Interactions between tectonics and Earth surface processes of the Central Anatolian Plateau and its southern margin during Mio-Pliocene surface uplift

SENCKENBERG world of biodiversity

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Leibniz Association

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Research questions

1. What was the timing and magnitude of surface uplift of the Central Anatolian Plateau (CAP) and its southern margin and what were the geodynamic drivers?
2. What was the hydrology of the lakes that covered central Anatolia during the Miocene-Pliocene and when and how did the drainages integrate?
3. What were the interactions between the mammal populations, the vegetation, and their changing physical environment?

Materials and methods

Fluvio-lacustrine sedimentary rocks:

-δ^{18}O-based paleoaltimetry

-Sedimentology and stable isotopes (δ^{18}O, δ^{13}C)

-Magnetostratigraphy

Mammal tooth enamel:

-Stable isotopes (δ^{18}O, δ^{13}C)

Volcanic rocks:

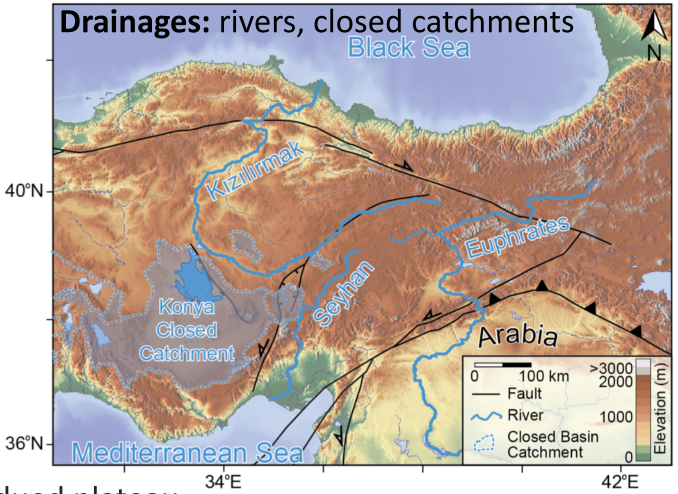
-^{40}Ar/^{39}Ar dating

Mammal diversity, species turnover:

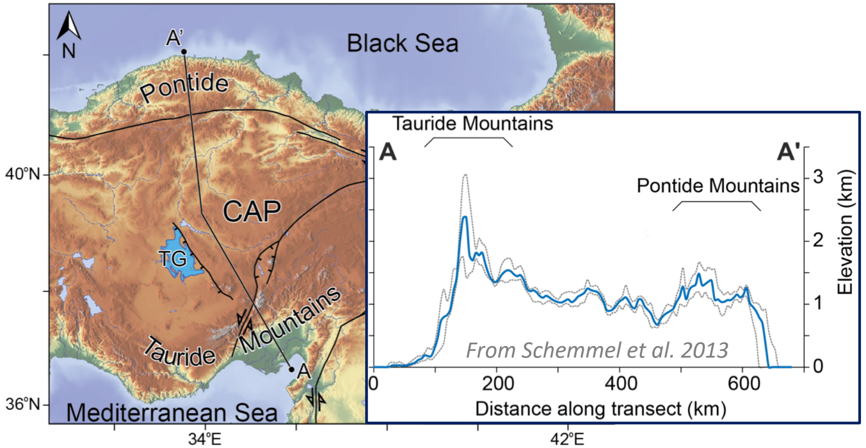
-NOW database

Literature, field and satellite observations

Drainages: rivers, closed catchments



Topography: subdued plateau, mountainous N and S margins



Present-day Anatolia (Turkey)

->1 km high Central Anatolian Plateau

-Bordered by steep, mountainous margins

-Plateau margins: (semi-)humid, MAP > 1000 mm

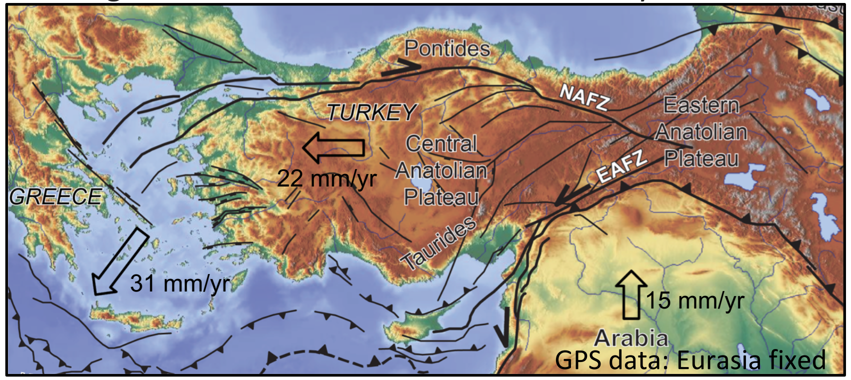
-Plateau interior: semi-arid, MAP 300-500 mm

