
Supplemental Materials

High-elevation orogenic plateau influences ecosystems

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1 Elevation and Moho depth estimation procedure using GAME

Ideally, the datasets ingested by the Geochemical Arc Moho Estimator app (GAME; Luffi and Ducea; ref. 2) should come from individual arc segments that are short enough to avoid significant along-strike Moho depth variations but long enough to remain unaffected by local disturbances of the isostatic equilibrium. Additionally, these datasets should span a short enough time interval of arc evolution to ensure that potentially significant thickness variations over time are captured. We attributed zircon U-Pb ages to each major and trace element dataset to facilitate the separation of sample sub-populations into subjectively predefined time intervals. The detailed division of arc segments is discussed in Section 2.

Sample grouping

The sample grouping process is essentially an optimization problem, with certain criteria driving us to maximize the number of samples in a group while others necessitate minimizing it. Although there is no straightforward or singular solution to this problem, a useful approach is to use the *Raw estimates* option in GAME. This allows for the calculation of elevations and Moho depths for individual samples, which can then be used for preliminary calculations. Plotting these raw estimates against spatial and temporal variables help determine how to partition the dataset for each examined arc. If these plots do not provide clear guidance, we proceed with more subjective decisions on how to group the samples within each arc to achieve meaningful subdivisions.

Data filtering

Samples with major element totals outside the 97–101 wt% range in general are considered significantly potentially altered and are by default discarded by GAME, as they may affect the final calculations. In order to use a statistically meaningful number of samples for each arc segment, we nevertheless slightly extend the acceptable major element totals to the 95–101wt% range for most crustal thickness calculations. MgO bin size was set to 1 wt% in order to obtain a more realistic data distribution across the modelled MgO range. Modern subduction zone magmatic rocks typically consist of a broad differentiation spectrum dominated by subalkaline compositions¹. In contrast, alkaline volcanics are numerically less common, unevenly distributed among different arcs, and commonly feature exotic trace element signatures². Therefore, samples with total alkali content exceeding the alkaline-subalkaline boundary by more than 1.5 wt% at any given SiO₂ value are automatically removed from the dataset. To maintain sufficient samples, we have slightly relaxed this limitation from 1.5 to 1.7 wt%. Samples with extreme mafic (SiO₂ < 45 wt%) and felsic (SiO₂ > 80 wt%) compositions are automatically discarded from the calculations². Before running GAME, we also exclude analyses that significantly deviate from common igneous differentiation trends, as

defined by major elements versus SiO₂ contents (Harker diagrams). These analyses may represent cumulates or cumulate-dominated rocks and may contribute to abnormal results in the calculations. One idea underlying GAME is that the robustness of a mohometer depends on how well it reproduces the model across wide differentiation intervals. When running GAME, it is essential to utilize as many MgO bins as possible while maintaining at least 10 to 15 mohometers in operation. By refining the data treatment and filtering, the resulting mean and median elevations and Moho depths are unlikely to change significantly, but the associated uncertainties may be different. By design, GAME computes elevations (h) directly from compositions and then, assuming isostatic equilibrium, it calculates Moho depths (H) using the formula: $H = 6.79 \times h + 26.40$ (Luffi and Ducea, 2022, eq. 17; ref. 2). For further details, the reader is referred to section 5.6.1. of Luffi and Ducea².

Medians + MAD (median absolute deviation) vs. Means + STD (standard deviation)

The GAME app provides two types of elevation and Moho depth results: Medians + MAD and Means + STD. Choosing between these options is crucial. Means with STD are appropriate for normally distributed data with negligible outlier effects. However, in GAME calculations, this may not hold true due to artificial sampling methods (MgO bins are delimited artificially, filters exclude data points artificially etc), which can leave significant outliers that affect precision. While the differences between median and mean estimates are in general minor, STD often exceeds MAD due to these outliers. For this reason, in this study we use Medians + MAD values.

2 The division of arc segments

Based on the data filtering principles and arc segment division strategy outlined in Sections 1, we have defined 10 arc segments in the Late Triassic–Early Cretaceous Northeastern Asia. For these arc segments, we calculated 26 paleo-elevation and crustal thickness values across different time periods (see Figure S2; Table S3).

Jiaodong Peninsula (JDP) arc segment: Jiaodong Peninsula is geographically separated from the Liaodong Peninsula and Taihangshan by the Bohai Bay Basin. The Early Cretaceous Paleo-Pacific subduction resulted in extensive Early Cretaceous magmatism in the Jiaodong Peninsula^{3, 4, 5}. Based on limited data filtering, we have divided the Jiaodong Peninsula arc segment into two distinct periods at ~133–125 Ma and ~125–110 Ma (Figures S2–4–5; Table S3).

Korea Peninsula (KP) arc segment: Due to the lack of published data on whole-rock major and trace element data from North Korea, the data available for the Korea Peninsula are primarily collected from South Korea. Consequently, we have divided the Korea Peninsula arc segment based on the data collected from South Korea alone. The southern Korean Peninsula experienced magmatic flare-ups during the Early–Middle Jurassic and the late Early Cretaceous–early Late Cretaceous

periods, which are associated with the Paleo-Pacific Plate subduction^{6, 7, 8, 9, 10}. Based on the available data and potentially significant elevation and crustal thickness variations over time by the averaging process, we divided the Korea Peninsula arc segment into three distinct periods: ~192–179 Ma, ~179–165 Ma, and ~112–109 Ma (Figures S2–6–7–8; Table S3).

Taihangshan (THM)-Yanshan Mountains (YSM)-Southern Great Xing'an Range (SGXR)-Northern Great Xing'an Range (NGXR)-Erguna Block (EGN) arc segments: The Taihangshan is primarily dominated by early Early Cretaceous magmatism (Figure 1). In contrast, the Yanshan Mountains and Great Xing'an Range experienced widespread Middle Jurassic–Early Cretaceous magmatism (Figure 1). Meanwhile, the Erguna Block is characterized by continuous Triassic–Early Cretaceous magmatism (Figure 1). The Jurassic–Early Cretaceous magmatism distributed in the Taihangshan and Yanshan Mountains is attributed to the coeval subduction of the Paleo-Pacific^{11, 12}. In the Great Xing'an Range and Erguna Block, Late Triassic–Jurassic magmatism is linked to both the subduction of the Paleo-Pacific Plate and the closure of the Mongol-Okhotsk Ocean^{13, 14, 15}. Conversely, the Early Cretaceous magmatism in these regions is associated with the ongoing subduction of the Paleo-Pacific Plate^{14, 15}.

Geospatially, the plot of individual Moho depth versus latitude for the Early Cretaceous THM-YSM-SGXR-NGXR-EGN arc segments reveals a noticeable variation in crustal thickness along the THM-YSM-SGXR-NGXR-EGN direction (Figures S2–16–17–20–21; Table S3). The southern Taihangshan and southern Great Xing'an Range exhibit a relatively shallow Moho, whereas the Yanshan Mountains, Northern Great Xing'an Range, and Erguna Block show a deeper Moho (Figure S2). Based on these results, we have divided the THM-YSM-SGXR-NGXR-EGN magmatic arc into four distinct arc segments: the Southern Taihangshan arc segment, the Yanshan Mountains arc segment, the Southern Great Xing'an Range arc segment, and the Northern Great Xing'an Range and Erguna Block arc segment. The plot of individual Moho depth versus latitude for the Jurassic SGXR-NGXR-EGN arc segments reveals some variation in Moho depth (Figures S2–15–19; Table S3). The Moho depth of the Jurassic Southern Great Xing'an Range is shallower compared to that of the Northern Great Xing'an Range and Erguna Block (Figures S2–15–19; Table S3), as well as the Yanshan Mountains (Figures S2–11–12; Table S3). Therefore, we have divided the YSM-SGXR-NGXR-EGN magmatic arc into three distinct arc segments: the Yanshan Mountains arc segment, the Southern Great Xing'an Range arc segment, and the Northern Great Xing'an Range and Erguna Block arc segment.

In terms of geological time, considering the limited major and trace element data and the potentially significant crustal thickness variations over time due to averaging process, we have divided the Taihangshan magmatic arc into three segments: Southern Taihangshan (135–125 Ma),

Northern Taihangshan (146–138 Ma), and Northern Taihangshan (133–120 Ma). Analyses from some alkaline and mafic magmatic rocks have been excluded from the final crustal thickness calculations (Figures S2–1–2–3; Table S3). For the Yanshan Mountains, the plot of individual Moho depth versus crystallization age does not show significant variations in Moho depths (Figures S2–11–12–13–14; Table S3). After excluding some analyses that fall into the alkaline region or exhibit characteristics of mafic magmatism, we have subdivided the Jurassic–Cretaceous Yanshan Mountains magmatic arc into four segments: Yanshan Mountains (173–160 Ma), Yanshan Mountains (160–150 Ma), Yanshan Mountains (140–125 Ma), and Yanshan Mountains (125–120 Ma). Most analyses from the Southern Great Xing’an Range exhibit consistent igneous differentiation trends (Figures S2–15–16–17). We have divided the Jurassic–Early Cretaceous Southern Great Xing’an Range magmatic arc into three time intervals: Southern Great Xing’an Range (160–140 Ma), Southern Great Xing’an Range (140–130 Ma), and Southern Great Xing’an Range (130–120 Ma). North China Craton and Siberia Craton have similar paleolatitudes since ca. 160 Ma, implying that final closure of the Mongol–Okhotsk Ocean in the eastern segment occurred after that time. Therefore, excluding the magmatic rocks younger than 160 Ma from the Northern Great Xing’an Range and Erguna Block, we identified four magmatic arc segments in different periods: Northern Great Xing’an Range and Erguna Block (206–186 Ma), Northern Great Xing’an Range and Erguna Block (180–160 Ma), Northern Great Xing’an Range and Erguna Block (143–128 Ma), and Northern Great Xing’an Range and Erguna Block (128–112 Ma). These arc segments exhibit significant variations in crustal thickness (see Figures S2–18–19–20–21; Table S3).

Songliao Basin (SB) arc segment: The Songliao basin is one of the major intra-continental rift basins along the eastern Asia continental margin (Figure 1; ref. 16), and experienced intense magmatism during the late Early Cretaceous syn-rift stage, attributed to the slab roll-back processes of the Paleo-Pacific plate^{17, 18, 19}. The data available from the late Early Cretaceous magmatism, primarily collected from the central Songliao Basin through oil drilling exploration, support the ~115–102 Ma Songliao Basin arc segment (Figures S2–22; Table S3).

Liaodong Peninsula (LDP)-Zhangguangcai Range (ZGR)-Jiamusi Block (JB) arc segments: Geospatially, the Liaodong Peninsula is situated far from the Zhangguangcai Range and Jiamusi Block. The plots of Early Cretaceous individual Moho Depth versus latitude, longitude, and crystallization age from the Liaodong Peninsula exhibit no significant temporal and spatial variation. Therefore, the Early Cretaceous arc magmatism of Liaodong Peninsula can be considered as a distinct arc segment, subdivided into two time intervals at ~135–125 Ma and 124–116 Ma (see Figures S2–9–10; Table S3). The collision between the Jiamusi Block and Songliao Block occurred during the Middle–Late Jurassic^{20, 21, 22}, which excluded the Middle–Late Jurassic magmatic rocks

found in the Zhangguangcai Range in the calculations. The plot of Late Triassic–Middle Jurassic individual Moho Depths versus crystallization ages shows a significant trend, potentially indicating crustal thickening (see Figures S2–23–24–25; Table S3). To account for the significant crustal thickness variations over time, we subdivided the ZGR-JMB arc magmatism into three time intervals at ~210–196 Ma, ~196–184 Ma, and ~183–173 Ma (see Figures S2–23–24–25; Table S3). Additionally, we calculated the crustal thickness for the ~113–100 Ma arc segment of ZGR-JMB (see Figures S2–26; Table S3).

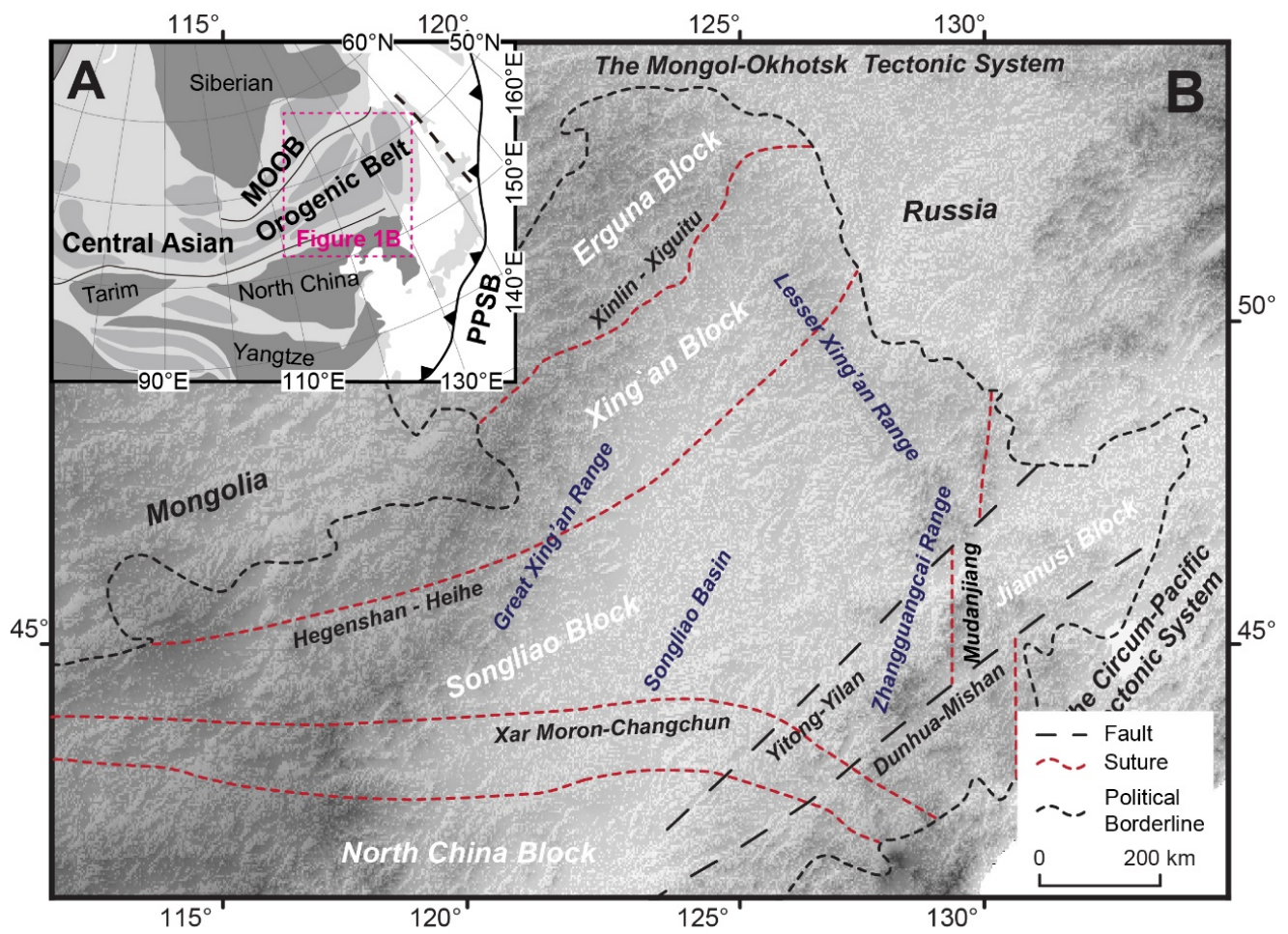
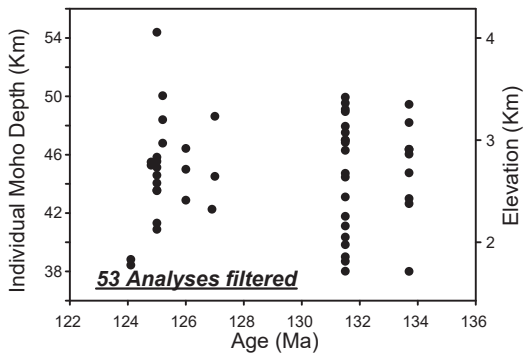


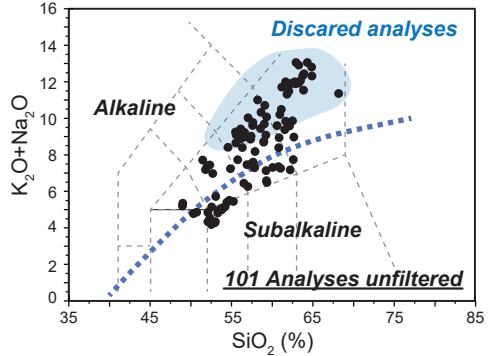
Figure S1.

A: Schematic tectonic subdivision of the Eurasian continent, modified after [Liu et al.²³](#). B: Regional tectonics and tectonic subdivision of Northeastern Asia, major faults are modified after [Wu et al.²⁴](#).

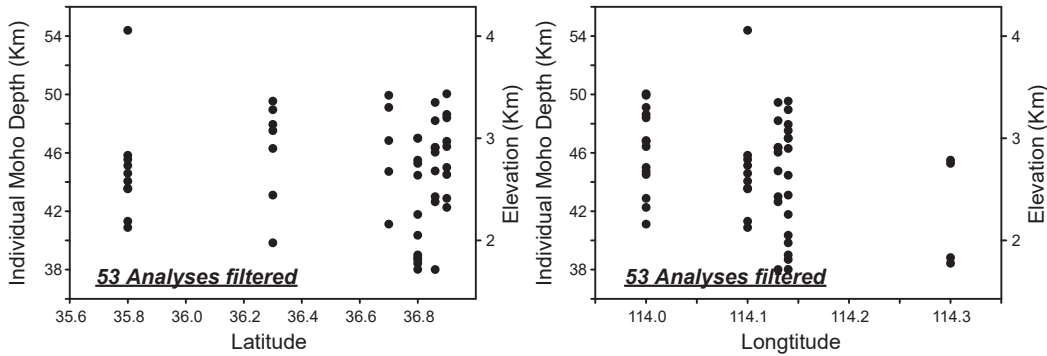
Individual Moho Depth vs. Age (135-125 Ma)



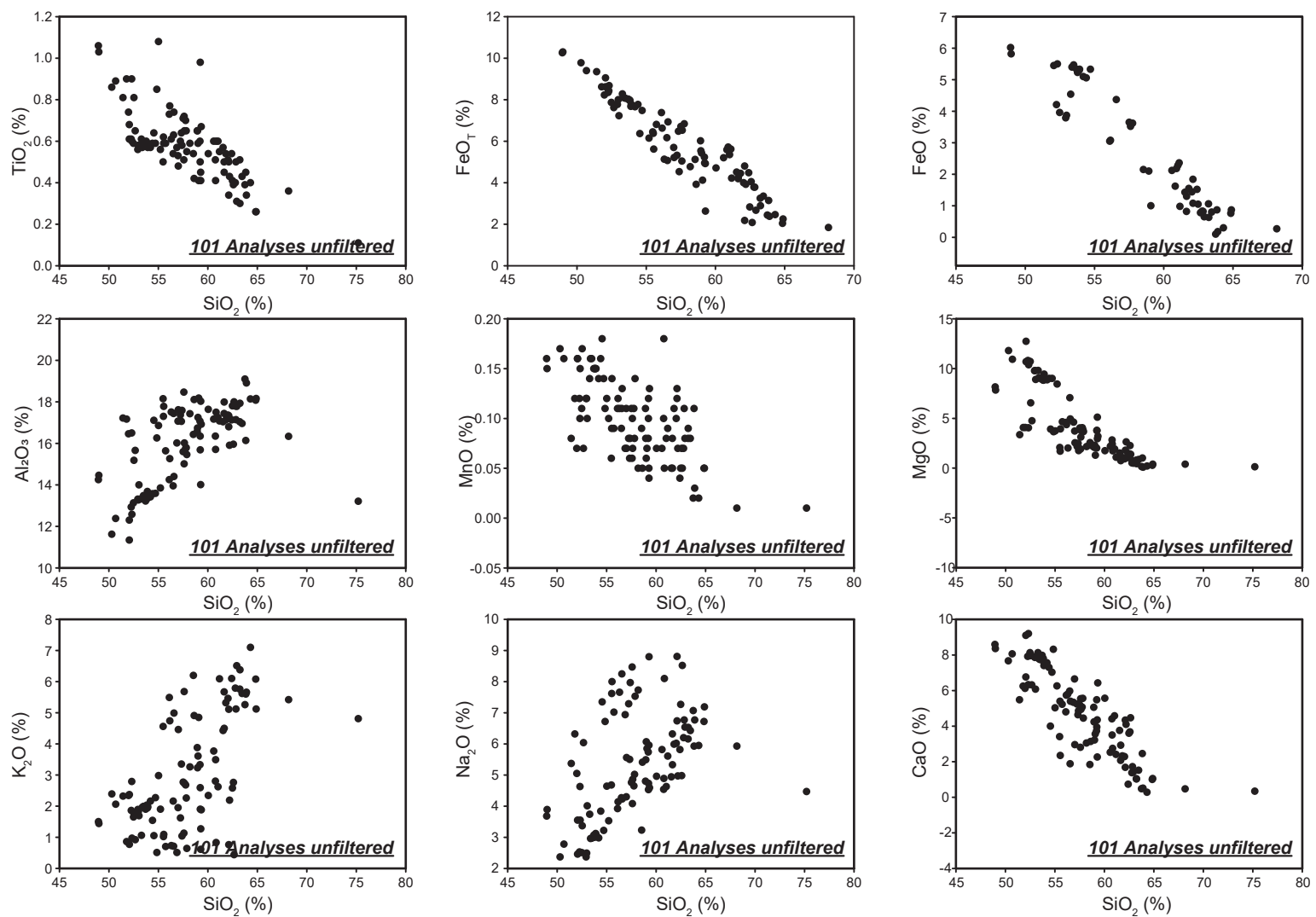
TAS diagram (135-125 Ma)



Individual Moho Depth vs. Longitude and Latitude (135-125 Ma)



Harker Diagrams (135-125 Ma)



Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the εmax limitation

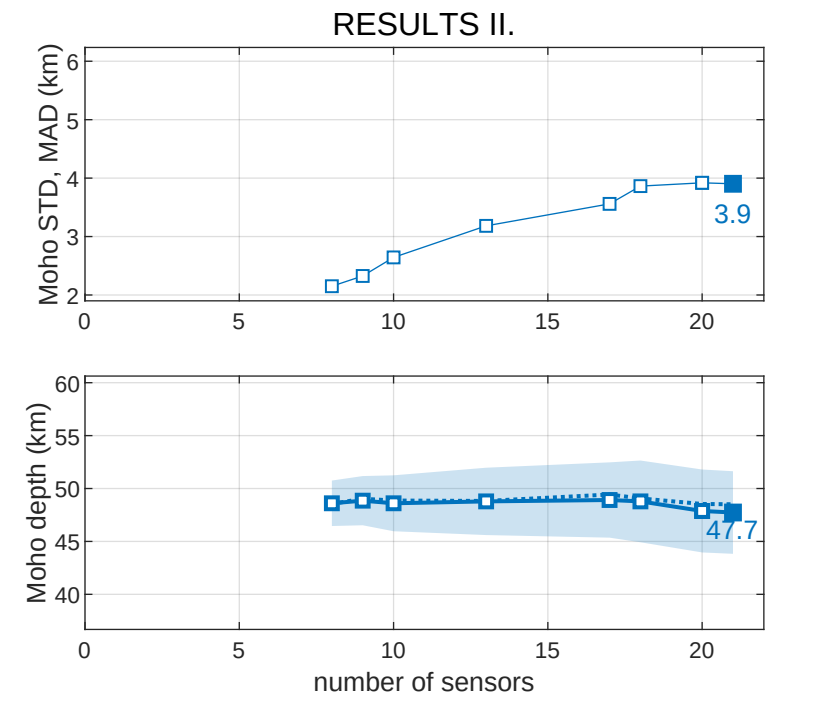
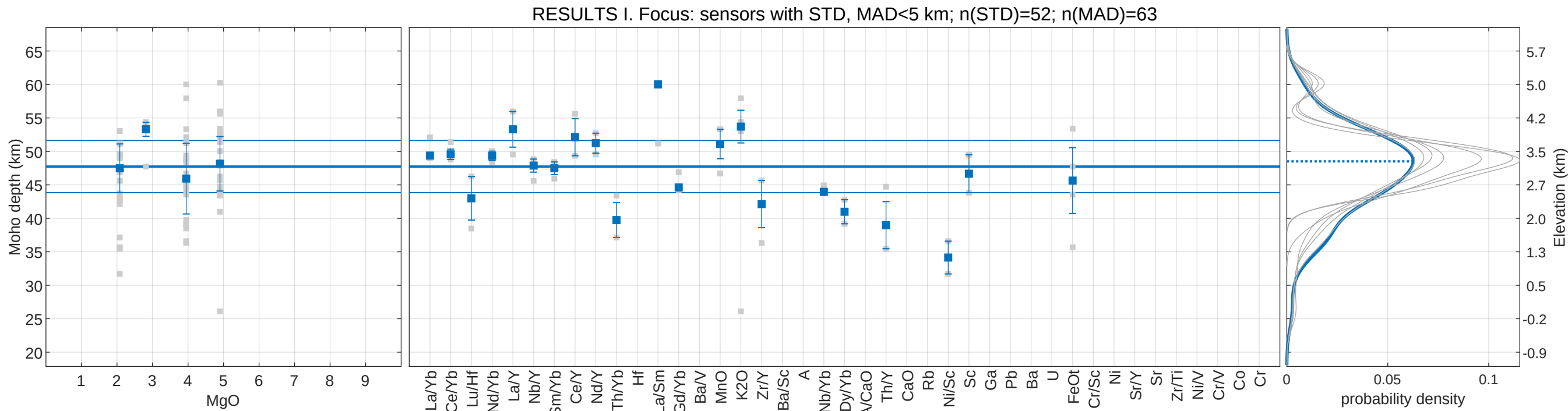
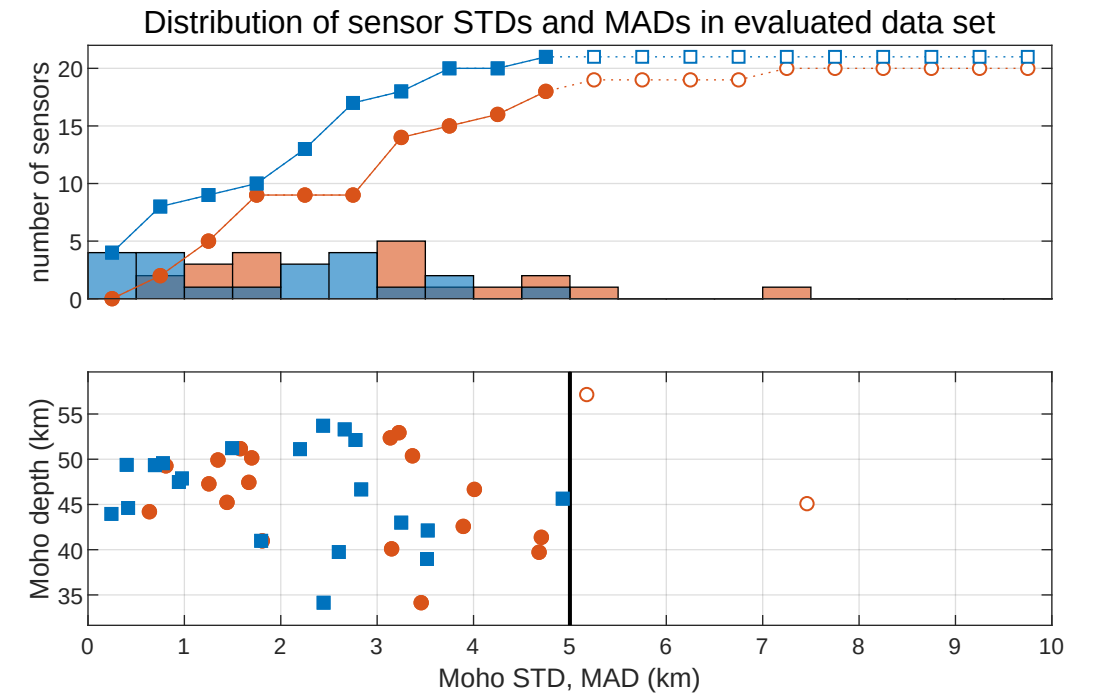
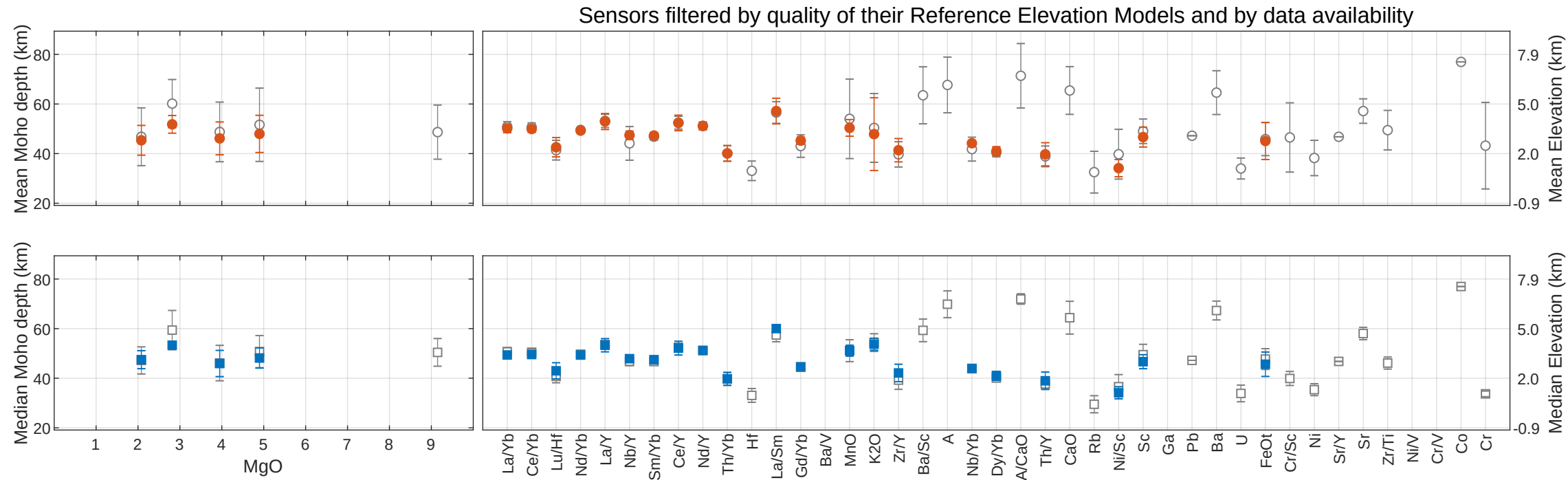
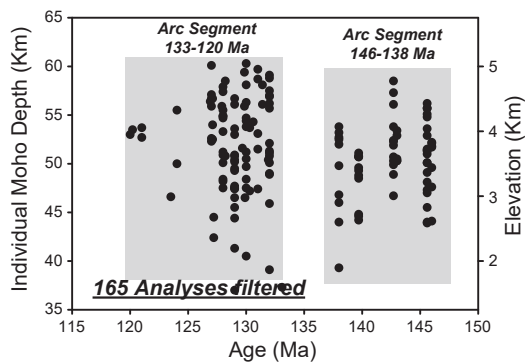


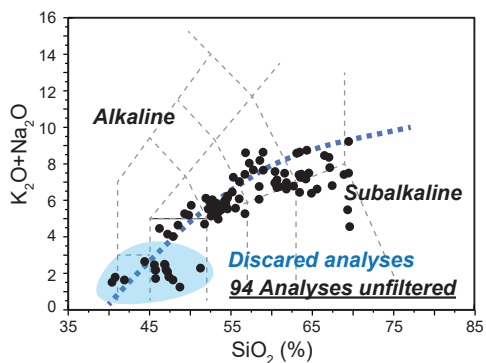
Figure S2-02

North Taihangshan Mountains: 146-138 Ma Magmatism

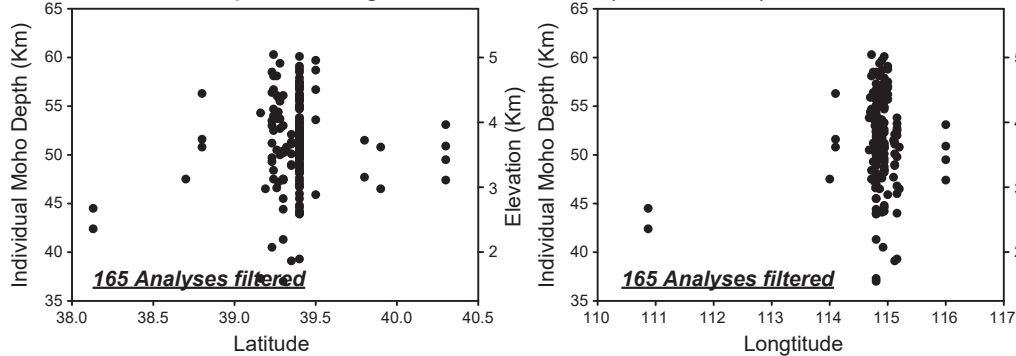
Individual Moho Depth vs. Age (146-120 Ma)



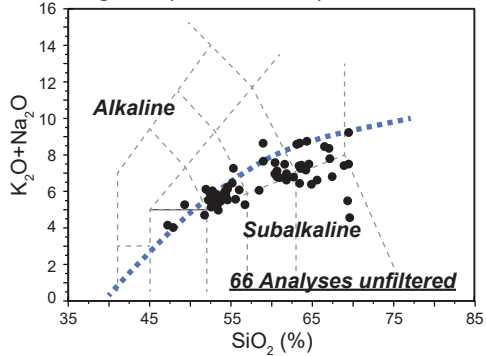
TAS diagram (133-120 Ma)



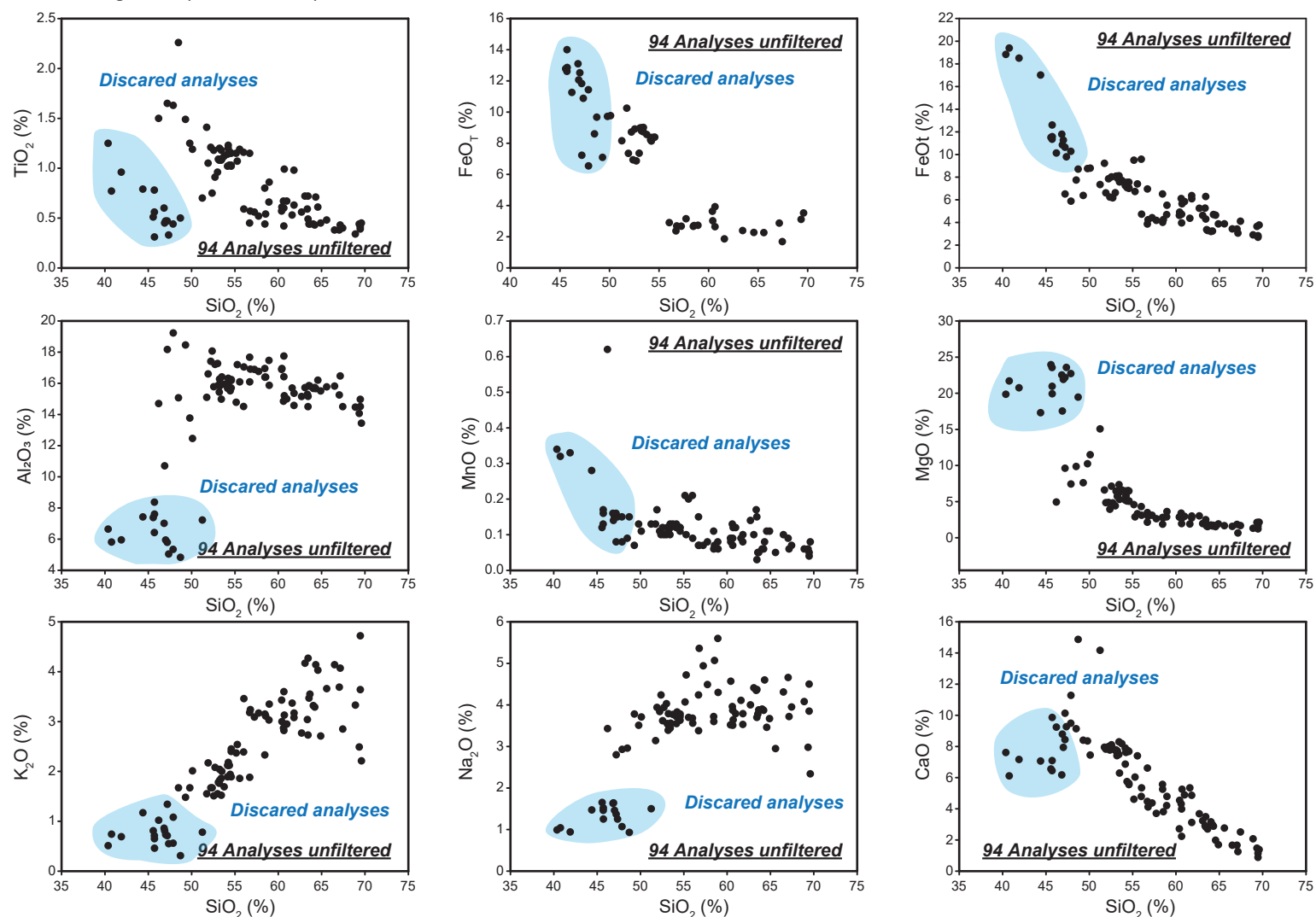
Individual Moho Depth vs. Longitude and Latitude (146-120 Ma)



TAS diagram (133-120 Ma)



Harker Diagrams (133-120 Ma)



Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation

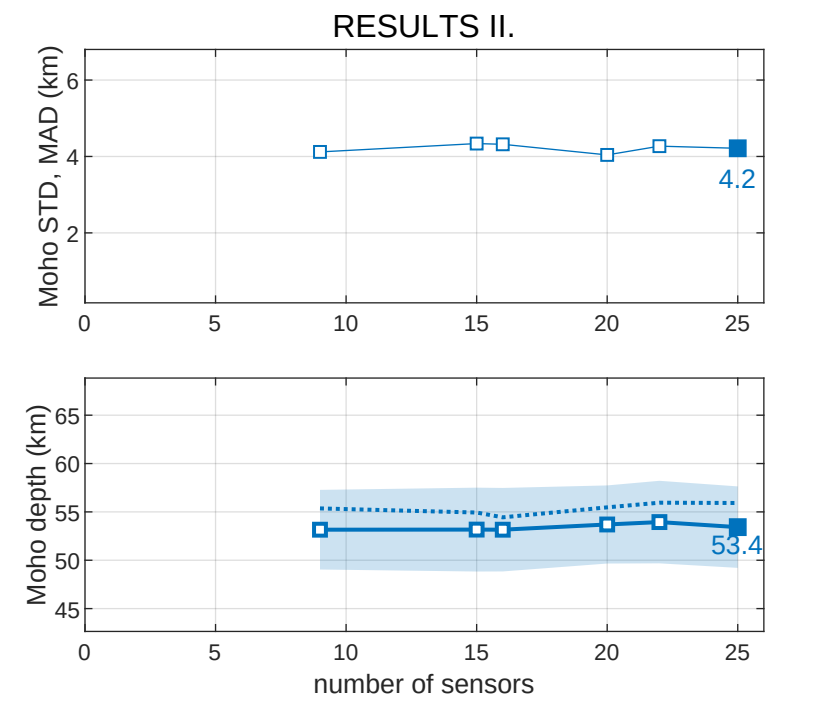
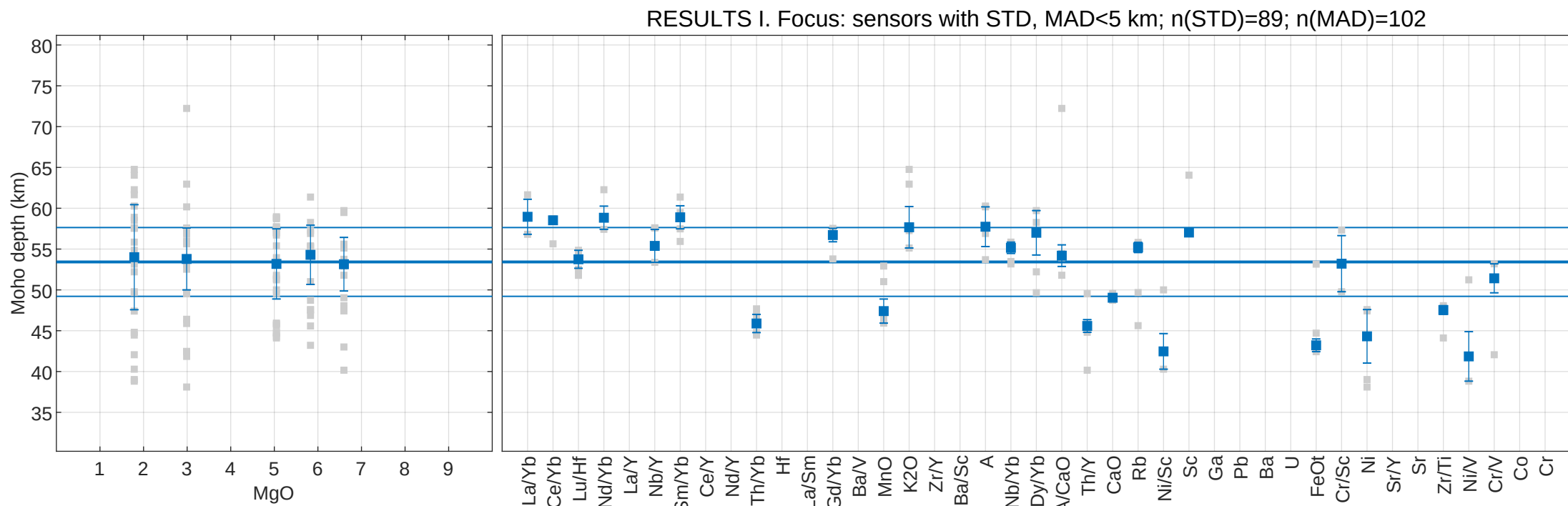
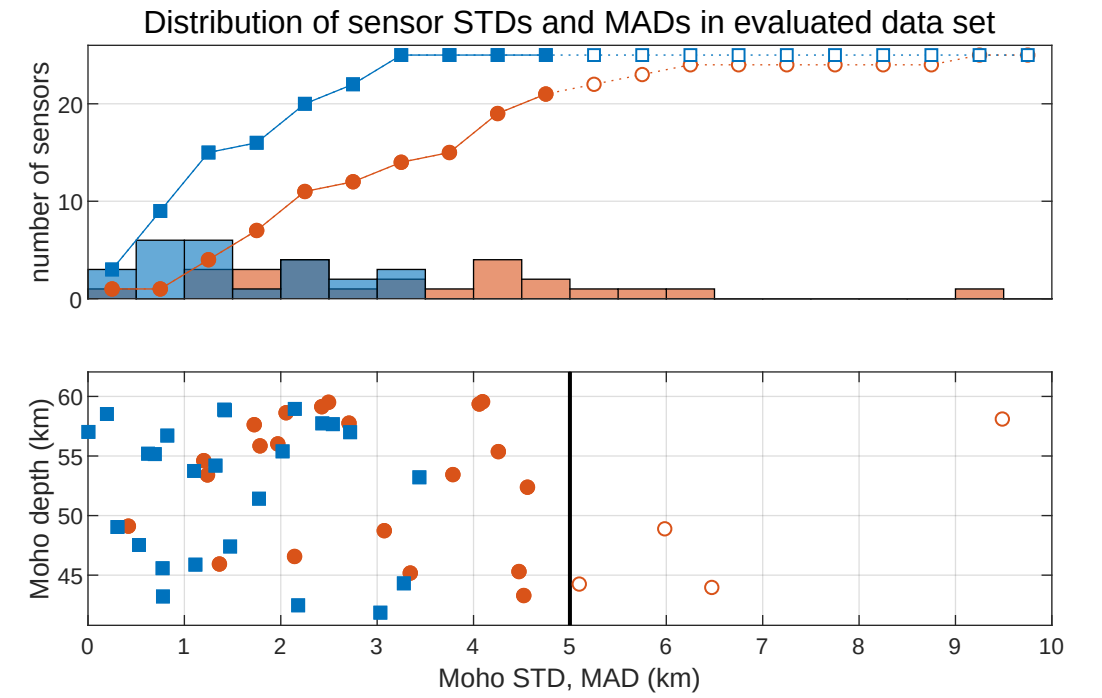
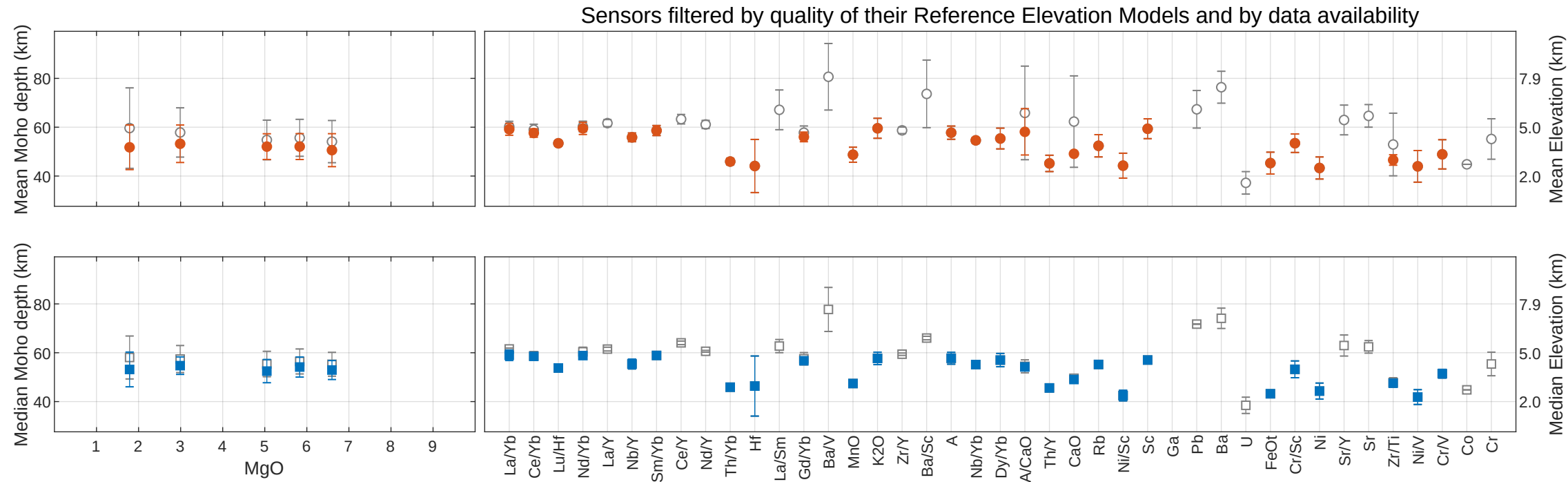
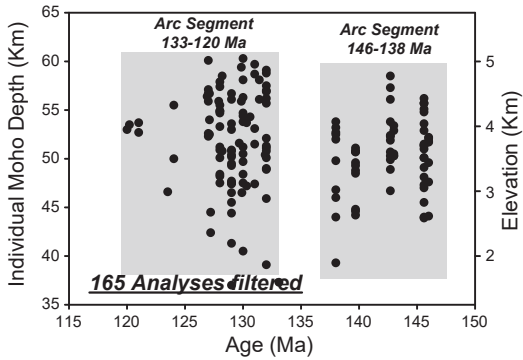
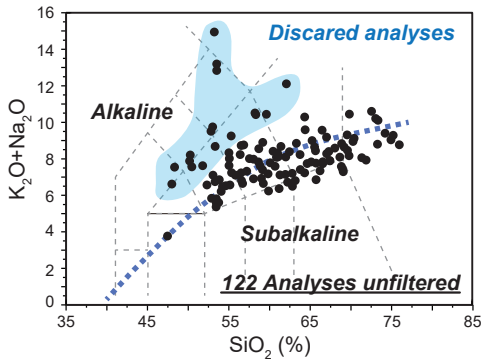


Figure S2-03 North Taihangshan Mountains: 133-120 Ma Magmatism

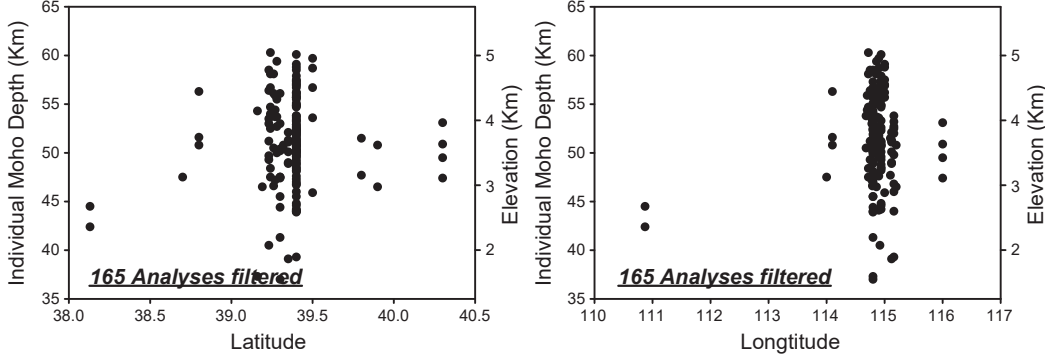
Individual Moho Depth vs. Age (146-120 Ma)



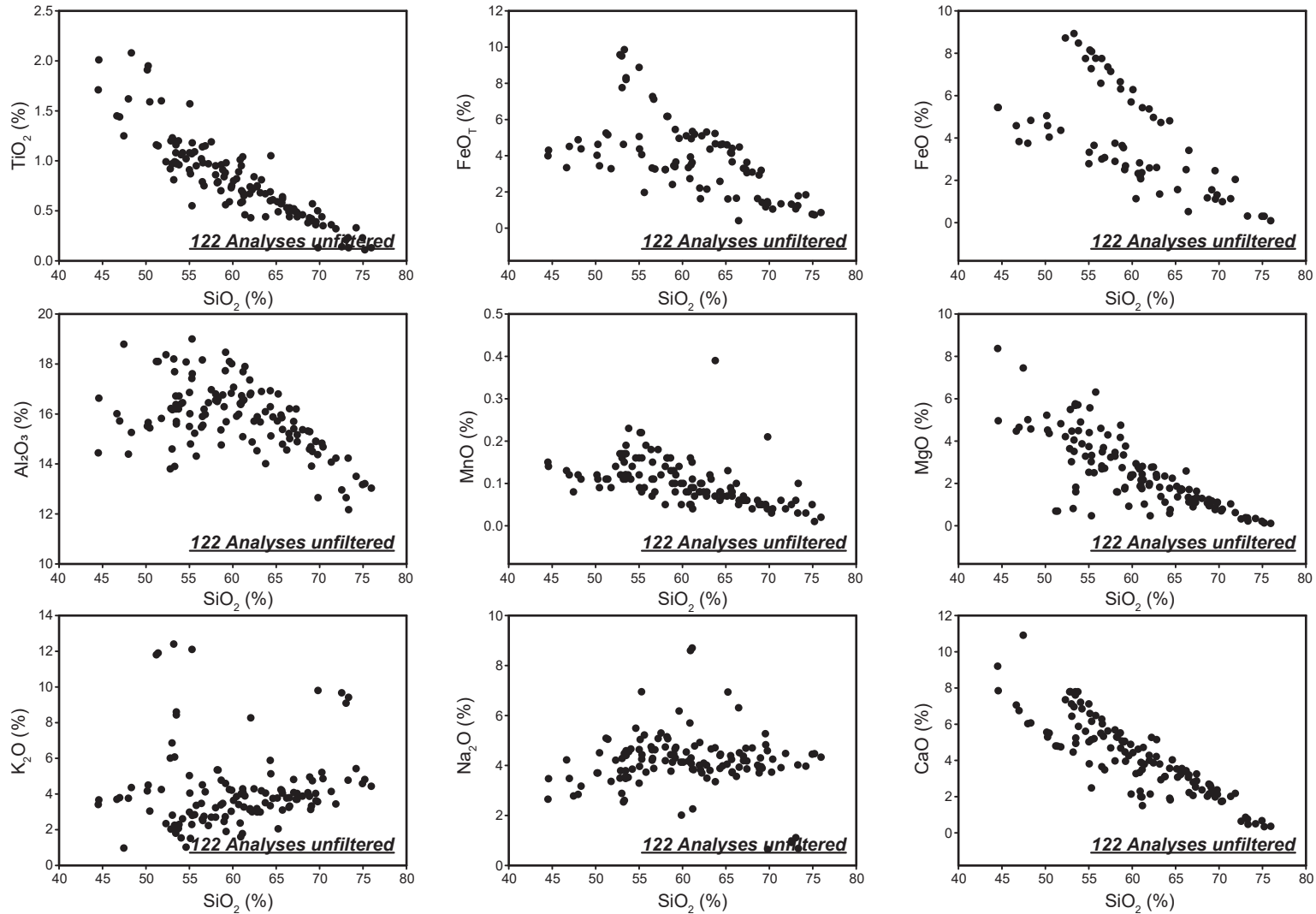
TAS diagram (133-120 Ma)



Individual Moho Depth vs. Longitude and Latitude (146-120 Ma)



Harker Diagrams (133-120 Ma)



Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation

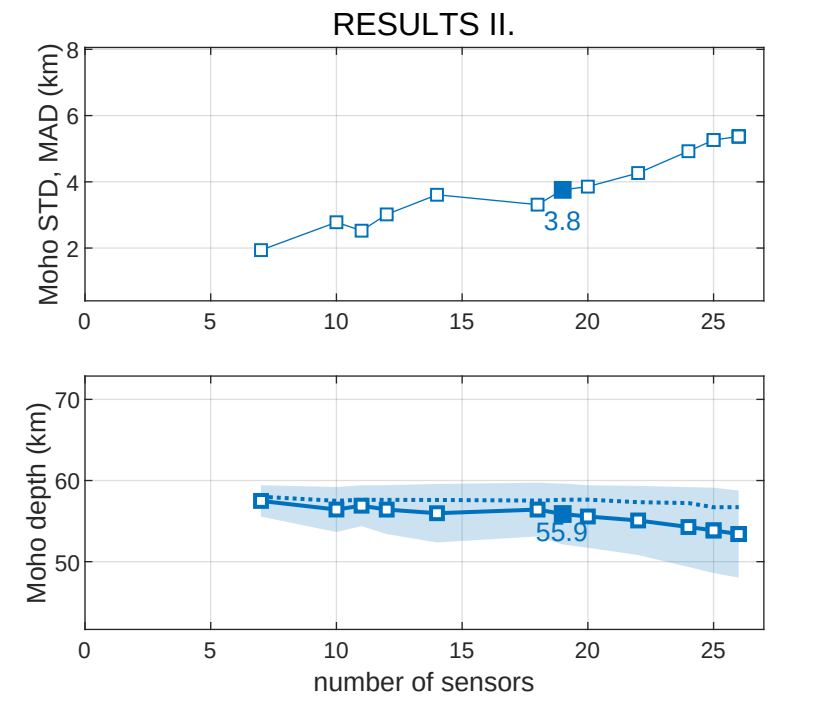
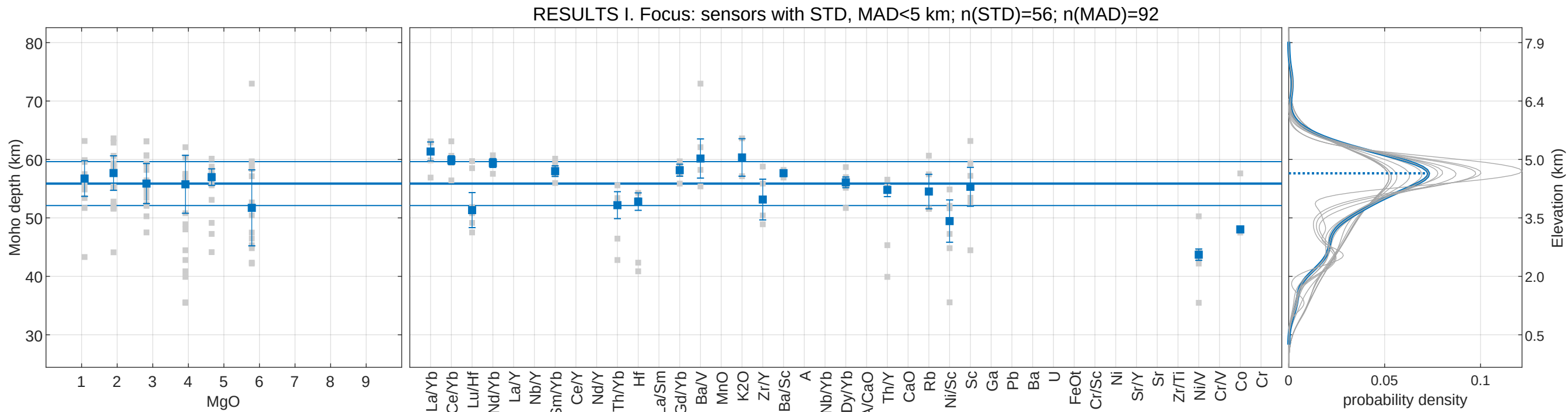
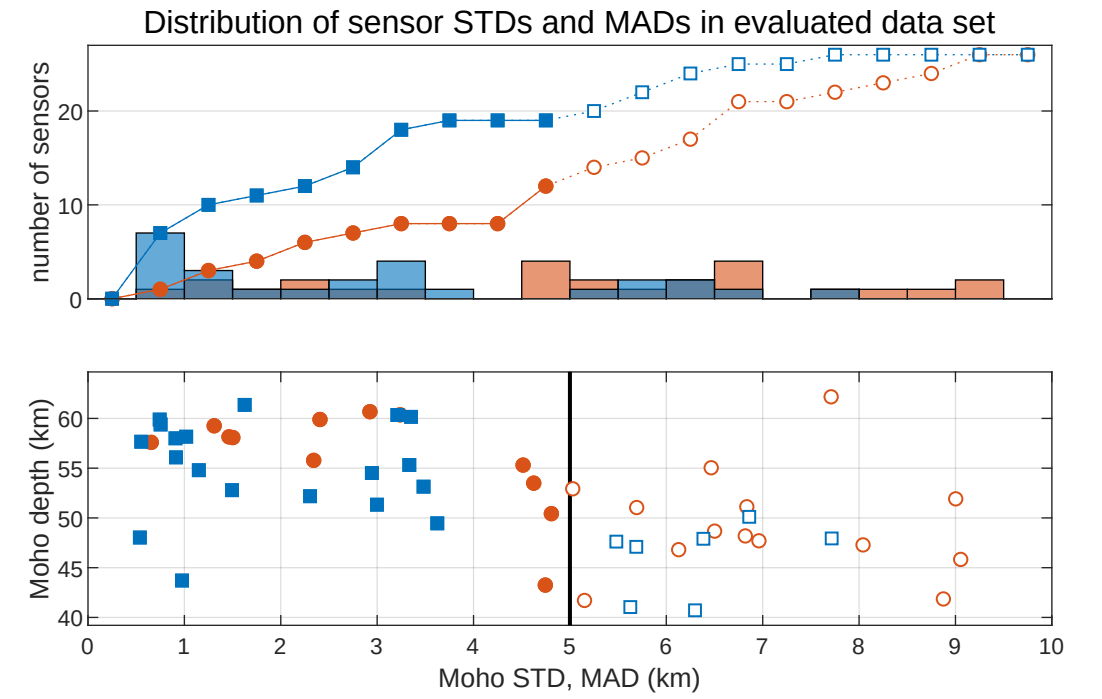
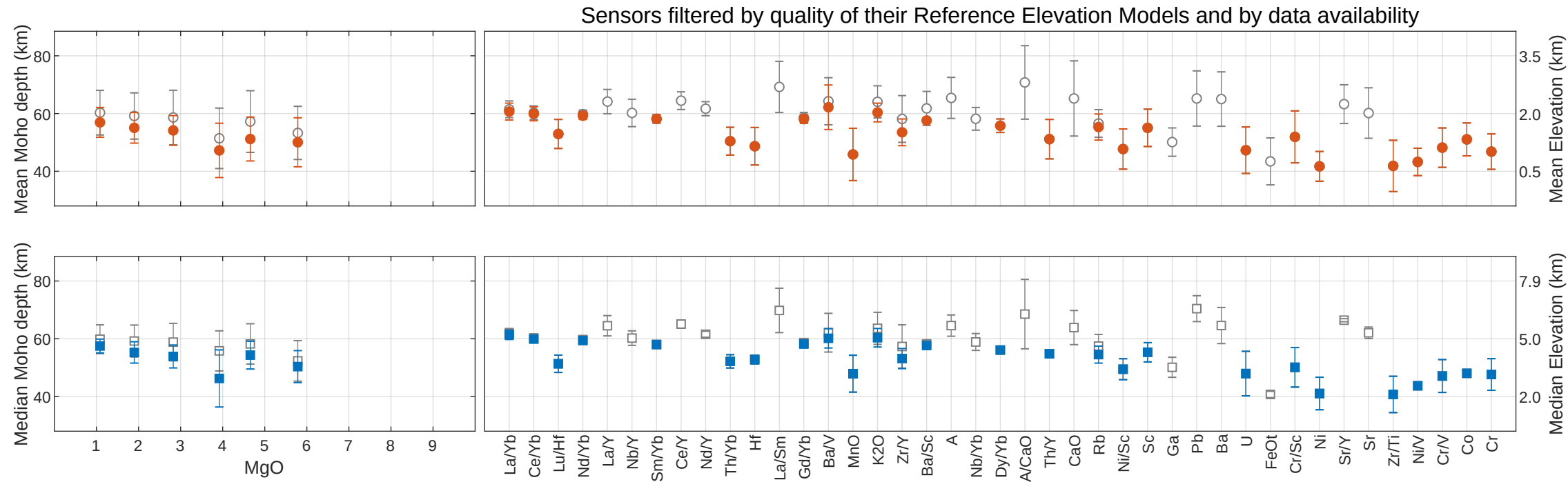
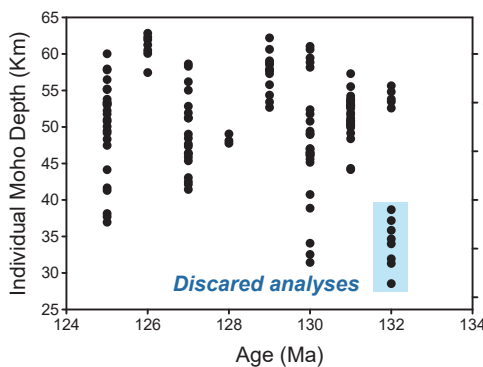
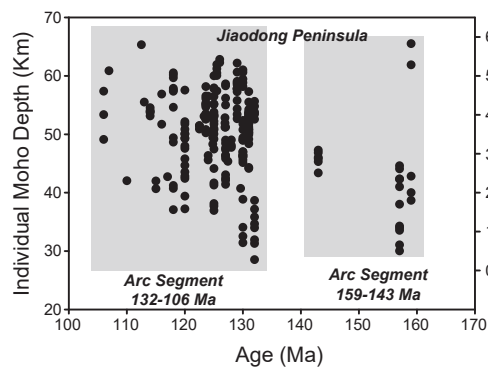


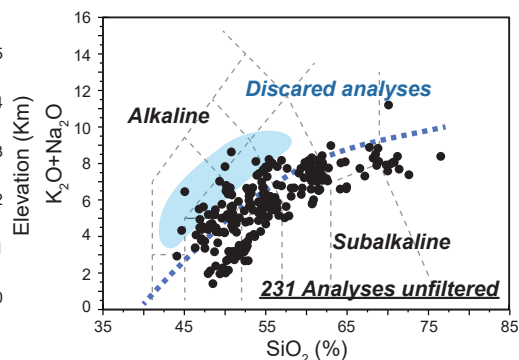
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Jiaodong Peninsula: 133-125 Ma Magmatism

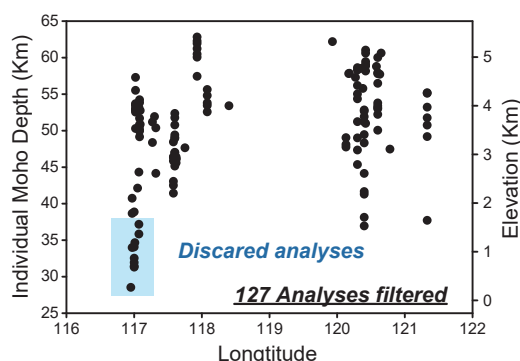
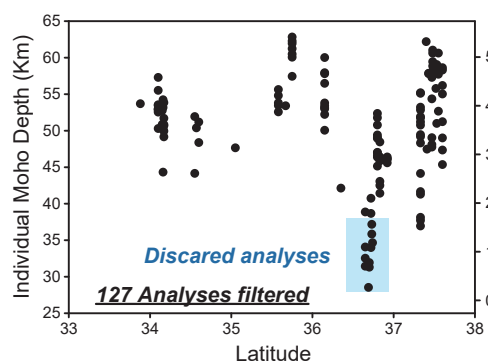
Individual Moho Depth vs. Age (159-106 Ma)



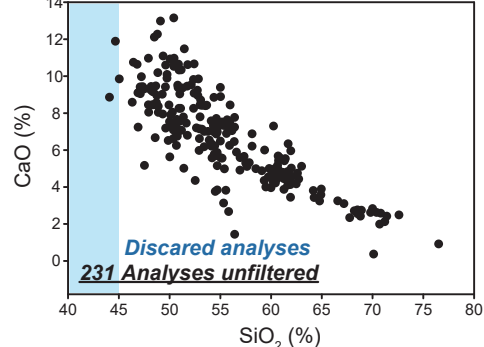
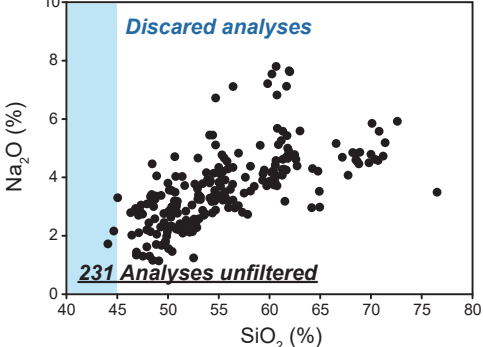
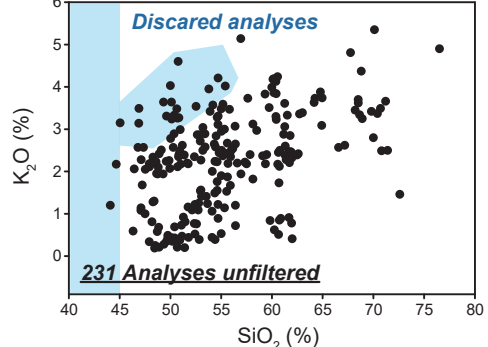
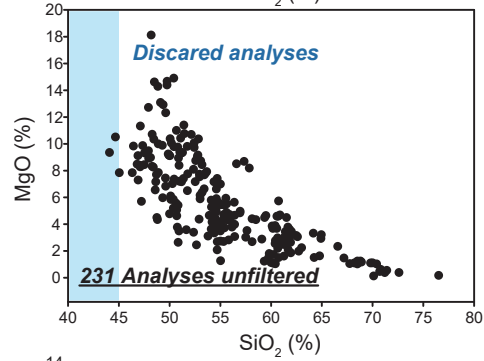
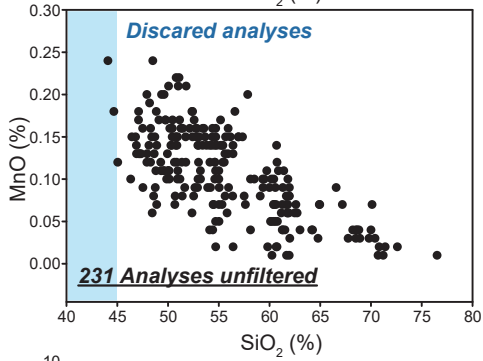
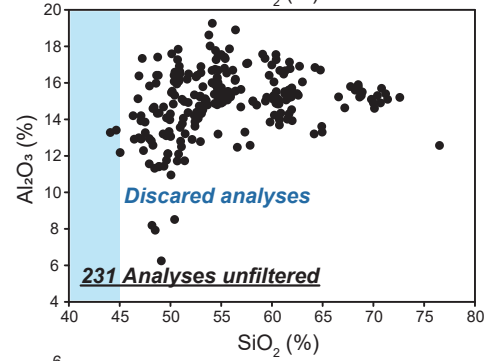
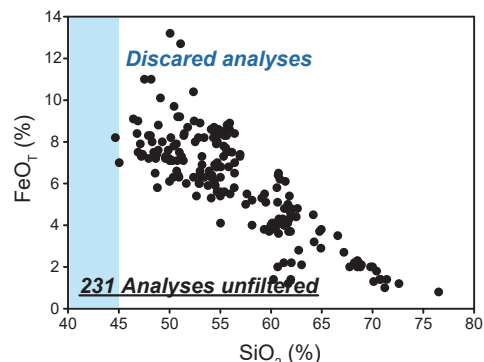
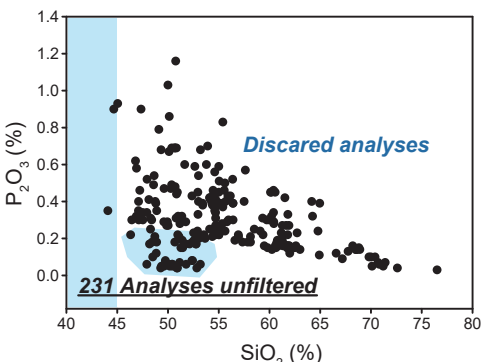
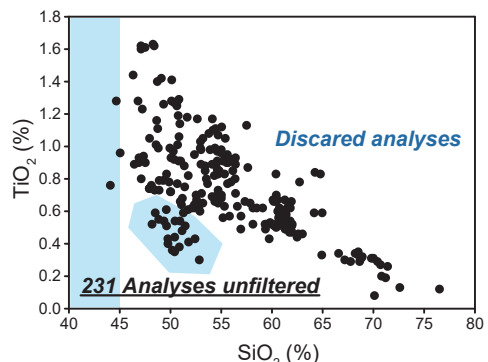
TAS diagram (133-125 Ma)



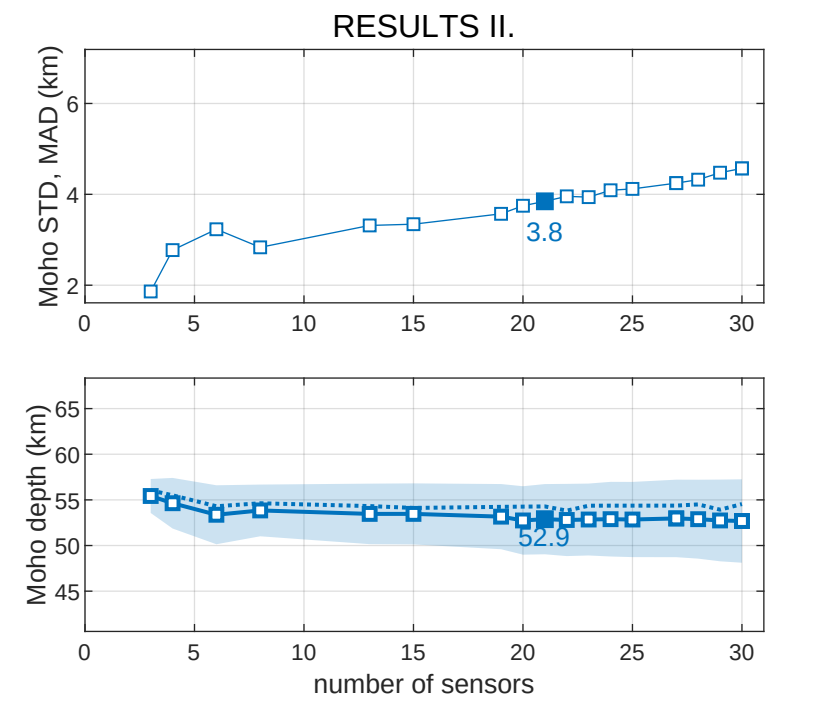
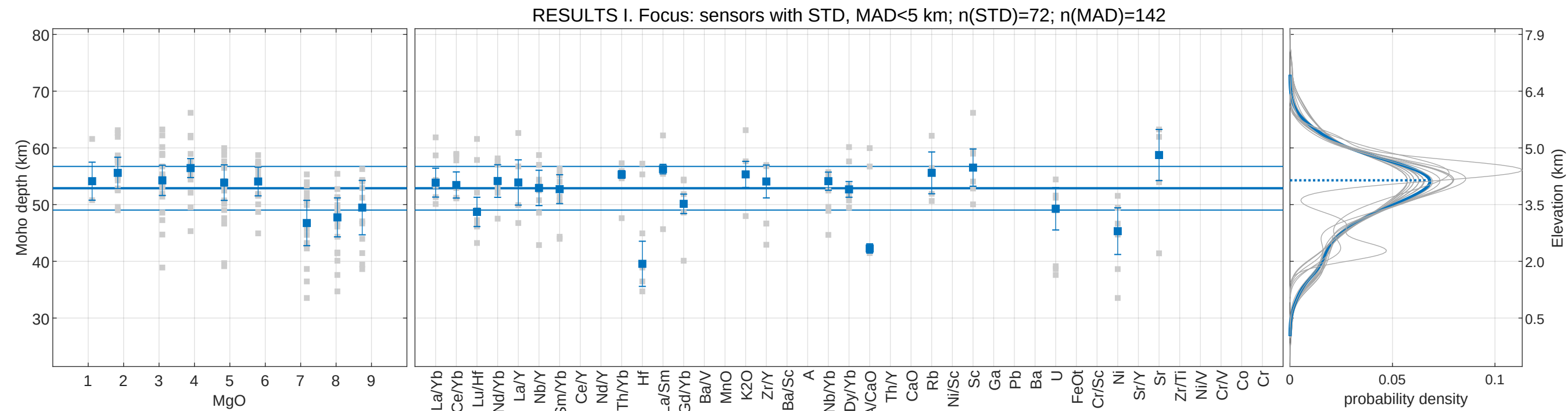
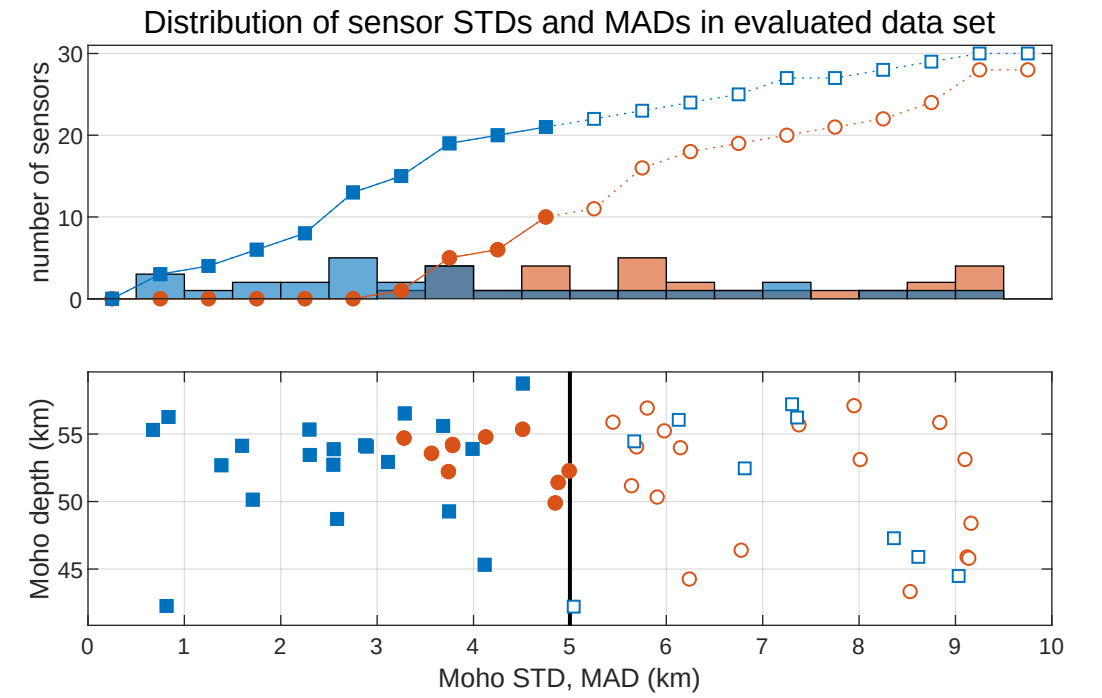
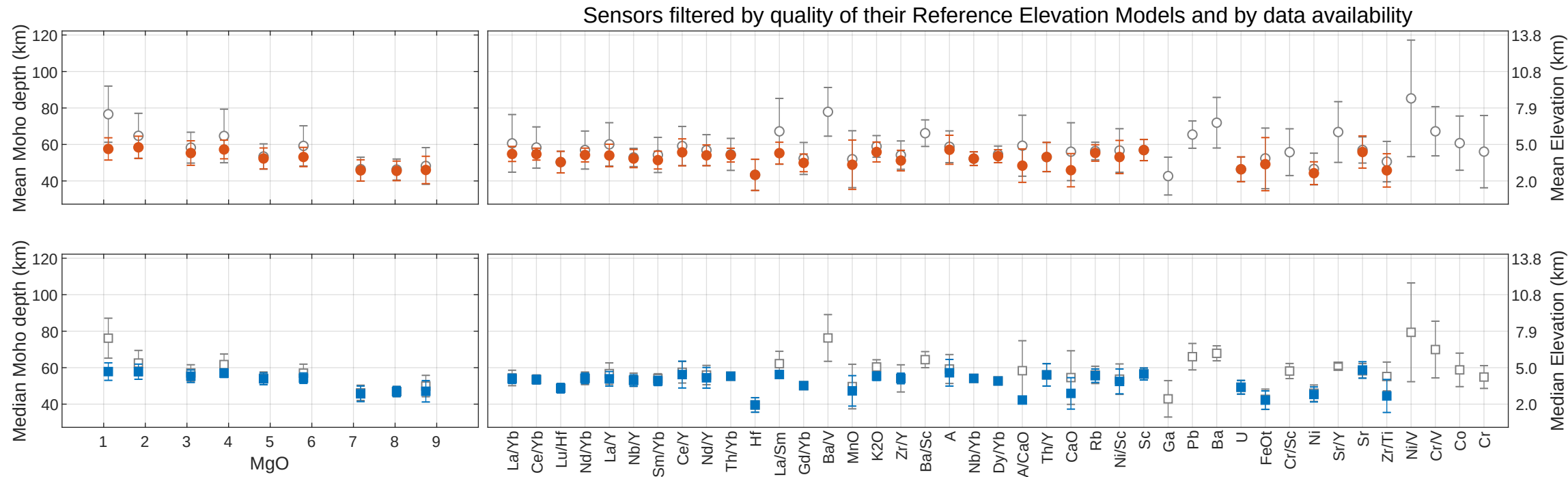
Individual Moho Depth vs. Longitude and Latitude (133-125 Ma)



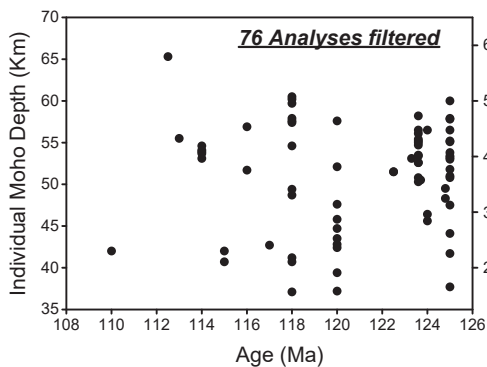
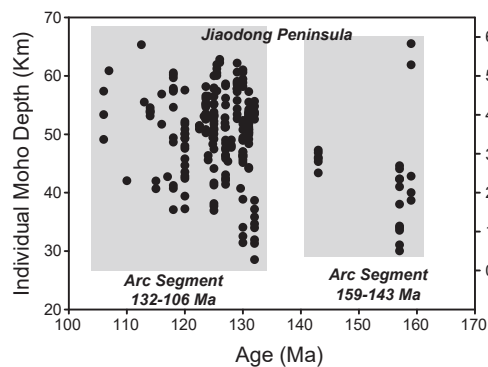
Harker Diagrams (133-125 Ma)



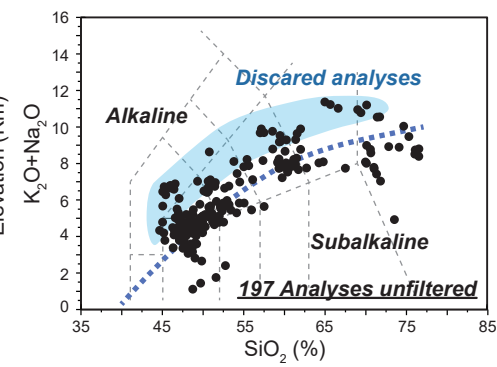
Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation



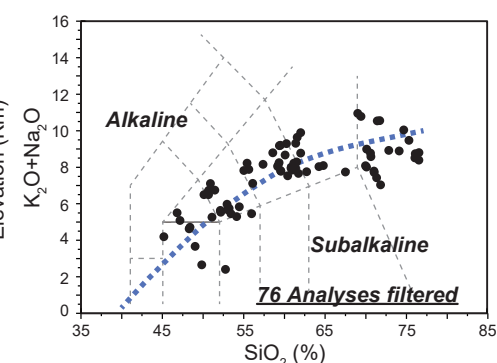
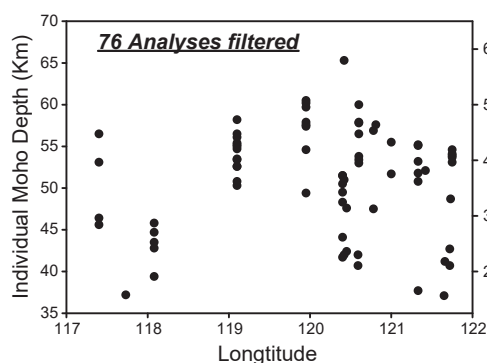
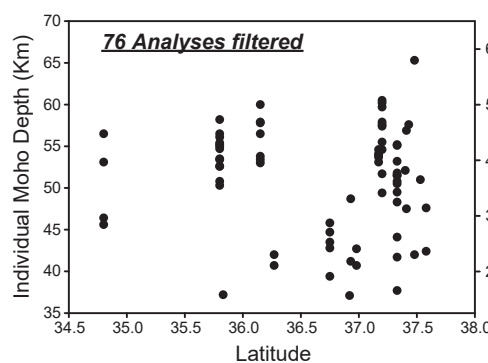
Individual Moho Depth vs. Age (159-106 Ma) (125-110 Ma)



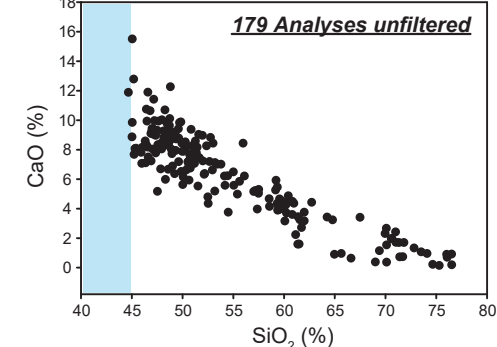
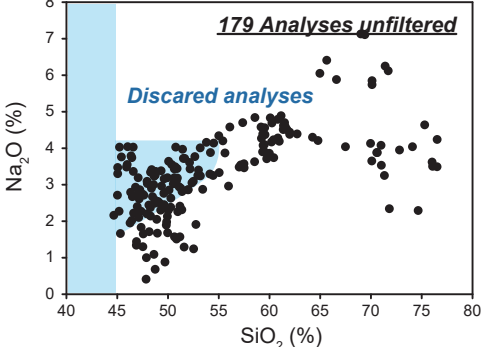
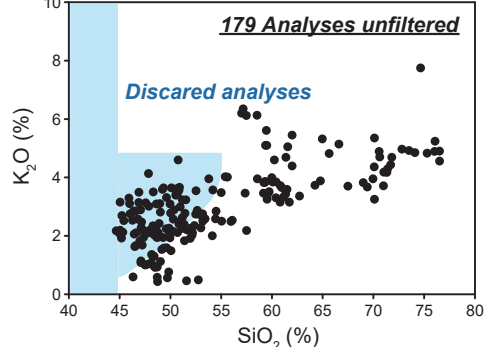
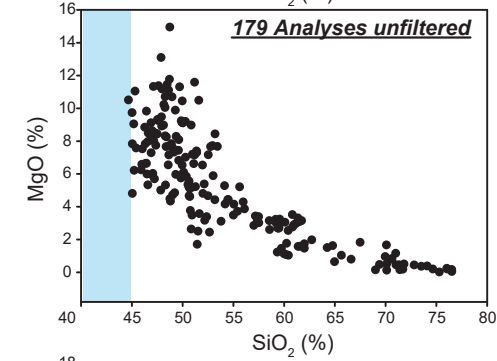
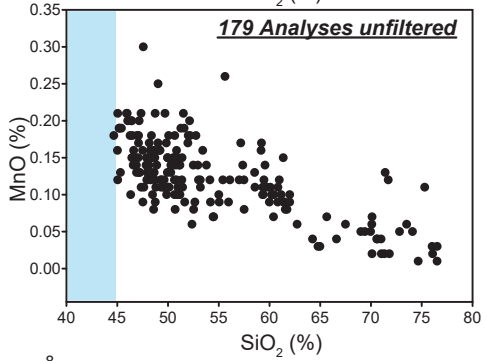
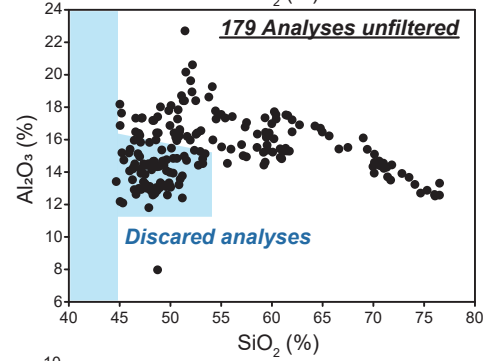
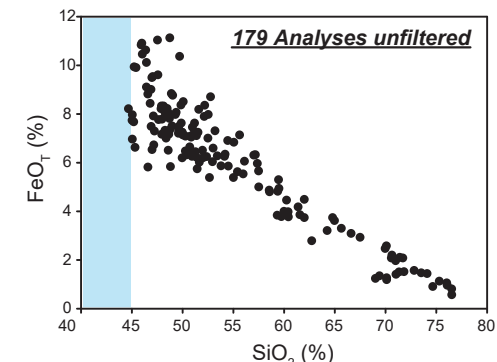
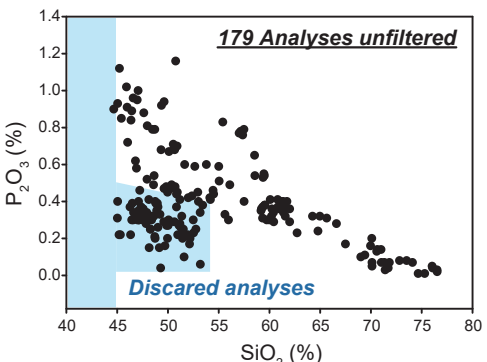
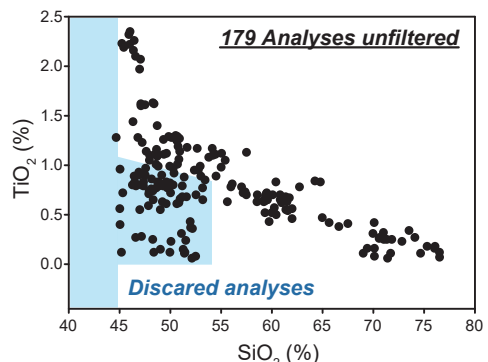
TAS diagram (125-110 Ma)



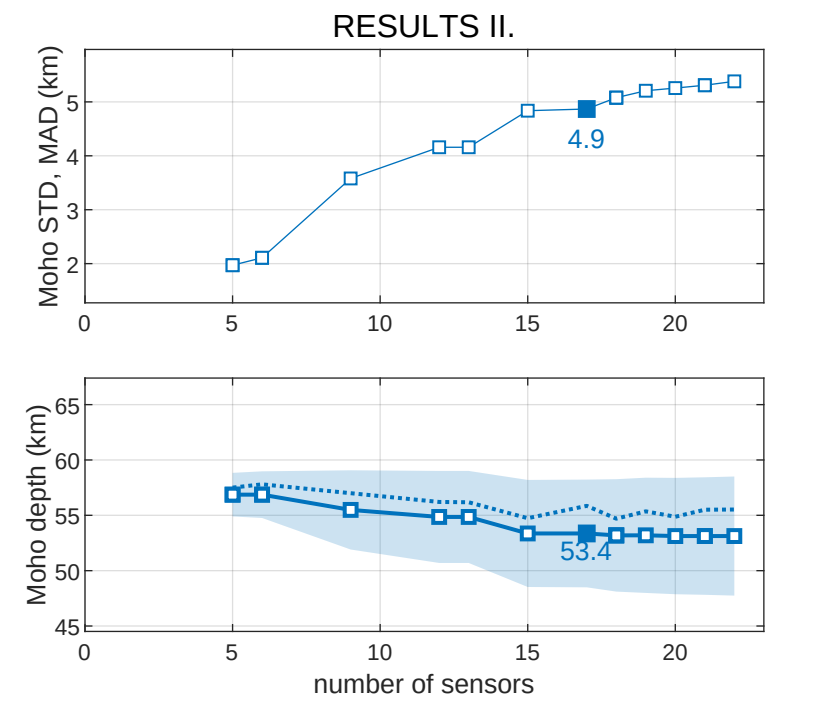
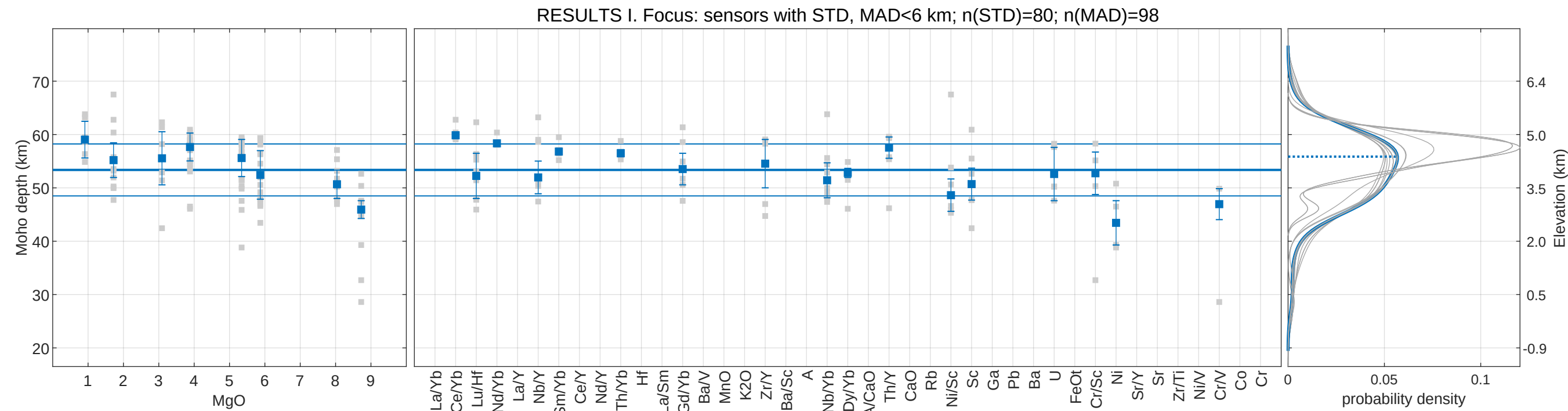
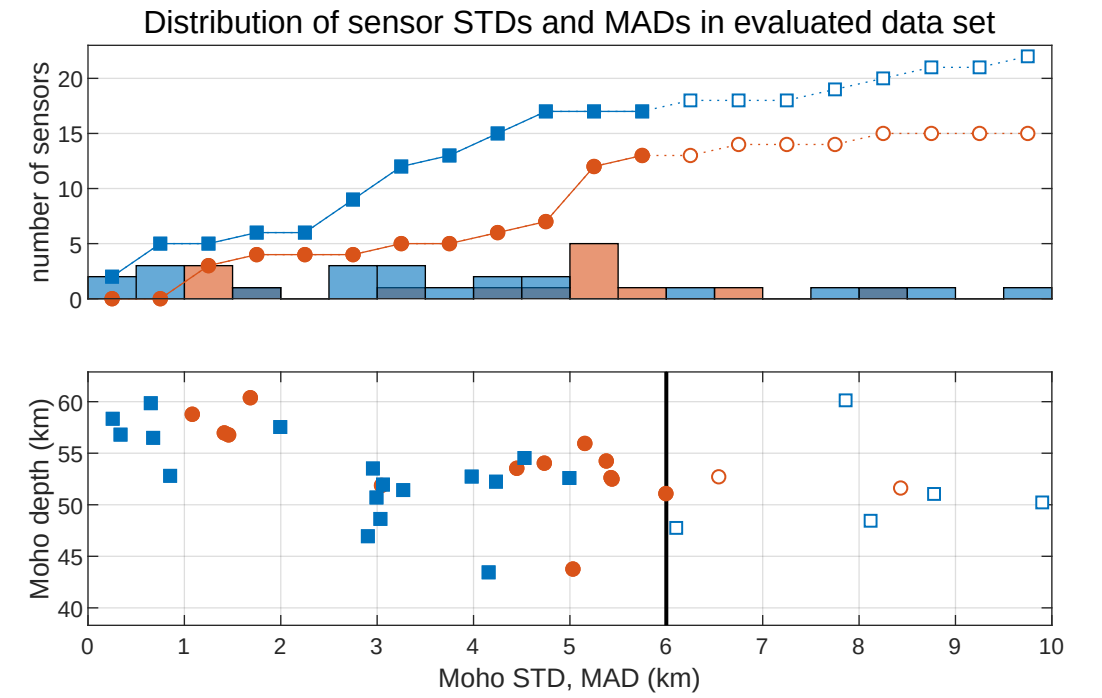
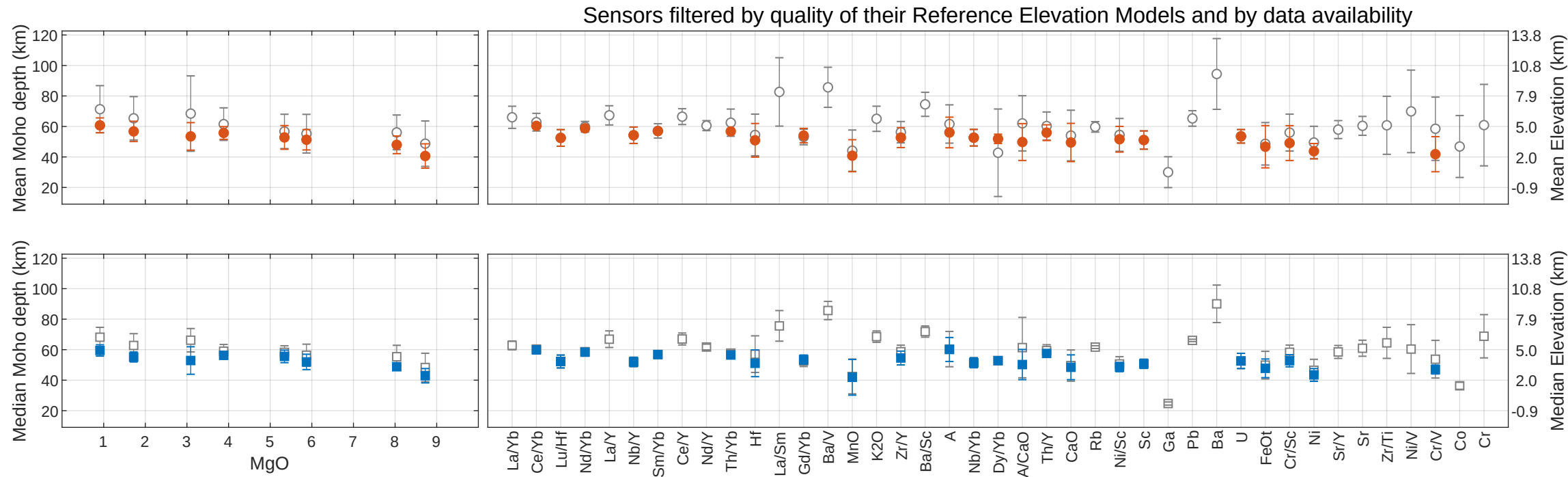
Individual Moho Depth vs. Longitude and Latitude (125-110 Ma)



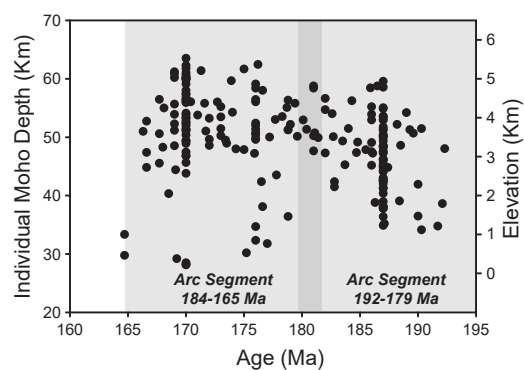
Harker Diagrams (125-110 Ma)



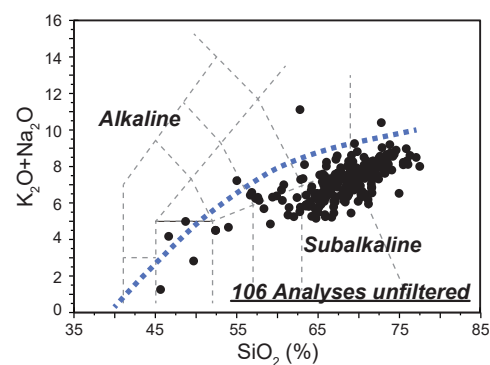
Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation



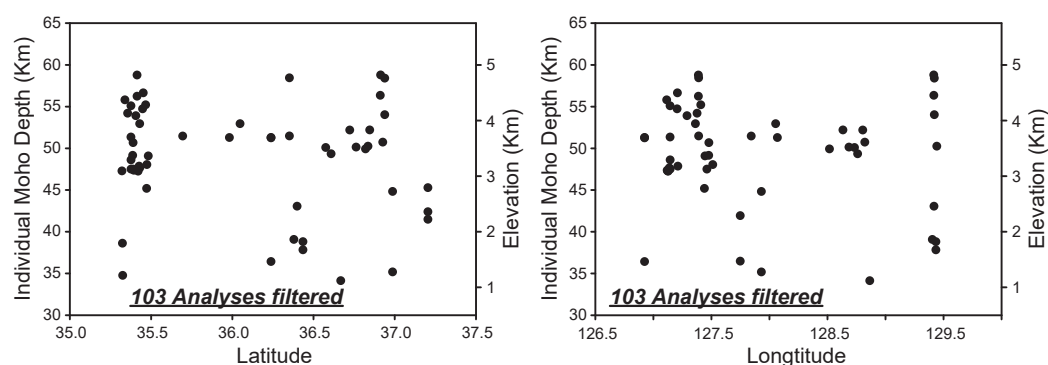
Individual Moho Depth vs. Age (192-165 Ma)



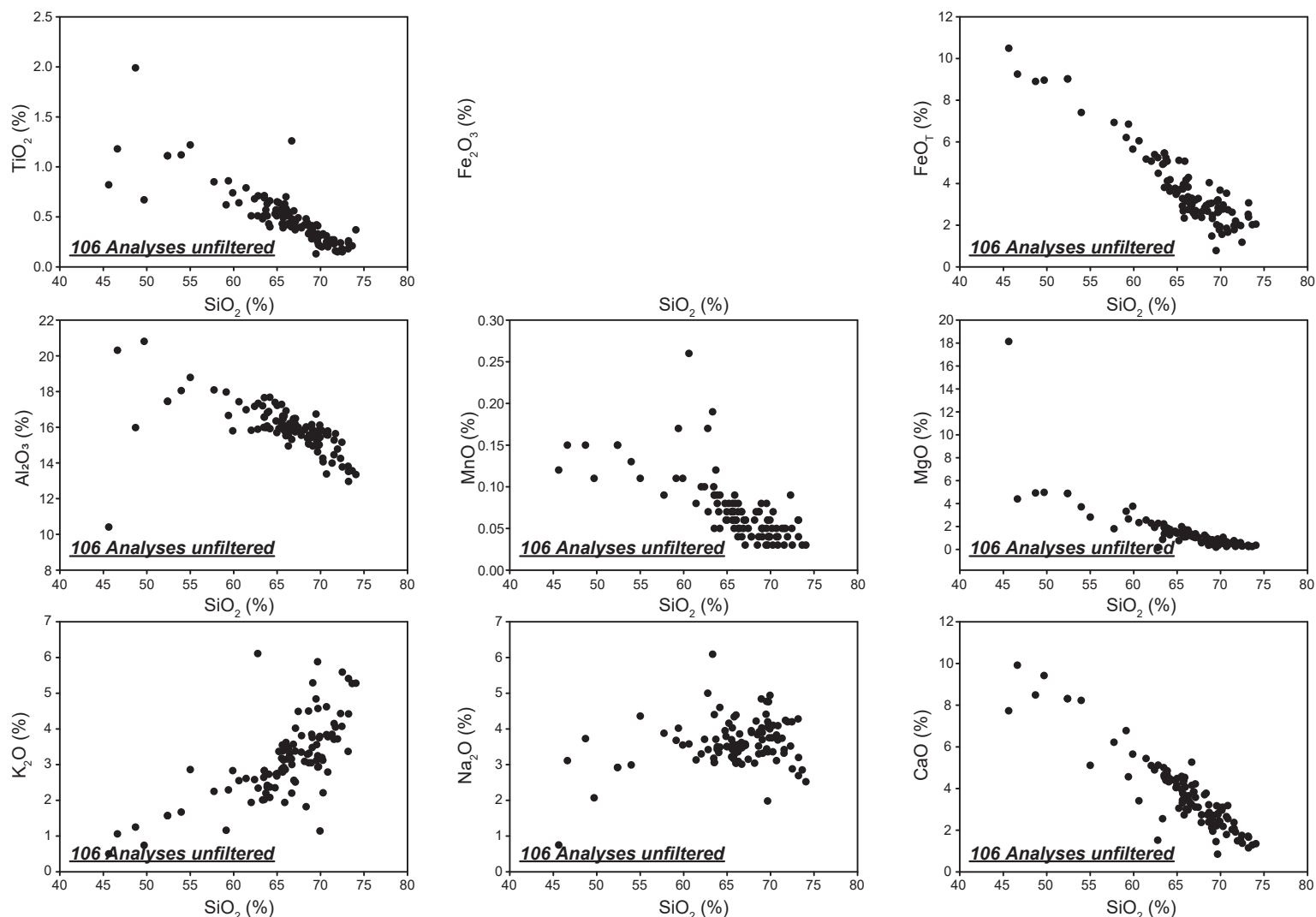
TAS diagram (192-179 Ma)



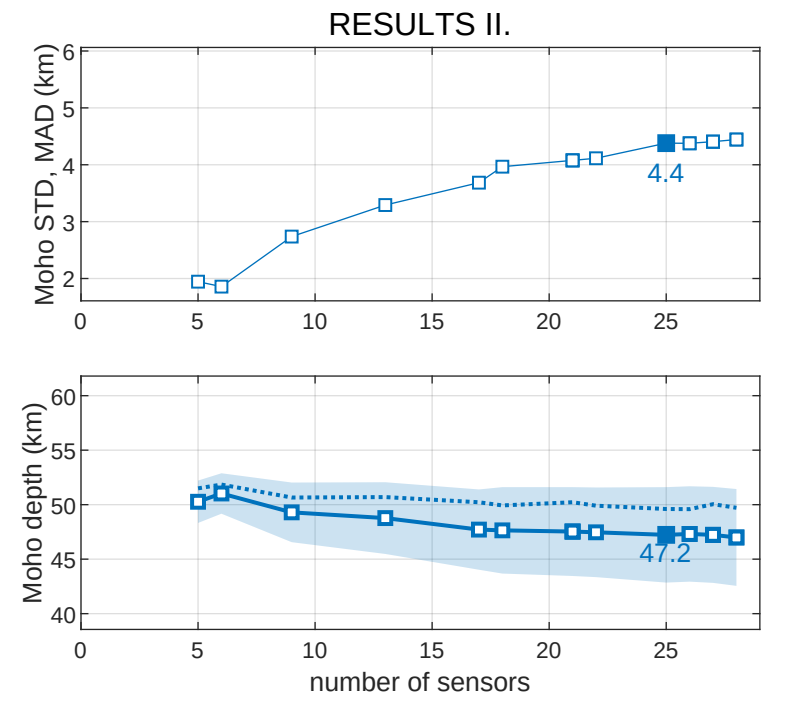
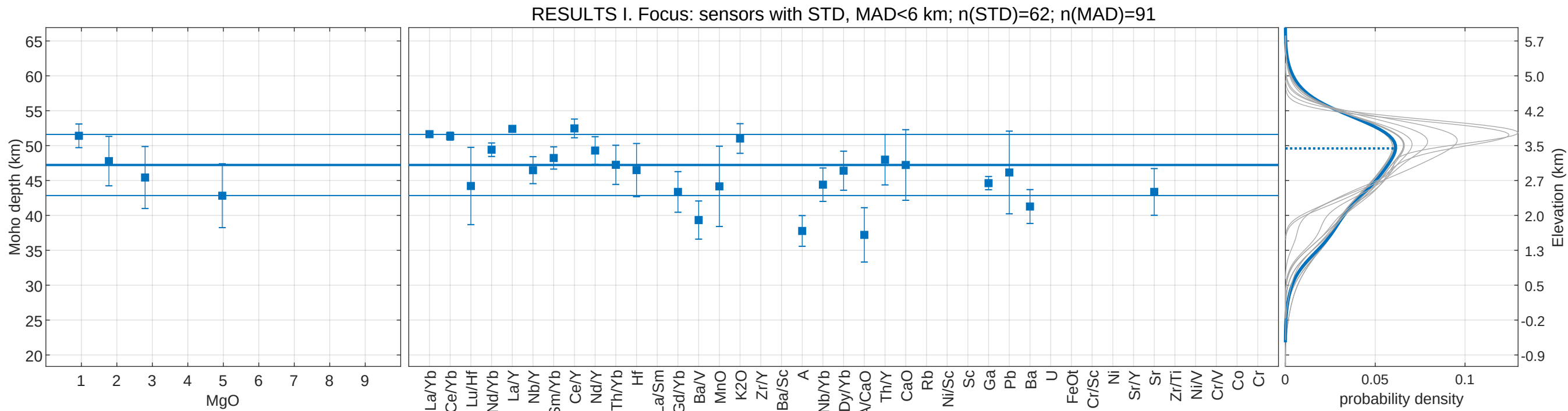
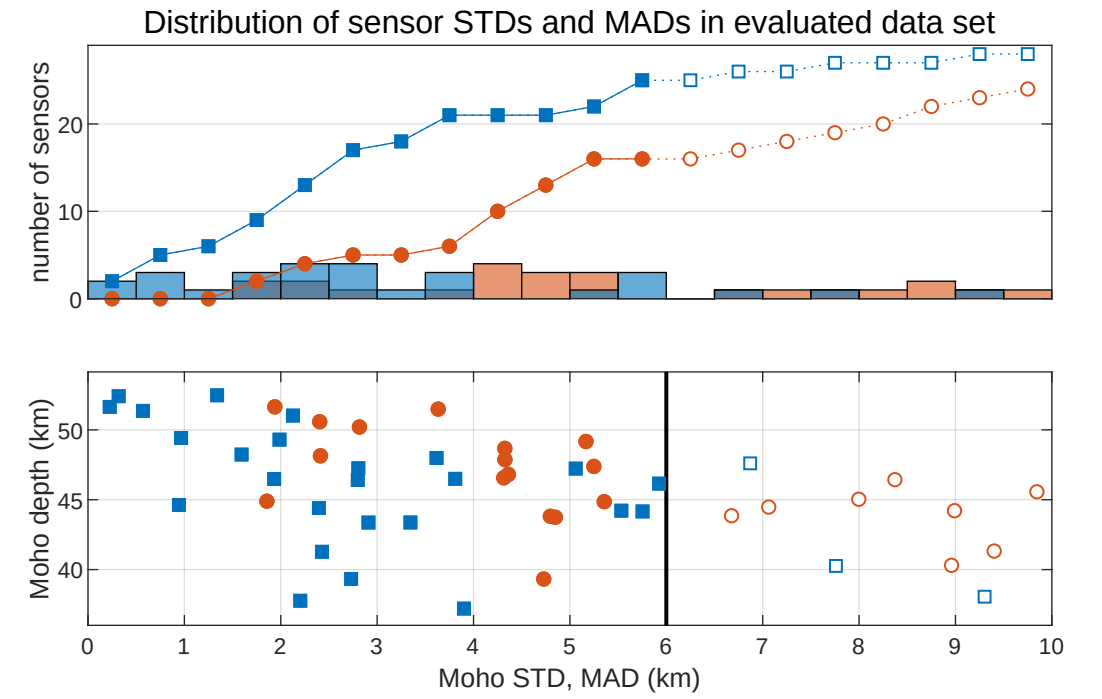
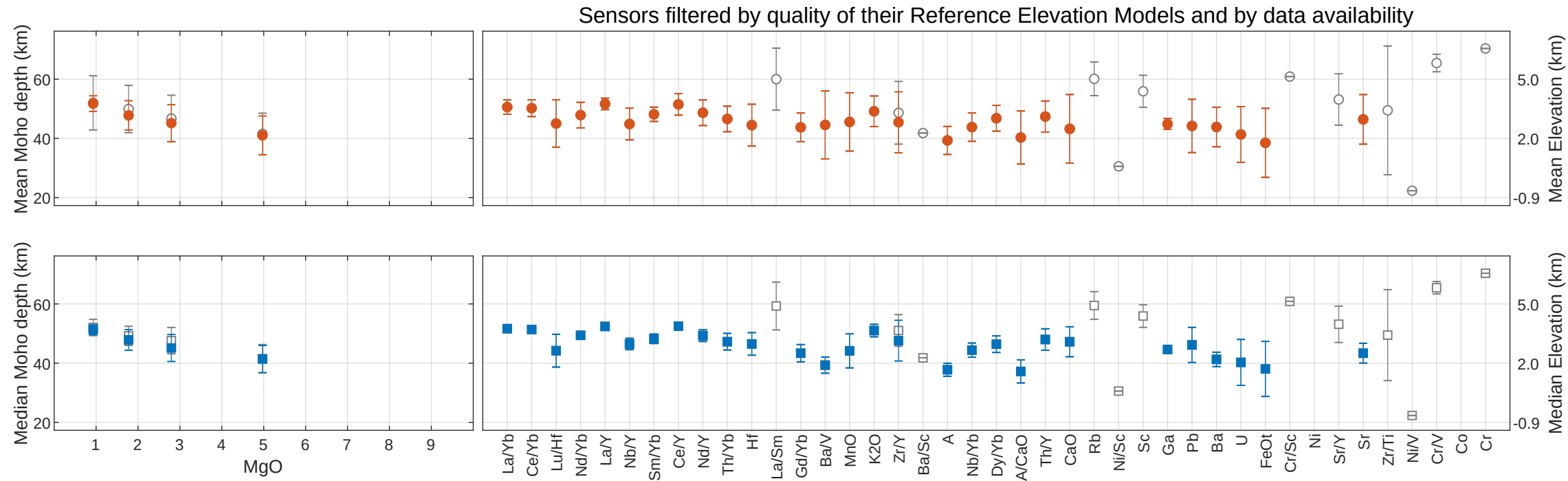
Individual Moho Depth vs. Longitude and Latitude (192-179 Ma)

