

Thermal histories of k-feldspar from granites located in the central and northern Menderes Massif, western Turkey: Implications for regional extension

Thomas Etzel¹, Elizabeth Catlos¹, and Ibrahim Cemen²

¹University of Texas at Austin

²The University of Alabama

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Abstract

Evidence of syntectonic magmatism associated with onset extension and unroofing of the Menderes Massif metamorphic core complex, western Turkey, is well documented. The Salihli and Turgutlu plutons, located along the Alasehir detachment in the Central Menderes Massif (CMM) and the Koyunoba and Eğrigöz Plutons located in the Northern Menderes Massif (NMM) are common targets for understanding the dynamics and timing of this Cenozoic activity. To this end, here we report new potassium feldspar $^{40}\text{Ar}/^{39}\text{Ar}$ ages from samples collected from each pluton and compare these to available zircon U-Pb and monazite Th-Pb crystallization ages. Argon age spectra were collected by incrementally heating bulk concentrates with a CO_2 laser and analyzing the gas released at each step. The peraluminous granite samples from the Koyunoba (AT17) and Eğrigöz (WA12) plutons both have effectively flat spectra with average plateau ages of 20.12 ± 0.05 Ma and 19.86 ± 0.05 Ma, respectively. The U-Pb age of zircon from WA12 is 20.5 ± 1.1 Ma [Catlos et al., 2012; doi: 10.2475/05.2012.03]; although a zircon U-Pb age from AT17 has not been reported, zircon from other Koyunoba rocks have U-Pb ages between 21.1 Ma and 23.2 Ma [1]. K-feldspar from sample EB06 (Turgutlu Granite) steadily increases in age from 10.62 ± 0.03 Ma to a plateau age of 14.06 ± 0.03 Ma, with similar inverse isochron (13.66 ± 0.29 Ma) and total gas ages (13.36 ± 0.2 Ma). Sample EB05 (Salihli Granite) increases in age from 3.27 ± 0.10 Ma (step 3, 0.5% ^{39}Ar released) to a maximum of 6.05 ± 0.09 Ma (step 33, 96.6% ^{39}Ar released). A plateau age could not be estimated for this sample, but two inverse isochron ages from different degassing steps are calculated (3.02 ± 0.09 Ma for the initial 19 steps and 3.29 ± 0.22 Ma, for the final steps 19-31). Regarding their crystallization histories, the oldest reported monazite Th-Pb age for EB06 is 15.5 ± 1.2 Ma [2] and reported monazite Th-Pb ages for Salihli granite ranges from 9.6 ± 1.6 Ma to 21.7 ± 4.5 Ma [Catlos et al., 2010; <https://doi.org/10.1016/j.tecto.2009.06.001>]. These $^{40}\text{Ar}/^{39}\text{Ar}$ ages suggest NMM plutons rapidly cooled whereas CMM Salihli and Turgutlu plutons not only remained at depth below the argon retention window for a prolonged period following emplacement, but each experienced unique thermal (exhumation) histories despite their geographic proximity.