-E CAP draining to marine basins

-SW CAP internally draining (closed catchment)

-Large part of CAP is covered with Neogene fluvio-lacustrine sedimentary rocks and volcanics

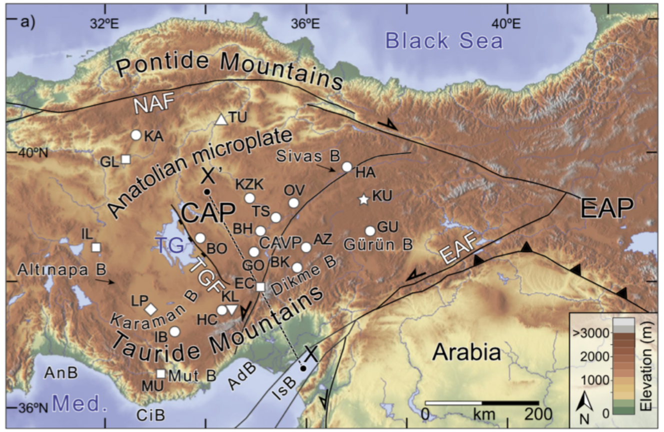
Escape tectonics along strike-slip faults in the Africa-Arabia-Eurasia collision zone, extensional tectonic regime since Miocene-Pliocene boundary

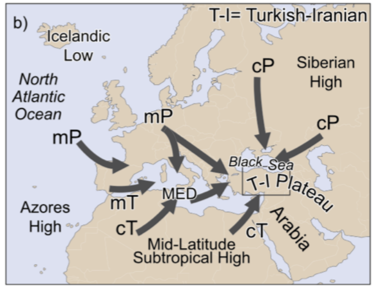


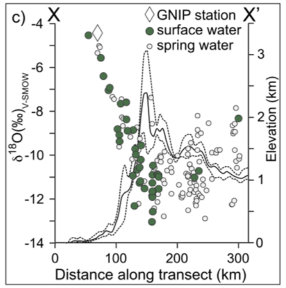
Meijers et al. Display 1308 EGU2020-9900

doi: 10.5194/egusphere-egu2020-9900

1. What was the timing and magnitude of surface uplift of the CAP and its southern margin and what were the geodynamic drivers?