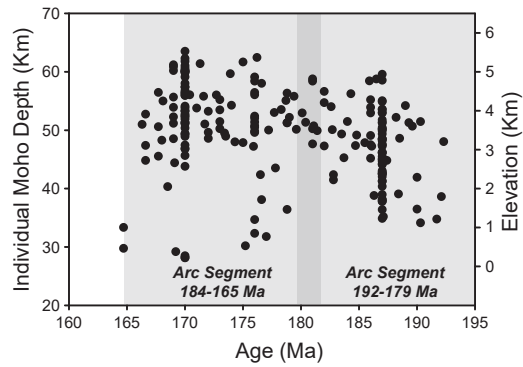
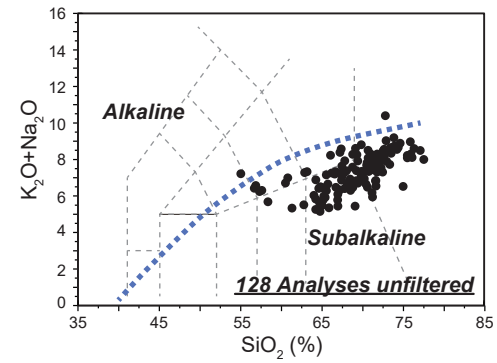
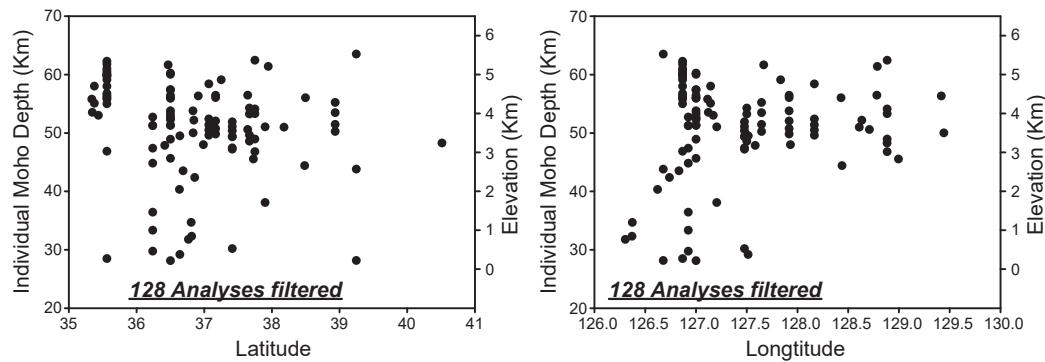
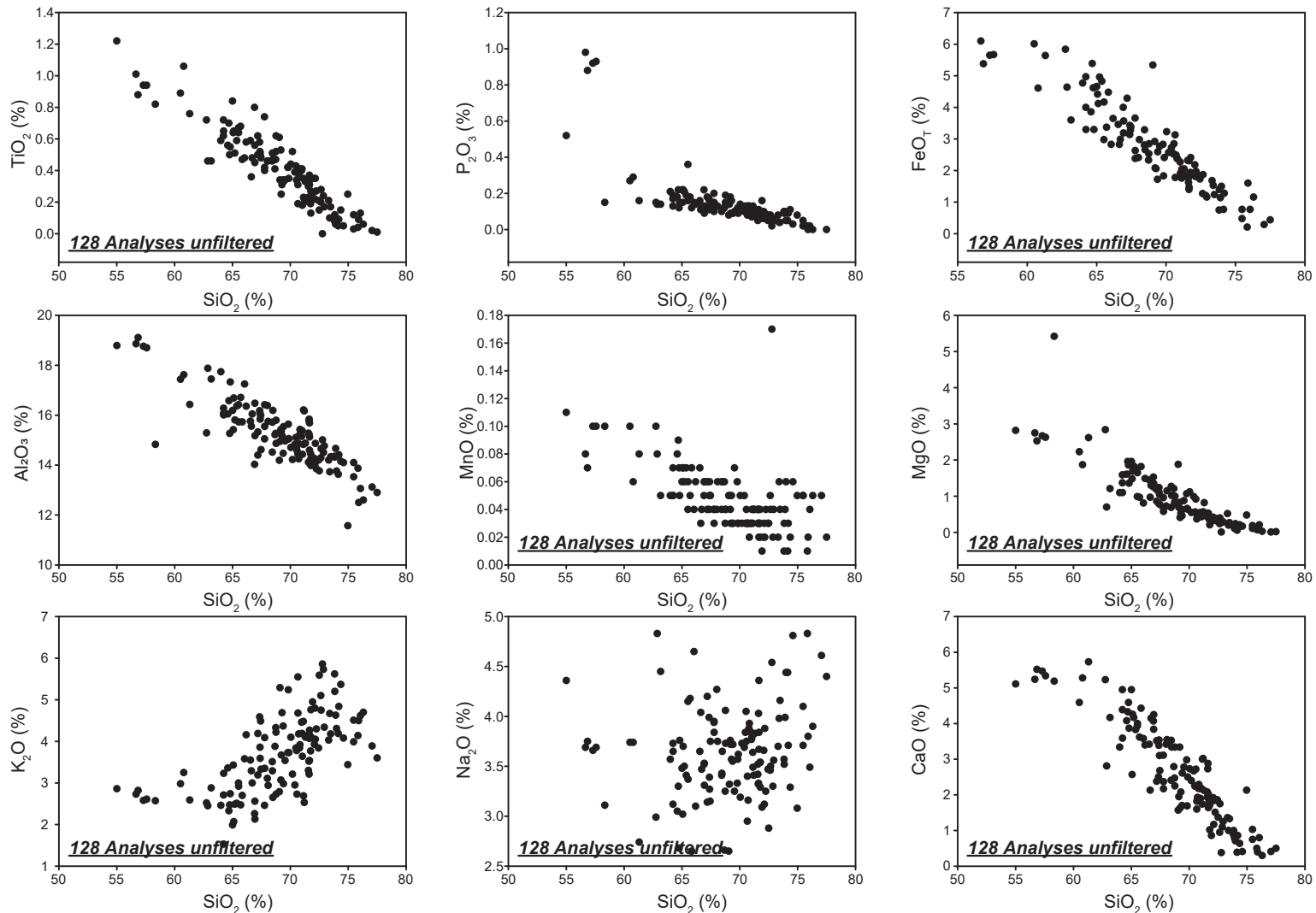


Harker Diagrams (192-179 Ma)



Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation



Individual Moho Depth vs. Age (192-165 Ma)TAS diagram (179-165 Ma)Individual Moho Depth vs. Longitude and Latitude (179-165 Ma)Harker Diagrams (179-165 Ma)

Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation

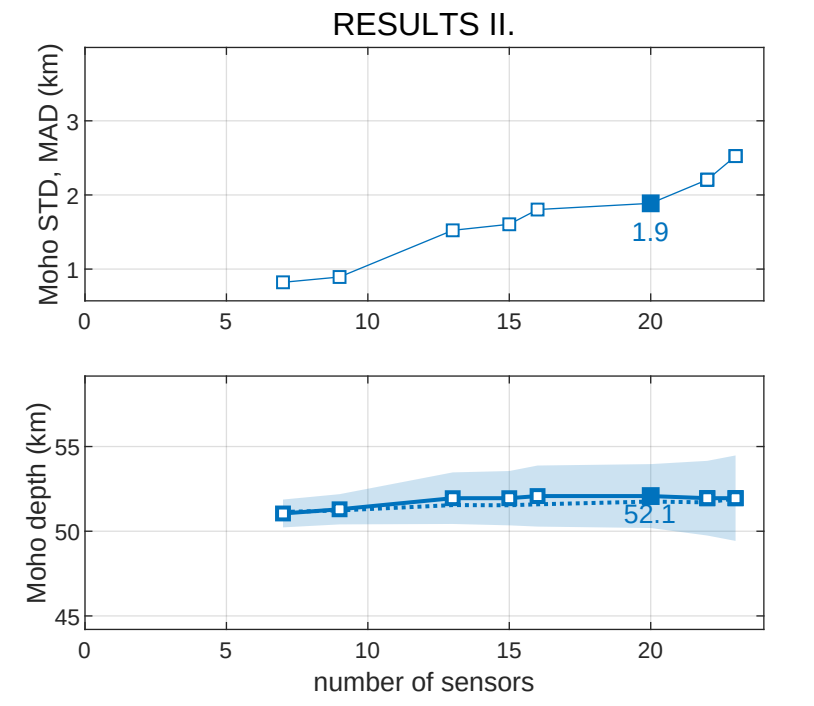
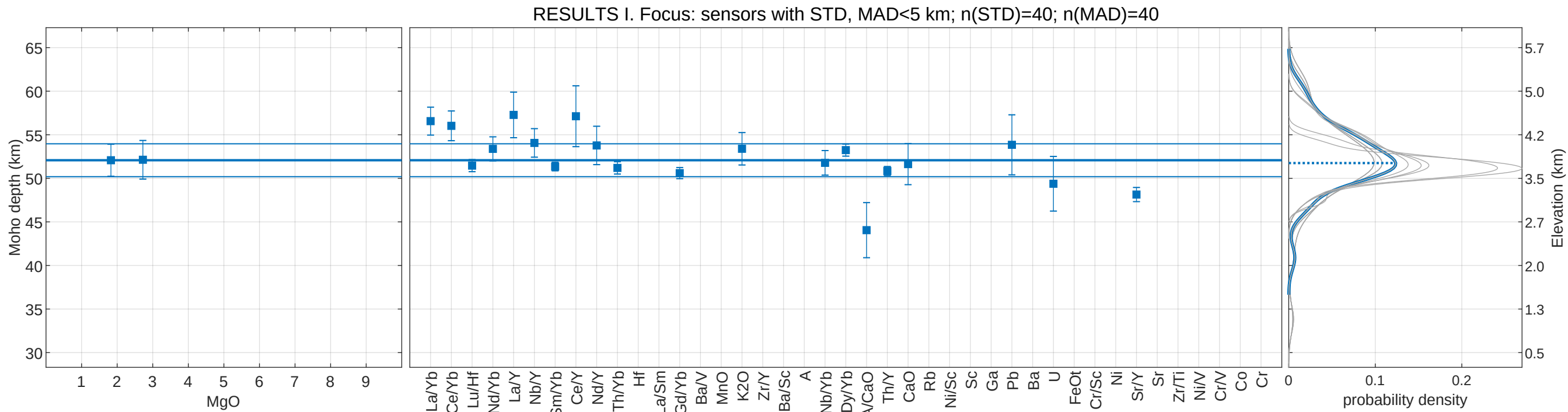
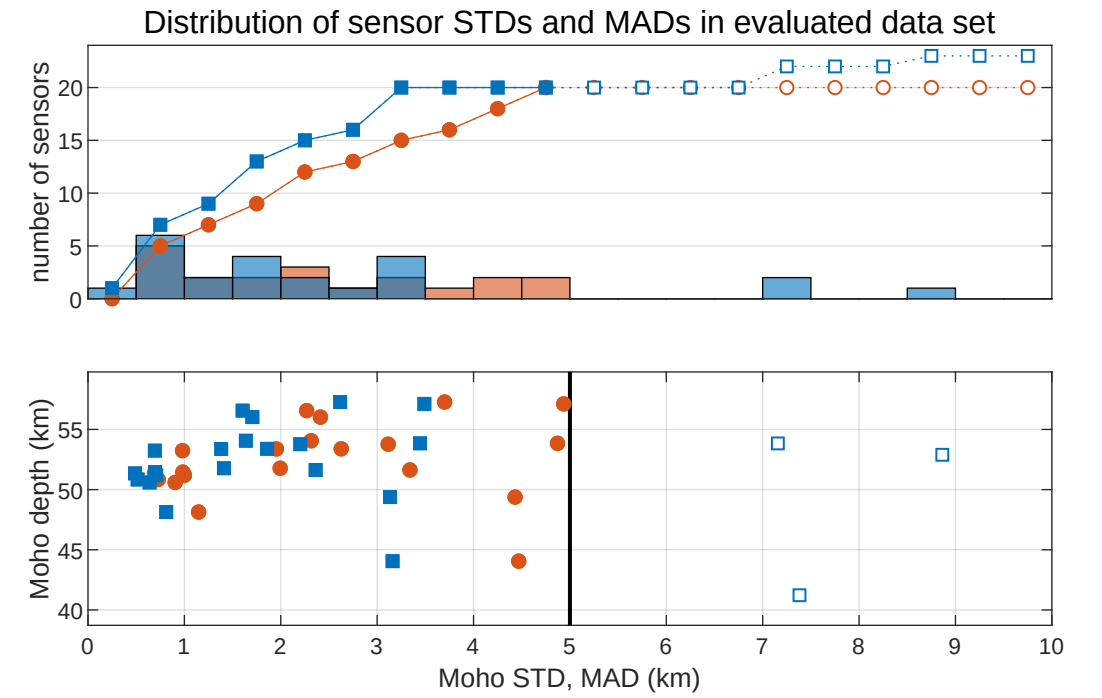
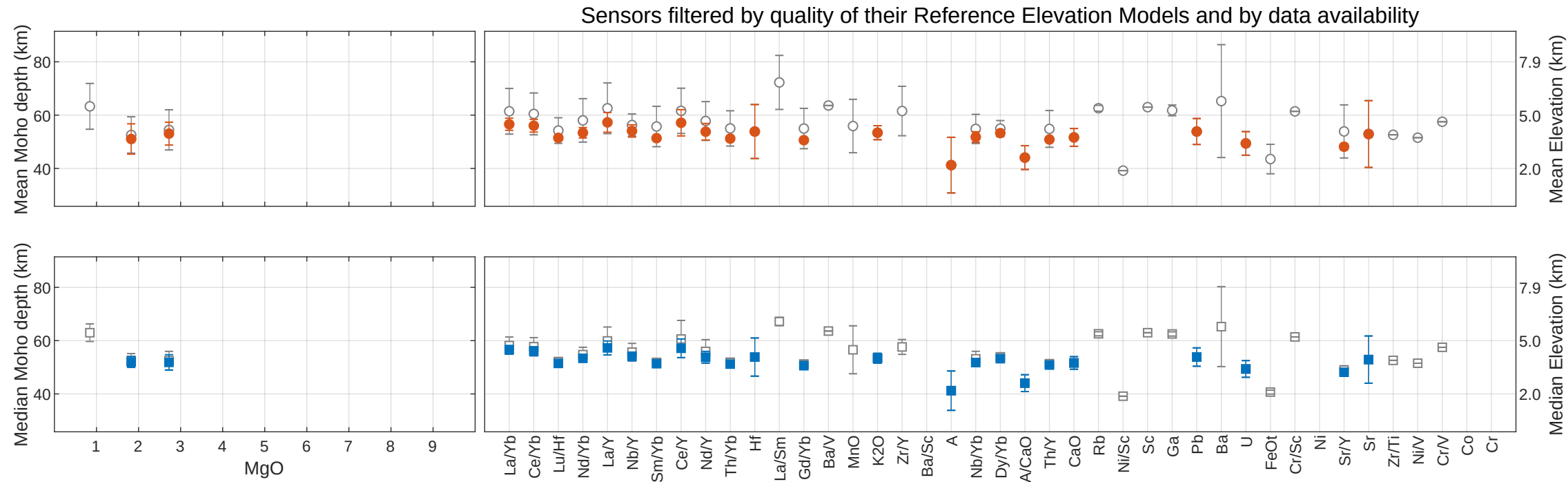
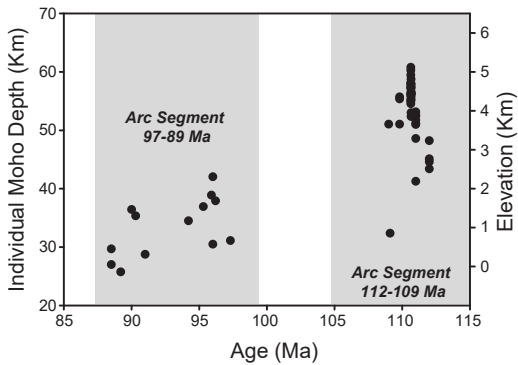


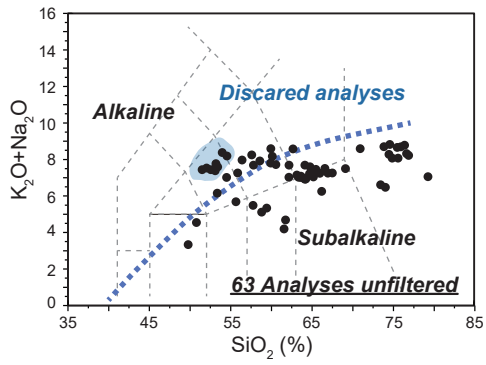
Figure S2-08

Korea Peninsula: 112-90 Ma Magmatism

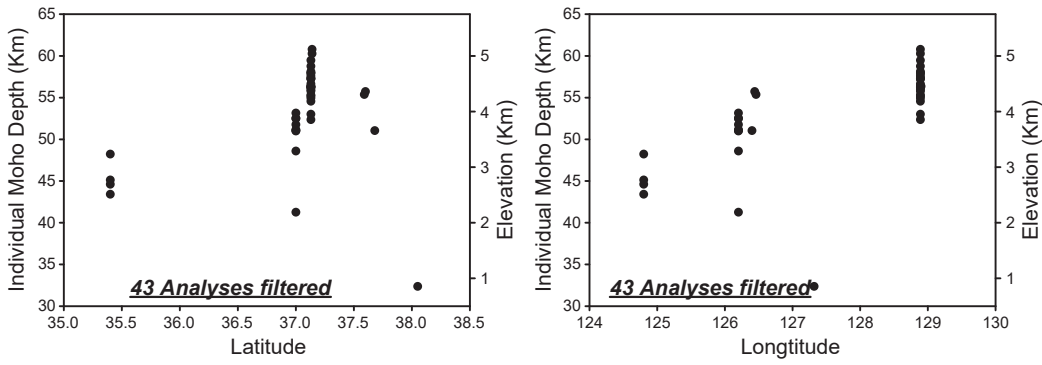
Individual Moho Depth vs. Age (112-90 Ma)



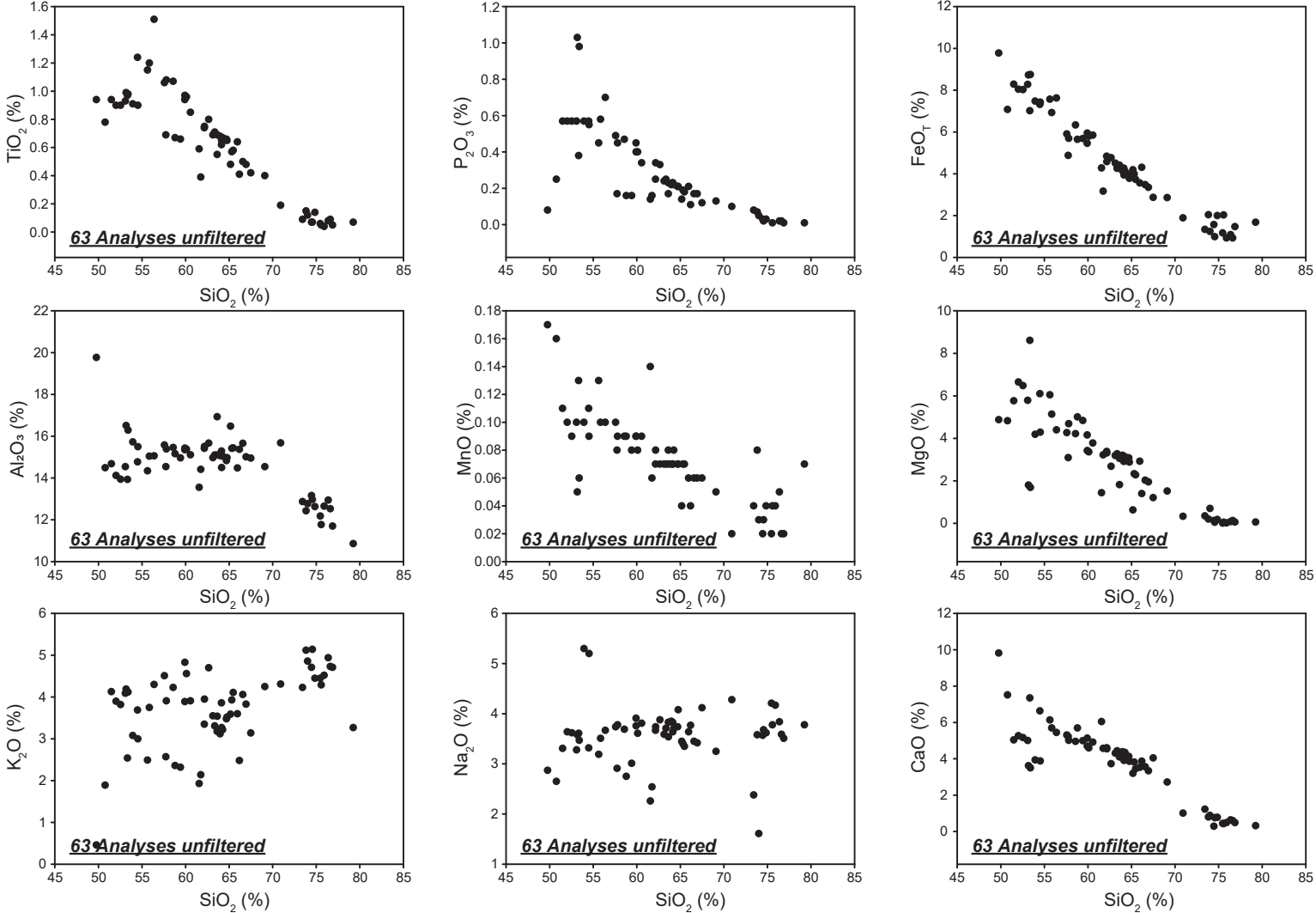
TAS diagram (112-90 Ma)



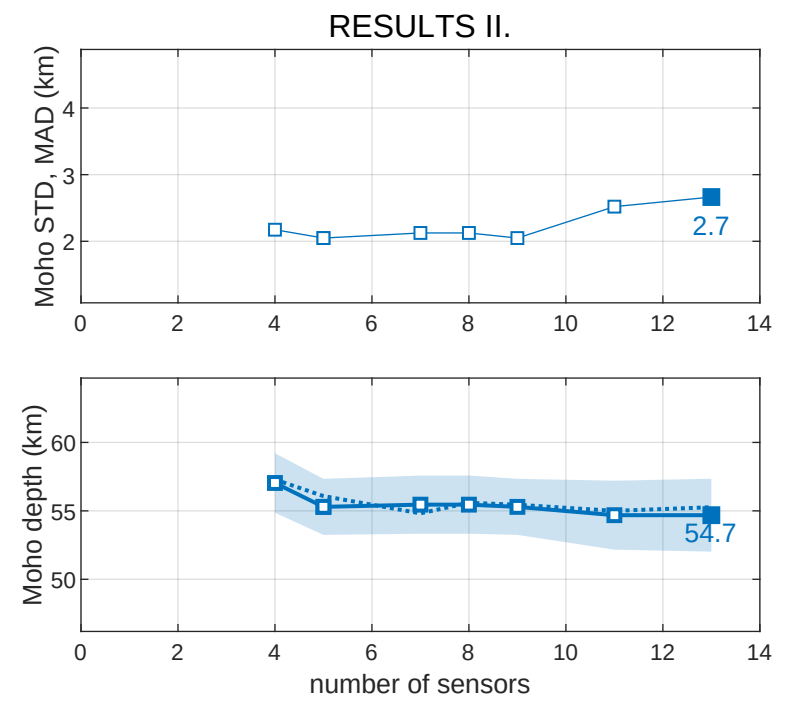
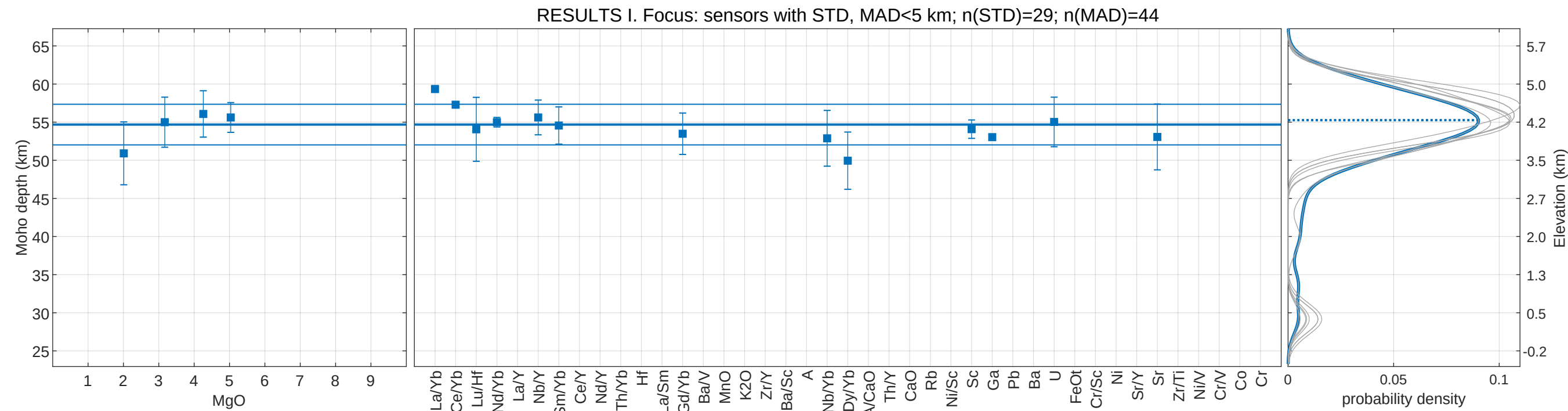
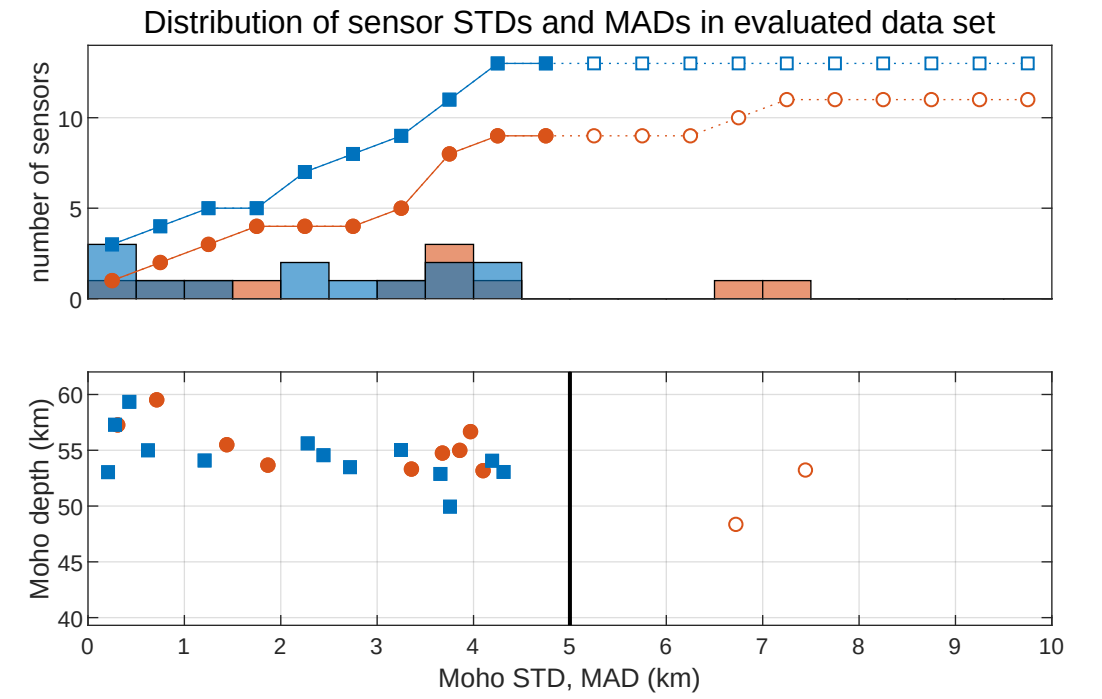
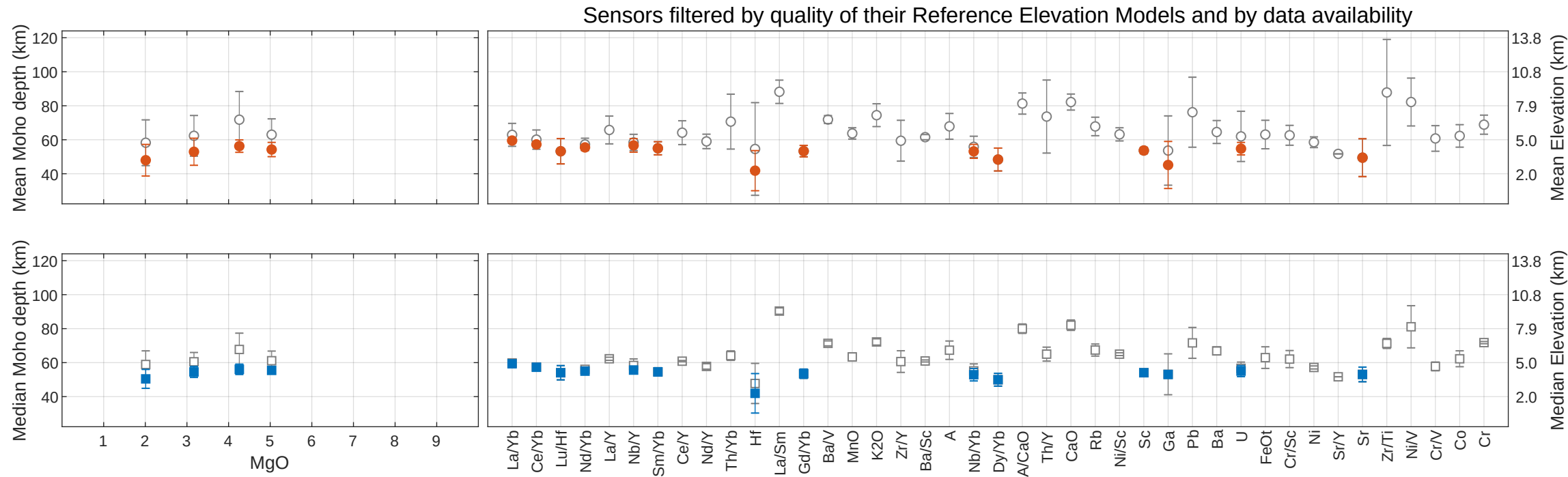
Individual Moho Depth vs. Longitude and Latitude (112-109 Ma)



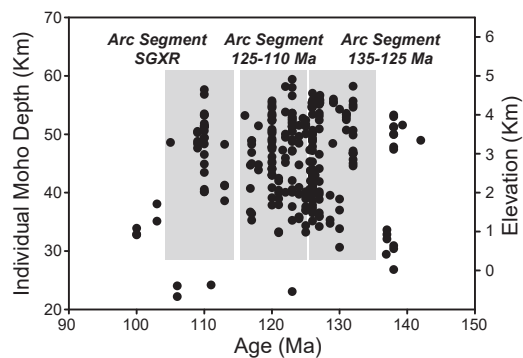
Harker Diagrams (112-90 Ma)



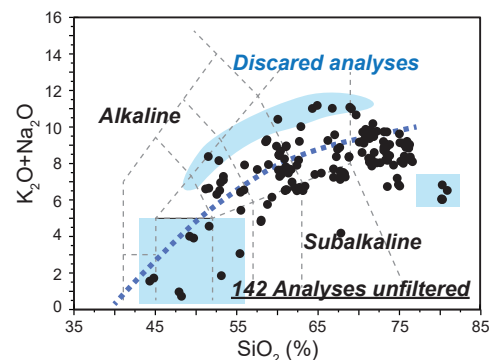
Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation



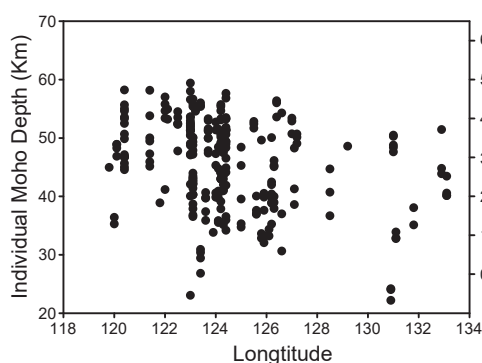
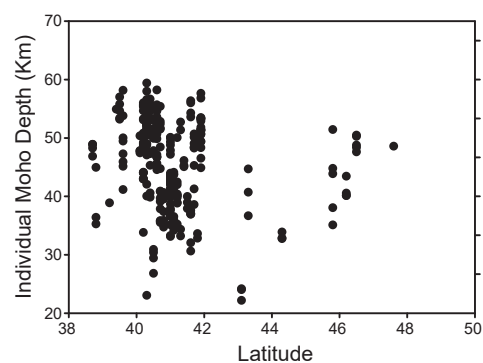
Individual Moho Depth vs. Latitude (140-100 Ma)



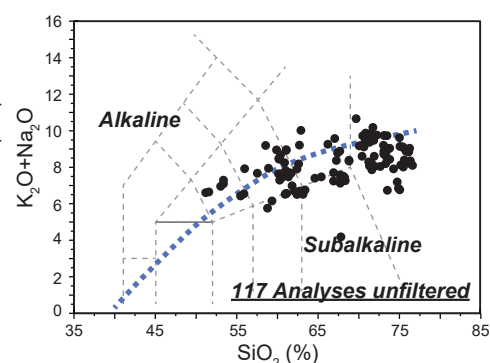
TAS diagram (135-125 Ma)



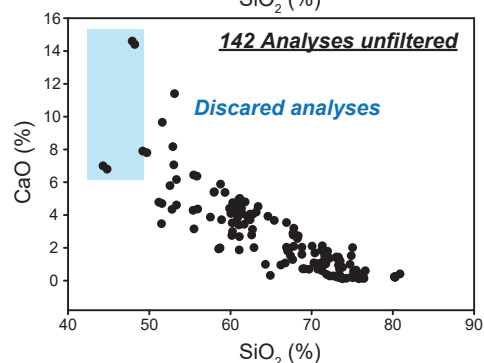
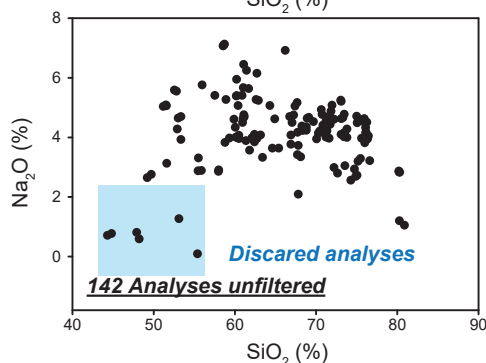
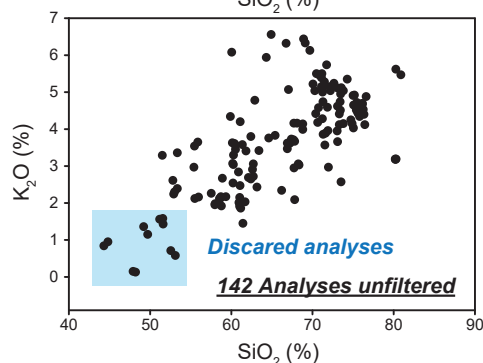
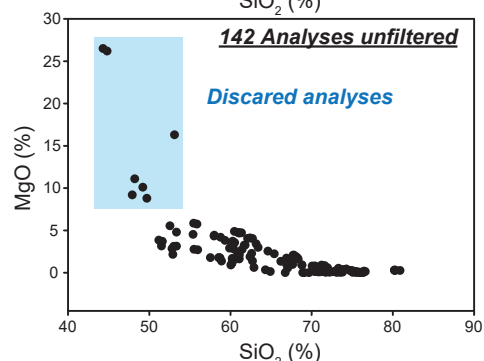
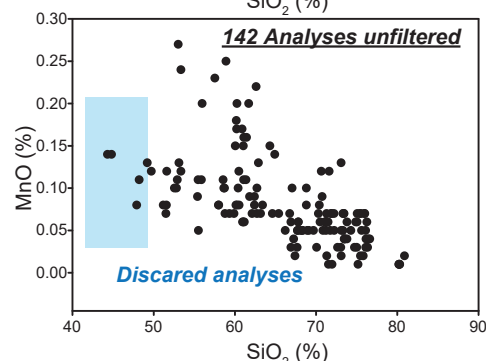
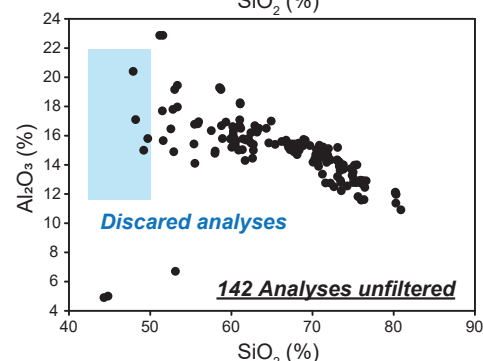
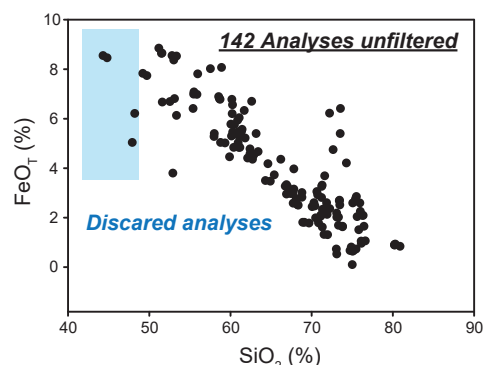
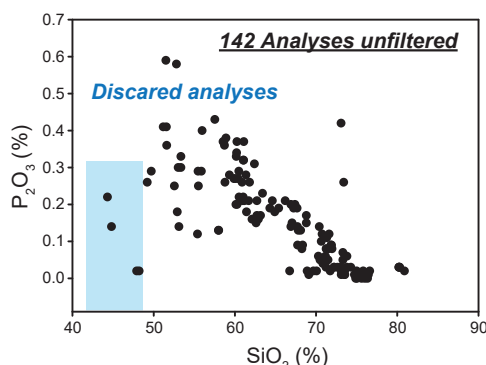
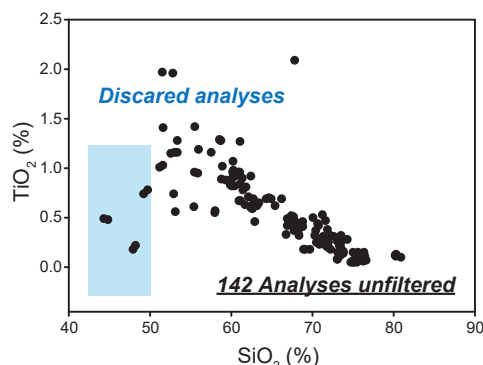
Individual Moho Depth vs. Latitude (140-100 Ma)



TAS diagram (135-125 Ma)



Harker Diagrams (135-125 Ma)



Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation

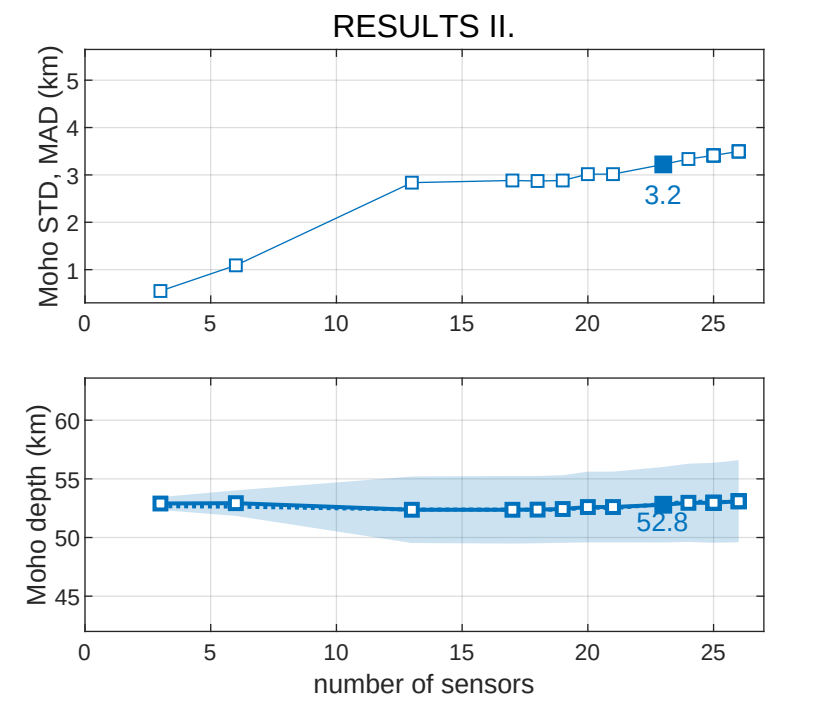
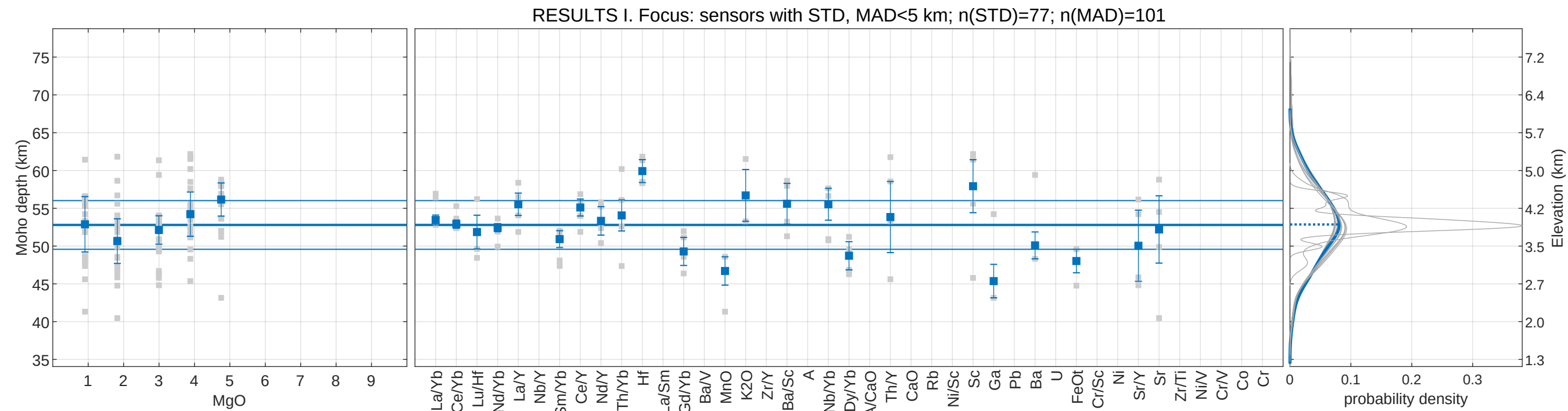
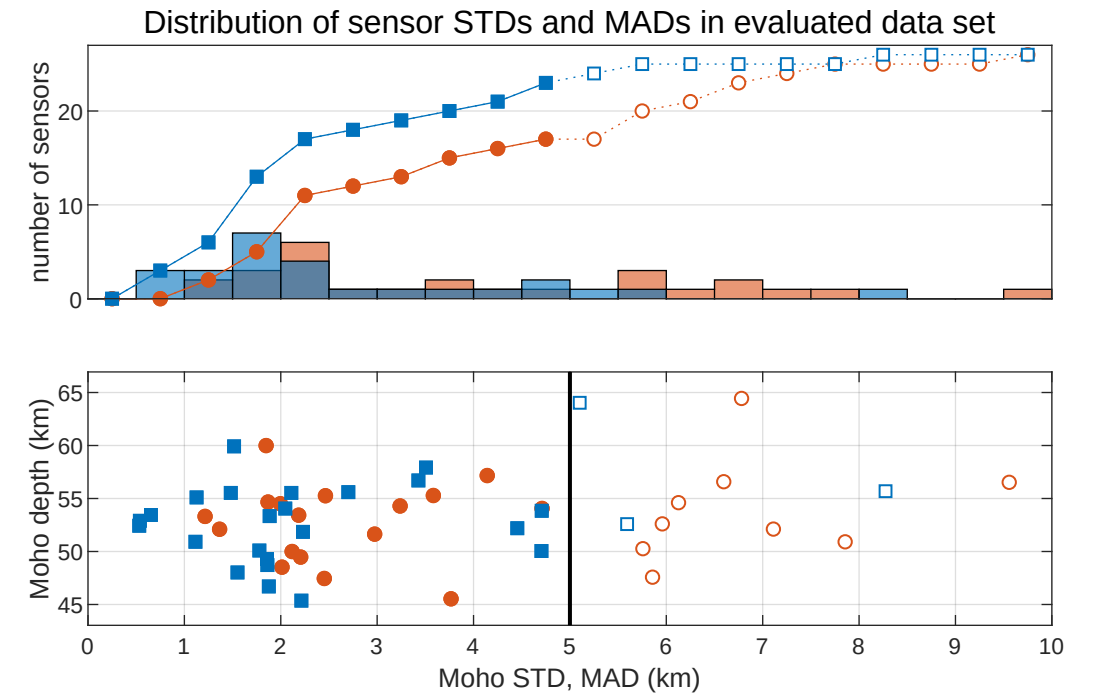
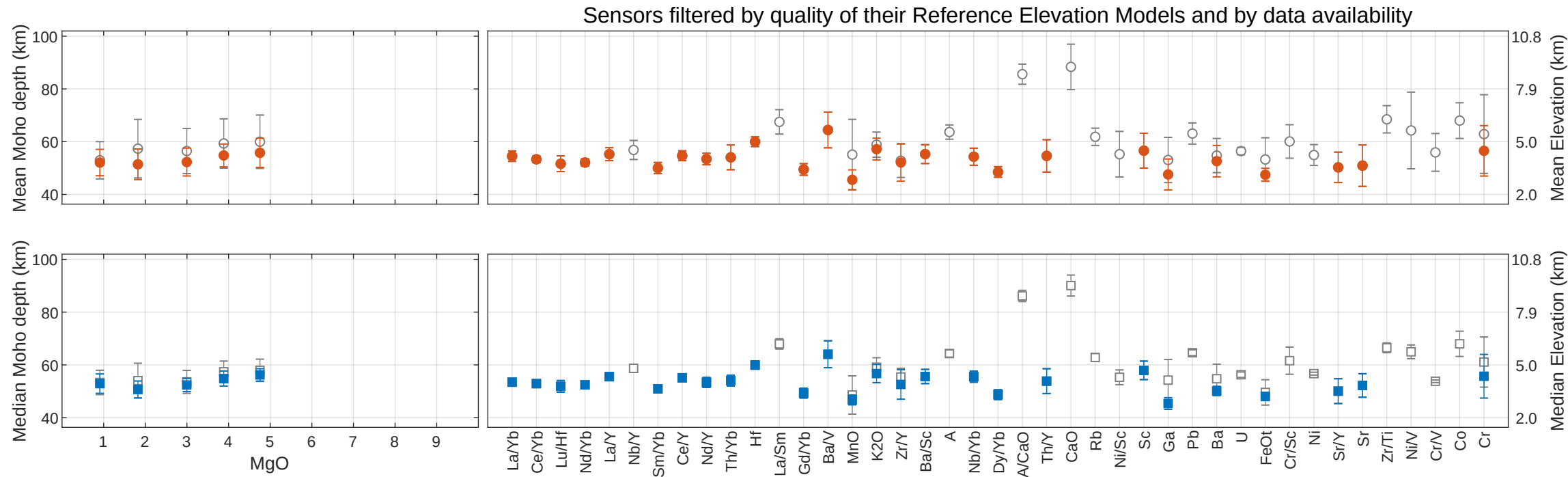
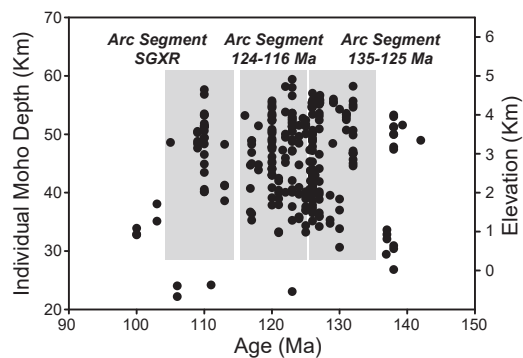


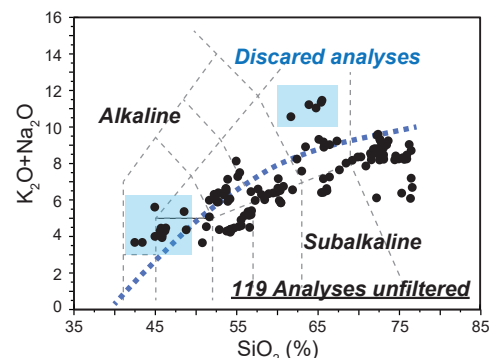
Figure S2-10

Liaodong Peninsula (LDP): 124-116 Ma Magmatism

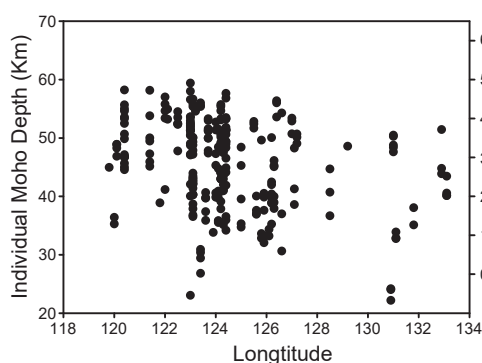
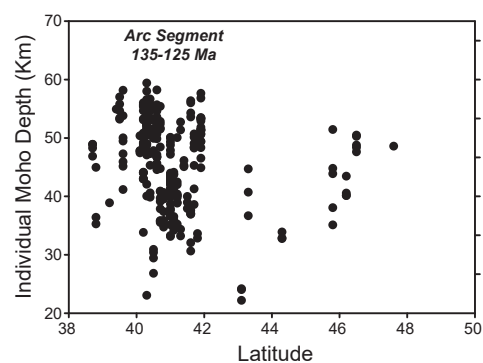
Individual Moho Depth vs. Latitude (140-100 Ma)



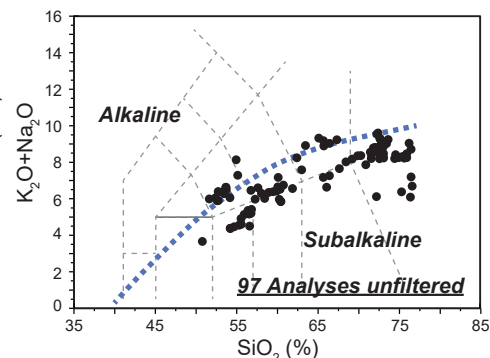
TAS diagram (124-116 Ma)



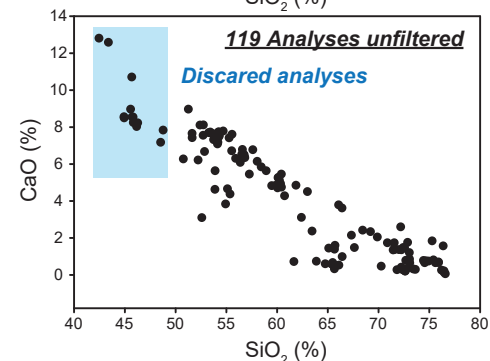
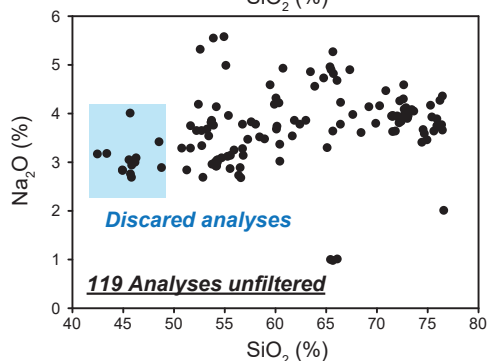
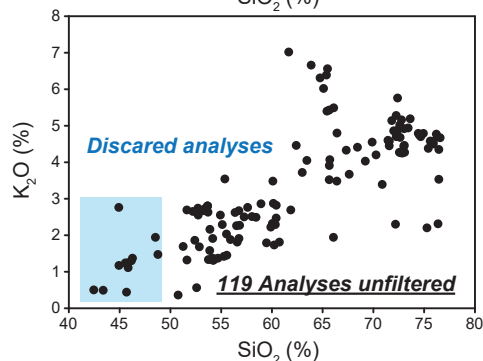
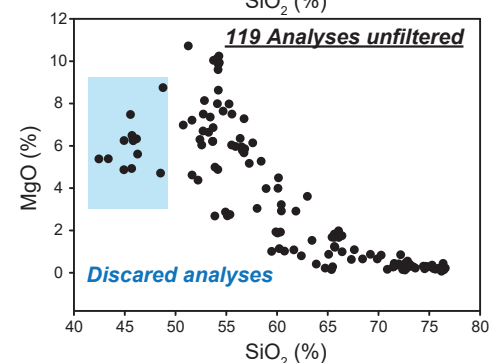
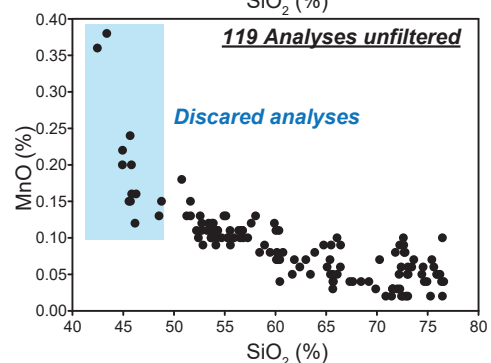
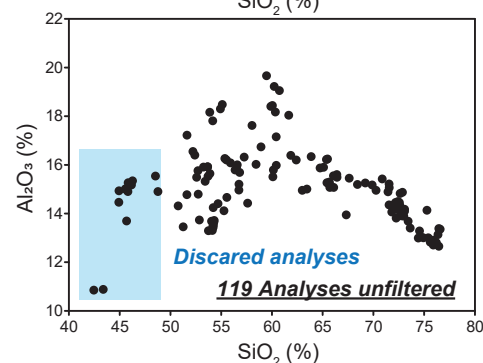
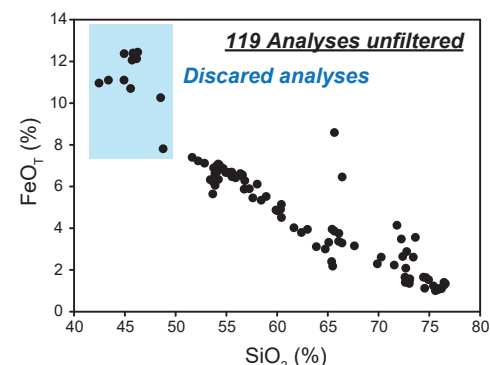
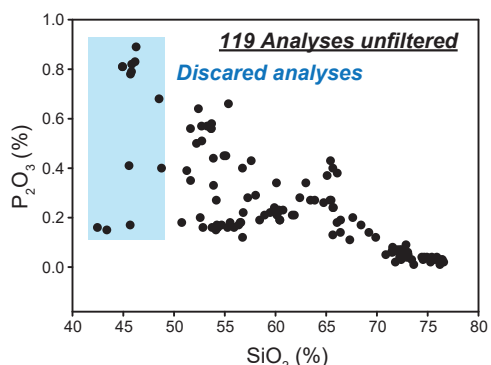
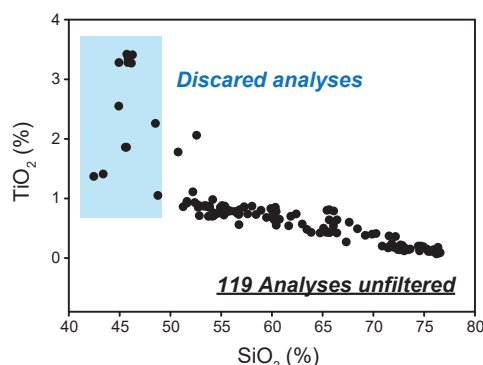
Individual Moho Depth vs. Latitude (140-100 Ma)



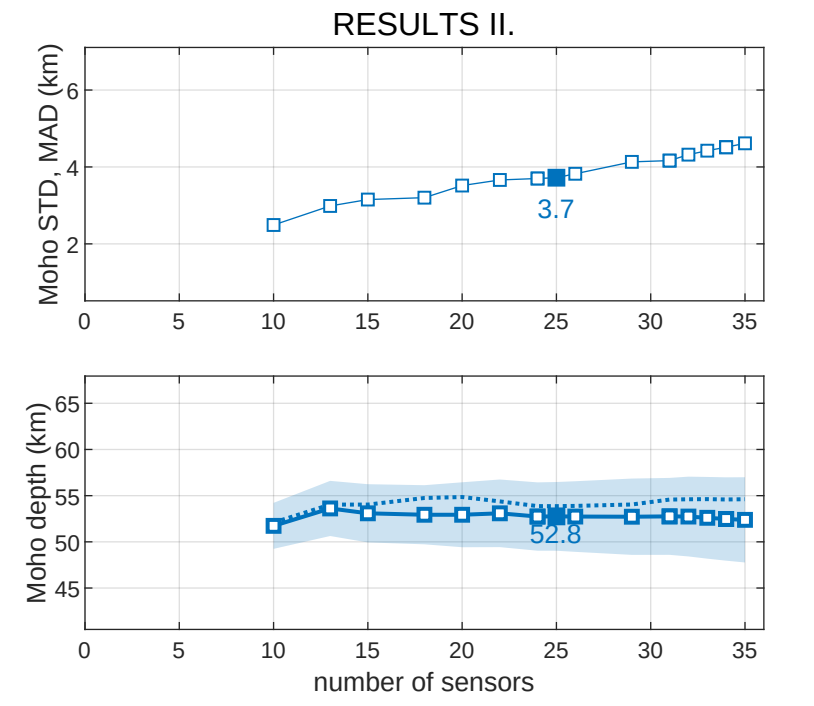
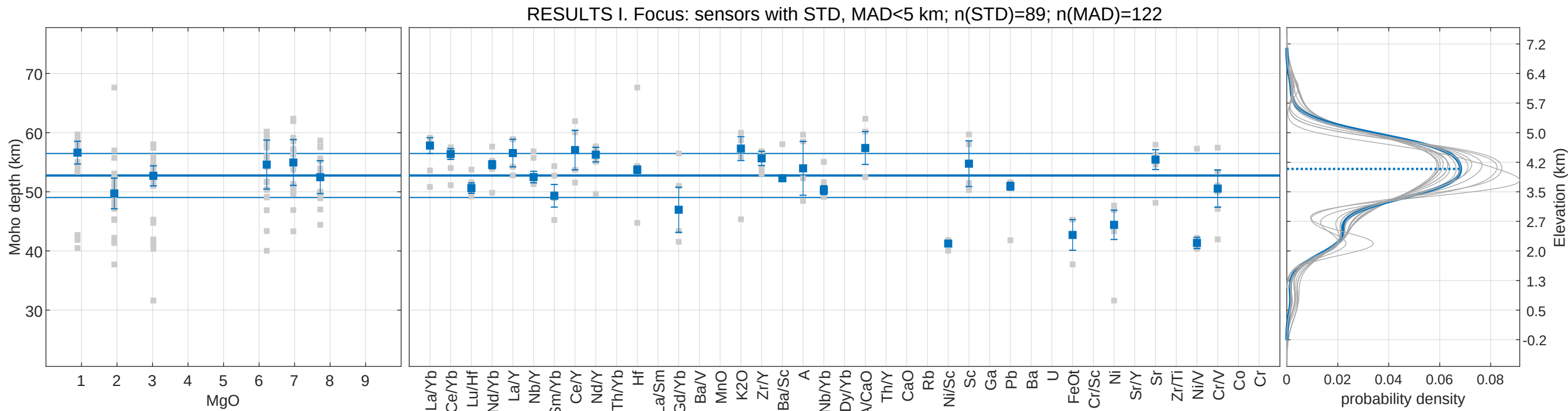
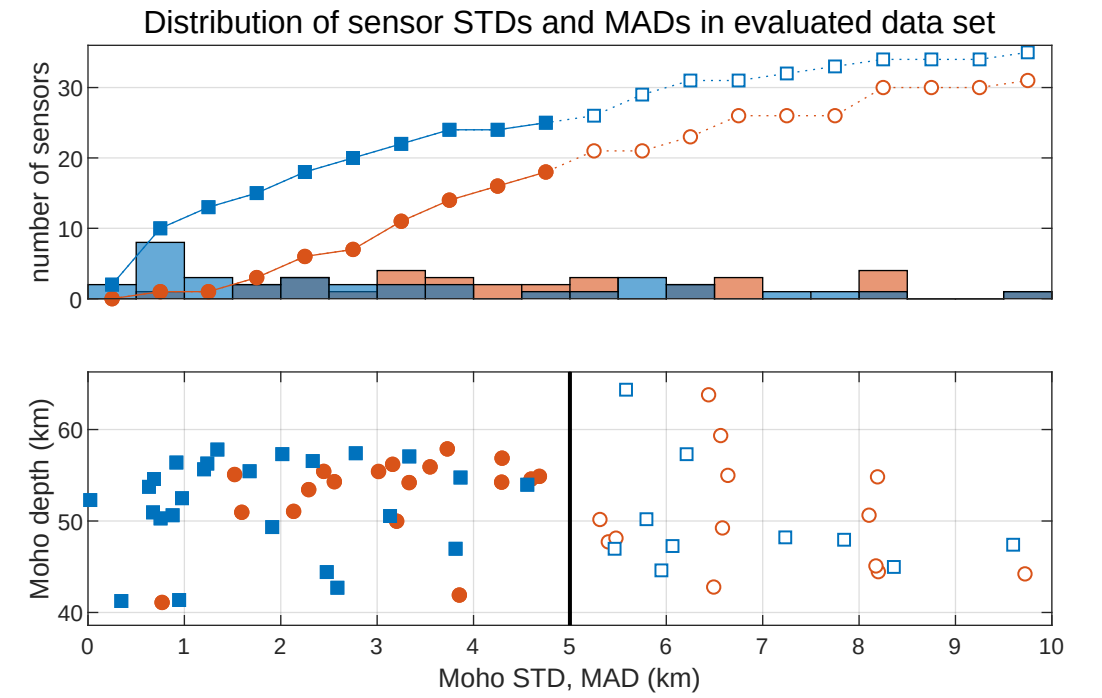
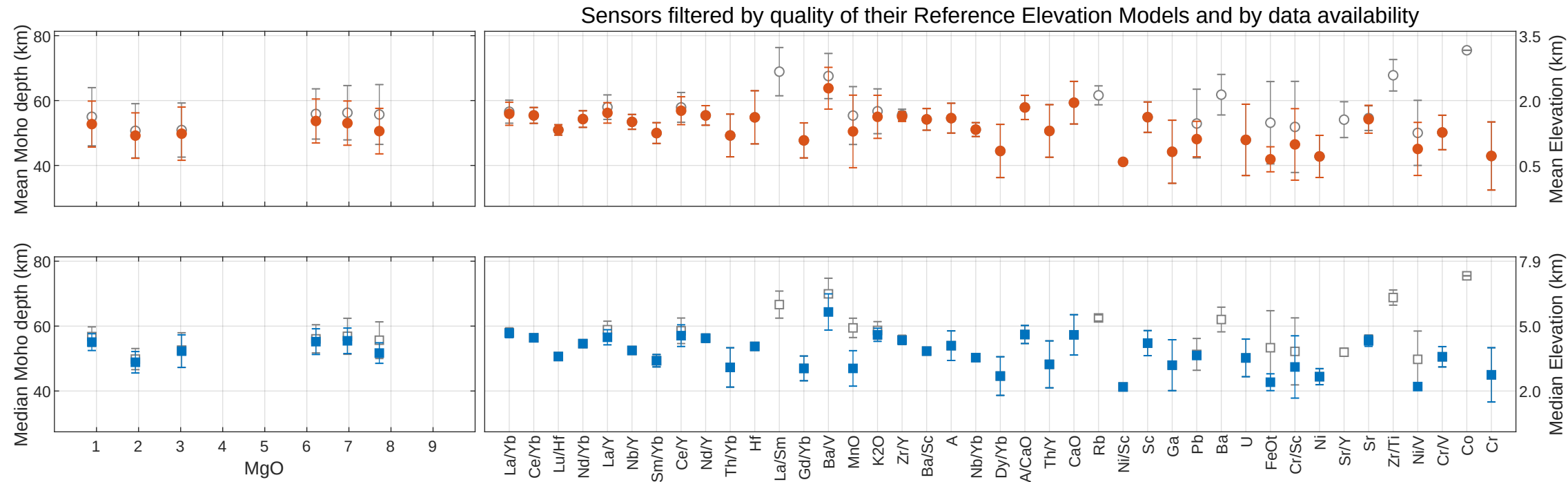
TAS diagram (124-116 Ma)



