Tectonophysics 822 (2022) 229131

Contents lists available at ScienceDirect

Tectonophysics

journal homepage: www.elsevier.com/locate/tecto

Preparing the ground for plateau growth: Late Neogene Central Anatolian uplift in the context of orogenic and geodynamic evolution since the Cretaceous

Peter J. McPhee[a,c,*], Ayten Koç[b], Douwe J.J. van Hinsbergen[a]

[a] Department of Earth Sciences, Utrecht University, Utrecht, the Netherlands
[b] Department of Geological Engineering, Van Yüzüncü Yıl University, Van, Turkey
[c] Institute of Geological Sciences, Freie Universität Berlin, Berlin, Germany

ARTICLE INFO

Keywords:
Central Anatolian plateau
Plateau uplift
Tectonic reconstruction
Subduction evolution
Lithospheric dripping
Peeling delamination
Orogenesis

ABSTRACT

Central Anatolia (Turkey) is a small and nascent example of a high orogenic plateau, providing a natural laboratory to study processes driving plateau rise. The 1-km-high plateau interior uplifted since c. 8–5 Ma, with a further phase of kilometre-scale uplift affecting the southern plateau margin since 0.45 Ma. Several causes of plateau rise have been proposed: peeling or dripping delamination of the lithospheric mantle; asthenospheric upwelling through slab gaps created by slab fragmentation or break-off, and; continental underthrusting and crustal shortening below the southern plateau margin. The Neogene history of the plateau has not been diagnostic of the causes of plateau rise. We thus evaluate proposed uplift causes in the context of the Anatolian orogenesis, which formed the plateau lithosphere during subduction since the Cretaceous. We combine this analysis with available constraints on uplift, and geophysical data that illuminate the modern mantle (and crustal) structure. Our analysis suggests that lithospheric dripping, which followed arc magmatism and shortening in the Kirsehir Block (eastern Central Anatolia), is the most likely cause of plateau interior uplift. Lithospheric dripping is, however, an unlikely sole driver of multi-phase uplift along the southern plateau margin. There, underthrusting of the African continental margin, recorded by c. 11–7 Ma thrusting on Cyprus, is a viable cause of uplift since 0.45 Ma, but cannot account for earlier uplift since c. 8–5 Ma. Instead, slab break-off below the southern plateau margin is likely in light of geophysical data. On the SW plateau margin, small-scale peeling delamination of the Central Taurides by the Antalya slab since early Miocene times accounts for >150 km slab retreat with no corresponding upper-plate deformation. A southwest-travelling wave of subsidence and uplift signalled this retreat and may have contributed to coeval oroclinal bending of the western Central Taurides and southeastward thrusting of the Lycian Nappes.

1. Introduction

High orogenic plateaus are broad high elevation regions, which have low topographic relief, have at least one steep outer-edge, and typically contain internal drainage systems. These regions, such as the Tibetan Plateau or Altiplano-Puna Plateau, are important physiographic features on Earth's continents: They form topographic barriers to atmospheric circulation (e.g., Ruddiman and Kutzbach, 1989), affect regional climate (e.g., Sobel et al., 2003), and contribute to continental deformation within plateaus and in surrounding regions via their gravitational potential energy (e.g., Coleman and Hodges, 1995; Molnar and Lyon-Caen, 1988).

Central Anatolia's physiography is typical of a high orogenic plateau (Fig. 1): It has an average elevation of 1 to 1.5 km across an area of approximately 250,000 sq. km, low topographic relief (Fig. 1B), and contains an internal drainage system (Fig. 1A). The steep southern edge of the plateau comprises the Central Taurides mountain range, which reaches 2 to 3.5 km elevation, and slopes southward towards the Mediterranean Sea. The northern edge comprises the Pontides mountain range, which reaches 2 km elevation and slopes northward towards the Black Sea.

The southern Central Taurides are covered by the Miocene-Pleistocene Mut Basin (Fig. 1A), which contains marine sedimentary rocks that recorded at least two phases of km-scale uplift in late Miocene

* Corresponding authors at: Institute of Geological Sciences, Freie Universität Berlin, Berlin, Germany
E-mail address: peter.mcphee@fu-berlin.de (P.J. McPhee).

https://doi.org/10.1016/j.tecto.2021.229131
Received 28 August 2020; Received in revised form 4 August 2021; Accepted 21 October 2021
Available online 25 October 2021

and Plio-Pleistocene times (e.g., Cosentino et al., 2012; Öğretmen et al., 2018). Channel incision and long-wavelength knick zones in northern Central Anatolia (Doğan, 2011; Çiner et al., 2015; McNab et al., 2017) and stable isotopes from continental basin rocks (e.g., Meijers et al., 2018) point to uplift since the late Miocene.

The specific geodynamic driving forces of Central Anatolian plateau rise remain debated, and several competing or perhaps complementary hypotheses have been proposed: 1) Miocene peeling delamination of a flat slab that would have existed below Central and East Anatolia (Bartol and Govers, 2014; Govers and Fichtner, 2016); 2) Paleogene thickening and late Neogene removal of lithospheric mantle by lithospheric dripping (Göğüş et al., 2017); 3) Upwelling of hot asthenosphere between segmented or detached slabs (e.g., Schildgen et al., 2014; Portner et al., 2018); 4) Continental collision driving underthrusting and thickening of the buoyant African margin below the southern Central Taurides (e.g., Robertson et al., 1995; Delph et al., 2017; Meijers et al., 2018; McPhee and van Hinsbergen, 2019), or deep underthrusting by subducted oceanic sedimentary rocks (Fernández-Blanco, 2014; Fernández-Blanco et al., 2020); and 5) rebound following late Miocene slab break-off of a subducted slab below the Mut Basin (e.g., Portner et al., 2018; Cosentino et al., 2012). The young Central Anatolian plateau thus provides a natural laboratory for the study of the surface expression of deep geodynamic processes and may be analogous to the early history of other, older and larger high orogenic plateaus where the early evolution is overprinted during plateau maturation.

Previous work on the causes of Central Anatolian plateau rise has focused on constraining the timing and spatial evolution of uplift, and/or insights from the modern crustal and mantle structure. These insights have inspired the above hypotheses, but the Neogene history alone has not been diagnostic in identifying the role and likelihood of the

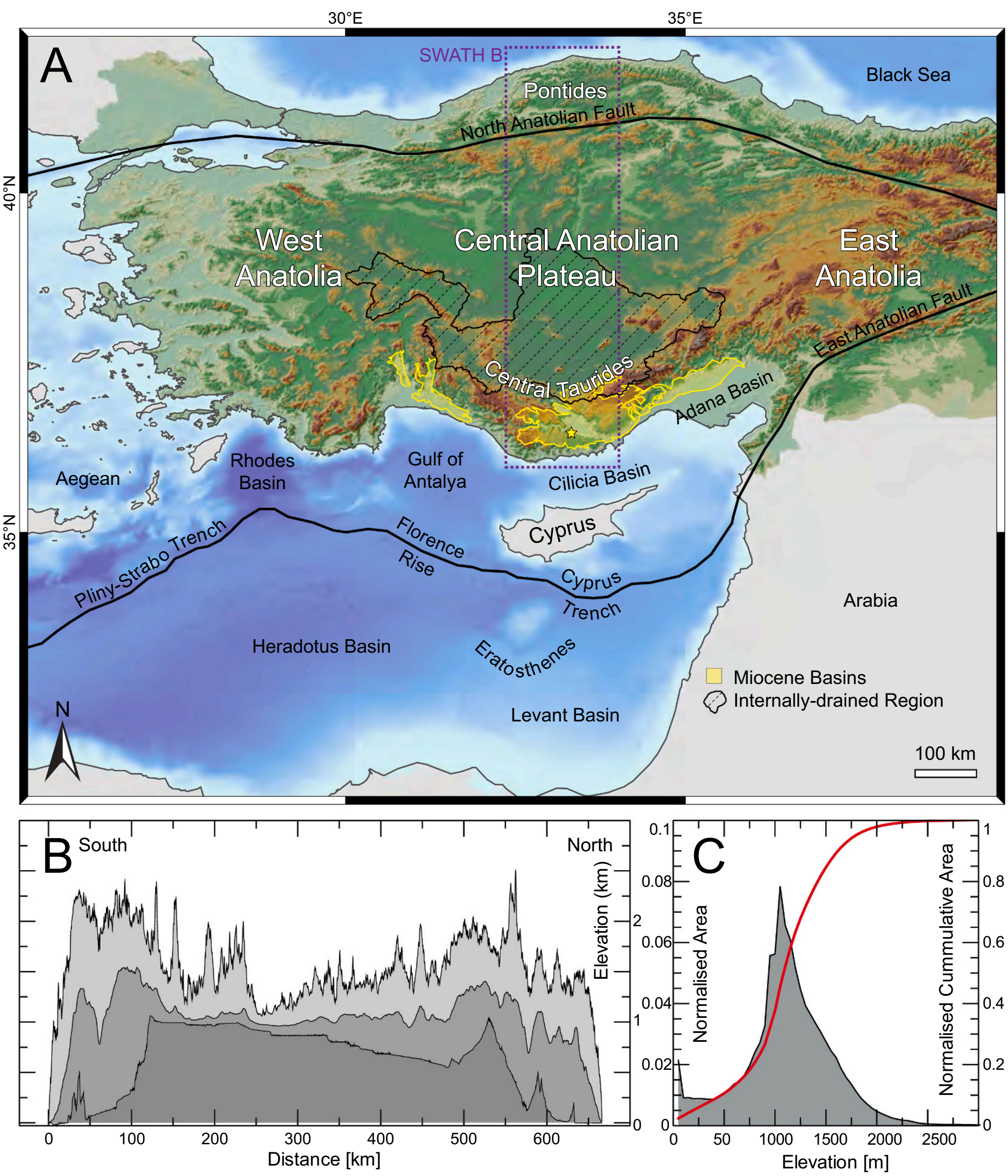


Fig. 1. A) Topography of Central Anatolia and surrounding regions, derived from ETOPO 1 data. The purple dashed-line box marks the area used in the generation of elevation swath profile shown in 1B. The hatched area represents the internally drained plateau interior. The yellow star marks the Mut Basin. B) N-S elevation swath profile is taken from within the purple dashed-line box marked on 1A. C) Elevation frequency and hypsometry of the plateau calculated from SRTM 90 elevation data (calculated in the region between 30°E and 36°E). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

proposed geodynamic drivers. In this contribution, we therefore review evidence for the long-term kinematic record of crustal deformation in Central Anatolia, which, when combined with the history of Africa-Eurasia convergence (constrained by Atlantic Ocean reconstructions), and present-day mantle structure, reveals the long-term evolution of subduction and collision of the African Plate. We combine this kinematic record with constraints on the spatial and temporal evolution of uplift to evaluate the geodynamic conditions that were present when plateau rise started, and use this to assess the viability and contribution of geodynamic mechanisms of Central Anatolian plateau rise.

2. Spatial and temporal evolution of late Neogene plateau rise

We start by reviewing evidence for the timing and spatial extent of late Neogene uplift in Central Anatolia, which form important constraints when evaluating potential geodynamic causes of plateau rise.

2.1. Uplift of the southern plateau margin (Taurides)

The Central Taurides form a high mountainous rim along the southern edge of the Central Anatolian plateau. Uplifted Neogene marine sedimentary rocks of the Mut, Adana, and Antalya Basin (including the Aksu, Köprüçay-Manavgat sub-basins) cover this margin, robustly constraining the timing and magnitude of late Neogene uplift.

The Mut Basin covers the southern Central Taurides and contains an Oligocene to Pleistocene stratigraphy. The lowermost stratigraphy in this basin consists of Oligocene-Burdigalian fluvial and lacustrine sedimentary rocks. These are covered by a Burdigalian – Tortonian sequence of marls, redeposited carbonates, and shallow-water ramp carbonates that have been mapped from sea level, up to a modern elevation of 2.2 km. The basin is tilted by a few degrees towards the south, forming an open, south-dipping monocline (Cosentino et al., 2012).

Pliocene-Pleistocene marine sedimentary rocks onlap the Tortonian strata, and are mapped up to 1.5–1.6 km elevation (e.g., Yildiz et al., 2003; Öğretmen et al., 2018) (Fig. 2A). The youngest dated strata in this unit were deposited at c. 0.45 Ma, and are currently found at 1 km elevation. Benthic fauna in these strata indicate deposition at a water depth of 0.4–0.5 km, consistent with geological relics of a Pliocene-Pleistocene paleocoastline at 1.5–1.6 km elevation (Öğretmen et al., 2018).

Onlap of Pliocene-Pleistocene rocks onto the Miocene sequence suggests that initial uplift of the plateau margin occurred in pre-Pliocene times (late Miocene), and was followed by a period of stability, or gentle subsidence (Schildgen et al., 2012a; Cosentino et al., 2012). This was followed by rapid Pleistocene uplift, at rates of 3.21–3.42 mm/yr (Öğretmen et al., 2018), which, based on modelling of marine terraces, likely peaked between 0.5 and 0.2 Ma (Racano et al., 2020). The multi-phased uplift history may also be reflected by relicts of a pre-Pleistocene drainage system in the upper reaches of the modern Ermenek River (Schildgen et al., 2012a; Fig. 2C). Incision rates of 0.52 to 0.67 mm/yr since c. 130 ka were calculated in this river system, based on the exposure ages of river terraces (Schildgen et al., 2012a), lending support to the idea that the most rapid rates of Pleistocene uplift were short-lived (Öğretmen et al., 2018).

Significantly lower rates of uplift affected the adjacent Adana Basin, which covers the south-eastern plateau margin. Pliocene (c. 5.3 Ma) marine sedimentary rocks deposited at up to 500 m water depth are exposed at 150 m elevation, constraining up to 0.65 km of uplift at rates of 0.02–0.13 mm/yr (Cipollari et al., 2013). Initial uplift of the eastern Central Taurides may have occurred at 5.45 Ma, based on a plateau-ward shift in sediment provenance during rapid deposition of a 1-km-thick package of conglomerates (Radeff et al., 2015).

The Antalya Basin (Figs. 2A, 5C, & 5D) covers the Tauride fold-thrust belt on the southwestern margin of the plateau. This basin includes the Manavgat, Köprüçay, and Aksu sub-basins, and forms the on-land equivalent of the offshore Gulf of Antalya Basin, which reaches depths of 2.5 km below sea level (Fig. 1 and 5C). The onshore basin contains a lower Miocene (locally Aquitanian and predominantly Burdigalian, c. 20 Ma) to Messinian sedimentary sequence of marine limestone, marine sandstone, marl, marginal marine conglomerates, and reefal limestones (Akbulut, 1977; Karabiyikoglu et al., 2000; Deynoux et al., 2005; Flecker et al., 2005; Çiner et al., 2008; Şiş et al., 2020). Deposition of continental rocks (tufas) constrains uplift and emergence of the Antalya Basin by late Pliocene times (c. 3.5 Ma) (Glover and Robertson, 1998). The basin was also deformed by late Miocene folding and thrusting, uplifting Messinian marine rocks of the eastern Köprüçay Basin up to 1.5 km elevation (Schildgen et al., 2012b), along the hinge of a west-verging asymmetric anticline (McPhee et al., 2018a).

On the eastern side of the Antalya Basin, in the western Central Taurides, low-temperature thermochronological data (apatite [U—Th]/He, apatite fission track, and zircon [U-Th]/He) constrain the thermal history of the plateau margin. An early to middle Miocene increase in cooling rate was identified, signalling a phase of exhumation. This was likely driven by erosion related to regional uplift, as no structural or climatic driver of erosional exhumation was identified (McPhee et al., 2019). These data show that in contrast to the southern Central Taurides, which was covered by the Mut Basin, the western Central Taurides were emergent and actively eroding throughout the Neogene.