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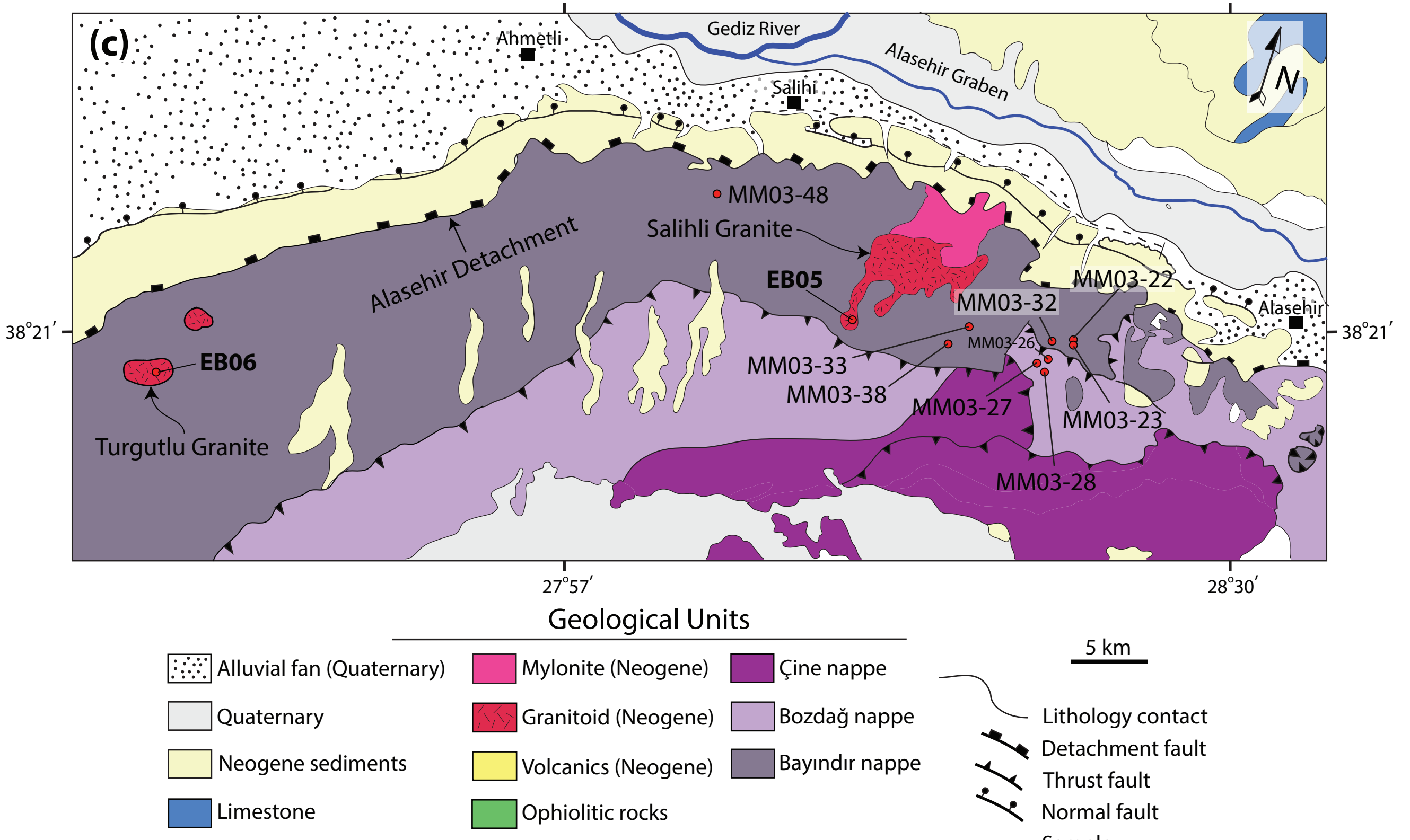