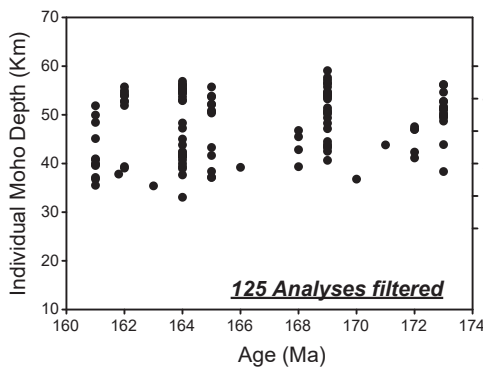
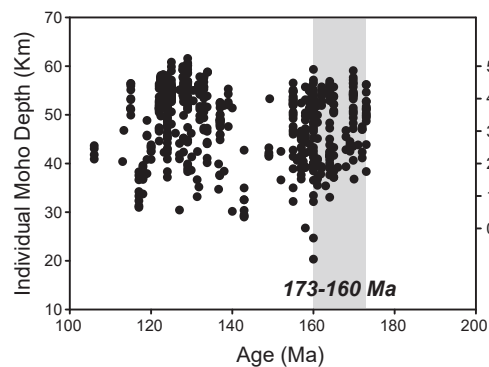
Harker Diagrams (124-116 Ma)



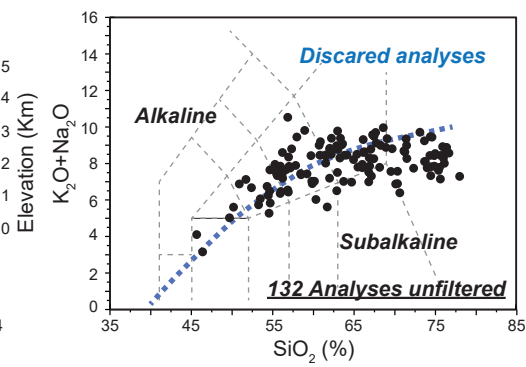
Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation



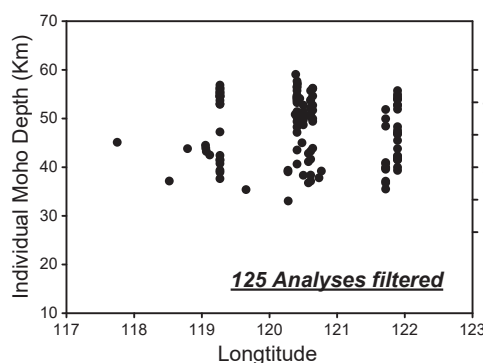
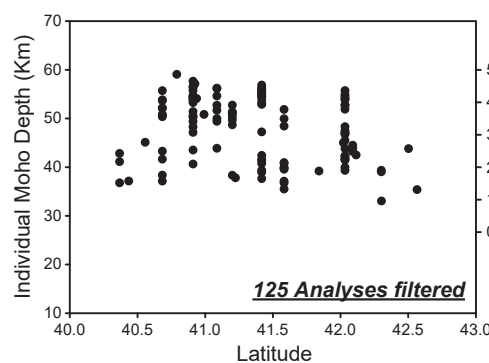
Individual Moho Depth vs. Age (173-113 Ma) (173-160 Ma)



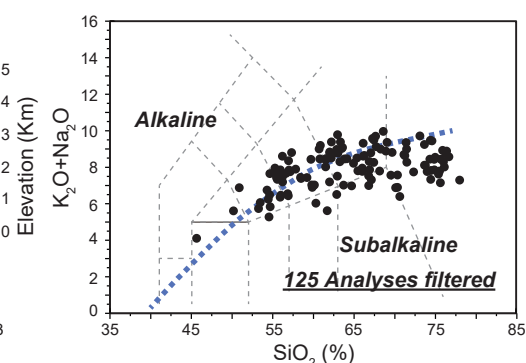
TAS diagram (173-160 Ma)



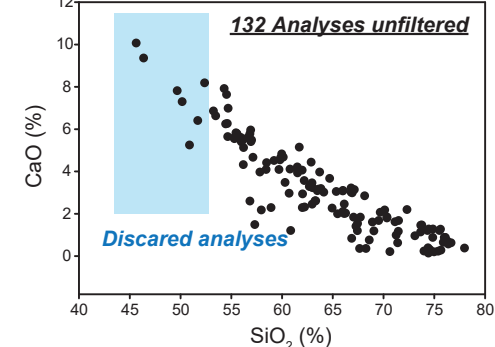
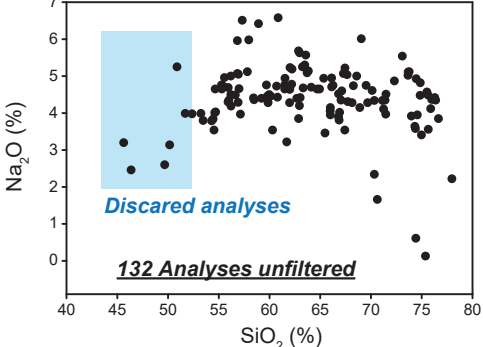
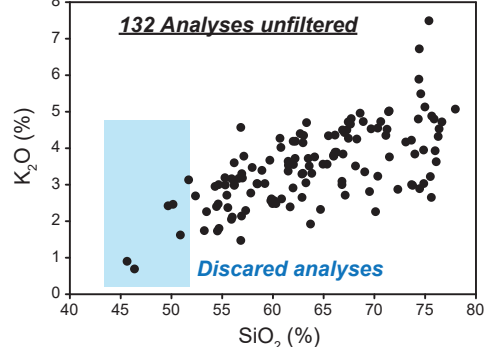
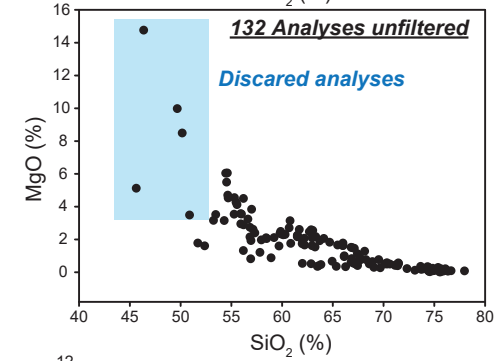
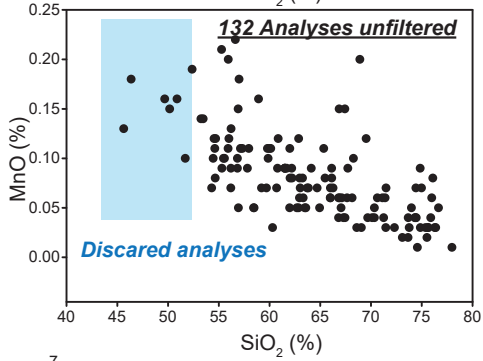
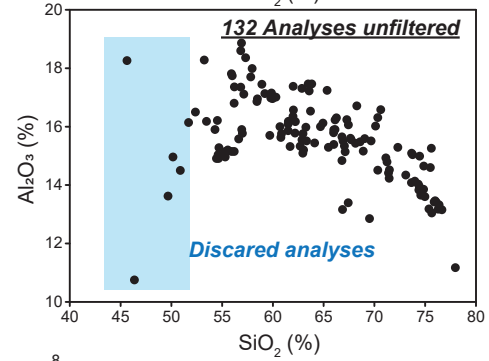
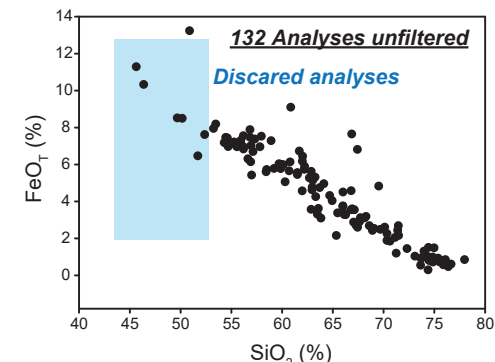
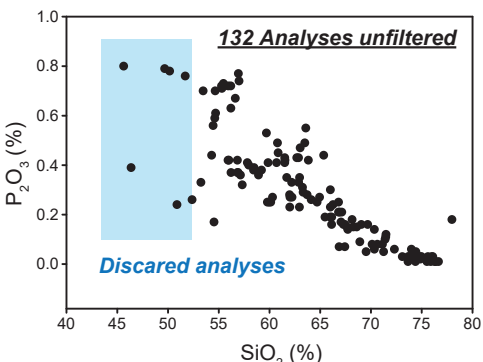
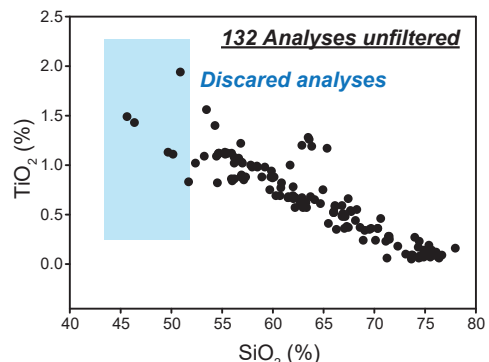
Individual Moho Depth vs. Longitude and Latitude (173-160 Ma)



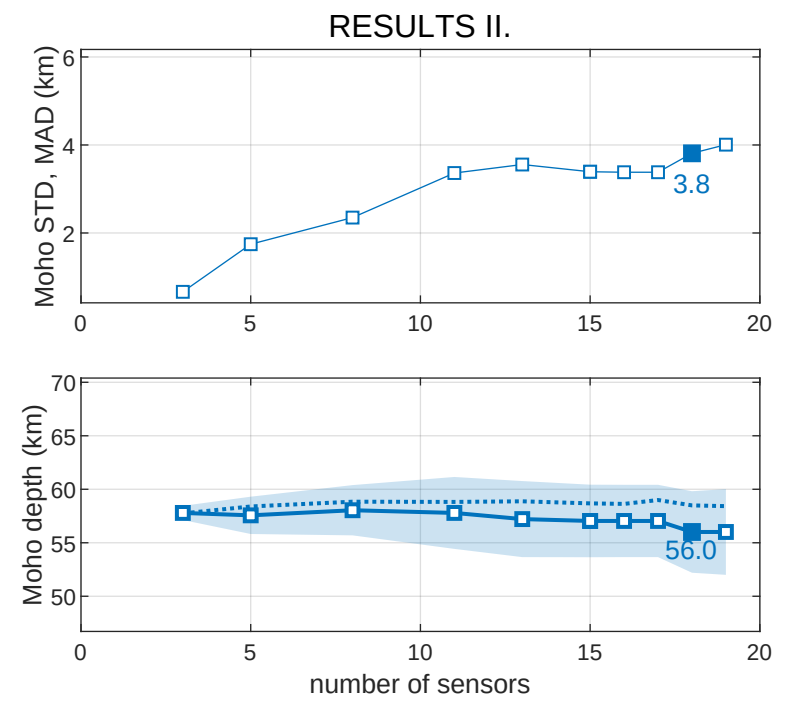
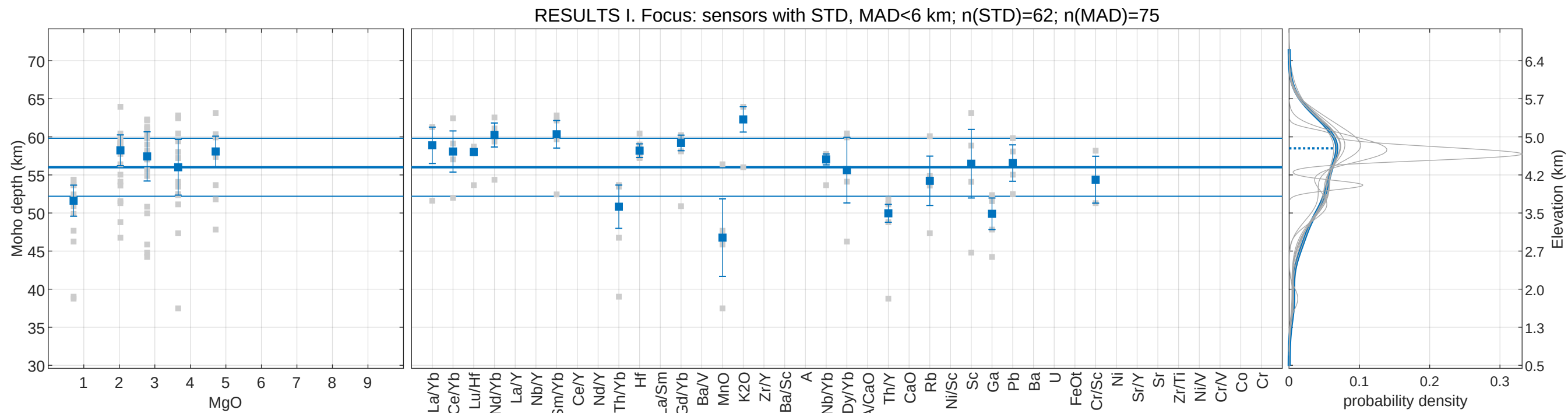
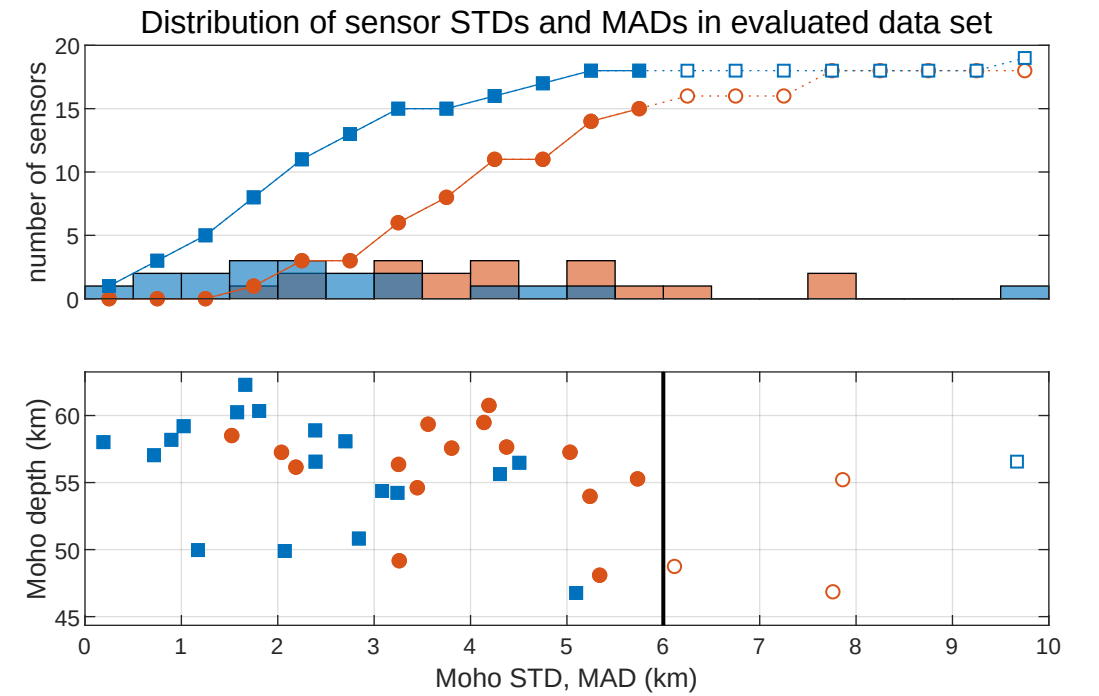
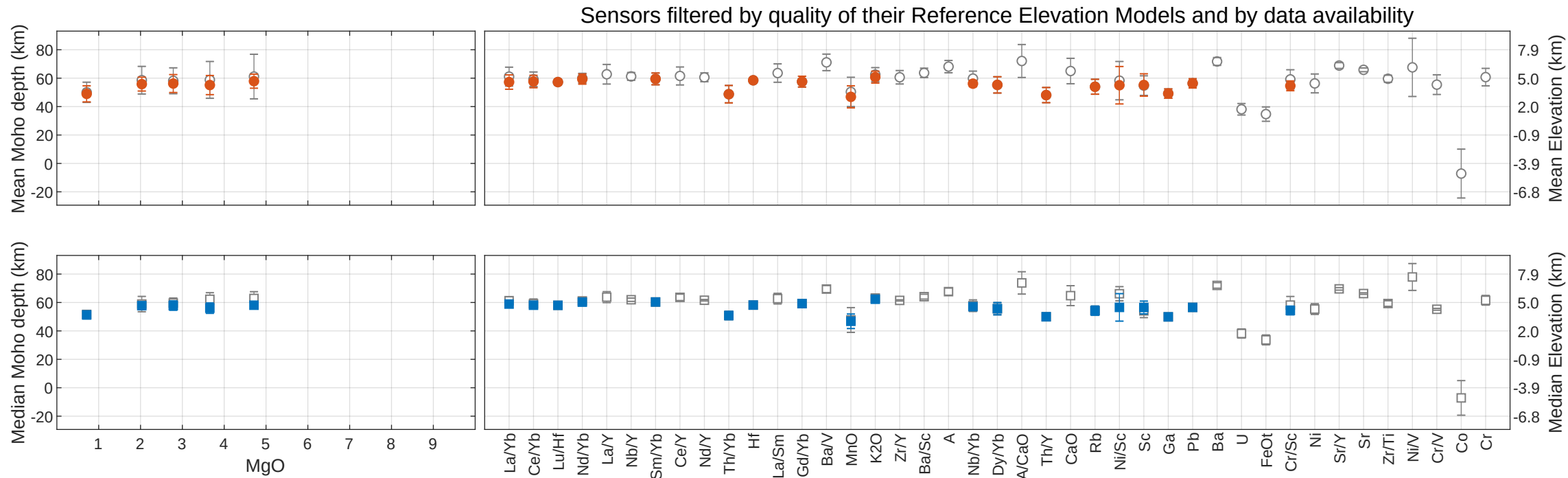
TAS diagram (173-160 Ma)



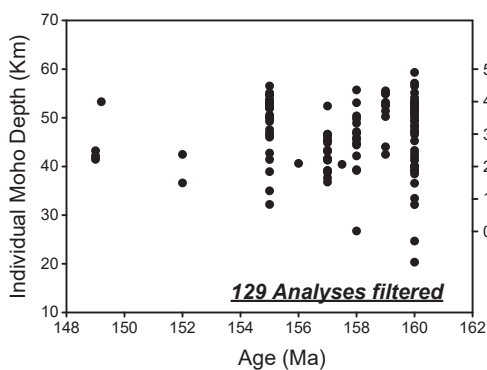
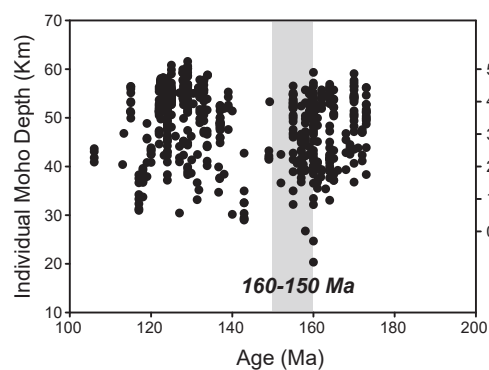
Harker Diagrams (173-160 Ma)



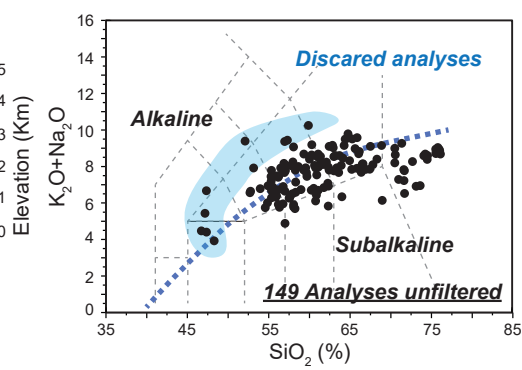
Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation



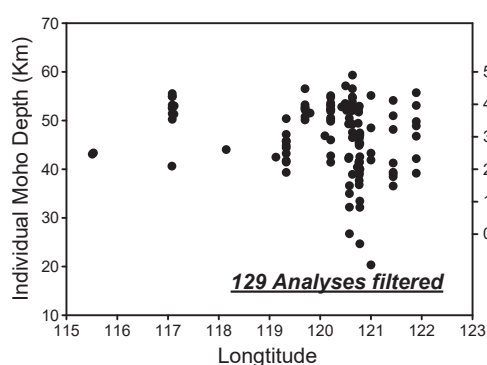
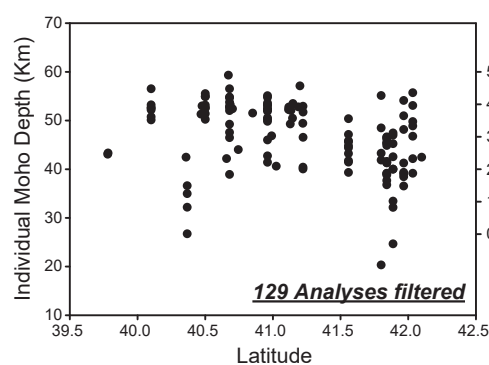
Individual Moho Depth vs. Age (182-113 Ma) (160-150 Ma)



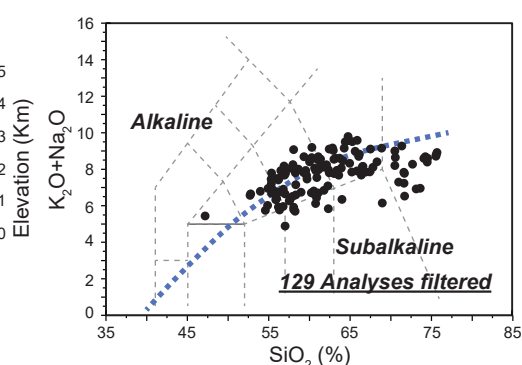
TAS diagram (160-150 Ma)



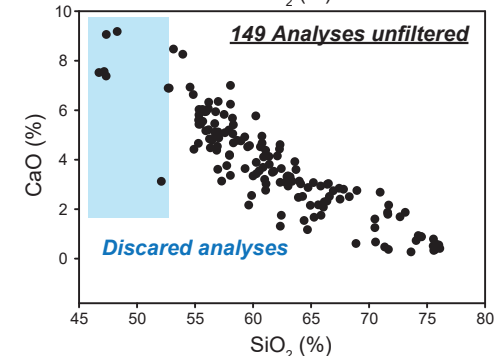
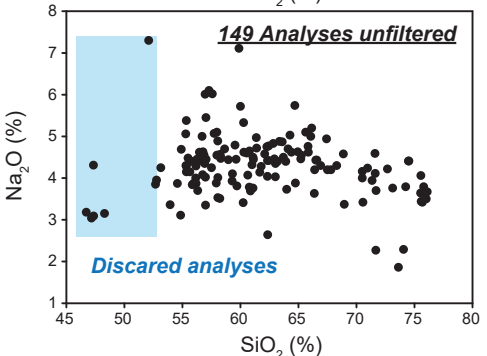
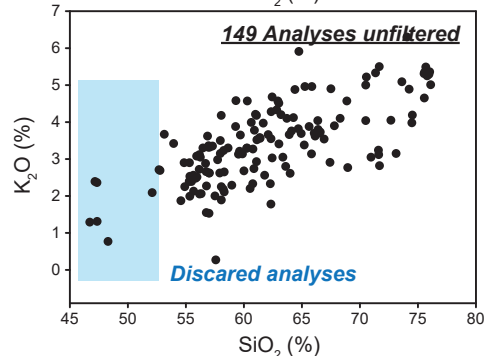
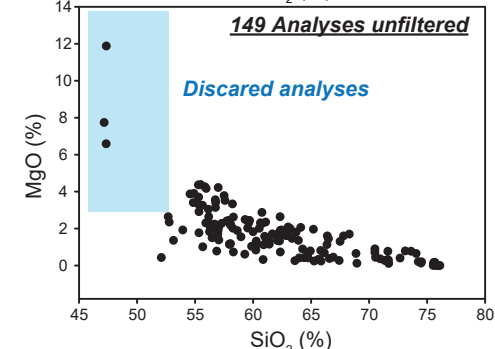
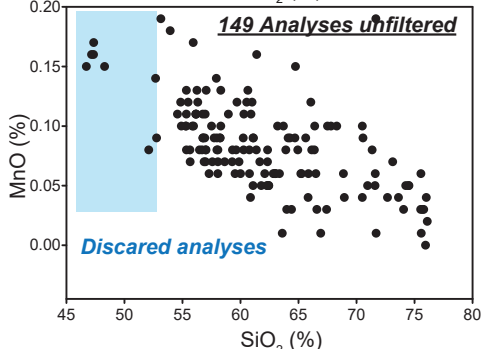
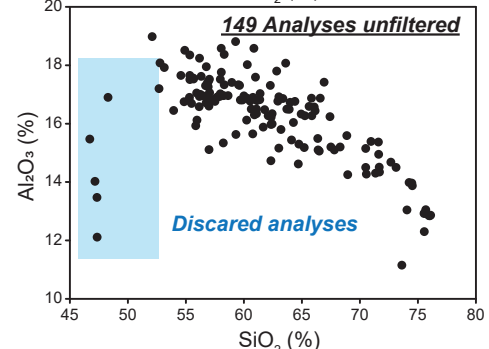
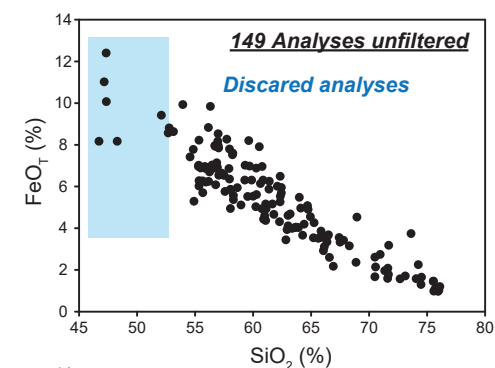
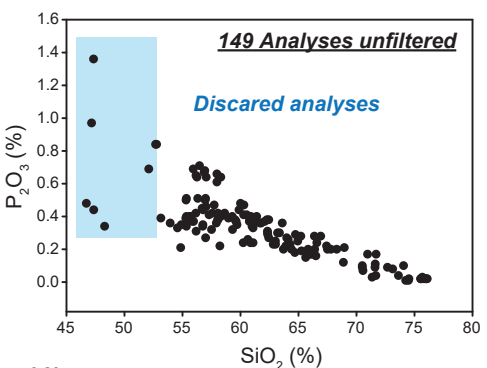
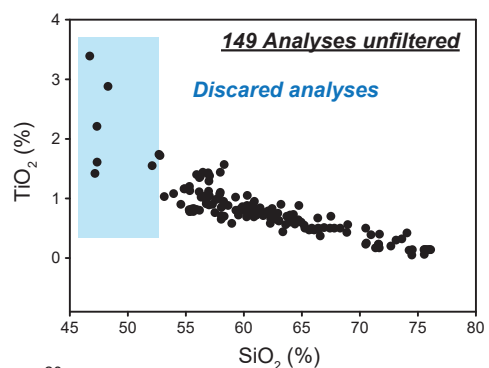
Individual Moho Depth vs. Longitude and Latitude (160-150 Ma)



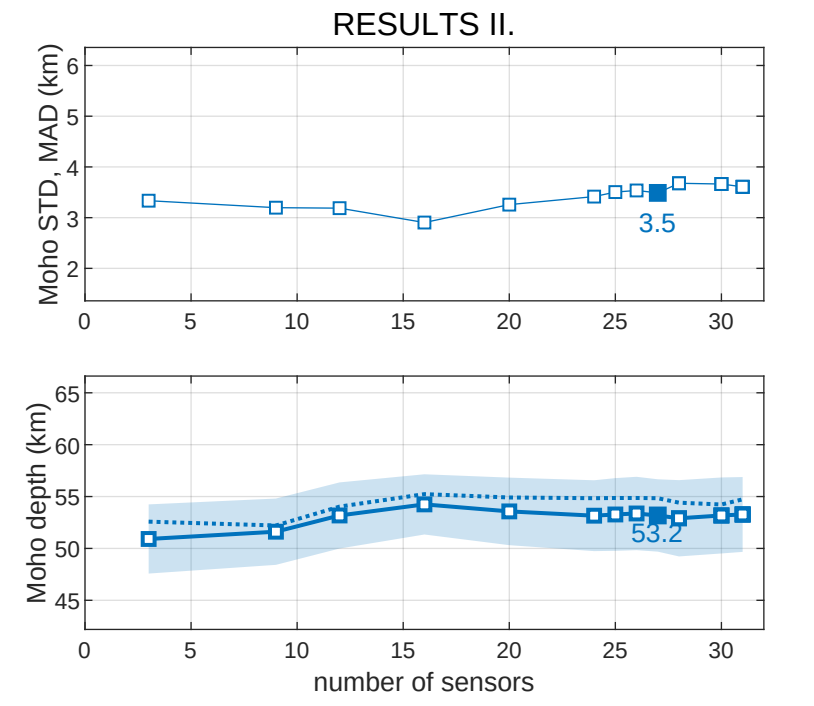
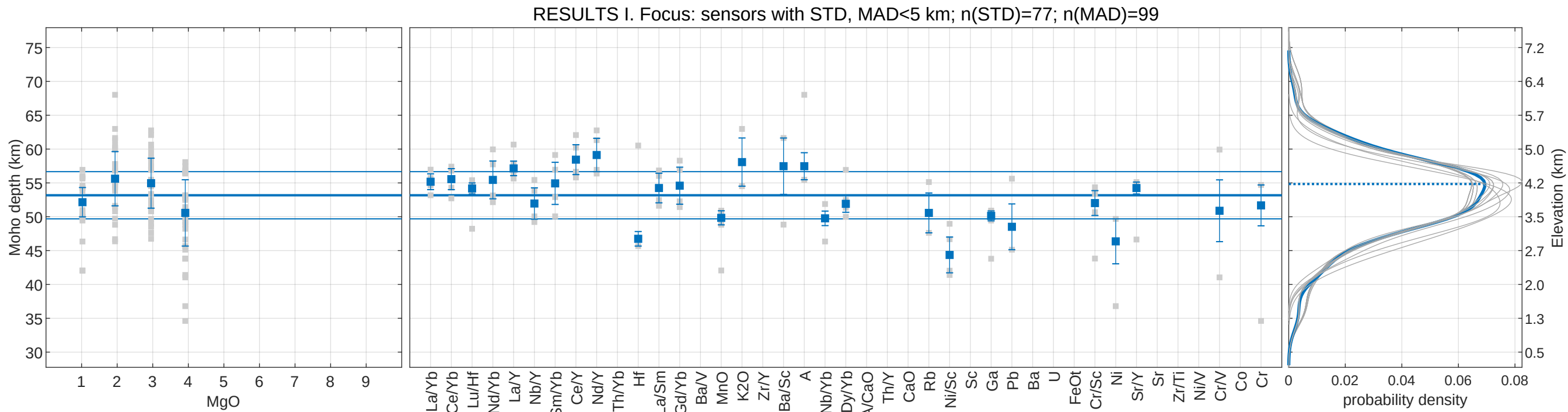
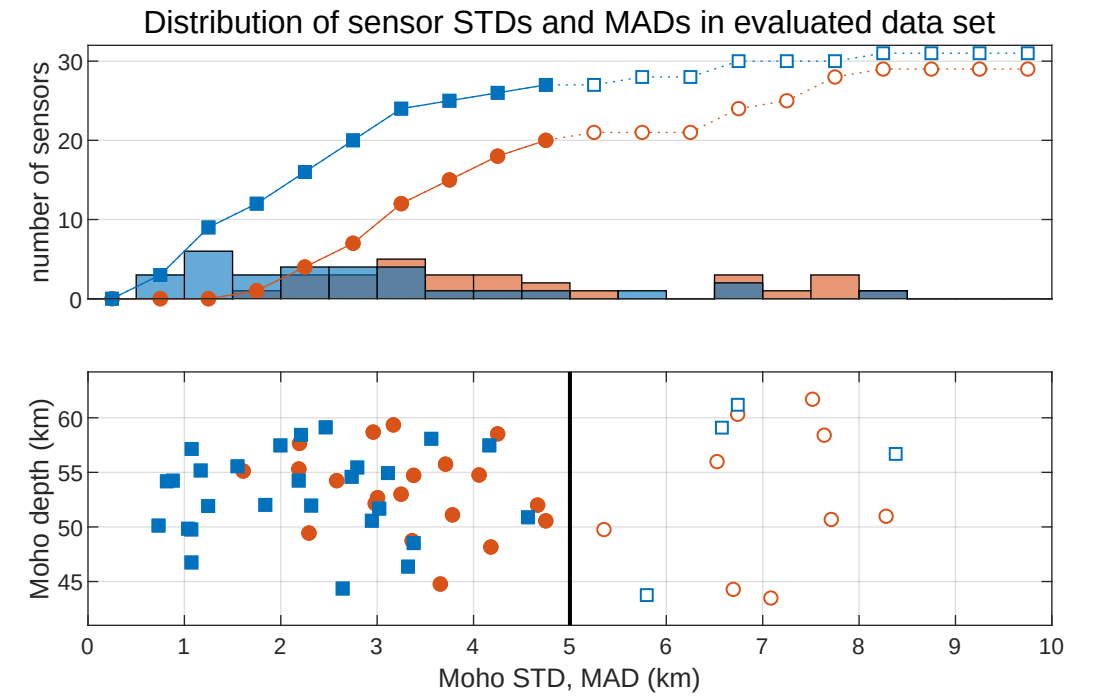
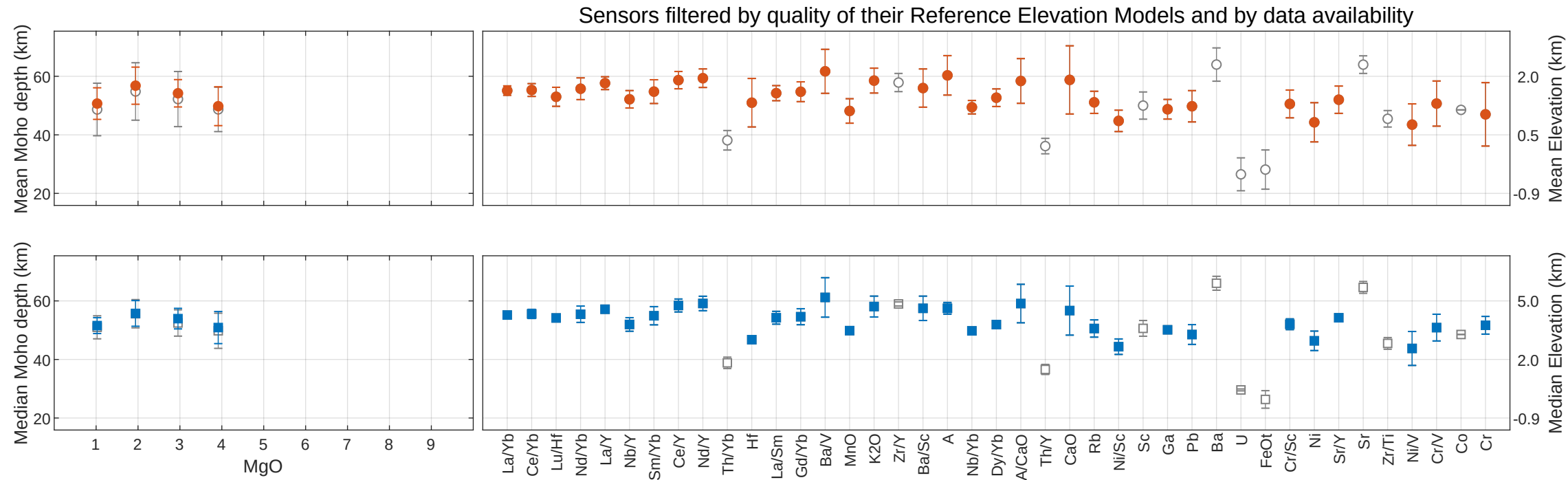
TAS diagram (160-150 Ma)



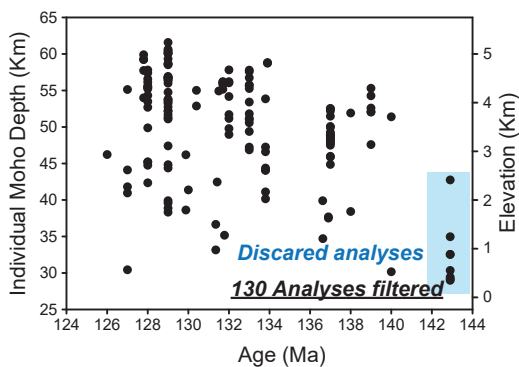
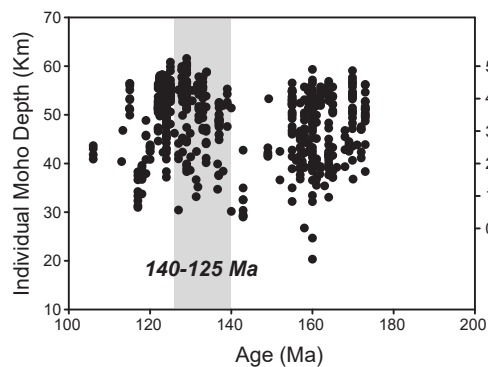
Harker Diagrams (160-150 Ma)



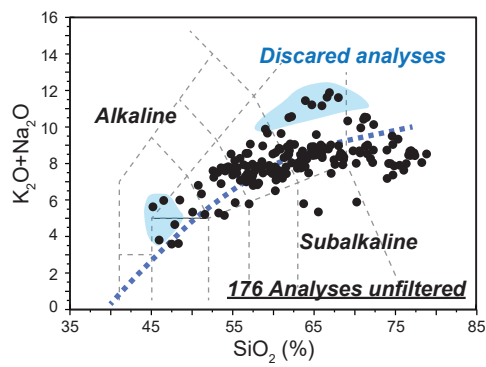
Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation



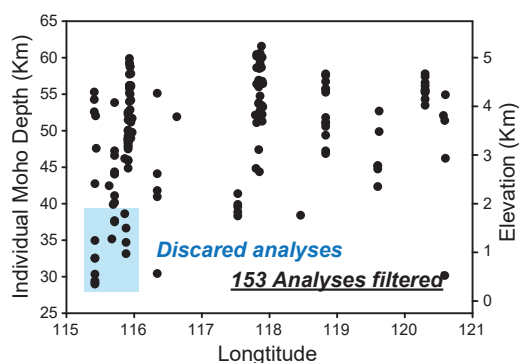
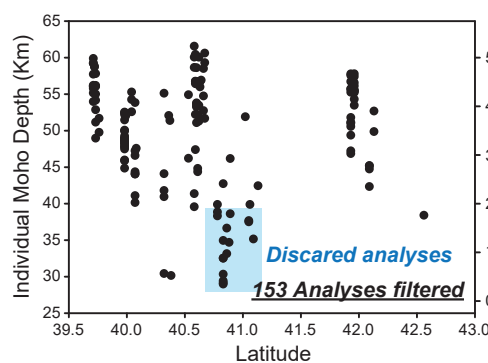
Individual Moho Depth vs. Age (182-113 Ma) (143-125 Ma)



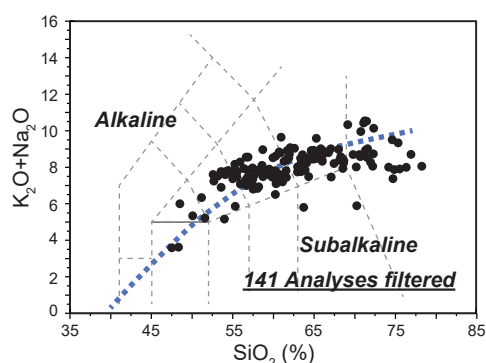
TAS diagram (143-125 Ma)



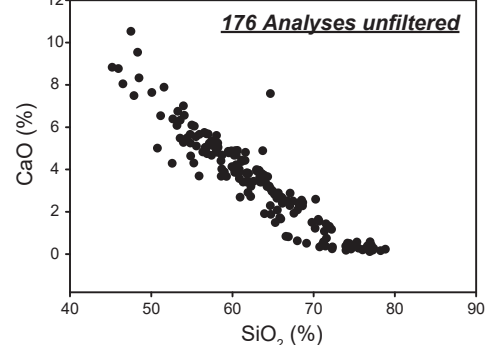
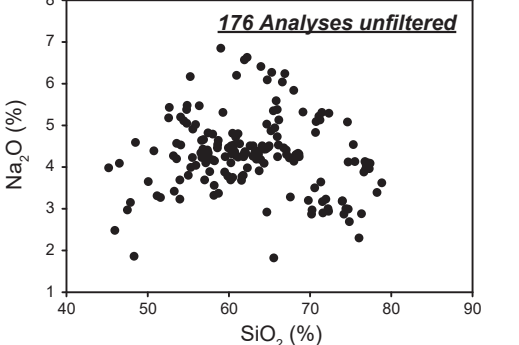
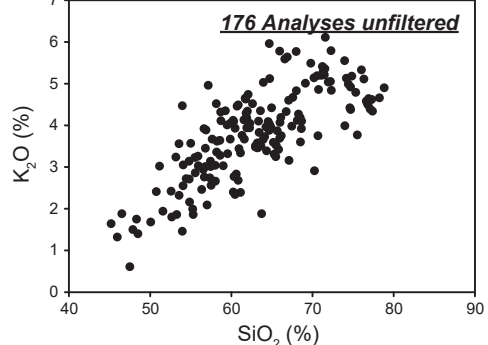
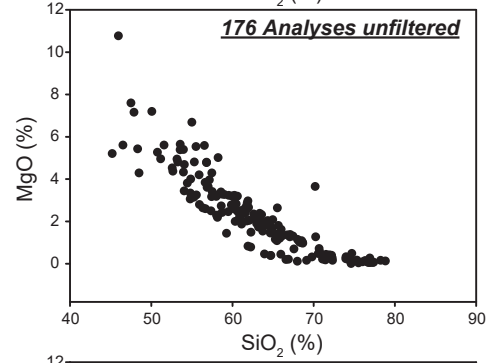
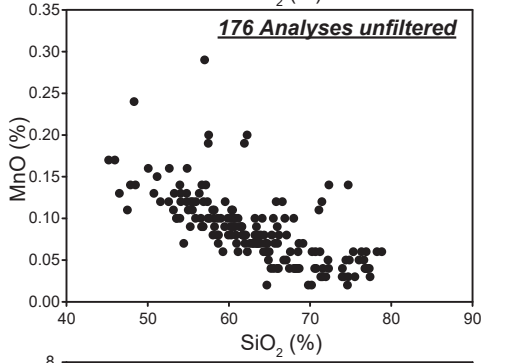
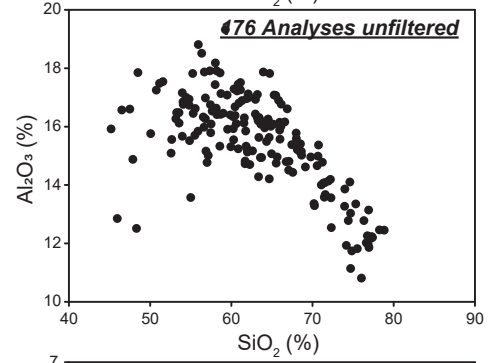
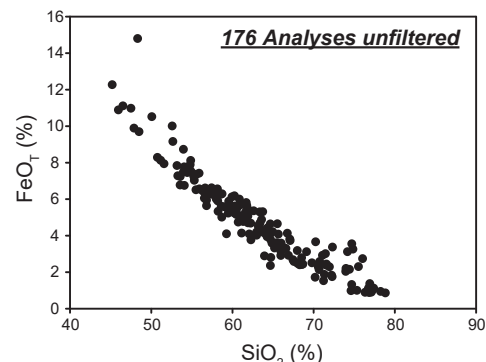
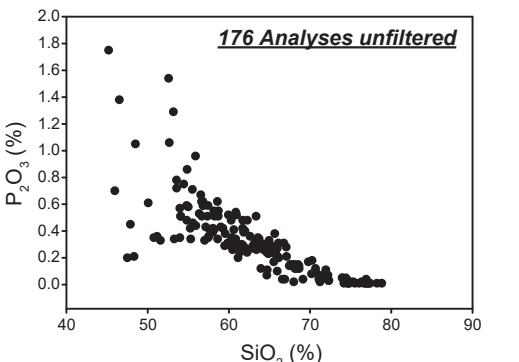
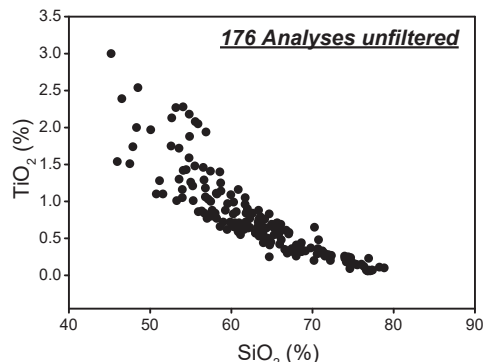
Individual Moho Depth vs. Longitude and Latitude (143-125 Ma)



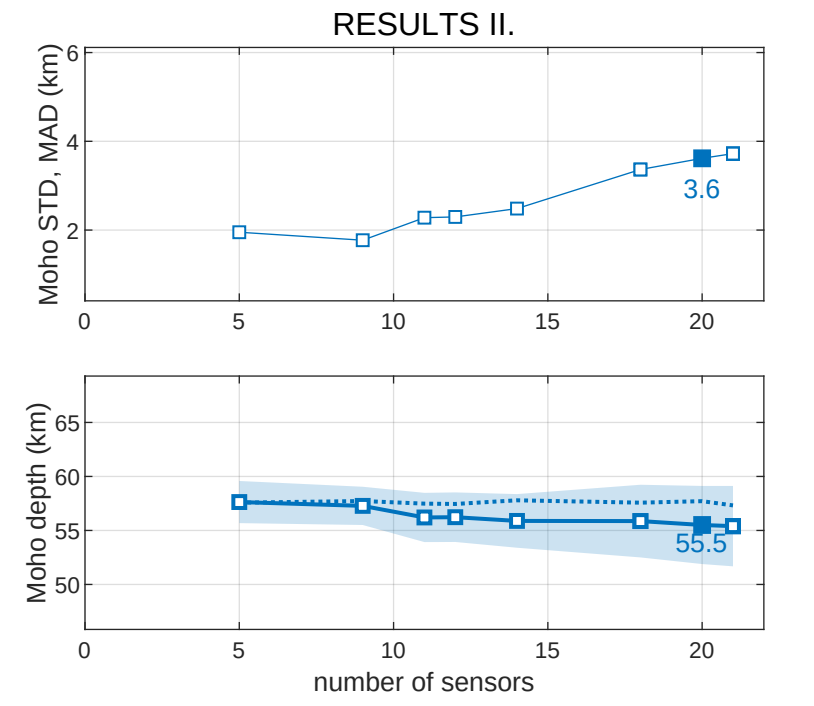
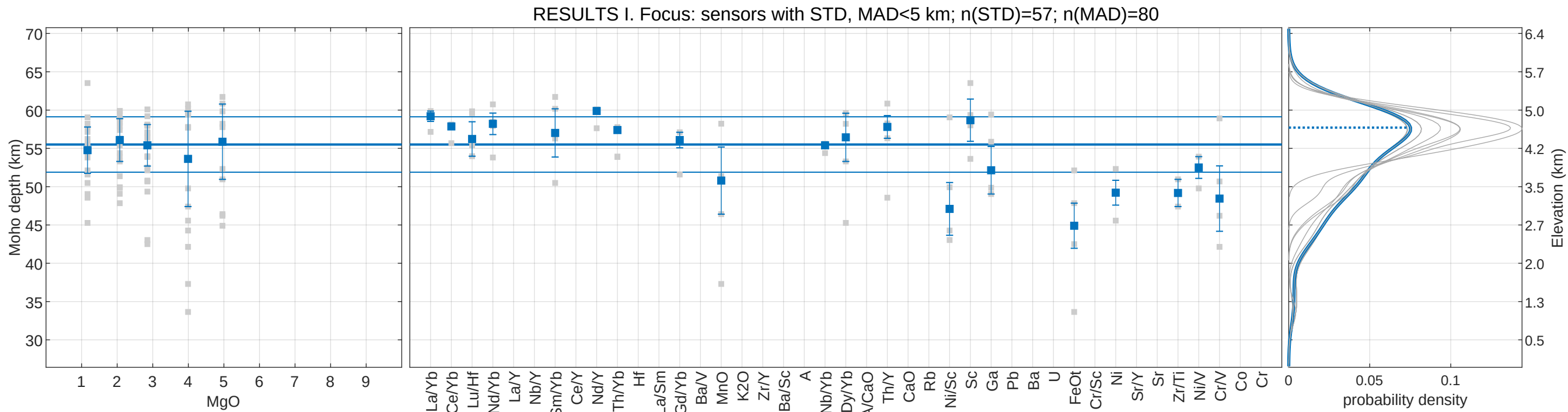
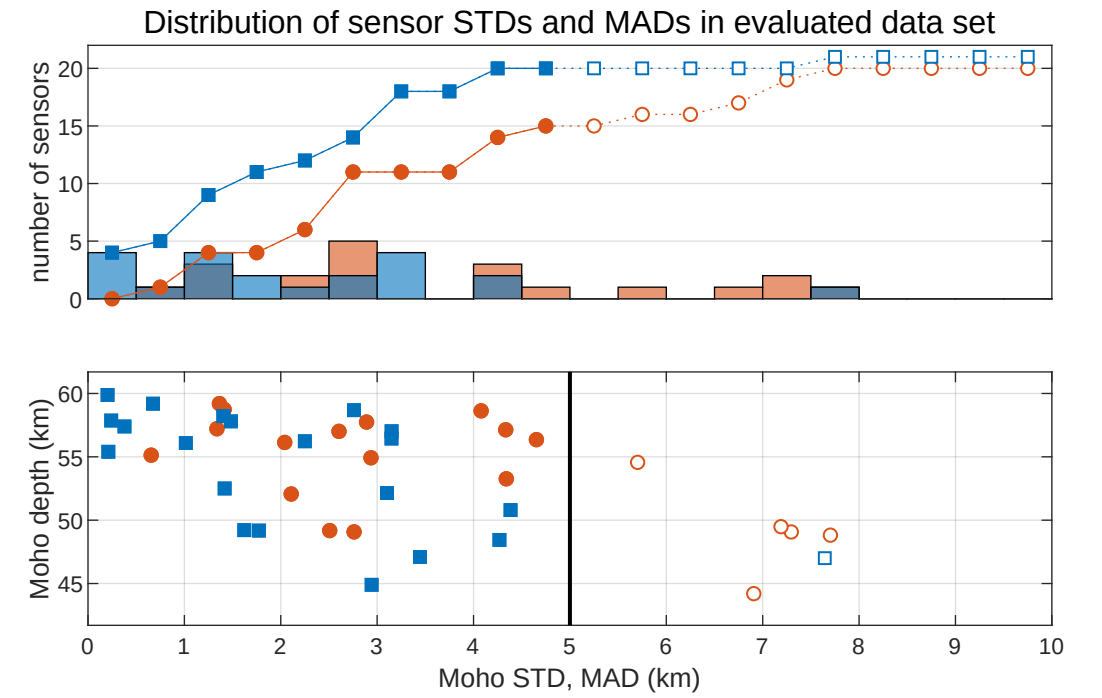
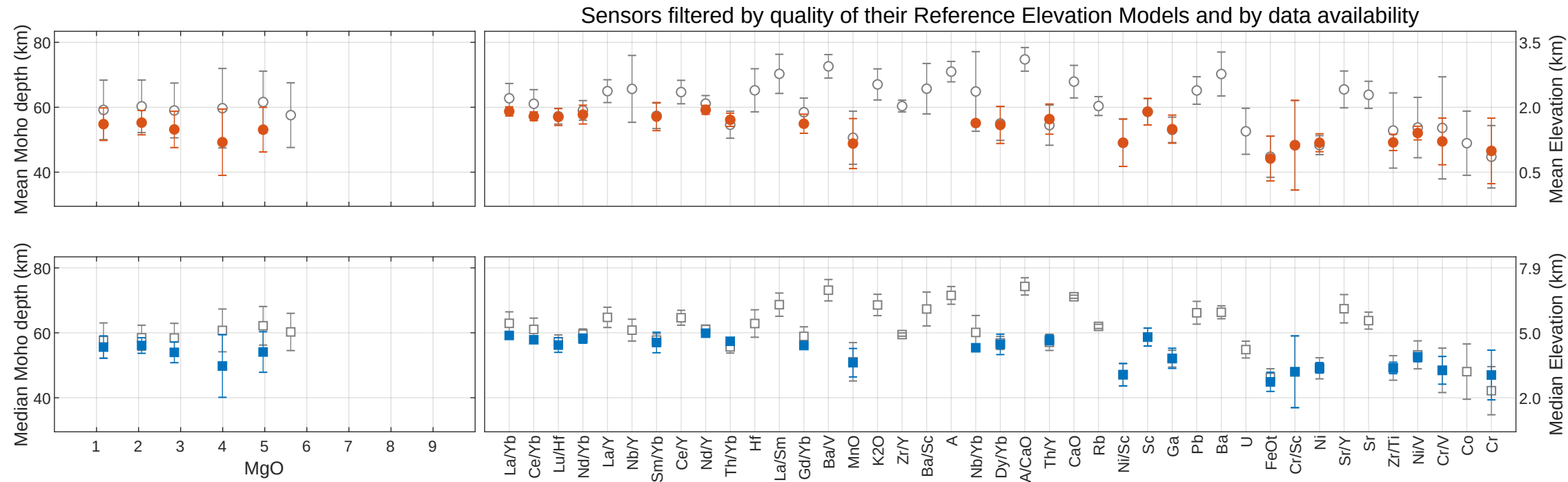
TAS diagram (140-125 Ma)



