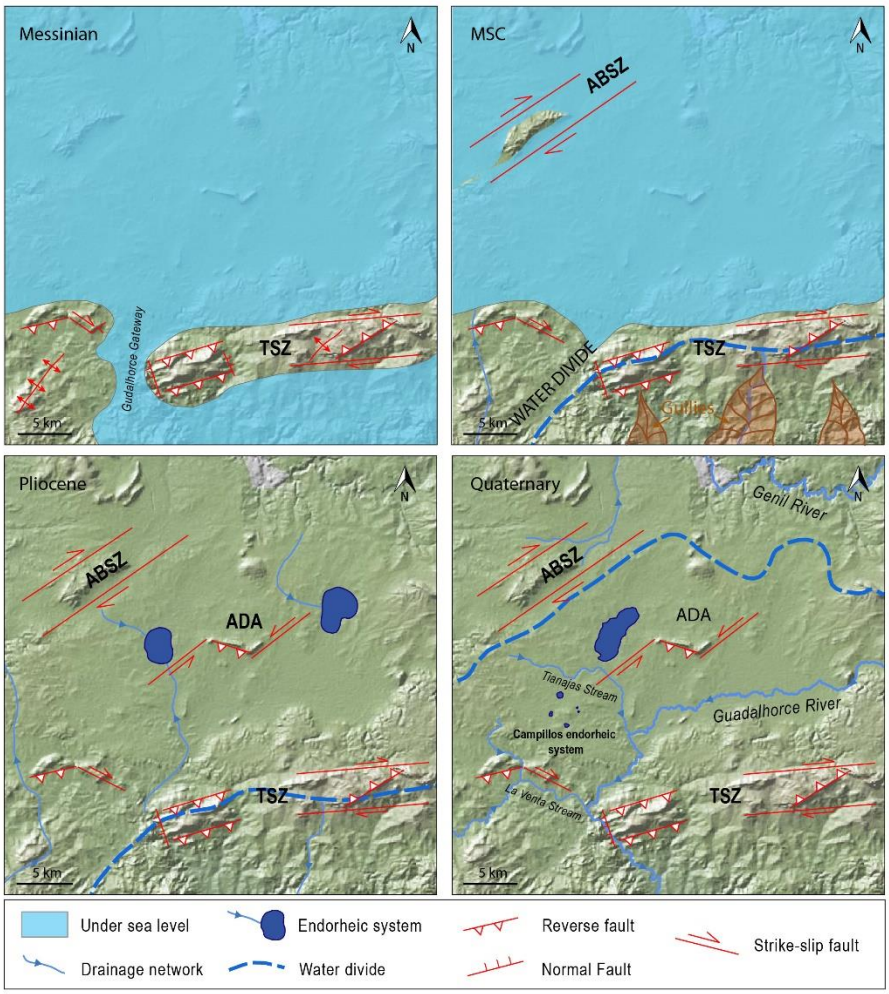
REVIEWER 1

The only comment I state here is related to the last figure. Authors show a really detailed history of the evolution and migration of the water divide, strongly influenced by the tectonic activity, yet the last figure (Figure 11) shows scarce details about it. I would challenge authors to be more creative with Figure 11 trying to propose a more detailed figure (some 3D cartoon with all 4 phases since Messinian time…), where tectonics is shown more clearly. For example, authors could show where the TSZ zone is within the bigger figure of the Atlantic-Mediterranean palaeogeography. I believe this would help readers to better see all the detailed evolution described in their Results and Discussion. Of course, this is not something that would stop the publication but I believe it could give the last missing bit to this paper.

Answer and Modification: Thank you very much for your valuable comments. We agree with the reviewer and we improved the figure. We added more information related to structures (adding some normal faults and folds) and to the Messinian Salinity Crisis. We added the effects of the sea level drop in the Mediterranean watershed during the Messinian, which probably lead to the formation of deep gullies. However, it is not possible to make a 3D model because the kinematics of structures is really complex and most of displacements would be out-of-plane.



LINE 18: How can say this. Perhaps it is something to show in the Discussion as possible scenario?

Answer and Modification: Thank you very much for this comment. We have included this hypothesis in the discussion section. Line 663: "). Nevertheless, they could be completely destroyed because of a quick NW-ward water divide movement."

LINE 82: I would change with… "In this study, we aim to explore… "

Answer and Modification: We totally agree, we changed it accordingly.

LINE 84: I would change with… "we analyse"

Modification: Changed.

LINES 122, 130, 308, 346, 511 and 683 mention small changes in the MS.

Answer and Modifications: We totally agree with these changes and we introduced them in the new MS.

LINE 518: What do you mean with "emersion"? Do you mean emersion from the sea level? Do you mean the onset of the uplift? You should rephrase it.

Answer and Modifications: This sentence is confusing; thus, we improved the sentence and we write: "emersion from the sea level". Uplift probably started before upper Miocene.

LINE 554: You need to specify units of measurements for strain rate values.

Answer and Modifications: We measured strain rate values in the Mesozoic units that crop out in the TSZ. We included it in the new MS.

LINE 562: Again, you need to explain better this word and the related meaning.

Answer and Modifications: Yes, we included the meaning: emersion from the sea level.

LINE 568: Rephrase it. I don`t understand what you mean.

Answer and Modifications: This sentence is confusing. We included: "from the rest of the Guadalquivir foreland basin".

Finally, we appreciate this reviewer for the precious time in reviewing the paper and the comments, which help to improve the manuscript.

The authors.

REVIEWER 2

In this study, the authors investigated the evolution of the Atlantic-Mediterranean water divide in the western Betics (southern Spain) following the Messinian Salinity Crisis, using hydro-geomorphic analysis and structural field data. Their results reveal that active tectonics have strongly reshaped the region, enhancing the incision power of Mediterranean streams, driving river captures, and influencing the persistence of endorheic basins within a tectonically constrained depression.

The study is well-organized, featuring a strong introduction and a comprehensive background section. The results are interesting, though they could be further enriched, and the discussion has room for improvement. Specifically, the role of karst processes in the development of endorheic basins and in the evolution of underground water circulation is not addressed. This omission could significantly influence the interpretation of results, especially in relation to the calculation of the χ index.

Answer and Modifications: We understand that the referee is suggesting that if karstification is responsible for the nucleation of playa-lakes and ponds, it

must also influence the drainage network and thus, the results derived from the application of the X metrics. However, our understanding is that classical karstification (at least in limestones) typically creates recharge systems, such as dolines. Those ecosystems are normally fresh-water bodies. However, countryside and playa-lakes in Andalusia tend to function as discharge systems. Although there are different types of playas, most of the systems could be classified as brackish-to-brine discharge water bodies (Rodríguez-Rodríguez, 2007). This distinction highlights a key difference in karstification processes in gypsum. Once the lake has formed, dissolution ceases to be effective, the basin is endorheic, and the bottom of the basin becomes a discharge playa-lake. Therefore, salts accumulate within the lake and below the lake, forming a groundwater brine below the surface of the playa-lake. A saline interphase is created in a similar way as in a coastal aquifer. The most evident case of this situation in Fuente de Piedra Playa-lake, in Málaga province (Kohfahl et al, 2008). Because of that, we discard the classical karstification process as a main process in the study area.

Kohfahl, C., Rodriguez, M., Fenk, C., Menz, C., Benavente, J., Hubberten, H., ... & Pekdeger, A. (2008). Characterising flow regime and interrelation between surface-water and ground-water in the Fuente de Piedra salt lake basin by means of stable isotopes, hydrogeochemical and hydraulic data. *Journal of Hydrology*, *351*(1-2), 170-187..

Rodríguez-Rodríguez, M. (2007). Hydrogeology of ponds, pools, and playa-lakes of southern Spain. Wetlands, 27(4), 819-830.

In conclusion, if the authors make an effort to address this aspect, the manuscript would be acceptable for publication.

TECHNICAL ISSUES

LINE 16: Capitalize "River" consistently

Answer and Modifications: Thank you very much, we homogenized in the ne MS.

LINES 35-38: The statement that drainage systems equilibrate over long timescales is debatable. Drainage system can equilibrate in a very short time. See Cook, K., Turowski, J. & Hovius, N. River gorge eradication by downstream sweep erosion. Nature Geosci 7, 682–686 (2014). https://doi.org/10.1038/ngeo2224

Answer and Modifications: Thank you very much for this comment. We actually mean that the drainage system equilibrate in short periods of time: " Afterward, drainage networks equilibrium is achieved in relatively short time, from 1000 to 100,000 yr., although the lithology, the climate or the watershed size may change this timespan

(Whipple and Tucker, 1999; Korup, 2006).". In order to make this sentence clearer, we removed "from 1000 to 100,000 yr", which may be confusing. Moreover, we added this reference.

LINES 40-41: Azañon et al. (2015) is not present in the reference list. Consider citing broader, more internationally oriented and recent examples - e.g. Moumeni, M., Delchiaro, M., Ballato, P., Della Seta, M., Nozaem, R., Clementucci, R., ... & Egli, M. (2025). Coupling of tectonics, climate, and lithology in orogenic systems: Insights from cosmogenic 10Be erosion rates and river profile inversion modeling in the Talesh Mountains, NW Iranian Plateau. Tectonics, 44(2), e2024TC008652. https://doi.org/10.1029/2024TC008652

Answer and Modifications: We totally agree with this comment, we removed Azañón et al. (2015) and we added Moumeni et al., 2025.

LINES 48-52: This is a very interesting point. Consider expanding on the implications of these findings and previous knowledge.

Answer and Modifications: We agree with the reviewer. We explain more in the new MS this issue and we added more references. We added: "These closed watersheds present a rather simple water balance, with inputs mainly from surface runoff and negligible infiltration (e.g. Rodriguez-Rodriguez et al., 2012; Jiménez-Bonilla et al., 2023)."

Jiménez-Bonilla, A., Díaz-Azpiroz, M., & Rodríguez, M. R. (2023). Tectonics may affect closed watersheds used to monitor climate change and human activity effects. *Terra Nova*, *35*(1), 58-65.

Jiménez Bonilla, A., Martegani, L., Rodríguez-Rodríguez, M., Gázquez, F., Díaz-Azpíroz, M., Martos, S., ... & Expósito, I. (2024). Late-Quaternary hydrological evolution of Fuente de Piedra playa-lake (southern Iberia) controlled by neotectonics and climate changes. *Hydrology and Earth System Sciences Discussions*, *2024*, 1-27.

LINE 64: Replace "inception" with "formation" or "initiation."

Answer and Modifications: We changed it into "water divide formation".

LINES 82-90: Reiterate the main comment - consider the role of karst in shaping endorheic basins. See for reference: Pavano, F., Tortorici, G., Romagnoli, G., & Catalano, S. (2022). Age attribution to a karst system using river long profile analysis (Hyblean Plateau, Sicily, Italy). Geomorphology, 400, 108095. https://doi.org/10.1016/j.geomorph.2021.108095

Answer and Modifications: In our study area, karstic processes are not significant in the endorheic watershed inceptions. Water balances of playa-lakes are actually conditioned by the presence of low-permeability rocks such as clays. In the study area, there are local karstic processes related to some isolated dolostones such as Mollina and Humilladero ranges. Karstic processes are not the dominant processes in the formation of these playa-lakes in the area. To make this point clearer, we have included the possibility of these processes in the introduction and we added it in the discussion.

LINE 173: Better say "aimed at estimating uplift"?

Answer and Modifications: We corrected it.

LINE 202: Correct "indices".

Answer and Modifications: Thanks. We changed it.

LINES 203-204: Better say "we analyzed the plano-altimetric characteristics of selected rivers"?

Answer and Modifications: It is better. We changed it.

LINE 211: Correct "knickpoints" without "- ". Check it in the entire manuscript.

Answer and Modifications: In order to be consistent, we removed the "-" in the new MS.

LINE 211: Did you distinguish lithological/tectonic controlled knickpoints? If yes, how? If not, why?

Answer and Modifications: We did not use knickpoints controlled by lithology. We explained better in the new MS by adding: "We discarded knickpoints due to lithological contrast by using the geological maps"

LINE 212: Why did you choose to use SL index and not ksn or mchi or slope area? I think a justification is needed here. As a possible helpful reference see the following paper:

Demoulin, A., Mather, A., & Whittaker, A. (2017). Fluvial archives, a valuable record of vertical crustal deformation. Quaternary Science Reviews, 166, 10-37. https://doi.org/10.1016/j.quascirev.2016.11.011

Answer and Modifications: It is truth that it is not well address, thus we included in the new MS: "We used this index because this normalization (Demoulin et al., 2017) allows us to obtain comparable values between different rivers and to compare with other works in the study area (e.g. Jiménez-Bonilla et al., 2015)."

LINES 215 and 218: Equations should be formatted. In "hf" should be a subscript. Use parentheses with "ln".

Answer and Modifications: We included them in the new MS.

LINE 216: How is the index normalized? State the equation SLk=...

Answer and Modifications: The mathematical development is well explained in Pérez-Peña et al., 2009. We included it in the new MS.

LINE 220: What do you do with this horizontal distance? Not clear.

Answer and Modifications: It was not clear, then we changed this sentence into: "Measurements were made each 250 m along stream profiles"

LINES 224-225: You already introduced those acronyms.

Answer and Modifications: Yes, then we removed the explanation and we used the acronyms.

LINE 225: Correct "Paleo-watershed".

Answer and Modifications: Thanks, we corrected.

LINE 228: How is it estimated? Or is it measured?

Answer and Modifications: It was estimated, we changed. We estimated because we considered W/AFS constant. We added it in the new MS.

LINE 234: Any karst role evidence?