2.2. Uplift of the plateau interior

In contrast to the plateau margin, sedimentary basins in the plateau interior have recorded terrestrial deposition since Oligocene times (e.g., Koç et al., 2012, 2016a, 2016b, 2017, 2018; Fernández-Blanco et al., 2013; Ozsayin et al., 2013). These basins form the characteristic low relief of the plateau interior, and include the Central Tauride Intramontane Basins (Koç et al., 2012, 2016b, 2017) and the Tuz Gölü Basin and its sub-basins (Fernández-Blanco et al., 2013; Ozsayin et al., 2013; Görür et al., 1984, 1998), as well as the Ulukışla Basin (Clark and Robertson, 2005; Gürer et al., 2016; Meijers et al., 2016) and basins overlying the Kırşehir Block (Gülyüz et al., 2013; Advokaat et al., 2014; Licht et al., 2017). The plateau interior basins are located at an average elevation of around 1 km: 1 km lower than Neogene marine sedimentary rocks preserved on the southern plateau margin. The southern plateau margin has therefore most likely experienced greater uplift (Koç et al., 2012, 2017; Schildgen et al., 2014).

Much of the plateau interior forms an internal drainage system (Fig. 1A), which, based on stable isotope studies of lacustrine sediments, has existed since at least early Miocene times (Meijers et al., 2020). Analyses of oxygen isotope data from upper Oligocene lacustrine rocks in the south-eastern plateau interior indicate a low elevation depositional environment with no significant orographic barriers in northern or southern Central Anatolia (Lüdecke et al., 2013; Meijers et al., 2016). In contrast, middle to upper Miocene lacustrine rocks contain low $\delta^{18}O$ values, interpreted to reflect kilometre-scale plateau uplift and the formation of an orographic barrier along the southern plateau margin around c. 11–5 Ma (Meijers et al., 2018).

Longitudinal river profiles from the externally drained northern half of the plateau contain long-wavelength knick zones, indicative of regional uplift (see for example Fig. 2C). Inverse modelling of the development of knick zones suggests that they formed in response to kilometre-scale uplift in the past c. 12 Ma, with highest rates of uplift in the past c. 6 Ma (McNab et al., 2017). Incision rates of 0.12 mm/yr between c. 5–2.5 Ma and 0.05 mm/yr since c. 1.9 Ma have been calculated based on exposure ages of abandoned fluvial terraces, and incision of well-dated volcanic rocks in the Cappadocia Volcanic Province (Çiner et al., 2015; Doğan, 2011; Aydar et al., 2013). These rates are lower than those calculated at the southern plateau margin.

2.3. Uplift of the northern plateau margin (Pontides)

The Central Pontides form the mountainous northern plateau

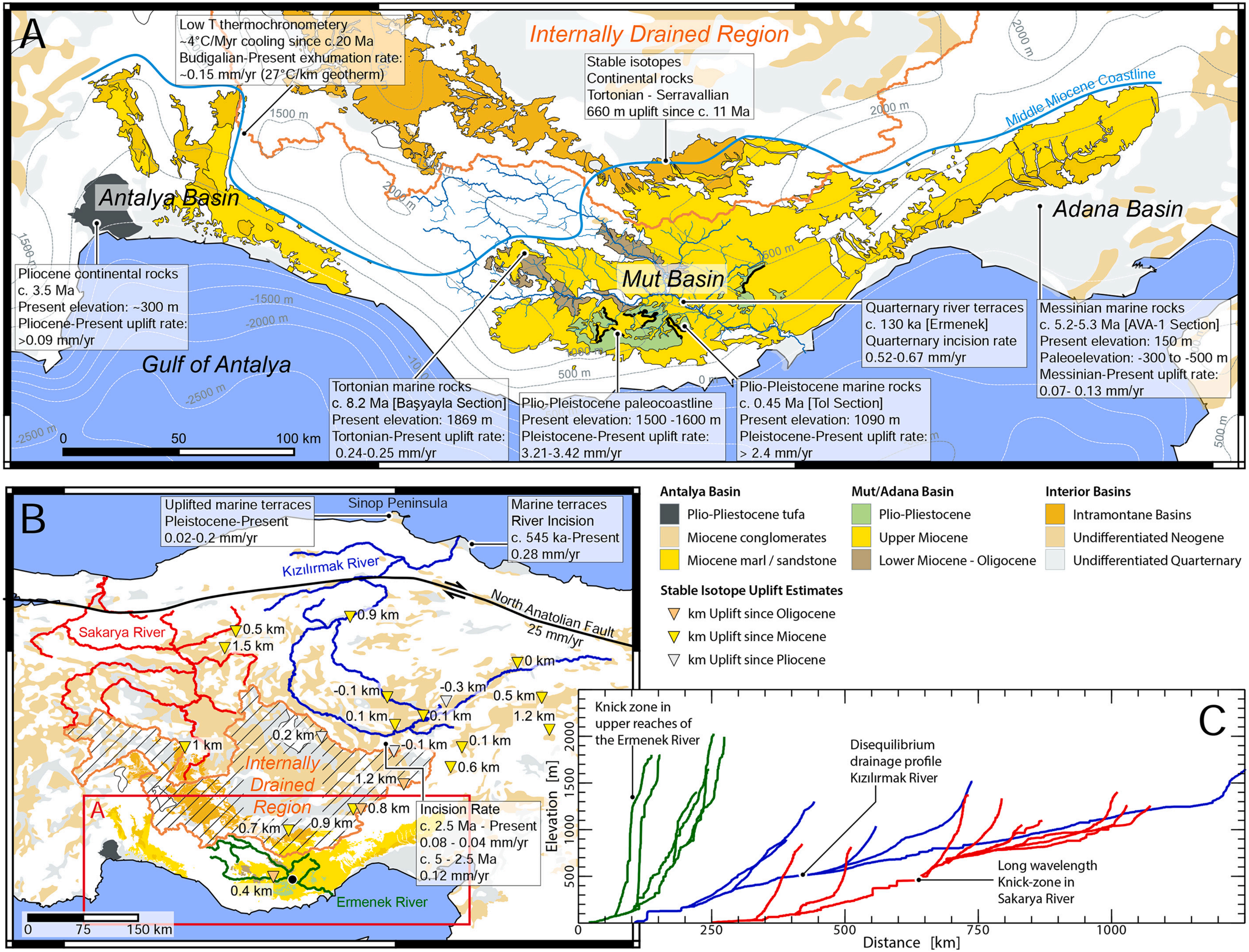


Fig. 2. Synthesis of uplift constraints across the Central Anatolian Plateau. A) Southern plateau margin, including the Antalya, Mut, and Adana basins. Contours are 10 km smoothed elevation. See text for citations. B) Uplift constraints across the plateau interior and northern plateau margin. Stable isotope uplift estimates are based on data from Meijers et al. (2018; and references therein), assuming a lapse rate of −2.9‰/km. C) Longitudinal river profiles from three major rivers that drain Central Anatolia.

margin. Pleistocene to Present uplift is constrained by incised river terraces (0.27–0.29 mm/yr; Yildirim et al., 2013b; Berndt et al., 2018), by uplifted paleodeltas (0.2–0.3 mm/yr; Demir et al., 2004), and by uplifted Pleistocene marine terraces on the Sinop Peninsula (0.02–0.2 mm/yr; Yildirim et al., 2013a) (Fig. 2B). Yildirim et al. (2013a, 2013b) showed that spatially variable Pleistocene to Present uplift rates and disequilibrium river profiles may be associated with active thrusting, linked to a restraining bend in the North Anatolian Fault (NAF) (Yildirim et al., 2011; Berndt et al., 2018).

3. Cretaceous to present geological evolution of Central Anatolia

3.1. Cretaceous to Eocene orogenesis

The Central Anatolian crust comprises oceanic and continental nappes that were assembled by subduction and collision since the Mesozoic. We aim to use the long-term geological record of this orogenesis to evaluate hypothesised geodynamic causes of plateau uplift. We start by describing the first-order modern tectonic units and their interpreted tectonic and paleogeographic origin, from north to south and downward through the regional tectonostratigraphy. These tectonic units are shown in the geological map and conceptual cross-sections in Fig. 3.

3.2. Pontides orogen and the southern eurasian margin

The Pontides orogen forms an east-west trending mountain range at the northern edge of the Central Anatolian plateau. In Early Jurassic times this orogen formed the southern continental margin of Eurasia (Sengör and Yilmaz, 1981; Okay and Nikishin, 2015; Dokuz et al., 2017; Topuz et al., 2014; van Hinsbergen et al., 2020), and was separated from the African continent by Tethyan ocean basins and Gondwana-derived continental blocks – the evidence of which we will describe in the following sections.

The Izmir-Ankara-Erzincan suture zone (IAESZ) marks the southern boundary of the Pontides orogen and contains Jurassic ophiolites with a so-called supra-subduction zone (SSZ) geochemical signature. These ophiolites were formed in the upper plate of a north-dipping subduction zone that existed from at least Early Jurassic time (Topuz et al., 2014; Hässig et al., 2013; Maffione and van Hinsbergen, 2018; Çelik et al., 2019). Sedimentary basins covering the IASZ suture demonstrate that in western and central Anatolia, subduction below the Pontides terminated in latest Cretaceous to Paleocene times with the collision of the Kırşehir Block and Tavşanlı zone that we describe in the following sections (Kaymakci et al., 2009; Meijers et al., 2010; Mueller et al., 2019). In East Anatolia however, oceanic subduction likely continued well into Paleogene times (Gürer and van Hinsbergen, 2019).

3.3. Late Cretaceous SSZ ophiolites

South of the IAESZ, the Central Anatolian lithosphere comprises an overall east-west trending orogenic belt of continental and oceanic nappes that were accreted from Late Cretaceous to Eocene times (e.g., Sengör and Yilmaz, 1981; Gürer et al., 2016; van Hinsbergen et al., 2016, 2020; Moix et al., 2008; Maffione et al., 2017; Okay, 1986; Plunder et al., 2013; Pourteau et al., 2018). All major nappes in this Anatolian orogen, which are rooted in the IAESZ, are overlain by klippes of Late Cretaceous (c. 94–90 Ma) SSZ ophiolites (Dilek et al., 1999; Robertson, 2004; Pourteau et al., 2010; Parlak, 2016; van Hinsbergen et al., 2016). The ophiolites are associated with metamorphic sole rocks that recorded subduction initiation at c. 105 Ma (Pourteau et al., 2018), and formed in the upper plate of an intra-oceanic subduction zone, below which oceanic and continental African Plate lithosphere subducted (e.g., Barrier and Vrielynck, 2008; Plunder et al., 2013, 2016; Menant et al., 2016; van Hinsbergen et al., 2016, 2020; Gürer et al., 2016; Gürer and van Hinsbergen, 2019). Based on paleomagnetic restorations of ophiolitic sheeted dykes, the SSZ ophiolites formed by NNE-SSW spreading (Maffione et al., 2017) This is interpreted to reflect ENE-dipping subduction, as part of a step-shaped subduction zone shown in Fig. 4 (100 Ma) (van Hinsbergen et al., 2016; Maffione et al., 2017; van Hinsbergen et al., 2021).

3.4. Metamorphism and exhumation of high-grade metamorphic rocks

The structurally highest and northernmost units below the Cretaceous ophiolite klippes are the high pressure-low temperature (HP-LT) metamorphic Tavşanlı zone in western Central Anatolia (Fig. 3A), and the high temperature-medium pressure (HT-MP) metamorphic Kırşehir Block in eastern Central Anatolia (Fig. 3B and C). These units underwent burial, metamorphism, and accretion by c. 90–85 Ma (Whitney and Hamilton, 2004; van Hinsbergen et al., 2016; Pourteau et al., 2018).

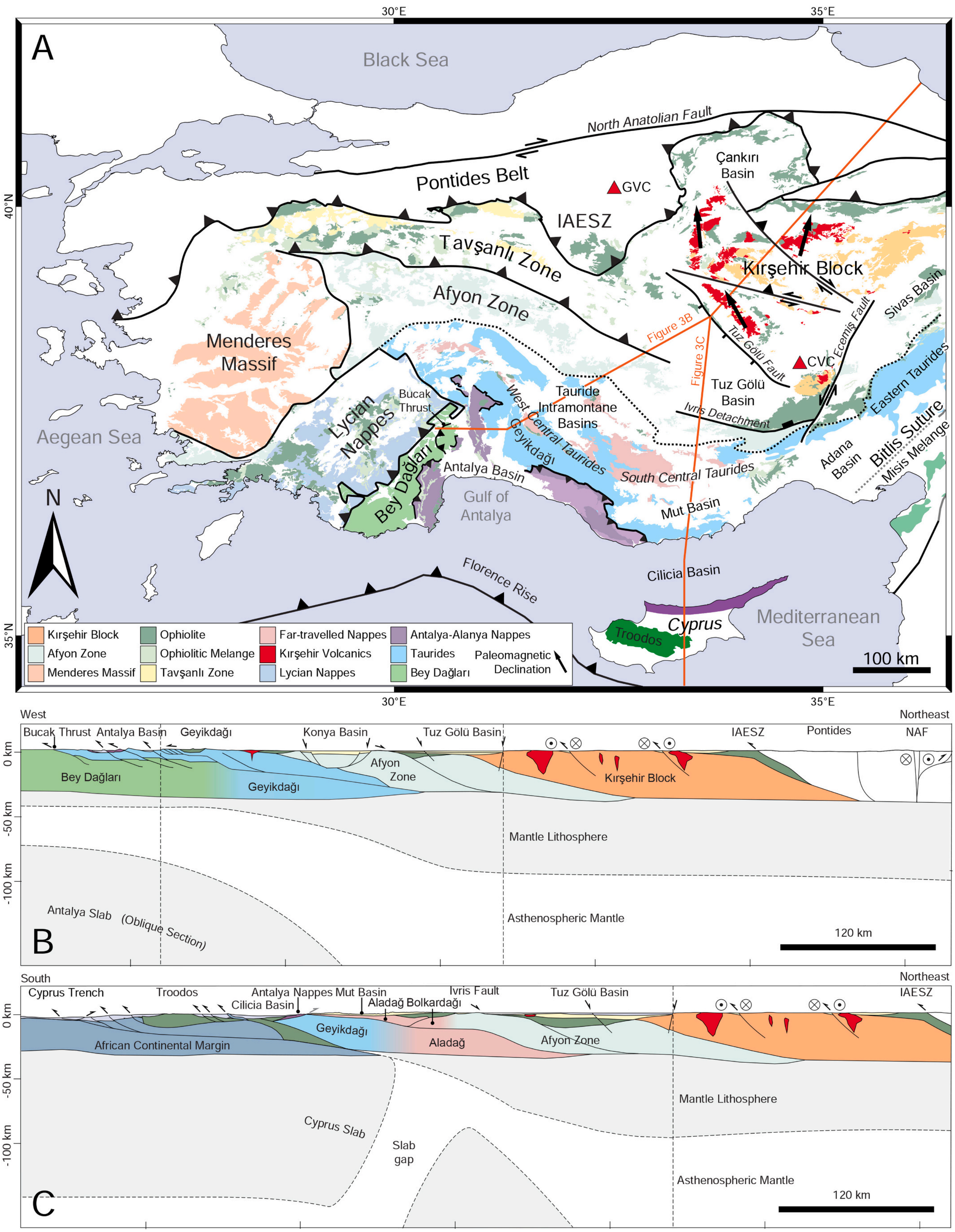
The HP-LT metamorphic Afyon zone is located south of and structurally below the Tavşanlı zone and Kırşehir Block and consists of continent-derived metasediments that were metamorphosed at c. 70–65 Ma (Candan et al., 2005; Pourteau et al., 2013; Özdamar et al., 2013). There is no record of accretion of major rock units between c. 85 Ma accretion of the Kırşehir Block and Tavşanlı zone and c. 70 Ma accretion of the Afyon zone. In this time period a conceptual ocean basin that likely separated these continental units – the Intra-Tauride Basin – is thought to have subducted, producing a contemporaneous volcanic arc on the Kırşehir Block after it was accreted to the oceanic lithosphere of the Central Anatolian ophiolites (Sengör and Yilmaz, 1981; Ilbeyli et al., 2004; Pourteau et al., 2010; Lefebvre et al., 2013; van Hinsbergen et al., 2016, 2020; Menant et al., 2016).