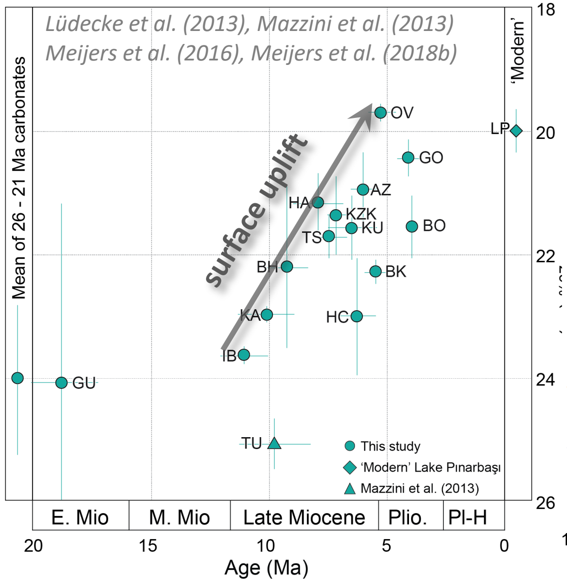


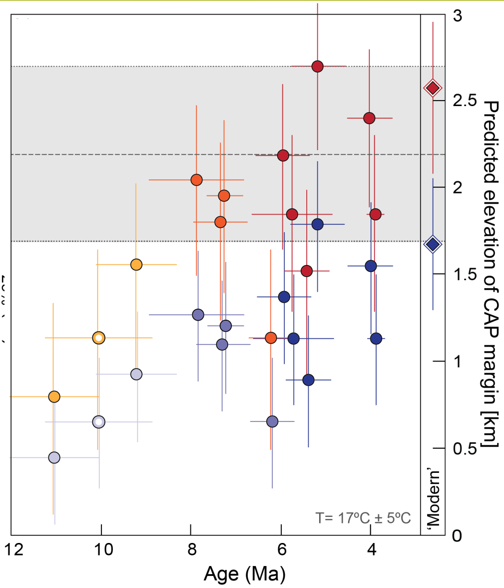


-Systematic decrease of $\delta^{18}O$ in modern precipitation from sea level to plateau across Tauride Mts.: −2.9 ‰/km

-Ancient rain water was incorporated in carbonate that formed in a fluvio-lacustrine setting

-We sampled ca. 12-4 Ma carbonates in CAP (13 sections, N= 637) to track the decrease of $\delta^{18}O$ with time and reconstruct paleotopography





Results and Conclusions

-$\delta^{18}O$ decreased 3–4 ‰ between 10 and 5 Ma

-At 5 Ma, $\delta^{18}O$ reached similarly low values as modern (Holocene) CAP lake $\delta^{18}O$

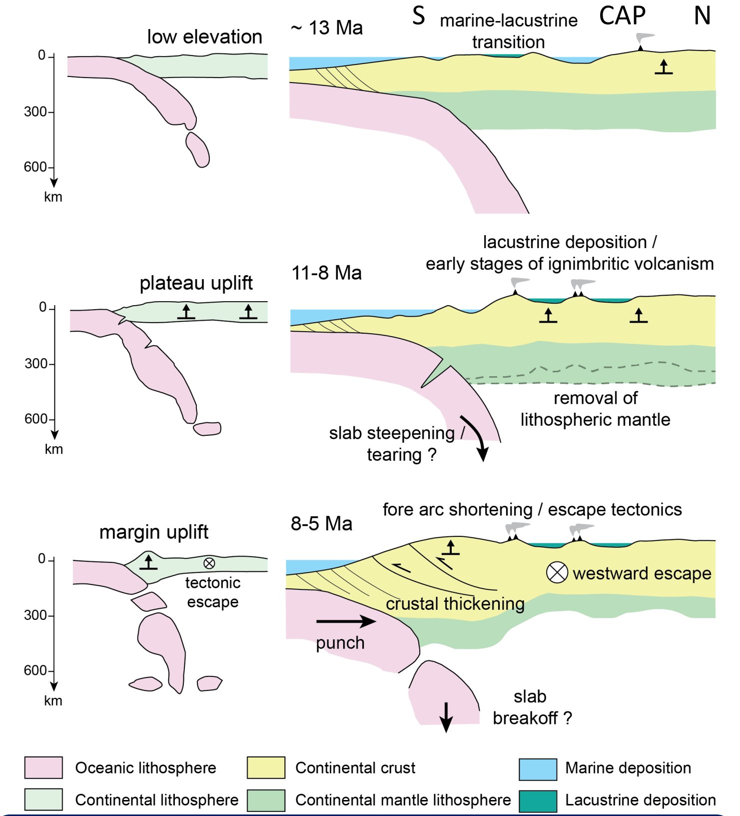
-Predicted elevations following the lapse rate of −2.9 ‰/km and model for equilibrium fractionation during Rayleigh distillation predict significant increase in orographic barrier elevations: 1450 m & 1900 m, resp.

-Predicted elevations by 5 Ma are comparable to the present-day average elevation of the Tauride Mtn. crest (2186 ± 507 m)

-Together with the timing of southern margin emergence from the Mediterranean Sea at 8-7 Ma, surface uplift rates are 0.60-0.90 or 0.90-1.35 mm/yr

-Southern CAP margin uplift by 5 Ma is in concordance with the large volumes of upper Miocene to Pliocene sedimentary rocks in the Cilicia and Adana basins

Reference Meijers et al. (2018a) Earth Planet Sc Lett
doi: 10.1016/j.epsl.2018.05.040