Answer and Modifications: Karstic processes are not dominant in the area. Although the karstification of small dolostones outcrops may condition the nucleation of some playa-lakes, they do not influence the endorheic watershed configuration. To make it clearer, we added in the new MS: ". Karstic processes as local processes may control the location of the playa-lakes (the flooded areas) (e.g. Ratosa playa-lake; Rodríguez-Rodríguez et al, 2015). However, low permeability rocks such as Triassic clays crop out in most of playa-lake watersheds and conditions the presence of dendritic drainage networks."

We added also a new reference:

Rodríguez-Rodríguez, M., Martos-Rosillo, S., Pedrera, A., & Benavente-Herrera, J. (2015). Ratosa playa lake in southern Spain. Karst pan or compound sink?. *Environmental Monitoring and Assessment*, *187*, 1-15.

LINE 235: What do you mean? A constant climate from when to when? And how can you assume that? Please explain.

Answer and Modifications: Climate maintained roughly constant during the Holocene, and changes occurred during the Pleistocene would not significantly change the flooded areas as observed in Jiménez-Bonilla et al., 2024. We better explained in the new MS.

LINE 243: Chi is not an index. Indeed, index does not have a physical unit of measure while Chi is in meters. It should be named "metric". Check the entire manuscript.

Answer and Modifications: Thank you very much for the valuable comment. We changed it along all the MS.

LINE 249: "b" should be a subscript. Moreover, "l/n" should be "1/n".

Answer and Modifications: Thanks, we changed.

LINE 251: "0" should be a subscript.

Modification: Changed

LINES 258-259: It is possible to assess the divide migration if same erodibility is assumed as well as the same base level. Here it is very important to justify the eventual effect of karst on the drainage area changes.

Answer and Modifications: Thank you very much because this issue had to be explained in the MS. Karstic processes may affect the application of X and the divide migration. As we explained before, karstic processes are not dominant in the study area. When water balances are made, groundwater recharge/discharge into the water body may be discarded, then, most of the endorheic watershed is low-permeable. Moreover, clays and other low-permeability rocks crop out in the study area. To make it clearer, we have included in the new MS: "Karstic processes as local processes may control the location of some playa-lakes (the flooded areas). Once the lake has formed, dissolution ceases to be effective, the basin is endorheic, and the bottom of the basin becomes a discharge playa-lake (e.g. Fuente de Piedra playa-lake; Kohfahl et al., 2008)."

LINE 268: I do not like the results' section subdivision (I, II, III, IV). I would prefer a unique Results section in which you can distinguish 3 subsections dedicated to the main results (Structural analysis, Uplift estimates and Geomorphic analyses).

Answer and Modifications: We totally agree with the reviewer, we changed it in the new MS.

LINE 308: What does the PNOA acronym stand for?

Answer and Modifications: It means Plan Nacional de Ortografía Aérea in Spanish. We included it in the new MS.

LINE 341: Correct "hm-hectometric-scale".

Answer and Modifications: Changed.

LINE 380: Should not be moved to the methods section?

Answer: This is the simplification of the equation because of the results in the study area. Then, we should maintain this part in the results sections.

LINES 407-408: "1" should be a subscript.

Answer and Modifications: Changed.

LINE 446 and LINE 463: Consider changing "source" with "channel-head".

Answer and Modifications: Changed.

LINE 455 and LINE 461: Correct "SLk"

Answer and Modifications: Corrected.

LINE 460 and LINE 468: Correct "River"

Answer and Modifications: Corrected.

LINE 511: Choose a more appropriate term instead of "birth". Maybe "formation"?

Answer and Modifications: Formation is a more adequate term, we changed it in the new MS.

LINE 540: Correct "geomorphological" and explain what models you are talking about.

Answer and Modifications: Formation is a more adequate term, we changed it in the new MS.

LINES 544-546: Give more details.

Answer and Modifications: We included sentences to explain better this model: "Previous works measured the post-Tortonian uplift using geomorphical features related to previous sea level. ". "These models do not consider either the post-Tortonian uplift in the Atlantic watershed."

LINE 583: Consider changing "inception" with "formation"

Answer and Modifications: Thanks. We changed along the new MS.

FIGURE 1: Correct "Guadalquivir River" and "Guadalhorce River". Is the tectonic map taken from some sources? If yes, cite them.

Answer and Modifications: Thanks. We changed "River" and we included the source: Balanyá et al., 2007 and Crespo-Blanc et al.., 2016.

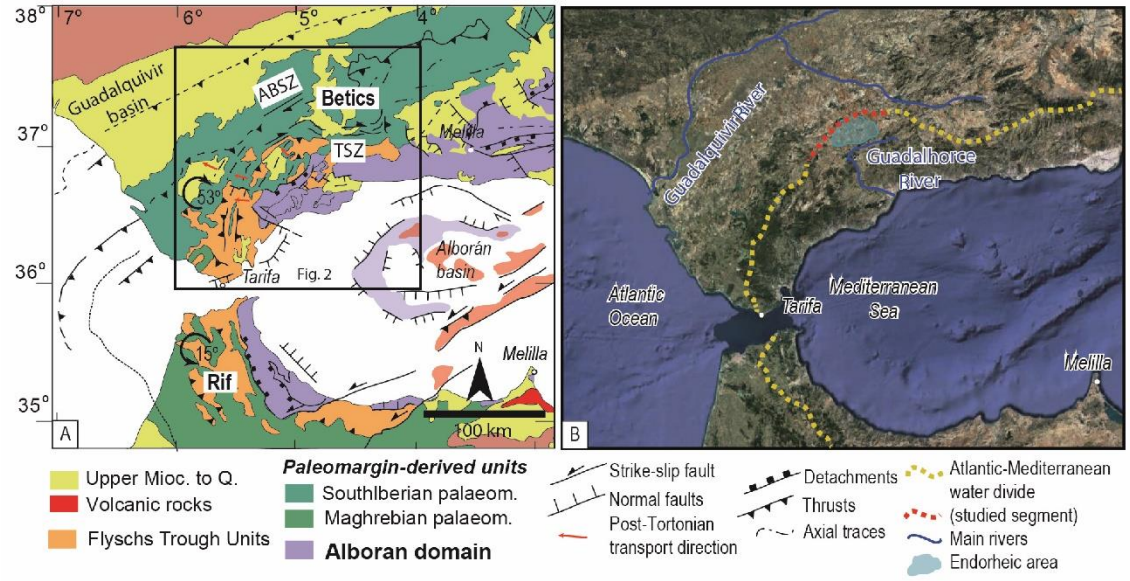


FIGURE 2: Explicit the coordinate reference system.

Answer and Modifications: They are UTM coordinates. We added them in the figure captions: "Coordinate system: WGS 84, zone 30N."

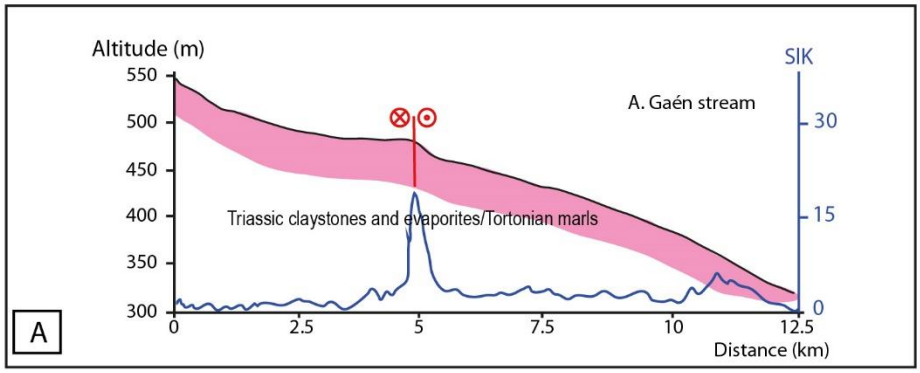
FIGURE 8: What do you mean by "modified"? Is it not a result of this study? Why show a modified figure here instead of new results?

Answer and Modifications: Sorry, they are new results, but geological and other information is extracted from other works. To be clearer, we removed "modified from" in the figure captions.

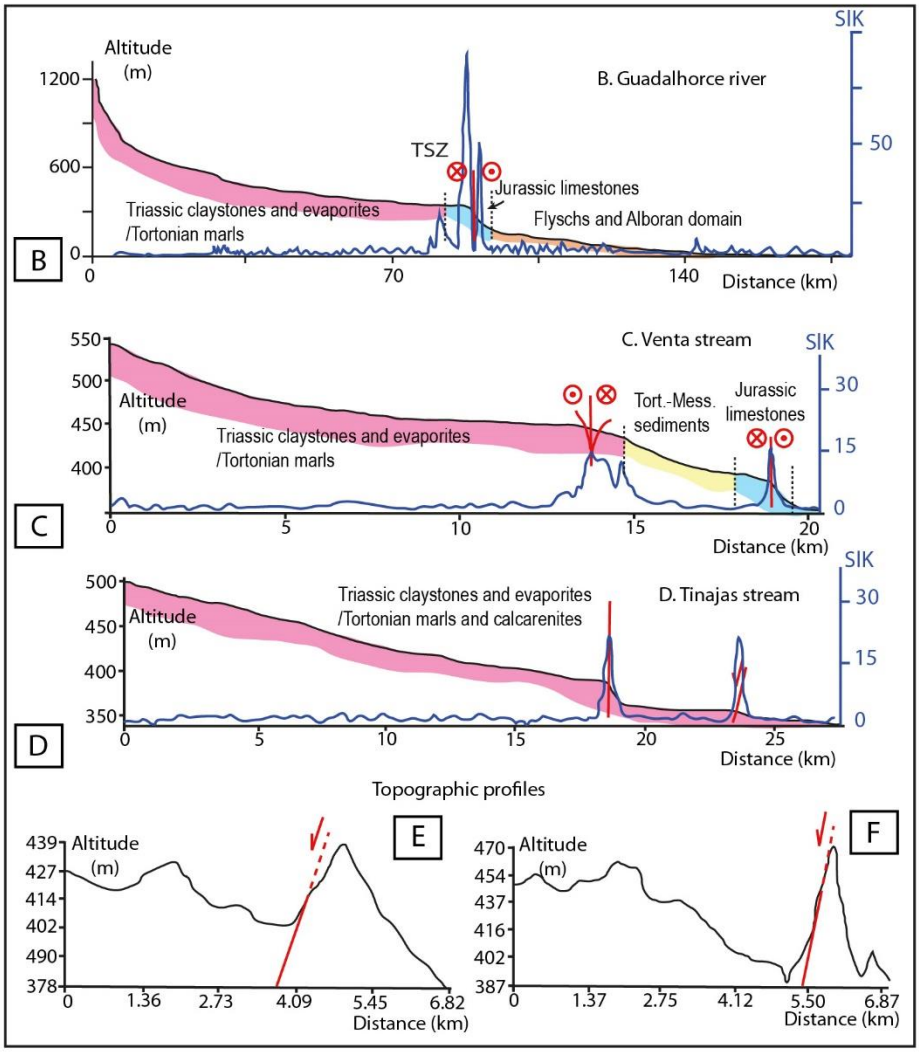
FIGURE 10: I think it would be better to implement also the lithology here so that you can easily distinguish the lithological controlled knickpoints.

Answer and Modifications: Lithologies were already included in the stream profiles. We added colours to make the figure more readable.

Atlantic watershed



Mediterranean watershed



REVIEWER 3

General comments

Dear editor, dear authors,

I have reviewed the manuscript titled "Tectonic controls on the formation and evolution of internally drained systems in the western Betics fold-and-thrust belt (S Spain)". The manuscript contains interesting data and interpretations of the Western Betic Cordillera in Andalucia, southern Spain. In my younger years I lived in Andalucia for half a year and am therefore reasonably familiar with its geology. My main impression after going through the manuscript is that the presented data and interpretations are reasonably solid and the paper is generally logically structured. I do not see any major scientific flaws in the methods and results. On the downside, the focus of the paper is clearly on the large-scale tectonic part. The authors, however, make a weak attempt to link this to the formation of the playa-lakes, thereby making the paper much less focused and disperse in its objectives. The paper could be streamlined a lot by reducing the importance of the playa-lake part and focusing on the much stronger tectonic part. In my opinion, the work can currently be considered of fair scientific quality and can become of good scientific quality once it has been refocused.

Regarding its scientific contribution: it is not entirely clear to me what the main objectives are. The authors place a heavy emphasis on the tectonic structures controlling the area and their deformation rates, but they also present river capture data related to Atlantic and Mediterranean sides, and at the beginning of the Discussion they state that the understanding of the playa lakes is the main objective, after which the authors delve deep into the closure of the various Mediterranean-Atlantic gateways. So, throughout the manuscript, the authors swing from one apparently important objective to another without sufficient focus. Not all these elements are satisfactorily tied together at the end of the paper, and their individual contribution to the overall scientific debate is not always clearly explored, making it difficult to estimate the quality of the manuscript's scientific contribution. The inclusion of paleolake levels especially, and a weak attempt to explain their Holocene evolution in relation to 20 Ma-present tectonics, makes the paper much less focused and messier than it should be. The playa lakes are basically sag ponds and it is common knowledge among structural geologists that sag ponds form in strike-slip shear zones. So, there is no need to overly complicate things by including a detailed investigation of paleo water levels. Instead, the authors should focus the paper on the tectonic aspects, as the bulk of their data is dealing with this. So, to me the scientific contribution at the moment is fair, and could become good once the connections between the results are better presented.

