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Comments on "Gravity Fault Subsidence and Beach Ridges Progradation in Quinta Cassino (RS) Coastal Plain, Brazil" by Bruno Silva da Fontoura, Adelir José Strieder, Iran Carlos Stalliviere Corrêa, Paulo Rogério Mendes, Alexandre Felipe Bruch, Angélica Cirolini. 2024 (Open Journal of Geology 14, 177-195, https://doi.org/10.4236/ojg.2024.142011)

Comentários sobre "Gravity Fault Subsidence and Beach Ridges Progradation in Quinta Cassino (RS) Coastal Plain, Brazil" by Bruno Silva da Fontoura, Adelir José Strieder, Iran Carlos Stalliviere Corrêa, Paulo Rogério Mendes, Alexandre Felipe Bruch, Angélica Cirolini. 2024 (Open Journal of Geology 14, 177-195, https://doi.org/10.4236/ojg.2024.142011)

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Abstract: The paper of Fontoura *et al.* (2024) presented results based on the interpretation of GPR records of good quality. However, after reviewing and analyzing their paper, we concluded that Fontoura *et al.* (2024) failed to show that gravity-driven large-scale faults control the mechanical subsidence and sedimentation of the prograding beach ridges in the Quinta-Cassino strandplain in southern Brazil. In this comments, the paper of Fontoura *et al.* (2024) is criticized due to: 1- the lack of presentation of appropriate data supporting the occurrence of potential recent tectonic events in the study area, 2- both a lack of criteria and wrong interpretations of GPR records, 3- disregard for the existence of direct data from 15 drill holes that could have been used to validate their solely indirect data, 4- a very poor discussion (in fact, no discussion at all) of their results with previous studies, and 5- a flawed and entirely incorrect interpretation of a wave-dominated coastal barrier as a deltaic depositional system.

Keywords: Wave-dominated barrier, Cassino barrier, GPR records interpretation.

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Resumo: O artigo de Fontoura *et al.* (2024) apresentou resultados obtidos a partir da interpretação de registros de GPR de boa qualidade. No entanto, após a apreciação e análise do artigo, concluímos que Fontoura *et al.* (2024) não conseguiram demonstrar que falhas de grande escala induzidas pela gravidade controlam a subsidência mecânica e a sedimentação das cristas de praia progradantes na planície costeira de Quinta-Cassino, no sul do Brasil. Nestes comentários, o artigo de Fontoura *et al.* (2024) é criticado devido a: 1- falta de apresentação de dados apropriados que apoiem a ocorrência de potenciais eventos tectônicos recentes na área de estudo, 2- falta de critérios e interpretações erradas dos registros GPR, 3- desconsideração da existência de dados diretos de 15 furos de perfuração que poderiam ter sido usados para validar seus dados exclusivamente indiretos, 4- discussão muito pobre (na verdade, nenhuma discussão) de seus resultados com estudos anteriores e 5- interpretação falha e totalmente incorreta de uma barreira costeira dominada por ondas como um sistema deposicional deltaico.

Palavras-chave: Barreira dominada por ondas, Barreira do Cassino, Interpretação de registros de GPR.

1. Introduction

Fontoura *et al.* (2024) presented results of an investigation of a regressive (or progradational) barrier in southern Brazil, intending to present a new model of barrier evolution during the Holocene, mainly based on tectonic control. Their results are essentially based on geophysical data collected by a Ground Penetrating Radar (GPR) system. The studied barrier corresponds to the Cassino Barrier (Dillenburg *et al.*, 2017), which was also studied earlier by Godolphin (1985), Long & Paim (1987), Clerot (2004), Dillenburg *et al.* (2009), Dillenburg *et al.* (2018), and Milana *et al.* (2016). Our motivation to present the following comments is that we utterly disagree with both the interpretation of the GPR records presented by the authors and the consideration of the Cassino Barrier as a delta.

2. Gravity tectonics

With regard to the gravitational tectonic model based on GPR data, it is very well documented that the South American Plate has experienced deformational events for the past millions of years and that the Northeastern Brazilian region is the most seismically active region Rossetti *et al.* (2011a), Gandini *et al.* (2014), Maia and Bezerra (2020), Lima *et al.* (2021), and Souza *et al.* (2022). The main evidence of such neotectonics is seismite-associated soft-sediment deformation Rossetti *et al.* (2011b); Pleistocene marine strata with incompatible heights with known marine transgressive events Gandini *et al.* (2014); and, reactivation of preexisting faults influencing topography, drainage basins, and river profiles Alves *et al.* (2019). None of this evidence was previously reported to apply to Holocene strata or to southern Brazil, which, by itself, does not mean that Fontoura *et al.* (2024) are wrong to point out that the Rio Grande do Sul State coastal plain records Holocene deformational events.