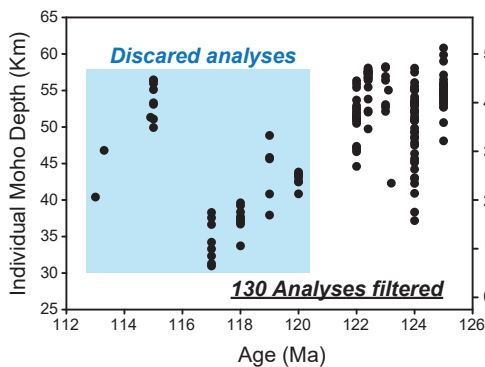
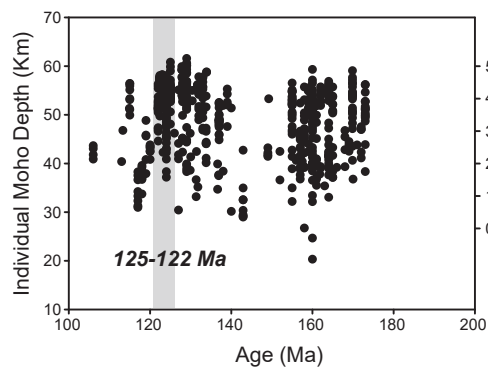
Harker Diagrams (143-125 Ma)



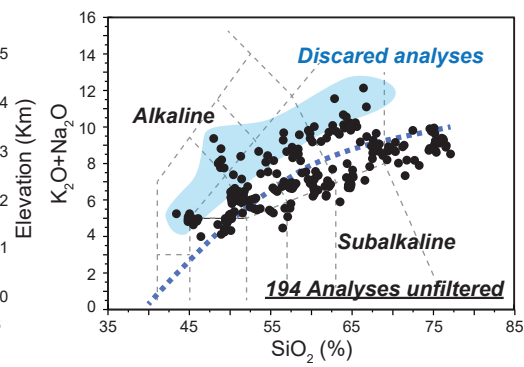
Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation



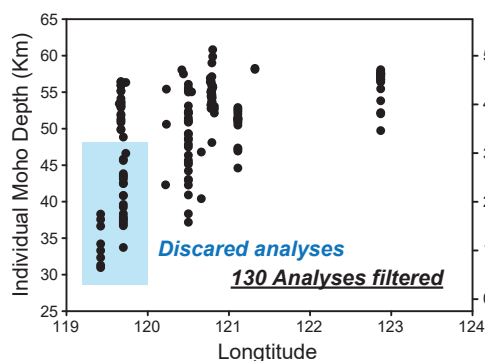
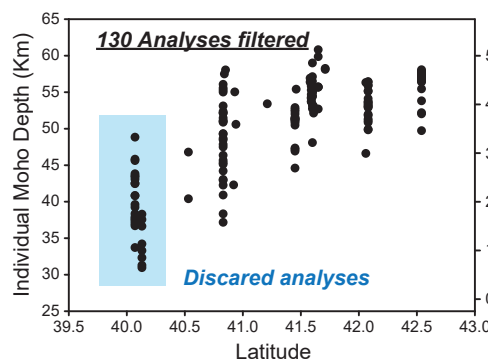
Individual Moho Depth vs. Age (182-113 Ma) (125-113 Ma)



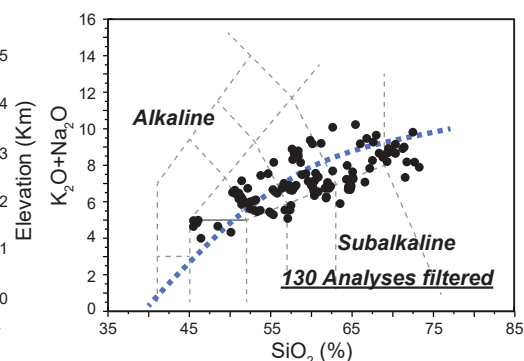
TAS diagram (125-113 Ma)



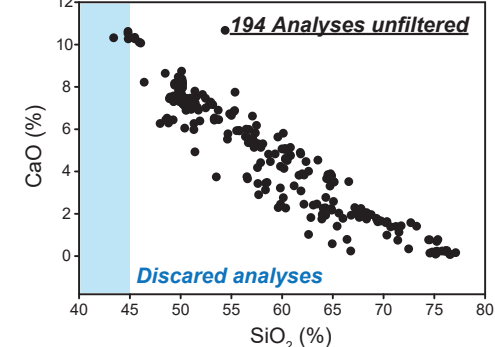
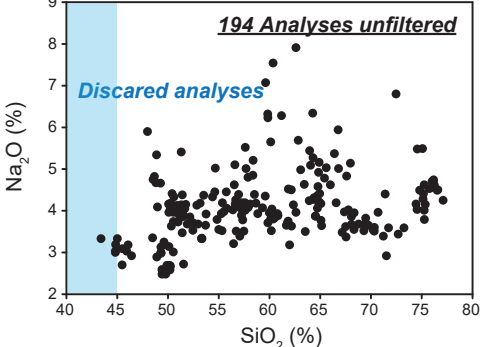
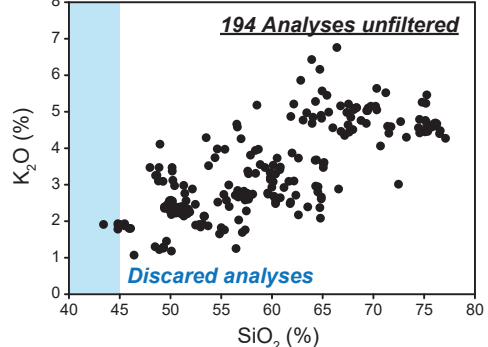
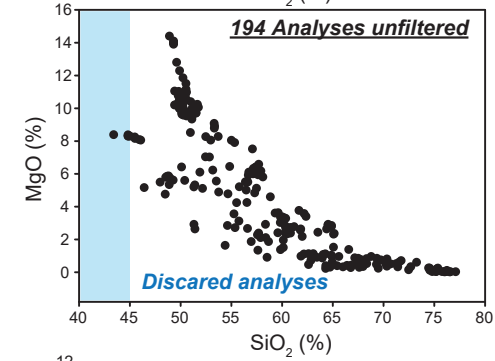
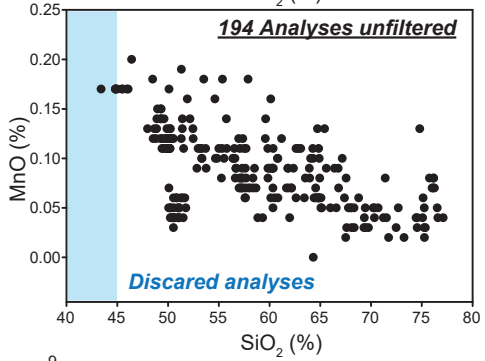
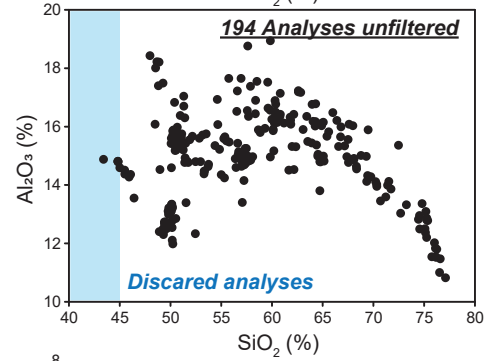
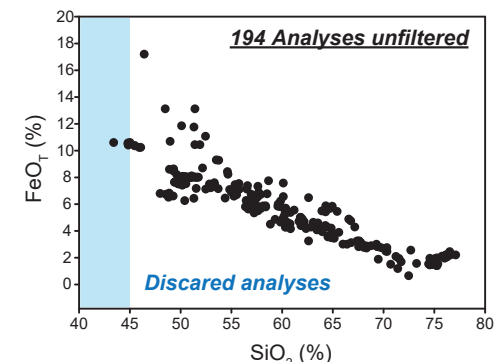
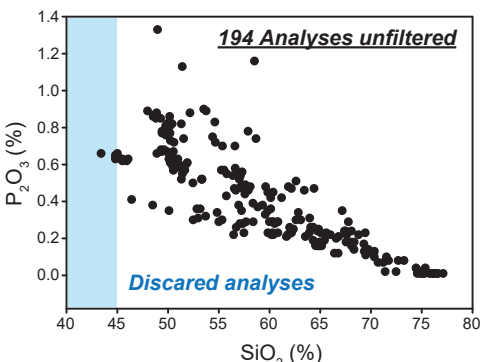
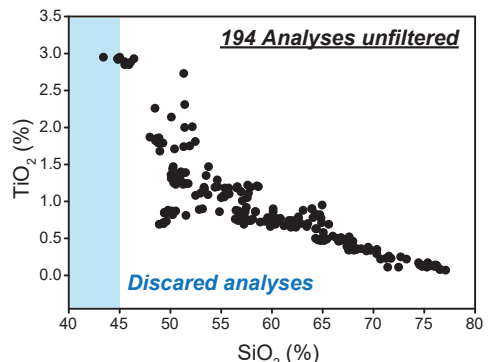
Individual Moho Depth vs. Longitude and Latitude (125-113 Ma)



TAS diagram (125-122 Ma)



Harker Diagrams (125-113 Ma)



Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation

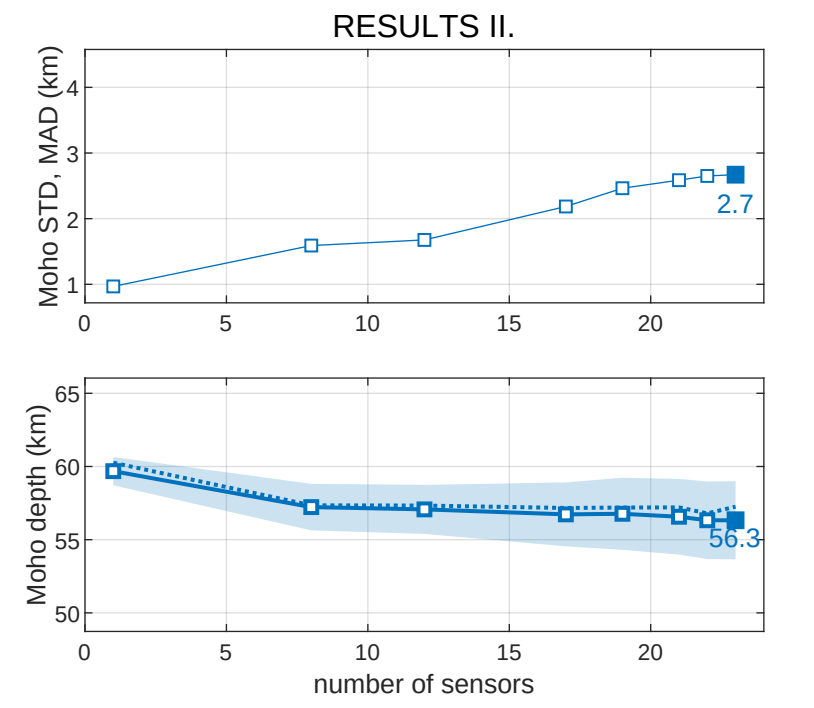
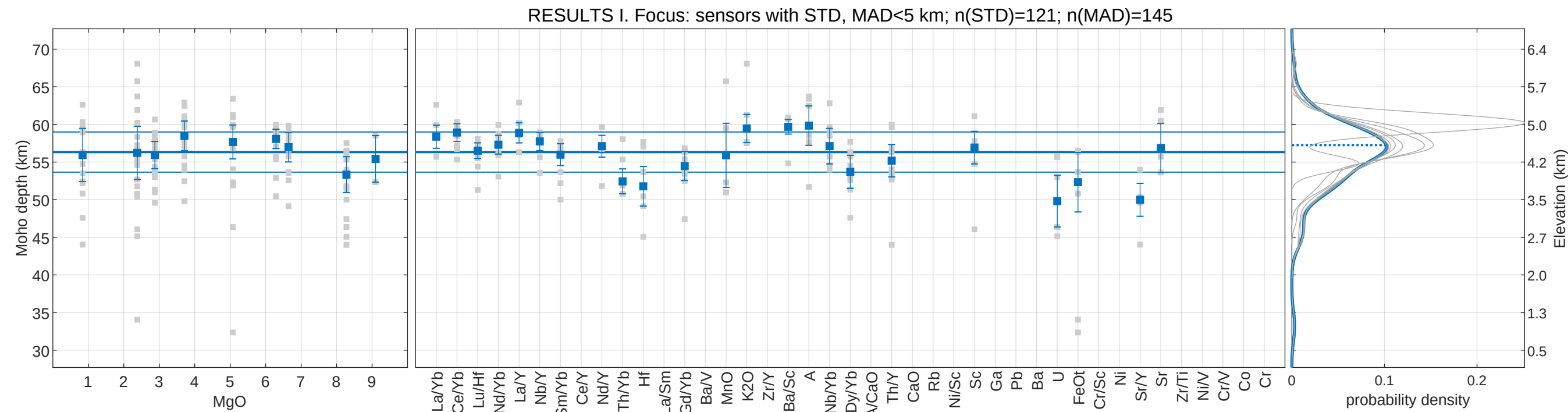
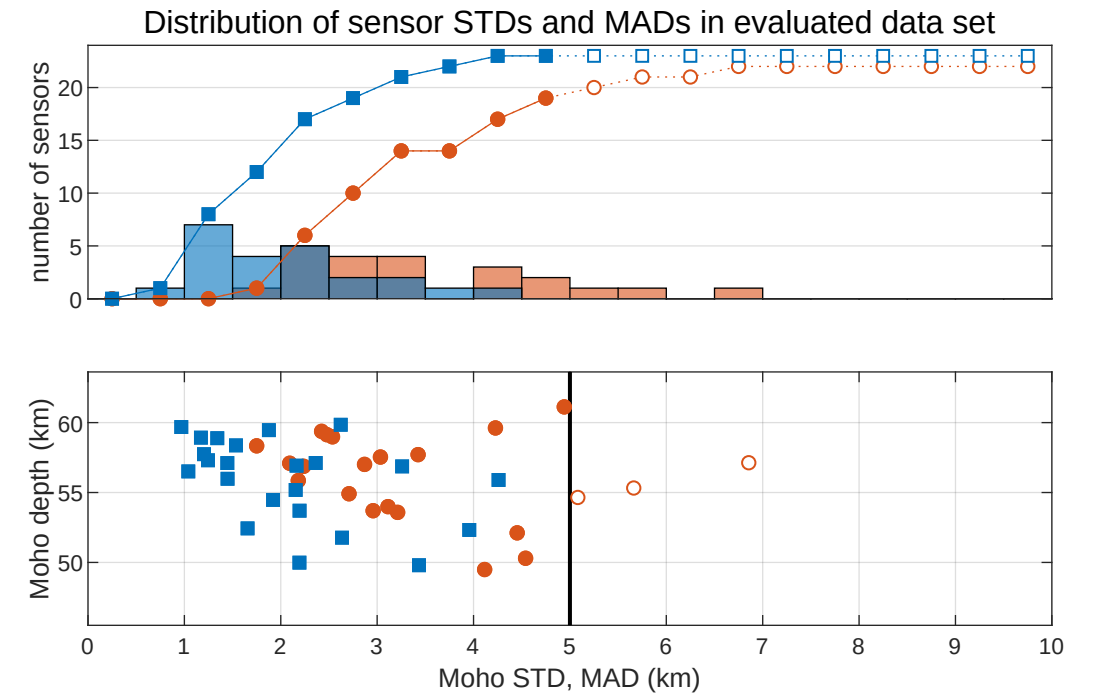
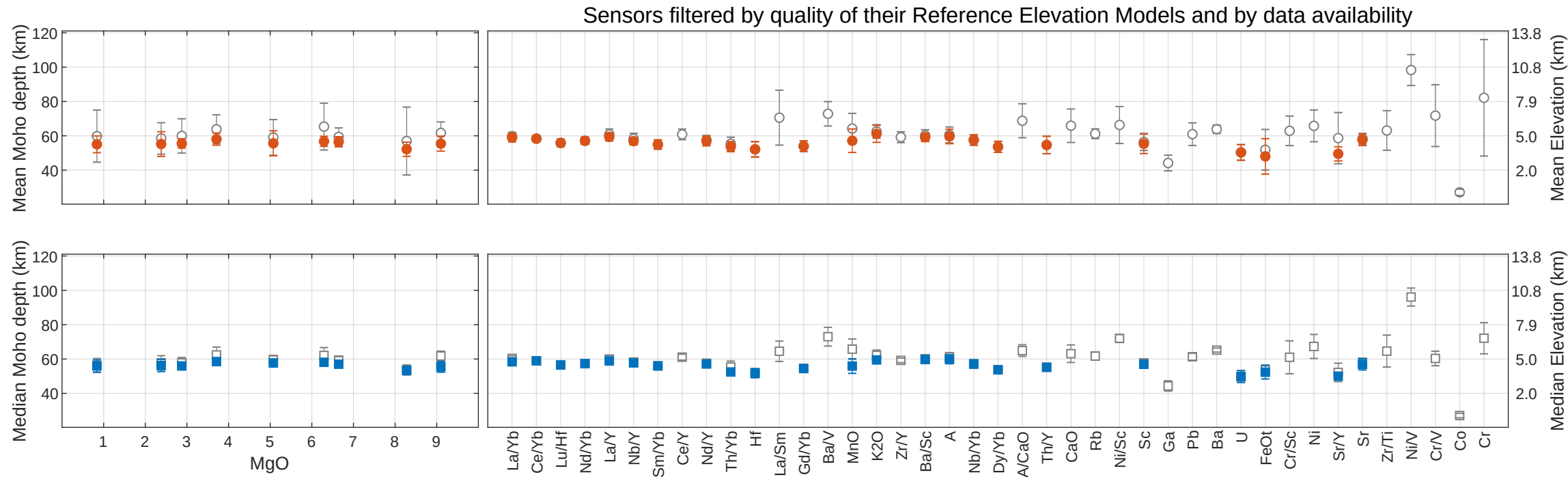
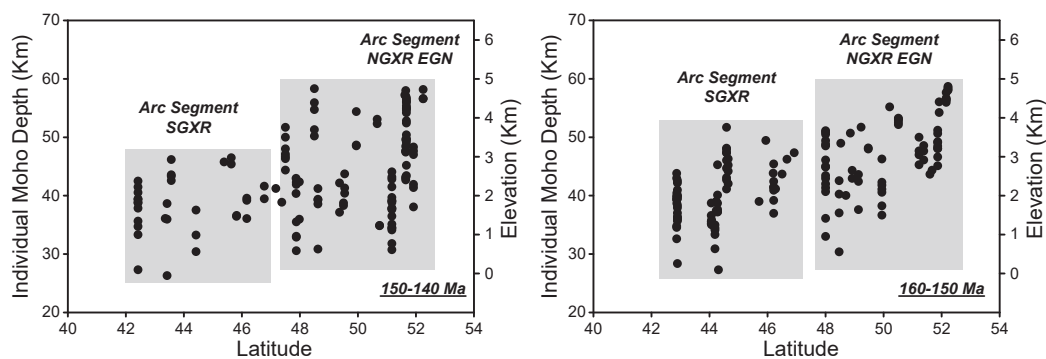


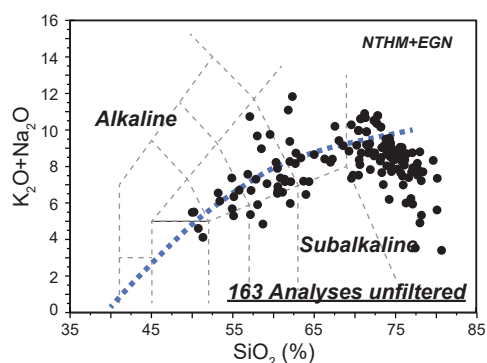
Figure S2-15

Southern Great Xing'an Range (SGXR): 160-140 Ma Magmatism

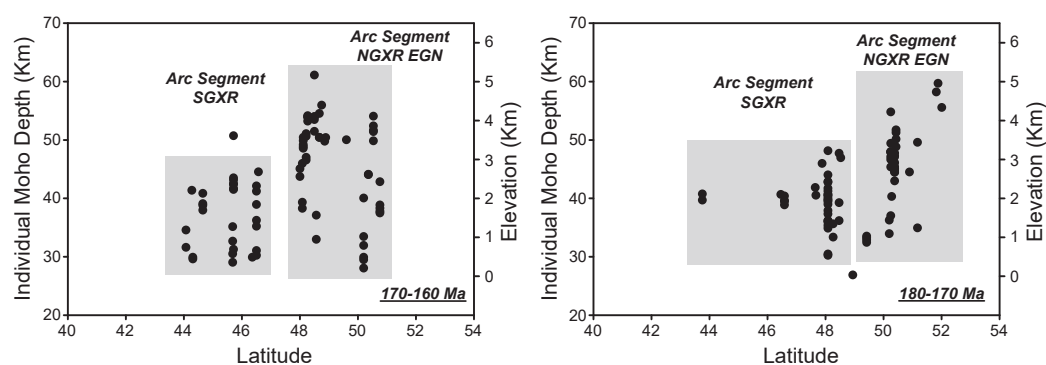
Individual Moho Depth vs. Latitude (150-140 Ma)(160-150 Ma)



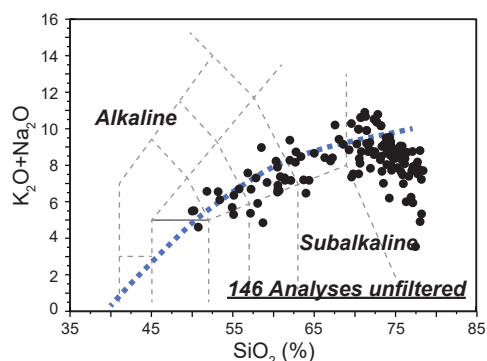
TAS diagram (160-140 Ma)



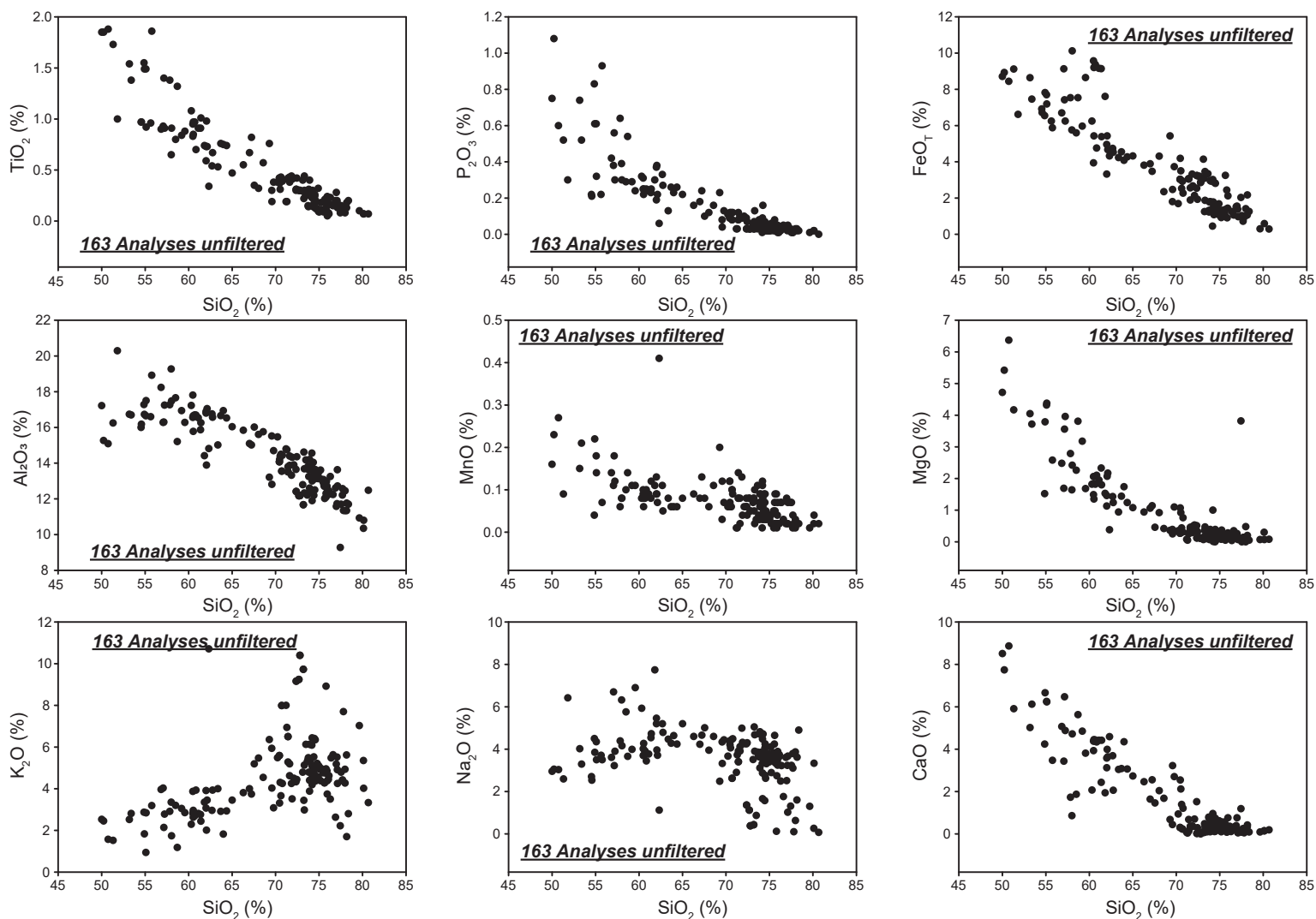
Individual Moho Depth vs. Latitude (170-160 Ma)(180-170 Ma)



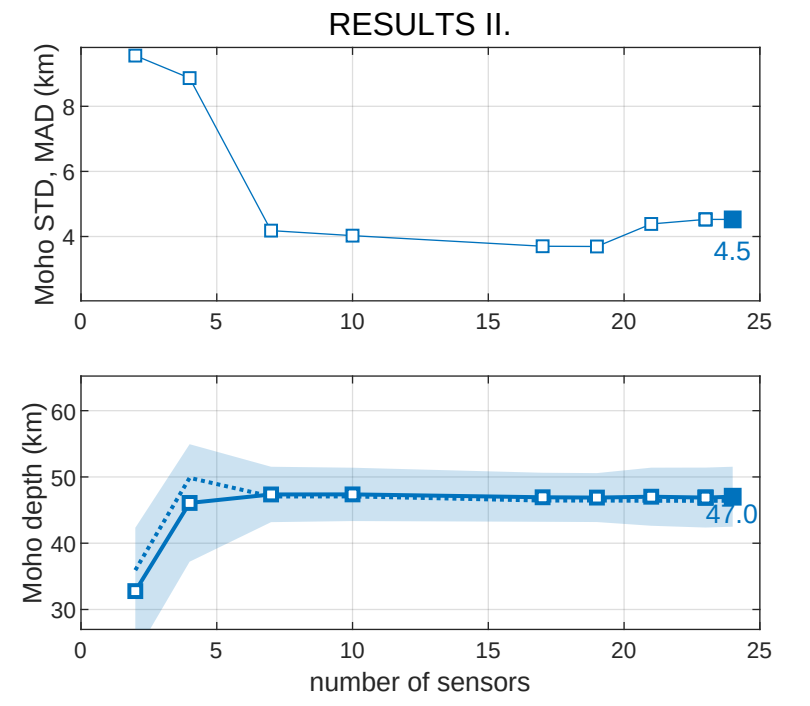
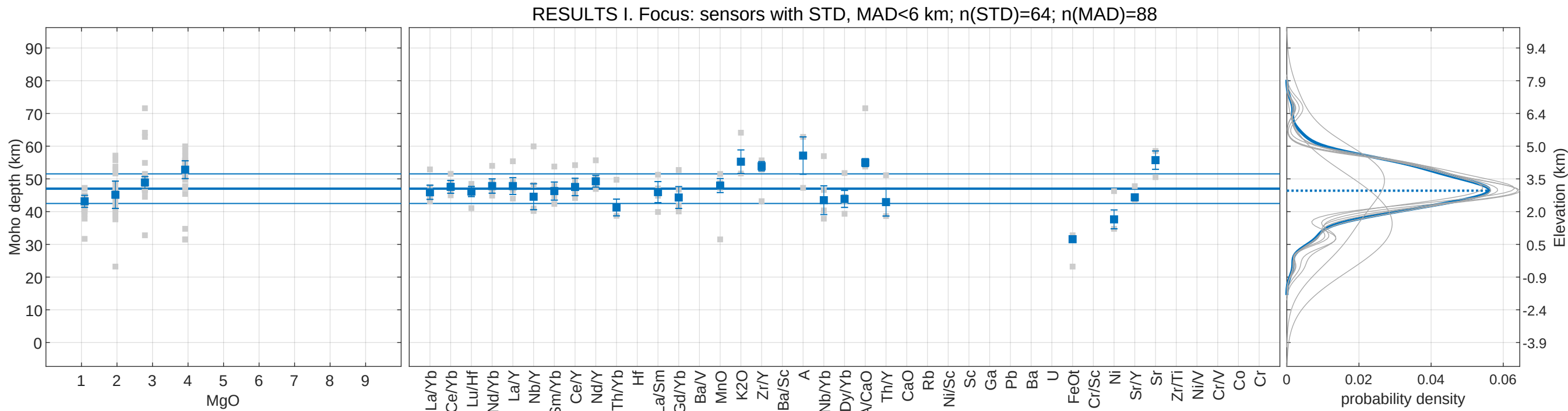
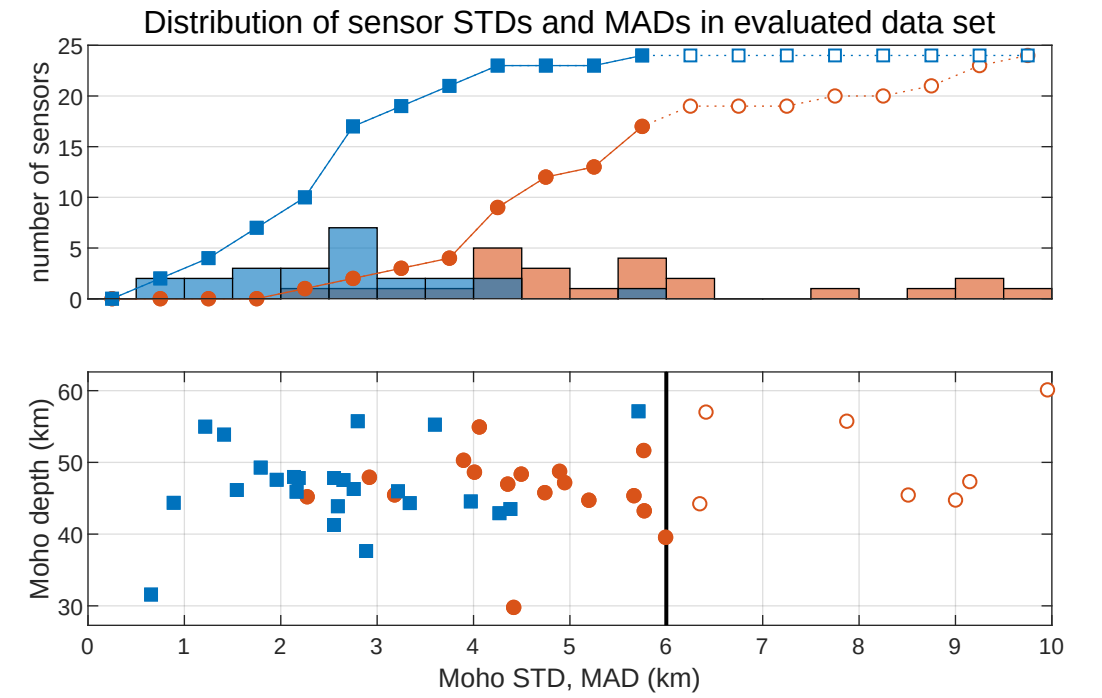
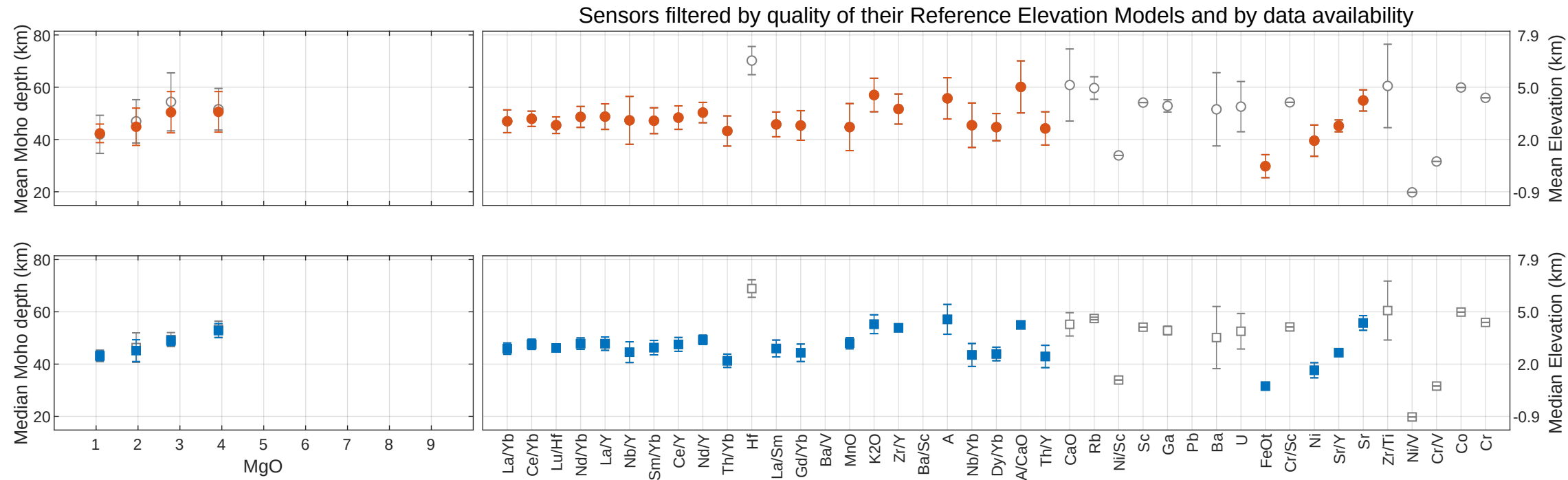
TAS diagram (160-140 Ma)



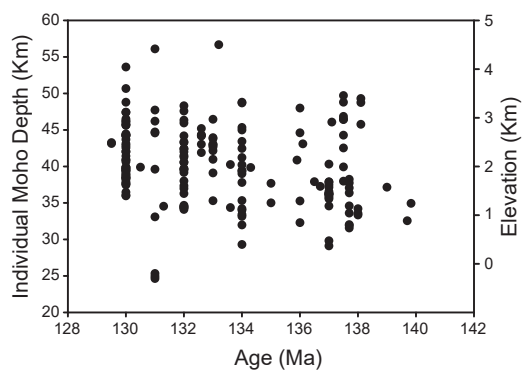
Harker Diagrams (160-140 Ma)



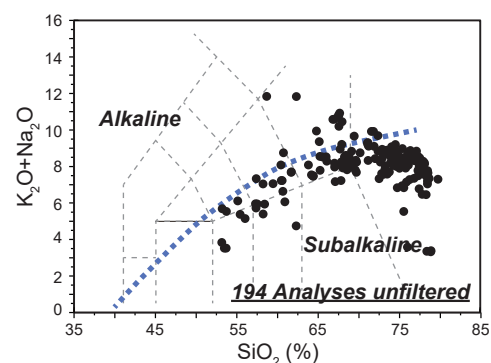
Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation



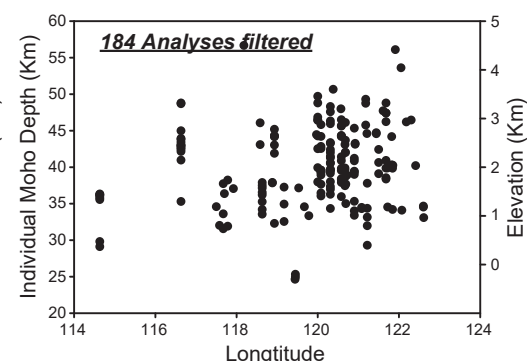
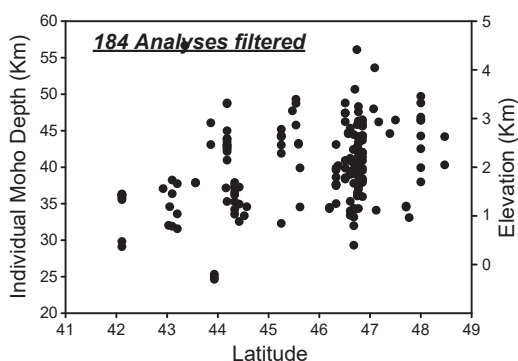
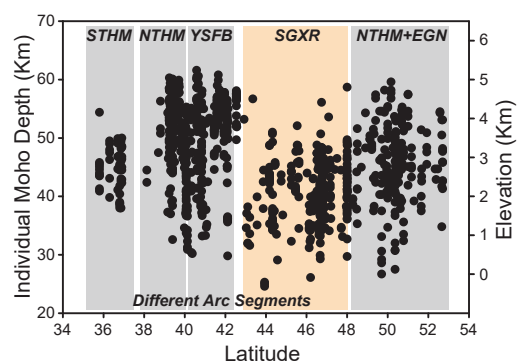
Individual Moho Depth vs. Age (140-130 Ma)



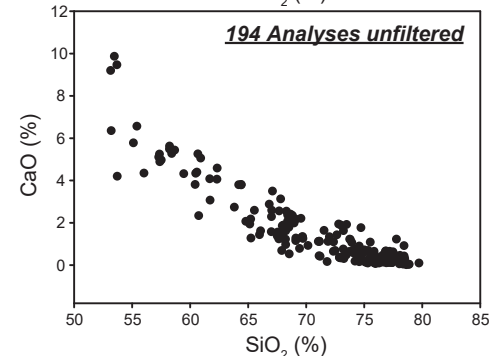
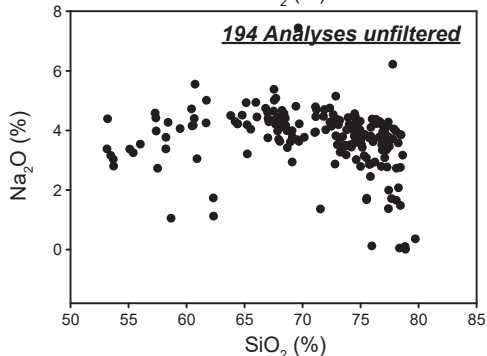
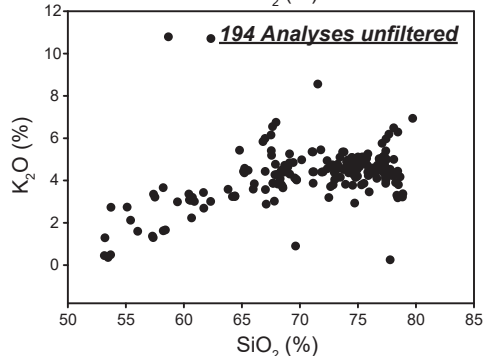
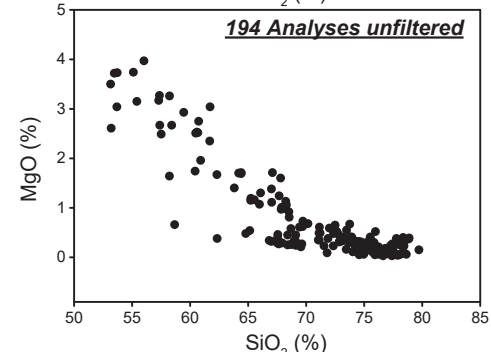
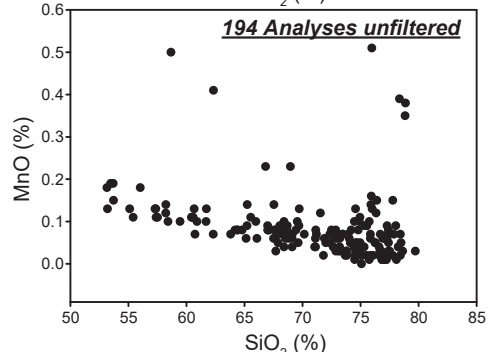
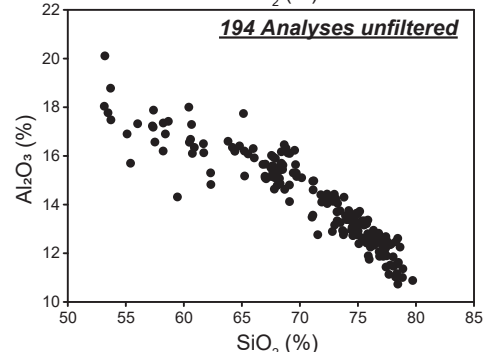
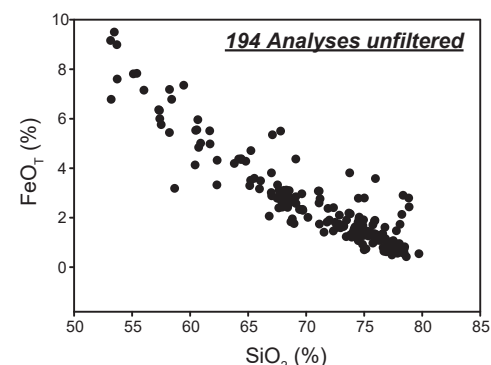
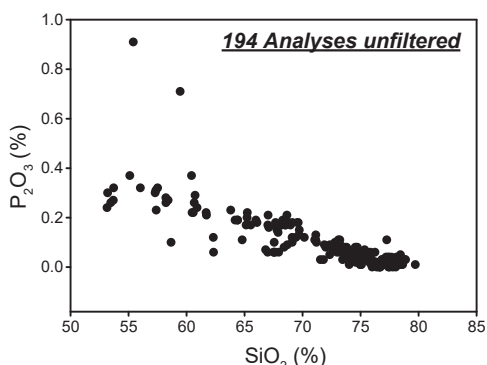
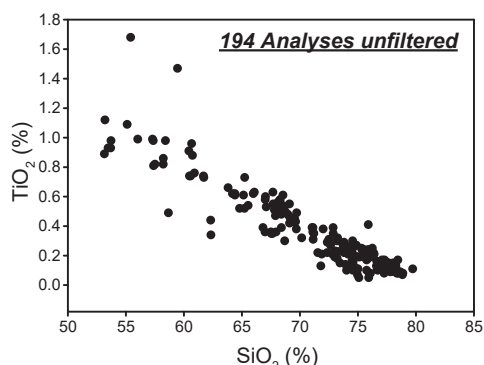
TAS diagram (140-130 Ma)



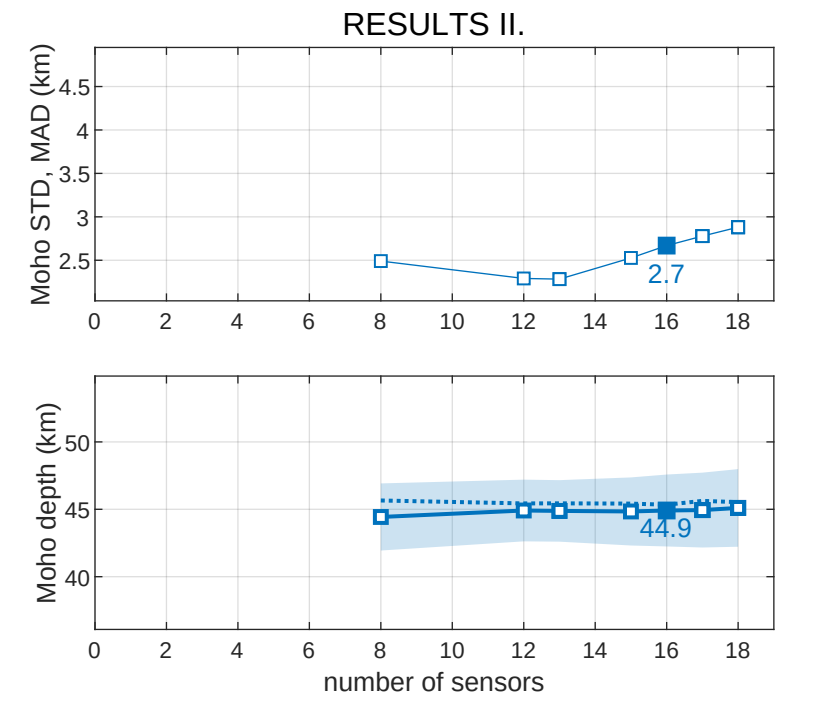
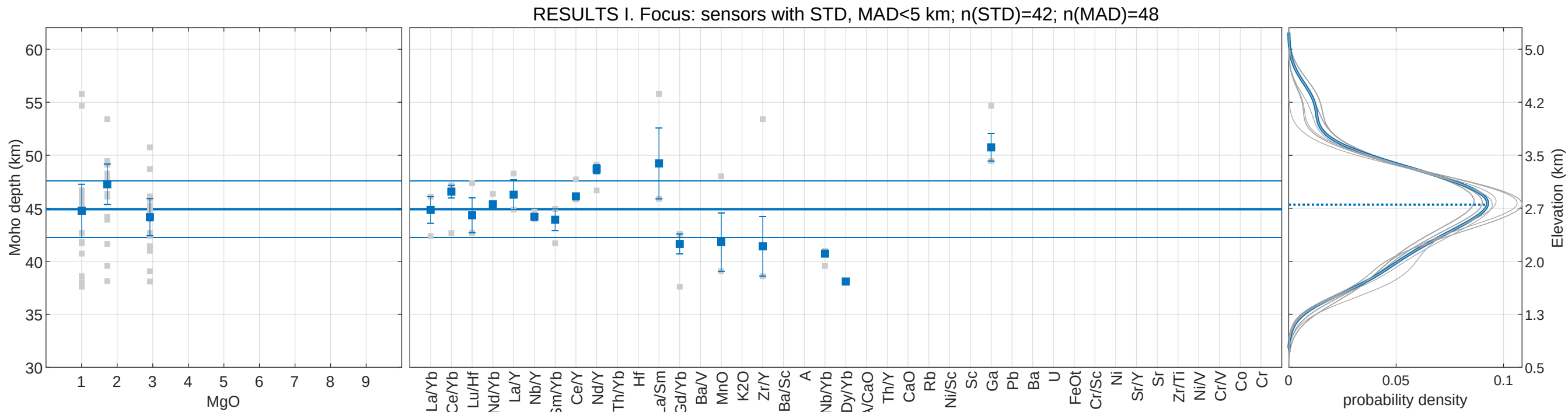
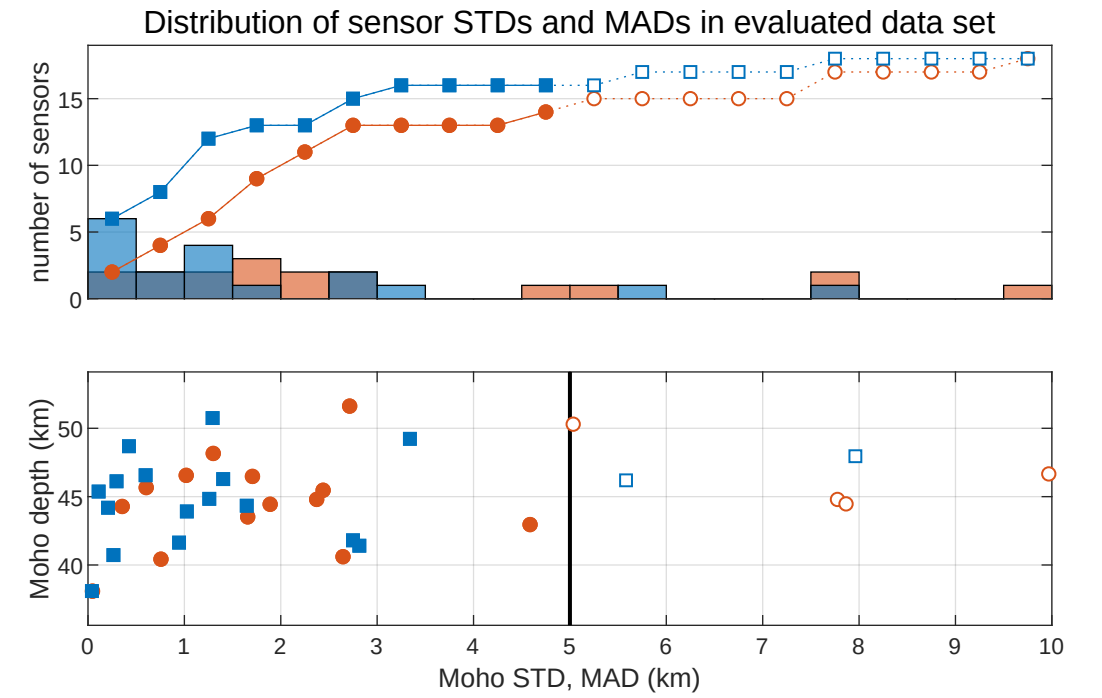
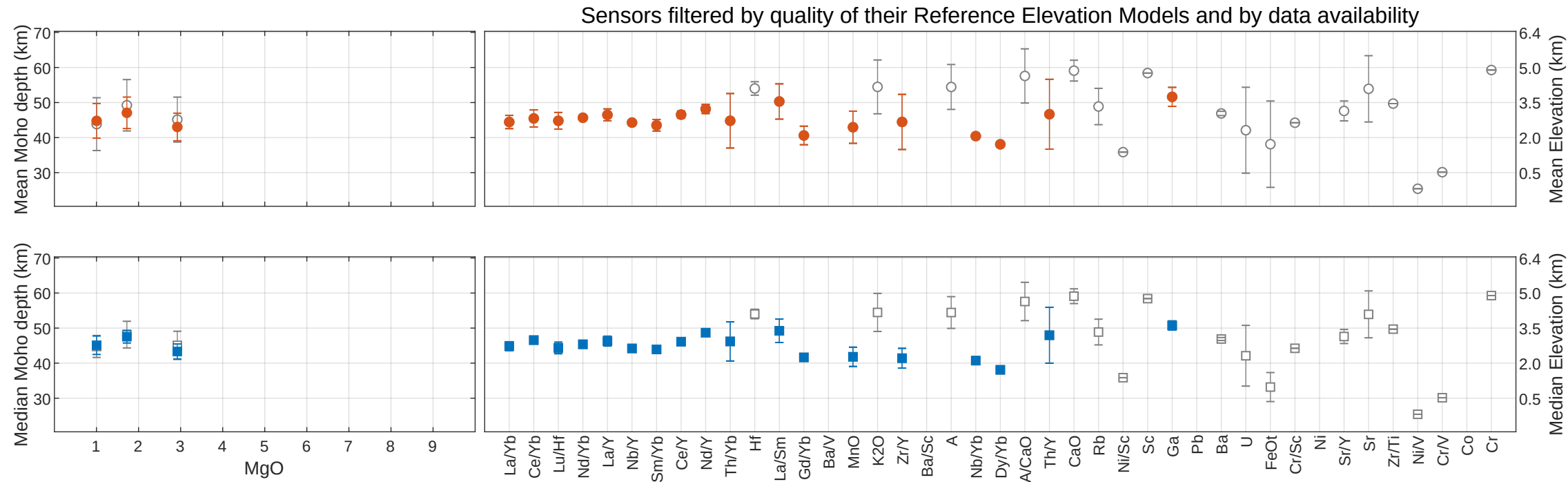
Individual Moho Depth vs. Longitude and Latitude (140-115 Ma) (140-130 Ma)



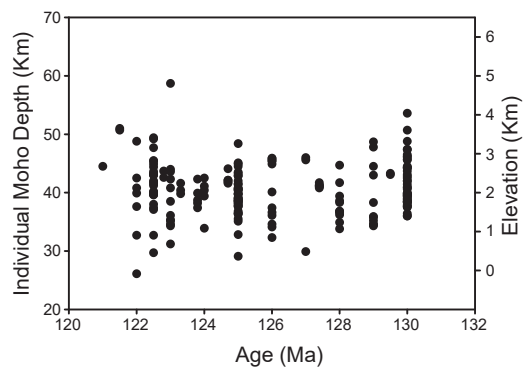
Harker Diagrams (140-130 Ma)



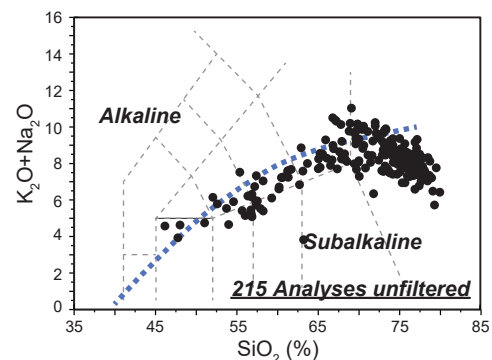
Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation



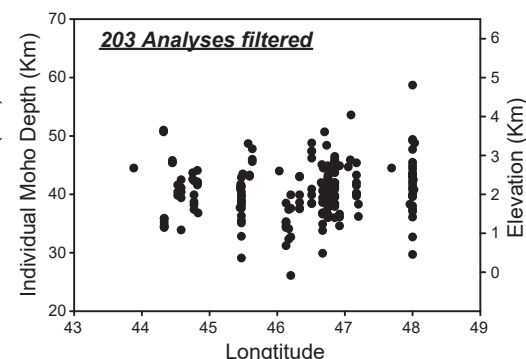
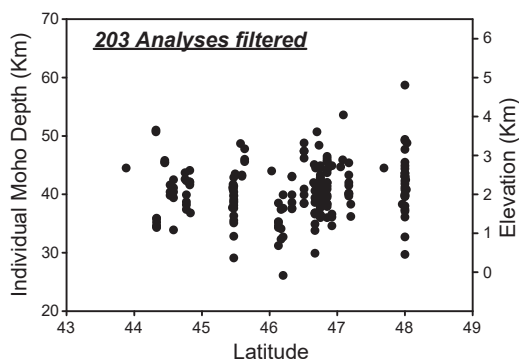
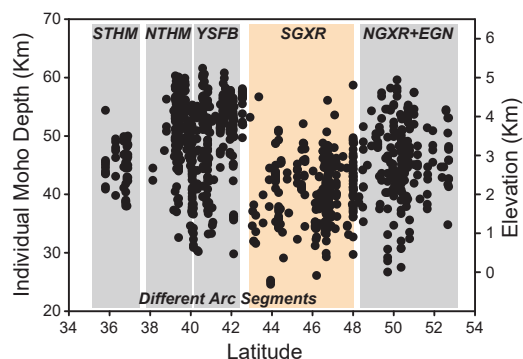
Individual Moho Depth vs. Age (130-120 Ma)



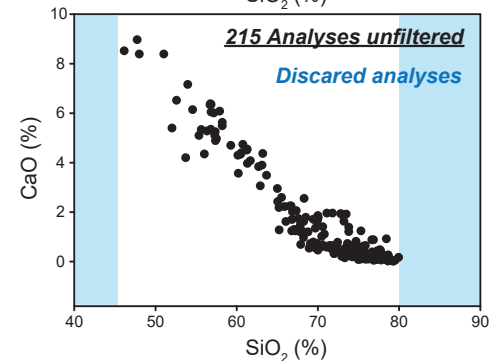
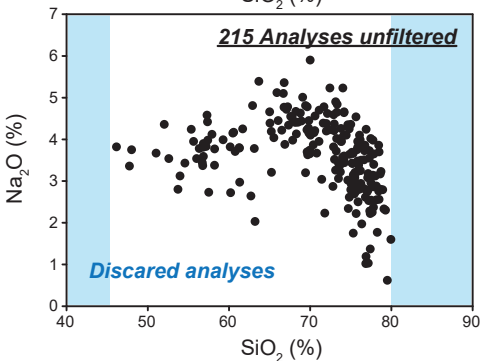
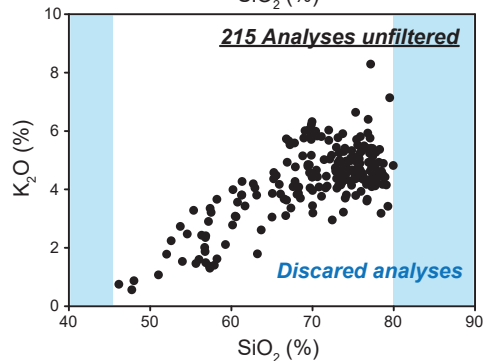
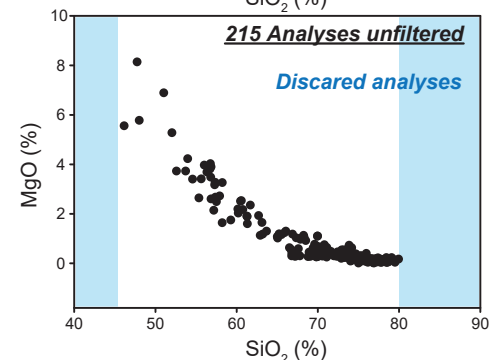
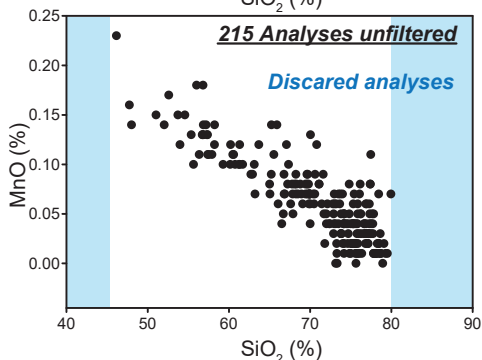
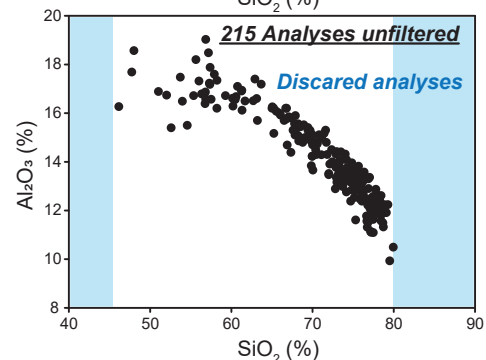
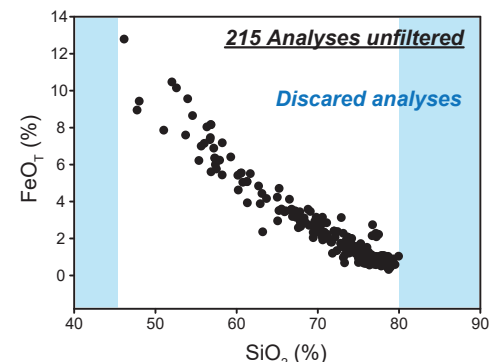
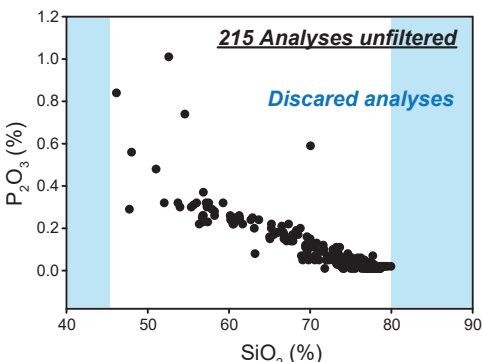
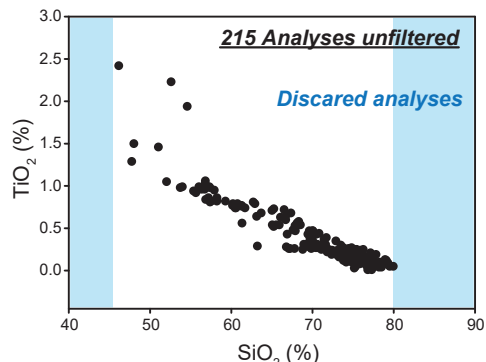
TAS diagram (130-120 Ma)



