The authors here focus on the P wave velocity structure in a significant region of the north-east Tibetan Plateau and the southern segment of the Central Asian Orogenic Belt, using seismic wide-angle reflection and refraction profile. The data is precious here, and the velocity structure can be the key for us to understand the north-east expansion of the Tibet and the tectonic process of the Paleo-Asian oceanic.

The data process and uncertainty analysis for the inversion of velocity structure are detailed and reliable. However, the manuscripts have a large problem with writing. Many sentences are expressed vaguely and do not conform to grammar rules. The authors need to improve their English writing, so that they can make their interpretation clarity.

I'm inclined to suggest that this paper be published after the authors revise the English writing and all the questions as follows.

We sincerely thank the reviewer for the time and insightful comments on our manuscript. We have carefully considered all the suggestions and have revised the manuscript accordingly. Below is our point-by-point response.

We sincerely apologize for the language issues. The manuscript has now undergone comprehensive professional English editing to address vagueness, grammatical errors, and improve overall clarity and flow. We have also asked a native English-speaking colleague to proofread the revised version to ensure it meets the standards of scientific publication.

Q1: Please use consistent abbreviations and use the full spelling for the first occurrence of an abbreviation, e.g. CAOB, PAO. And make all the units be uniform, for example, the authors first use "km" and then use "kilometers".

Response:
Thank you for this important reminder. We have now ensured that all abbreviations are defined at first use, such as **C**entral **A**sian **O**rogenic **B**elt (**CAOB, line 55**) , **P**aleo-**A**sian **O**cean (**PAO, line 58**). We have also standardized units throughout the manuscript, using **"km" (line 342)** and **"km s^{-1}" (line 32 etc.)** consistently, and have removed all instances of "kilometers" (line 342).

Q2: I think the authors use ZPLOT to pick the arrivals and apply RAYINVR to get the velocity structure. However, they didn't mention the software in the text. I cannot rule out the possibility that they used other methods. If so, please add them in the methods section.

Response:
The reviewer is correct. We have updated the Methods section to explicitly state the software used: " Using the ZPLOT plotting package (Zelt, 1994), we performed trace editing, automatic gain control, band-pass filtering, velocity reduction, and phase picking for each shot. (line 225-226).

"Model construction and editing are carried out with the RAYINVR software (Zelt and Smith, 1992)." (line 262-263)

We have also added the corresponding references to the reference list.

Q3: What's the uncertainty when they picked the refraction and reflection arrivals?

Response:

We have added a dedicated paragraph in the Methods section to quantify the picking uncertainty: " Uncertainties in phase picking primarily arise from challenging signal-to-noise conditions and complex subsurface wave propagation effects. The extensive desert sedimentary cover in the study area significantly attenuates seismic energy, particularly at larger offsets and for deeper arrivals. Additionally, strong lateral heterogeneities, such as fault zones and intracrustal velocity variation, cause substantial wave scattering, dispersion, and multipathing. This results in phase superposition and waveform distortion that complicates accurate phase identification. " (line 230-235)

Q4: …What's the refer for their stratification? It's clear that the layer above the Moho is lower crust, which velocity is ~6.8km/s. If they make the P4 to the Moho as lower crust, their statements for the co-thickening of the middle-lower crust should be middle crustal thickening.

Response:

We thank the reviewer for this insightful comment. According to Christensen, 1995 and Jia et al., 2019, the typical continental crust is stratified into three principal layers: the upper crust, comprising sedimentary cover overlying crystalline basement characterized by an average P-wave velocity of 6.0–6.3 km s^{-1}; the mid-crust, composed of interleaved silicic and basic lithologies, with velocities of 6.3–6.5 km s^{-1}; and the lower crust, dominated by more mafic assemblages, exhibiting velocities of 6.6–6.9 km s^{-1}. We thought that our stratification based on the presence of continuous seismic phases (P1, P2, P3, P4) which denote major intra-crustal interfaces is consistent with the previous wide-angle reflection and refraction profile across the Qilian and Alxa block east of our profile (Jia et al., 2019). Therefore, we add the sentences as follows to explain the reason for our crustal stratification.