Answer and Modifications: Thanks for the valuable comments and the deep review. We know that the paper was not clear enough, thus we have tried to make it clearer. To do that, we have made significant changes:

- We have rewritten the abstract, making clearer the main points of the paper.
- The evolution of the zone (the closure of the Atlantic-Mediterranean corridor, the water divide, the streams, the playa-lakes…) is highly influenced by tectonics and in this paper we investigate the tectonic control on the evolution of this area. We make it clearer in the paper adding some changes. We also rewrote the objectives of this study.See the following comments.
- We know that there are different temporal levels and they were not well linked. We introduced some changes in the new MS. From 15 My, tectonics played a crucial role on the mountain chain building. After that, at ca. 5 My, geomorphic processes together with the tectonic activity of shear zones controlled the Atlantic-Mediterranean closure and the MSC. Finally, during the last 50 Ky geomorphic processes dominated with the evolution of playa-lakes and water divide movements.
- Playa-lakes is a term, which has been used by geomorphologist. Most playa-lakes in the study area are sag ponds, but not all of them. We actually used the playa-lakes that are highly influenced by active tectonics in this area. Other playa-lakes such as Amarga lake (to the NE) is controlled by karstic processes. We have included the term "sag ponds" when it is possible in both the introduction and the discussion.

To sum up, we have made all changes suggested in "Specific comments" and and "Thecnical corrections" in addition to others to make the paper more readable and clearer.

The paper needs improvements in terms of legibility. Not all methods are equally well explained and especially in the results section, page upon page of detailed, map-based descriptions are presented that are difficult to understand without continuously going back to one or two figures. There are also results that need extra figures in order to be understandable. There is an abundance of abbreviations used for all the geographic locations. It is impossible to remember all these abbreviations without making a list and keeping track of any new ones being introduced. It would be much better to write out the names of the geographic locations instead of abbreviating them. The usage of English is also inconsistent. Some sections are better written than others, seemingly dependent on which co-author has written what. I would strongly urge the authors to have the manuscript checked by a native English speaker. The presentation is therefore, of fair quality and could become of good quality after improvements are made.

Answer and Modifications: It is truth that the paper could be much improved. In order to make the paper more readable, we have removed some of the abbreviations and we added complete name in figures and/or figure captions. We added more information to figures (such as geology in Fig. 10, Fig. 2…). We also homogenized and revised the MS.

Overall, the paper merits being published, after improvements upon the text. Therefore, I recommend a major revision.

Specific comments

Abstract:

In the Results and Discussion there is a heavy focus on tectonic structural data and the calculation of deformation rates. Strangely enough this is not mentioned in the Abstract. Please mention this in the abstract as well.

Answer and Modifications: Thank you for this suggestion because the abstract was not compensated with the results and discussion of this MS. We rewrote the abstract by adding the structural results. We also added the calculation of uplift rates associated with the studied shear zones:

"Active mountain chains host internally drained systems that can be developed in a great variety of tectonic settings including contractional, extensional and strike-slip dominated cases. The aim of this work is twofold: first, to analyse the tectonic framework linked to the inception and later development (15 My and onwards) of endorheic systems enclosed in a depressed area located within the Western Betics fold-and-thrust belt (the Antequera Depressed Area; ADA); second, to give a close look on the hidro-geomorphic dynamics and structural controls of the current drainage system and its relation with the recent changes in the Atlantic-Mediterraneran water divide.

Results from detailed field-based analyses of post-Serravallian deformation structures show that ADA endorheic zone was born during the Upper Miocene by the progressive emersion of a relative depressed zone bounded to the North and to the South by two morphostructural highs. These correspond to two regional-scale transpressive shear zones, Upper Miocene to Recent in age, that cut across the fold-and-thrust belt. Although the Atlantic-Mediterranean water divide probably moved NW-ward during the last 5 My, endorheic basins endured, hosted between the two active transpressive zones. We calculated the uplift rates associated with these shear zones from upper Miocene.

The analysis of current stream profiles and the application of SLk index and χ metrics show that Mediterranean streams present a higher incision capacity than Atlantic streams. Moreover, several river captures of Atlantic river watersheds and endorheic basins have been described and quantified, revealing that active tectonics, mostly strike-slip dominated, have reshaped the area more intensively than previously considered*."*

The authors start the abstract stating that they want "*to investigate the Atlantic-Mediterranean water divide evolution after the Messinian Salinity Crisis (last 5 My)*". But they do not explain why, nor what the current state of knowledge is, regarding this process.

Answer and Modifications: The study of the Atlantic-Mediterranean water divide is interesting to delve into the evolution of the Betics during the last 5 My. Previous

studies associated the water divide evolution with isostatic processes, instead of active structures. In this work, we point out the importance of structures on the Atlantic-Mediterranean closure and the water divide evolution. These structures are responsible for the ADA inception and the formation of endorheic basins in the current Atlantic-Mediterranean water divide. To make it clearer, we have rewritten the abstract, and especially these two parts:

"... to give a close look on the hidro-geomorphic dynamics and structural controls of the current drainage system and its relation with the recent changes in the Atlantic-Mediterraneran water divide." And "Although the Atlantic-Mediterranean water divide probably moved NW-ward during the last 5 My, endorheic basins endured, hosted between the two active transpressive zones."

It is also not clear why they place such heavy emphasis on the tectonic evolution since 20 Ma, whereas the MSC occurred during the Pliocene.

Answer and Modifications: The tectonic evolution since 15 My (Serravallian) is interesting to observe the Betics fold-and-thrust belt formation and the Atlantic-Mediterranean gateway closure and the MSC. This is the context to understand the ADA location and inception. We have explained it better in the new abstract:

"Active mountain chains host internally drained systems that can be developed in a great variety of tectonic settings including contractional, extensional and strike-slip dominated cases. The aim of this work is twofold: first, to analyse the tectonic framework linked to the inception and later development (15 My and onwards) of endorheic systems enclosed in a depressed area located within the Western Betics fold-and-thrust belt (the Antequera Depressed Area; ADA)…"

l.16. Here endorheic basins are mentioned, but it is not clear what their relation to river capture is.

Answer and Modifications: Endorheic basins are areas where the runoff does not flow towards a sea/ocean. Runoff is accumulated in the low-lying areas of the basin, giving rise wetlands such as playa-lakes. Consequently, if a stream reaches one of these endorheic basins because of headwater erosion, all this area/or part of it will be drained towards the sea/ocean, disappearing the associated wetland. The presence of endorheic basins in a main water divide is striking and their capture or preservation are may be used to investigate active tectonics processes. We have changed the MS according to this.

"…The analysis of current stream profiles and the application of SLk index and χ metrics show that Mediterranean streams present a higher incision capacity than Atlantic streams. Moreover, several river captures of Atlantic river watersheds and endorheic basins have been described and quantified, revealing that active tectonics, mostly strike-slip dominated, have reshaped the area more intensively than previously considered."

l.16. Further in the text, the endorheic basins are referred to as "playa-lakes". This is confusing.

Answer and modifications: We acknowledge the referee comments about the inclusion of the term “sag pond” in the revised version of this MS. Anyhow, while the depressions described in this study could structurally be classified as “sag ponds”, given their tectonic origin along fault zones (e.g. Fuente Piedra, being the most representative lake originated by tectonic processes, among other geological factors) they also function hydrologically and geomorphologically as playa lakes. It is important to note that not all playa lakes are associated with tectonic subsidence; some originate from karstic (e.g. Archidona endorheic system in Málaga) or other processes in arid environments. Therefore, we propose to clarify this duality early in the manuscript, acknowledging that certain features may be referred to as sag ponds when their structural genesis is relevant, while retaining the term playa lake where hydrological behavior is the focus. Accordingly, we will revise the terminology throughout the manuscript to reflect this distinction more accurately. On the other hand, as a research group, we have consistently employed the term playa lake over many years in our hydrological studies of endorheic basins and ephemeral water bodies in arid and semi-arid environments. This terminology is well-established within hydrological scientists worldwide and reflects the hydrological and sedimentary dynamics of these features, regardless of their structural origin. While we acknowledge that the depressions analyzed in this study may also be classified as sag ponds due to their tectonic context, which is in fact the scope of this paper, our long-standing use of playa lake is grounded in its descriptive relevance to the geomorphological processes observed. The integration of both terms in this manuscript aims to enhance terminological precision while maintaining continuity with previous research.

To make it clearer, we have included in the introduction of the MS: “In this study, we recognize a terminological and conceptual duality regarding the depressions analyzed. From a structural standpoint, several of these features can be classified as sag ponds, as they are genetically linked to fault-related subsidence. However, their hydrological behavior and geomorphological characteristics also align with the definition of playa lakes, which are typically ephemeral water bodies in arid or semi-arid regions. It is important to emphasize that not all playa lakes originate from tectonic processes; many are formed through other mechanisms unrelated to faulting (e.g., karstic processes or diapiric phenomena). To address this distinction, we adopt a dual terminology: we refer to these features as sag ponds when discussing their tectonic origin, and as playa lakes when focusing on their hydrological and geomorphological dynamics. This clarification will guide the revised use of terminology throughout the manuscript.”

l.19-22. Here, for the first-time tectonic control is mentioned. Since tectonics are described in the first paragraph of the Methods and also Results, the abstract should also start with an explanation of the tectonic part.

Answer and Modifications: Thank you very much again for this comment. The abstract was not compensated with the new MS. As mentioned above, we have rewritten all the abstract.

Introduction:

l.36. here They state that drainage networks may reach equilibrium in 1 to 100 ka. But this contradicts the author´s own Results and Discussion as they use river profile disequilibrium to infer tectonic activity over timescales of 20 Ma.

Answer and Modifications: We do not use the drainage networks evolution to study the tectonic activity during the last 20 My. We use the presence of knick points, χ metrics and Slk, but also the endorheic basins evolution to investigate the recent tectonic activity (during the Pleistocene-Holocene). We have removed this time scale range (reach equilibrium in 1 to 100 Ka) because it was confusing. We have also included that we used them to study the recent tectonic evolution of this area:

"It is for this reason that both qualitative and quantitative analysis of drainage systems have often been used for the characterization of active tectonics (e.g. Pérez-Peña et al., 2010; Moumeni et al., 2025). Nevertheless, endorheic basins have been rarely analysed for such purpose,…"

l.49-52. This is too specific for the Introduction and the placement of a statement related to ecology is also really weird as the Introduction treats tectonic-related themes here. I therefore suggest to delete these phrases.

Answer and Modifications: We completely agree with the reviewer, then we removed it in the new MS.

l.52. Tectonics, but also changes in subterranean water flow and changes in evaporation due to seasonal or climate change.

Answer and Modifications: It is truth, thanks. These sentences were removed in the new version of the MS.

l.56. What exactly are "internal zones" in the context of tectonics? The authors place them in the same list as fold and thrust belts and foreland basins. Internal zones, however, is not a tectonic designation. Please use another word, such as tectonic basin, syncline, etc.

Answer and Modifications: This area has been defined as "the internal zones" of the Betics orogen for a long time (e.g. Bekker et al., 1989; Lonergan, 1993; Booth-Rea et al,. 2005). The internal zones of an orogen are composed of highly deformed and metamorphic rocks due to intense compressional events. This is what we mean when we call the "internal zones" in this paper: a tectonomethamorphic complex deformed during the Betics formation. The internal zones in the Betics coincide with the Alborán domain. In the new MS, this sentence was removed and in the rest of the paper (figures also), we call this complex as Alborán domain. Moreover, we included in the introduction: "*the Alboran domain* ***(inner orogenic core)***"

Bakker, H. E., Jong, K. D., Helmers, H., & Biermann, C. (1989). The geodynamic evolution of the Internal Zone of the Betic Cordilleras (south-east Spain): A model based on structural analysis and geothermobarometry. *Journal of metamorphic Geology*, *7*(3), 359-381.

Lonergan, L. (1993). Timing and kinematics of deformation in the Malaguide Complex, Internal Zone of the Betic Cordillera, southeast Spain. *Tectonics*, *12*(2), 460-476.

Booth-Rea, G., Azañón, J. M., Martínez-Martínez, J. M., Vidal, O., & García-Dueñas, V. (2005). Contrasting structural and P-T evolution of tectonic units in the southeastern Betics: Key for understanding the exhumation of the Alboran Domain HP/LT crustal rocks (western Mediterranean). *Tectonics*, *24*(2).

l.62-61. The existence of playa-lakes in this topographic depression is in my opinion related to tectonics. After having read the Results presented by these authors, I am under the impression that this topographic depression is situated in a strike-slip shear zone and that the playa-lakes are actually tectonic sag ponds due to localised Riedel shears. If the authors agree with these inferences, they could already mention this hypothesis here. It would immediately make the connection between the playa-lakes and the tectonic context a lot more obvious to the reader, thereby improving upon the readability of the paper.

Answer and Modifications: The existence of the studied playa-lakes in this topographic depression is probably related to tectonics, but it is a discussion matter. The inception of some of these playa-lakes may be also linked to karstic processes (e.g. Valero-Garcés et al., 2000; Rodríguez-Rodríguez et al., 2015). To make it clearer, we have added this in the new MS: *"These endorheic basins frequently host playa-lakes and ponds (e.g. Rodríguez-Rodríguez, 2007; Rodríguez-Rodríguez et al., 2016). Because of their location near the source of highly energetic Mediterranean rivers, their existence is often ephemeral (ca. 1000 yrs.; Rodríguez-Rodríguez et al., 2016). In this study, we recognize a terminological and conceptual duality regarding the depressions analyzed. From a structural standpoint, several of these features can be classified as sag ponds, as they are genetically linked to fault-related subsidence. However, their hydrological behavior and geomorphological characteristics also align with the definition of playa lakes, which are typically ephemeral water bodies in arid or semi-arid regions. It is important to emphasize that not all playa lakes originate from tectonic processes; many are formed through other mechanisms unrelated to faulting (e.g., karstic processes or diapiric phenomena). To address this distinction, we adopt a dual terminology: we refer to these features as sag ponds when discussing their tectonic origin, and as playa lakes when focusing on their hydrological and geomorphological dynamics. ".*

Valero-GarcÉs, B. L., Delgado-Huertas, A., Navas, A., MachÍn, J., GonzÁlez-SampÉriz, P., & Kelts, K. (2000). Quaternary palaeohydrological evolution of a playa lake: Salada Mediana, central Ebro Basin, Spain. *Sedimentology*, *47*(6), 1135-1156.