After burial and metamorphism, the Kırşehir Block, Tavşanlı zone, and Afyon zone were continually exhumed from below ophiolites and are now widely exposed on the plateau interior (Figs. 3 and 5A). This started with east-west extensional exhumation of the Kırşehir Block by Late Cretaceous time (Gautier et al., 2002, 2008; Isik, 2009; Lefebvre et al., 2011, 2015; Advokaat et al., 2014; Genç and Yürür, 2010), and was followed by latest Cretaceous to early Eocene east-west extensional exhumation of the Afyon zone (Seyitoglu et al., 2017; Gürer et al., 2018b). Widespread exposure of these high-grade metamorphic rocks demonstrates several hundred kilometres of east-west upper plate extension, which was most likely driven by westward retreat of a subducting slab (Gürer et al., 2018b; van Hinsbergen et al., 2020).

3.5. Accretion of the Central Taurides fold-thrust belt

The Central Taurides are a non-metamorphic fold-thrust belt that forms the high southern plateau margin to the south of the Afyon zone. The Late Cretaceous SSZ ophiolite-bearing Bozkır Nappes form the uppermost tectonic unit of the fold-thrust belt (Özgül, 1984; Andrew and Robertson, 2002; Çelik and Delaloye, 2006; Mackintosh and Robertson, 2012). The Bolkardağı and Aladağ nappes, which are interpreted as the southern non-metamorphic continuations of the Afyon zone (Özgül, 1984; Okay, 1986; Altıner et al., 2000), were accreted below the Bozkır Nappe in late Maastrichtian times (c. 72–66 Ma) based on the ages of underthrusted synorogenic sedimentary rocks (Özgül, 1984; Mackintosh and Robertson, 2012).

In middle Eocene times (c. 45–41 Ma) the Bozkır, Bolkardağı, and Aladağ nappes were thrusted at least 70 km south-westward over the Geyikdağı platform, which was subsequently deformed by thin-skinned folding and thrusting (Gutnic et al., 1979; McPhee et al., 2018a, 2018b). In the western Central Taurides the Geyikdağı Platform formed a nappe that was thrust south-westward over the adjacent Bey Dağları platform (Fig. 5D). Southward-increasing underthrusting of the Bey Dağları platform accommodated a paleomagnetically-constrained 40° CW rotation of the Geyikdağı Nappe experienced by late Eocene times, underpinning much of the western Central Taurides with continental Beydağları Platform lithosphere (Fig. 4: 40 Ma) (McPhee et al., 2018a, 2018b, 2019). In contrast, the southern Central Taurides were not



(caption on next page)

Fig. 3. A) Major tectonic units and contacts of Turkey modified from the MTA 1:500,000 geological map series. CVP = Cappadocia Volcanic Centre; GVC = Galatia Volcanic Centre. Far-travelled Nappes are the undifferentiated Bozkır, Aladağ, and Bolkardağı nappes.
B) Conceptual cross-section across Anatolia (approximately to scale), extending southwest to the Bey Dağları Platform, incorporating the Bucak-Seydişehir cross-section of McPhee et al. (2018a). C) Conceptual cross-section across Anatolia (approximately to scale), extending southward over Cyprus and the Cyprus Trench. Geology of Cyprus, based on seismic sections of the Cyprus Trench from Reiche and Hübscher (2015); Symeou et al. (2018); a geological map of south Cyprus by Bagnall (1960); and the cross-section of the Kyrenia range from McPhee and van Hinsbergen (2019).

affected by shortening after the middle Eocene accretion of the Geyikdağı Platform (McPhee et al., 2018b).

3.6. Antalya and Alanya Nappes

In a separate latest Cretaceous to Paleocene event, Late Cretaceous SSZ ophiolites were thrust from south(west) to north(east) over the southern margin of the Geyikdağı Platform (Özgül, 1984; McPhee et al., 2018a). Around the Gulf of Antalya, these ophiolites are associated with the far-travelled HP-LT metamorphic Alanya Nappes (Çetinkaplan et al., 2016), and the non-metamorphic Antalya Nappes that were derived from the southern margin of the Geyikdağı Platform (e.g., Robertson and Woodcock, 1981; Vrielynck et al., 2003). The Alanya and Antalya Nappes were later incorporated into the Eocene age (south)westward thrusting of the Central Taurides (McPhee et al., 2018a, 2018b) that we describe above.

3.7. Correlation with West Anatolia

In West Anatolia (Figs. 1A and 3A), a series of deeply underthrusted continental nappes equivalent to the Geyikdağı Nappe accreted until late Eocene time (Gessner et al., 2001; Lips et al., 2001; van Hinsbergen et al., 2010b; Schmidt et al., 2015), and are exposed in an extensional window in the Miocene age Menderes extensional province (e.g., Ring et al., 2003). The lowermost exposed nappe has a preserved Pan-African crystalline basement and may be contiguous with the Bey Dağları Platform that forms the foreland of the western Central Taurides (Collins and Robertson, 1998; van Hinsbergen et al., 2010b). The Lycian Nappes are exposed between the Miocene-age Menderes extensional province and the Bey Dağları platform, and comprise a Late Cretaceous to Eocene nappe stack equivalent to the Bozkır and Bolkardağı nappes, including Late Cretaceous SSZ ophiolites (Collins and Robertson, 1997, 1998, 2003; van Hinsbergen et al., 2020; Plunder et al., 2016).

The structural trend of the West Anatolian fold-thrust belt was modified by a 75 km (and likely as much as 150 km) south-eastward translation of the Lycian Nappes over the Bey Dağları platform, coeval with c. 25–15 Ma extensional unroofing of the Menderes Massif (Hayward and Robertson, 1982; van Hinsbergen, 2010; van Hinsbergen et al., 2010b). The Bey Dağları platform and Lycian Nappes were then also affected by a 25° CCW rotation from c. 15–5 Ma (Kissel and Poisson, 1986; Morris and Robertson, 1993; van Hinsbergen et al., 2010b).

3.8. Post-Eocene subduction and deformation

3.8.1. Subduction of the Eastern Mediterranean Ocean

Plate circuit reconstructions of the Atlantic Ocean show around 450 km of post-Eocene Africa- Eurasia convergence in the Central Anatolian region (e.g., Seton et al., 2012). The amount of convergence increased to the east, reaching 800 km of convergence north of Arabia (e.g., van der Boon et al., 2018). There is no record of post-Eocene crustal shortening in the Central Taurides associated with this convergence, and so subduction thrusts must have been located to the south of and structurally below the Central Taurides (van Hinsbergen et al. 2010; McPhee and van Hinsbergen, 2019; McPhee et al., 2018a).

Upper Cretaceous oceanic lithosphere is preserved as ophiolites in the Antalya Nappes, on Cyprus (Troodos Ophiolite), and on northwest Arabia (Hatay and Baer-Bassit ophiolites; see Fig. 5B) (Parlak et al., 1996; Moix et al.,2011; Morris et al., 2017; Aldanmaz et al., 2020). These ophiolites, and relics of Palaeozoic oceanic lithosphere preserved in sub-ophiolitic melanges (Moix et al., 2011; Granot, 2016), are remnants of an Eastern Mediterranean Ocean lithosphere that once separated the African margin from the Geyikdağı and Bey Dağları Platforms (Figs. 4, 100 Ma) (e.g., Robertson et al., 2009; Moix et al., 2008; Menant et al., 2018; Maffione et al., 2017; Barrier and Vrielynck, 2008; van Hinsbergen et al., 2020).

The emplacement of Late Cretaceous ophiolites was likely caused by westward invasion of subduction zone that originated in East Anatolia and rolled back into the Eastern Mediterranean Ocean (Figs. 4 and 10) (e.g., Maffione et al., 2017; van Hinsbergen et al., 2020). This replaced a Palaeozoic to lower Mesozoic oceanic lithosphere with a Late Cretaceous oceanic lithosphere that is partially preserved as ophiolites (Fig. 4; 80 Ma and 60 Ma)(Moix et al., 2008; Barrier et al., 2018; Maffione et al., 2017; van Hinsbergen et al., 2020). After the Eocene accretion of the Central Taurides, the Eastern Mediterranean Ocean lithosphere was subducted without accretion (van Hinsbergen et al., 2010a; McPhee et al., 2018b), except for the accretion of the Misis Melange east of Adana (Fig. 3A) (Robertson et al., 2004). This accounted for 400 km of Africa-Eurasia convergence (van Hinsbergen et al., 2010a; McPhee and van Hinsbergen, 2019).

In East Anatolia, subduction of the Eastern Mediterranean Ocean ended with middle to late Miocene continent-continent collision of Arabia and Eurasia at the Bitlis Suture Zone (Figs. 4, 15 Ma) (Şengör et al., 2003; Hüsing et al., 2009; Okay et al., 2010; Cavazza et al., 2010; 2018). In northern Cyprus, crustal shortening recorded the onset of a collision of the Central Taurides with the African distal continental margin and overlying ophiolites sometime between c. 11 to 7 Ma (McPhee and van Hinsbergen, 2019). After that, the subduction plate boundary propagated to the south of and structurally below the Troodos Ophiolite, accreting the ophiolite, underlying African distal continental margin rocks, and overlying sedimentary basins to the Anatolian orogen (McPhee and van Hinsbergen, 2019). Seismic stratigraphy across major faults, the development of flexural basins (e.g., Hall et al., 2005; Symeou et al., 2018), and structural and stratigraphic constraints on the onset of upper-plate contractional deformation in southern Cyprus (e.g., Kinnaird & Robertson, 2013) all suggest that the modern trench formed only in latest Miocene or Pliocene time. Furthermore, a long-lived subduction zone below Troodos is at odds with Late Cretaceous emplacement of the adjacent Hatay and Baer-Bassit ophiolites onto Arabia (McPhee & van Hinsbergen, 2018), which based on paleomagnetic and geochronological constraints, were part of the same microplate (e.g., Al-Riyami et al., 2002; Morris et al., 2006). Underthrusting of the African distal continental margin at the Cyprus Trench (Fig. 4) (e.g., Robertson, 1998; Ben-Avraham et al., 2002) is ongoing at rates of 9 km/Myr, accommodating Africa-Eurasia convergence (Reilinger et al., 2006).

3.8.2. Upper plate shortening in the Kırşehir Block

From the Kırşehir Block, to the east, a part of the reconstructed Late Cretaceous to early Miocene Africa-Europe convergence was taken up by shortening within the Anatolian orogen. Gurer & van Hinsbergen (2018) reconstructed c. 320 km of north-south shortening across Central Anatolia in Paleogene times (c. 60–25 Ma). Their reconstruction included c. 115 km shortening by restoration of oroclinal bending in the Central Pontides (Meijers et al., 2010) and Cankiri Basin (Espurt et al., 2014) (see Figure #). Approximately 200 km of Eocene-Oligocene shortening was reconstructed within the Kırşehir Block using paleomagnetically constrained restoration of vertical axis rotations (Lefebvre et al., 2013;

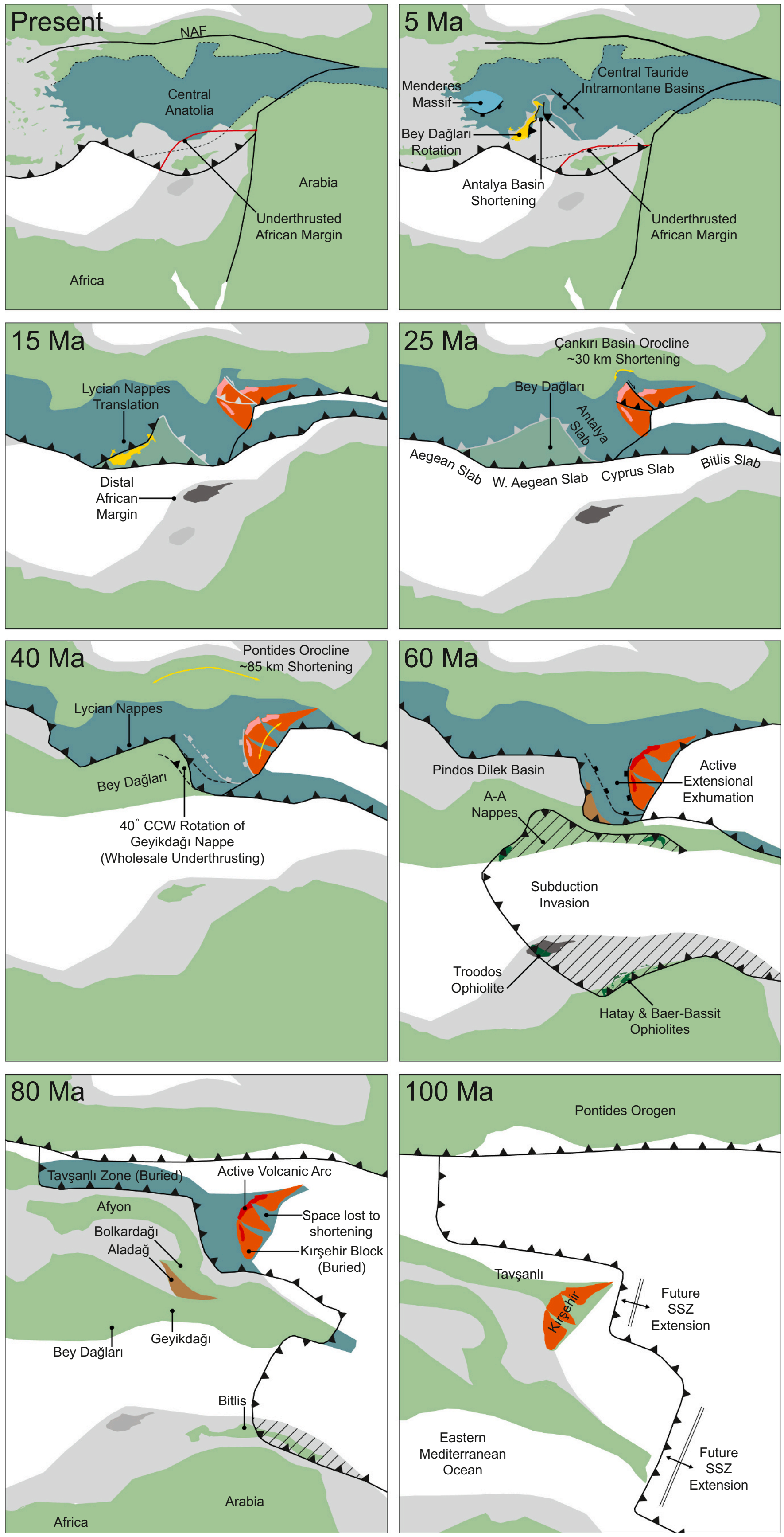


Fig. 4. Palinspastic map-view restoration of Anatolia from 100 Ma to Present, incorporating restorations of Greece and western Turkey from van Hinsbergen and Schmid (2012); central and eastern Turkey from Gürer and van Hinsbergen, 2019; the Central Taurides from McPhee et al., 2018b; Miocene oroclinal bending of the Central Taurides from Koç et al. (2018), and; Cyprus from McPhee and van Hinsbergen (2019) and Maffione et al. (2017).