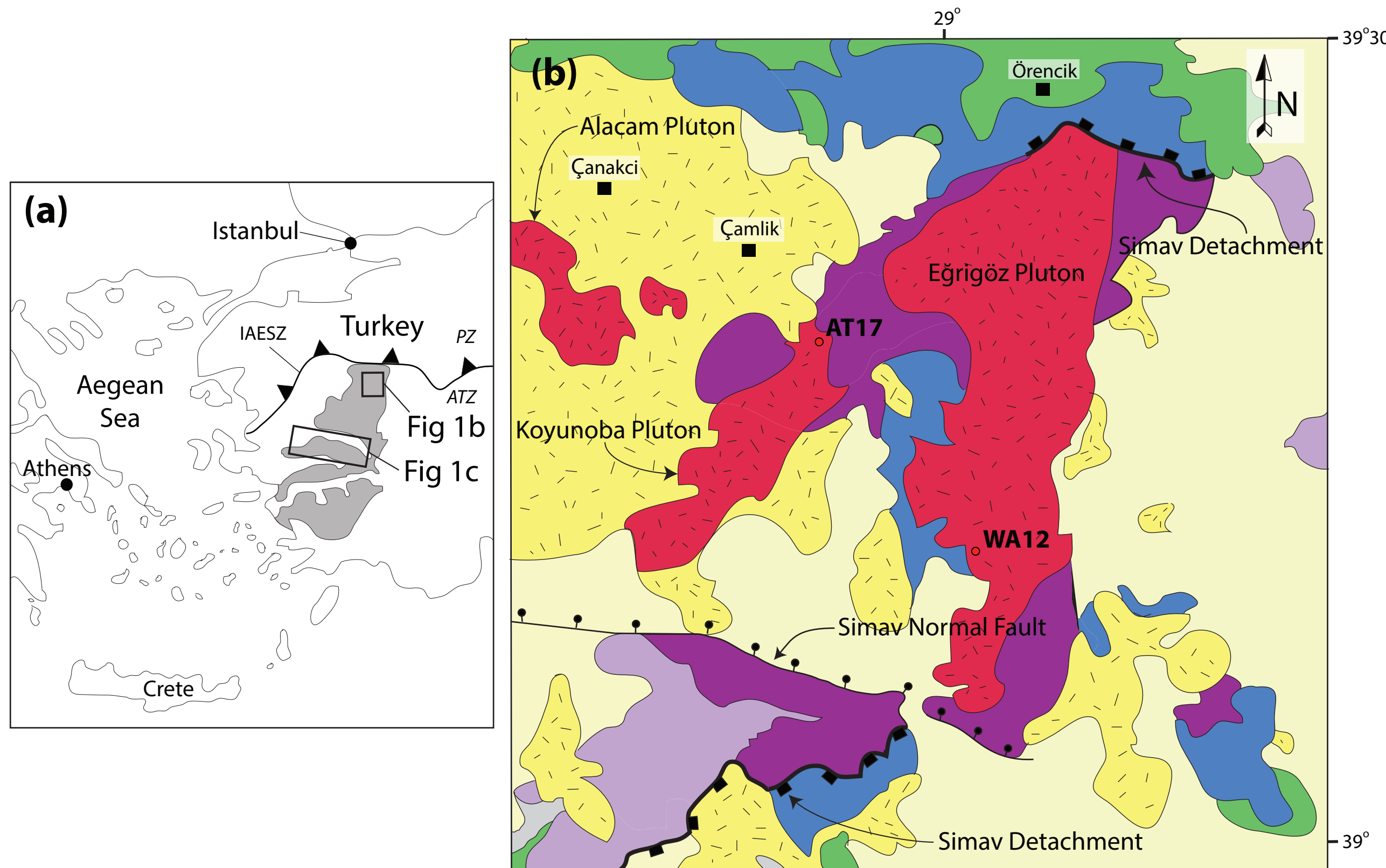
Thomas M. Etzel¹, E.J. Catlos¹, I. Çemen², C. Ozerdem³, T. Oyman⁴, T. O'Brien⁵, D. Miggins⁶