Rodríguez-Rodríguez, M., Martos-Rosillo, S., Pedrera, A., & Benavente-Herrera, J. (2015). Ratosa playa lake in southern Spain. Karst pan or compound sink?. *Environmental Monitoring and Assessment*, *187*(4), 175.

l.63. Here the authors seemingly contradict themselves again. They state that the playa-lakes are short-lived features, yet in the Results/Discussion they talk about playa-lakes that have aged as old as the early Pleistocene. Also, how can you infer long-term tectonics based on such short-lived features?

Answer and Modifications: Thank you for this comment, the use and age of these wetlands were quite confusing. Playa-lakes as seasonal wetlands located within endorheic basins are short-lived features. The oldest one is the Fuente de Piedra (ca. 30 Ky). Playa-lakes are located in endorheic basins, but climate conditions their hydroperiod, which permits to defined them as playa-lakes. However, endorheic basins may host permanent water bodies such as lakes during the Pliocene. Some lacustrine deposits crop out to the east of the ADA. We have included some corrections in the MS to make it clearer.

- We do not have the certainty of the presence of playa-lakes during the early Pleistocene, thus we removed "early" in this sentence. Fuente de Piedra is, at least, 30Ky (Höbig et al., 2016), thus Pleistocene is correct.
- We explained better the formation of endorheic basins during the Pliocene (comments in the following sections): To the E of the ADA, there are some Pliocene lacustrine deposits, probably related to permanent water bodies (Medina, 1991; Vera, 2004).
- We also changed the paragraph related to the playa-lakes inception and evolution in the discussion section: "Playa-lakes stricto sensu **(seasonal water bodies)**, probably developed during **the Pleistocene** probably because of the aridification of climatic conditions. Due to their ephemerous lifespan, they probably disappeared or/and were reshaped and their sediments probably eroded. The earliest age obtained for current playa-lakes associated with endorheic basins is of 30 ky in the Fuente de Piedra playa-lake (Late Pleistocene; Höbig et al., 2016). Previous works have pointed out that since endorheic systems were formed, they were strongly conditioned by climatic changes and human modifications because of their weak equilibrium between water inputs and outputs (Rodríguez-Rodríguez et al., 2007; 2012). As we observed, the large number of playa-lakes preserved in the ADA because of the most recent uplifts caused by both the TSZ and ABSZ and their respective tip zones, which shaped a roughly triangular closed zone that contains all the studied cases (see sections 4 and 5; Fig. 2) and act as relief barriers that prevent erosion from the Atlantic and Mediterranean streams (Fig. 2). **Consequently, these playa-lakes may be also considered as sag ponds controlled by active tectonics.** Additionally, active tectonics in this sector may also influence the shrinkage or disappearance of some endorheic watersheds hosting playa-lakes because of the reduction of the overall water input due to stream captures (Figs. 3, 9 and Table 2; Jiménez-Bonilla et al., 2023)."

l.65. Is the Guadalhorce gateway somehow related to "El Chorro"? Please clarify.

Answer and Modifications: The Guadalhorce gateway was the corridor that connected the Atlantic Ocean with the Mediterranean Sea during the upper Miocene. At this time, El Chorro formed in this gateway. El Chorro outcrop is made up of upper Miocene calcarenites located in the Guadalhorce gateway. To make it clearer, we included this in the MS:

*"During this age, shallow marine sediments deposited in this area, which are currently uplifted more than 600 m. a.s.l. (**El Chorro outcrop**; Martín et al., 2001)."*

l.67-70. The authors do not explain why the gateway closure was related to the MSC, nor do they mention any literature references of who has said this.

Answer and Modifications: The Guadalhorce gateway closure provoked the isolation of the Mediterranean sea. This together with the negative water balance of this sea (water inputs from rivers are less than water outputs due to evaporation) caused the MSC. We explained it better including the negative water balance of this sea:

". This, together with arid conditions that provoked a negative water balance of this water body caused the subsequent Messinian Salinity Crisis (MSC) responsible for the significant drop of the Mediterranean Sea level."

l.70. Not only tectonics, but also an arid climate contributed to increased evaporation and lowering of the Mediterranean Sea level.

Answer and Modifications: It is truth and we have included it in the new MS:

". This, together with arid conditions that provoked a negative water balance of this water body caused the subsequent Messinian Salinity Crisis (MSC) responsible for the significant drop of the Mediterranean Sea level."

l.73-75. Here, the authors appear to give the reason why they performed a tectonic structural analysis in the study area. It would be better to place this information at the beginning of the Introduction and also introduce it in the Abstract as a reason for this writing of this paper. This appears to be one of the main reasons for the paper, so it should have a prominent position in the Abstract/Introduction.

Answer and Modifications: Thanks for this comment. It was actually one of the reasons (but not the only one) to write this paper. Because of that, and to make the paper clearer, we have introduced some changes in the abstract: e.g:

Calculated uplift rates are congruent with the tectonic activity of these shear zones.

And in the introduction, we placed the information related to isostasy before the playa-lakes information.

l.82. The objective should go in the same order as the Methods/Results, starting with the tectonic bit.

Answer and Modifications: The objectives were not well written, then we changed them:

"In this study, we aim to explore the nature of the main tectonic factors that control the formation and later evolution of a topographic depressionlocated in the western Betics fold-and-thrust belt (the Antequera Depressed Area; ADA) which nowadays host one of the main playa-lake systems of the Betic Cordillera. This objective is adressed in two time scales. Firstly,we study theinception of the former o ADA, associated with the Betics emersion and the Atlantic-Mediterranean water divide migration during the upper Miocene-Pliocene. To do that, we collected structural data associated with post-Serravallian structures and we made uplift estimations from the upper Miocene. Secondly we analyseit's the last stage of the ADA evolution, characterized by the development of endorheic systems during the Pleistocene-Holocene. For this end we explored the hydro-geomorphic dynamics and structural controls of the current drainage system both endorheic (playa-lakes) and exoreic."

l.89-90. By stating this at the end of the objectives, the authors suggest that this is the most important aim of the paper. At the same time, no mention of this was made in the Abstract, generating confusion to the reader. I hope that my above comments have shown that the objectives are not properly explained and confusing to the reader.

Answer and Modifications: We completely agree with the reviewer, we considered all comments and we have rewritten the objectives, as we explained in the comment before. We also changed the abstract, as above mentioned.

Main geological and geomorphological features of the study area

l.95. Paleomargins is unclear. Paleomargins of which age and of which inherited tectonic context? Break-up of Pangea, or more recent?

Answer and Modifications: South Iberian and Maghrebian paleomargins are commonly used in the literature. We think that these terms could be a bit confusing for outsiders. To make this sentence more readable, we included:

"These passive conjugate margins formed after the Pangea breakup (Vera, 2004)"

l.96. Please indicate the age and depositional setting (shallow marine?) of the Flysch deposits. Explain what "trough" means in this context.

Answer and Modifications: Flyschs trough units were deposited on an attenuated continental lithosphere or oceanic crust. They are turbiditic sequences deposited in a deep marine environment. To make it clearer, we included:

"Flysch trough units correspond to the detached cover (Cretaceous to Lower Miocene) of a deep trough partially developed on oceanic lithosphere (Durand-Delga et al., 2000)."

l.97. When where the Betics and back-arc basin formed? Late Miocene?

Answer and Modifications: The back-arc basin is the Alborán basin (Fig. 1A) and it developed during the Miocene. We have included this in the new MS:

At the concave side of the arc, a marine back-arc basin developed during the Miocene (Comas et al., 1999; See Alborán basin in Fig. 1A).

l.113. When looking at Fig. 1a, the name of the Western Gibraltar Arc goes from Marocco to Andalucia and passes through the Atlantic. To me, this seems to suggest that the part of the Arc in the Atlantic was eroded. If this is the case, this should be mentioned here to avoid further confusion.

Answer and Modifications: The Western Gibraltar Arc is composed of both branches: the Betics, In Andalusia, and the Rif, in Morocco, as explained in the geological setting. This arc is currently active and some structures related to its fold-and-thrust belt are below the sea level. To avoid confusion, we have deleted the "western Gibraltar arc" in the figure, as suggested

also by other reviewers. We maintained some of the thrusts that draw the arc and link the Rif with the Betics chains.

Fig. 2. This figure needs the inclusion of a proper geological map with stratigraphic formations and structural features. The authors make the strange decision to show a geological cross section, but not the geological map. Later on in the text, the authors also present new geological and structural mapping. Without the inclusion of a proper geological map in Fig. 2, it is impossible to compare the already existing geological data with this new data.

Answer and Modifications: Thank you very much for this comment. We realized that we need a geological map at the same scale as Fig. 2a. We included it on the new version of the MS. We have also added a simplified stratigraphic column of the Subbetic. We cannot include thicknesses because they vary a lot along the Betics chain.

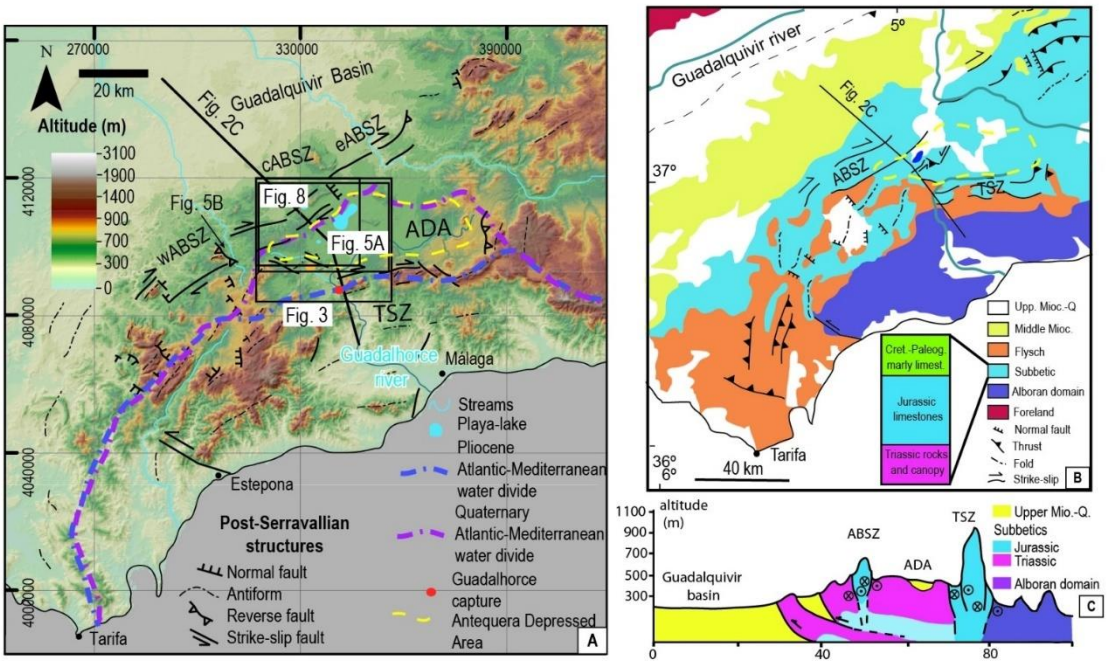


Fig. 2 indicate names of the two shear zones where the shear zones are located. The names are now on top of the fold and thrust belts.

Answer and Modifications: We do not have space to write ABSZ and TSZ in Fig. 2A. However, thanks for the Fig. 2B, we have written both ABSZ and TSZ within these shear zones.

Fig. 2 Write out "ADA" in full. Not clear what it means.

Answer and Modifications: We have included it. We also drew the Antequera Depressed Area in the geological map of current Fig. 2B.

Fig. 2. Playa-lake is a strange name in the context of the figure. The figure shows mainly tectonic features, whereas playa-lake is a geographic

denomination Playa-lakes are often related to hydrological-meteorological conditions. Referencing to my earlier comment, I think these playa-lakes are actually sag ponds related to the shear zone. So, it would be better to call them sag ponds. That makes the connection to their tectonic origin a lot clearer.

Answer and Modifications: We really realize that most playa-lakes in the study area may be described as sag ponds thank for the reviewer comment. However, playa-lake is a geomorphologic term (instead of geographic name), which has been used not only to describe some of these lakes in Spain, but also in the United States, North of Africa, Asia… For example, in the Utah basin (e.g. Putman et al., 2025), in Africa (e.g. Briere, 2000), and in Asia (Wu et al., 2021). It is a common term used for these wetlands in arid/semi-arid regions. Because of that, we maintain this term in the figure. In this Figure we show streams and main water bodies in the area.

Briere, P. R. (2000). Playa, playa lake, sabkha: Proposed definitions for old terms. *Journal of Arid Environments*, *45*(1), 1-7.

Putman, A. L., Blakowski, M., DiViesti, D., Fernandez, D., McDonnell, M., Longley, P., & Jones, D. K. (2025). Contributions of Great Salt Lake playa-and industrially sourced priority pollutant metals in dust contribute to possible health hazards in the communities of northern Utah. *GeoHealth*, *9*(8), e2025GH001462.

Wu, N., Ge, Y., & Abuduwaili, J. (2021). Grain size characteristics of sediments found in typical lANDSCAPES in the Playa of Ebinur Lake, Arid Central Asia. *Land*, *10*(11), 1132.

l.140-156. This text is impossible to follow with a proper geological map of the study area, including stratigraphic column, that should be incorporated in Fig. 2.