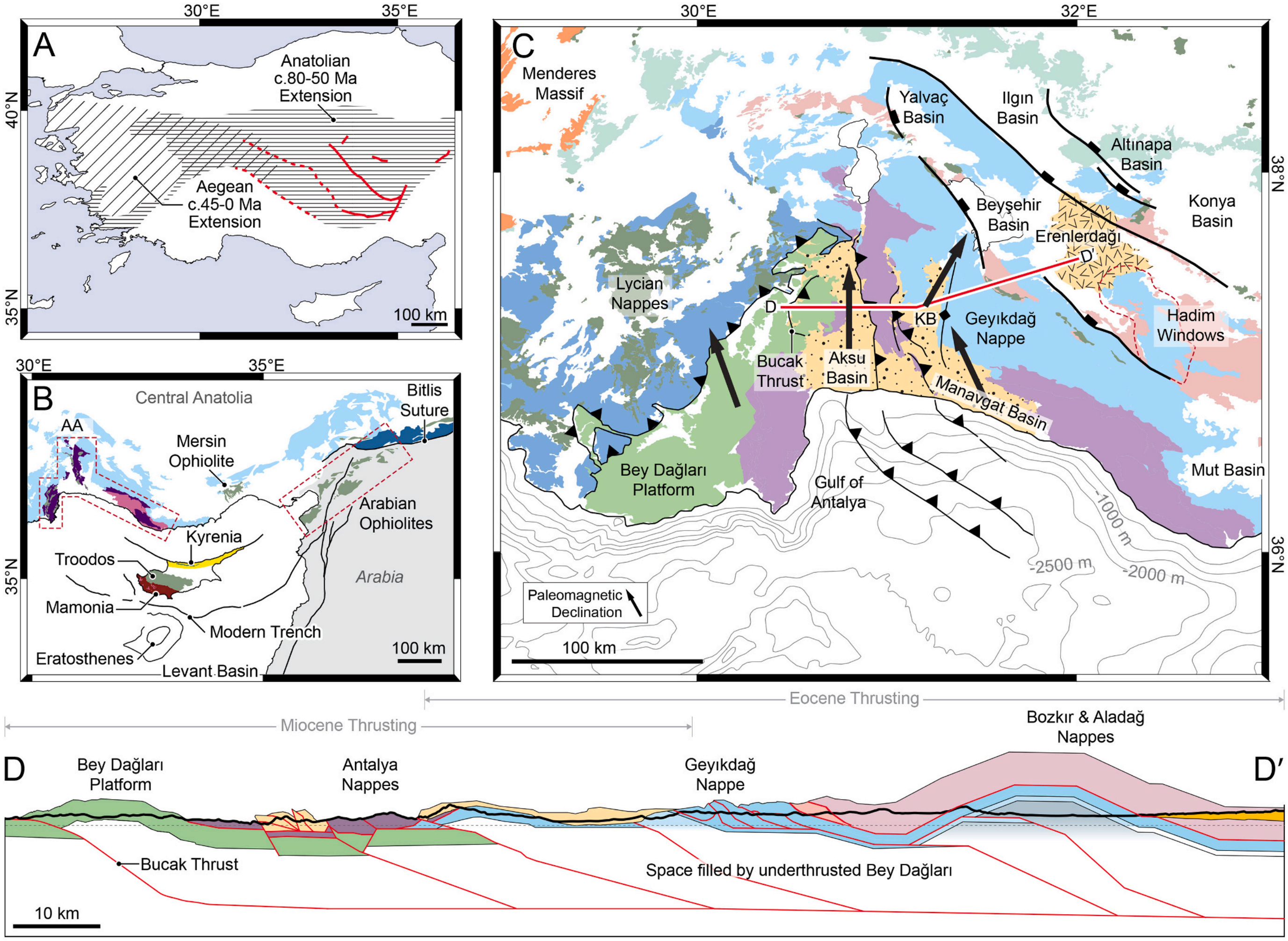


Fig. 5. A) The Aegean Extensional Province and Anatolian Extensional Province in Central and Western Anatolia, redrawn from Gurer et al. (2018). Red lines mark mapped (solid) and inferred (dashed) Central Anatolian extensional detachment faults. B) Late Cretaceous ophiolites of the Eastern Mediterranean Ocean that separated Anatolia from Africa and Arabia in late Eocene times. Redrawn from McPhee & van Hinsbergen (2018). AA = Antalya and Alanya Nappes, and associated ophiolitic rocks. C) Generalised geological map of the western Central Taurides, the Bey Dağları Platform, and the Lycian Nappes, showing the largest Miocene extensional and contractional structures (Koç et al., 2018; McPhee et al., 2018b). Offshore thrusts are from seismic interpretations of Hall et al. (2014). Miocene paleomagnetic data are summarised by black arrows in the Antalya Basin by Koç et al. (2016) and the Bey Dağları Platform from van Hinsbergen et al. (2010b). KB = Köprüçay Basin (sub-basin of the Antalya Basin). D) East-west cross-section along line D-D′ (panel C of this figure), showing the internal structure of the western Central Taurides. Redrawn from McPhee et al. (2018a). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Gurer et al., 2018a) and restoration of motion on major fault zones (Lefebvre et al., 2013; Gülyüz et al., 2013; Espurt et al., 2014; Advokaat et al., 2014; Gürer et al., 2016). A further 5 km of Eocene-Oligocene shortening deformed the Bolkar Mountains between the Mut Basin and Ecemiş fault (Fig. 3A), forming a north-verging anticline and raising the Taurides to 1.5 km above the Ulukışla Basin (Gürer et al., 2016). This deformation of the Bolkar Mountains explains most of the modern topographic difference along the western Central Taurides, which rise from the 2 km elevation in the Mut Basin to 3.5 km elevation in the Bolkar Mountains (Fig. 3A).

3.8.3. *Formation and deformation of Miocene to present basins*

In early Miocene times, basins formed across southern Central Anatolia, including the Central Taurides Intramontane Basins (Koç et al., 2012, 2016b, 2017) and Antalya Basin (Fig. 5C) (Karabiyikoglu et al., 2000; Flecker et al., 2005; Çiner et al., 2008; McPhee et al., 2018a). The lower Miocene to Present Central Taurides Intramontane Basins formed by bidirectional extension, forming NW-SE and NE-SW basin-bounding faults that were parallel and perpendicular to western Central Tauride thrusts respectively (Koç et al., 2012, 2016b, 2017). Koç et al. (2018) used paleomagnetic data to investigate vertical axis rotations of relay ramps between the basin-bounding faults, restoring up to 25 km of NE-SW Miocene extension. The Tuz Gölü Basin, which initially formed as a Paleogene sag basin, was affected by only a few hundred meters to a few kilometres of Miocene extension on steep normal faults (Fernández-Blanco et al., 2013; Ozsayin et al., 2013).

The Antalya Basin, which covers the western Central Taurides, was deformed by Miocene-Pliocene NW-SE-trending folds and thrusts (Çiner et al., 2008; Koç et al., 2016b; Poisson et al., 2003; McPhee et al., 2018a; Wasoo et al., 2020). These included a 70-km-long west-verging anticline that formed along the eastern margin of the Köprüçay Basin, uplifting Miocene marine sedimentary rocks to 1.5 km elevation (McPhee et al., 2018a). Shortening in the Antalya Basin was approximately equal to extension in the Central Tauride Intramontane Basins (McPhee et al., 2018a), leading to the development of a paleomagnetically-constrained westward-convex orocline that affected the eastern Antalya Basin and the underlying western Central Taurides in the Miocene (Fig. 5C) (Koç et al., 2016a, 2018).

4. Geophysical constraints

4.1. Modern mantle structure

Seismic tomography of the mantle below Anatolia (Fig. 7 A-D) shows high-velocity anomalies that are interpreted as subducted slabs. A north-northeast-dipping high-velocity anomaly beneath the Gulf of Antalya and western Central Anatolia is well defined in the upper mantle (Fig. 7B) and is interpreted as the Antalya slab. This slab anomaly is associated with a well-defined Wadati-Benioff zone that extends to 130 km depth (Howell et al., 2017; Kalyoncuoğlu et al., 2011) (Fig. 7E). The Antalya slab anomaly is separated from the Aegean slab anomaly to the west by a well-resolved gap in the high-velocity anomaly (van Hinsbergen et al., 2010a; Biryol et al., 2011; Govers and Fichtner, 2016; van der Meer et al., 2018; Portner et al., 2018) associated with a conspicuous lack of a Wadati-Benioff zone (Bocchini et al., 2018) (Fig. 7E).

A second high-velocity anomaly is resolved below Cyprus and southern Central Anatolia: this is associated with a diffuse zone of seismicity below Cyprus that reaches down to 60–70 km depth (Fig. 7E) and is interpreted as the north-dipping Cyprus slab (Fig. 7C). The upper part of the Cyprus slab anomaly may still be contiguous with the African plate (Biryol et al., 2011), or recently detached from the African plate (Portner et al., 2018; see also Gürer, 2017; van der Meer et al., 2018; Fig. 6 and 7C). Most tomographic models (but not all, see Portner et al., 2018) suggest a vertical gap separates the Antalya slab from the Cyprus slab (de Boorder et al., 1998; Faccenna et al., 2006; Biryol et al., 2011; van der Meer et al., 2018; Figure Fig. 6 and 7C.

Regional seismic tomographic models, which focus on Anatolian mantle structure, only resolve upper mantle tomographic features (Biryol et al., 2011; Portner et al., 2018). Global tomography models reveal that the majority of subducted lithosphere associated with Central Anatolian subduction resides in the lower mantle (Gürer, 2017; van der Meer et al., 2018). In the mantle transition zone and below, the Cyprus and Antalya slabs become indistinguishable in the tomography. The Cyprus slab appears to be overturned in the lower mantle, likely as a result of northward Cretaceous advance of the slab prior to closure of the IAESZ, and Paleogene Central Anatolian shortening (Gürer et al., 2016; Gürer, 2017).

There is no upper mantle high-velocity anomaly above the mantle transition zone (Fig. 7D), and no reported earthquakes at depths greater than 50 km (Fig. 6E) to the east of Cyprus, below the Miocene Bitlis Suture. This suggests that a slab associated with the Bitlis Suture broke-off and sank into the lower mantle (Faccenna et al., 2006; Hafkenscheid et al., 2006; Lei and Zhao, 2007; Biryol et al., 2011; Skobeltsyn et al., 2014).

Finally, the Pontides slab associated with the IAESZ reaches from the transition zone to the deep lower mantle (Gürer, 2017). Slab break-off along the IAESZ in western and central Anatolia probably occurred in Eocene time (e.g., Keskin et al., 2008), long before the uplift of the Central Anatolian plateau.

4.2. Modern lithospheric structure

Geophysical and petrological data constrain the thickness of the Central Anatolian crust and lithospheric mantle. The Central Anatolian crust is between 30 and 45 km thick, based on receiver functions (Tezel et al., 2013; Vanacore et al., 2013; Abgarmi et al., 2017; Çivgin and Kaypak, 2017), seismic refraction data (Feld et al., 2017) and regional full-waveform tomography (Govers and Fichtner, 2016). On Cyprus and in the Levant Basin (Fig. 5B), receiver functions (Vanacore et al., 2013), regional tomography (Koulakov and Sobolev, 2006), and wide-angle seismic data (Ben-Avraham et al., 2002; Feld et al., 2017) suggest that the crust is between 26 and 30 km thick.

Estimates of the depth of the lithosphere-asthenosphere boundary (LAB) below Central Anatolia suggest that the region has an anomalously thin or even absent lithospheric mantle. The LAB has been estimated at <50–100 km based on S-receiver functions (Kind et al., 2015), and joint inversion of P and S receiver functions (Vinnik et al., 2014;

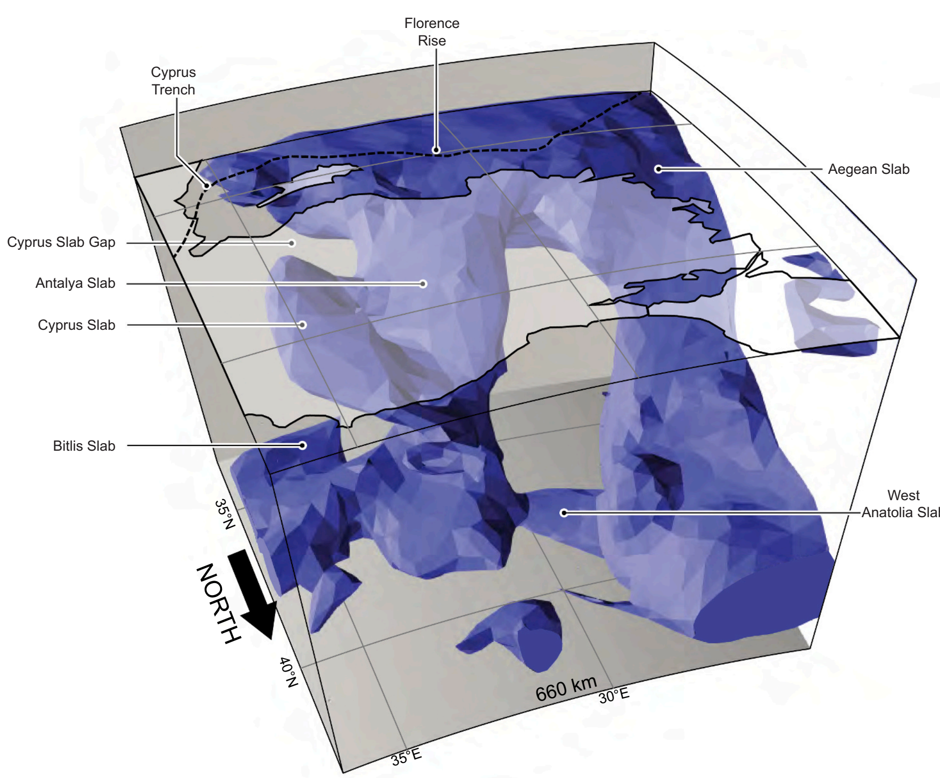


Fig. 6. 3D rendering of the UU-P07 tomographic model in the study area. The blue mesh is a 0.4% isosurface extracted using marching cubes. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