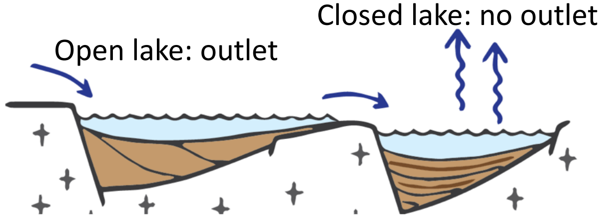
CAP interior: complex crustal and lithospheric structure, with areas devoid of significant crustal thickening and thin mantle lithosphere: surface uplift from removal of lithospheric mantle

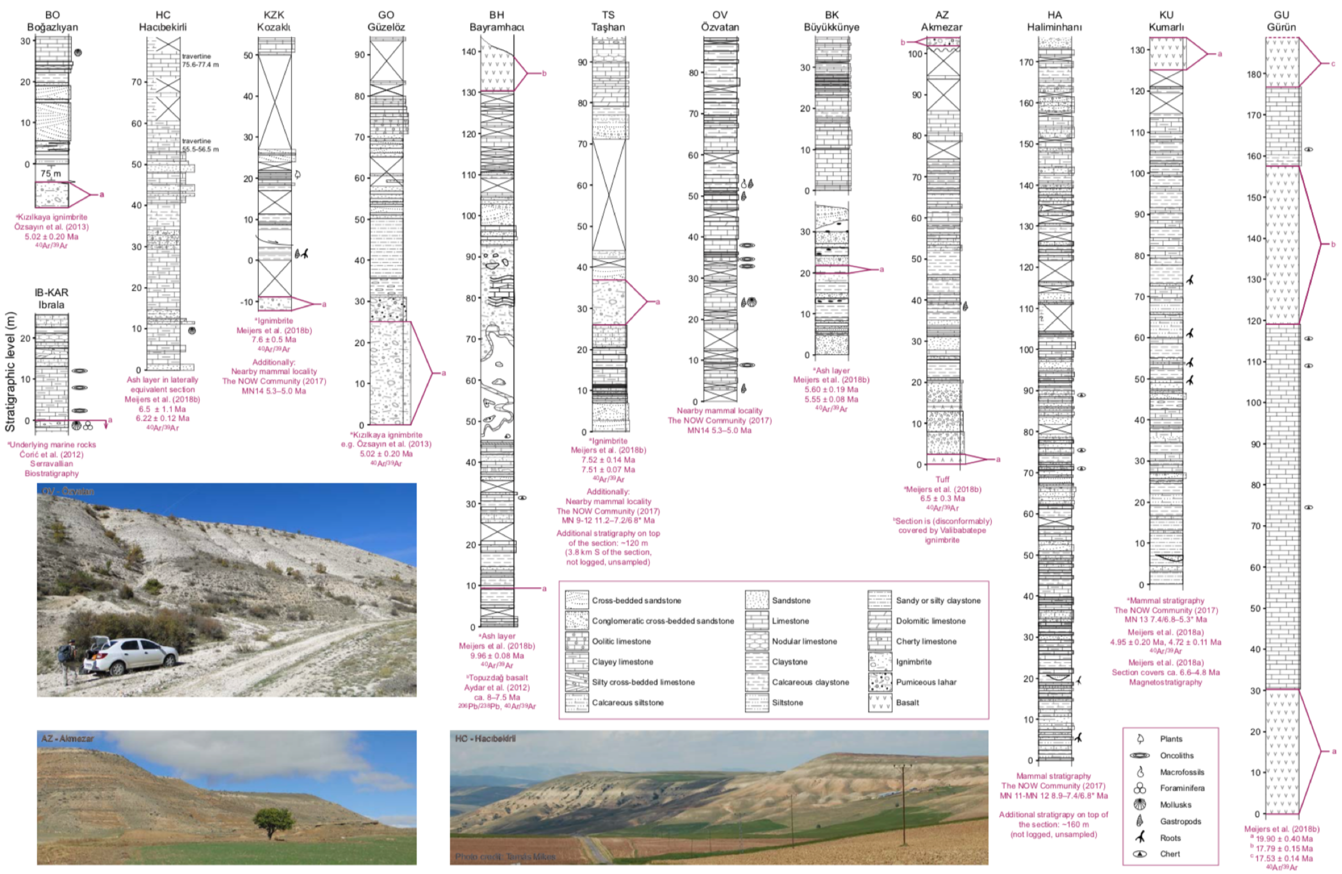
Southern CAP margin: Isostatically compensated topography, thick mantle lithosphere, 13-5 Ma shortening in forearc basins, ca. 5 Ma shift from shortening to extension in CAP interior: surface uplift from crustal thickening