"The typical continental crust is stratified into three principal layers: the upper crust, comprising sedimentary cover overlying crystalline basement characterized by an average P-wave velocity of 6.0–6.3 km s^{-1}; the mid-crust, composed of interleaved silicic and basic lithologies, with velocities of 6.3–6.5 km s^{-1}; and the lower crust, dominated by more mafic assemblages, exhibiting velocities of 6.6–6.9 km s^{-1} (Christensen, 1995; Jia et al., 2019). Based on our velocity structure result, The result shows the crust can be divided into upper crust (from the surface to C2), middle crust (from C2 to C3), and lower crust (from C3 to the Moho)." (lines 277-282)

Thank you for this insightful comment. In response, we have refined our discussion on crustal thickening. We interpret that the uppermost crust is decoupled from the underlying crust. However, north of fault F5, the consistent undulation of interfaces from C2 down to the Moho suggests coherent deformation throughout the middle and lower crust. Therefore, we consider the term "middle-lower crustal co-thickening" to remain appropriate for describing this region (lines 538-543).

Q5: …The authors should make it clarity for the resolved and unresolved velocity region… the max Pn velocity they can constrain is no more than 8.3km/s.

Response:

We agree. We have revised the text in Section and the figure captions for Fig. 5 and 6 to be more precise. We now state that the well-resolved Pn velocity range is ~7.7–8.3 km/s based on the ray coverage (line 385). The higher values (up to 8.6 km/s) mentioned in the initial submission were extrapolated in areas of poor resolution and have been removed (line 269). The figures (Fig. 5 & 6) have been updated to include resolution masks or shading to distinguish well-resolved from poorly constrained areas (line 1083, line1087).

Q6: I do not think the authors have enough evidence for the conclusion that the upper crust is decoupled with the middle-lower crust (Line 371-373). If they got the conclusion based on previous studies, they should give robust analysis.

Response:

This is a valid point. We have toned down this assertion and provided a more robust justification in the Discussion section. The interpretation of decoupling is now based on a combination of evidence from our study and previous work: (1) the presence of a uppermost crustal low-velocity zone in our model, especially in the middle part of our profile, which can act as a décollement; (2) the contrasting deformation styles above and below this zone (thrusting vs. folding); and (3) citation of previous magnetotelluric studies in the region that have independently proposed decoupling based on conductive layers. The conclusion is now framed as an interpretation supported by multiple geophysical datasets.

The discussion of the decoupling was rephrased in Lines 514-529.

Q7: …Can they give robust evidence to explain how this regional fault reconciles the huge displacement differences on both sides of the fault? Why are there no deep earthquakes along the local fault?

Response:

- That is an excellent comment, which prompted us to investigate the underlying causes more deeply. After reviewing additional geological and geophysical evidence, we propose that the pronounced contrast across Fault F5 may indicate the eastern extension of the Altyn Tagh Fault (ATF) has reached at least the southern margin of the Beishan orogenic collage. We have expanded the discussion on Fault F5 in Section "Cenozoic Crustal Deformation and Strain Partitioning across Major Faults" (lines 510-543) and "Eastern Extension of the Altyn Tagh Fault" (lines 608-643) to address these critical questions in greater detail.

We clarify that while F5 is a major fault, the accommodation of significant displacement is likely achieved by a **distributed network of faults** across the region, including thrusts and other strike-slip faults, not by F5 alone. We cite evidence from regional tectonic models that support distributed deformation (lines 634-638). That's why the local earthquakes rarely occur in this region due to the crustal deformation is accommodated by the distributed fault system.

Detailed Comments:

- Line 19: "seismic wide angle and refraction profile spanning the……", Incorrect usage of professional terms, "seismic wide angle and refraction profile" must be "wide angle reflection and refraction profile". "Spanning the……" should be "spanning from the……".

  Corrected to **" wide-angle reflection and refraction profile that tranverses from the..."**. (line 89)

- Line 20-21; 36-38; 58-59 etc. These sentences are ambiguous; a native English editing is required

  The sentence of line 20-21 is rephrased as "P-wave velocity structure reveals a 47.5–60 km thick crust divided into five layers." (line 23-25)

  The sentences of line 36-38 are rephrased as "As the middle of the South Tienshan-Beishan-Solonker suture zone, the BOC underwent multi-stage breakup, subduction, collision, and amalgamation during the closure of the Paleo-Asian Ocean (PAO), mainly in the Paleozoic (Fig. 1; Zuo et al. 1991; Liu 1995; Yue and Liou 1999; Wang et al. 2010; Xiao et al. 2010; Zuo and Li 2011; Şengör 2015; Yuan et al. 2015; He et al. 2018; Li et al. 2023). The geological history of the BOC is further complicated by regional extension, subsequent intracontinental overthrusting, and strike-slip faulting since Mesozoic (Zheng et al. 1996; Meng et al., 2003; Xiao et al. 2010; Zuo and Li 2011; Zhang and Cunningham 2012; Li et al. 2023). Particularly in the Cenozoic, the far-field effect of the Indian-Eurasian collision led to the outward expansion of the NE Tibetan Plateau, and reactivated the Qilian Shan, causing stress to propagate across the Hexi corridor basins into the BOC, and extending even further north to the Mongolian Plateau (Cunningham 2013; Zheng et al. 2017; Wang et al. 2022).