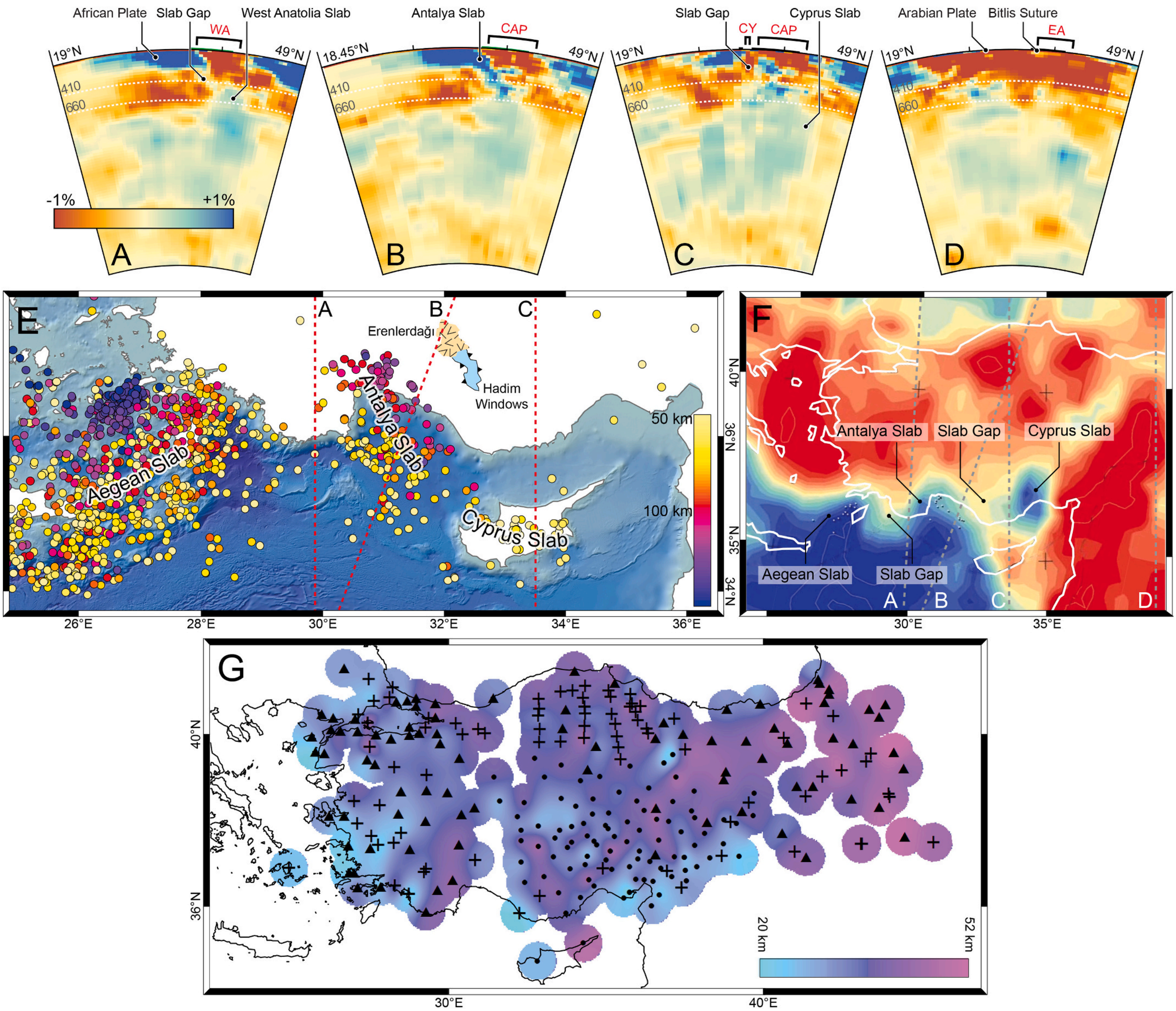


Fig. 7. A-E) Tomography slices from the UUP07 model (Amaru, 2007; Hall and Spakman, 2015) extracted using the Hades Underworld Explorer (van der Meer et al., 2018) WA = western Anatolia; CAP = Central Anatolian plateau; CY = Cyprus; EA = East Anatolia. The locations of the tomographic slices relative to Turkey are marked in Fig. 5A. Note that these slices extend far to the north and south of Turkey (49°N to ~19°N). A) Detached West Anatolia slab; B) Antalya slab; C) Cyprus slab; D) Detached Bitlis slab. E) Earthquake hypocentres below 50 km depth, extracted from the USGS earthquake catalogue (1970–2016). Note that the colour depth scale is non-linear. F) Horizontal slice through the UUP07 model at a depth of 125 km, showing slab anomalies and gaps that separate them. G) Crustal thickness from receiver function data. Points are locations of seismic stations where receiver functions were calculated: triangles from Abgarmi et al. (2017); circles from Tezel et al. (2013); crosses from Vanacore et al. (2013). Points were interpolated using a spline algorithm with a barrier formed by a 50 km buffer around seismic data.

Delph et al., 2017). In southeast Central Anatolia, the lithosphere is estimated to be around 55 km thick based on modelled melt equilibrium conditions (Reid et al., 2017).

5. Discussion

We have reviewed evidence for the rise of the plateau and its margins, and found a complex history. In a first phase, the southern plateau margins, including the Mut Basin, recorded uplift from c. 8–5 Ma at rates of around 0.15 mm/yr. This is consistent with uplift in the plateau interior that started at some time between c. 12–5 Ma based on stable isotope altimetry (e.g., Meijers et al., 2018) and the modelled and observed evolution of the plateau drainage system (e.g., McNab et al., 2017). We will evaluate different potential drivers of this plateau-scale uplift, and then address the multi-phase uplift of the plateau margins.

5.1. *Crustal thickening as a driver of plateau-scale Neogene uplift*

Crustal thickening has been an important contributor to surface uplift at various stages of Himalayan-Tibetan orogenesis (e.g., Kapp and DeCelles, 2019, and references therein) and in the Central Andes (e.g., Barnes and Ehlers, 2009, and references therein). We start our discussion by evaluating the potential role of crustal thickening as a driver of the c. 8–5 Ma plateau-scale uplift.

The 30-45-km-thick Central Anatolian crust may isostatically support the 1-km-high plateau surface because the dense underlying lithospheric mantle is only 5–55 km thick, as shown by seismological and petrological data (Fig. 7G) (e.g., Reid et al., 2017; Kind et al., 2015). To drive Late Neogene plateau rise, crustal shortening should have occurred in response to Neogene convergence.

In the Central Anatolia region, Africa-Eurasia convergence averaged

8 km/Myr in the Neogene (e.g., van Hinsbergen et al., 2020, and references therein). One kilometre of uplift would require 7 km of crustal thickening (assuming 3300 kg.m^{-3} asthenosphere and 2800 kg.m^{-3} crust), equivalent to 20% shortening of the 550-km-wide plateau (35-km-thick crust), and consuming all Africa-Eurasia convergence from 17 Ma to the Present. Neogene basins across central and southern Central Anatolia contain no evidence for such shortening, with the exception of the Antalya Basin, where around 15 km of Miocene-Pliocene shortening occurred (McPhee et al., 2018a), and the Kırşehir Block where oroclinal bending ended in earliest Miocene times (Gürer et al., 2018a, 2018b). Instead, Neogene basins in the plateau interior formed by extension (e.g., Ozsayin et al., 2013; Koç et al., 2018), and Africa-Eurasia convergence was accommodated by subduction of the African Plate south of Central Anatolia (e.g., McPhee and van Hinsbergen, 2019). The 30–45-km-thick crust was developed by the Late Cretaceous to Eocene orogenesis that we reviewed in Section 3.

In the northern plateau margin the Central Pontides are presently affected by an additional 8 km/Myr NW-SE convergence within a restraining bend of the NAF (Yildirim et al., 2011). Schildgen et al. (2014) calculated that associated crustal shortening, which was limited to the Central Pontides, may have driven spatially variable Pleistocene uplift rates of 0.02–0.3 mm/yr (Yildirim et al., 2013a, 2013b; Berndt et al., 2018).

5.2. Lithospheric removal by peeling delamination or dripping

Post c. 8–5 Ma plateau-scale uplift was therefore not driven by crustal shortening. Instead, we must look to modification or removal of the lithospheric mantle, and/or dynamic topography as drivers. Two general mechanisms explain regional mantle lithospheric removal on this scale: lithospheric dripping and peeling delamination (Fig. 8C and E). Peeling delamination is the separation of the dense lower lithosphere from the crust by bending and sinking, with negligible internal shear strain (e.g., Bird, 1979), and is comparable to slab retreat (e.g., Göğüş and Ueda, 2018, and references therein). Lithospheric dripping is the sinking of the lower lithosphere while still attached to the crust, with high internal shear strain (e.g., Houseman and Molnar, 1997; Beall et al., 2017).

5.2.1. Peeling delamination

Peeling delamination of flat slabs may be an important driver of uplift and upper crustal deformation in regions such as the Central Andes (e.g., Ramos and Folguera, 2009), and has been proposed for the Central and East Anatolian plateaus. In a peeling delamination scenario (Fig. 8C), a flat slab initially existed from the Eastern Mediterranean to the Pontides (Bartol and Govers, 2014; Govers and Fichtner, 2016). In Miocene times the slab steepened and retreated, peeling off the lithospheric mantle, and driving uplift by unloading the crust and exposing it to the asthenosphere. The process would be signalled by the enigmatic middle to late Miocene (c.16–9 Ma) onset of volcanism, including the late Miocene Galatia and the Cappadocia volcanic centres (Bartol and Govers, 2014).

Seismic tomography of the mantle below southern and western Central Anatolia contains slab anomalies that reach well into the lower

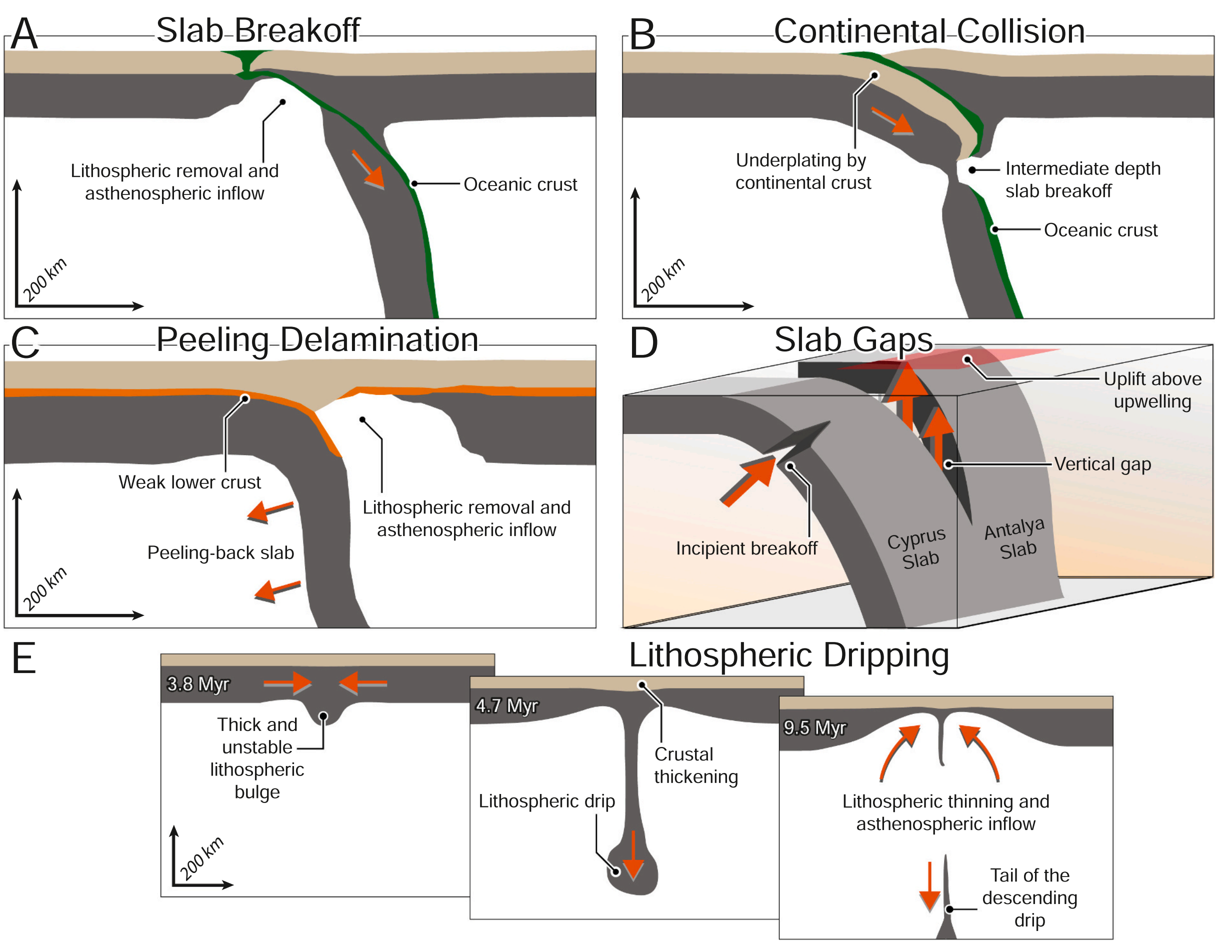


Fig. 8. Uplift mechanisms applied to Central Anatolia: i) Peeling delamination, based on modelling results in Memiş et al. (2020); ii) Continental collision (with incipient break-off), based on modelling results of Duretz et al. (2011); iii) Lithospheric dripping, based on modelling results of Göğüş et al. (2017); iv) Inflow of asthenosphere, between slab gaps, and during incipient break-off; v) Shallow slab break-off, based on modelling results of Duretz et al. (2011).

mantle where they appear to be folded and thickened (Fig. 7A-D) (Gürer, 2017; van der Meer et al., 2018; Portner et al., 2018). These slabs must have formed during a long history of African plate subduction because Cenozoic Africa-Eurasia convergence rates averaged only 15 km/Myr (e.g., Seton et al., 2012). The slabs are also much longer than the reconstructed paleogeographic width of the Eastern Mediterranean Ocean (450 km; van Hinsbergen et al., 2020) (Fig. 4; 60 Ma). Subduction on these slabs therefore links back to Eocene and older continental subduction in Central Anatolia, and likely to Cretaceous subduction initiation (van Hinsbergen et al., 2016, 2020; Plunder et al., 2013; Pourteau et al., 2018).

Late Cretaceous to early Eocene subduction was recorded by the continual burial, accretion, metamorphism, and extensional exhumation of the Kırşehir Block and Tavşanlı zone, and then the Afyon zone. This history was analogous to the Miocene evolution of the Aegean region (Gürer et al., 2018b), where Aegean slab retreat was a driver, also exposing high-grade metamorphic rocks (e.g., van Hinsbergen et al., 2005; Faccenna et al., 2003). In Central Anatolia, several hundred kilometres of Late Cretaceous to early Eocene east-west upper-plate extension have been reconstructed, recording the westward retreat of an east-dipping Antalya slab, plus southward retreat of the Cyprus slab (Gürer et al., 2018b; van Hinsbergen et al., 2020) (Fig. 5A).

A flat slab could only form in post-early-Eocene times, after extensional exhumation related to slab retreat. While Eocene-Miocene convergence may have been sufficient to transport a flat slab across Central Anatolia, based on the tectonic history we reviewed in Section 3, there is no structural or uplift-related expression of such transport (e.g., Ramos and Folguera, 2009) and no geodynamic argument to invoke slab-flattening such as a wide and unbroken slab (e.g., Schellart, 2020), ridge or oceanic plateau subduction (e.g., Gutscher et al., 2000), or rapid advance of the upper plate (e.g., Schepers et al., 2017).

Peeling-off delamination is also inconsistent with global tomographic models of the upper mantle (Figs. 6C and 7). Across the Mediterranean region, slabs that steepened and retreated in Neogene times are now flat-lying on the mantle transition zone (e.g., Wortel and Spakman, 2000; Jolivet et al., 2009; see also the Aegean Slab in Fig. 7). In contrast, the Cyprus and Antalya slab anomalies reach no farther than halfway across the plateau and dip steeply into the lower mantle (Gürer, 2017; van der Meer et al., 2018), ruling out recent plateau-scale slab steepening and retreat associated with peeling delamination.

5.2.2. *Lithospheric dripping*

Lithospheric dripping is thought to be an important process in regions such as the Sierra Nevada (e.g., Zandt et al., 2004) and the Central Andes (e.g., DeCelles et al., 2015; Beck et al., 2014), and has been proposed as a driver of Central Anatolian uplift (Göğüş et al., 2017) (Fig. 8E). Models of this phenomenon generally invoke localised thickening of the lithosphere (or eclogitisation of the lower crust), which becomes gravitationally unstable (e.g., Göğüş and Pysklywec, 2008; Houseman and Molnar, 1997; Marotta et al., 1998). The resulting instability grows and sinks, entraining the surrounding lithospheric mantle before finally detaching. The development of these drips drives uplift by thinning the dense lower lithosphere, and in Anatolia may have driven kilometre-scale uplift over a period of around 10 Myrs (Göğüş et al., 2017).

Göğüş et al. (2017) proposed that a lithospheric drip formed below the Kırşehir Block because after its accretion to the Anatolian orogen it was intruded by a Late Cretaceous magmatic arc and shortened by Paleogene oroclinal bending (e.g., Lefebvre et al., 2013). Also, the surrounding late Miocene Galatia and the Cappadocia volcanic centres (e.g., Kürkcüoglu et al., 2004; Reid et al., 2017) correspond to the edge of a high-velocity anomaly in the regional tomography of Fichtner et al. (2013), interpreted by Göğüş et al. (2017) as the remnants of a detached lithospheric drip.