¹The University of Texas at Austin; ²University of Alabama; ³Alini Impregilo S.p.A.; ⁴Dokuz Eylül University; ⁵Syracuse University; ⁶Oregon State University

1. Summary

- The Menderes Massif (western Turkey) is a large metamorphic core complex.
 - Divided into 3 submassifs (southern or Çine, central, northern)
 - Consists of 4 nappes (Bayındır, Bozdağ, Çine, Selimiye)
- Metamorphic and igneous rocks formed from recurrent collisions between Gondwana related terranes and Laurasia
- Syntectonic magmatism associated with onset extension and unroofing
 - CMM: Salihli and Turgutlu Plutons located along Alasehir detachment
 - NMM: Koyunoba and Eğrigöz Plutons
- We report new k-feldspar ⁴⁰Ar/³⁹Ar ages for each above mentioned pluton to explore potential variability in cooling/exhumation histories
 - Compared to known crystallization ages (zircon U-Pb; monazite Th-Pb)

2. Samples & methods

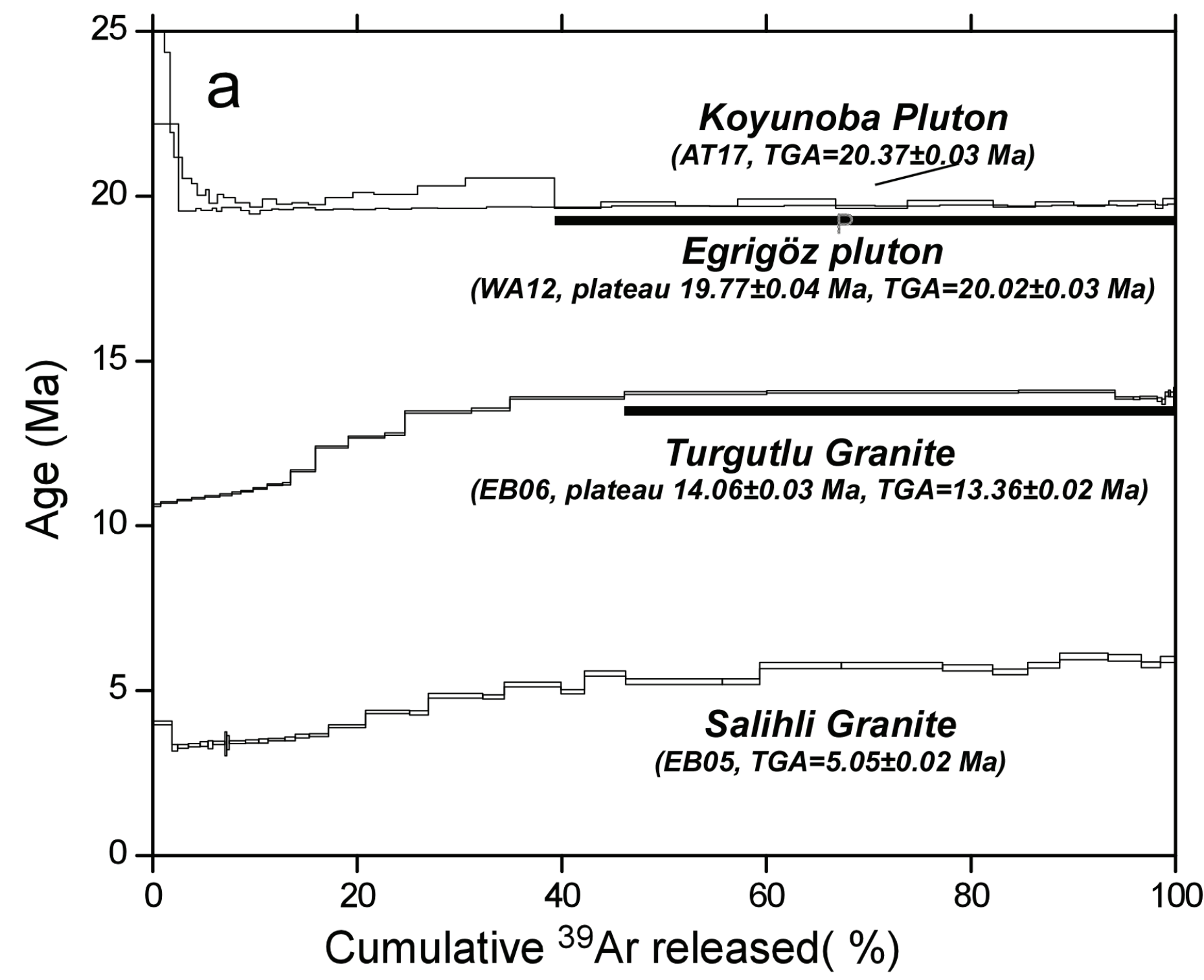


- Samples for k-feldspar ⁴⁰Ar/³⁹Ar geochronology from the NMM Koyunoba (AT17) and Eğrigöz (WA12) plutons, and the CMM Salihli (EB05) and Turgutlu (EB06) Plutons.
- K-feldspar separates heated using a continuous 25 W CO₂ laser that incrementally increased in intensity from 0.2% to 13.0% total intensity over 31-36 steps.
- MM samples on CMM map relate to a broader study on reconstructing the Cenozoic thermo-tectonic history of the Menderes Massif - preliminary results presented here