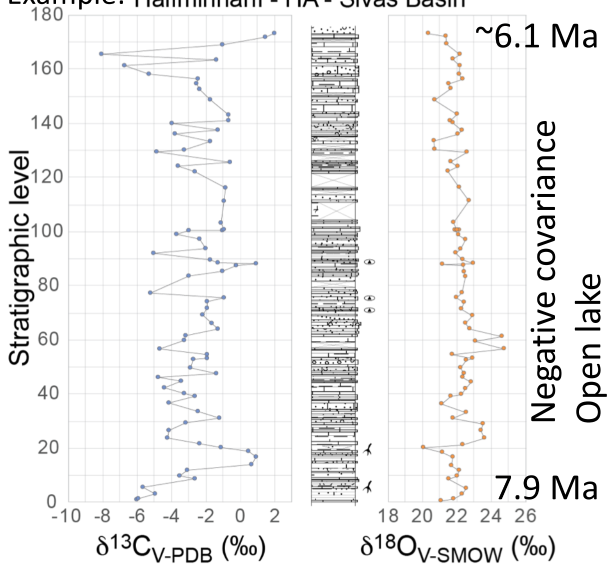
2a. What was the hydrology of the lakes that covered central Anatolia during the Miocene-Pliocene?

2b. When and how did the drainages integrate? *Check back later: Brocard, Meijers et al. (in revision)*

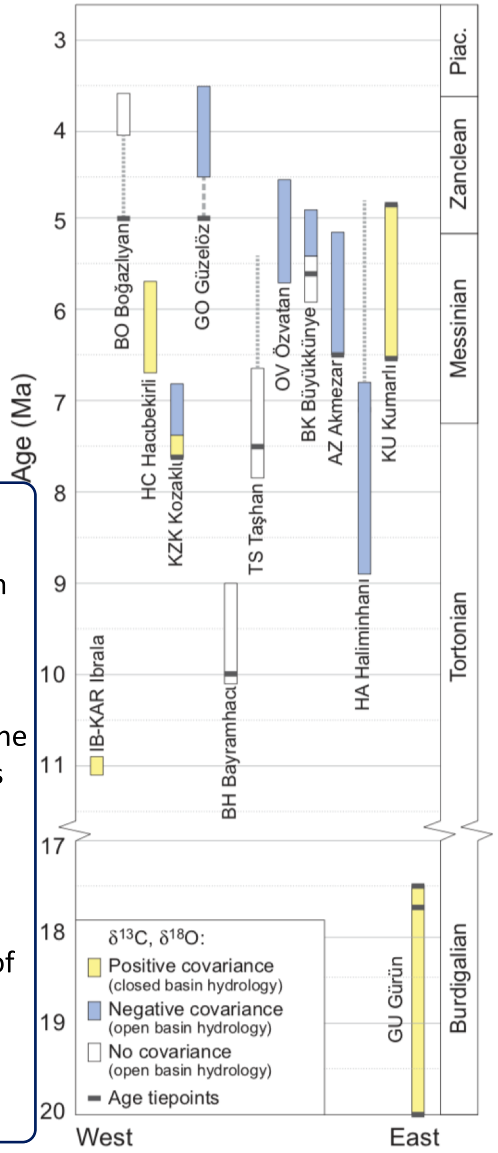
Methods: Sedimentology, dating ($^{40}Ar/^{39}Ar$, magnetostratigraphy) and $\delta^{13}C$, $\delta^{18}O$ stable isotope geochemistry (N= 665) of 13 sections