The Late Cretaceous to Eocene evolution of the Anatolian orogen may have impacted the footprint of this process. Accretion of upper-crustal nappes, as seen in Central Anatolia or the Aegean was balanced by subduction of the lithospheric mantle (e.g., Tirel et al., 2013; Brun and Faccenna, 2008; van Hinsbergen et al., 2005). Subduction and the associated upper-plate extension in Central Anatolia thus left a thin or absent lithospheric mantle on the upper plate despite shortening relating to nappe accretion. Neogene lithospheric dripping likely affected a post Late Cretaceous lithospheric mantle – in contrast to conditions considered in numerical modelling. Paleogene oroclinal bending shortened the Kırşehir Block by around 40% (Gürer and van Hinsbergen, 2019), and so an instability may have developed even though the Kırşehir Block was likely delaminated during Late Cretaceous accretion. At least 45 km of lithospheric mantle removal is needed to drive one kilometre of uplift (e.g., Lachenbruch and Morgan, 1990), and so beyond the Kırşehir Block, uplift may have been limited by a thinly developed Paleogene-Neogene lithospheric mantle, possibly requiring additional uplift mechanisms.

Whilst lithospheric dripping below the Kırşehir Block is likely a kinematically-viable driver of Miocene uplift in eastern Central Anatolia, additional causes are needed to explain the uplift history of the plateau margin, including uplift relative to the plateau interior, the preceding and intervening marine transgressions in the southern plateau margin basins, and rapid Pleistocene uplift of Mut Basin.

5.3. *Mantle upwelling through slab gaps*

Ingress and upwelling of hot asthenosphere around the edges of subducted slabs has been proposed as a driver of Central Anatolian uplift by heating and thermal removal of the lithosphere, and as dynamic topography caused by changing mantle flow (Cosentino et al., 2012; Schildgen et al., 2014). Flow has been proposed between the Cyprus and Antalya slabs (Fig. 7F), through the Antalya and Aegean slab gap (Fig. 7E & F and Fig. 8D), and as a result of Bitlis slab break-off farther east (Fig. 7D).

By late Eocene times, the extensional exhumation of high-grade metamorphic rocks in Central Anatolia had ended, and the Taurides fold-thrust belt was accreting. In the south Central Taurides, post-Eocene wholesale underthrusting of the African Plate left little or no accretionary record until the Miocene formation of a fold-thrust belt in northern Cyprus (Figs. 3C and 4) (McPhee and van Hinsbergen, 2019). In the western Central Taurides, the Bey Dağları Platform had accreted to the Anatolian orogen by middle to late Eocene time (Figs. 3B and 4).

In West Anatolia, the Bey Dağları Platform was accreted by late Eocene times (c. 35 Ma). The Bey Dağları platform is underpinned by a 30–35 km thick crust, leading van Hinsbergen et al. (2010a) to suggest that continuous subduction of the north-dipping West Anatolia slab, which is a coherent tomographic anomaly from 1400 km to 400 km depth (Fig. 7A), was facilitated by delamination of the Bey Dağları Platform crust and its underthrusted equivalents in the Menderes Massif. The subduction thrust jumped from the deepest thrust of the Menderes Massif to the base of the Bey Dağları Platform, where it is currently piercing the surface along the Florence Rise, connecting the Aegean and Cyprus trenches. The Bey Dağları platform also formed the foreland of the western Central Taurides and was connected to the north-east-dipping Antalya slab in the Eocene. Trench jump associated with the West Anatolian slab subduction thus isolated the Antalya slab as a within-plate, passive body, still connected to the relict lithospheric mantle of the eastern Bey Dağları platform (Figs. 9 and 10)(McPhee et al., 2018a). This history suggests that the Cyprus and Antalya slabs had been separated since Eocene or earlier times (McPhee et al., 2018a) – though these slabs may even have been separated since Late Cretaceous subduction initiation at *E*-W and N-S trenches (Figs. 4, 100 Ma) (e.g., Maffione et al., 2017). The south and western Central Taurides experienced differing post-Eocene histories in terms of erosion, deposition, deformation, and uplift, likely relating to the subduction dynamics of the separate slabs (e.g., McPhee et al., 2018a, 2019).

Elsewhere, break-off of the Bitlis slab has been inferred at c. 13–10

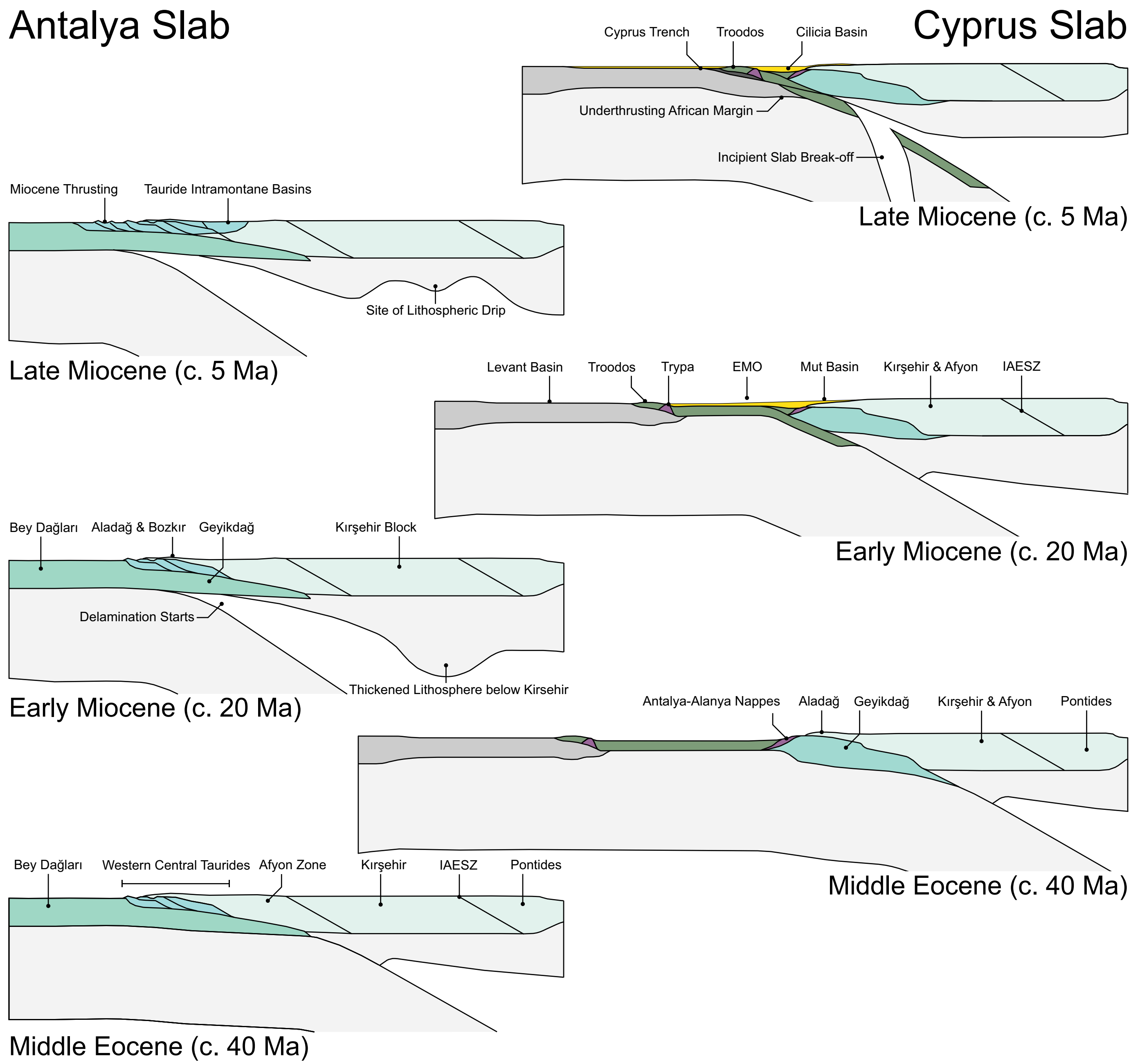


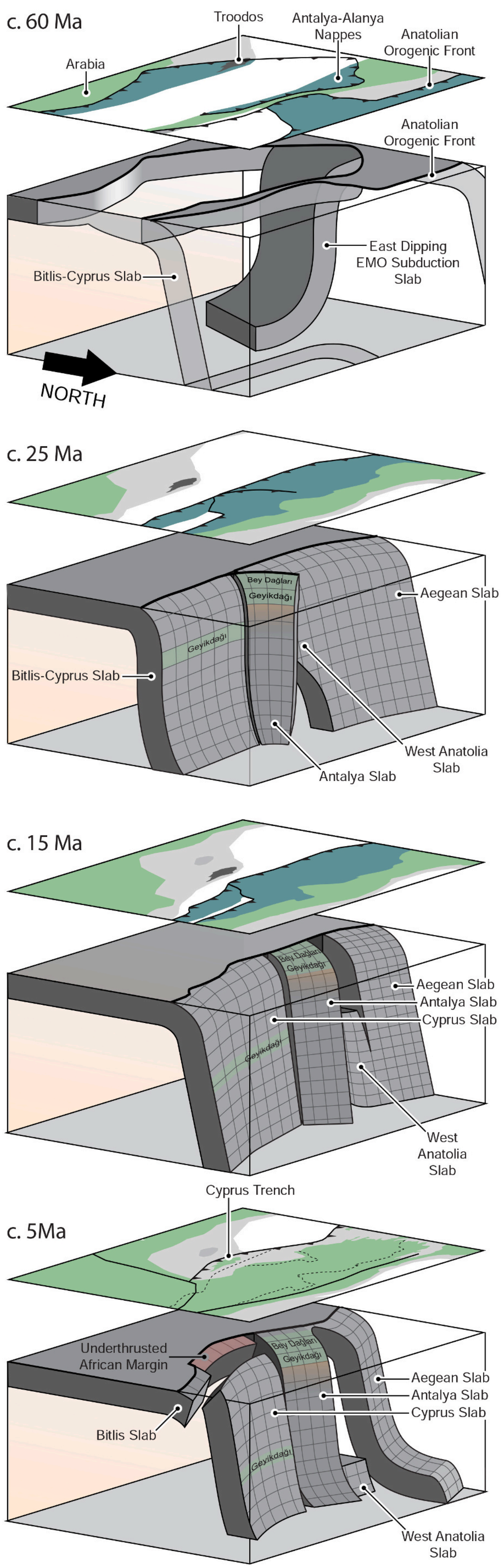
Fig. 9. Conceptual early Eocene to Present evolution of subduction on the Cyprus slab along an approximate N-S section line (Fig. 3B) and the Antalya slab along an ENE-WSW section line (Fig. 3C). These cross-sections are approximately to scale, with 2× vertical exaggeration.

Ma, based on a volcanic flare-up in East Anatolia, the rapid erosional exhumation of the overlying Bitlis region, and the end of deposition of deep marine rocks in the collision zone (Keskin, 2003; Şengör et al., 2003; Faccenna et al., 2006; Hüsing et al., 2009; Okay et al., 2010). The Antalya-Aegean slab gab formed at c. 15 Ma, based on c. 15–8 Ma clockwise rotation of the eastern Aegean region (external Hellenides; van Hinsbergen et al., 2005) at the edge of the retreating Aegean slab, coeval with alkaline and shoshonitic volcanism, and intrusion of granitic rocks (Jolivet et al., 2015 and references therein).

The slab gaps, and magmatism related to their formation, thus formed before the late Miocene uplift of Central Anatolia and were thus unlikely to have been a sole cause of uplift. Asthenospheric inflow may have contributed to processes such as thermal weakening of the Kırşehir Block lithosphere (Göğüş et al., 2017). It is also likely, based on evidence from generic modelling results (e.g., Király et al., 2020), that dynamic topography related to changes in slab configuration had some effect in Central Anatolia. Estimates of the contribution of dynamic topography in Central Anatolia, however, range from +2 km to −2 km (Gvirtzman et al., 2016; Howell et al., 2017; Şengül Uluocak et al., 2016): it is difficult to evaluate its effect on the plateau. Capturing modern vertical motions from the existing GPS network may allow testing of the importance of dynamic topography in the future, but dynamic topography does not seem to be a key cause of c. 8–5 Ma plateau rise.

5.4. Antalya slab evolution and the uplift of the western Central Taurides

In the western Central Taurides, the Geyikdağı Nappe was connected to the northeast-dipping Antalya slab anomaly at the time of its Eocene accretion (Fig. 9). This slab must have been located below or to the northeast of the Geyikdağı Nappe, which is presently exposed as far



(caption on next column)

Fig. 10. Interpreted evolution of upper mantle below Central Anatolia combined with plate reconstructions shown in Fig. 4. 60 Ma: East-dipping slab subducts the Triassic and older oceanic lithosphere of the EMO. North and north-northeast-dipping slabs related to the Anatolian orogen have been omitted. 25 Ma: The Antalya slab has been abandoned in the upper plate, and subduction continues on the Bitlis-Cyprus, West Anatolian, and Aegean slabs. 15 Ma: The Antalya Slab fills a gap formed by West Anatolian slab break-off. 5 Ma: The Bitlis and West Anatolian slabs have entered the lower mantle. The Cyprus slab has broken off, and the African Margin lithosphere is subducting. The Antalya Slab continues to steepen and slowly delaminate the western Central Taurides.

northeast as the Hadim tectonic window (Fig. 5C). McPhee et al. (2019) noted that the modern Wadati-Benioff zone of the Antalya slab has been displaced westwards by at least 150 km relative to its Eocene position (Fig. 6E). They thus inferred post-Eocene retreat of the slab to its present-day position below the Gulf of Antalya. There is no Eocene to early Miocene crustal deformation associated with this south-westward slab retreat (McPhee et al., 2018a), and only 25 km of NE-SW extension from the Miocene to the present (Koç et al., 2018), suggesting that most of this offset was accommodated by small-scale peeling delamination. Numerical models of this process predict a wave of vertical motions: subsidence at the point of peeling where the lithosphere is still connected to the crust, followed by uplift where the lithospheric mantle has peeled-off (e.g., Göğüş and Ueda, 2018; Memiş et al., 2020). We envisage peeling along deeply underthrusted Bey Dağları platform rocks that underpinned the western Central Taurides.

Low-temperature thermochronology data in the western Central Taurides suggest that Eocene erosion-related cooling was restricted to major thrust culminations (McPhee et al., 2019), rather than reflecting widespread uplift that could be related to peeling delamination. Low rates of cooling dominated until the early Miocene, and then increased across the western Central Taurides, likely signalling uplift and the erosion of the Bozkır and Aladağ nappes (McPhee et al., 2019). This inferred uplift was coeval with the enigmatic early Miocene subsidence and submergence of the Antalya Basin, which occurred without major deformation.

In middle Miocene times, kinematically-balanced extension in the Central Tauride Intramontane Basins (Koç et al., 2018) and shortening in the Antalya Basin region (McPhee et al., 2018a) formed the Central Taurides orocline (Koç et al., 2016a) (Fig. 5C), signalling either gravitational sliding from the uplifted western Central Taurides into the Antalya Basin (McPhee et al., 2019), or retreat of the Antalya slab (Koç et al., 2016a). This may have been coeval with development of poorly-dated Miocene-Pliocene volcanism in the Erenler Dağı volcanic field (Fig. 5C), which is interpreted to have formed in a volcanic arc to post collisional setting (Uyanık and Koçak, 2017). Following this, the Antalya Basin was uplifted above sea level by c. 3.5 Ma (Glover, 1995), with subsidence of the Gulf of Antalya Basin continuing to the present day, defining a southwest-travelling wave of subsidence followed by uplift, as predicted by peeling delamination models.

The early Miocene subsidence of the Antalya Basin was coeval with both the subsidence of the Bey Dağları Platform (Hayward and Robertson, 1982; van Hinsbergen et al., 2010b) and southeastward gravitational sliding of the Lycian Nappes (Figs. 4, 15 and 5 Ma)(Hayward and Robertson, 1982; Collins and Robertson, 1998; van Hinsbergen, 2010). This sliding was balanced by extension and unroofing of the southern Menderes Massif (van Hinsbergen, 2010; van Hinsbergen et al., 2010a). Peeling-delamination-induced subsidence in the Antalya Basin region may have contributed to the subsidence of the Bey Dağları Platform. Lycian Nappes translation ended around c. 15 Ma (van Hinsbergen et al., 2010b) - around the same time as the inferred break-off/tearing of the West Anatolian slab (Figs. 4, 6A, and 7) (van Hinsbergen et al., 2010a; Jolivet et al., 2015). Rebound of the Bey Dağları because of break-off may thus have decreased the topographic gradient, leading to an arrest in the motion of the Lycian Nappes. Shortening, oroclinal bending, and extension associated with the Central Tauride orocline, however, continued.