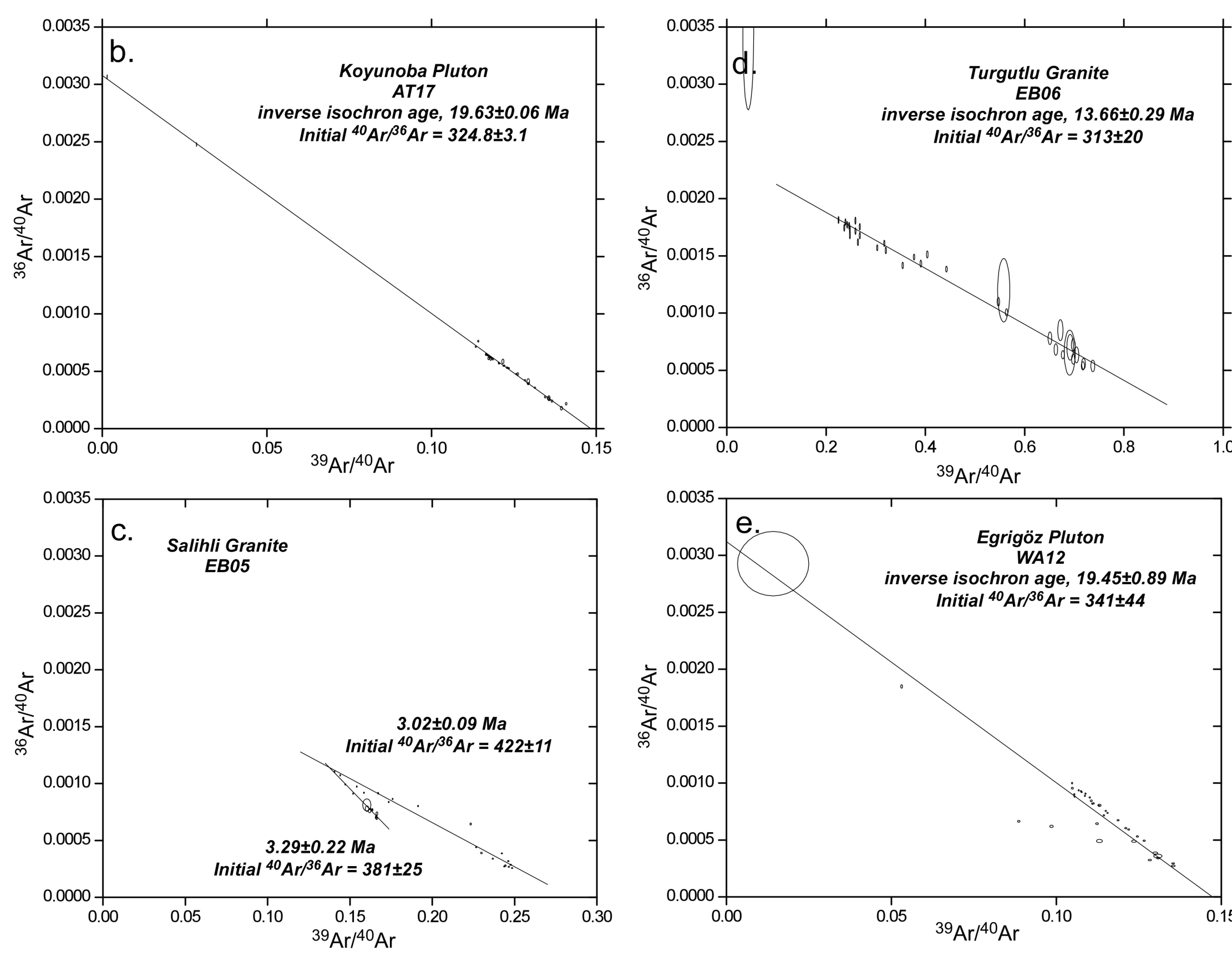
3. New k-feldspar ⁴⁰Ar/³⁹Ar ages

Results at a glance:

