RC1: 'Comment on egusphere-2023-3123', Ali Mohammadi, 11 Feb 2024

The manuscript “Miocene evolution of the NW Zagros foreland basin reflects SE-ward propagating tear of the Neotethys slab” by Koshnaw, Kley, and Schlunegger provides a set of new and important data about the Miocene foreland basin of the Iraqi part of Zagros Mountain range. The manuscript is well written and the multi-proxy data including isopach maps, subsidence curves, flexural profile modeling along with Bouguer gravity anomaly, tomography maps, and dynamic topography data, support the author's findings and their conclusions.

Adding a new chapter “Regional Tectonic Implications” and comparing and discussing some of the other foreland basins in the Tethyan belt makes it interesting for a wider community working on the collisional system of the Tethyan orogenic belt. For example, the Geological evolution of the South Sistan Basin (Sistan Suture Zone) and its Miocene foreland Basin (Karvandar Basin) in SW Iran are very similar to the author's studies foreland basin. The width of the foreland basin and sediment thickness increased toward the south and similar asthenosphere flow after the final collision occurred in the South Sistan Basin. Unlike Zagros, there are limited studies in the Sistan Basin. However, I think the brief discussion of similarities between Zagros and the Sistan Foreland Basin (Karvandar Basin) would further support the author's findings. These two papers would be helpful in this case.

Mohammadi, A., Burg, J.P., Bouilhol, P. and Ruh, J., 2016. U–Pb geochronology and geochemistry of Zahedan and Shah Kuh plutons, southeast Iran: Implication for closure of the South Sistan suture zone. Lithos, 248, pp.293-308.

Ruh, Jonas Bruno, Luis Valero, Mohammad Najafi, Najmeh Etemad-Saeed, J. Vouga, Ali Mohammadi, Fabio Landtwing, Marcel Guillong, Miriam Cobianchi, and Nicoletta Mancin. "Tectono-Sedimentary Evolution of Shale-Related Minibasins in the Karvandar Basin (South Sistan, SE Iran): Insights From Magnetostratigraphy, Isotopic Dating, and Sandstone Petrology." Tectonics 42, no. 11 (2023): e2023TC007971.

Dear R1 (Ali Mohammadi),

Thank you for your helpful comments. We agree that providing relevant foreland bain examples will enhance the manuscript. In accordance with your suggestion, we added the following text to the discussion section 5.2 (line 620-630):

Along the Tethyan realm, the effects of the lithosphere dynamics on the surface geology have been documented in the Alpine Molasse basin, which led to a change in basin stratigraphy from the Flysch stage to the Molasse stage (Sinclair, 1997; Schlunegger and Kissling, 2022), Apenninic basin that controlled foredeep migration (Meulen et al., 1998), and in the Mediterranean region, where the eastern part is influenced by slab detachment and resulted in the switching of volcanism's geochemical character from calk-alkaline to alkaline (Wortel and Spakman, 1992). To the southeastern frontier of the Zagros orogenic belt, north of the Makran accretionary complex, the Karvandar basin adjacent to the South Sistan Suture Zone (SE Iran) contains 3.5 km shallow-marine to nonmarine rocks. The Karvandar basin is interpreted to represent a peripheral foreland that underwent a renewed phase of subsidence ∼10–15 Myr after the Sistan Suture Zone development, possibly due to slab rollback of the downgoing plate and lithospheric mantle delamination of the overriding plate (Mohammadi et al., 2016; Ruh et al., 2023).

In addition, please instead of review papers, cite the original papers. For example, in the caption of Fig. 9

“present-day width of the Makran accretionary wedge (~500-300 km; e.g., Burg et al. 2018)” Please cite:

McCall, G.J.H., 1997. The geotectonic history of the Makran and adjacent areas of southern Iran. Journal of Asian Earth Sciences, 15(6), pp.517-531.

Or Farhoudi, G. and Karig, D.E., 1977. Makran of Iran and Pakistan as an active arc system. Geology, 5(11), pp.664-668.

Now "Farhoudi and Karig, 1977" is cited in the caption of Fig. 9

Some recent papers about the timing of the collision support the Late Oligocene Arabia-Eurasia continental collision. It's worth citing them too. For example:

Cai, F., Ding, L., Wang, H., Laskowski, A.K., Zhang, L., Zhang, B., Mohammadi, A., Li, J., Song, P., Li, Z. and Zhang, Q., 2021. Configuration and timing of collision between Arabia and Eurasia in the Zagros collision zone, Fars, southern Iran. Tectonics, 40(8), p.e2021TC006762.

In the Tectonostratigraphic context section, the new text below is introduced to provide that rationale for the preferred age of collision in the NW Zagros, and the relevant papers are cited.

Various ages for the Arabia-Eurasia collision have been suggested, spanning from the late Cretaceous to the Pliocene (Dewey et al., 1973, 1986; Berberian and King, 1981; Stoneley, 1981; Dercourt et al., 1986; Hempton 1987; Alavi 1994; Agard et al. 2005, 2011; Fakhari et al. 2008; Ballato et al. 2011; Khadivi et al. 2012; McQuarrie and van Hinsbergen 2013; Saura et al. 2015; Gholami Zadeh et al., 2017; Pirouz et al., 2017; Darin and Umhoefer, 2022; Sun et al., 2023). However, as continental collision is a prolonged process, the onset and culmination of the process need to be distinguished. Additionally, the collisional age must agree with well-constrained global paleotectonic models and geologic records. Continental collision is defined by the total subduction of oceanic crust between two continental crusts (Dewey and Horsfield, 1970). In the NW Zagros belt, considering the Arabia-Eurasia collisional age older than Oligocene is less likely due to (1) the necessity for unrealistically long post-collisional subduction of the Arabian continental crust beneath Eurasia (e.g., McQuarrie and Hinsbergen, 2013) and (2) the pervasive occurrence of oceanic crust subduction-related magmatism during Paleocene and Eocene (e.g., Chiu et al., 2013). Considering the Arabia-Eurasia collisional age younger than Oligocene, does not account for lines of evidence from provenance, geochronology, and thermochronology studies, and timing crustal deformation as well as regional tectonostratigraphic observations (Allen and Armstrong, 2008; Koshnaw et al., 2019, 2021; Cai et al., 2021; Song et al., 2023).