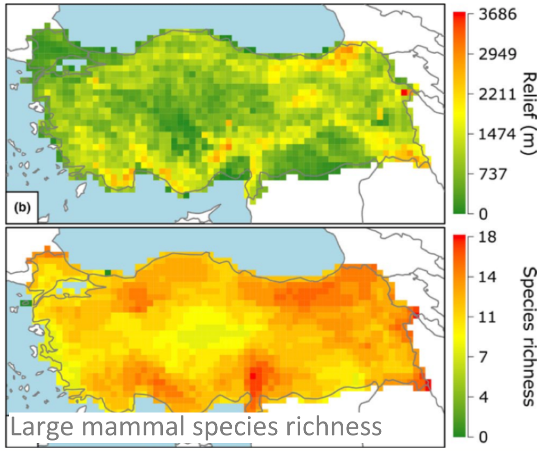


Reference Meijers et al. (2020) Geosphere doi: 10.1130/GES02135.1

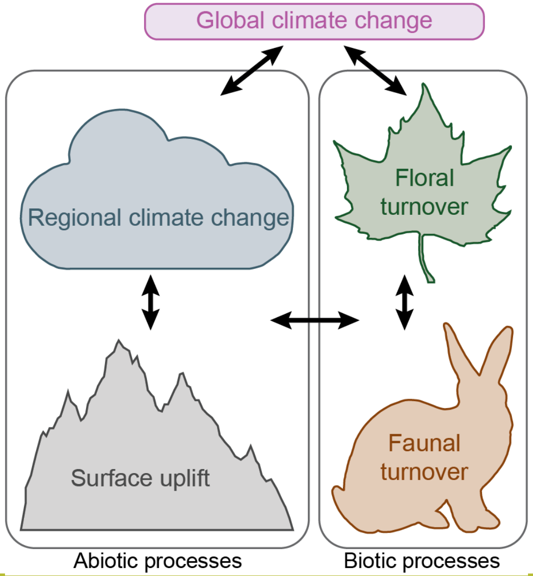


Results and Conclusions

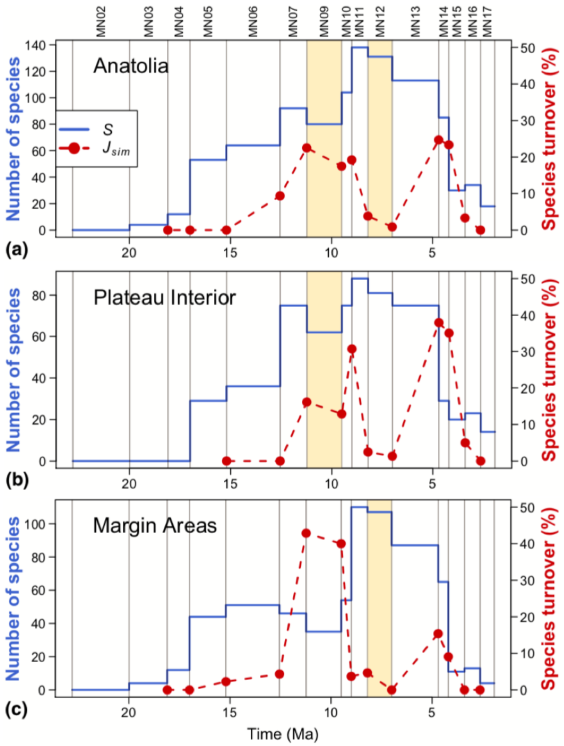
- Fluvio-lacustrine sedimentation ended mostly lacustrine during early Pliocene: onset of river incision
- Stable hydrological conditions in most lakes over >1 Myr time scales
- Open lake hydrology persisted in eight of the fluvio-lacustrine basins during surface uplift; suggests that the plateau interior was disconnected from marine basins
- No marine connection: lakes were draining inward
- $\delta^{18}O$ values indicate absence of aridification during surface uplift
- Onset of river incision during switch from compressional to extensional deformation. Creation of new, tectonically-induced relief across the subdued plateau topography generated new depocenter partitioning. Modified water balance promoted drainage integration across the eastern CAP