Finally, we consider it possible that following a phase of peeling delamination, Antalya slab subduction again caused underthrusting of the Bey Dağları Platform below the Taurides along the Bucak Thrust (Fig. 5C). This would kinematically facilitate, and perhaps even drive the counter-clockwise rotation of southwest Anatolia and the southeast Aegean region (van Hinsbergen et al., 2010b; Koç et al., 2016a), including the rotation of the Bey Dağları Platform.

5.5. Cyprus slab evolution and the uplift of the Mut Basin

By Eocene times, the Cyprus slab was associated with the accretion of the southern Central Taurides fold-thrust belt that was resting on a continental foreland – the accreting Geyikdağı Nappe (Fig. 9). After the accretion of the Geyikdağı Nappe, Eastern Mediterranean Ocean lithosphere was subducted, accounting for 400 km of post-Eocene convergence between Anatolia and Africa, for which there is little or no accretionary record. This transition to subduction of oceanic lithosphere (Figs. 4 and 9), which has a low bathymetry, may explain why the southern Central Taurides were apparently tectonically quiet throughout the Oligocene to middle Miocene, escaping erosional denudation such that even the structurally highest ophiolite-bearing Bozkır Nappes are widely preserved (McPhee et al., 2018b, 2019) (Fig. 3A). Ultimately, oceanic subduction led to the transgression of the Mut Basin over the southern Central Taurides, possibly because of subduction-related process such as transient slab suction, as seen in generic models of forearc subsidence (e.g., Buiter et al., 2001a, 2001b; Bonnardot et al., 2008; Husson et al., 2012; Chen et al., 2017).

The Mut Basin, which was initially uplifted at c. 8–5 Ma, contains no evidence for upper crustal shortening (Fernández-Blanco, 2014; Fernández-Blanco et al., 2019), and so three sub-upper crustal causes of uplift have been proposed, each relating to the Miocene evolution of the Cyprus slab. Fernández-Blanco (2014) suggested that if deformation of the overriding plate occurred above a region of thermal weakening at the base of the overriding plate (e.g., Fuller et al., 2006; Fernández-Blanco et al., 2020), then surface-breaking thrusts would not form. They inferred inflation of the Mut Basin monocline by underthrusting and accretion of subducted sediments during oceanic subduction. Schildgen et al. (2014), however, demonstrated that given slow rates of Neogene convergence, uplift by accretion of subducted sediments would take tens of millions of years.

As an alternative, deep underplating of the African distal continental margin following continental collision to the south has been proposed (Delph et al., 2017; Meijers et al., 2018; McPhee and van Hinsbergen, 2019). The onset of the Tauride collision with the North African continental margin likely occurred around c. 11–7 Ma, based on the age of thrusting on the distal, previously obducted African margin exposed on northern Cyprus (McPhee and van Hinsbergen, 2019). Reconstructed Neogene Africa-Eurasia convergence of 8 km/Myr (e.g., van Hinsbergen et al., 2020), could have feasibly brought the North African continental margin below the Mut Basin by c. 0.45 Ma, and may therefore, have caused or contributed to 1.6 km of late Pleistocene uplift documented by Öğretmen et al. (2018). This continental collision may have caused uplift by replacing an oceanic foreland with a thicker and more buoyant continental foreland, and/or by accretion and duplexing of rocks deep below the Taurides. Miocene and younger underthrusting would cause short-wavelength flexural uplift of the southern plateau and could explain coeval subsidence of the Cilicia Basin (Walsh-Kennedy et al., 2014) (Fig. 2). This mechanism, however, cannot account for any earlier uplift, because the African margin was located too far south at c. 8–5 Ma.

Slab break-off has been invoked as a cause of c. 8–5 Ma uplift of the southern Central Taurides and southern plateau interior (e.g., Abgarmi et al., 2017; Meijers et al., 2018; Öğretmen et al., 2018; Portner et al., 2018; Schildgen et al., 2012b). In this scenario, uplift would be driven by rebound after removal of the slab load, and inflow of asthenosphere into the gap created (Wortel and Spakman, 1992; Davies and von Blanckenburg, 1995; Buiter et al., 2001a, 2001b). Numerical modelling results suggesting long-term uplift rates of around 0.1–0.8 mm/yr, peaking at 2 mm/yr (Duretz et al., 2011; Duretz et al., 2014) - comparable with post c. 8–5 Ma rates observed in the southern plateau margin. Based on tomographic models it is unclear if the Cyprus slab has broken-off (Biryol et al., 2011; van der Meer et al., 2018; Portner et al., 2018), but if slab break-off has occurred, it probably did so geologically recently, as the gap in the slab is narrow in the tomography (Fig. 7C). A lack of seismicity at depths exceeding 50 km (Fig. 7E) supports the possibility of break-off below Cyprus and south Central Anatolia. It is also possible that slab break-off was contemporaneous with and perhaps linked to underthrusting of the African margin. It is, however, difficult to discriminate between the effects that the two mechanisms may have had on uplift. In any case, our analysis suggests that mild Pliocene drawdown and Pleistocene uplift (Öğretmen et al., 2018) are straightforwardly explained as the combined effects of recent slab break-off and the collision of Anatolia and the African margin on Cyprus.

5.6. Outlook for other plateau regions

The discussion above illustrates the use of the Central Anatolia for studying the geodynamic causes of plateau rise. Where in more evolved plateaus such as the Tibetan, Colorado, or Altiplano-Puna plateaus, discerning the various contributions of crustal thickening, slab evolution, and lithosphere dynamics may be challenging, the young and well-resolved Anatolian case has already revealed some of its great potential to contribute fundamentally to our understanding of the relationship between orogeny, geodynamics, and the formation of high topography. Studying the plateau crustal evolution and kinematic history provides essential constraints on the geodynamic conditions that preceded and changed to cause plateau rise (Fig. 10). Our analysis shows that orogenic architecture and evolution itself may not explain the formation of high topography – Central Anatolian plateau rise clearly postdates most of the crustal accretion and deformation. Later subduction dynamics have played a crucial role by modifying the plateau margin via collision, delamination, and break-off - and likely to a lesser extent by modifying mantle flow (Fig. 11).

6. Conclusions

We have evaluated potential causes of Central Anatolian Plateau rise using the long-term kinematic record of Anatolian orogenesis that, when combined with a history of Africa-Europe convergence, reveals subduction evolution. We combined this review with constraints on the spatial and temporal evolution of uplift, as well as geophysical data sets that illuminated mantle (and crustal) structure, and found that:

- Neogene crustal thickening is not a viable contributor to plateau-scale uplift since c. 8–5 Ma because there is no corresponding record of Neogene crustal shortening. Instead, plateau-scale uplift was driven by the modification or removal of the lithospheric mantle.
- Miocene plateau-scale peeling delamination of a flat slab is inconsistent with Late Cretaceous-Eocene slab retreat that widely exhumed high-grade metamorphic rocks. Global tomographic models of the mantle also show no evidence for plateau-scale slab retreat below Central Anatolia.
- A lithospheric instability may have formed by Late Cretaceous arc magmatism and 40% shortening of the Kırşehir Block. Lithospheric dripping in the plateau interior is, therefore, a viable mechanism of lithospheric mantle removal and uplift.
- Ingress of hot asthenosphere through slab gaps was likely active for millions of years before rapid plateau uplift, given the timing of gap formation. This phenomenon may have contributed to the long-wavelength uplift of the plateau interior but was unlikely to have been its sole cause.

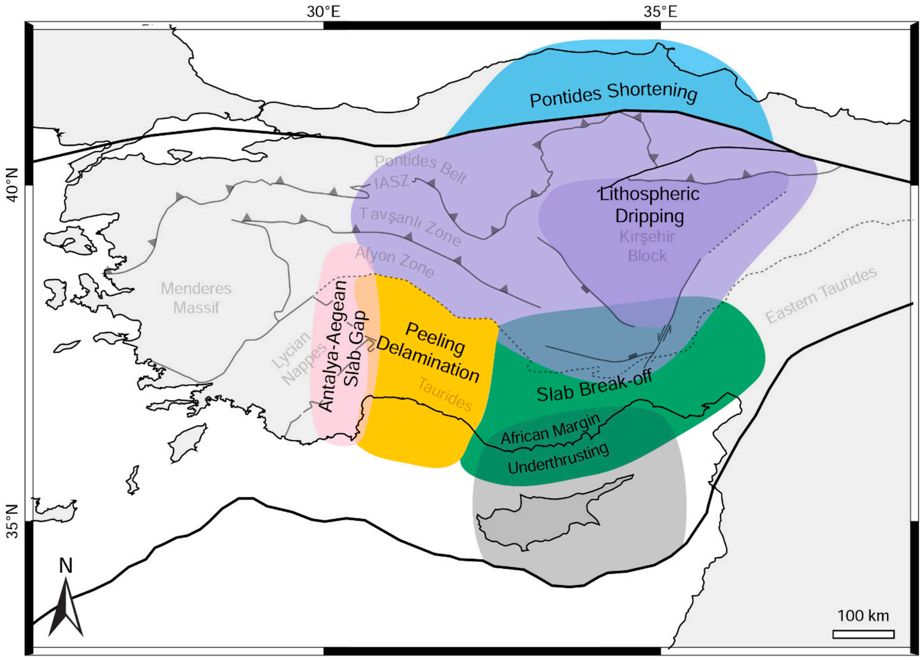


Fig. 11. Interpreted footprint of the processes we have discussed in this section.

- Early to middle Miocene uplift of the western Central Taurides, and coeval subsidence and subsequent Pliocene uplift of the Antalya Basin signalled retreat and small-scale peeling delamination of the Antalya slab. Subsidence associated with this process may have also contributed to the coeval translation of the Lycian Nappes and orоclinal bending of the western Central Taurides.
- Underthrusting of the African continental margin may be a kinematically-viable cause of post 0.45 Ma Mut Basin uplift but cannot explain any earlier uplift. Shallow break-off of the Cyprus slab is consistent with most seismic tomography models and an absence of deep seismicity below Cyprus: this is a plausible driver of c. 8–5 Ma Mut Basin uplift.
- The nascent nature of the Central Anatolian plateau allows an assessment of the relative timing and importance of different processes during plateau formation, and it may, therefore, inspire the analysis of the growth of mature high orogenic plateaus elsewhere.

Credit author statement

P.J. McPhee: Conceptualisation, Writing, Visualisation; A. Koç: Conceptualisation; D.J.J. van Hinsbergen: Supervision, Editing, Conceptualisation, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

D.J.J.v.H acknowledges NWO Vici grant 865.17.001. We thank Laurent Jolivet and Oğuz Göğüş for their constructive reviews.

References

Abgarmi, B., Delph, J.R., Arda Ozacar, A., Beck, S.L., Zandt, G., Sandvol, E., Turkelli, N., Biryol, C.B., 2017. Structure of the crust and African slab beneath the central Anatolian plateau from receiver functions: new insights on isostatic compensation and slab dynamics. Geosphere 13 (6), 1774–1787. https://doi.org/10.1130/GES01509.1.

Advokaat, E.L., van Hinsbergen, D.J.J., Kaymakcı, N., Vissers, R.L.M., Hendriks, B.W.H., 2014. Late cretaceous extension and Palaeogene rotation-related contraction in Central Anatolia recorded in the Ayhan-Büyükkışla basin. Int. Geol. Rev. 56 (15), 1813–1836. https://doi.org/10.1080/00206814.2014.954279.

Akbulut, A., 1977. Etude geologique d'une partie du taurus occidentale au sud d'Egridir (Turquie). University Paris-Sud, Orsay.

Aldanmaz, E., van Hinsbergen, D.J.J., Yıldız-Yüksekol, Ö., Schmidt, M.W., McPhee, P.J., Meisel, T., Mason, P.R.D., 2020. Effects of reactive dissolution of orthopyroxene in producing incompatible element depleted melts and refractory mantle residues during early fore-arc spreading: constraints from ophiolites in eastern Mediterranean. Lithos 360–361, 105438. https://doi.org/10.1016/j.lithos.2020.105438.

Al-Riyami, K., Robertson, A.H.F., Dixon, J., Xenophontos, C., 2002. Origin and emplacement of the Late Cretaceous Baer-Bassit ophiolite and its metamorphic sole in NW Syria. Lithos 65. https://doi.org/10.1016/S0024-4937(02)00167-6, 1–2, 225–260.

Altıner, D., Özkan-Altiner, S., Koçyiğit, A., 2000. Late Permian Foraminiferal Biofacies Belts in Turkey: Palaeogeographic and Tectonic Implications. Geol. Soc. Lond., Spec. Publ. 173 (1), 83–96. https://doi.org/10.1144/GSL.SP.2000.173.01.04.

Amaru, M.L., 2007. Global travel time tomography with 3-D reference models. Geol. Ultraiect. 274, 174.

Andrew, T., Robertson, A.H.F., 2002. The Beysehir - Hoyran - Hadim Nappes: genesis and emplacement of Mesozoic marginal and oceanic units of ther northern Neotethys in southern Turkey. J. Geol. Soc. Lond. 159, 529–543. https://doi.org/10.1144/0016-764901-157.

AYDAR*, Erkan, ÇUBUKÇU, H. Evren, ŞEN, Erdal, AKIN, Lütfiye, 2013. Central Anatolian Plateau. Turkey: incision and paleoaltimetry recorded from volcanic rocks. Turkish Journal of Earth Sciences. https://doi.org/10.3906/yer-1211-8.

Bagnall, P.S., 1960. The geology and mineral resources of the Pano Lefkara-Larnaca area. In: Memoir (Cyprus. Geological Survey Department), vol. 5. Published by the authority of the Govt. of Cyprus, p. 116.

Barnes, J.B., Ehlers, T.A., 2009. End member models for Andean Plateau uplift. Earth Sci. Rev. 97, 105–132.

Barrier, E., Vrielynck, B., 2008. Atlas of Paleotectonic Maps of the Middle East (MEBE Program) (Commission for the Geological Map of the World).

Barrier, E., Vrielynck, B., Brouillet, J., Brunet, M., 2018. Paleotectonic Reconstruction of the Central Tethyan Realm. Tectonono-Sedimentary-Palinspastic Maps from Late Permian to Pliocene. CCGM/CGMW, Paris. CCGM/CGMW Pari, France.

Bartol, J., Govers, R., 2014. A single cause for uplift of the Central and Eastern Anatolian plateau? Tectonophysics 637, 116–136. https://doi.org/10.1016/j.tecto.2014.10.002.

Beall, A.P., Moresi, L., Stern, T., 2017. Dripping or delamination? A range of mechanisms for removing the lower crust or lithosphere. Geophys. J. Int. 210 (2), 671–692. https://doi.org/10.1093/gji/ggx202.

Beck, S.L., Zandt, G., Ward, K.M., Scire, A., 2014. Multiple styles and scales of lithospheric foundering beneath the Puna Plateau, Central Andes. In: DeCelles, P.G., Ducea, M.N., Carrapa, B., Kapp, P.A. (Eds.), Geodynamics of a Cordilleran Orogenic System: The Central Andes of Argentina and Northern Chile (Vol. 212, p. 0). Geological Society of America. https://doi.org/10.1130/2015.1212(03).

Ben-Avraham, Z., Ginzburg, A., Makris, J., Eppelbaum, L., 2002. Crustal structure of the Levant Basin, eastern Mediterranean. Tectonophysics 346 (1–2), 23–43. https://doi.org/10.1016/S0040-1951(01)00226-8.

