General Comment:

This manuscript presents a detailed investigation of the crustal-upper mantle velocity structure across the North Qilian Shan to the Beishan block using a 460-km-long seismic wide-angle reflection/refraction profile. The study provides valuable insights into the tectonic evolution of the northeastern Tibetan Plateau and the southern Central Asian Orogenic Belt (CAOB). The seismic profile is well-designed, and the processing techniques (e.g., phase identification, velocity modeling) are appropriately applied. The error analysis (e.g., RMS traveltime residuals) supports the reliability of the results. The proposed northward subduction polarity of the Qilian Ocean and the role of the southern Beishan boundary fault (F5) as a major strike-slip structure are significant contributions. The findings enhance understanding of crustal deformation mechanisms in the transition zone between the Tibetan Plateau and the CAOB. The data are robust, and the methodology is sound, but the manuscript requires improvements in clarity, interpretation, and presentation before it can be published finally:

Response:

We extend our sincere thanks to Prof. Xu for his positive evaluation of our work and for providing valuable suggestions. In response, we have undertaken a comprehensive revision of the manuscript aimed at enhancing its clarity, interpretive depth, and overall presentation. Specifically, we have rephrased both the Introduction and Discussion sections to improve logical coherence and scientific rigor. The detailed responses to each comment are provided below.

Q1: Terminology Consistency: Use either "Beishan block" or "Beishan orogenic belt" consistently. Define abbreviations (e.g., PAO, CAOB) at first use.

Response:

We have standardized the terminology throughout the manuscript, using **"Beishan orogenic collage"** (BOC, line 23) consistently, as it accurately reflects the complex accretionary nature of the region. All abbreviations, including **P**aleo-**A**sian **O**cean (PAO, line 58) and **C**entral **A**sian **O**rogenic **B**elt (CAOB), are now explicitly defined upon their first occurrence in the text The simplified acronym CAOB was added in parentheses after its first full mention: “Central Asian Orogenic Belt (CAOB)”. (line 55).

Q2: In lines 33–34 of the introduction, the sentences are overly complex or ambiguous; a thorough language edit by a native English speaker is recommended.

Response:

We have performed a comprehensive language edit of the entire manuscript with the assistance of a native English speaker. The sentences in lines 33–34 and similar complex passages throughout the introduction have been simplified and rewritten for improved clarity and readability. the original text of lines 33-34 has been revised to: " The NW-SE-trending Qilian Shan, situated in the NE Tibet, is bounded by the Altyn Tagh fault (ATF) to the west, the

northern Qaidam thrust system to the south, the Haiyuan fault to the east, and the north Qilian Shan fault to the north (Fig. 1b). The present-day Qilian Shan exhibits a Cenozoic fold-thrust belt with multi-stage tectonic deformation prior to the Cenozoic (Yin and Harrison 2000; Gehrels et al. 2003; Song et al. 2014; Wu et al. 2016; Zuza et al. 2017; 2019). North of the Qilian Shan, the Hexi corridor basins and the Beishan Orogenic Collage (BOC) form the southern section of the Central Asian Orogenic Belt (CAOB, Xiao et al., 2010; Li et al., 2023; Xiong et al., 2024)." **(line 48-56)**

The whole Introduction section was reorganized in line 48-95.

Q3: For figure captions: Fig. 1: Add scale bars and clarify tectonic unit labels; Fig. 5-6: Improve visibility of velocity contours and annotations.

Response:
We have revised all figures as suggested:

- **Fig. 1:** Scale bars have been added, and all tectonic unit labels have been clarified and made consistent with the text (line 1072).
- **Fig. 5 & 6:** The visibility of velocity contours and annotations has been enhanced by adjusting line weights, colors, and font sizes. Poorly-resolved areas based on ray coverage have been masked to prevent overinterpretation (line 1103, line 1107).

Q4: Compare results with existing seismic/gravity/MT studies (e.g., Cui et al., 1995; Xiao et al., 2017) to strengthen interpretations. Discuss potential biases (e.g., ray coverage gaps, trade-offs between velocity and interface depth).

Response:
A new subsection has been added to the **Discussion Section** to compare our findings with existing geophysical studies:

- Our velocity model is now compared with results from Cui et al. (1995), Xiao et al. (2015), and other key seismic, gravity, and magnetotelluric (MT) models. This comparison strengthens our interpretations of crustal nature of the Beishan Orogenic Collage (line 459-470).
- We explicitly discuss potential biases and limitations, including **ray-density gaps** and the velocity–interface trade-off in seismic inversion. (line 271-276)

Q5: In the "Discussion" section, compare results with existing seismic/gravity/MT studies (e.g., Cui et al., 1995; Xiao et al., 2017) to strengthen interpretations. Provide more geological evidence (e.g., paleo-trench positions, slab remnants) to support the north-dipping Qilian Ocean model.

Response:

As noted in Q4, we have expanded the **Discussion section** to include direct comparisons with previous geophysical studies. Furthermore, we have integrated additional **geological evidence** to support the north-dipping subduction model for the Qilian Ocean:

- The positive upper-mantle velocity anomaly we identify is discussed as a potential **slab remnant**, linking it to the north-dipping subduction and closure of the Beishan Ocean. This provides a more robust, multi-disciplinary foundation for our tectonic interpretations (line 484-506).