Individual Moho Depth vs. Longitude and Latitude (140-115 Ma) (130-120 Ma)



Harker Diagrams (130-120 Ma)



Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation

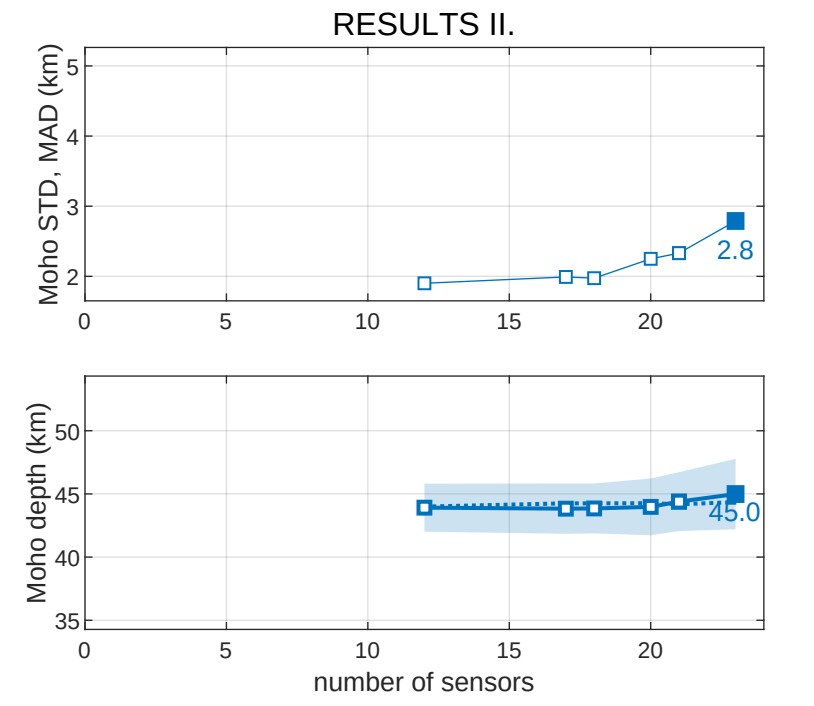
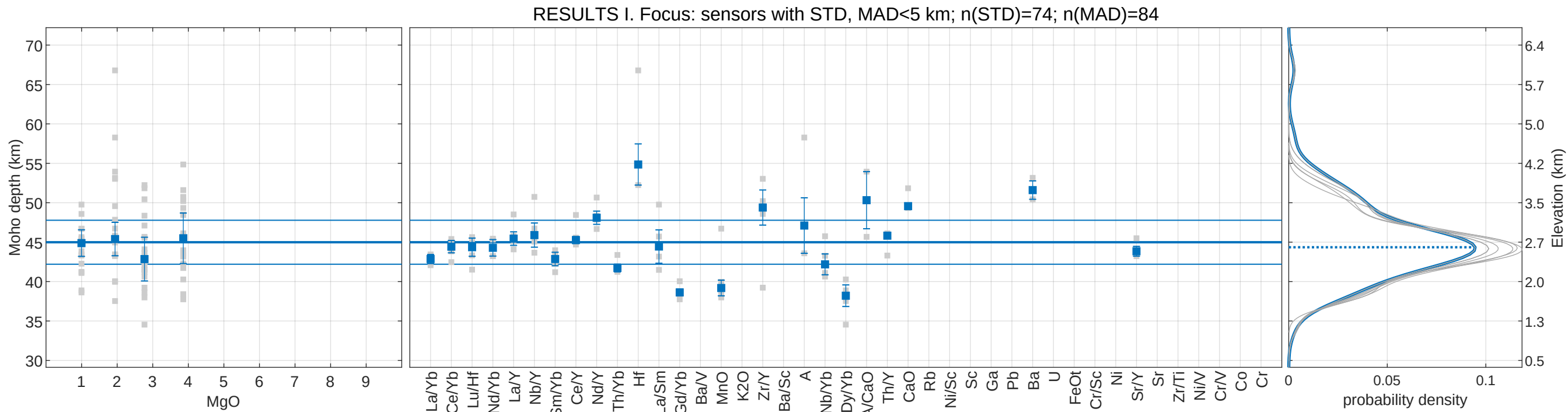
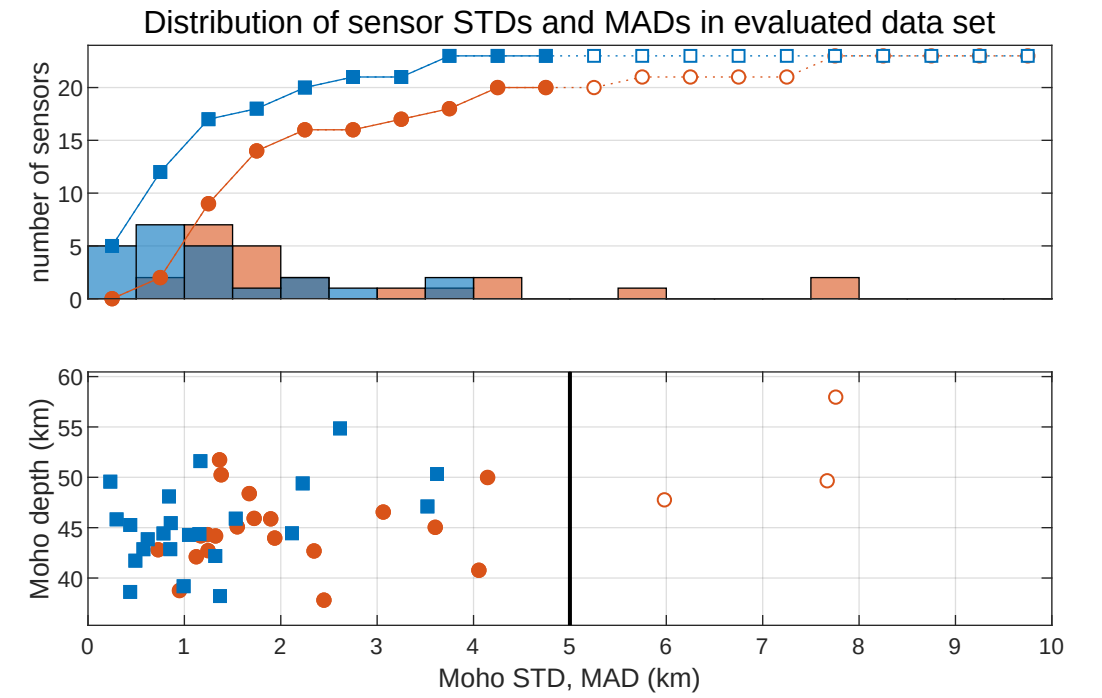
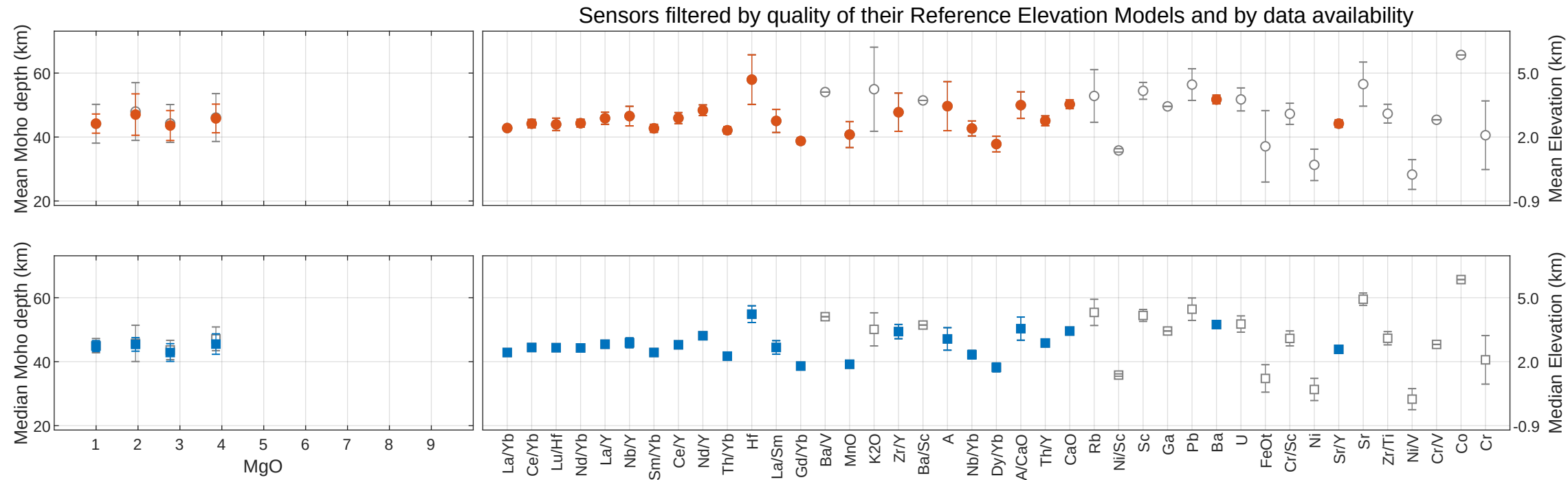
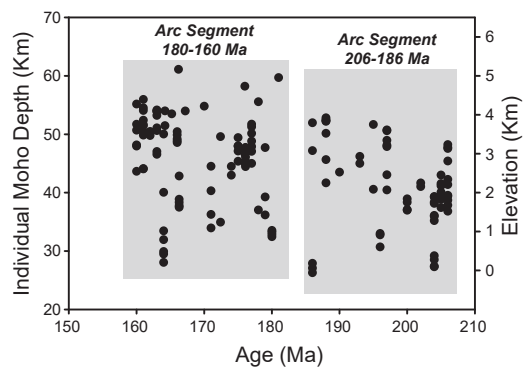


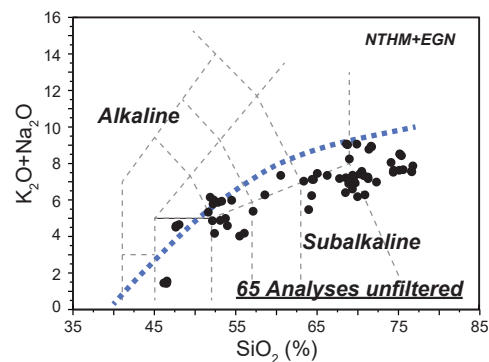
Figure S2-18

Northern Great Xing'an Range (NGXR) and Ergna Block (EGN): 206-186 Ma Magmatism

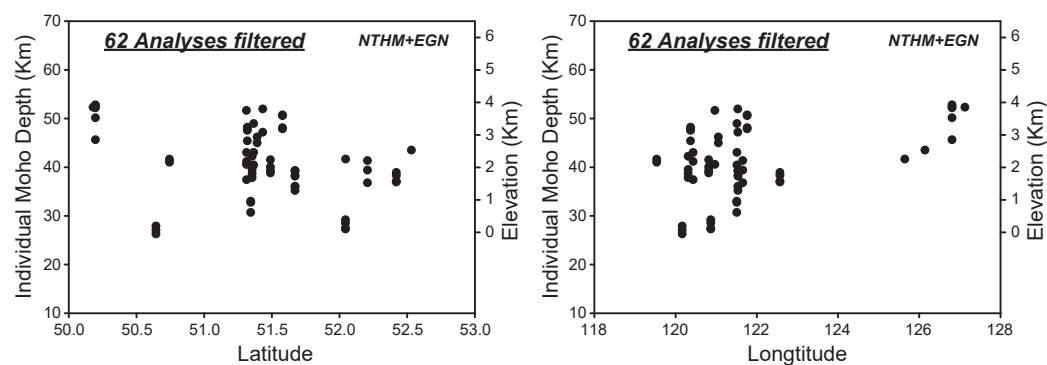
Individual Moho Depth vs. Age (206-160 Ma)



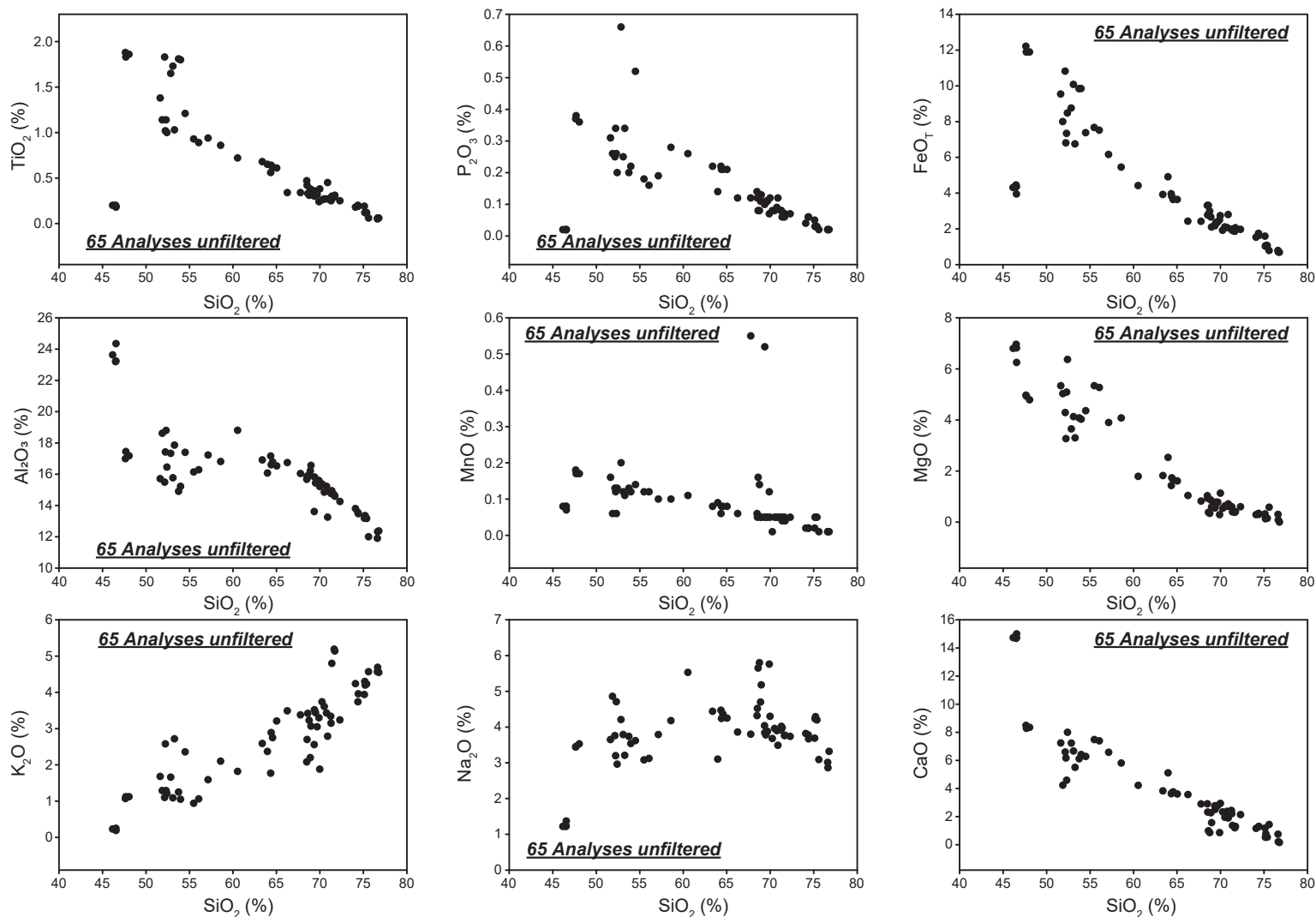
TAS diagram (206-186 Ma)



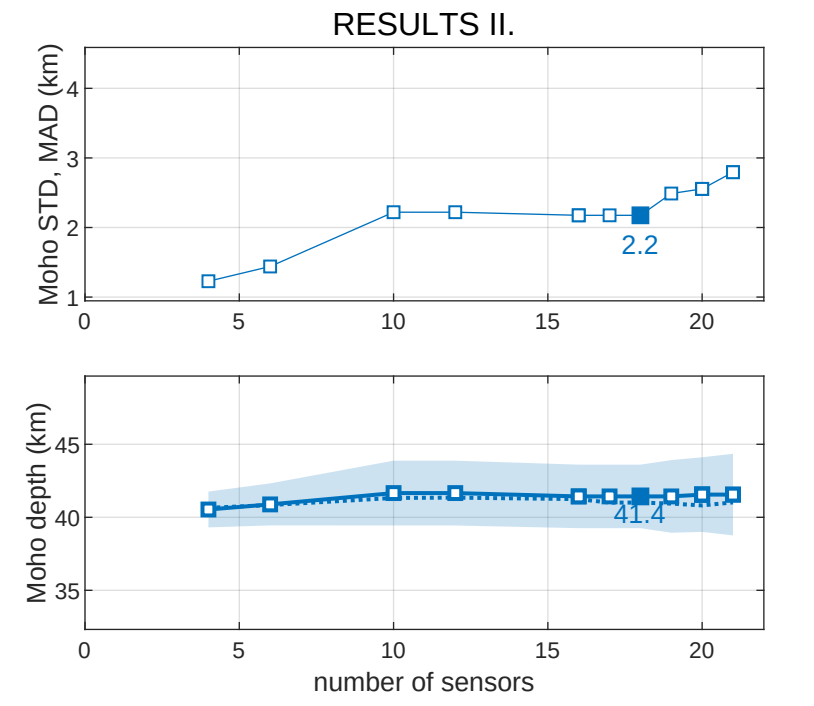
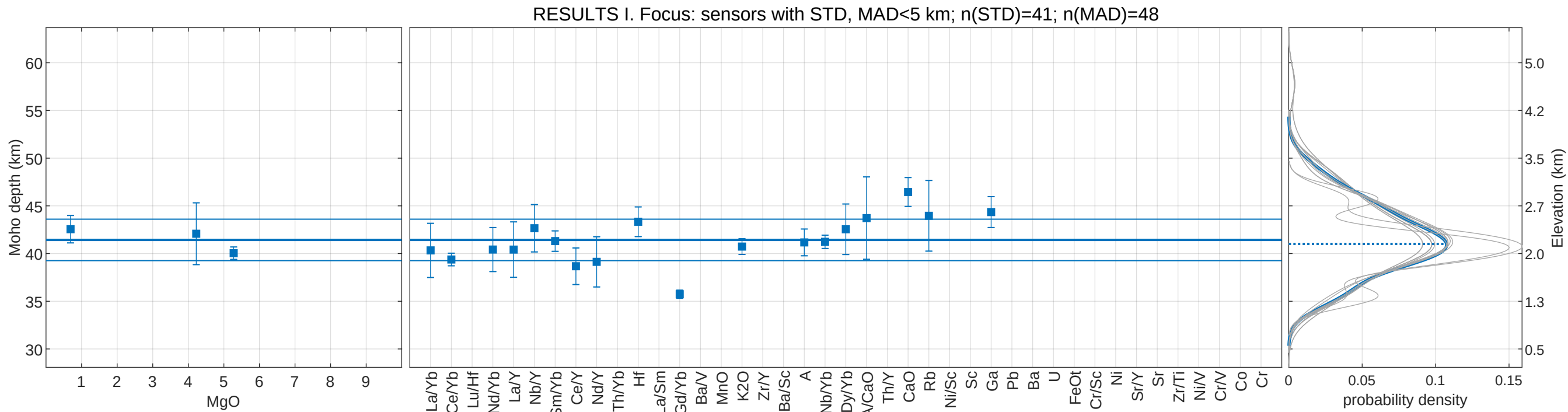
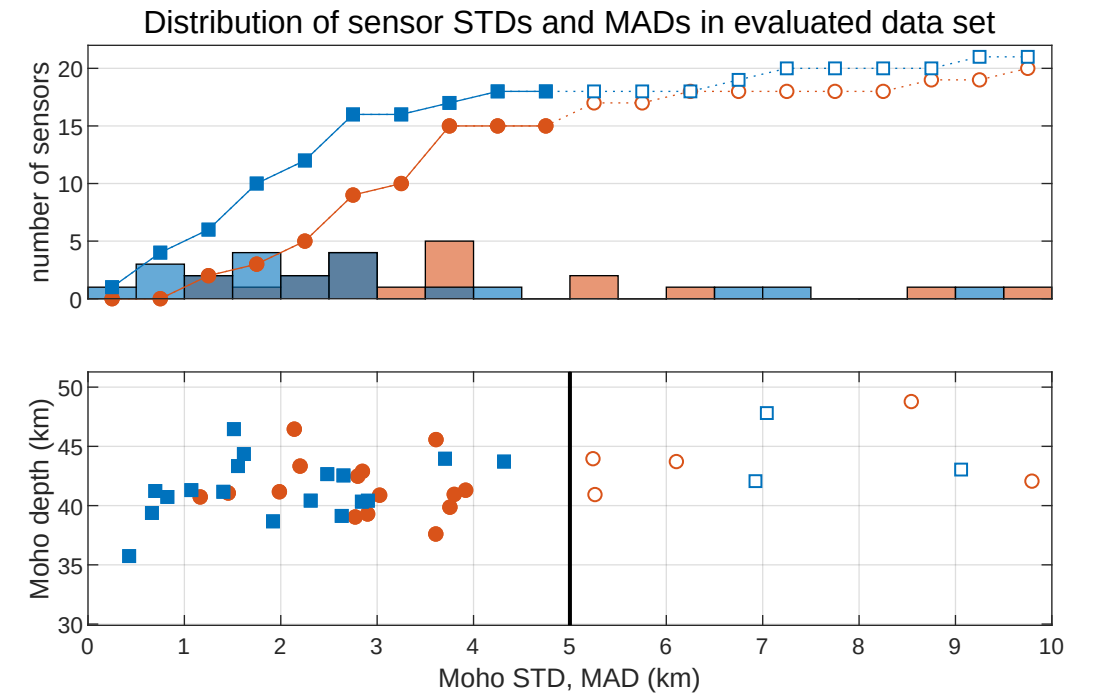
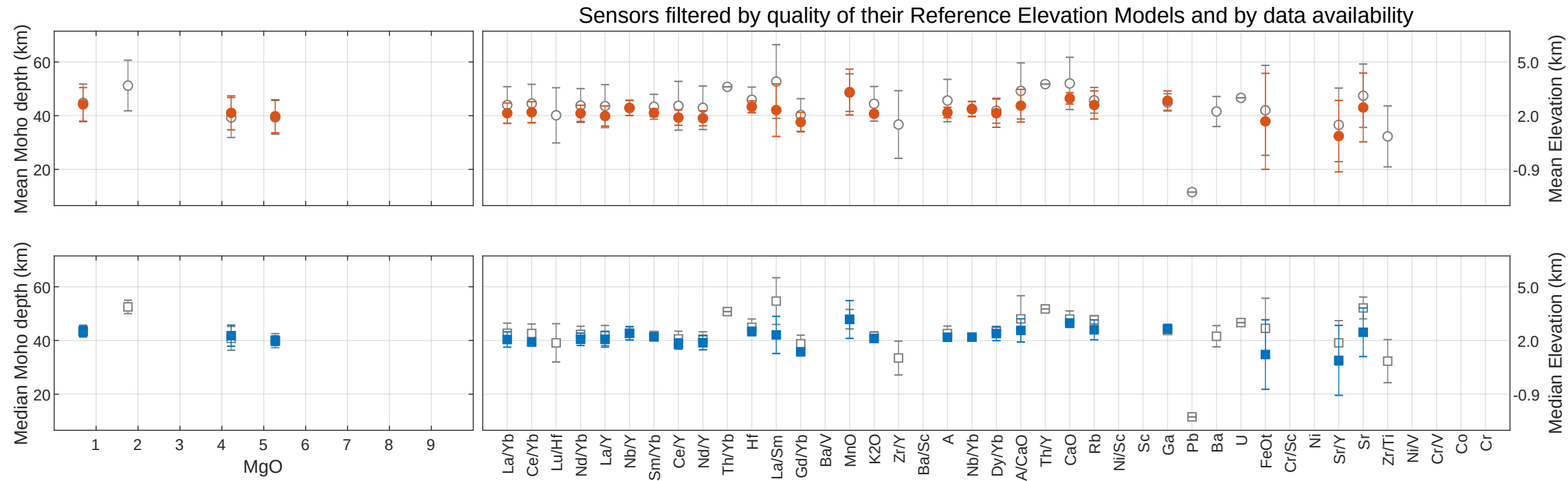
Individual Moho Depth vs. Longitude and Latitude (206-186 Ma)



Harker Diagrams (206-186 Ma)

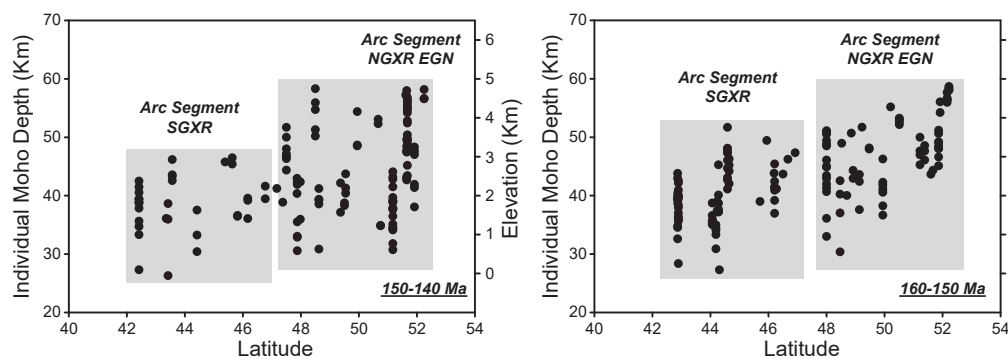


Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation

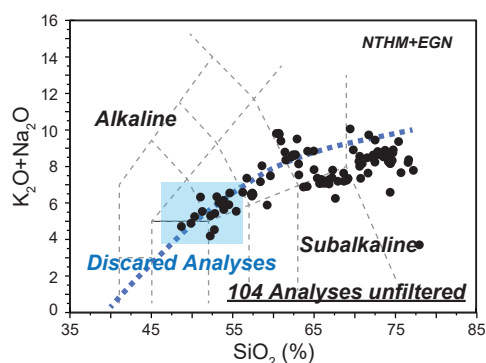


Northern Great Xing'an Range (NGXR) and Ergna Block (EGN): 180-160 Ma Magmatism

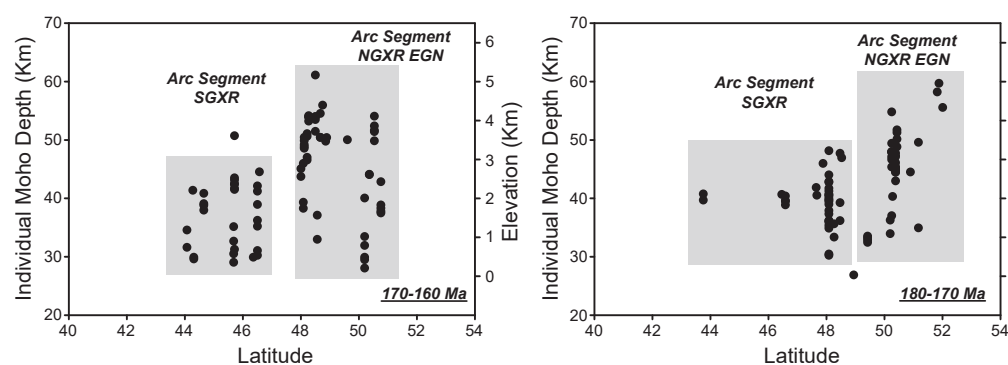
Individual Moho Depth vs. Latitude (150-140 Ma)(160-150 Ma)



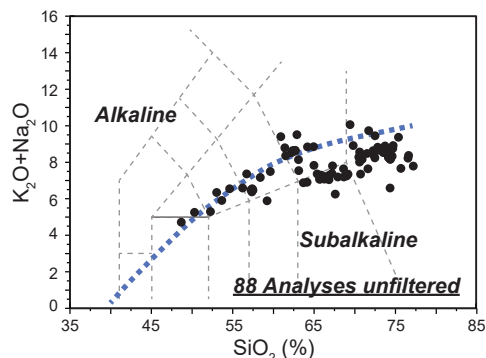
TAS diagram (180-160 Ma)



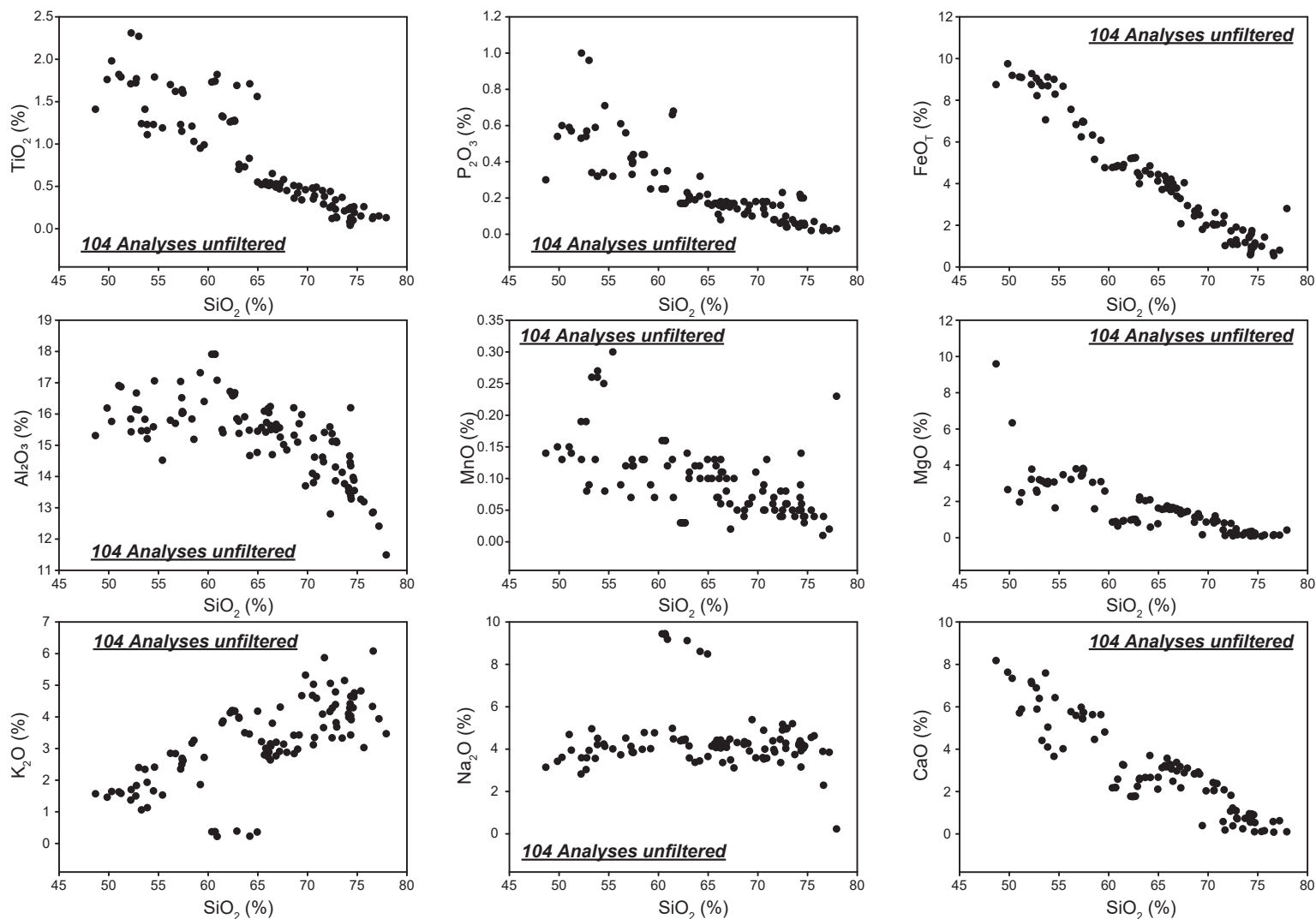
Individual Moho Depth vs. Latitude (170-160 Ma)(180-170 Ma)



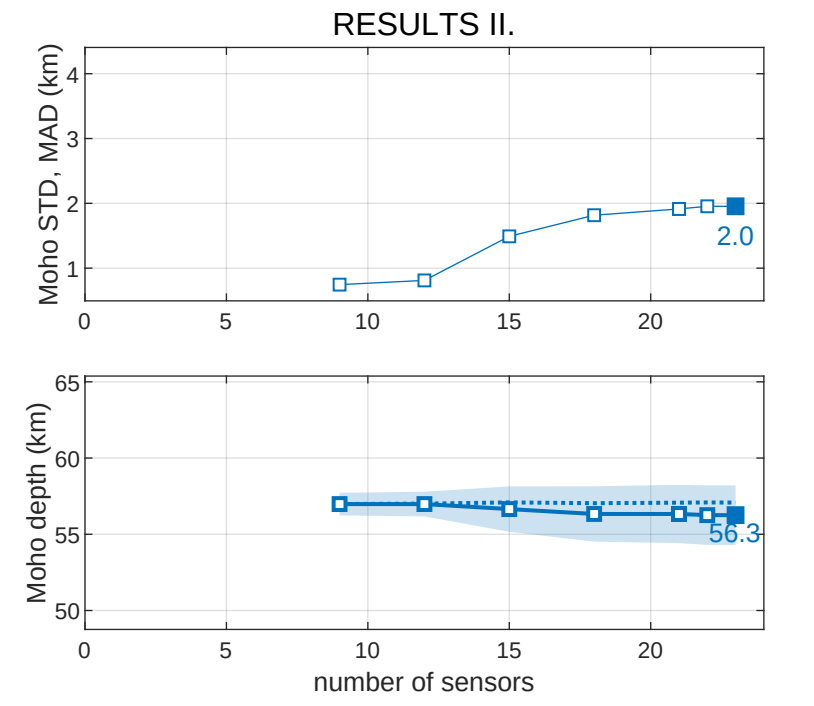
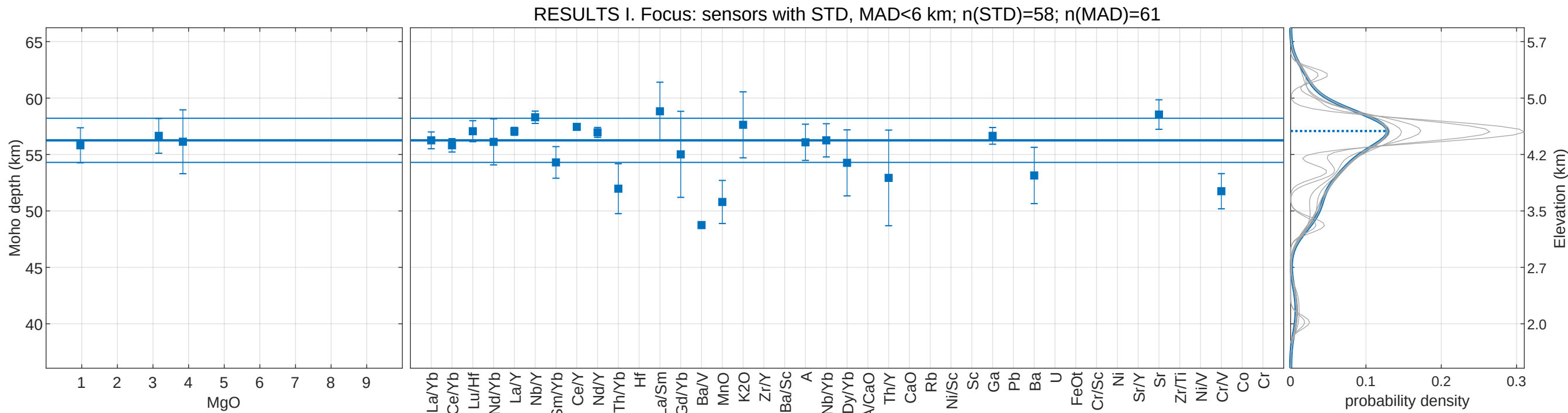
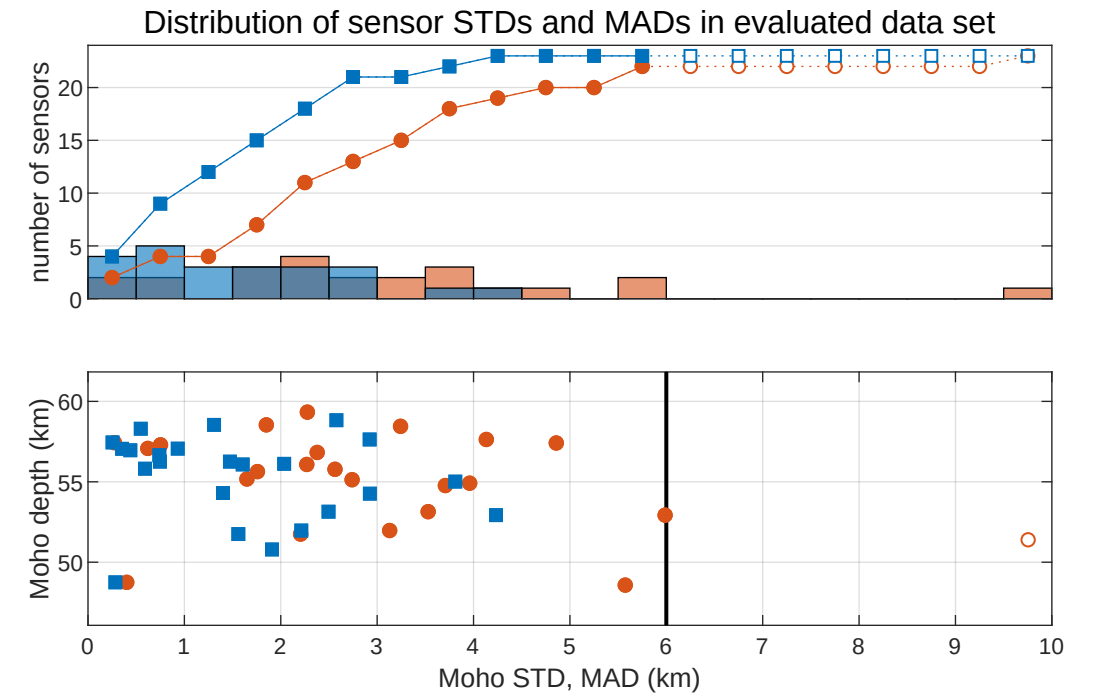
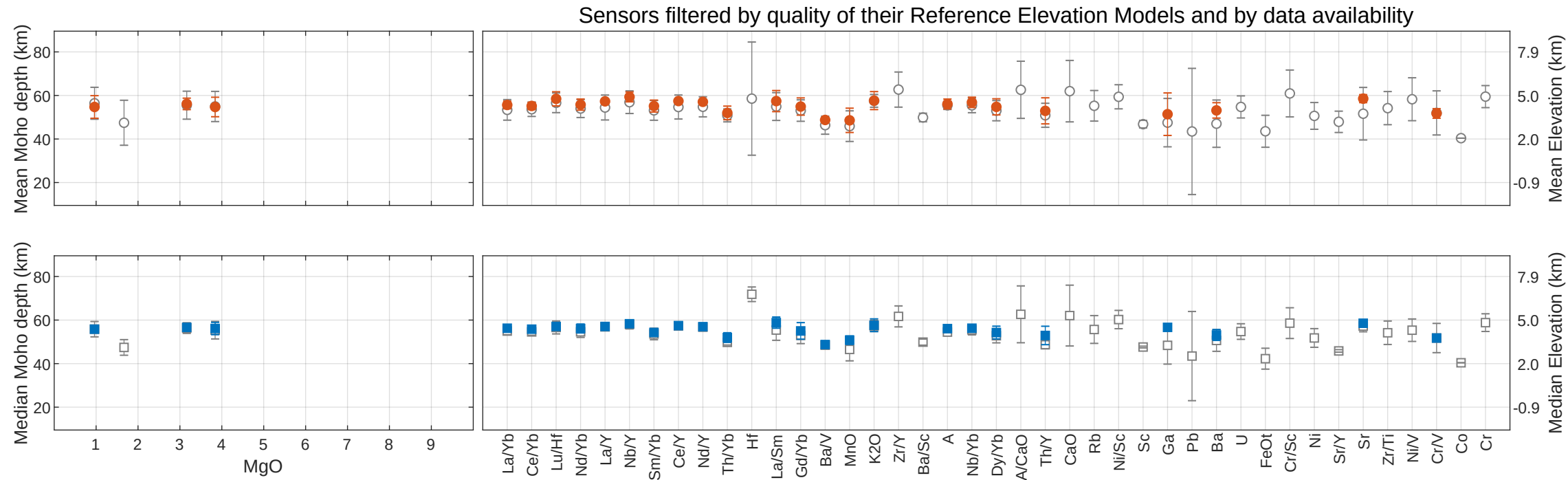
TAS diagram (180-160 Ma)



Harker Diagrams (180-160 Ma)

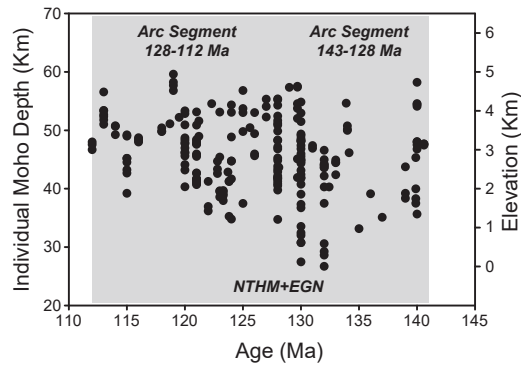


Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation

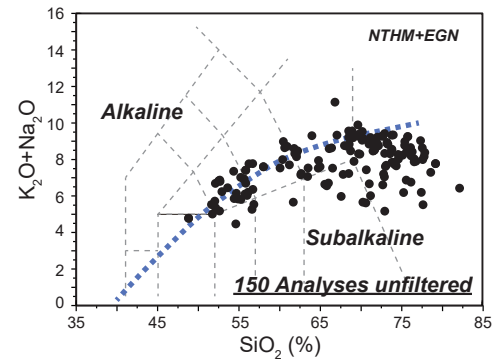
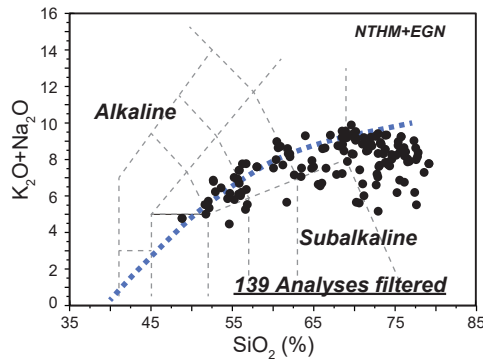


Northern Great Xing'an Range (NGXR) and Ergna Block (EGN): 143-128 Ma Magmatism

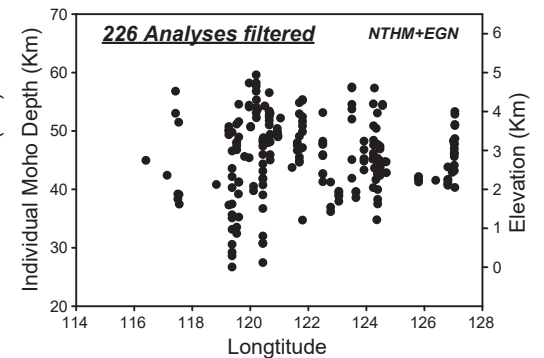
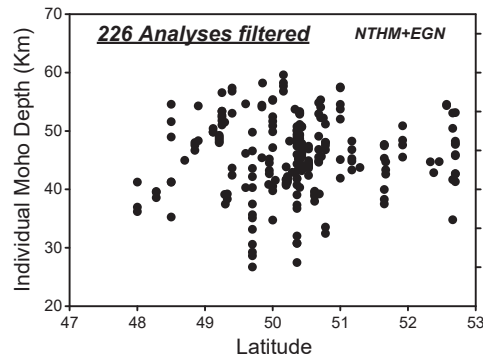
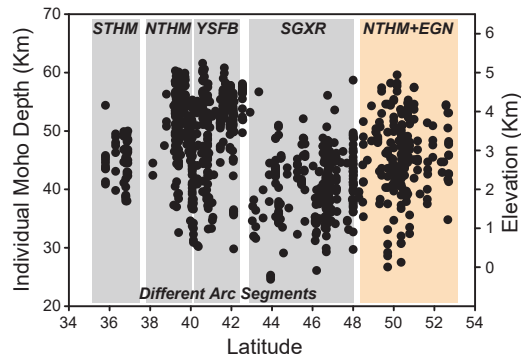
Individual Moho Depth vs. Age (143-112 Ma)



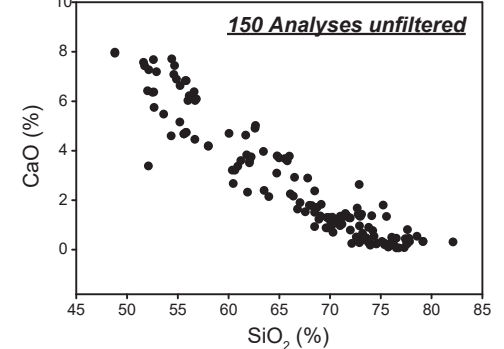
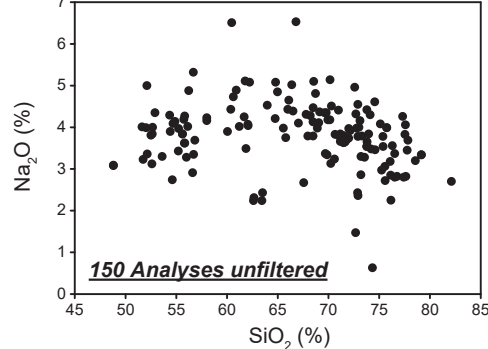
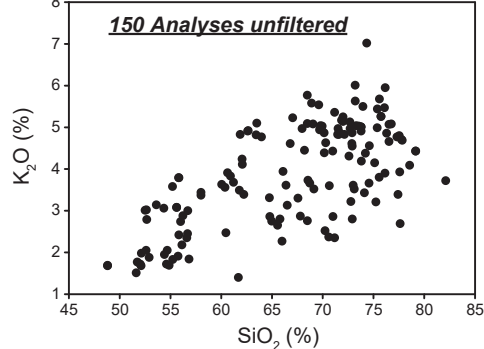
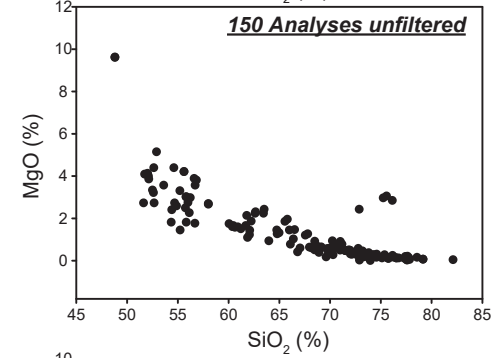
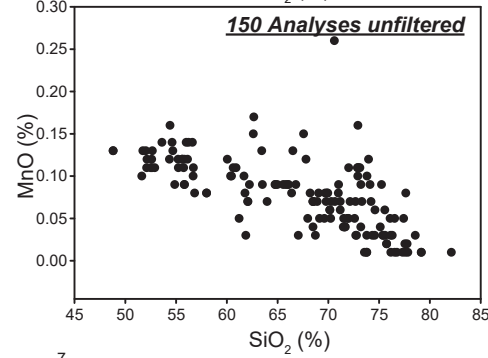
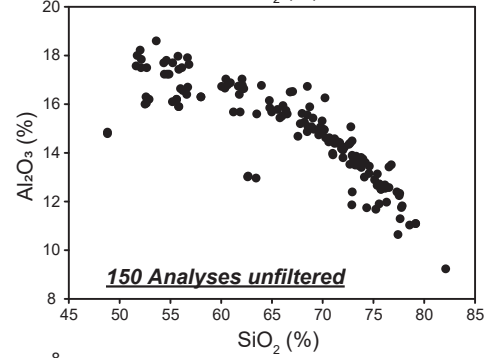
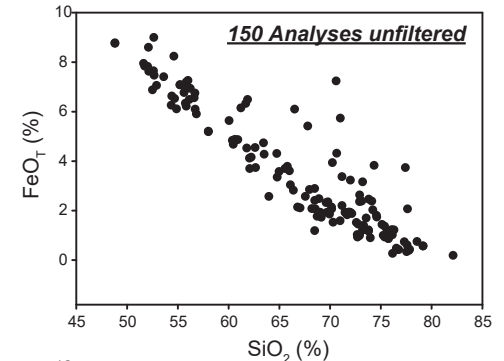
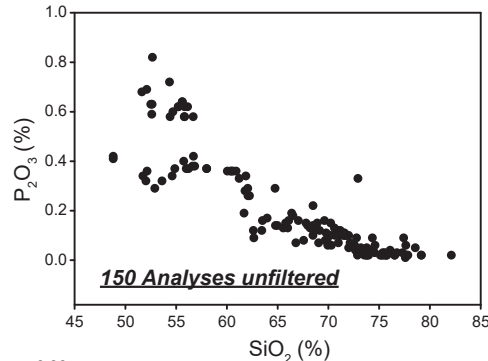
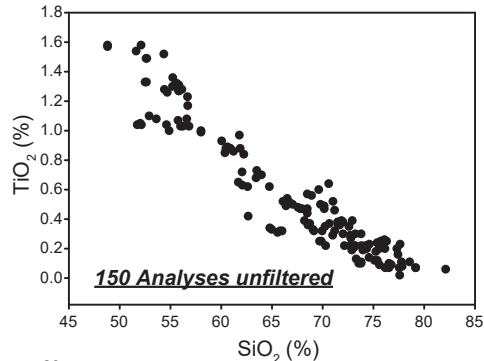
TAS diagram (143-128 Ma)



Individual Moho Depth vs. Longitude and Latitude (140-115 Ma) (143-112 Ma)



Harker Diagrams (143-128 Ma)



Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation

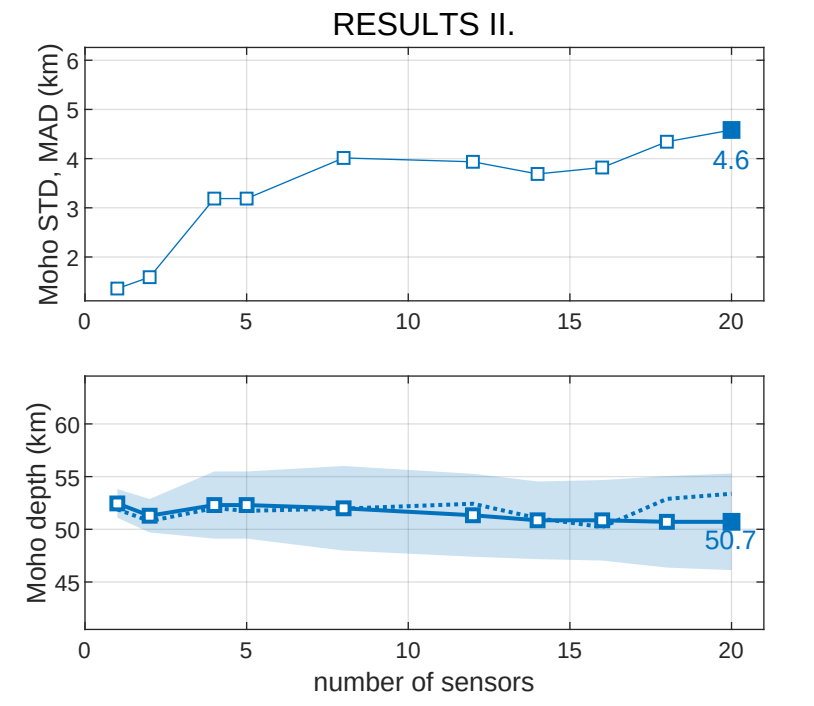
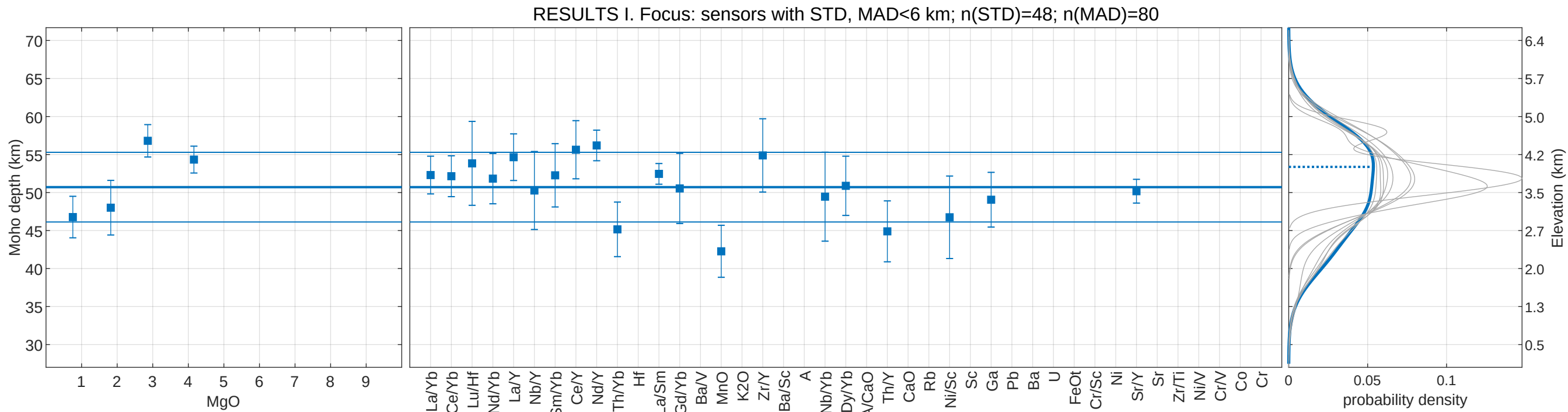
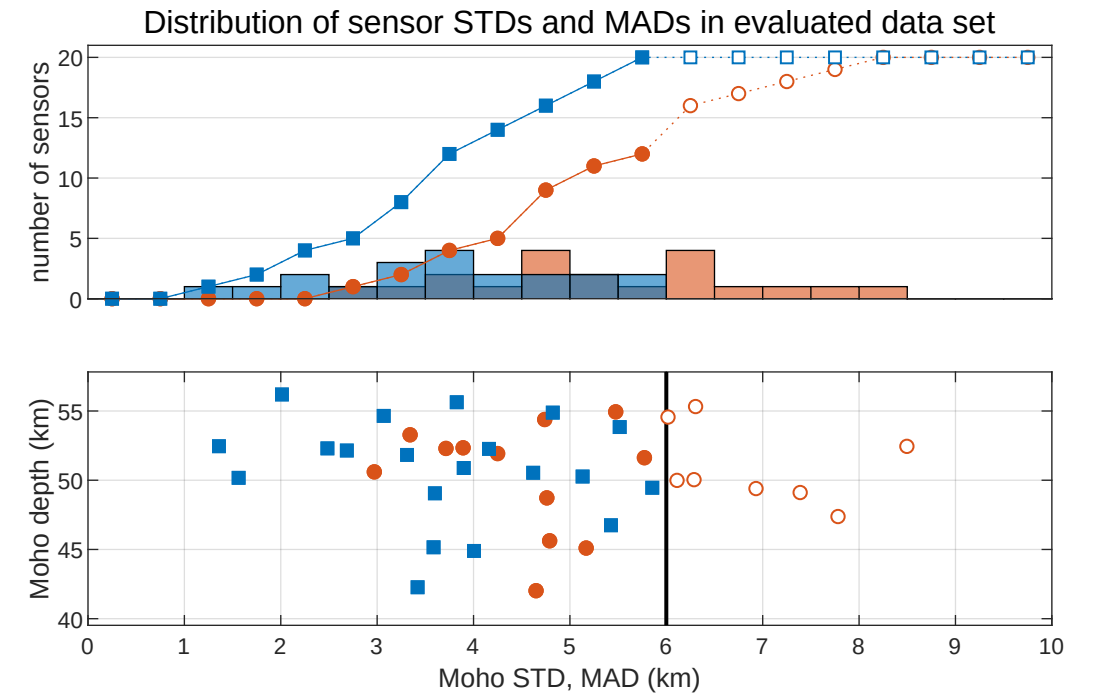
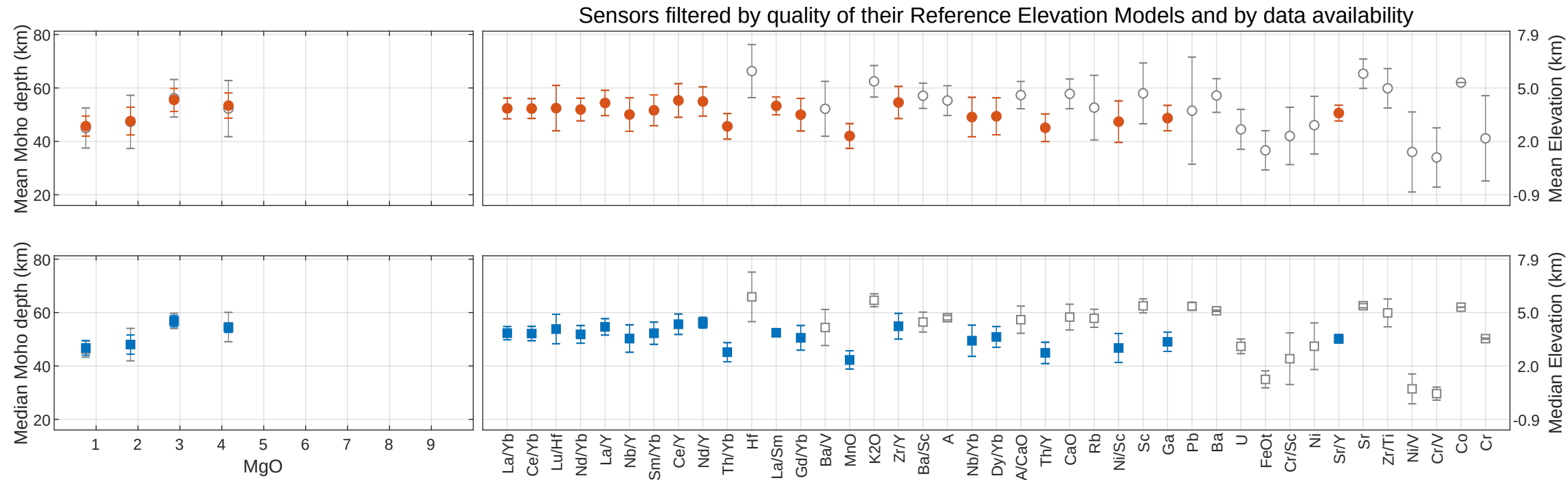
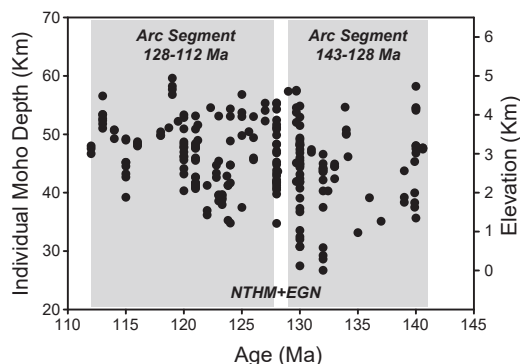