Answer and Modifications: Thank you very much for your comment. We have included one stratigraphic column and also a geological map in order to make the geological setting clearer.

Methodology

l.174. In the Results new mapping and structural data is presented. In the Methodology it should therefore be clearly stated that this was done and how the data was collected. The authors should also state why this was necessary, e.g., because of contradicting findings by other workers, or absence of certain data that is critical to estimate uplift rates. All this information should be given in a separate paragraph 3.1 with a separate heading called "3.1 Field-based collection of structural data" or something similar.

Only then follows a second paragraph called "3.2 Uplift estimates".

Answer and Modifications: It is truth that recent papers do not usually include a "field-based collection of structural data", but we think that it could be useful for readers. We have included this new section explaining which kind of structural data we collected:

"Field-based methods and structural data

We collected new data from structures located in the study area, within the ADA and in its boundaries. The N and S ADA boundaries coincide with the ABSZ and the TSZ, respectively (Fig. 2). Both shear zones were described in previous works (e.g. Barcos et al., 2015; Jiménez-Bonilla et al., 2023). In this work, we compiled new data from these shear zones.

To this end, we measured the orientation and dipping of fault planes that cut recent sediments (upper Miocene or younger rocks). When possible, we measured the direction and kinematics of slickenlines on fault planes. We also measured the bed orientation of post-Serravallian rocks to constrain folds. These data allow us to discuss the ADA evolution, the water divide migration and the endorheic basins reshaping. New structural data were presented in stereoplots and in the geological map in section 4.1. "

l.175-177. Here the authors state the estimation of uplift rates as one of the main objectives of the paper. In the Abstract and Introduction, however, this is not clearly stated as an important objective. Please make sure that the importance of this objective is clearly stated in all relevant chapters of the paper. I suggest the authors also clearly explain what the relevance is of late Tortonian uplift in relation to the drainage captures, divide migration and the formation of sag ponds.

Answer and Modifications: Uplift rates is an important issue in this MS. As above mentioned, we have changed both the abstract and we have rewritten the objectives in the paper.

l.203. Please explain briefly why exactly the drainage networks were analysed? How is this related to the tectonic part of the former paragraph?

Answer and Modifications: We have analysed the drainage network in order to detect active tectonics processes that control the ADA evolution during the Pleistocene-Holocene. We have included this in this part:

"We have analyzed the drainage network in order to detect active tectonic processes or recent structures that control the Pleistocene-Holocene evolution of the ADA."

l.224. I do not understand how the average flooded surface can be mapped from a DEM.Wouldn´t it be better to use Google Earth satellite images?

Answer and Modifications: Average flooded area is controlled by topography. Playa-lakes are characterized by flat floor, which indicates the average area flooded every year. If we chose google Earth images, you would measure different areas depending on the season. They are dry during summer and they extend over wide areas during wet years. To be clearer, we have included:

"AFSs are controlled by topography because they are characterized by flat floor".

l.224. Only here, for the first time it is mentioned that the playa-lakes may be related to tectonics. As I said before, this should be stated much earlier in the Abstract and Introduction. Also, it is commonly known that sag ponds are related to strike-slip tectonics and that they often from (ephemeral) lakes. So why do the authors not state this more clearly? It would make the link with tectonics so much easier to understand to the reader right from the beginning.

Answer and Modifications: As mentioned above, we thank a lot to the reviewer for this comment. We have introduced the term of sag ponds and we discuss in the discussion section that most playa-lakes may be considered as sag ponds according to our results. We have modified both the abstract, the introduction and the discussion (see comments above). However, we cannot call them as sag ponds in all the MS because these playa-lakes have not been characterized as structurally controlled wetlands until this work.

l.225. Why is the paleo watershed boundary important? Please explain the relation to tectonics.

Answer and Modifications: If paleo watershed and watershed areas do not coincide, it means that the endorheic watershed reshaped in recent times. It could be related to a stream capture conditioned by active structures. On the other hand, if the watershed area maintains, it is probably preserved because active tectonics prevents their capture from Mediterranean streams (aggressors streams). To sum up, paleo watersheds area is used to study active structures that control the Pleistocene-Holocene evolution of the ADA. To make it clearer, we included:

"P-W area reshaping may be related to active structures.".

l.228. Average run-off. But this should be paleo run-off, right? Because you are measuring paleolake dimensions. So which paleoclimatic data was used?

Answer and Modifications: Runoff has not considerably changed from the Pleistocene, as stated in previous works (Jiménez-Bonilla et al., 2024). Consequently, W/AFS relationship should maintain through time. We have included it in the new MS:

"W/AFS ratio and runoff should be maintained for each playa-lake, as observed in previous works (Jiménez-Bonilla et al., 2024)."

l.229. Why are paleo water balances important? I still do not understand their relation to tectonics? Please explain.

Answer and Modifications: As above mentioned, if paleo watershed and watershed areas do not coincide, it means that the endorheic watershed reshaped in recent times. It could be

related to a stream capture conditioned by active structures. On the other hand, if the watershed area maintains, it is probably preserved because active tectonics prevents their capture from Mediterranean streams (aggressors streams). To sum up, paleo watersheds area is used to study active structures that control the Pleistocene-Holocene evolution of the ADA.

l.242-244. Please explain why it is important to assess water divide migration in relation to the objectives of the manuscript? See also lines 256-258 where this was not sufficiently explained.

Answer and Modifications: The location and the migration of the Atlantic-Mediterranean water divide is important to study the ADA inception and evolution. We thanks the reviewer because this point was not clear enough. Consequently, we changed the abstract, the objectives:

"In this study, we aim to explore the nature of the main factors that control the formation of a depressed zone: the Antequera Depressed Area (ADA), located in the western Betics fold-and-thrust belt. We study it from its formation, associated with the Betics emersion and the Atlantic-Mediterranean water divide inception and migration during the upper Miocene-Pliocene, until its last stage, characterized by the development of endorheic systems during the Pleistocene-Holocene To do that, we collected structural data associated with post-Serravallian structures and we made uplift estimations from upper Miocene. We also explored the hydro-geomorphic dynamics and structural controls of the current drainage system both endorheic (playa-lakes) and exoreic. "

We have also included it in this methodology section:

"The Atlantic-Mediterranean water divide inception and migration is studied to investigate the ADA formation within this Betics fold-and-thrust belt segment."

Results

l.275. "Our new structural data". This is very contradicting, because earlier on the authors stated that they only used existing data. Also, in the Methods no mention is made at all of the collection of new, field-based data. The authors present stereo plots of fault planes in Fig. 5, but in the methods, this is not mentioned once. What kind of data did you collect? These data should be presented first instead of jumping to the tectonic interpretations in l.277 and further down below. Later on, in the Results the authors mention uplifted blocks, faults and folds and slickensides. Here, one or two figures with photos showing these features should be presented first, before jumping to tectonic interpretations.

Answer and Modifications: Thank you very much for this comment. We realized that "new structural data" was confusing. In the new version of the MS, we have differentiated between previous results and our new results. According to this, we have included a methodology section where we explain which kind of structural data we collected*:*

"Field-based methods and structural data

We collected new data from structures located in the study area, within the ADA and in its boundaries. The N and S ADA boundaries coincide with the ABSZ and the TSZ, respectively (Fig. 2). Both shear zones were described in previous works (e.g. Barcos et al., 2015; Jiménez-Bonilla et al., 2023). In this work, we compiled new data from these shear zones.

To this end, we measured the orientation and dipping of fault planes that cut recent sediments (upper Miocene or younger rocks). When possible, we measured the direction and kinematics of slickenlines on fault planes. We also measured the bed orientation of post-Serravallian rocks to constrain folds. These data allow us to discuss the ADA evolution, the water divide migration and the endorheic basins reshaping. New structural data were presented in stereoplots and in the geological map in section 4.1. *"*

According to this, we have also made some changes along the results and discussion sections.

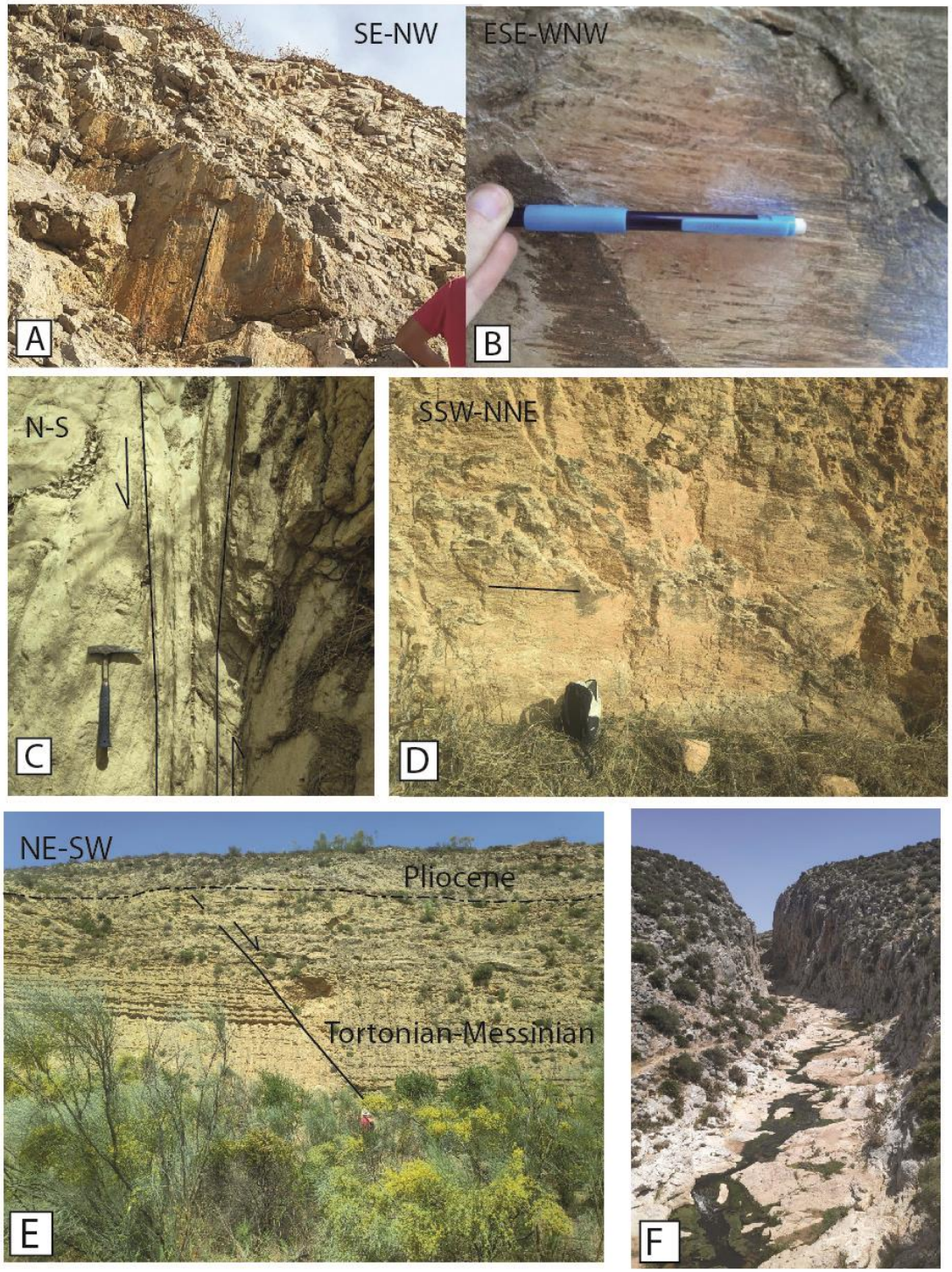
On the other hand, if there is no new data at all and if this is compilation of existing data, the data sources should be clearly mentioned and this entire paragraph including the figures, should be moved to Chapter 2, where the study area characteristics are described.

Answer and Modifications: In this section (4.1. Post-Serravallian structures), we have described the new structural data from the TSZ and ABSZ but also from the ADA, which is defined in this work. The TSZ and ABSZ were already defined in previous works, as mentioned in the new section Field-based methods and structural data, but we included new structural data associated with structures within both shear zones. Moreover, this is the first time that structural data within the ADA are presented. We explained it in the methodology section (see above) and we also modified the first sentence of this results section to make it clearer:

" On the basis of previous works on the structure and kinematics of the TSZ and ABSZ, we have completed the structural record of these shear zones in the study area with new data (Fig. 5). Additionally, we include for the first time kinematic data within the ADA."

l.290 and below. Here the authors clearly state that they collected new data and they show some photos. Again, this is very confusing. See my comment above in relation to l.275. Figure 6 does not nearly show enough of the described tectonic deformation. I would like to see more photo of displaced strata with fault planes and close-ups of slickensides. From photo A I personally cannot deduct a strike-slip movement, nor the presence of a strike-slip fault. Photos C and D are not helpful at all and should be replaced by more useful photos of tectonic structures. In this paragraph tectonic structures are mentioned, so I don´t understand why there should be photos of lake water balances here.

Answer and Modifications: These comments allowed us to improve the structural/tectonic part of the paper. We have changed the methodology section, as we explained before to make our results clearer. We have included three pictures related to faults and slickenlines from the ADA, the western TSZ and the c ABSZ. We also changed Fig 5A. See below the new Fig. 6.



l.312-343. These results should be explained by means of photos. For each tectonic feature you describe, please show a photo. Only referring to Fig. 5 is not helpful at all as it does not sufficiently show what you are describing.

