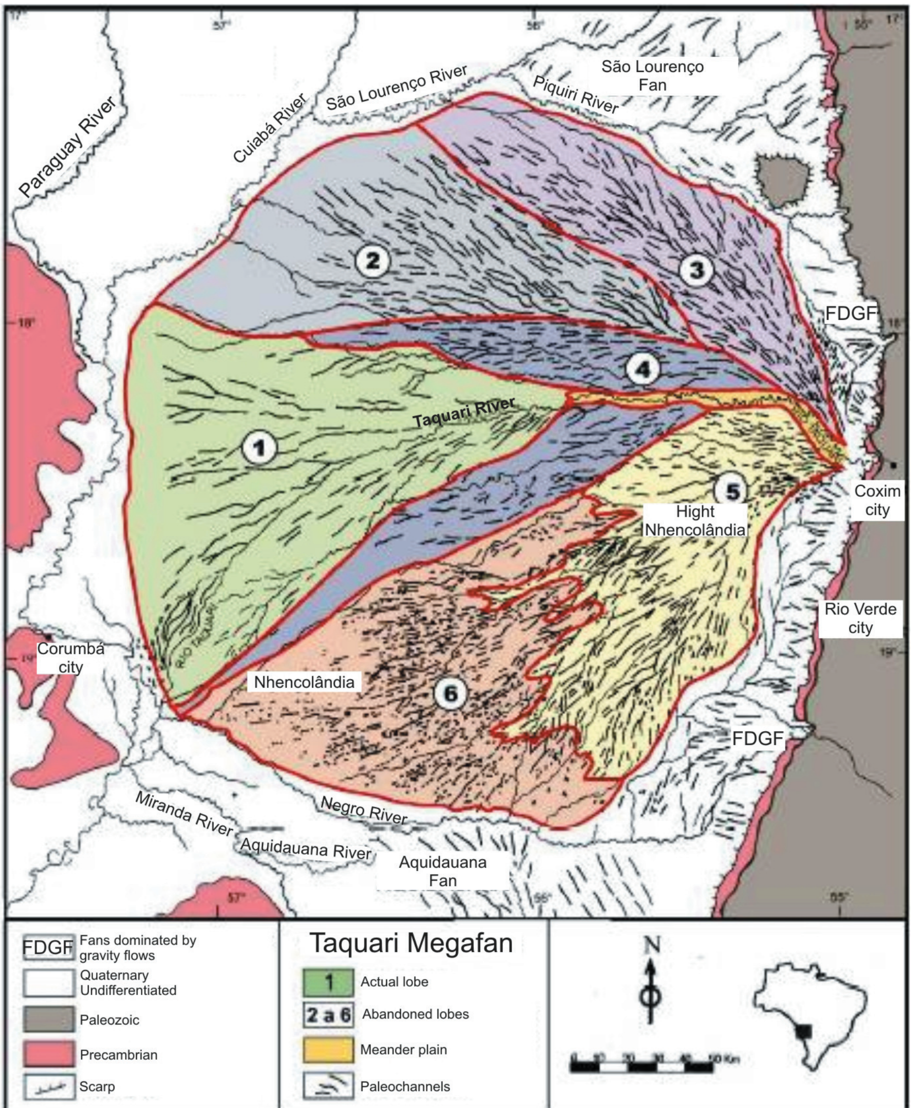


Figure 4 – Depositional lobes of the Taquari mega-fan. Zani et al. (2006)

In compartment II, there are elevated features (*Cordilheiras*) in the form of branched elongated ridges with narrow fronts turned to the natural deposition direction of the fan. These features were described by Zani et al. (2006) as distributing paleo-channels of lobe 5.

From this point on, in the distal direction, already in Compartment I, the elevation form is modified. This occurs when there is a continuity of the elongated ridges, but they become irregular, without narrowing, and present a significant increase in the number of depressions (ponds) between elevated features.

This limit between two elevation forms occurs close to the height value of 120m (Figure 5). We interpret it as the point of the system where there would be no more energy to superpose deposits over Compartment I, in this case it is deposition lobe 5 over deposition lobe 6. According to Soares et al. (2003), lobe 5 is where the preterit dune field occurs.