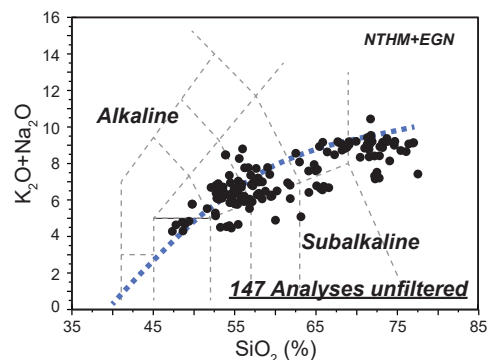
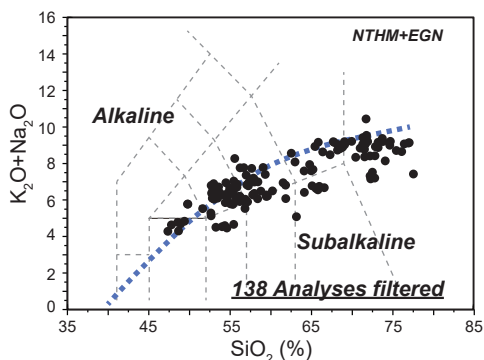
Figure S2-21

Northern Great Xing'an Range (SGXR) and Ergna Block (EGN): 128-112 Ma Magmatism

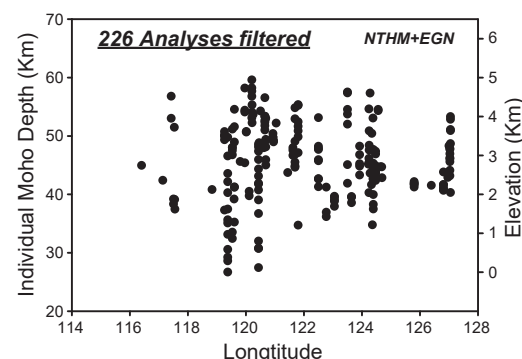
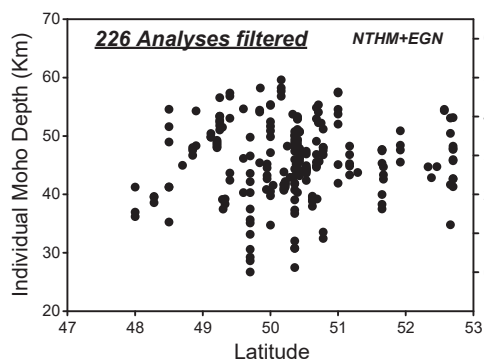
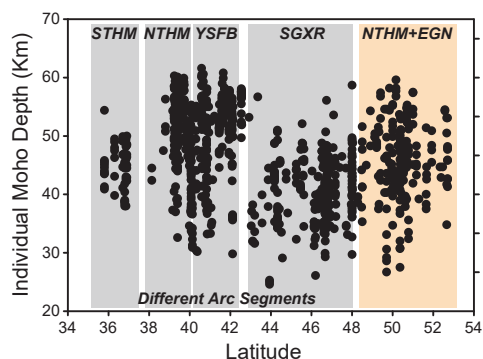
Individual Moho Depth vs. Age (143-112 Ma)



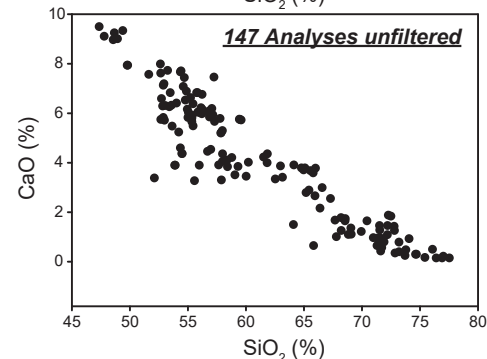
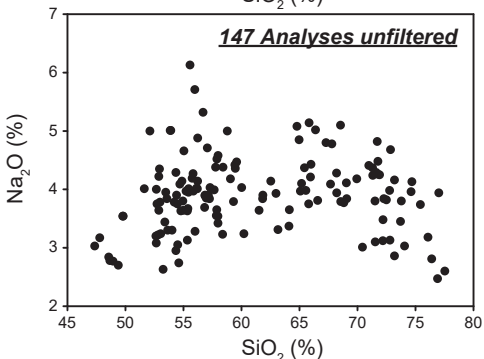
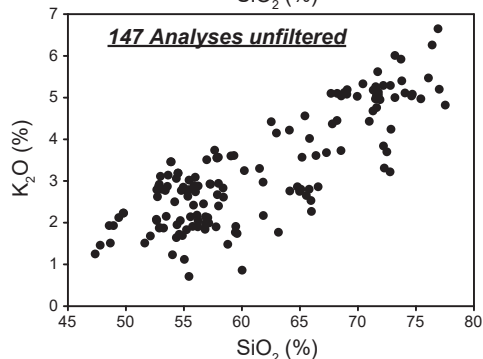
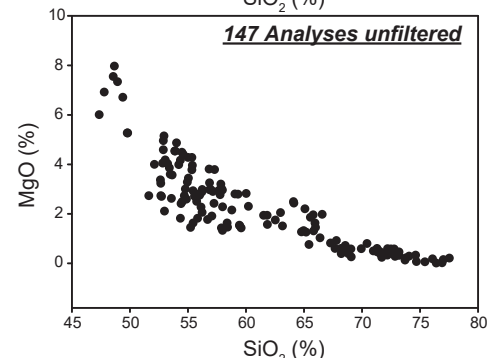
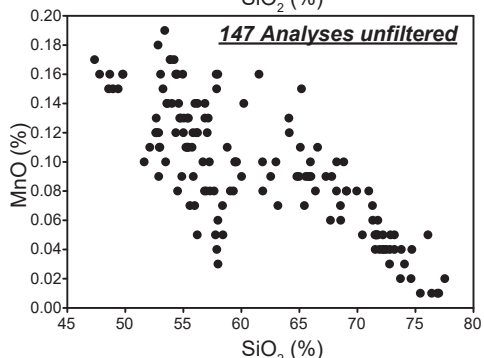
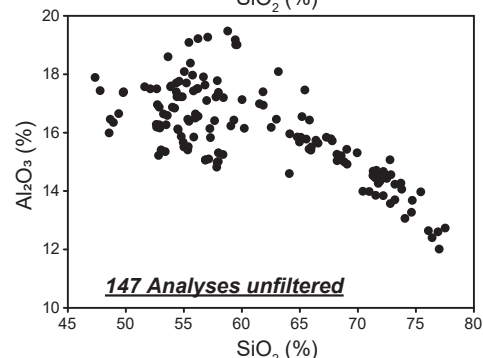
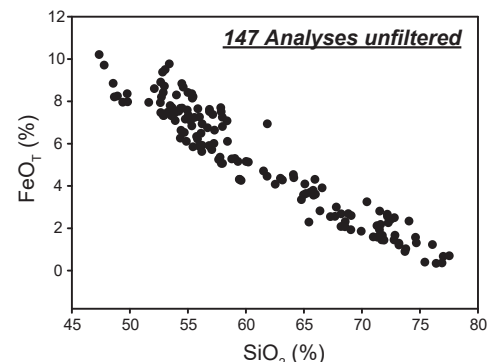
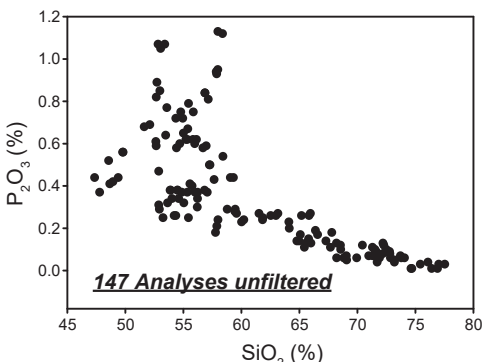
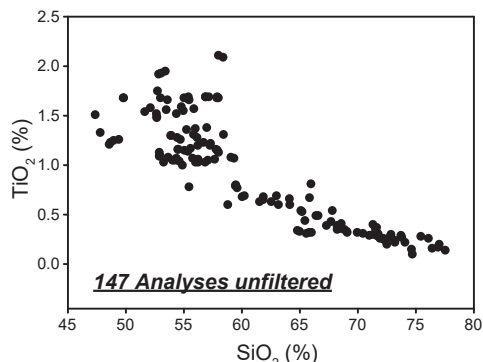
TAS diagram (128-112 Ma)



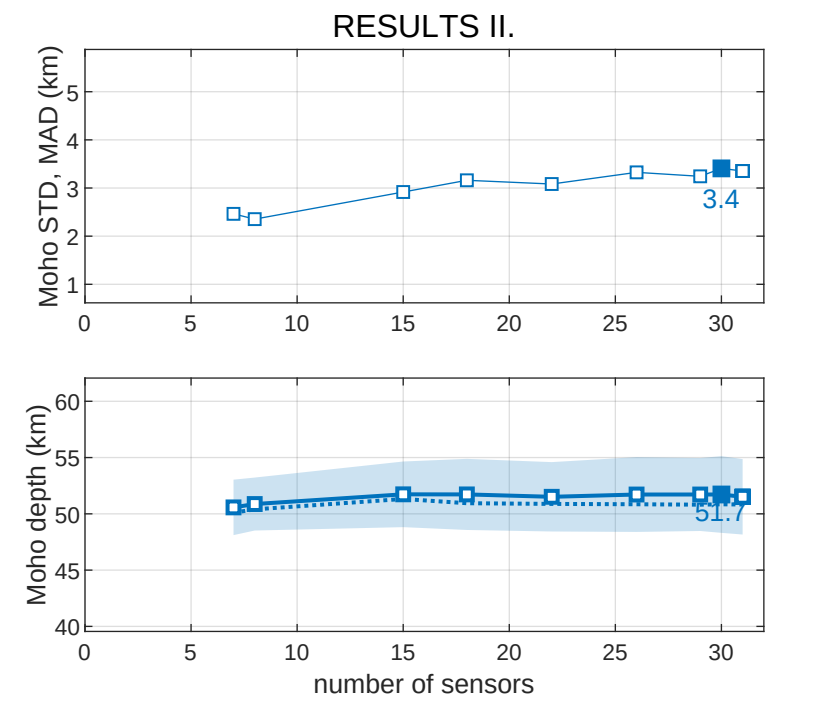
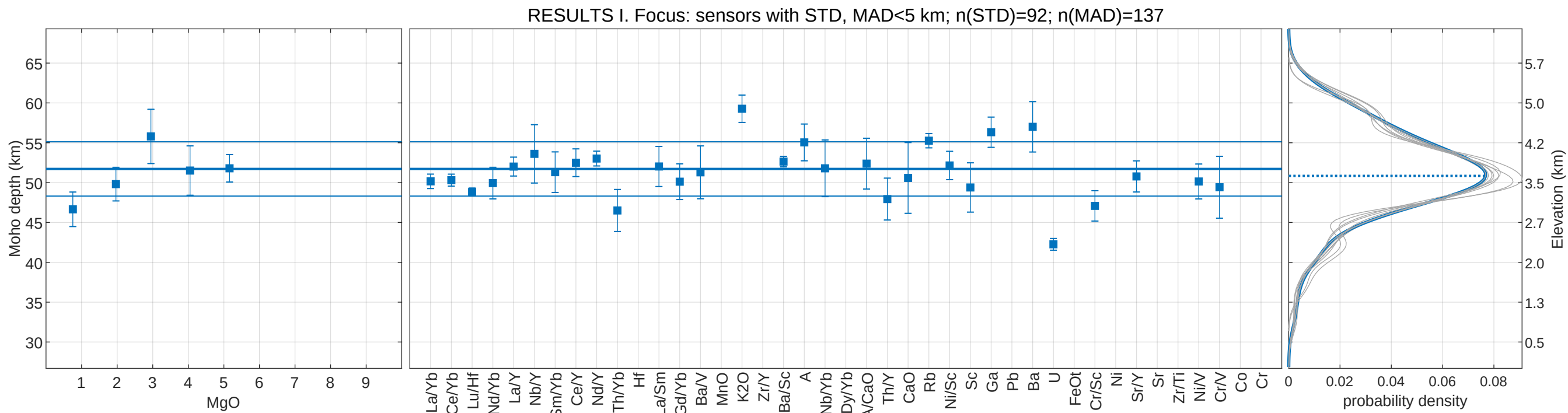
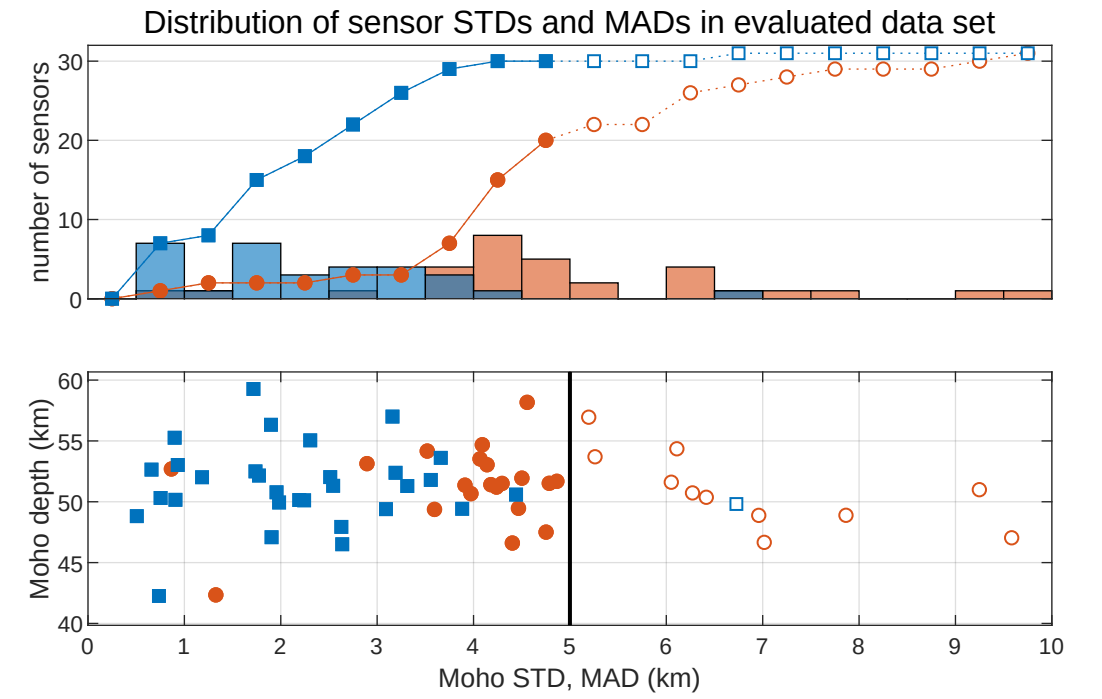
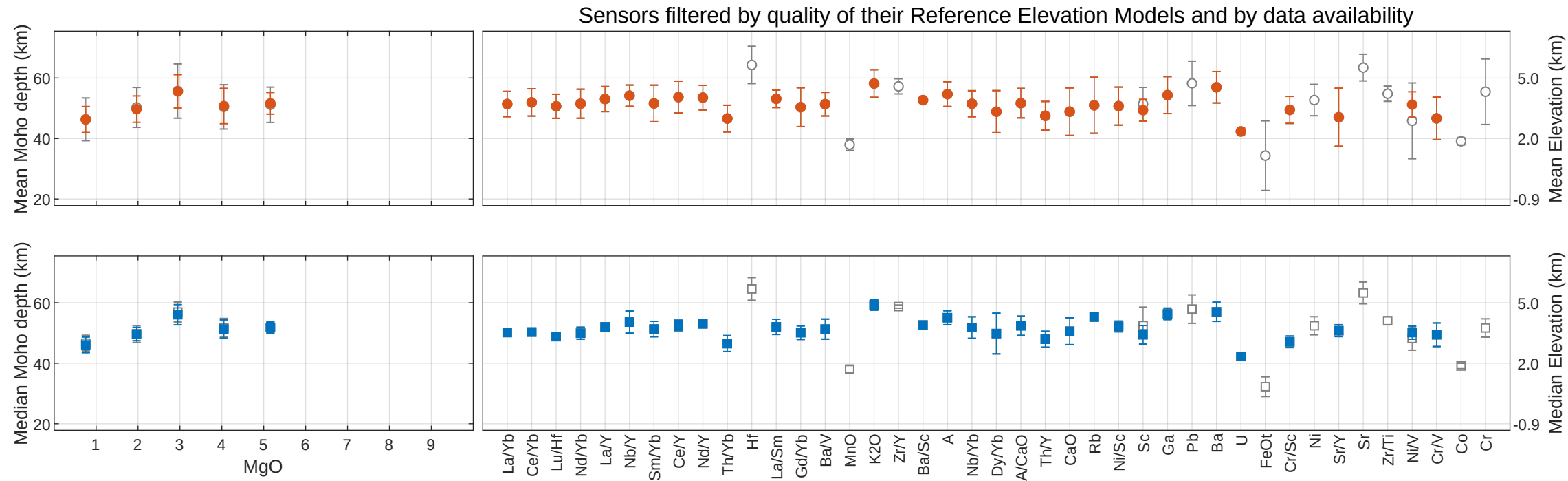
Individual Moho Depth vs. Longitude and Latitude (140-115 Ma) (143-112 Ma)



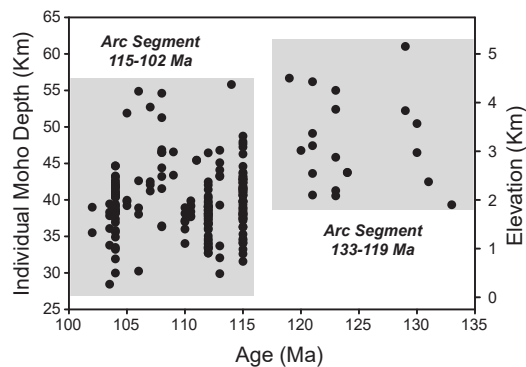
Harker Diagrams (128-112 Ma)



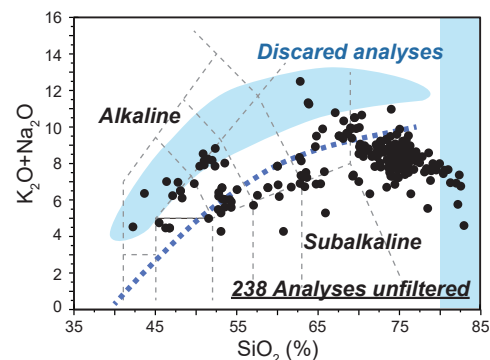
Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation



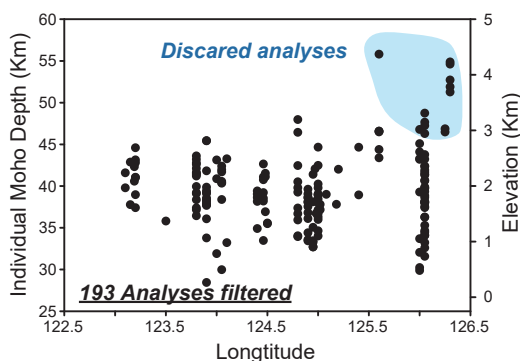
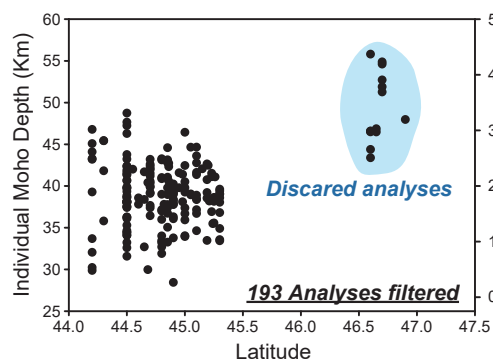
Individual Moho Depth vs. Age (133-102 Ma)



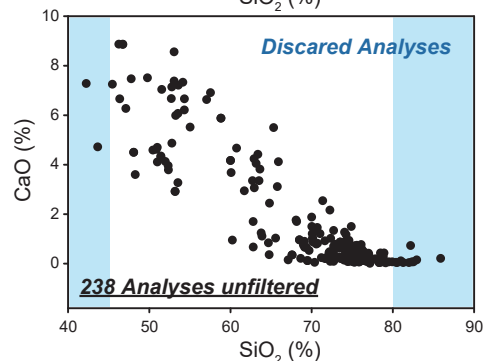
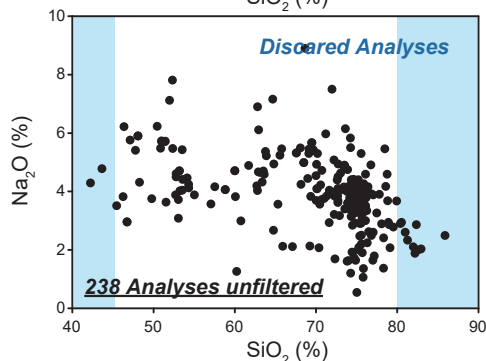
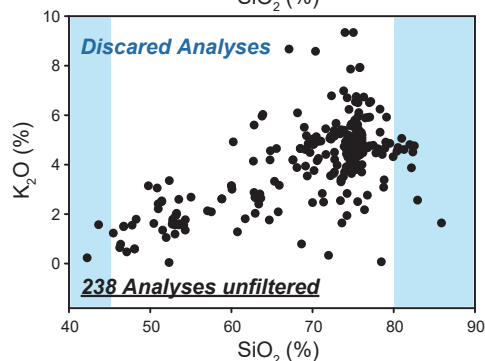
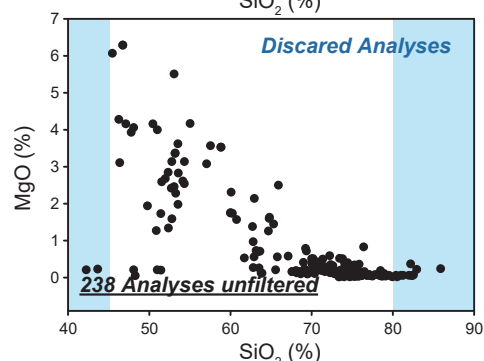
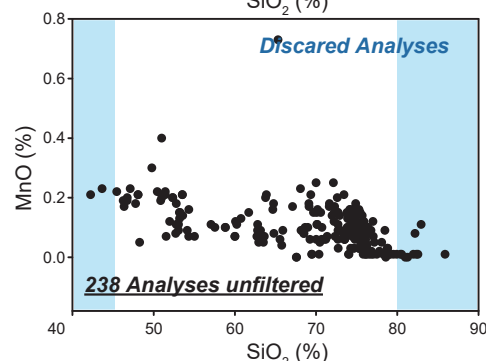
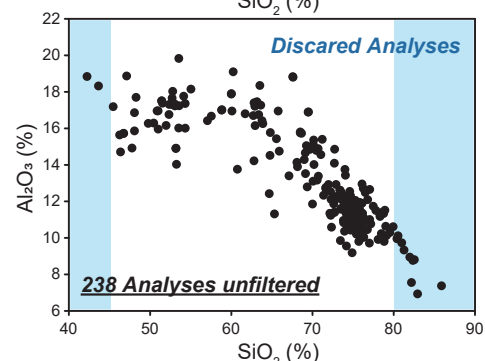
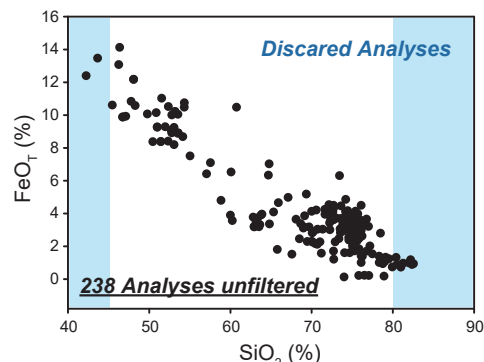
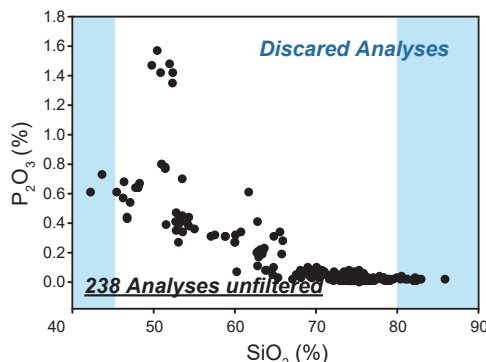
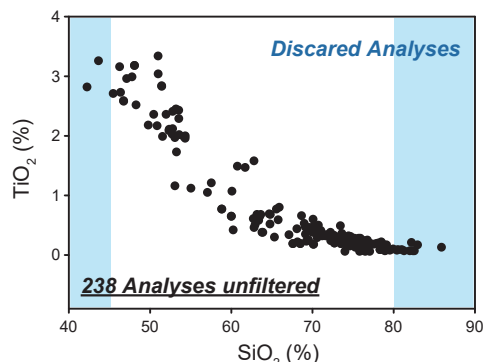
TAS diagram (115-102 Ma)



Individual Moho Depth vs. Longitude and Latitude (115-102 Ma)



Harker Diagrams (115-102 Ma)



Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation

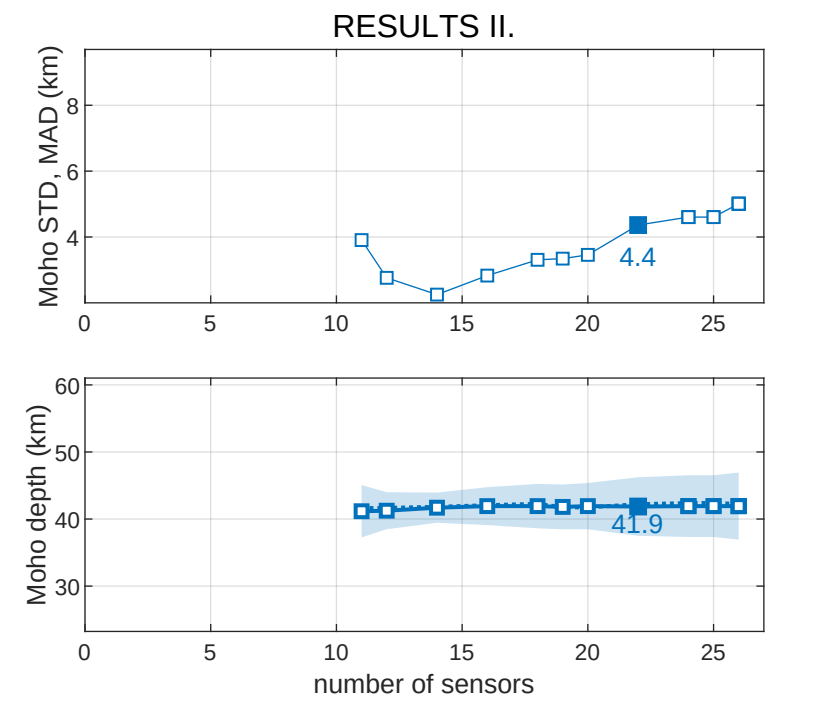
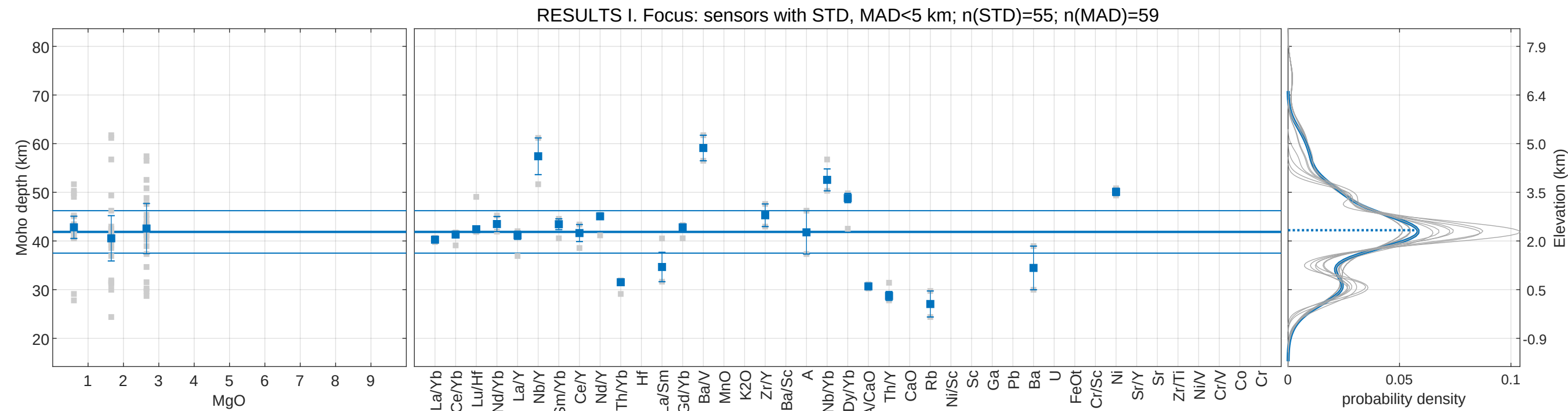
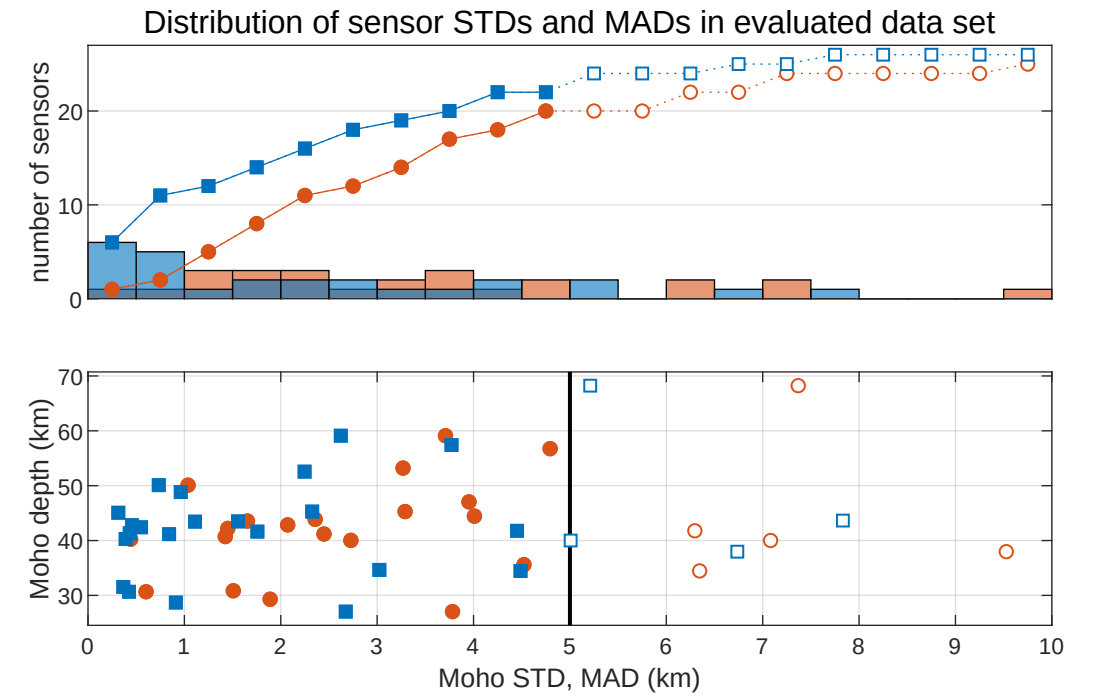
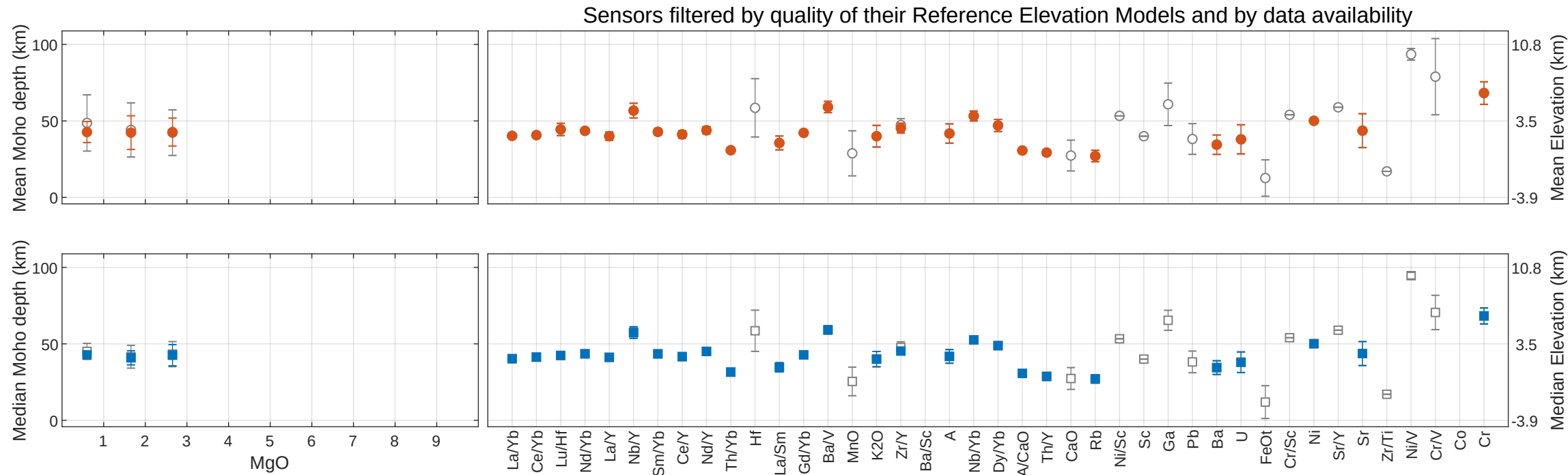
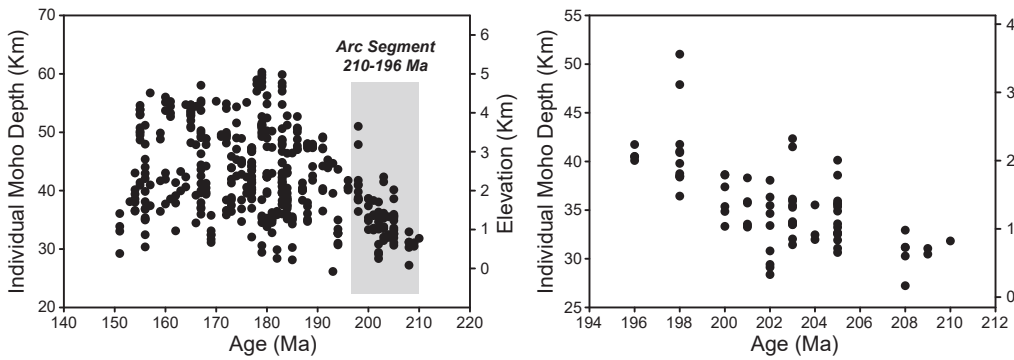
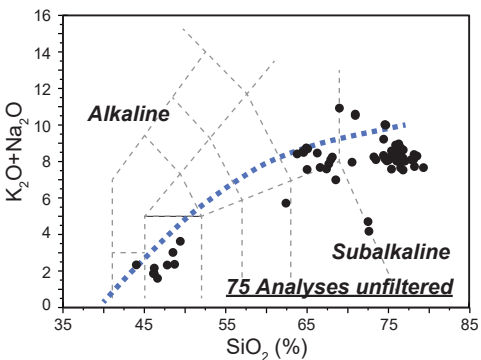


Figure S2-23 Zhangguangcai Range (ZGR) and Jiamusi Block (JMB): 210-196 Ma Magmatism

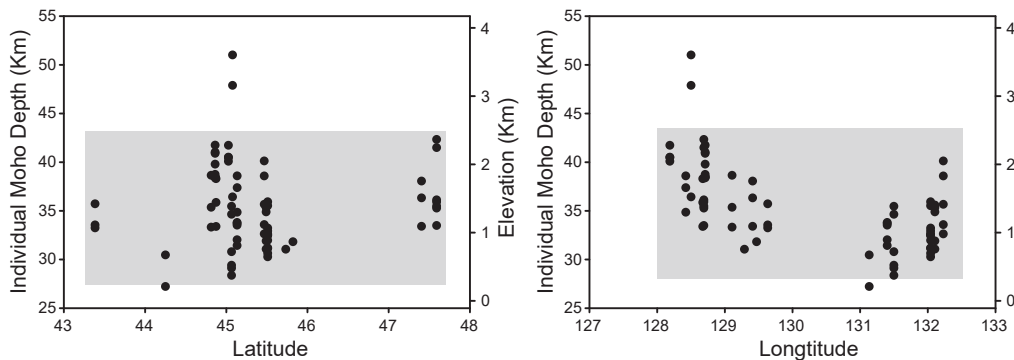
Individual Moho Depth vs. Age (210-140 Ma)(210-196 Ma)



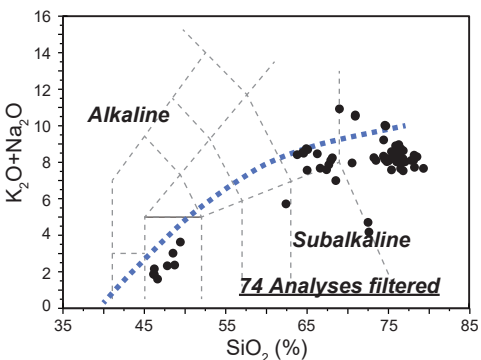
TAS diagram (210-196 Ma)



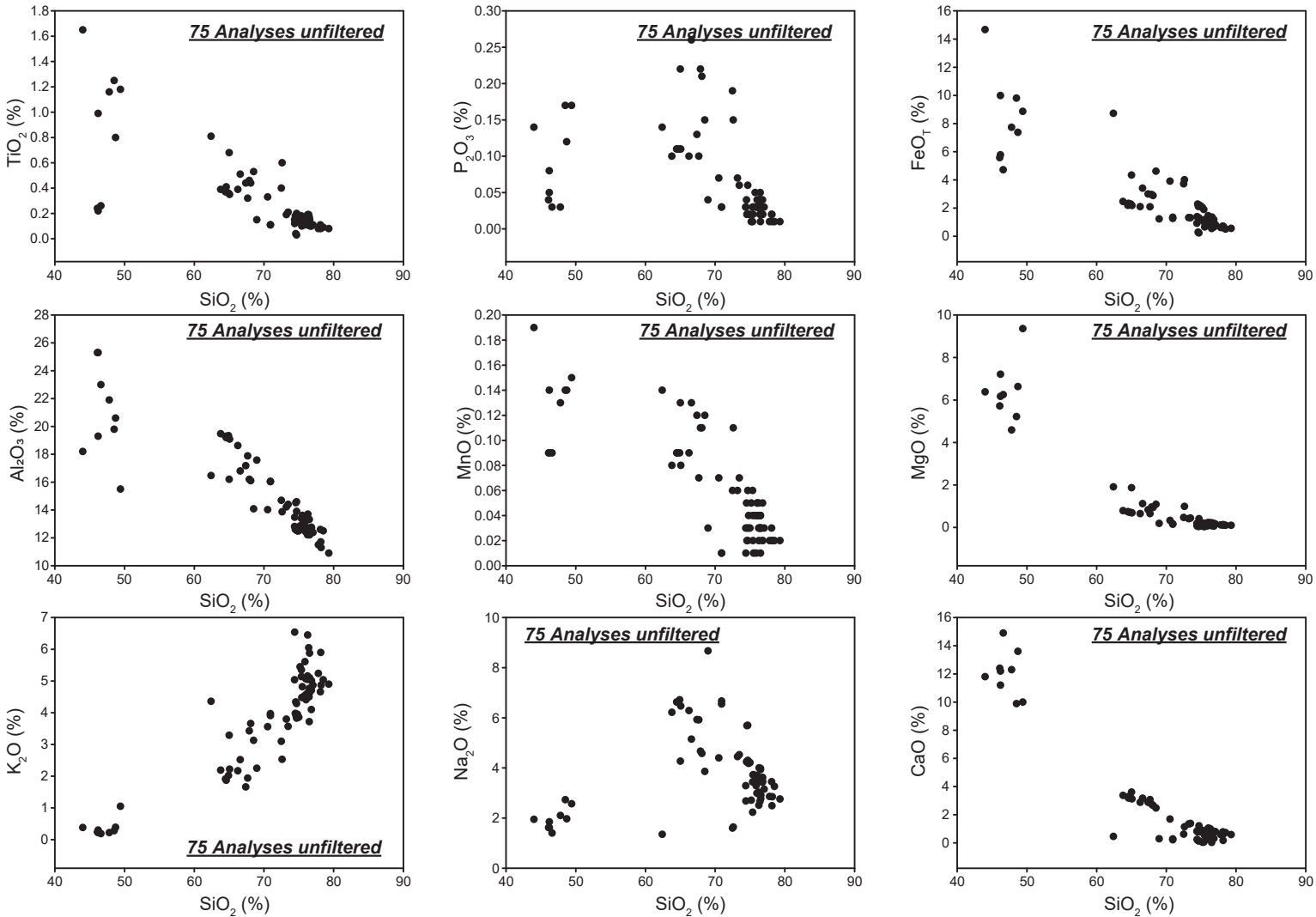
Individual Moho Depth vs. Latitude and Longitude (210-196 Ma)



TAS diagram (210-196 Ma)



Harker Diagrams (210-196 Ma)



Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the ϵ_{max} limitation

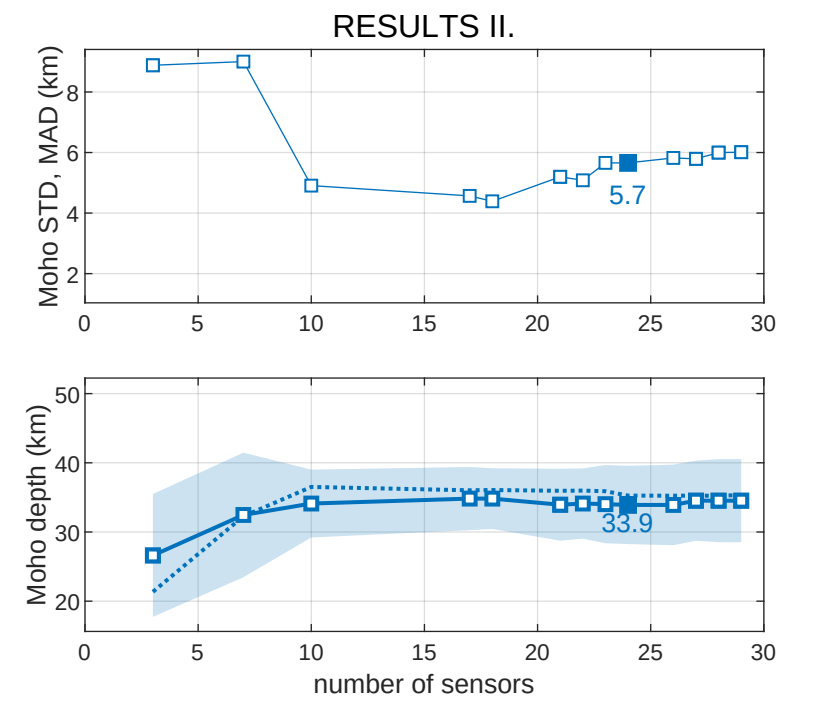
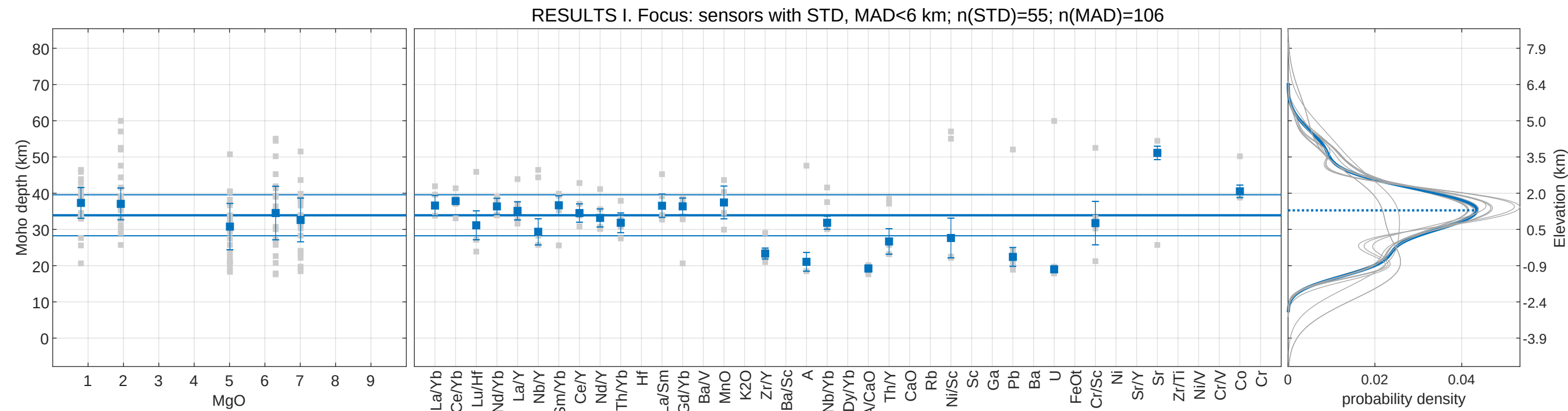
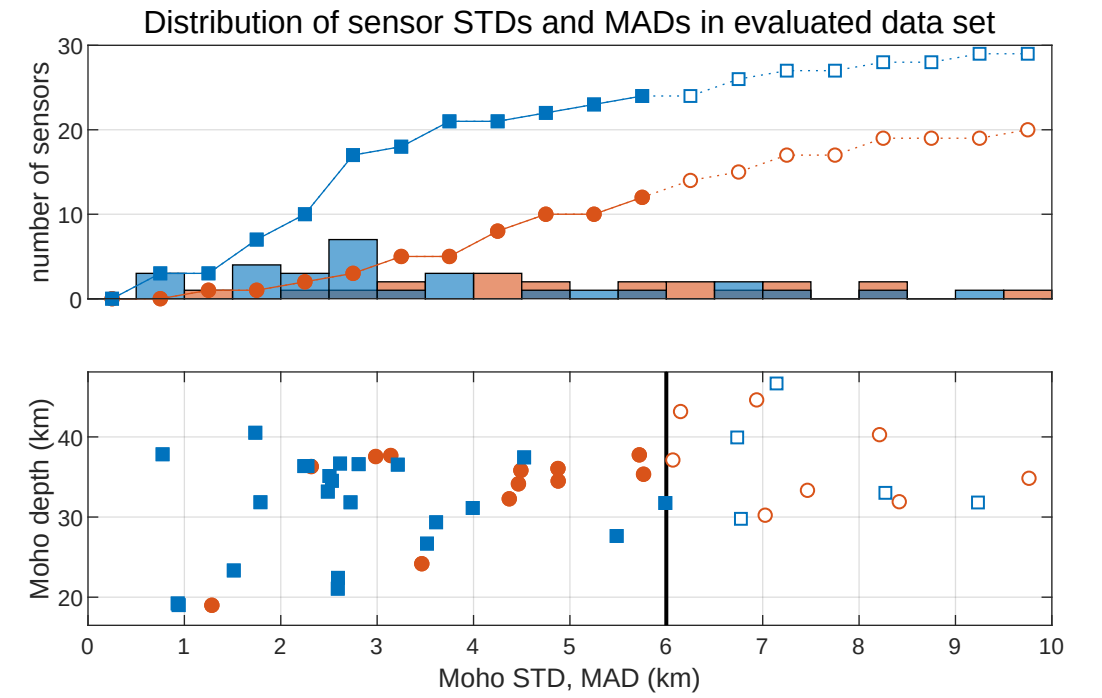
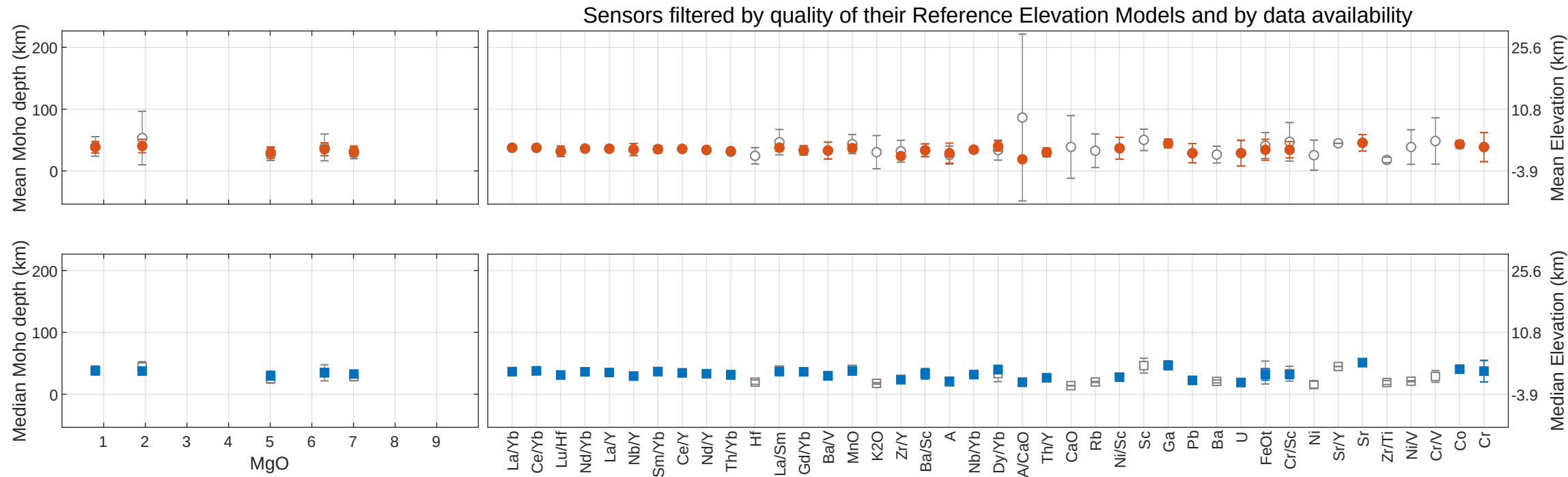
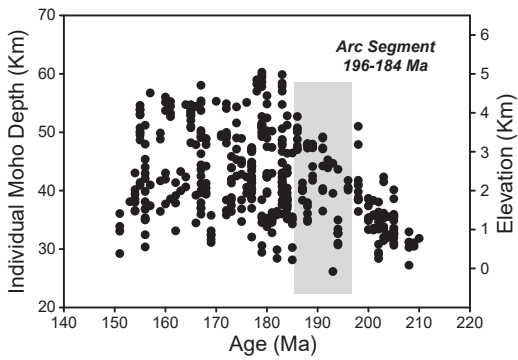
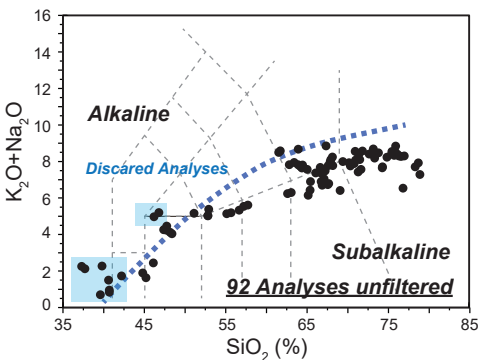


Figure S2-24 Zhangguangcai Range (ZGR) and Jiamusi Block (JMB): 196-184 Ma Magmatism

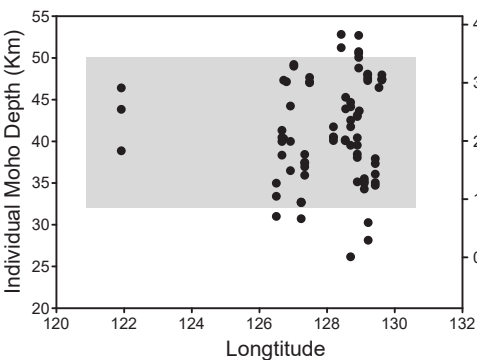
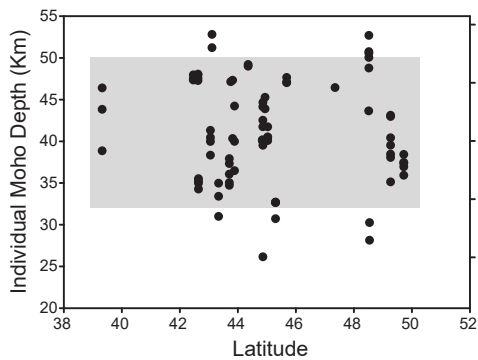
Individual Moho Depth vs. Age (210-140 Ma)(196-184 Ma)



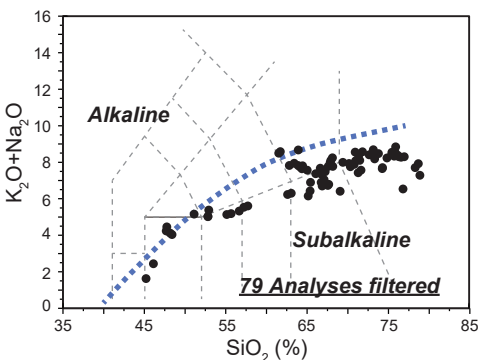
TAS diagram (196-184 Ma)