Q6: Update citations (e.g., Wu et al., 2024; Xie et al., 2023; Yao et al., 2025; Zhang et al., 2023) and include key regional studies (e.g., Zuza et al., 2019).

Response:

The reference list has been thoroughly updated to include the suggested recent publications (Wu et al., 2024; Xie et al., 2023; Zhang et al., 2023,in line 609-611) and key regional studies (Zuza et al., 2019; in line 157, 480,540). All in-text citations have been checked for consistency and relevance. The reference list now comprehensively reflects the current state of knowledge in the field.

Detailed Comments and Corrections:

- **Line 1-3 (Title):** Modified to: **"Crustal-Upper Mantle Velocity Structure from the North Qilian Shan to the Beishan Block: Tectonic Significance of Crustal Deformation"**.

  We adopted this suggestion, the title was changed to "Crustal-upper mantle velocity structure from the North Qilian Shan to Beishan Orogenic Collage: tectonic significance of crustal deformation**" (line 2-3)**

- **Line 4-10 (Address):** Corrected extra commas (e.g., "Beijing 100094, China").

  We corrected it. (line 7-8)

- **Line 14:** "constitutes" → **"represents"**.

  We corrected it. (line 16)

- **Line 17:** "serves" → **"acts"**.

- **We rephrased this sentence as "**The crustal-mantle structure of the study area, a transition zone, is crucial to understanding the deep processes of accretion and crustal deformation.**"** (line 16)

- **Line 23:** "considerable variance" → **"significant variations (6.24–6.43 km/s)"**.

We rephrased this sentence as "Average crustal velocities (6.24—6.43 km s^{-1}) and Pn values (7.7—8.1 km s^{-1}) reveal strong lateral heterogeneity." **(line 28-29)**

- **Line 35–36:** Rewritten for clarity: **"As a transition zone between the NE Tibetan Plateau and the CAOB, the crust-mantle structure of the study area is crucial for understanding..."**

  the crustal-mantle structure of the study area is crucial for understanding the regional evolution and interaction of Tibetan Plateau, part of 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 76-81)

- Line 43: "has witnessed" → "experienced"

  We reorganized the Introduction section as the reviewers suggested; this sentence was deleted. (line 98)

- **Line 48:** "Experiencing multi-stage breakup..." → **"The block underwent multi-stage breakup..."**

- We reorganized the Introduction section as the reviewers suggested; this sentence was deleted. (line 102)

- **Line 138:** "To make... clearer" → **" To improve the signal-to-noise ratio, we applied each trace was bandpass filtered up to 8 Hz and displayed..."**

  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 141:** "first arriving phase" → **"first-arrival phase"**.

  It was corrected. (line 238)

- **Line 179:** "The base of interface C1 corresponds..." → **"Interface C1 marks the basement surface (3.4–6.5 km/s)..."**

  It was corrected. (line 296)

- **Line 202:** "Qilian and the Jiuquan basin" → **"the NQS and the Jiuquan basin"**.

- It was corrected. (line 352)

- **Line 257-258:** "are with negative" → **"show negative"**.

- It was corrected. (line 406)

- **Line 259:** "which are prevented by" → **"which terminate at"**.

  It was corrected. (line 407)

- **Line 264:** "dives northward" → **"extends northward"**.

  It was corrected. (line 413)

- **Line 267:** "C1and C3" → **"C1 and C3"**.

- It was corrected. (line 416)

- **Line 313:** "Our data demonstrates" → "Our data demonstrate"

  The Discussion section was rephrased. This sentence was rewritten as "we observed north-dipping velocity contour from interface C2 to the uppermost mantle beneath the Qilian Shan, coupled with a lower-crust–upper-mantle low velocity anomaly beneath the Hexi Corridor…" (line 486)

- **Line 315:** "We speculate that" → "We interpret this as"

  The Discussion section was rephrased; we rewrote this sentence as " These features most plausibly record early Paleozoic north-dipping subduction of the Qilian Ocean…"(line 488-489).

- **Line 338:** "could represent" → **"likely represents"**.

  It was corrected. (line 502)

- **Line 345:** "regarded as the youngest uplifted Mts." → "considered the most recently uplifted mountains"

  The Discussion section was rephrased; this sentence was deleted. (line 584)

- **Line 347:** "by a series" → **"through a series"**.

- The Discussion section was rephrased; this sentence was deleted. (line 585)

- **Line 381:** "was playing the function" → "functioned as"

  The Discussion section was rephrased; this sentence was deleted. (line 654)

- **Line 399:** "with the highest height" → "with the highest elevation"

  The Conclusion section was rephrased; this sentence was deleted. (line 686)

- **Line 402:** "is grouped" → "can be divided"

  The Conclusion section was rephrased; this sentence was deleted. (line 689)

- **Line 406:** "(3) Subduction..." → "Third, subduction..."

  The Conclusion section was rephrased; the numbering was reshaped. (line 667-680)

- **Line 408:** "(4) Bounded by..." → "Fourth, the F5 fault demarcates..."

  As the last question, the Conclusion section was rephrased; the numbering was reshaped. (line 667-680)