Answer and Modifications: We totally agree with that, pictures may clarify the description of structural results. As we explained before, we have included three pictures more in Fig. 6. We

also changed Fig. 5 accordingly. We could upload more pictures in supplementary information if they are needed.

l.346-361. Here the authors describe the features of Fig. 3 as new Results. But this figure and its content was already presented in the Methods chapter as existing data. Therefore, this is highly contradicting. It is one way or another, but not both.

Answer and Modifications: Figure 3 is a new map that we used to locate some of streams for methodology section and to observe the altitude of upper Miocene sediments. However, the data to make this map are not our results. To make this point clearer, we have specified that it is a new map "*this is a new map*", but we maintain this figure as a methodology figure, given that we use to locate the selected rivers such as Gaén and Tinajas streams.

l.424-425. How do you know they are 3000 years old?

Answer and Modifications: Sorry, it was a mistake. At least, 30,000 years old, which is the oldest playa-lake: the Fuente de Piedra playa-lake. According to this, we have changed this sentence:

"during the last 30,000 years according to the oldest playa-lake: the Fuente de Piedra (Höbig et al., 2016)"

We think that it has caused confusion in other sections along the MS, explained in the comments below.

l.424-425 Also, the location of the mapped sag ponds was already shown in Fig. 3. Why are these sag ponds presented here again as new data? To me, they do not represent new data.

Answer and Modifications: In Fig. 3, playa-lakes are shown together with their current watersheds. These wetlands have been studied previously. Our new data consist of delimitating paleo flooded areas and paleo watersheds to investigate changes in the landscape and active structures. This is the reason why we use Fig. 9 and Table 2. Moreover, we use a more detailed map in Fig. 9 (higher scale). Fig. 9 shows modifications in flooded areas and endorheic watershed reshaping.

To make it clearer, we have explained it better in the methodology section:

"Never before have the paleo watersheds and flooded areas studied in this area."

Fig. 9. This figure apparently shows the same things as Fig. 3. My suggestion would be to delete Fig. 9.

Answer and Modifications: As above explained, this is not possible, because Fig. 9 shows both paleo flooded areas and paleowatersheds, which mean the evolution of the endorheic systems during the Pleistocene-Holocene. It is important for this work because some discussion points

are based on these results (e.g. the La Venta stream capture of Campillos system, the partial preservation of the Fuente de Piedra endorheic watershed, the Fuente de Piedra flooded area splitting into two subflooded areas…; see section 5.2).To make it clearer, we introduced a new sentence in the Methodology section:

"Never before have the paleo watersheds and flooded areas studied in this area."

l.443 and below about the SLk index. The authors have analysed long profiles and knickpoints in relation to tectonics. To improve the readability of the paper, it would be better to discuss the SLK results in a separate paragraph directly below paragraph "4.2 Estimates of post-Tortonian differential surface uplift", as both paragraphs deal with tectonics. Then a paragraph 4.4 about the Chi values and drainage divide migration should be introduced, followed by 4.5 paleo lake level estimates" or something alike.

Answer: Both the endorheic watershed captures, SLk index and X metrics are studied together to understand active tectonics in this area. This is the reason why we describe these results together. If not, the paper lengthens unnecessarily. SLk profiles are actually linked to endorheic watershed captures. Some of these profiles show knickpoints that could be related with paleo water divides of paleo watersheds. Uplift estimates are structural results, instead of geomorphic results.

We realized that this issue was not clear enough, so we made some modifications in the new MS:

- We changed the objectives of this work, as above explained.
- We made some changes in the introduction.
- In the Methodology section, we have introduced these changes:

- *"We have analysed the drainage network in order to detect active tectonic processes or recent structures that control the Pleistocene-Holocene evolution of the ADA"*
- *"The Fuente Piedra playa-lake and the Campillos endorheic system are studied in relation to their drainage network evolution, geometric changes and stream captures, which are potentially controlled by active tectonics. To do that, we delimited the average flooded surface (AFS) and the endorheic watershed (W) using a 5-m DEM from Junta de Andalucía. AFSs are controlled by topography because they are characterized by flat floor. Never before have the paleo watersheds and flooded areas studied in this area. Paleo-watershed (p-W) can be delimited by the presence of knickpoints along stream profiles, which are used as a part of the water divide (Fig. 4A). P-W area reshaping may be related to active structures. However, p-W are sometimes estimated indirectly by the relationship between W and AFS, because we considered the W/AFS constant."*

l.442-504. The authors describe the longitudinal profile characteristics and SLK values in detail for each river. This makes the text a bit tedious to read. It would be much better to give a short summary of the main findings without going in so much detail.

Answer and Modifications: We totally agree with the reviewer. In this section, we describe the results together with endorheic watersheds modifications. We have simplified the results and the description of stream profiles.

l.442-481. There are studies that used the SLk values to classify fault slip in terms of activity intensity. Perhaps it would be interesting to the authors to do the same? It could provide a better understanding of which faults are most active in their study area. See for instance: https://www.sciencedirect.com/science/article/abs/pii/S0040195121002249

Answer and modifications: This paper makes statistical analysis from the results of SLk in a drainage network. > 106.000 points were analyzed in this work because they only focused on the SLk analysis. In our work, we use information from the drainage network (including endorheic basins), geomorphic indices and also structural data to delve into the active structures. We have compared the SLk values obtained in our rivers with other works in the area to discuss the recent tectonic activity of the faults of this work:

"Similar SLk values were obtained for active structures in the Betics (e.g. Pérez-Peña et al., 2009; Jiménez-Bonilla et al., 2015)"

l.482-489. Here, the authors switch from longitudinal profiles to lake levels and from l.490 onwards they switch again to longitudinal profiles. Please make a separate paragraph for the lake level data.

Answer and modifications: We have tried to make this section clearer but longitudinal profiles are related to endorheic basins evolution, as explained above. Knick-points along stream profiles may be actually ancient water divides of endorheic watersheds during the Pleistocene and later captured by aggressor streams.

l.482-489. The authors show variations in lake levels based on DEM mapping and age estimates (unclear to me where the age estimates come from). To me, this does not present additional evidence for tectonic movements. Lake level variations may also be related to climate change, earthquakes, or changes in ground water levels related to agriculture, mining or any other human activity. The time span on which these lake levels changed (the authors stated 3000 years, although unsure where this age is based on), is way too short when compared to the 20 Ma time period on which they analysed tectonic activity. For me personally, the presence of mapped sag ponds in a shear zone, together with all the other structural data, is enough evidence for active shearing. So, my suggestion would be to remove all this paleolake level stuff from the paper. It would make the paper a lot easier to understand. In its current state, there are simply too many different results from very different time periods, generating a "messy" paper if I may say so.

Answer and modifications: Thank you for the comment. Sorry 3,000 years was a mistake, we changed it: 30,000 years. We have tried to make the temporal issue clearer. Firstly, we do not really use the flooded area to assess active tectonics, we mostly use endorheic basin captures, which may be related to active tectonics. We have changed along the MS the use of endorheic watershed instead of playa-lake. In this

way, flooded area changes could be used to infer changes in the endorheic watershed area, as used in previous works (Jiménez-Bonilla et al., 2023). Moreover, the endorheic basins inception and evolution represent the Pleistocene-Holocene evolution stage of the ADA, which is the study area.

We have introduced some changes in the abstract, introduction, methodology and results to improve it.

Jiménez-Bonilla, A., Díaz-Azpiroz, M., & Rodríguez, M. R. (2023). Tectonics may affect closed watersheds used to monitor climate change and human activity effects. *Terra Nova*, *35*(1), 58-65.

Discussion

l.511-513. There are too many concepts cobbled together here and to me, not everything is related. For instance, to me the playa lakes are sag ponds related to the shear zone. Is this directly related to drainage migration? Not really. Is drainage migration related to the calculated differential uplift of the western Betics? Yes.

Answer and modifications: Sorry, this paragraph was too messy. We have rewritten the main aims of this work and we also changed all the MS. According to that, we refocused more on the tectonic/structural issue in the studied area: the ADA. According to these changes, we have changed this paragraph into:

"To understand the ADA inception and evolution from upper Miocene to Holocene, we investigate the tectonic mechanisms that control the Atlantic-Mediterranean water divide inception and migration and the endorheic watersheds origin and evolution during the last stage of the ADA. Our results will be put in context together with data from previous works that account for some of these processes."

So, to me, these are two different topics that the authors fail to merge sufficiently into one coherent unit in this manuscript. By removing the paleolake level stuff from the equation, the paper will become much more streamlined.

Answer and modifications: We have tried to explain along the MS how we use the lake levels. We actually use to calculate paleo-watersheds. We do not really use directly lake levels to explain active tectonics. We have use lake levels to infer changes in the area of endorheic watersheds, which may be related to active structures. This is the case of the Campillos playa-lake system, which lost watershed areas due to the capture of the La Venta stream during the last stage evolution of the ADA. It was influenced by the balance between active tectonics in the wTSZ and the power erosion of Mediterranean rivers (aggressors). As above mentioned, we have introduced some changes along the MS to make it clearer.

l.523-525. Here a statement is made about the Mediterranean-Atlantic gateway. This was briefly mentioned in the Introduction and then never touched upon again until now. This statement further decreases the understandability of the paper as it was not mentioned as one of the main objectives. Therefore, any reference to this gateway would be better removed from the paper. It only generates confusion.

Answer and modifications: Thank you very much for this comment. We have rewritten the objectives of this work. When we focus on the ADA, the Atlantic-Mediterranean water divide inception (when the Guadalhorce gateway closes), marks the first stage evolution of the ADA, when its S boundary builds up (see Fig. 10):

"In this study, we aim to explore the nature of the main tectonic factors that control the formation and later evolution of a topographic depressionlocated in the western Betics fold-and-thrust belt (the Antequera Depressed Area; ADA) which nowadays host one of the main playa-lake systems of the Betic Cordillera. This objective is adressed in two time scales. Firstly,we study theinception of the former o ADA, associated with the Betics emersion and the Atlantic-Mediterranean water divide migration during the upper Miocene-Pliocene. To do that, we collected structural data associated with post-Serravallian structures and we made uplift estimations from the upper Miocene. Secondly we analyseit's the last stage of the ADA evolution, characterized by the development of endorheic systems during the Pleistocene-Holocene. For this end we explored the hydro-geomorphic dynamics and structural controls of the current drainage system both endorheic (playa-lakes) and exoreic. "

We also changed the introduction:

"Before the Atlantic-Mediterranean water divide formation, this area included one of the upper Miocene Atlantic-Mediterranean corridors: the Guadalhorce gateway (Martín et al., 2001; 2014). Shallow Marine sediments were deposited down to 120 m depth in this area during this time period, and are currently uplifted more than 600 m.a.s.l. (El Chorro outcrop; Martín et al., 2001). The Guadalhorce gateway closure, which is not yet fully understood, contributed to the isolation of the Mediterranean Sea. This, together with arid conditions, which provoked a negative water balance of this sea, caused the subsequent Messinian Salinity Crisis (MSC)"

l.518-538.This information was already mentioned in Chapter 2. Why is this repeated here? Not only that, but the authors switch from tectonics, to gateway closures to drainage migration to ocean base level lowering in only a few sentences, making the text very unfocused. Please delete these sentences.

Answer and modifications: In the discussion of this section, we began with the ADA inception. To do that, we have started with the Atlantic-Mediterranean water divide inception and the Guadalhorce gateway closure. Moreover, previous works related the part of the ADA emersion to an isostatic rebound, thus it is important to discuss how this segment emerged from the sea level and how shear zones controlled the evolution of this orogenic segment. To make this issue clearer, we have changed the beginning of this paragraph:

"First evidences of ADA inception are the emersion from the sea level of this orogen segment. The upper Miocene coastline in the study area has been mapped in previous works by detecting

Tortonian and Messinian abrasion platform borders (Elez et al., 2016; Braga et al., 2003; Fig. 11). "

l.606-611. Here the authors state that the lakes are from early Pleistocene age, but elsewhere they stated they were 3000 years, and now they state the oldest known playa-lakes are 30 ka… Please be consistent.

Answer and modifications: Sorry, we explained before that 3,000 years was a mistake, we changed it into 30 ka.

l.606-621. This information is all very inconclusive and does, in my opinion, not add anything useful to what we already know. It is enough to know they are sag ponds in a shear zone. So, to improve the readability of the manuscript, my suggestion would be to delete these sentences.

Answer and modifications: As above explained, all playa-lakes cannot be considered as sag ponds. Sag ponds refer to the genetic origin of these playa-lakes. Playa-lake, as a seasonal wetland, is a geomorphologic term that has been used to characterize these wetlands for decades in this area. In this work, we discuss the structural control on the inception and evolution of these playa-lakes, which is the first time that this issue is discussed. Consequently, this paragraph cannot be removed. The origin of some of these playa-lakes is not completely associated with transpression. Karstic processes may also influence on their playa-lake inceptions. To make it clearer, we have changed this paragraph into:

*" **Going to the recent evolution of the ADA, a crucial question is the evolution of current endorheic watersheds and their associated playa-lakes close to the Atlantic-Mediterranean water divide. Playa-lakes stricto sensu (seasonal water bodies),** probably developed during the Pleistocene probably because of the aridification of climatic conditions. Due to their ephemerous lifespan, oldest ones probably disappeared or/and were reshaped and their sediments probably eroded. The earliest age obtained for current playa-lakes associated with endorheic basins is of **30 ky** in the Fuente de Piedra playa-lake (Late Pleistocene; Höbig et al., 2016). Previous works have pointed out that since endorheic systems were formed, they were strongly conditioned by climatic changes and human modifications because of their weak equilibrium between water inputs and outputs (Rodríguez-Rodríguez et al., 2007; 2012). As we observed, the large number of playa-lakes preserved in the ADA because of the most recent uplifts caused by both the TSZ and ABSZ and their respective tip zones, which shaped a roughly triangular closed zone that contains all the studied cases (see sections 4 and 5; Fig. 2) and act as relief barriers that prevent erosion from the Atlantic and Mediterranean streams (Fig. 2). **Consequently, some of these playa-lakes may be also considered as sag ponds controlled by transpressive deformation**. Additionally, active tectonics in this sector may also influence the shrinkage or disappearance of some endorheic watersheds hosting playa-lakes because of the reduction of the overall water input due to stream captures (Figs. 3, 9 and Table 2; Jiménez-Bonilla et al., 2023)."*

l.622-631 and below. Here the authors make a much better link between water preservation in the sag ponds and tectonic activity. So, to me, this part of the Discussion is ok, but I do suggest to simplify it a bit and not go into detail about the individual lakes 3 and 3B. Just keep it more general.