- Northern Menderes Massif
 - Samples are peraluminous calc-alkaline granites to granodiorites
 - Effectively flat age spectra for both samples
 - Both early Miocene in age
 - Rapidly cooled below Ar retention window (~250°C)
- Known crystallization ages:
 - Eğrigöz pluton: 22.3±1.1-19.0±1.4 Ma (zircon U-Pb; Catlos et al., 2012)
 - Koyunoba pluton: 30.0±3.9-14.7±2.6 Ma (zircon U-Pb; Catlos et al., 2012)



- Central Menderes Massif
 - Samples are calcic to alkali-calcic granites
 - Ar degassing patterns not flat (protracted cooling)
 - Turgutlu ages: ranges from 10.62±0.02 Ma to plateau age of 14.06±0.03 Ma
 - Inverse isochron age: 13.66±0.29 Ma
 - Salihli ages: ranges from 3.27±0.10 Ma to a maximum age of 6.05±0.09 Ma
 - Two inverse isochron ages:
 - 3.02±0.09 Ma (from initial to step 19)
 - 3.29±0.22 Ma (from step 20 to 31)
- Crystallization ages:
 - Turgutlu granite: 15.0±1.7 Ma (monazite; Catlos et al., 2010)
 - Salihli granite: 15.0±2.8 Ma (monazite; Catlos et al., 2010)



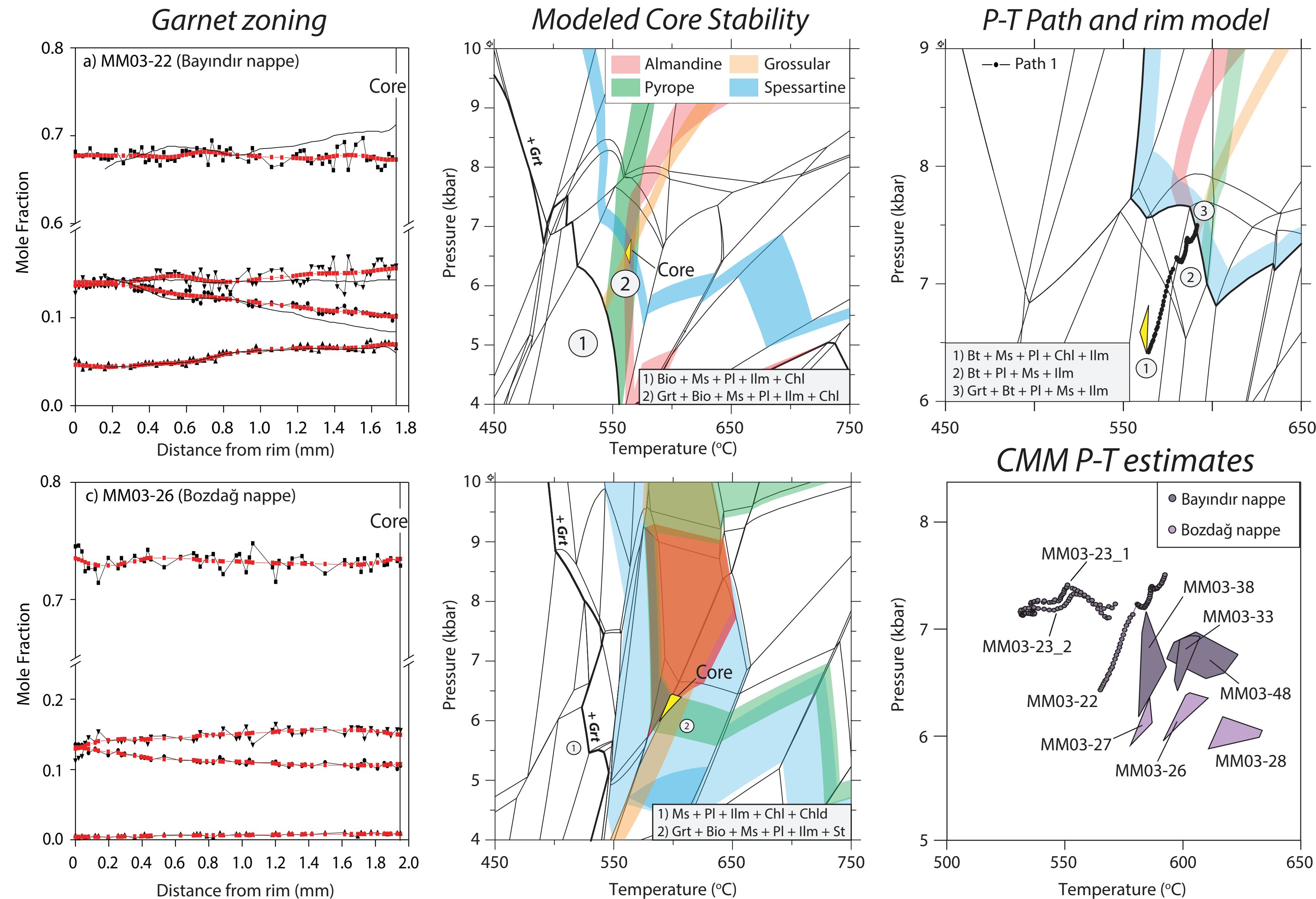
4. Cenozoic Metamorphism in the CMM: reconstructing pre-extensional tectonics