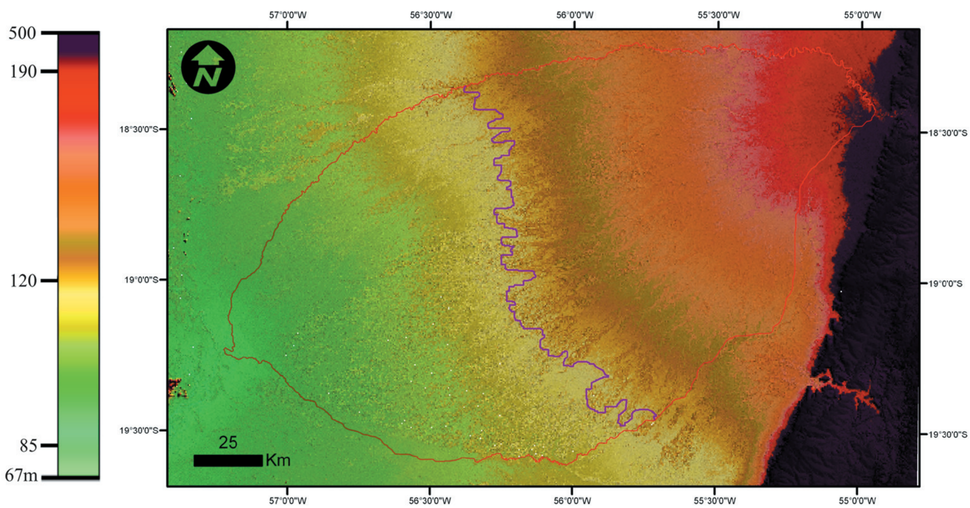


Figure 5 – Limits between eolian and fluvial features. The purple line highlights the height value of 120m

Using DEM it was evidenced that the relief is more irregular in Compartment I than in all other sections of Nhecolândia, which is consonant with the information given by Mendes et al. (2006). However, these authors assert that Compartment I is more elevated than the area influenced by the Transbrasiliano Lineament.

The abrupt difference of geomorphologic elements between these two areas is notable in satellite images, with the predominance of a vast basin in the Transbrasiliano Lineament area and an irregular surface with adjacent elevations and depressions in Compartment I, an observation made also by Mendes et al. (2006). This roughness effect caused the densification of the level curve, which probably corresponds to a more elevated area.

Assine (2003) mentions that tectonic events can alter the base level and generate accommodation spaces. Mendes et al. (2006) agrees with that and suggests that the Transbrasiliano Lineament area would be in a lower level because it suffered abasement.

As presented, the two compartments show similar levels, and the fact that the Transbrasiliano Lineament presents an extensive basin is possibly due to abasement with the appearance of an accommodation space that was later accreted, superposing the old morphology of the area, similar to that of Compartment I nowadays. The area of the Transbrasiliano Lineament is the deposition lobe 4 (Figure 4) described by Zani et al. (2006). According to the most recent chronology, this is a more recent area where the older forms were obliterated.

All this information suggests that there is a superposition of older features over younger ones, altering relict forms. Despite depositions in lobes 4 and 5, part of the old features are still preserved, similar to those at lobe 6.

CONCLUSIONS

Computational techniques utilized in geo-processing together with different types of remote sensing optical and radar data, contributed to highlight the deposition features that are presented superimposed in the mega-fan surface. Moreover they allow the revision of geomorphologic definitions of the area under study and the generation of more representative information.

With the information obtained in this study, differences in elevation form between Compartments I and II and the existence of ponds not only in Compartment I but also in Compartment II (although smaller in number) could be identified.

Based on these results, it is possible to indentify that the preterit dune field was larger than the present areas of ponds. The disappearance of the ponds in the proximal section of the fan and in the indicated Transbrasiliano Lineament area, indicate that the deposits after the wind rework were responsible for the obliteration of these features. Feature superposition is very evident in portion (A) where there is a reduction in the number of ponds, which represents a transition area between old and recent deposits.

More detailed work is needed using geochronology data to indicate formation processes and elevation ages in Compartments I and II, in order to confirm the hypothesis of a former dune field.

ACKNOWLEDGEMENTS

The authors would like to thank CNPq for the graduate scholarships granted, to FAPESP for the scholarships granted and for the financial support to this research (Process Nr. 07/55987-3), to UFMS for the logistical support during field survey, UFOPA for its support in the research project (Nr. 078/2010), and to Stella Zucchetti Schons for the translation and spelling correction.

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