Answer and modifications: We totally agree with the reviewer, we have simplified this paragraph:

“ *“The long lifespan of some playa-lakes such as Fuente de Piedra (30 Ky; Höbig et al., 2016) is probably conditioned by active tectonics. The dip-slip movement of the left-lateral dominated fault of the transverse zone within the ADA (see section 4.3) located at the E boundary of this playa-lake could have prevented this playa-lake capture, despite being located only about 1 km away from a Mediterranean stream (Table 2 and Fig. 5A; see also χ values on Fig. 8 and Fig. 9). Moreover, the Fuente de Piedra paleo-AFS would be bigger (Fig. 9 and Table 2). This left-lateral dominated fault would have splitted the playa-lake into two (Table 2 and Fig. 9).”*

l.632-635. Not useful. Lines can be deleted.

Answer and modifications: Removed

l.636-656. Same. Please simplify the text to ~5 lines and do not go into so much detail about the individual playa lakes. The strong part of the paper is the large-scale tectonic part and not the playa-lake part.

Answer and modifications: We have simplified this paragraph:

“Regarding the Campillos endorheic system (playa-lakes 4 to 12), its evolution seems to be conditioned by the balance between the western TSZ segment uplift and the headward erosion capacity of the La Venta stream. Although the La Venta stream is an antecedent river, as indicated by its strong incision (Fig. 6D), its upper course could have been transiently disconnected from the drainage network due to the uplift of western TSZ during the Quaternary. This disconnection probably formed an endorheic area where the Campillos endorheic system (Fig. 9 and Table 2). The age of the travertine associated with the wTSZ uplift (9,000 years old, see section 6) must pre-date the recapture of some endorheic watershed areas (e.g. playa-lake 17 and the reduction of watershed area in the Campillos system; Table 2). The partial preservation of this system would be due to the recent activity of a left-lateral dominated transpressive fault, at the western TSZ (see section 4.1.1). This fault together with all the structures related to this tip generate a relief barrier which slows down the migration of the knickpoint upstream (Fig. 10C), which is congruent with the calculated post-Tortonian uplift (Fig. 3). If the tectonic activity stopped at the western TSZ, the Campillos endorheic system would likely be captured in some hundred years. In the N ADA boundary, because of central ABSZ recent tectonic activity, playa-lakes 1 and 2 have been partially or completely captured during the last 2,000 years (Recio-Ruíz and Ruiz-Somavilla, 1990; Jiménez-Bonilla et al., 2023; Fig. 9).“

l.657-669. Please delete. It detracts from the focus of the paper.

Answer and modifications: Removed

Conclusions

Please refocus the conclusions according the improved focus on tectonics of the manuscript.

Answer and modifications: We have changed the conclusions according to new MS:

"In this work, we study a depressed area topographic depression (ADA), limited by two transpressional shar zones, the TSZ and the ABSZ to the S and to the N, respectively, within the Betics fold-and-thrust belt. To do that, we studied the Atlantic-Mediterranean water divide inception, and migration, which is characterized by the presence of endorheic watersheds since the ADA emersion from the sea level (base of the Pliocene). We combined structural and hydro - geomorphic analysis: we collected kinematic data from faults active from the Upper Tortonian onwardsand we analysed the drainage network and endorheic watersheds using geomorphic indexes such as SLk and χ. ".

We observed differences on the post-Tortonian surface uplift within the study area that are congruent with the tectonic activity of both the TSZ and the ABSZ. Consequently, structures must be considered in studies of orogenic uplift in this Betics segment. The relative uplift built up by these shear zones condition the relief evolution and the drainage network development:

The early uplift of the TSZ probably influenced the Guadalhorce gateway closure and it did not reopen even though the high erosion power of Mediterranean streams during the Messinian Salinity Crisis (MSC). The TSZ uplift controlled the location and geometry of the Pliocene Atlantic-Mediterranean water divide, ***which is the S boundary of the ADA.***

The ABSZ tectonic activity would start later than the TSZ, which suggests a migration of the deformation towards the foreland at this fold-and-thrust belt segment. This migration of the deformation probably conditioned the Quaternary migration of the Atlantic-Mediterranean water divide.

The tectonic activity of both transpressive zones (the TSZ and the ABSZ) generated the ADA, where many endorheic watersheds develop from the Pliocene to Holocene. ***These endorheic watersheds hosted permanent water bodies, which evolved into seasonal (playa-lakes) due to a climate aridification since the Pleistocene. The recent tectonic activity of faults associated with TSZ and ABSZ prevents the capture of these endorheic watersheds from streams, especially those draining to the Mediterranean Sea. The kinematics of active faults condition the evolution of playa-lakes (movement, split, diminution or increase of its average flooded area). In these cases, they correspond to sag ponds.***

Technical corrections

Abstract

l.9. “depressed area” is incorrect English. The correct term would be “topographic depression”.

Answer: We think that our study work is a depressed area, instead of a depression. It is actually an area topographically depressed within another area. In the Betics, when we call depression, we usually think about intermontane depressions (Ronda basin, Granada basin...) or the foreland basin (Guadalquivir basin).We observed that “depressed area” is also used in other scientific works, then we maintained:

1. Abbate, E., Bruni, P., & Sagri, M. (2015). Geology of Ethiopia: a review and geomorphological perspectives. *Landscapes and landforms of Ethiopia*, 33-64.

*“The Afar region is a quasi-triangularly shaped **depressed area** at the intersection of the Red … incipient oceanization, volcanic rocks cover wide areas of the Afar depression “*

2. Ferrari, L., Garduño, V. H., Pasquarè, G., & Tibaldi, A. (1991). Geology of Los Azufres caldera, Mexico, and its relationships with regional tectonics. *Journal of Volcanology and Geothermal Research*, *47*(1-2), 129-148.

*“the canyons have gullied walls indicative of extensive headward erosion since their initial formation. Regionally **depressed areas** …””*

3. Delaney, A. A. (1970). Demonstrating topographic elevation and depression. *Science Education*, *54*(2), 197-201.

“The representation of **depressed areas** may be shown by simply reversing the procedure used in the second demonstration on elevation. …”

l.32” In this regard” can be removed. Just start the sentence with “Drainage networks…”

Answer and modifications: This sentence was changed in the new MS.

l.33 please change to “…by undergoing changes in longitudinal profile shape….”

Answer and modifications: This sentence was changed in the new MS.

l.34 “topological reshape”. Please change to “..by changing the shape of…”

Answer and modifications: Thanks for this comment, we changed.

l.36 “networks” should be “network”

Answer and modifications: We changed this mistake along the MS.

l.37 please change to "although this depends on the lithology, the climate or the watershed size."

Answer and modifications: We changed this sentence into:

"However, other factors such as the lithology, the climate or the watershed size may influence this timespan (Whipple and Tucker, 1999; Korup, 2006; Cook et al., 2014)."

l.42 please change "governs" to "create".

Answer and modifications: Changed.

l.43. delete "both favouring their inception".

Answer and modifications: Deleted

l.43 "…and control their subsequent evolution".

Answer and modifications: Deleted

l.58. As stated before, please change "depressed area" to "topographic depression". Please change in all other parts of the text as well.

Answer and modifications: Changed along all the MS.

l.62 headwaters.

Answer and modifications: Changed

l.62. Illogical sentence. There is not logical connection between headwaters of Mediterranean rivers and being ephemeral. Ephemeral lakes are related to seasonal rainfall. Please rephrase.

Answer and modifications: This sentence was changed

l.66 change to "Shallow marine sediments were deposited in this area during this time period and are currently uplifted more than 100 m. a.s.l."

Answer and modifications: Changed

l.78. Please delete "In this regard, it is worth noting that.."

Answer and modifications: Deleted

l.84-85. Delete "To do that, we zoom into this time frame to…" and start the phrase with "We analyse in detail…"

Answer and modifications: Deleted

l.85. Delete "timing, reshaping and fluvial captures."

Answer and modifications: Deleted

l.86-88. This phrase is badly written. Please delete and rephrase as "We analyse the evolution of fluvial longitudinal profiles by examining tectonogeomorphic indicators such as the normalised stream length gradient index (*SLk*), the normalised steepness index (*Ksn*) and the concavity index *Chi*." Please also state the original references.

Answer and modifications: Changed

Main geological and geomorphological features of the study area

Figure 1 is difficult to read due to its small size. Please enlarge the figure.

In the legend of Figure 1a, what kind of sediment is Upper Mioc. to Q? Please spell out late Miocene to Quaternary.

Answer and modifications: We enlarged and we spell out it in the figure captions.

In Fig. 1b, please indicate which side of the water divide is Atlantic and which side is Mediterranean.

Answer and modifications: It is quite repetitive to write Atlantic watershed and Mediterranean watershed in a small figure when Atlantic ocean and Mediterranean sea are spell out.

Legend Fig. 1b and manuscript text in general: be consistent in the use of "endorheic area"or "topographic depression" when referring to this area.

Answer and modifications: Thank you very much, it has been changed along the MS.

Fig. 1a and 1b. Please make sure that both figures are exactly the same size and oriented in the same directions. This makes going back and forth between both figures a lot easier.

Answer and modifications: Checked

l.102. Not orthophoto but satellite image.

Answer and modifications: Changed

l.106. Betic not Betics.

Answer and modifications: changed

l.110 "along, and across the Betics," Two commas.

Answer and modifications: We added a comma.

l.113. Delete "the second-order"

Answer and modifications: Deleted

l.114. Fig 1 should be Fig. 1a.

Answer and modifications: Changed

l.118. These kinematics

Answer and modifications: We changed

l.125. ADA. As said before, "depressed area" is incorrect English. I would suggest "Antequera topographic depression" or "Antequera Depression". Please clarify you name this area after the town of Antequera located in the area.

Answer and modifications: In order to avoid repetitions, we changed it into Antequera Depression

l.126-127. Sentence is too long. I suggest to delete "located close to the contact with the Alboran domain."

Answer and modifications: Deleted

l.129 are these endorheic basins the playa-lakes, or as I prefer to call them, the sag ponds? It is really confusing to the reader you use different names for the same topographic feature.

Answer and modifications: As explained along the rest of the comments, endorheic watershed is the area where the runoff does not flow towards the sea or the ocean. Instead of it, the runoff is accumulated in the low lands, producing playa-lakes (with the current climate) or permanent lakes. Playa-lake is the wetland, endorheic watershed is a basin. We tried to be clearer in the new MS, as explained in the comments above.

l.130. It is surrounded by areas rising over 100 m above this topographical depression. The highest elevational differences between the basin floor and surrounding peaks are found in the NW, SE and SW boundaries (Fig. 2b).

Answer and modifications: We changed this sentence into:

" It is surrounded by areas rising over 100 m above this topographic depression, being the most prominent relief drops found in its NW, SE and SW boundaries (Fig. 2)."

l.132-139. This is good example of the number of abbreviations that are used. It makes the text really hard to follow, unless the reader starts making a list with abbreviations and their meaning almost immediately. I strongly urge the authors the spell out the names without using the abbreviations in the entire manuscript.

Answer and modifications: We have tried to make the paper more readable. The main abbreviations of the paper are: ADA, ABSZ and TSZ.

l.146. Please explain how "allochthonous" should be interpreted?

Answer and modifications: We explained

l.146. canopy is another word for a collection of tree tops. I have never heard of this term in a geological context. Please check if canopy is really used in a geological context.

Answer and modifications: A canopy is a term that is frequently use in structural geology, this is not too strange. Moreover, this is how this unit has been recently defined. To make it clearer, we have introduced a new sentence:

"previously defined as an evaporitic nappe"

l.147. overlie not lie over.

Answer and modifications: Changed

150-151. How is this information relevant to the manuscript? If it is not directly important to the paper, it would be best removed.

Answer and modifications: It is important, we use it to calculate post-Tortonian uplifts.

l.153. What sedimentary origin do the Pliocene sediments have? Fluvial, alluvial, glacial?

Answer and modifications: They are alluvial, we included.

l.155 Lacustrine dark quaternary sediments should be Quaternary, dark-coloured lacustrine sediments

Answer and modifications: Changed

1.556 delete "being often useful to identify paleo playa lakes. Some of these outcrops are larger than 1,000 hm2".

Answer and modifications: We deleted "some of these outcrops are larger than 1000 hm2"

l.158 delete “near the divide”

Answer and modifications: Deleted

l.160 drained by the…

Answer and modifications: Changed

Methodology

l.172-173 these sentences can be deleted.

Answer and modifications: Deleted

l.177 upper Miocene, shallow-marine sediments

Answer and modifications: Changed

l.180 simple shear, not simple shearing

Answer and modifications: Changed

l.182. Here for the first time “extrusion” is used. Before, the term “transpression” was used. Please be consistent and only use one term.

l.184. Here extrusion and transpression are used as two separate terms. But in reality, it is the same thing. I would change “extrusion” for “movement” here.