Approach:

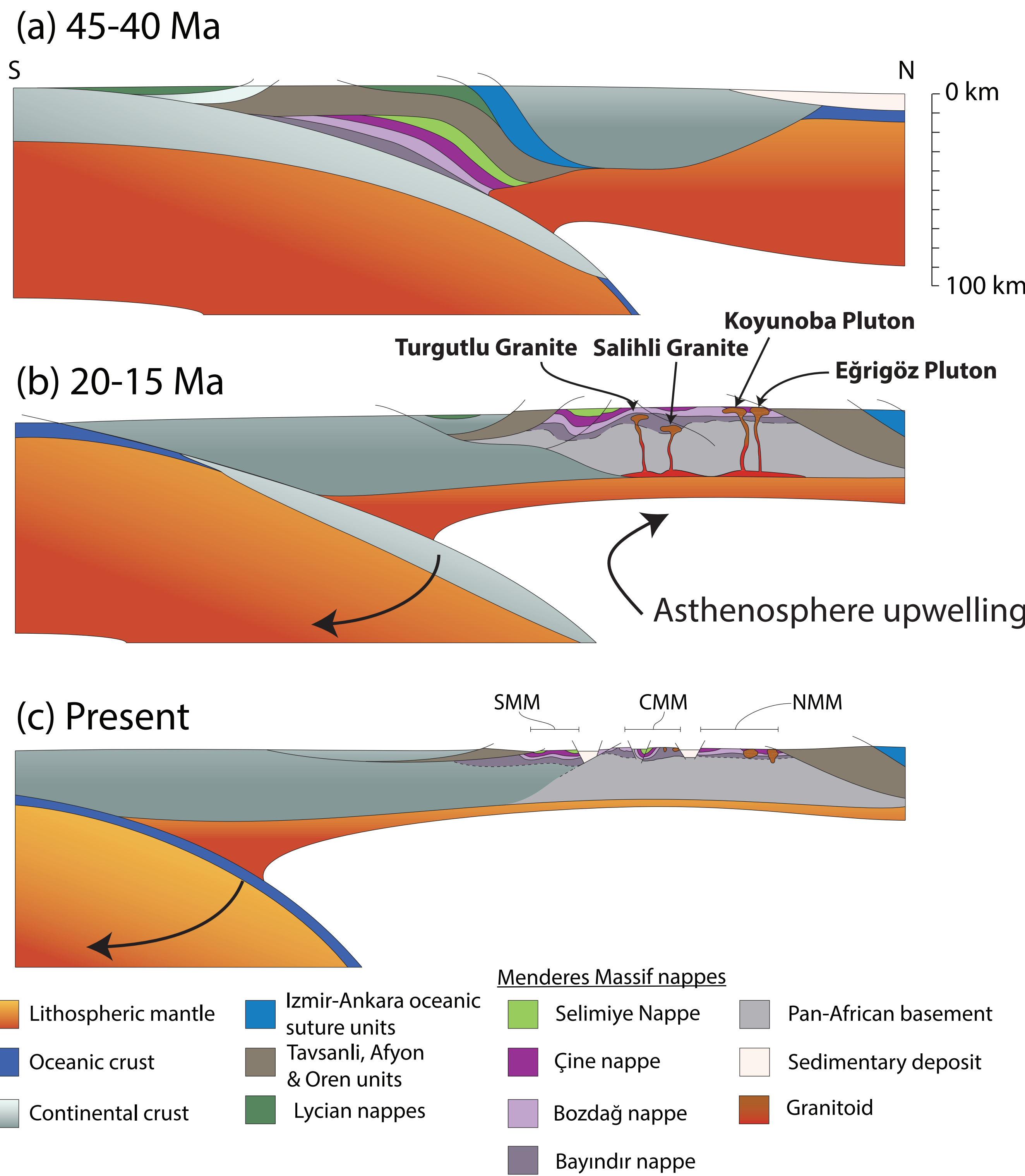
- Metamorphic conditions were estimated for Bayındır and Bozdağ nappe garnet-schists using a new method recently applied elsewhere in the Menderes Massif (Etzel et al., 2019).