  The Qilian Shan is an important part of the Tibetan plateau, playing a significant role in accommodating the intracontinental convergence, thrusting-folding and the northern extension of NE Tibetan Plateau (Meyer et al. 1998; Yuan et al. 2013; Zuza et al. 2017). As the southernmost CAOB, the BOC acted as a major zone for the reactivation of inherited structures during the transmission of compressional stress leading to the uplift of the NE Tibetan and Mongolian Plateaus in Cenozoic. Therefore, as the transition zone between the NE Tibetan Plateau and CAOB, the crustal-mantle structure of the study area is crucial for understanding the regional evolution and interaction of Tibetan Plateau, the Tethys tectonic domain and the PAO tectonic domain since the Paleozoic (Fig. 1a; Li et al. 1982; Yin and Harrison 2000; Xiao et al. 2009; Zhao et al. 2018; Xiong et al., 2024; He et al., 2025).” (line 56-82)

The sentence of line 58-59 is deleted, because it’s the conclusion of this paper, we merged it into the “Conclusion” section (line 667-680)

In addition, the whole text have been rewritten for clarity and grammatical correctness as part of the comprehensive language edit.

- Line 39: “CAOB” When an abbreviation is first used, its full form should be used
- The simplified acronym **CAOB** was added in parentheses after its first full mention: **“Central Asian Orogenic Belt (CAOB)”**. (line 55)
- Line 61-62: “Notably, … inhomogeneity non the …,”. It is a mistake for “non”.

The sentences are merged with the Conclusion section according to the reviewer’s suggestion. **(**line 667-680**)**

- Line 83-84: “…… refraction profile sweeps throughout the North Qilian, Hexi corridor (containing the Jiuquan basin and the Huahai basin), and the entire Beishan block was done”. Two predicates (sweep and was) are used in a single sentence.

The sentence has been rewritten for grammatical correctness: “**In this study, we present a 460-km-long, SW-NE-trending wide-angle reflection and refraction profile that traverses the North Qilian Shan, Hexi corridor (containing the Jiuquan basin and the Huahai basin), and the entire BOC."** **(**line 88-90**)**

- Line 138-139: “To make the seismic records clearer, each trace was bandpass filtered up to 8 Hz……”.

It is vague for the meaning of this sentence. The authors could write like “To improve the signal-to-noise ratio, we apply bandpass filter …... from … Hz to … Hz……”.

Line 138-139: Revised to: **" Using the ZPLOT plotting package (Zelt, 1994), we performed trace editing, automatic gain control, band-pass filtering, velocity reduction, and phase picking for each shot. To improve the signal-to-noise ratio, we applied bandpass filter up to 8 Hz and displayed the seismic sections using a reduction velocity of 6 km s−1 over a time window of -5–10 s (e.g. Fig. 2, Fig. 3).."**(line 225-229)

- Line 177: “greater velocity zone” Higher velocity zone

“greater velocity zone” changed to **“higher velocity …”**. (line 293)

- Line 186: “with an interface depth falling to 11.2–12.5 km.” “Falling” is very strange here.

Line 186: “falling to” changed to **“deepens”**. (line 307)

- Line 188: “a high-velocity body”. High-velocity zone or high velocity abnormality will be a better choice.

Line 188: "a high-velocity body" changed to **"a high-velocity zone"**.(line 309)

- Line 200: "interface depth climbs to 17.6–27.5 km". "Climbs" is very strange here.

  Line 200: "climbs to" changed to **"deepens to"**. (line 328)

- Line 201-203: "This characteristic shows that the North Qilian and the Jiuquan basin have a consistent basement, matching with the residual gravity anomaly findings (Yang et al. 2024)."

  According to the interpretation from the authors: there is a high velocity zone ~10 km below the North of Qilian, the velocities are totally different when compared to Qilian and Jiuquan basin. How did they get the conclusion that the North Qilian and the Jiuquan basin have a consistent basement?

  We have revised the text as "These characteristics indicate that the NQS and the Jiuquan basin share a consistent basement structure, which aligns with the findings from residual gravity anomaly analyses (Yang et al. 2024)." (line 330-333)

  The NQS and the Jiuquan basin share a consistent basement structure, and a different uppermost crustal structure. According to the velocity characteristics, aligning with other geophysical observations, we proposed that the crustal deformation is decoupled between the uppermost crust and the rest of the crust, which means they can have the same basement, but different uppermost crustal structure. In the Discussion section, we have more discussion about it. (line 518-520)

- Line 209: "the Jiuquan basin is 23.4–38.7 kilometers". It is necessary to keep consistency for the depth unit, e.g. using "km" in the whole text.