The Rio Grande do Sul State coastal plain is part of the Pelotas Basin, a passive-margin basin. These margins were formed by rifts of ancient continental lithosphere followed by margin subsidence. These basins can be divided into syn-rift and post-rift phases, where the latter is driven by thermal re-equilibration as the lithosphere cools and thickens back to equilibrium Allen and Allen (2013). The post-rift phase is marked by slow subsidence rates Sapin *et al.* (2021). Extensional faulting is restricted to minor reactivation of older normal faults in the post-rift passive margin phase Allen & Allen (2013). Growth faults may occur in zones with high sedimentation rates and continental slope and rise regions of the continental margin Allen and Allen (2013). The areas studied by Fontoura *et al.* (2024) are 6 to 1 ka barrier sediments with no overburden and are entirely unrelated to older normal faults.

Fontoura *et al.* (2024) interpreted listric normal faults in 10x vertical exaggerated GPR sections (Figure 1, A). If we consider that the authors are right in their interpretation when one analyzes the same section with no vertical exaggeration (Figure 1, B and C), what the authors point out as “the existence of listric faults controlling the beach ridges in the escarpments and hanging-wall blocks” are low angle features which may be related to GPR acquisition and processing artifacts, or are normal contacts of eolian and beach depositional surfaces, as presented by Dillenburg *et al.* (2017), and as shown by many others (Dougherty & Nichol, 2007; Angulo *et al.*, 2009; Giannini *et al.*, 2009; Mauz *et al.*, 2013; Shan *et al.*, 2015; McBride *et al.*, 2021).

Moreover, the authors conclusion: “deformational features indicate that the extensional zone of a large-scale gravity-driven structure controlled the mechanical subsidence” is not possible because the newly presented data, 10 times exaggerated GPR sections, with 200 to 800 meters length and 15 meters height, cannot be used to unravel a “large-scale gravity-driven structure” nor to relate those to a mechanical subsidence. The authors could have only presented this conclusion if they had presented a robust backstripping analysis and an exploration-scale seismic survey (Xie and Heller, 2009; Allen and Allen, 2013).

3. GPR records and interpretation

The GPR sections presented have good penetration and signal return, with adequate processing, providing excellent depth recording. However, the authors have made incorrect measurements of elevations in the GPR sections. For instance, their Figure 9 shows sections with elevations close to +15 m, but the terrain elevations where they obtained the sections vary from 3 to 5 m only (Dillenburg *et al.* 2017). Also, the elevation information presented to the right of sections A and B is wrongly referred to as depths. In their Figure 10, they changed from elevation to depth? (see that the terrain surface corresponds to zero).

It is very common to draw lines on the GPR records to direct attention to some depositional surfaces, stratigraphic boundaries, truncations, and other features when interpreting those records. However, when doing that, some reflections are masked (hidden) by these lines, not allowing the readers to evaluate if they agree with the interpretation, or even to better understand the interpretation presented. This is the reason why a scientific paper making use of GPR records must present, together with the interpreted record, a non-interpreted section and, eventually, the raw data as supplementary material. Otherwise, the reader may be conditioned by the author's biases and interpretations. This is an important error in the paper of Fontoura *et al.* (2024).

In regard to interpretations, a very significant mistake was made by the authors. Unfortunately, they demonstrated no criteria for their interpretations. GPR criteria interpretation is based on reflections terminations (onlap, downlap, toplap, and truncations), geometry, pattern, and stratigraphy stacking patterns (Mitchum *et al.*, 1977; Abreu *et al.*, 2010; Neal *et al.*, 2016; Barboza *et al.*, 2021), adapted for GPR (Neal, 2004). Unfortunately, in many of their interpretations, the authors did not take into account those criteria. For instance, when interpreting the listric faults, continuous reflections were simply cutted, as it is possible to observe in their Figure 11, to the left of the interpreted horst. To draw the line representing the listric fault that dips toward the NW, at least five continuous reflections were cut.