Results at a glance:

- Bayındır nappe (MM03-22, 23, 32, 33, 38, 48)
 - Range of modeled core P-T conditions: 6.5-7 kbar and 540-600°C
 - Two successful garnet P-T paths
 - Isobaric with increasing T
 - Increasing P with increasing T
 - Monazite ages (Th-Pb): 20.6±3.3-31.5±2.7 Ma
- Bozdağ nappe (MM03-26, 27, 28)
 - Range of modeled core P-T conditions: 6-6.3 kbar and 575-625°C
 - Unable to model P-T path due to partial diffusion and resorption
 - Monazite ages (Th-Pb): 28.0±2.5-35.8±3.0 Ma



5. Schematic evolution of the Menderes Massif



Based on results presented here, and in previous interpretations (e.g., Erkul and Erkul, 2012; Baran et al., 2017; Rossetti et al., 2017), we propose the following tectonic evolution model of the Menderes Massif from the Eocene to the present:

- Barrovian-style prograde metamorphism in the CMM reached peak conditions by late Eocene - Early Oligocene. This resulted from collision between Gondwana and Laurasia.
- The region transitioned from shortening to extension by the mid-Oligocene. Extension was likely driven by rollback of the subducting oceanic lithosphere. Decoupling and rollback led to asthenosphere upwelling, which was responsible for melt generation and emplacement of the Oligo-Miocene granites exposed in the Central and Northern Menderes Massifs.
- As extension continued, the Eğrigöz and Koyunoba Plutons exhumed and rapidly cooled below ~250°C by 20 Ma. In the CMM, the Turgutlu and Salihli Granites experienced a more prolonged cooling/exhumation history. Largely driven by tectonic extension, the Turgutlu granite cooled below 250°C over a 3 m.y. period between 13.5 Ma and 10.5 Ma. Undoubtedly the Salihli granite was also partially exhumed during this period, however, our ⁴⁰Ar/³⁹Ar data suggest it did not cool below 250°C until ~5 Ma, where a combination of tectonic forces and erosional denudation acted in concert to exhumate this granitic body along the Alaşehir detachment. The results suggest the detachment did not have a homogeneous extensional history along strike.

Acknowledgements

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- References can be provided upon request