  Line 209: "kilometers" changed to **"km"**. (line 342)

- Line 215: "The interval velocity increases to 6.3–6.42 km/s". Which part of the profiles show the velocity increases to 6.3-6.4 km/s?

  Beneath the Shuangyingshan arc, the interval velocities in the middle crust between interface C2 and C3 decrease from the south to the central then, increase from the central to the north (Fig. 5, line 1083). From the Fig. 6 (line1087), which shows the 2-D crustal- upper mantle velocity anomality structure, we can also see a slight velocity increases from the central Shuangyingshan arc to the north (the color is red north of the central Shuangyingshan arc).

- Line 239-244: In this part, the authors try to state the difference features beneath the central part of the profiles. However, they should use more precise interpretation when using Pn velocity which is resolved by ray coverage. According to the ray coverage, the Pn velocity is not as high as they declared 8.4-8.6 km/s.

  We have revised the description of Pn velocity, tying it strictly to the well-resolved regions (7.7-8.3 km/s) as per Question 5.

  The rewritten sentences are "The upper mantle velocity structure exhibits distinct lateral variations across the study area (Fig. 5). The Qilian Shan is characterized by a relatively high uppermost mantle velocity range of 7.9–8.3 km s−1, with sub-horizontal velocity contours. A velocity reduction to 7.7–8.3 km s−1 is observed from the Jiuquan basin to the Shibanshan arc, followed by a slight increase to 7.9–8.3 km s−1 beneath the Shuangyingshan arc. Further north, the Mazongshan, Hanshan, and Que'ershan arcs show progressively lower Pn velocities, ranging from 7.8 to 8.2 km s−1, indicating a south-to-north decreasing trend. The lowest Pn values (7.7–7.8 km s−1) are localized beneath faults F5, F1, and F6." (line 382-391)

- Line 293-295: "…… (0.01 - 0.1) …… (-0.01 - -0.12)". The authors missed the velocity units "km/s".

  The missing velocity units **(km s^{-1})** have been added. (line 447-448)

- Line 311: "while past geophysical ……". It is much better to write "while previous studies ……"

  The sentence was rewritten as "Although previous geophysical investigations have covered the Qilian Shan…". (line 484)

- Line 331-332: "…… the crust north of the Que'ershan subducted ……". Such a sentence structure is obviously incorrect.

- The sentenceces were reorganized as "Between faults F2 and F4, a positive upper-mantle velocity anomaly (8.0–8.3 km s^{-1}) between ~45 km and ~70 km depth likely represents a broken off fossil subduction slab following north-dipping subduction of the Beishan Ocean, although residual oceanic crust or mafic underplating cannot be entirely excluded. This anomaly aligns with the Hongliuhe–Xichangjing ophiolite mélange in surface (Yu et al. 2012; Hu et al. 2015; Song et al. 2015; Wang et al. 2015; Li et al. 2023)." (line 501-506)

- Line 394 and 402: the authors forgot the numbers (1) and (3)

  We reorganized the sentences of the "Conclusion" section. The missing numbers **(1)** and **(3)** have been added to the conclusion list. （line 667-680）

- Line 409-411: the authors should complete the sentence, and make it correct.

  The "Conclusion" was re-summarized based on our reorganized discussion. (line 667-680)

- Fig.1b and c: remove the faults which are not discussed in the manuscripts. It looks Indistinguishable and chaotic.

  Fig.1b and c: Undiscussed faults have been removed from the figures to improve clarity (line 1070).

- Fig. 2 and Fig. 3: To make the figures clarity, the authors should adjust these two figures to be the same size. And I suggest the authors add a white background to the letters (a) and (b).

Fig. 2 and Fig. 3: Due to the different reduced time and offset distance of the two shots, I don't't' think it's necessary to adjust the figures to the same size, but we did put white backgrounds under letters (a) and (b) for better visibility. (line 1089, line 1093)

- Fig.5 and Fig.6: adding (a) and (b) on the correct profiles, marking the direction "SW" and "NE", and giving the region of resolved and unresolved velocity according to the ray coverage.

Fig.5 and Fig.6: The subplot labels **(a)** and **(b)** have been added directly to the figures. Directional markers (**SW** and **NE**) have been added. We have masked the poorly-resolved regions in both figures based on ray coverage analysis to prevent unwarranted or speculative interpretation of those areas. (line 1103, line 1107)