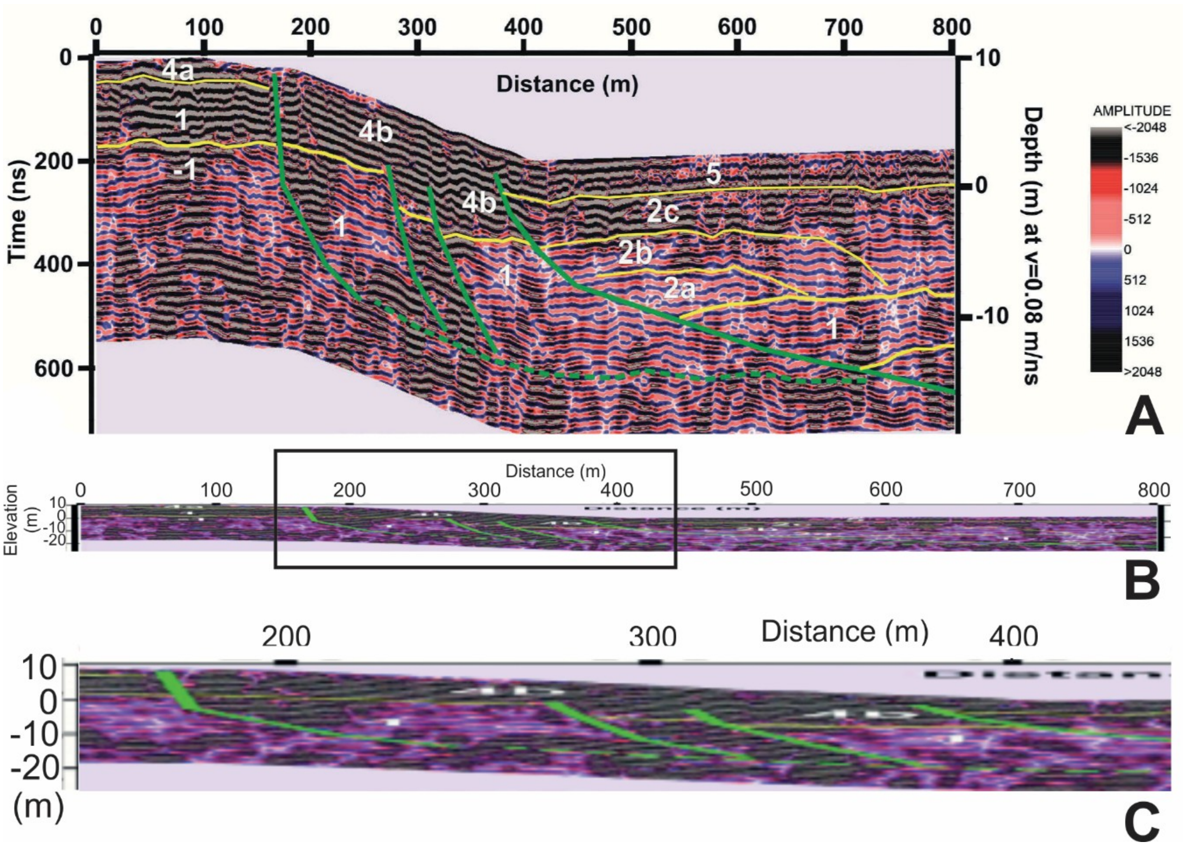

Figure 1. Original Torotama GPR section (vertical exaggeration 10x) of Fontoura et al. (2024) in A. And the same section re-scaled to a 1x vertical exaggeration in B (see a partial amplification in C). The fault surfaces interpreted by the authors (green lines) appear (in C) as very low-angle surfaces in soft sediments, not compatible with fault surfaces.

Figura 1. Seção GPR original de Torotama (exagero vertical de 10x) de Fontoura *et al.* (2024) em A. E a mesma seção, redimensionada para um exagero vertical de 1x, em B (veja uma ampliação parcial em C). As superfícies de falha interpretadas pelos autores (linhas verdes) aparecem (em C) como superfícies de ângulo muito baixo em sedimentos inconsolidados, o que é incompatível com a presença de superfícies de falha.