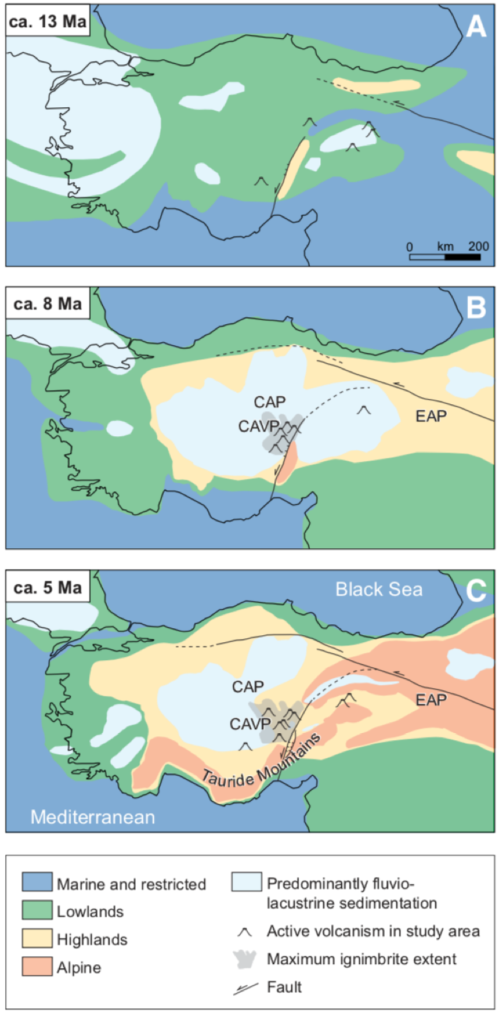
Rationale: Large mammal species richness and relief correlate in present-day Anatolia. We examine biodiversity dynamics during mountain building using an interdisciplinary approach, integrating geology and paleobiology



3. What were the interactions between the mammal populations, the vegetation, and their changing physical environment?



Number of species and species turnover derived from NOW database reveals different turnover patterns between the plateau interior and the margin areas. Changes in vegetation (not shown) are less clear.

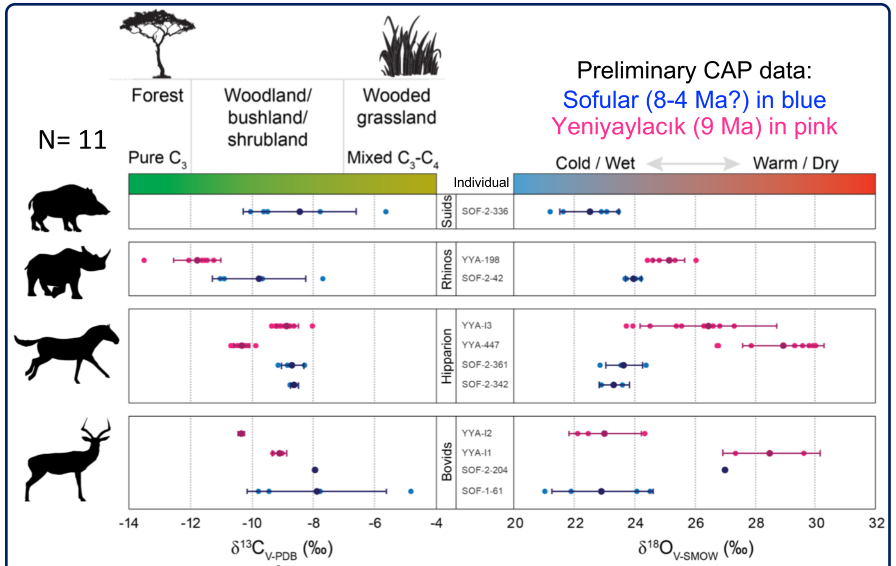


Paleogeographic maps based on quantitative and qualitative evidence show spatio-temporal changes in topography and dominant depositional environments

Reference Huang, Meijers et al. (2019) Journal of Biogeography
doi: 10.1111/jbi.13622

Results The CAP and its mountainous margins display different histories of surface uplift that are detectable in the fossil record of large mammals. Changes in vegetation and climate for the whole region also align with the general time frame of surface uplift, needs to be disentangled.

Conclusions We highlight the value of an integrative biogeographic framework, combining geology and paleobiology to simultaneously consider spatio-temporal biotic and environmental dynamics, using innovative methods to uncover how environmental and biotic processes have shaped mountain biodiversity.



Upcoming: seasonality, vegetation reconstructions

$\delta^{13}C$ and $\delta^{18}O$ analysis of herbivore mammal tooth enamel allows for the reconstruction of vegetation (C_3 vs. C_4).

Intra-tooth sampling enables detecting multiple food and water sources, and seasonality as teeth grow over months to years.