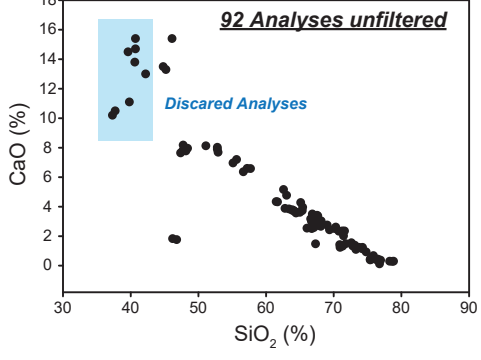
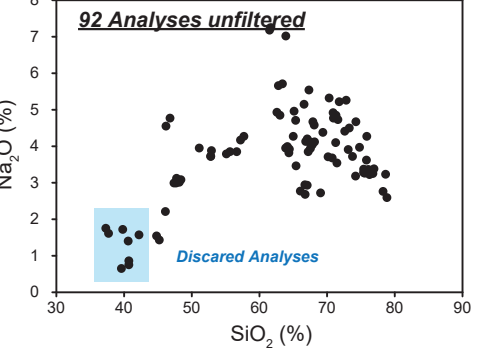
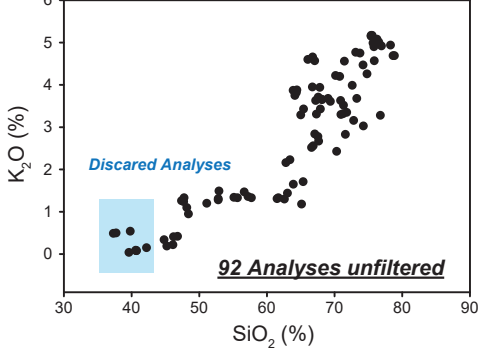
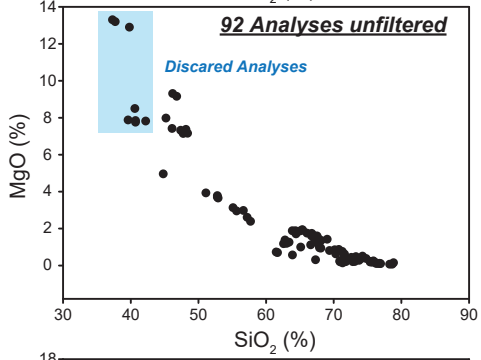
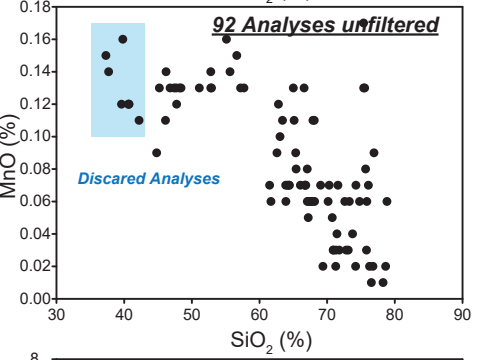
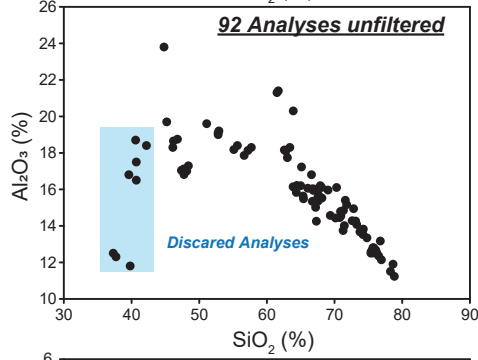
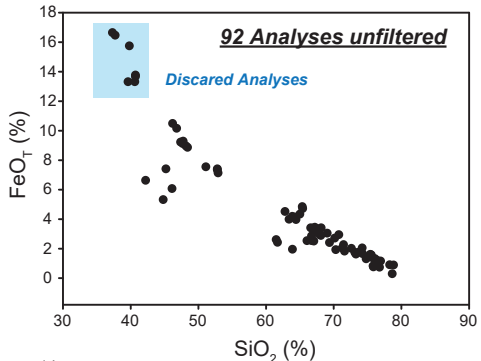
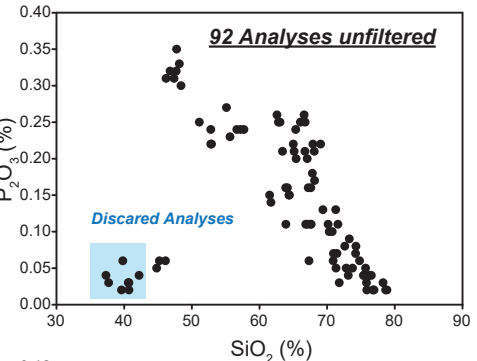
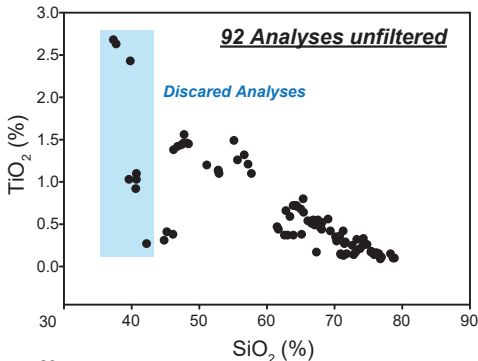
Individual Moho Depth vs. Latitude (196-184 Ma)



TAS diagram (196-184 Ma)



Harker Diagrams (196-184 Ma)



Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the εmax limitation

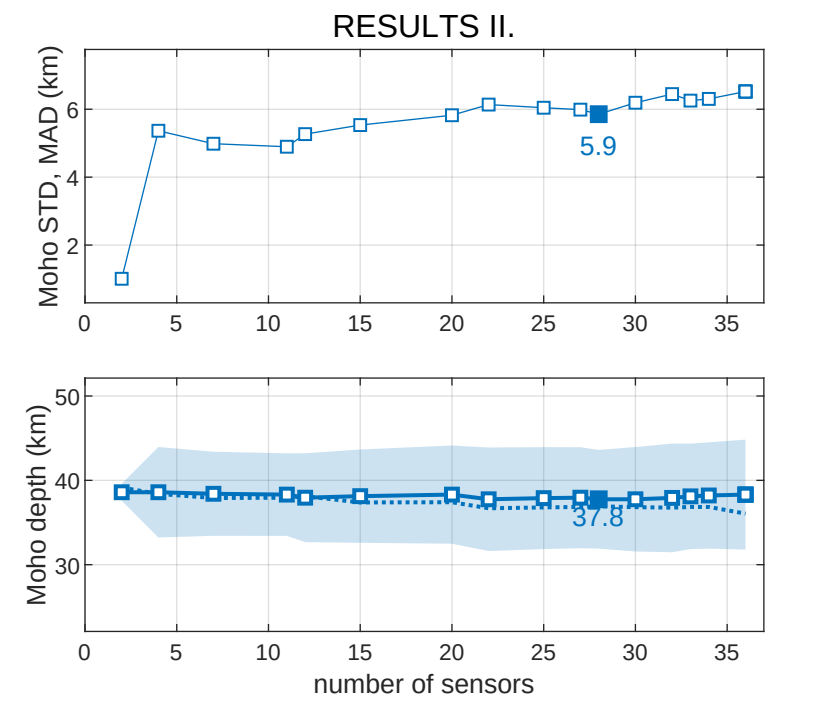
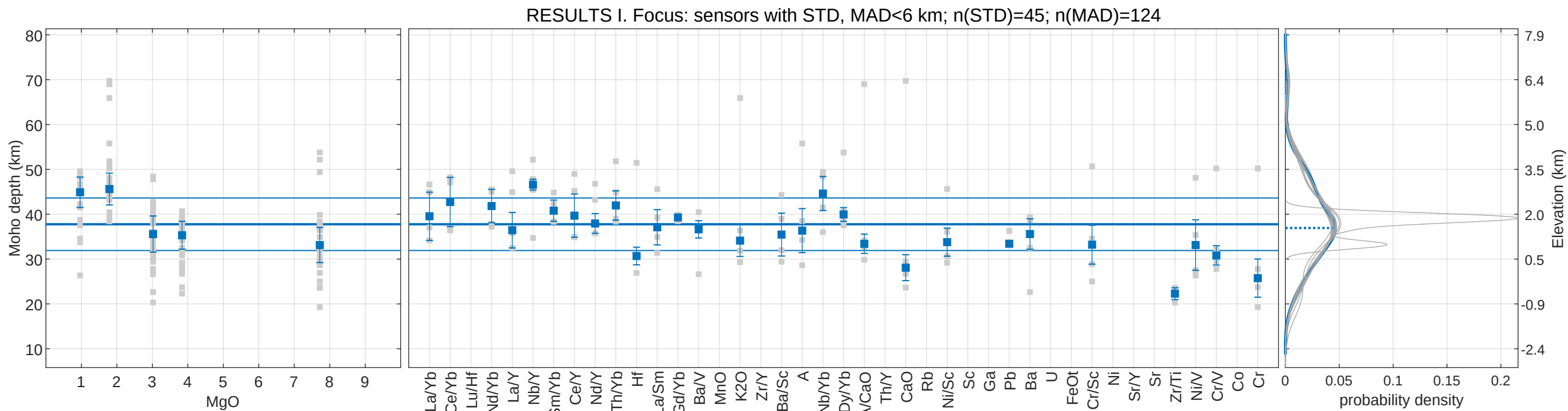
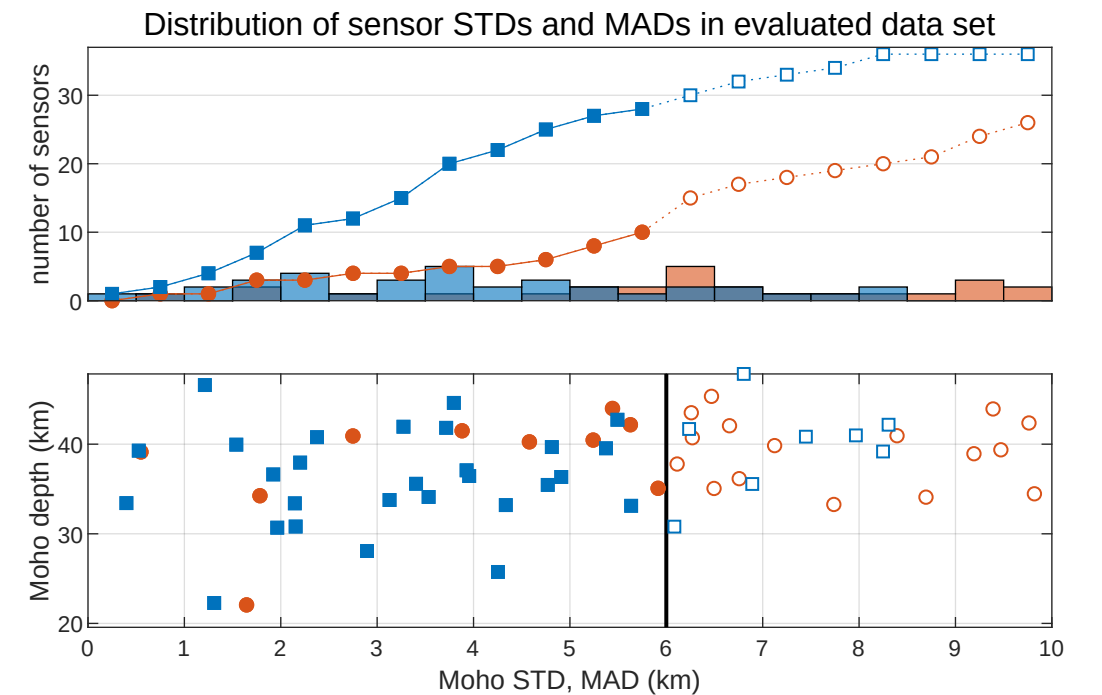
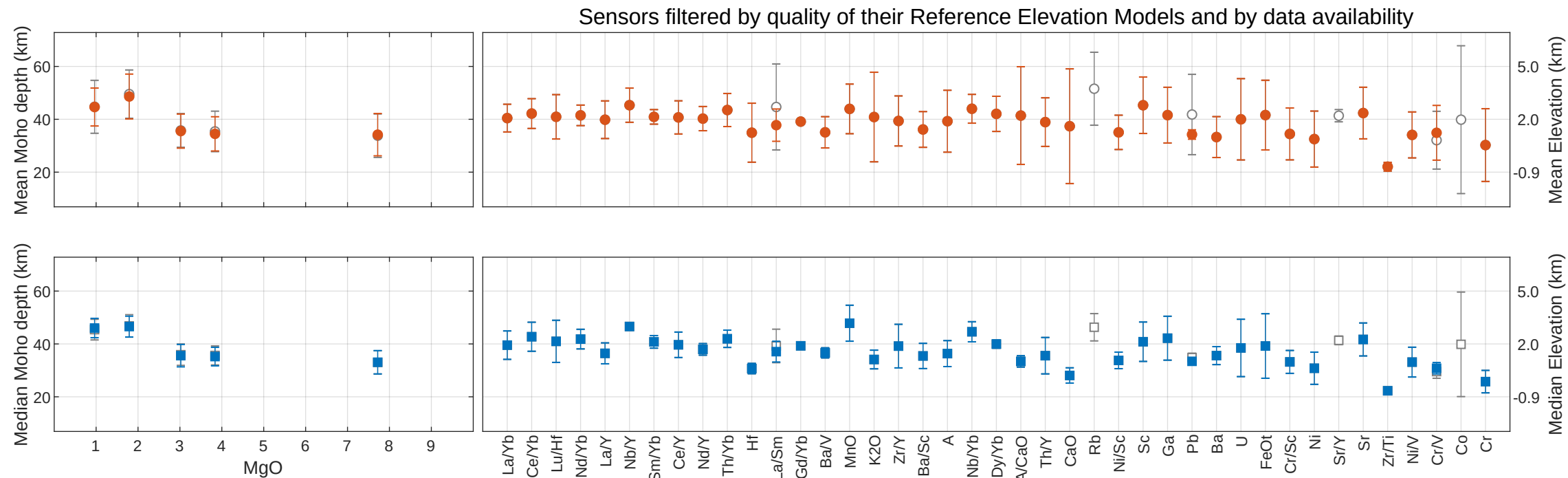
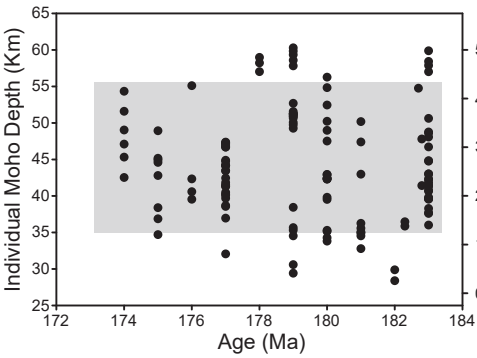
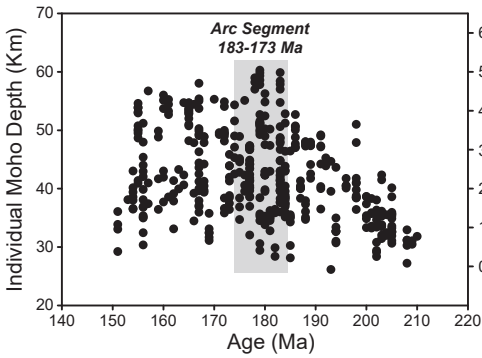
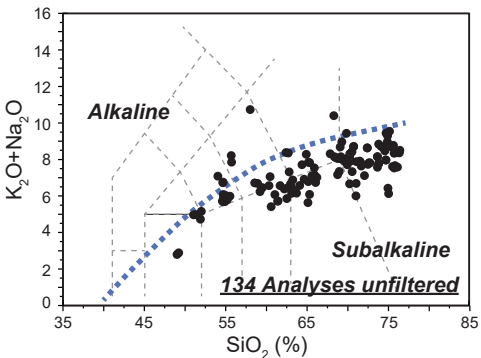


Figure S2-25 Zhangguangcai Range (ZGR) and Jiamusi Block (JMB): 183-173 Ma Magmatism

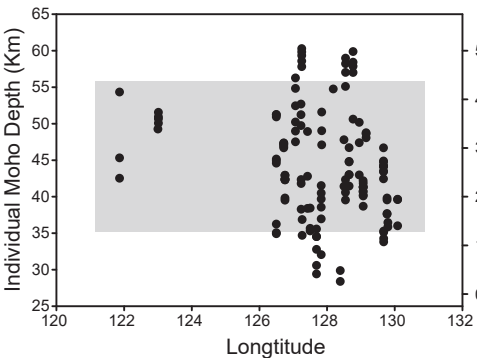
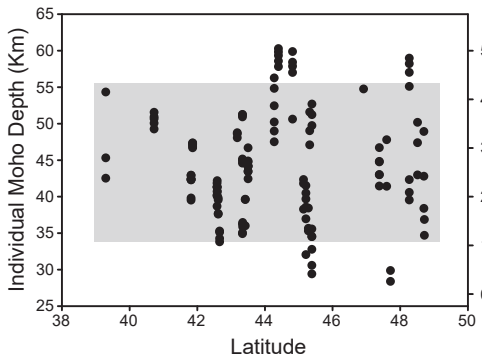
Individual Moho Depth vs. Age (210-140 Ma)(183-173 Ma)



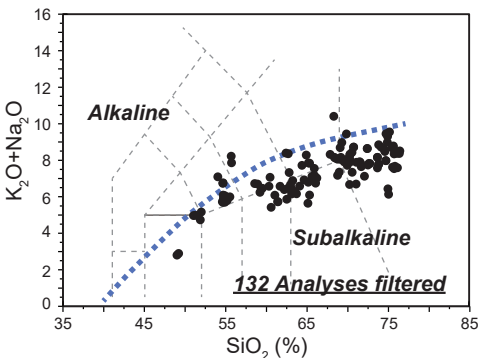
TAS diagram (183-173 Ma)



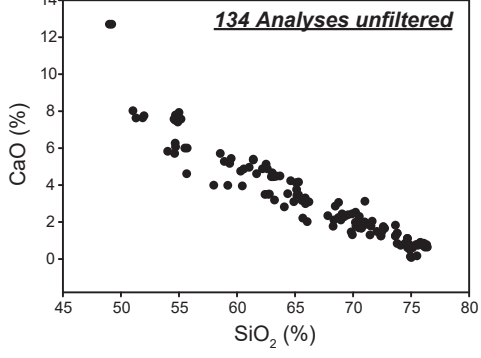
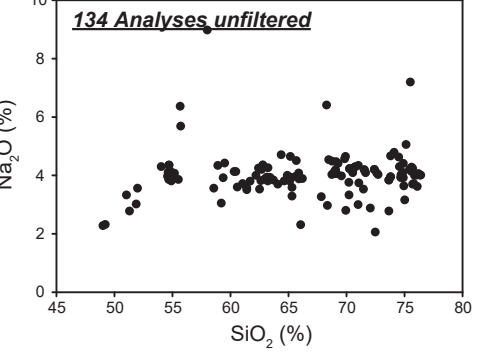
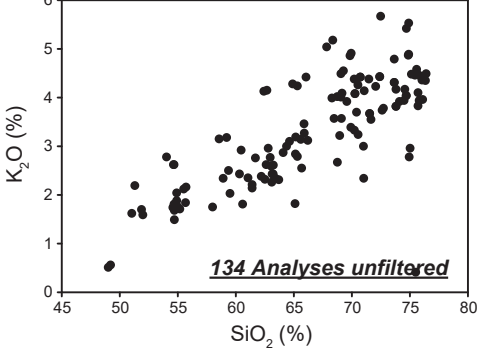
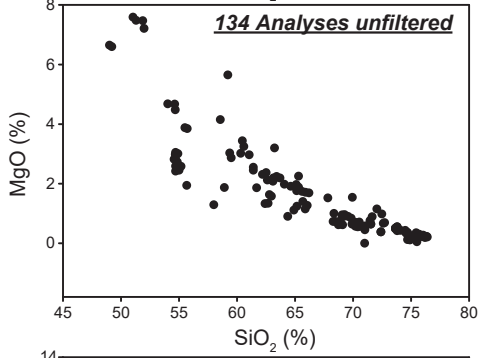
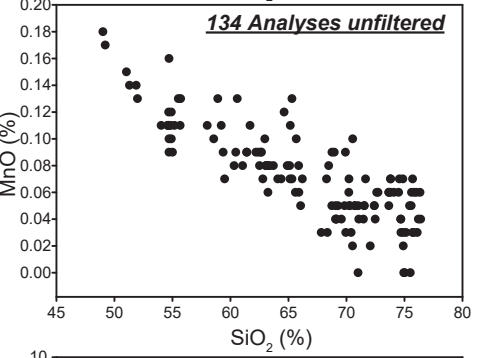
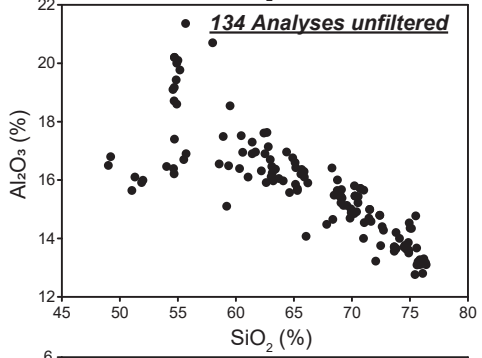
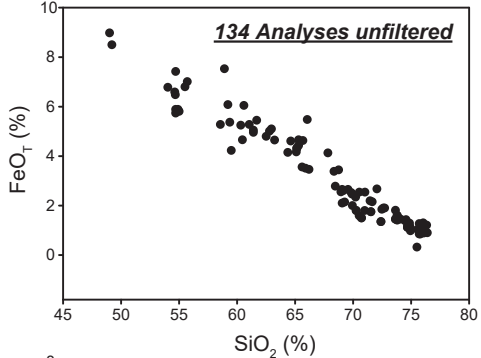
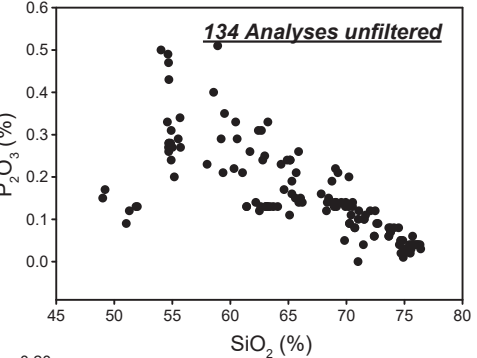
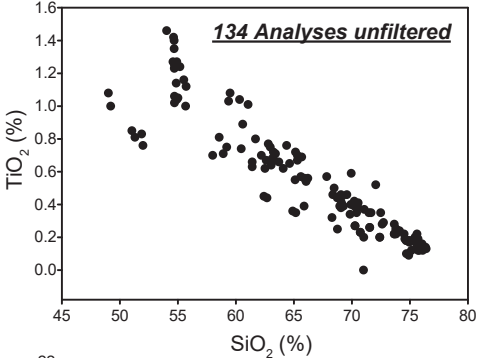
Individual Moho Depth vs. Latitude (183-173 Ma)



TAS diagram (183-173 Ma)



Harker Diagrams (183-173 Ma)



Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the εmax limitation

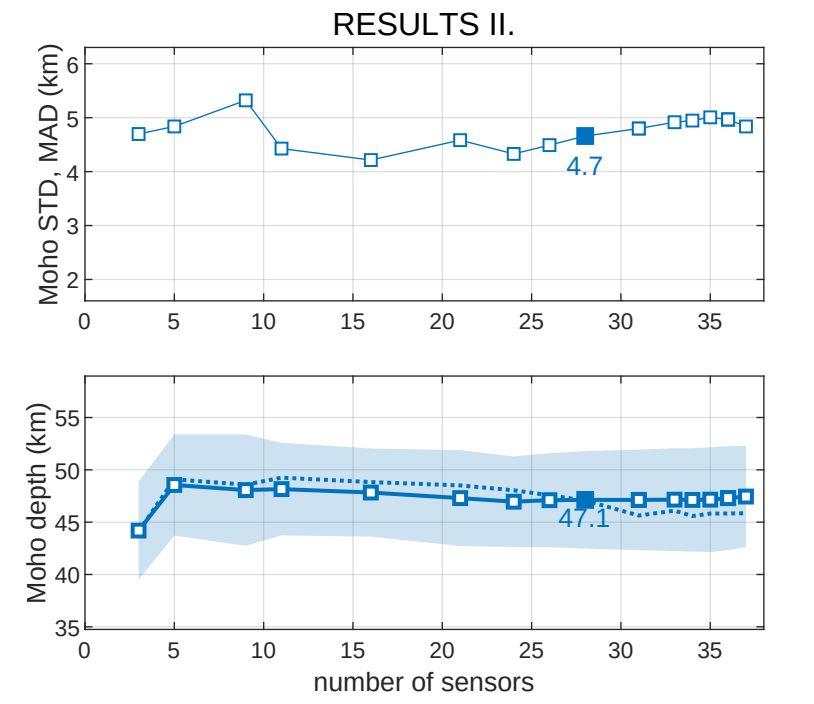
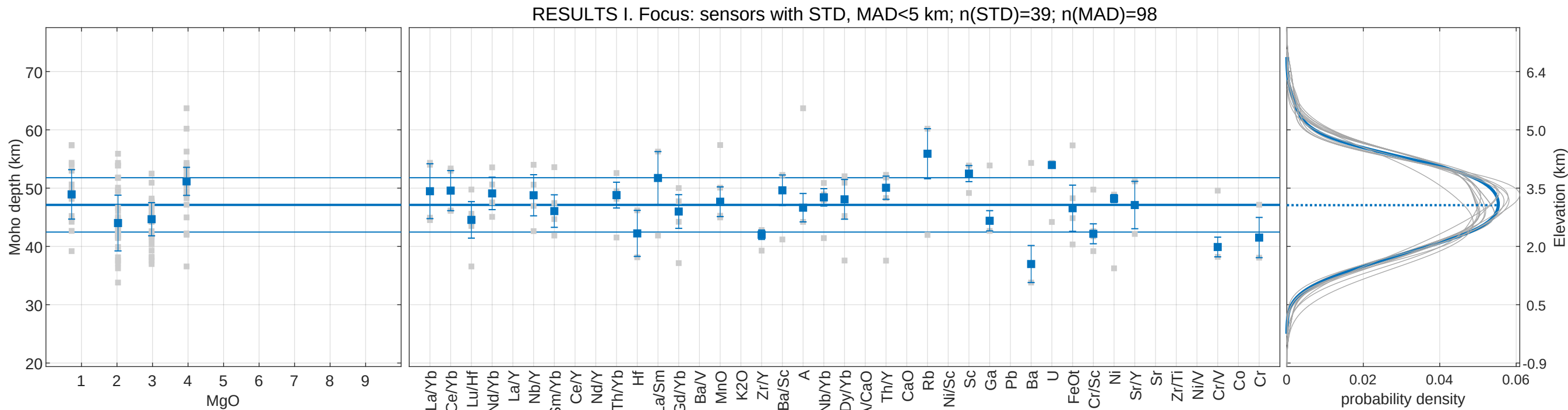
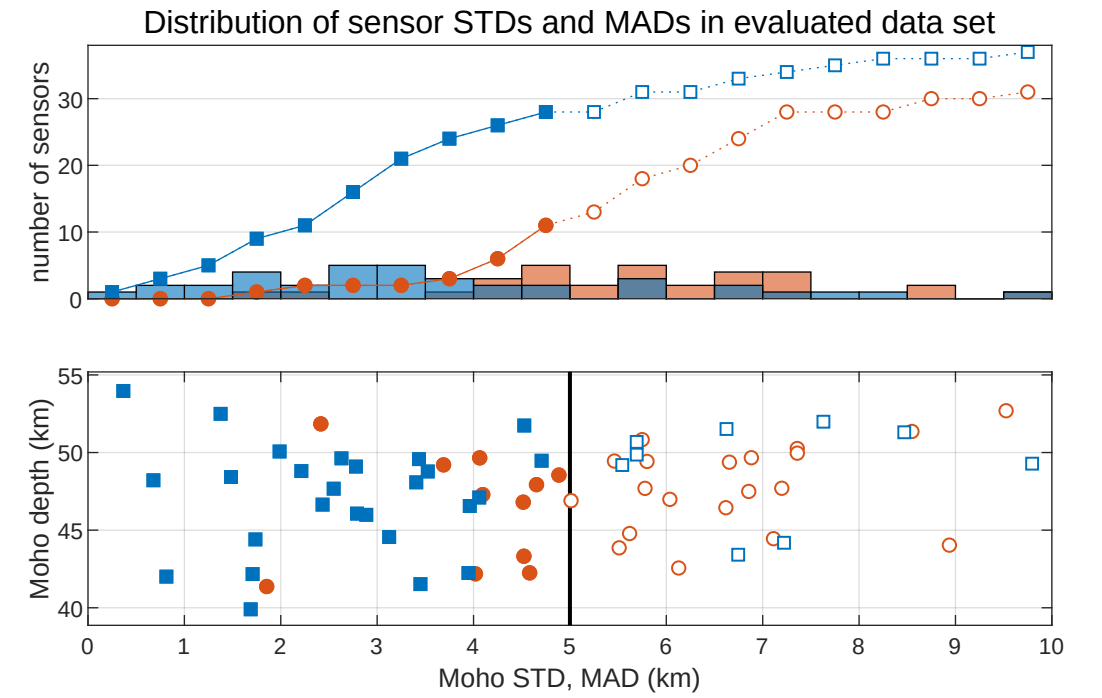
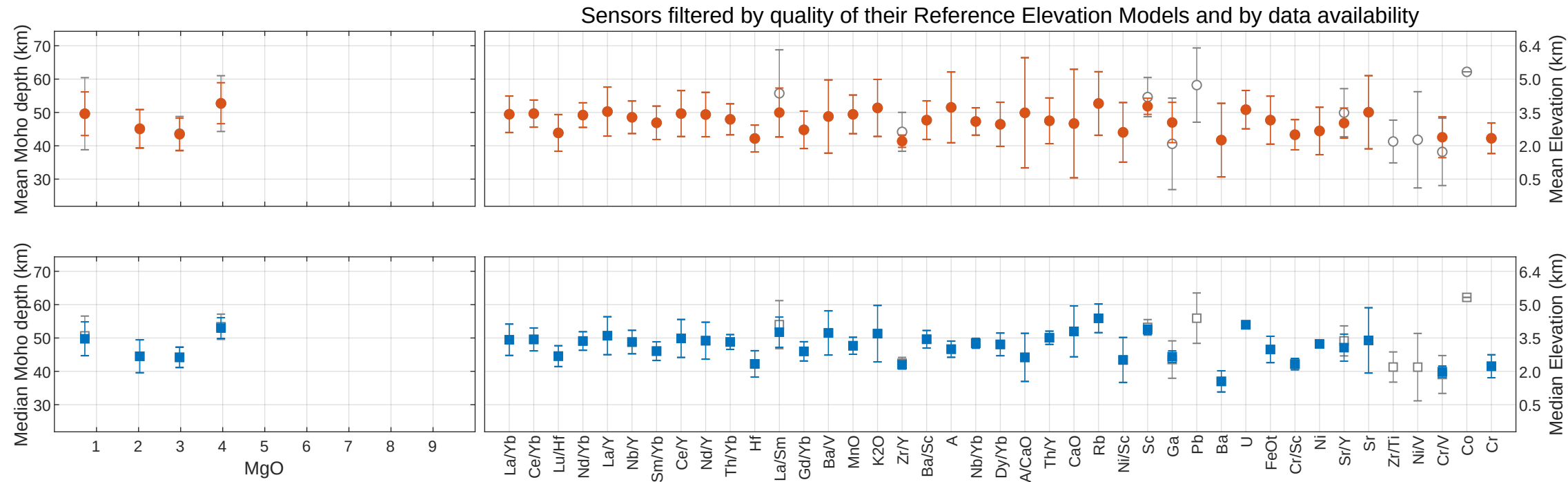
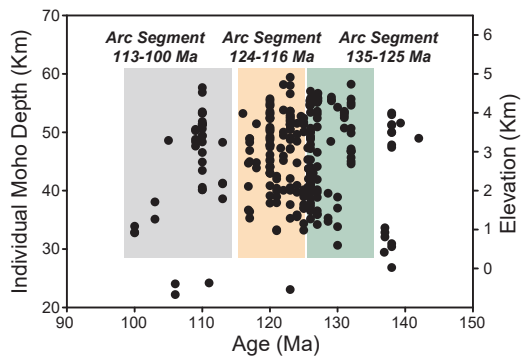
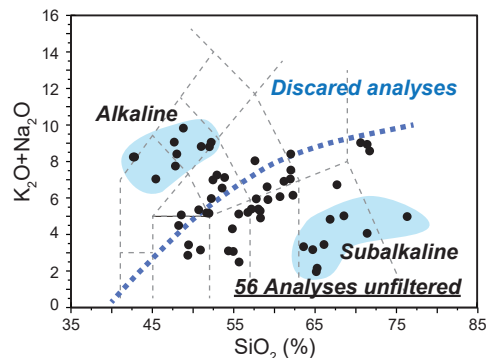


Figure S2-26 Zhangguangcai Range (ZGR) and Jiamusi Block (JMB): 113-100 Ma Magmatism

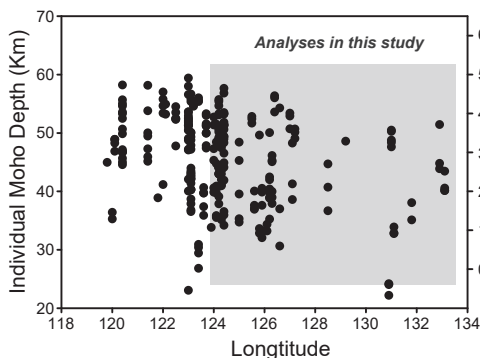
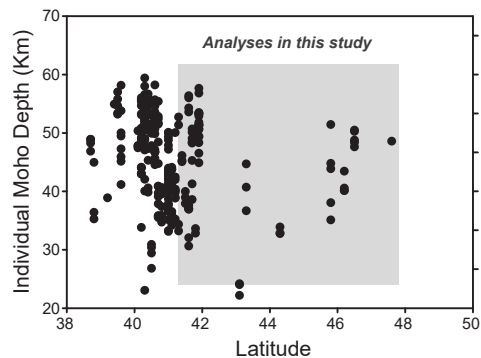
Individual Moho Depth vs. Latitude (140-100 Ma)



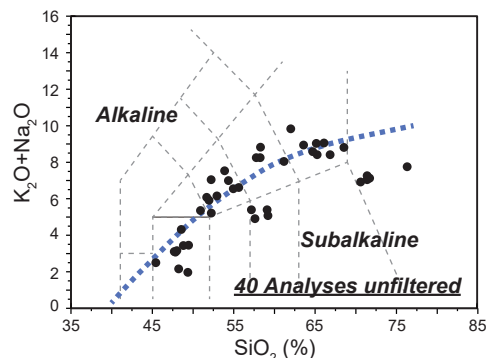
TAS diagram (113-100 Ma)



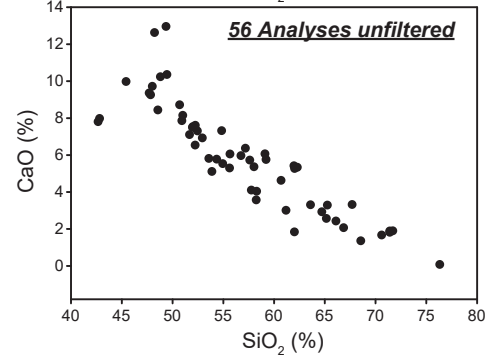
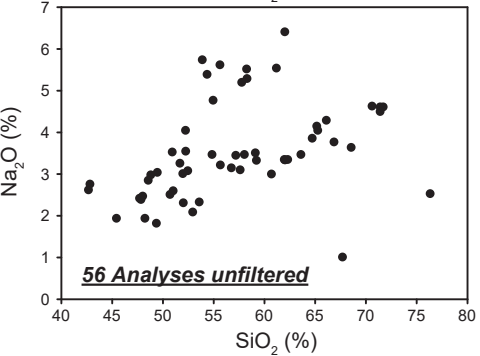
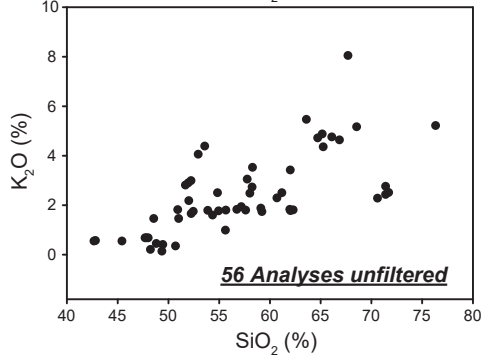
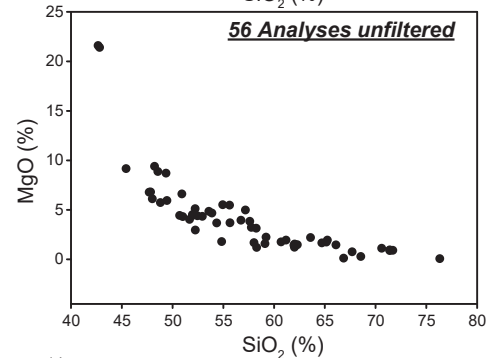
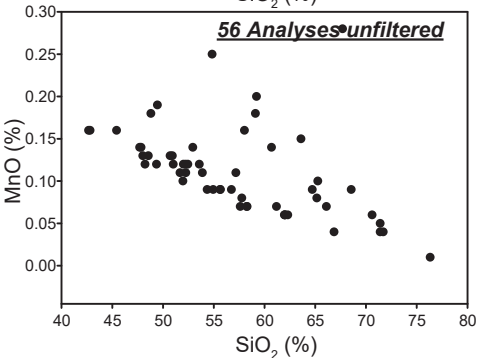
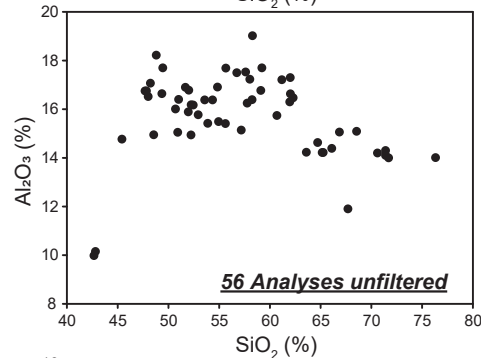
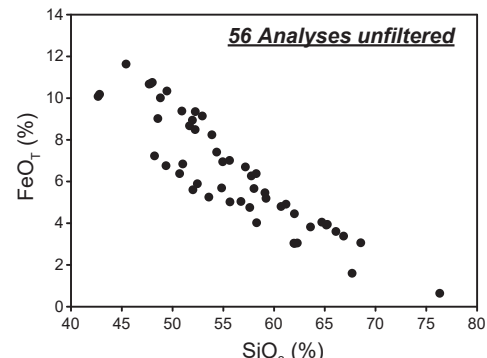
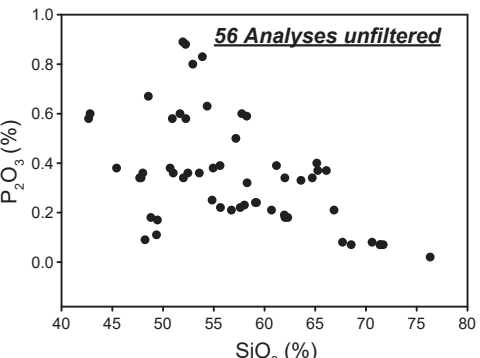
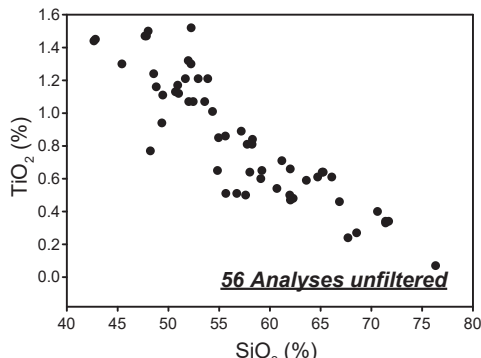
Individual Moho Depth vs. Latitude (140-100 Ma)



TAS diagram (113-100 Ma)



Harker Diagrams (113-100 Ma)



Notes: Individual Moho Depth—Average moho estimate for the quality-filtered individual samples using all proxies that satisfy the emax limitation

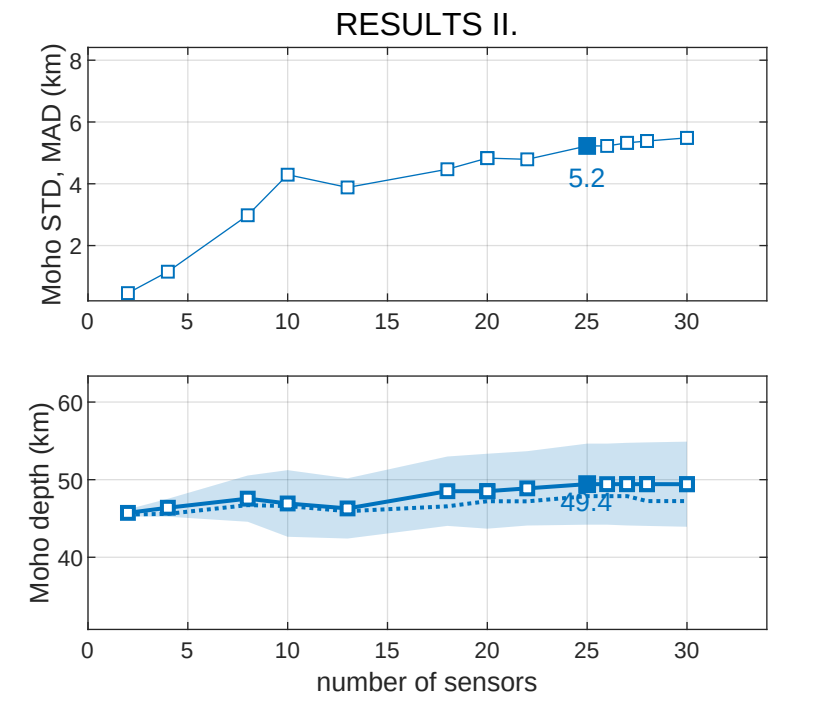
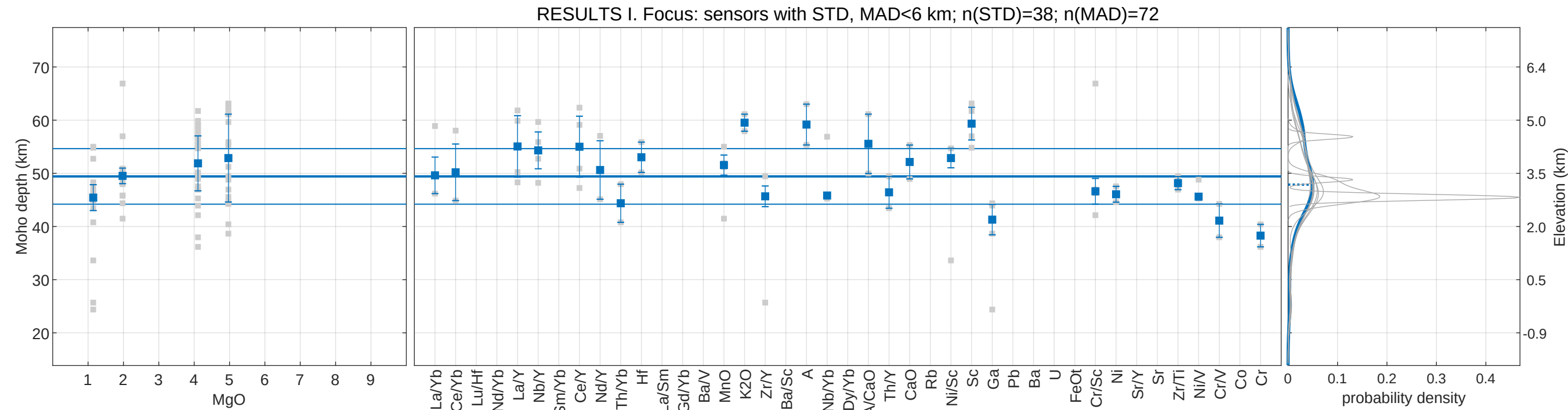
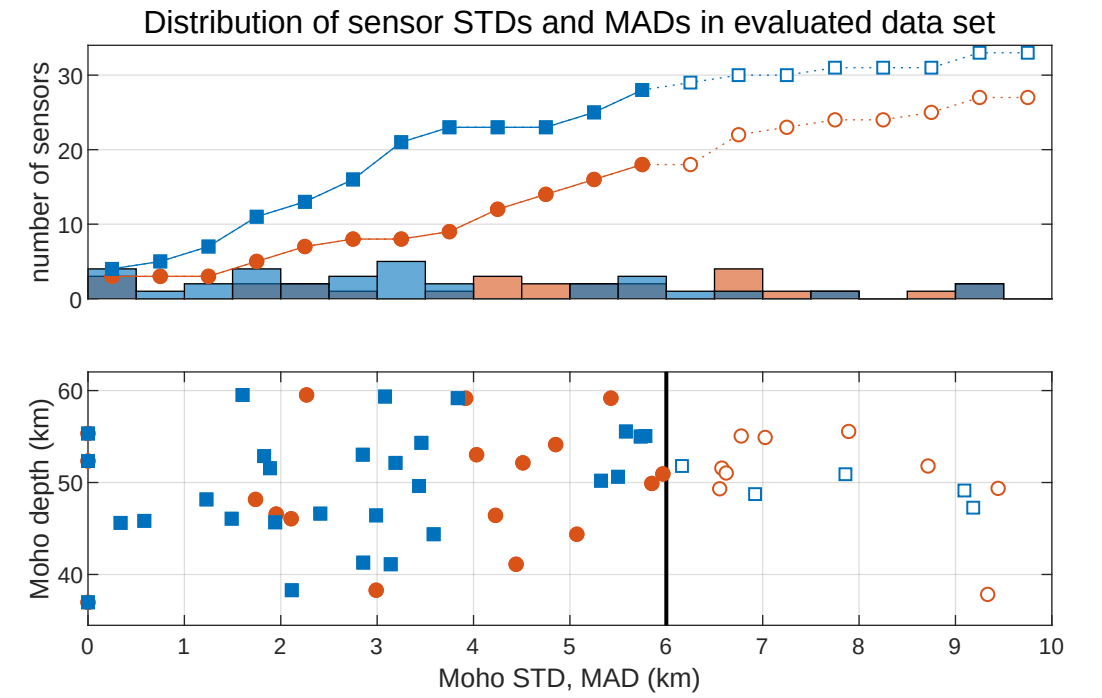
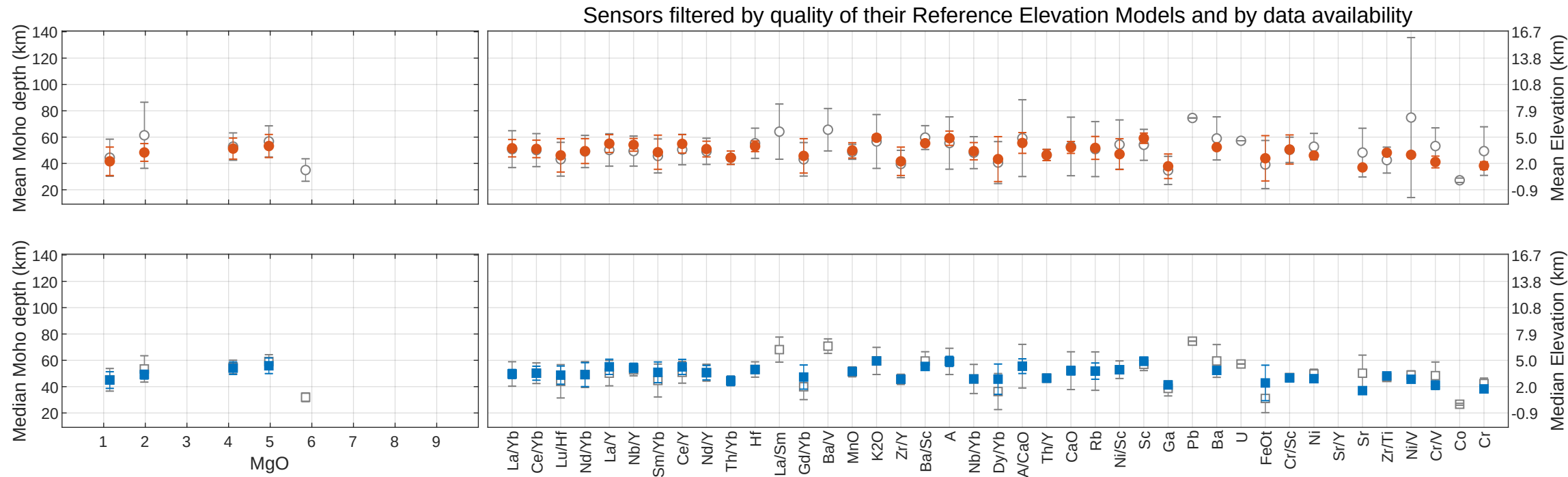


Figure S2.

Individual Moho depth versus crystallization age, individual Moho depth versus latitude, individual Moho depth versus longitude, TAS and Harker diagrams, and GAME results for each arc segment. Individual Moho depths represent the average Moho estimates obtained for the quality-filtered individual samples, computed by using all applicable mohometers that satisfy the imposed ϵ_{max} limitation.

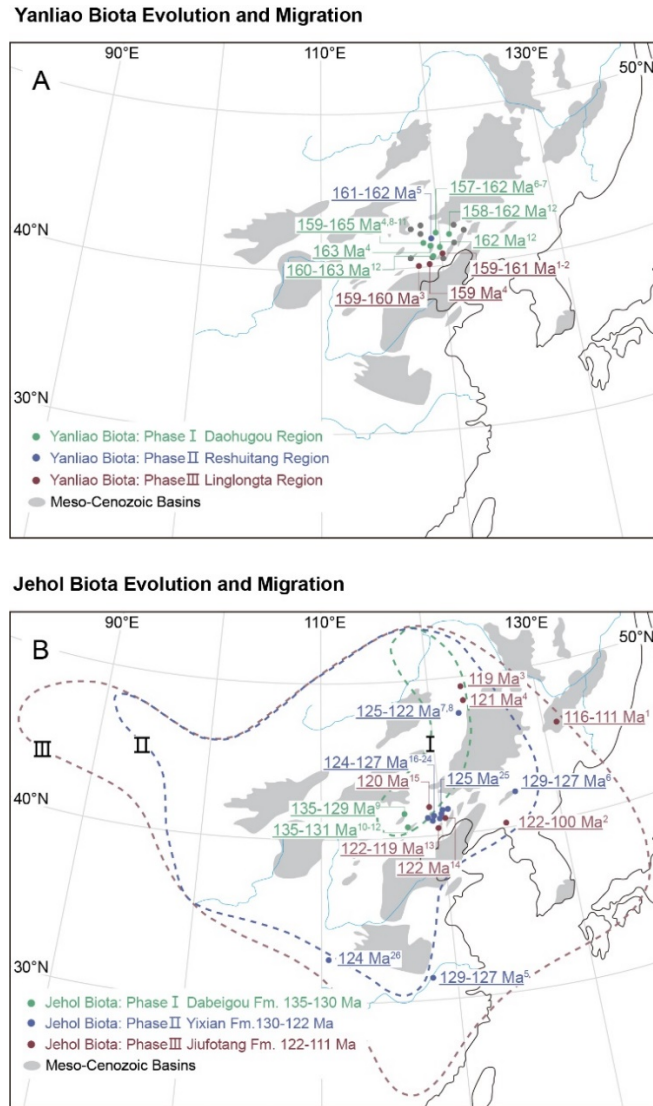


Figure S3.

A-B: Evolution and migration trends of the Yanliao and Jehol biotas. Yanliao biota data: 1 and 2- Chu et al.²⁵, Wang et al.²⁶, 3-Yu et al.²⁷, 4- Yu et al.²⁸, 5- Li et al.²⁹, 6- Liu et al.³⁰, 7- Liu et al.³¹, 8- He et al.³², 9-Meng³³, 10-Chen et al.³⁴, 11-Liu et al.³⁵, 12-Zou et al.³⁶. Jehol biota data: 1- Chen et al.³⁷, 2- Chang et al.³⁸, 3- Yu et al.³⁹, 4- Wang et al.⁴⁰, 5- Chang et al.⁴¹, 6- Wang and Zhong⁴², 7- Li and Reisz⁴³, 8- Li et al.⁴⁴, 9- Yang et al.⁴⁵, 10- Fang et al.⁴⁶, 11-Liu et al.⁴⁷, 12-Zhang et al.⁴⁸, 13-Yu et al.⁴⁹, 14-Chang et al.⁵⁰, 15-He et al.⁵¹, 16-Chang et al.⁵², 17-He et al.⁵³, 18- Li et al.⁵⁴, 19- Swisher et al.⁵⁵, 20-Swisher et al.⁵⁶, 21-Wang et al.⁵⁷, 22-Yang et al.⁵⁸, 23-Zhong et al.⁵⁹, 24-Zhu et al.⁶⁰, 25-MacLennan et al.⁶¹, 26-Song et al.⁶². The distributions of the Jehol biota at different evolution stages are modified from Zhou et al.⁶³.

Supplementary Table S1

Zircon U-Pb ages published for Northeastern Asia. References and data mainly refer to [Ma and Xu¹¹](#), [Zhang et al.¹²](#), and [Wu et al.²⁴](#). Some papers do not provide accurate GPS locations; therefore, we have estimated the GPS coordinates based on the geological maps included in those papers.

Supplementary Table S2

Whole-rock major and trace element data (approximately 4500 samples) from Northeastern Asia, processed by GAME. Data sources are provided in Supplementary Table S2. Some papers do not publish accurate GPS locations; therefore, we have estimated the GPS locations based on the geological maps provided in those papers. Similarly, for samples lacking precise ages, we have estimated the ages according to published zircon U-Pb age data from surrounding plutons. The estimated GPS locations and zircon U-Pb ages are highlighted in red.

Supplementary Table S3

Detailed GAME parameters used for the different arc segments.

Supplementary Table S4

The summary of major tectonic deformation, sedimentation, and rapid cooling and exhumation events across the Jurassic–Early Cretaceous Northeastern Asia. References are provided below.

Supplementary Table S5

The summary of the timing of the Yanliao and Jehol Biotas in Northeastern Asia. References are provided below.

Supplementary Table S6

Evidences of climate and elevation for the Jehol and Yanliao Biotas in Northeastern Asia. References are provided below.

Supplementary Table S7

Calculation results of paleo-temperatures across the Jurassic–Early Cretaceous Northeastern Asia.

References for the Figure 2

1. Jiaodong Peninsula (JDP)

Reference 1-2 (Yang et al., 2020; Zhang et al., 2020a)

2. Liaodong Peninsula (LDP)

Reference 3-8 (Lin et al., 2011; Liu et al., 2020; Ren et al., 2022; Wang et al., 2022; Yang et al., 2007; Zhou et al., 2021)

3. Taihangshan (THM)

Reference 9-16 (Cao et al., 2015; Clinkscales and Kapp, 2019; Clinkscales et al., 2021; Clinkscales et al., 2020; Zhang et al., 2020b; Zhang et al., 2021; Zhang et al., 2022c; Zhang et al., 2020c)

4. Yanshan Mountains (YSM)

Reference 17-33 (Hou et al., 2023; Li et al., 2016; Liang et al., 2022; Lin et al., 2019; Lin et al., 2022; Lin et al., 2018; Lin et al., 2013a; Lin et al., 2013b; Liu et al., 2018; Liu et al., 2021; Ma et al., 2023; Pei and Liu, 2016; Shi et al., 2019; Wang et al., 2023; Wang et al., 2012; Wu et al., 2021; Zhu et al., 2015)

5. Great Xing'an Range (GXR), Songliao Basin (SB), Erguna Region (ER)

Reference 34-40 (Guo and Yang, 2023; Li et al., 2021; Sun et al., 2022; Wu et al., 2023; Zhang et al., 2017; Zhang et al., 2022a; Zhang et al., 2022b)

6. Zhangguangcai Range (ZGR) and Jiamusi Region (JR)

Reference 41-44 (Aouizerat et al., 2018; Chen, 2016; Wang et al., 2021; Zhou et al., 2024)

1. Yang F, Santosh M, Glorie S, Jepson G, Xue F, Kim SW. Meso-Cenozoic multiple exhumation in the Shandong Peninsula, eastern North China Craton: Implications for lithospheric destruction. *Lithos* **370-371**, 105597 (2020).
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7. Wang Y, Wang F, Wu L, Zhang Z, Shi W, Yang L. Differential post-mineralization thermal evolution of the Jiaodong and Liaodong Areas, Eastern China: An indicator of regional tectonic activity. *Gondwana Research* **103**, 502-521 (2022).
8. Zhou Z, Meng Q, Zhu R, Wang M. Spatiotemporal evolution of the Jehol Biota: Responses to the North China craton destruction in the Early Cretaceous. *Proceedings of the National Academy of Sciences* **118**, e2107859118 (2021).
9. Clinkscales C, Kapp P. Structural style and kinematics of the Taihang-Luliangshan fold belt, North China: Implications for the Yanshanian orogeny. *Lithosphere* **11**, 767-783 (2019).
10. Clinkscales C, *et al.* Regional Exhumation and Tectonic History of the Shanxi Rift and Taihangshan, North China. *Tectonics* **40**, e2020TC006416 (2021).
11. Clinkscales C, Kapp P, Wang H. Exhumation history of the north-central Shanxi Rift, North China, revealed by low-temperature thermochronology. *Earth and Planetary Science Letters* **536**, 116146 (2020).
12. Cao X, *et al.* Mesozoic-Cenozoic evolution and mechanism of tectonic geomorphology in the central North China Block: constraint from apatite fission track thermochronology. *Journal of Asian Earth Sciences* **114**, 41-53 (2015).
13. Zhang J, *et al.* Tectonothermal events in the central North China Craton since the Mesozoic and their tectonic implications: Constraints from low-temperature thermochronology. *Tectonophysics* **804**, 228769 (2021).
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