RC2: 'Comment on egusphere-2023-3123', Anonymous Referee #2, 06 May 2024

Based on the isopach maps, subsidence curves, and reconstructions of flexural profiles, supported by Bouguer anomaly data and maps of dynamic topography and seismic tomography, the authors discussed the intricate interplay between deep earth dynamics and surface processes, and then proposed a two-stage evolution of the NW Zagros foreland basin from flexural subsidence to dynamic subsidence. Moreover, the authors suggested that the subsidence of the Zagros foreland basin was triggered by surface loading and slab subduction during the early Miocene, and the tear propagation of the NeoTethys horizontal slab during the late Miocene.

Overall, this manuscript exhibits a high level of organization and clarity in its presentation. I would suggest a middle revision before final acceptance.

General comments:

1. The authors proposed the notion of northward flow of the Afar plume, drawing from the spatial distribution analysis of the crystallization age of mantle magmatism (Ball et al., 2021; Fig. 7). However, it's important to note that the spatial distribution analysis provided may not be comprehensive. There are many Late Eocene mantle magmatic outcrops in Iran (e.g. Deevsalar et al., 2018, JGS), which are missing in Fig. 7c. Therefore the evidence supporting this northward flow remains uncertain.

If the authors maintain their stance on the northward flow of the Afar plume, it is essential that they provide additional evidence to support their claim. This could include a comparative analysis highlighting the similarities and differences between plume-derived magmatism and other types of mantle sources. For instance, it would be valuable to discuss how mantle-derived magmatism resulting from processes like slab break-off, slab tearing, and sub-parallel subduction of the NeoTethys ridge can be distinguished from plume-related magmatism.

Dear R2 (Anonymous),

Thank you for your supportive and constructive comments:

We proposed a northward flow of the Afar plume based on the distribution of mantle magmatism, upper mantle structure as imaged by teleseismic, and fast velocity polarization orientation analysis (SKS splitting) as documented in previous publications (Camp and Roobol, 1992; Ershov and Nikishin, 2004; Faccenna et al., 2013; Kaviani et al., 2018). We agree that further geochemical synthesis will enhance the manuscript, but it may deviate from the focus of our manuscript, which basin analysis.

Indeed the plotting of the 20 (?) samples from Deevsalar et al. (2018) is not included, but the plotted complication from Ball et al., 2021 represents 4443 samples of alkaline and sub-alkaline mafic and ultramafic rocks. Furthermore, the samples from Deevsalar et al. are located in the central part of the Zagros, away from the northwestern segment, which is the focus of this study.

2. The timing of continental collisions is a topic fraught with controversy. While the authors have chosen to adopt the Oligocene time frame in the text and Fig. 4, it would enhance the logical flow of the discussion to provide a comprehensive summary of the various proposed collision times. Furthermore, it would be beneficial for the authors to elucidate the criteria used to select the Oligocene time frame as the preferred collision time, thereby providing readers with insight into the rationale behind this decision.

In the Tectonostratigraphic context section, the new text below is introduced to provide that rationale for the preferred age of collision in the NW Zagros, and the relevant papers are cited.

Various ages for the Arabia-Eurasia collision have been suggested, spanning from the late Cretaceous to the Pliocene (Dewey et al., 1973, 1986; Berberian and King, 1981; Stoneley, 1981; Dercourt et al., 1986; Hempton 1987; Alavi 1994; Agard et al. 2005, 2011; Fakhari et al. 2008; Ballato et al. 2011; Khadivi et al. 2012; McQuarrie and van Hinsbergen 2013; Saura et al. 2015; Gholami Zadeh et al., 2017; Pirouz et al., 2017; Darin and Umhoefer, 2022; Sun et al., 2023). However, as continental collision is a prolonged process, the onset and culmination of the process need to be distinguished. Additionally, the collisional age must agree with well-constrained global paleotectonic models and geologic records. Continental collision is defined by the total subduction of oceanic crust between two continental crusts (Dewey and Horsfield, 1970). In the NW Zagros belt, considering the Arabia-Eurasia collisional age older than Oligocene is less likely due to (1) the necessity for unrealistically long post-collisional subduction of the Arabian continental crust beneath Eurasia (e.g., McQuarrie and Hinsbergen, 2013) and (2) the pervasive occurrence of oceanic crust subduction-related magmatism during Paleocene and Eocene (e.g., Chiu et al., 2013). Considering the Arabia-Eurasia collisional age younger than Oligocene, does not account for lines of evidence from provenance, geochronology, and thermochronology studies, and timing crustal deformation as well as regional tectonostratigraphic observations (Allen and Armstrong, 2008; Koshnaw et al., 2019, 2021; Cai et al., 2021; Song et al., 2023).

Detailed comments:

1. The conclusion section could benefit from some refinement. The authors may consider restructuring it with a series of concise paragraphs following a brief summary to enhance clarity and reader comprehension.

The conclusion section is extensively edited and organized into two paragraphs.

2. The font size in some figures appears to be too small, such as the well names in Fig. 5 and the age legend in Fig. 7c.

The font size in both figures has been updated.

3. The reference list requires updating.

The reference list has been updated.