Reviewer’s comments to L182 and 184 are very similar: transpression and extrusion are the same. We disagree with this statement. From the first kinematic definition of transpression (Sanderson & Marchini, 1984), through subsequent works developing this concept , from a theoretical/analytical perspective (the works of Fossen and Tikoff, Jones and co-workers, Jiang and co-workers or Fernández and Díaz-Azpiroz, among others) and/or analyzing natural transpressional zones, transpression combines a simple shear component of deformation (originally strike-slip, later oblique also) with a coaxial component of deformation (originally pure shear, later broadened to general coaxial strain). The latter produces shortening across the deforming zone that, in order to maintain constant volume (if this is the case), has to be compensated by displacement of material along the zone boundaries. This was called extrusion because it extracts the material upwards along the dip direction (vertical in the original models, also inclined in later examples, e.g., Jones et al.,

2004). In later models, extrusion was allowed to depart from the dip direction to be horizontal (Jones et al., 1997) or, more generally, oblique (Czeck and Hudleston, 2003; Fernández and Díaz-Azpiroz, 2009). We have followed all these previous works to describe both processes mathematically (see Appendix A1), such that transpression is defined by a 3 x 3 strain tensor where extrusion is only one of its components (F_{33}). Therefore, it results extrusion is one part of one of the two main strain components (coaxial) of transpression and, consequently, we maintain our terms transpression and extrusion, with the meaning given by all transpression papers we are aware of, as different processes.

Additional references not included in this manuscript:

Czeck, D.M., Hudleston, P.J. 2003. Testing models for obliquely plunging lineations in transpression: a natural example and theoretical discussion, Journal of Structural Geology 25, 959-982.

Jones, R.R., Holdsworth, R.E., Bailey, W. 1997. Lateral extrusion in transpression zones: the importance of boundary conditions. Journal of Structural Geology 19, 1201-1217.

Jones, R.R., Holdsworth, R.E., Clegg, P., McCaffrey, K., Tavarnelli, E. 2004. Inclined transpression. Journal of Structural Geology 26, 1531-1548.

l.188-192. Please describe the units of the parameters. For instance, in which units is coaxcial strain expressed' Time t is in seconds, days, years…etc?

Answer and modifications: The units may change depending on the specific features of the studied transpressional zone. In this case, units are presented in the description of the input values and Table 1: strain rate is given in s^{-1}, time in my ,(both described in former lines 389-391, now in the methods section in the revised manuscript: " From these values, the resulting average pure shear strain rate related to transpression that acted in the TSZ in the last 11.6-20.4 my ranges between 3.2 · 10-16 s^{-1} and 7.4 · 10-16 s^{-1}.") and all lengths are in m (see, for example, former lines 369-373, now in the methods section in the revised manuscript).

Figs. 1, 2 and 3: Which DEM did you use?

Answer and modifications: We have included it in the new MS:

"using a 5-m DEM from Junta de Andalucía. This DEM is used for Figs. 1, 2 and 3"

l.195 post-Serravallian, main tectonic structures

Answer and modifications: Changed

Fig. 3 blue arrows are flow directions of the rivers? Please indicate in the legend.

Answer and modifications: Added

Fig. 3 I don´t understand why two separatee designations are used for playa-lake and endorheic basin? Playa-lakes are also endorheic basins! Why not use the name "sag pond" for both?

Answer and modifications: As explained along the rest of the comments, endorheic watershed is the area where the runoff does not flow towards the sea or the ocean. Instead of it, the runoff is accumulated in the low lands, producing playa-lakes (with the current climate) or permanent lakes. Playa-lake is the wetland, endorheic watershed is a basin. We tried to be clearer in the new MS, as explained in the comments above.

l.200. Why is the Junta de Andalucía, 2016 mentioned here? What exactly did the regional government of Andalucía provide?

Answer and modifications: They provided the DEM, this is the cite.

l.206-207 have also been added

Answer and modifications: Changed

l.2010-211. The authors should first explain what features (e.g., knickpoints, concavity, etc) of the rivers they are investigating. Only after that, the authors can state "We displayed post-Serravallian structures on stream profiles to investigate the relationship between knick-points and recent structures".

Answer and modifications: We have included it in the new MS:

l.211. Why are knickpoints studied? Is this in the context of tectonics and/or drainage capture? Please explain, so the reader knows why you are doing this?

Answer and modifications: As above explained, we have added a new section called:

Field-based methods and structural data

l.2019. I would avoid using "River head" here. It would be better to say "the most upstream elevation of the longitudinal river profile", or "the headwaters of the river"

Answer and modifications: As above explained, we have added a new section called:

l.219. River elevation at the river mouth.

Answer and modifications: Changed

l.222. This is the first time that the Fuente Piedra playa-lake and the Campillos playa-lake are mentioned. Why are these playa-lakes important and where are they located? Please insert a reference to the figure where their locations can be found.

Answer and modifications: Added

l.225. From the Junta de Andalucia.

Answer and modifications: Changed

l.232-233. Please cite the bibliographic reference for these precipitation values?

Answer and modifications: The reference is at the end of the sentence (Rodríguez-Rodríguez et al., 2007)

l.230-235. This is a sentence made up of 6 lines. The sentence is too long. Please insert a full stop after "..western Atlantic coast)." And start a new sentence stating "Variations are also related to local factors…".

Answer and modifications: Modified

l.237. Paleo flooded surface has been mentioned earlier, but is only explained in detail here. It would be better to remove the earlier mentioning of paleo flooded surface to avoid confusion.

Answer and modifications: Removed

l.239. "perched over" is incorrect English. Please frame it differently.

Answer and modifications: Modified

l.240. Can easily be estimated.

Answer and modifications: Changed

l.246. Depends on, not depends to.

Answer and modifications: Changed

Results

l.268. It would be better to number the paragraphs with the Results instead of saying "Results I", "Results II", etc. Just state "4.1 Post-Serravallian structures".

Answer and modifications: Changed

l.268-271. These lines can be deleted.

Answer and modifications: Reduced

Fig. 5. Please indicate "C", "D", etc. for the stereo plot subfigures.

Answer and modifications: They are written

Fig. 5 legend. Where does T-travertines belong to? Does it need a separate colour code, or is it included in Quaternary paleo soils or Quaternary lake sediments?

Answer and modifications: T-travertines mean a part of the Quaternary sediments. In the map, they can be detected by a T over the grey quaternary sediments.

Fig. 5. Why are Quaternary paleo soils mentioned? Please explain this a bit better in the main body of the Results text.

Answer and modifications: Q paleo-soils may be differentiated from the terraces because they are not associated with stream dynamics. We introduced some changes in the results section.

Fig. 5. It is unclear to me if this map was taken from one of the IGME geological maps, or if this is a completely new map based on field data of the authors. Please indicate which is the case.

Answer and modifications: As we have written in the figure caption, this geological map is modified from previous ones. With our new data, we improved the previous geological map:

"(Modified from Jiménez-Bonilla et al., 2023)."

Fig. 5. Why is there a black square border surrounding stereplots 1 to 5, and no black border surrounding plots 6 and 7?

Answer: Because they are different study areas, TSZ, ABSZ and ADA.

Fig. 5. The Quaternary lake sediments in dark grey are the playa-lakes, endorheic basins or sag ponds the authors referred to earlier? The number of names for the same thing keeps increasing. Please be consistent and use only one designation.

Answer and modifications: As explained along the rest of the comments, endorheic watershed is the area where the runoff does not flow towards the sea or the ocean. Instead of it, the runoff is accumulated in the low lands, producing playa-lakes (with the current climate) or permanent lakes. Playa-lake is the wetland, endorheic watershed is a basin. We tried to be clearer in the new MS, as explained in the comments above.

Fig. 5. In the main figure, please indicate where more or less the ADA, ABSZ, wTSZ, TSZ and any other abbreviations you have come up with so far, are located. Based on the current figure, I cannot clearly see where the shear zones are located.

Answer and modifications: We have included it in the new MS.

l.281. Riedel shears, not Riedel.

Answer and modifications: Changed

l.324 highly dipping is incorrect English. Please change to "strongly tilted".

Answer and modifications: Changed

l.331. Quaternary, not quaternary.

Answer and modifications: Changed

l.345. Delete “5. Results II: Estimates of post-Tortonian differential surface uplift” and replace with “ 4.2 Estimates of post-Tortonian differential surface uplift”.

Answer and modifications: Deleted

l.348. as follows

Answer and modifications: Deleted

l.364-366. This is interpretative and should be saved for the Discussion.

Answer and modifications: We changed the writing

l.367-398 and Table 1. These are Methods and should be moved to the Methods. Only the results (l.398-404 and Fig. 7) of the calculations should be presented in the Results chapter.

Answer and modifications: We agree and thank the reviewer for this comment. Accordingly, we have moved most of this section (former lines 365-396, plus former equation 6, now new equation 2, and Table 1) to the method section, and maintain here only the results description (former lines 395-402 and Figure 7). We hope this change has increased the readability of the manuscript.

Fig. 7 contains the main results of this paragraph, but this figure is not described in detail in this section. It is only passingly mentioned in l.398. Please describe the figure in more detail and give it more importance in the text.

Answer and modifications: We agree this is one of our main results, but it is quite simple to describe in our opinion. We have differential uplift values in the natural zone and model outcome obtained using reasonable input values for this case. Both data sets overlap for some specific modelling input values, thus these values would explain the observed differential uplift. This is presented in the text and the figure is quite illustrative. Just to highlight differences between valid and invalid modelling results for this case, we mention which ones overlap with natural data. Further conclusions derived from these results are discussed later, in former lines 505-553: “Therefore, our results indicate that transpression at the TSZ with moderate strain rate values observed in Mesozoic rocks (likely resulting in total contraction between 0.09 and 0.11), roughly constant since the Messinian, would suffice to explain the observed differential uplift with respect to the depressed sector of the study area.”

l.400-401. Please explain why a total contraction value of 0.09-0.11 is better?

Answer and modifications: Figure 7 compares 1) the results of the differential uplift range between the TSZ and surrounding areas, recorded in this study from the current altitude of Tortonian deposits at both locations (colored lines), with 2) the modelling output (black lines with different dash styles). All model results with e = 0.11 and most model results with e = 0.09 overlap with the differential uplift range, thus these e values would probably explain better the observed differential uplift. There are other e values at both sides of these two (0.07-0.09 and 0.11-0.15) that would partially overlap with the same field with specific values of other parameters (large z(t0) values for e < 0.09 and small z(t0) values for e > 0.11). There are e values (< 0.07 and > 0.15) that produce no overlapping. We think the figure is explicit enough and there is no real need to do an extensive description. However, for the sake of clearness, we have mentioned distinct overlapping depending of e values.

l.419. Please change to "4.3 Drainage network characteristics" or something similar. The word "Geomorphic" was not used in the Methods so to avoid confusion it would be better to not use it.

Answer and modifications: Changed

Please separate the longitudinal profile analysis and the paleolake levels in two different paragraphs with two individual headers.

Answer and modifications: We explained above why we cannot separate these results.

l.431. "Playa-lakes are located in Fig. 9 by numbering". Please change to "The location of the playa lakes is shown in Fig. 9."

Answer and modifications: Changed

l.505-508 Can be deleted. Does not provide any new or interesting data.

Answer and modifications: Deleted

Discussion

1. **512 it is important to…**

Answer and modifications: Changed

l.521. during the late Tortonian…above sea level.

Answer and modifications: Changed

l.539-544. Another sentence made up of 6 lines. Please separate in two or three full sentences.

Answer and modifications: We changed it accordingly:

“ There is consensus about the importance of post-Tortonian uplift in the western Betics and in the study area. Previous works measured the post-Tortonian uplift using geomorphic features related to previous sea level. They attributed 50-55% of the upper Miocene uplift (or all post-Messinian uplift) observed in the Guadalhorce watershed to an isostatic rebound, produced by differential erosion rates between Atlantic and Mediterranean watersheds provoked by the sea level drop in the Mediterranean watershed, a direct consequence of the MSC (Farines et al., 2015; Elez et al., 2016, 2020)”

Fig. 11. Not a good figure. Please delete.

Answer and modifications: We think that this figure allow readers to understand the evolution of the ADA. We have modified it according to the other reviewers comments.

l.590 Please do not place so much emphasis on the gateway closure. Instead, start the sentence with the tectonic part, then state something about the gateway closure and finish the sentence with the establishment of the drainage divide.

Answer and modifications: Thank you very much for your comments, we have rewritten the discussion according to these comments.

EDITOR

Dear authors,

we have now received comprehensive comments from a third reviewer. Before we can proceed with a final decision, we would like to ask you to address these comments carefully and revise the manuscript accordingly, please.

In support of the reviewer's general call for refocusing the work on the tectonic aspects of the research, I would like to add an additional review request for the authors' consideration. Section 5 aims to estimate shortening rates from the finite shortening of folds between ~20 and 12 Ma. These results are employed to ultimately estimate uplift rates. However, how the finite shortening was obtained is not documented. Cross-sections and fold asymmetry are mentioned. Please, consider presenting and discussing these in the article.

With the best wishes from Brisbane,

Christoph Schrank

Answer and modifications: Thank you very much for this comment. We have added an Appendix 1 with more information related to how uplift rates are estimated

For further information, we have included the reference where all variables are calculated for the TSZ: Díaz-Azpiroz et al., 2014.

Díaz-Azpiroz, M., Barcos, L., Balanyá, J. C., Fernández, C., Expósito, I., & Czeck, D. M. (2014). Applying a general triclinic transpression model to highly partitioned brittle-ductile shear zones: A case study from the Torcal de Antequera massif, external Betics, southern Spain. *Journal of Structural Geology*, *68*, 316-336.