When obtaining indirect data, such as geophysical data, it is necessary to validate the data and their interpretations. The authors missed this opportunity because the studied barrier has 15 drill holes obtained at two transverse profiles (Dillenburg *et al.* 2017). The geological sections interpreted from those drill holes show that there are no horst-type structures of the Pleistocene substrate in the studied area, as wrongly interpreted in their Figure 11. As their paper is only based on GPR data and considering the absolute lack of acceptable criteria for the interpretation of GPR records, we come to the conclusion that the paper of Fontoura *et al.* (2024) has failed in intending to show that gravity-driven large-scale faults control mechanical subsidence and sedimentation of the prograding beach ridges in the Quinta-Cassino strandplain.

4. Discussion of results

In their discussion, the authors intended to refute previous interpretations of the development of the foredune ridge plain of the barrier (called by them a strandplain) by just saying that tectonics have controlled the development of the Cassino regressive barrier (strandplain), and that factors such as sea-level oscillations and coastal dynamics were secondary factors. They did not discuss these factors nor their scientific reasoning, they merely stated that in one and a half pages. This is not a discussion. This is not a reasonable scientific procedure or discourse. If they intended to present a new model, they must have explained, in detail, how the development of listric faults had controlled the sedimentation of the strandplain. More specifically, they must have presented a model of formation of sets of foredune ridges interspersed with phases of transgressive dunefields and transgressive sand sheets, controlled by tectonic processes. On the contrary, they did not present any words or data about that. Additionally, they disregarded the massive discussion existing in the literature about the development of foredune ridge plains coupled with phases of formation of transgressive dunefields and transgressive sand sheets (Hesp & Thom, 1990; Thom *et al.*, 1992; Barboza *et al.*, 2013; 2018; Dillenburg *et al.*, 2016; 2024; Moulton *et al.*, 2019; Hesp *et al.*, 2022).

5. The delta interpretation

The authors mentioned that the beach ridge plain of Cassino (which is a foredune ridge plain) is part of an asymmetric delta that was built as a strandplain. We do not intend to present a long text to demonstrate how wrong this interpretation or claim is. But an interrogation is necessary here: which river has discharged dominantly sandy sediments to build such a delta during the last 6-5 ka? The potential and closest rivers are the Jacuí and Camaquã. However, at least since the maximum sea level was reached at 6-5 ka, those rivers have been building deltas within the Guaíba Lake and the Patos Lagoon, respectively. This means that their coarse sediments (gravels and sands) have been deposited in the domains of the lagoon deltas as stated by Dillenburg *et al.* (2018). Many authors studying this modern coastal system stated that there is no modern contribution of coarse-grained sediments from rivers to the modern beach, at least since the drowning of the main fluvial systems by lagoonal waters during the final stages and at the climax of the Postglacial Marine Transgression (Tomazelli and Villwock, 1996; Tomazelli *et al.*, 1998; Dillenburg *et al.*, 2000; 2009). The Rio Grande channel of the Patos Lagoon operates as a lagoonal channel by which the waters of the main tributaries of the lagoonal system are discharged to the Atlantic. The system could be seen, from a morphological point of view, as a wave-dominated estuary system as described by Dalrymple *et al.* (1992), where the rivers are building bay-head deltas along the mainland margins of the Guaíba Lake and Patos Lagoon, very far from the Rio Grande channel. For clarification, Figure 1 of Fontoura *et al.* (2024) shows the location of the Rio Grande channel right between the localities of Rio Grande and São José do Norte. The figure also shows the Camaquã river discharging at the western margin of Patos lagoon, in front of Bujuru district. Towards the north (it is not shown in Figure 1), the Jacuí River mouth built a delta close to Porto Alegre.

6. Summary

The paper presented by Fontoura *et al.* (2024) shows results based on the interpretation of GPR records of good quality. However, the authors made fragile and unsupported assumptions and statements in regard to potential recent tectonic events that may have occurred in the study area. Also, their interpretations of the GPR records do not follow the classical and well-established criteria based on seismic stratigraphy and adapted to GPR. In summary, the paper of Fontoura *et al.* (2024) is criticized here due to the following problems: 1- lack of presentation of appropriate data supporting the occurrence of potential recent tectonic events in the study area, 2- both a lack of criteria and wrong interpretations of GPR records, 3- disregard for the existence of direct data from 15 drill holes that could have been used to validate their solely indirect data, 4- a very poor discussion (in fact, no discussion at all) of their results with previous studies, and 5- a flawed and entirely incorrect interpretation of a wave-dominated coastal barrier as a deltaic depositional system.

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