Berndt, C., Yıldırım, C., Çiner, A., Strecker, M.R., Ertunç, G., Sarıkaya, M.A., Kiyak, N.G., 2018. Quaternary uplift of the northern margin of the Central Anatolian Plateau: New OSL dates of fluvial and delta-terrace deposits of the Kızılırmak River, Black Sea coast, Turkey. Quat. Sci. Rev. 201, 446–469. https://doi.org/10.1016/j.quascirev.2018.10.029.

Bird, P., 1979. Continental Delamination and the Colorado Plateau. J. Geophys. Res. 84 (B13), 7561–7571.

Biryol, B.C., Beck, S.L., Zandt, G., Özacar, A.A., 2011. Segmented African lithosphere beneath the Anatolian region inferred from teleseismic P-wave tomography. Geophys. J. Int. 184, 1037–1057. https://doi.org/10.1111/j.1365-246X.2010.04910.x.

Bocchini, G.M., Brüstle, A., Becker, D., Meier, T., van Keken, P.E., Ruscic, M., Friederich, W., 2018. Tearing, segmentation, and backstepping of subduction in the Aegean: New insights from seismicity. Tectonophysics 734–735, 96–118. https://doi.org/10.1016/j.tecto.2018.04.002.

Bonnardot, M.A., Hassani, R., Tric, E., 2008. Numerical modelling of lithosphere-asthenosphere interaction in a subduction zone. Earth Planet. Sci. Lett. 272 (3–4), 698–708. https://doi.org/10.1016/j.epsl.2008.06.009.

van der Boon, A., van Hinsbergen, D.J.J., Rezaeian, M., Gürer, D., Honarmand, M., Pastor-Galán, D., Krijgsman, W., Langereis, C.G., 2018. Quantifying Arabia–Eurasia convergence accommodated in the Greater Caucasus by paleomagnetic reconstruction. Earth Planet. Sci. Lett. 482, 454–469.

de Boorder, H., Spakman, W., White, S., Wortel, M.J., 1998. Late Cenozoic mineralization, orogenic collapse and slab detachment in the European Alpine Belt. Earth Planet. Sci. Lett. 164 (3–4), 569–575. https://doi.org/10.1016/S0012-821X(98)00247-7.

Brun, J.-P., Faccenna, C., 2008. Exhumation of high-pressure rocks driven by slab rollback. Earth Planet. Sci. Lett. 272 (1–2), 1–7. https://doi.org/10.1016/j.epsl.2008.02.038.

Buiter, S.J.H., Govers, R., Wortel, M.J.R., 2001a. A modelling study of vertical displacements at convergent margins. Geophys. J. Int. 147 (June), 415–427. https://doi.org/10.1046/j.1365-246X.2001.00545.x.

Buiter, S.J.H., Govers, R., Wortel, M.J.R., 2001b. A modelling study of vertical displacements at convergent margins. Geophys. J. Int. 147 (June), 415–427. https://doi.org/10.1046/j.1365-246X.2001.00545.x.

Candan, O., Çetinkaplan, M., Oberhänsli, R., Rimmelé, G., Akal, C., 2005. Alpine high-P/low-T metamorphism of the Afyon Zone and implications for the metamorphic evolution of Western Anatolia, Turkey. Lithos 84 (1–2), 102–124. https://doi.org/10.1016/j.lithos.2005.02.005.

Çelik, Ö.F., Delaloye, M.F., 2006. Characteristics of ophiolite-related metamorphic rocks in the Beysehir ophiolitic mélange (Central Taurides, Turkey), deduced from whole rock and mineral chemistry. J. Asian Earth Sci. 26 (5), 461–476. https://doi.org/10.1016/j.jseaes.2004.10.008.

Çelik, Ö.F., Topuz, G., Billor, Z., Özkan, M., 2019. Middle Jurassic subduction-related ophiolite fragment in Triassic accretionary complex (Mamu Dağı ophiolite, Northern Turkey). Int. Geol. Rev. 61, 2021–2035.

Çetinkaplan, M., Pourteau, A., Candan, O., Koralay, O.E., Oberhänsli, R., Okay, A.I., Chen, F., Kozlu, H., Şengün, F., 2016. P–T–t evolution of eclogite/blueschist facies metamorphism in Alanya Massif: time and space relations with HP event in Bitlis Massif, Turkey. Int. J. Earth Sci. 105, 247–281.

Chen, Z., Schellart, W.P., Duarte, J.C., Strak, V., 2017. Topography of the Overriding Plate during Progressive Subduction: a Dynamic Model to Explain Forearc Subsidence. Geophys. Res. Lett. 44 (19), 9632–9643. https://doi.org/10.1002/2017GL074672.

Çiner, A., Karabiyiko, M., Monod, O., Deynoux, M., Tuzcu, S., 2008. Late Cenozoic Sedimentary Evolution of the Antalya Basin, Southern Turkey. Turk. J. Earth Sci. 17 (July 2007), 1–41.

Çiner, A., Doğan, U., Yıldırım, C., Akçar, N., Ivy-Ochs, S., Alfimov, V., Schlüchter, C., 2015. Quaternary uplift rates of the Central Anatolian Plateau, Turkey: insights from cosmogenic isochron-burial nuclide dating of the Kızılırmak River terraces. Quat. Sci. Rev. 107, 81–97. https://doi.org/10.1016/j.quascirev.2014.10.007.

Cipollari, P., Cosentino, D., Radeff, G., Schildgen, T.F., Faranda, C., Grossi, F., Gliozzi, E., Smedile, A., Gennari, R., Darbaş, G., Dudas, F.Ö., Gürbüz, K., Nazik, A., Echtler, H.P., 2013. Easternmost Mediterranean evidence of the Zanclean flooding event and subsequent surface uplift: Adana Basin, southern Turkey. In: Robertson, A.H.F., Parlak, O., Ünlügenç, U.C. (Eds.), Geological Development of Anatolia and the Easternmost Mediterranean Region, vol. 372. Geological Society of London Special Publications, pp. 473–494.

Çivgin, B., Kaypak, B., 2017. Estimation of the crustal structure in Central Anatolia (Turkey) using receiver functions. Turk. J. Earth Sci. 26 (4), 314–330. https://doi.org/10.3906/yer-1703-14.

Clark, M., Robertson, A.H.F., 2005. Uppermost Cretaceous–lower Tertiary Ulukışla Basin, south-Central Turkey: sedimentary evolution of part of a unified basin complex within an evolving Neotethyan suture zone. Sediment. Geol. 173 (1–4), 15–51. https://doi.org/10.1016/j.sedgeo.2003.12.010.

Coleman, M., Hodges, K., 1995. Evidence for Tibetan plateau uplift before 14 Myr ago from a new minimum age for east–west extension. Nature. https://doi.org/10.1038/374049a0.

Collins, A.S., Robertson, A.H.F., 1997. Lycian melange, southwestern Turkey: an emplaced late cretaceous accretionary complex. Geology 25 (3), 255–258. https://doi.org/10.1130/0091-7613(1997)025<0255:LMSTAE>2.3.CO;2.

Collins, A.S., Robertson, A.H.F., 1998. Processes of late cretaceous to late Miocene episodic thrust-sheet translation in the Lycian Taurides, SW Turkey. J. Geol. Soc. 155 (5), 759–772. https://doi.org/10.1144/gsjgs.155.5.0759.

Collins, A.S., Robertson, A.H.F., 2003. Kinematic evidence for late Mesozoic-Miocene emplacement of the Lycian Allochthon over the Western Anatolide Belt, SW Turkey. Geol. J. 38 (3–4), 295–310. https://doi.org/10.1002/gj.957.

Cosentino, D., Schildgen, T.F., Cipollari, P., Faranda, C., Gliozzi, E., Hudáčková, N., Strecker, M.R., 2012. Late Miocene surface uplift of the southern margin of the Central Anatolian plateau, Central Taurides, Turkey. Bull. Geol. Soc. Am. 124 (1), 133–145. https://doi.org/10.1130/B30466.1.

Davies, J.H., von Blanckenburg, F., 1995. Slab breakoff: a model of lithosphere detachment and its test in the magmatism and deformation of collisional orogens. Earth Planet. Sci. Lett. 129 (1–4), 85–102. https://doi.org/10.1016/0012-821X(94)00237-S.

DeCelles, P.G., Carrapa, B., Horton, B.K., McNabb, J., Gehrels, G.E., Boyd, J., 2015. The Miocene Arizaro Basin, central Andean hinterland: Response to partial lithosphere removal? In: DeCelles, P.G., Ducea, M.N., Carrapa, B., Kapp, P.A. (Eds.), Geodynamics of a Cordilleran Orogenic System: The Central Andes of Argentina and Northern Chile, vol. 212. Geological Society of America Memoir, pp. 359–386. Geodynamic.

Delph, J.R., Abgarmi, B., Ward, K.M., Beck, S.L., Özacar, A.A., Zandt, G., Türkelli, N., 2017. The effects of subduction termination on the continental lithosphere: linking volcanism, deformation, surface uplift, and slab tearing in Central Anatolia. Geosphere 13 (6), 1788–1805. https://doi.org/10.1130/GES01478.1.

Demir, T., Yeşilnacar, İ., Westaway, R., 2004. River terrace sequences in Turkey: sources of evidence for lateral variations in regional uplift. Proc. Geol. Assoc. 115 (4), 289–311. https://doi.org/10.1016/S0016-7878(04)80010-5.

Deynoux, M., Çiner, A., Monod, O., Karabıyıkoglu, M., Manatschal, G., Tuzcu, S., 2005. Facies architecture and depositional evolution of alluvial fan to fan-delta complexes in the tectonically active Miocene Köprüçay Basin, Isparta Angle, Turkey. Sediment. Geol. 173 (1–4), 315–343. https://doi.org/10.1016/j.sedgeo.2003.12.013.

Dilek, Y., Thy, P., Hacker, B., Grundvig, S., 1999. Structure and petrology of Tauride ophiolites and mafic dike intrusions (Turkey): Implications for the Neotethyan Ocean. Geol. Soc. Am. Bull. 111 (8), 1192–1216. https://doi.org/10.1130/0016-7606(1999)111<1192:SAPOTO>2.3.CO;2.

Doğan, U., 2011. Climate-controlled river terrace formation in the Kizilirmak Valley, Cappadocia section, Turkey: Inferred from Ar-Ar dating of Quaternary basalts and terraces stratigraphy. Geomorphology 126 (1–2), 66–81. https://doi.org/10.1016/j.geomorph.2010.10.028.

Dokuz, A., Aydınçakır, E., Kandemir, R., Karslı, O., Siebel, W., Derman, A.S., Turan, M., 2017. Late Jurassic Magmatism and Stratigraphy in the Eastern Sakarya Zone, Turkey: evidence for the Slab Breakoff of Paleotethyan Oceanic Lithosphere. J. Geol. 125 (1), 1–31. https://doi.org/10.1086/689552.

Duretz, T., Gerya, T.V., May, D.A., 2011. Numerical modelling of spontaneous slab breakoff and subsequent topographic response. Tectonophysics 502 (1–2), 244–256. https://doi.org/10.1016/j.tecto.2010.05.024.

Duretz, T., Schmalholz, S.M., Gerya, T.V., 2012. Dynamics of slab detachment. Geochem. Geophys. Geosyst. 13, Q03020 https://doi.org/10.1029/2011GC004024.

Espurt, N., Hippolyte, J.C., Kaymakci, N., Sangu, E., 2014. Lithospheric structural control on inversion of the southern margin of the Black Sea Basin, Central Pontides, Turkey. Lithosphere 6 (1), 26–34.

Faccenna, C., Jolivet, L., Piromallo, C., Morelli, A., 2003. Subduction and the depth of convection of the Mediterranean mantle. J. Geophys. Res. 108, 2099.

Faccenna, C., Bellier, O., Martinod, J., Piromallo, C., Regard, V., 2006. Slab detachment beneath eastern Anatolia: a possible cause for the formation of the North Anatolian fault. Earth Planet. Sci. Lett. 242 (1–2), 85–97. https://doi.org/10.1016/j.epsl.2005.11.046.

Feld, C., Mechie, J., Hübscher, C., Hall, J., Nicolaides, S., Gurbuz, C., Weber, M., 2017. Crustal structure of the Eratosthenes Seamount, Cyprus and S. Turkey from an amphibian wide-angle seismic profile. Tectonophysics 700–701, 32–59. https://doi.org/10.1016/j.tecto.2017.02.003.

Fernández-Blanco, D., 2014. Evolution of Orogenic Plateaus at Subduction Zones Sinking and raising the southern margin of the Central Anatolian Plateau. PhD Thesis. VU University Amsterdam.

Fernández-Blanco, D., Bertotti, G., Çiner, A., 2013. Cenozoic tectonics of the Tuz Gölü Basin (Central Anatolia Plateau, Turkey). Turk. J. Earth Sci. 22 (5), 715–738. https://doi.org/10.3906/yer-1206-7.

Fernández-Blanco, D., Bertotti, G., Aksu, A., Hall, J., 2019. Monoclinal flexure of an orogenic plateau margin during subduction, South Turkey. Basin Res. 31 (4), 709–727. https://doi.org/10.1111/bre.12341.

Fernández-Blanco, D., Mannu, U., Bertotti, G., Willett, S.D., 2020. Forearc high uplift by lower crustal flow during growth of the Cyprus-Anatolian margin. Earth Planet. Sci. Lett. 544, 116314. https://doi.org/10.1016/j.epsl.2020.116314.

Fichtner, A., Saygin, E., Taymaz, T., Cupillard, P., Capdeville, Y., Trampert, J., 2013. The deep structure of the North Anatolian Fault Zone. Earth Planet. Sci. Lett. 373, 109–117. https://doi.org/10.1016/j.epsl.2013.04.027.

Flecker, R., Poisson, A., Robertson, A.H.F., 2005. Facies and palaeogeographic evidence for the Miocene evolution of the Isparta Angle in its regional eastern Mediterranean context. Sediment. Geol. 173 (1–4), 277–314. https://doi.org/10.1016/j.sedgeo.2003.10.014.

Fuller, C.W., Willett, S.D., Brandon, M., 2006. Formation of forearc basins and their influence on subduction zone earthquakes. Geology 34 (2), 65–68.

Gautier, P., Bozkurt, E., Hallot, E., Dirik, K., 2002. Dating the exhumation of a metamorphic dome: Geological evidence for pre-Eocene unroofing of the Nigde Massif (Central Anatolia, Turkey). Geol. Mag. 139, 559–576.

Gautier, Pierre, Bozkurt, E., Bosse, V., Hallot, E., Dirik, K., 2008. Coeval extensional shearing and lateral underflow during Late Cretaceous core complex development in the Niğde Massif, Central Anatolia, Turkey. Tectonics 27 (1). https://doi.org/10.1029/2006TC002089 n/a-n/a.

Genç, Y., Yürür, M.T., 2010. Coeval extension and compression in late Mesozoic-recent thin-skinned extensional tectonics in Central Anatolia, Turkey. J. Struct. Geol. 32 (5), 623–640. https://doi.org/10.1016/j.jsg.2010.03.011.

Gessner, K., Ring, U., Passchier, C.W., Gungor, T., 2001. How to resist subduction: evidence for large-scale out-of-sequence thrusting during Eocene collision in western Turkey. J. Geol. Soc. 158 (5), 769–784. https://doi.org/10.1144/jgs.158.5.769.

Glover, C.P., 1995. Plio-Quaternary Sediments and Neotectonics of the Isparta. PhD Thesis. The University of Edinburgh.

Glover, C.P., Robertson, A.H.F., 1998. Role of regional extension and uplift in the Plio-Pleistocene evolution of the Aksu Basin, SW Turkey. J. Geol. Soc. 155 (2), 365–387. https://doi.org/10.1144/gsjgs.155.2.0365.

Göğüş, O.H., Pysklywec, R.N., 2008. Near-surface diagnostics of dripping or delaminating lithosphere. J. Geophys. Res. Solid Earth 113 (11), 1–11. https://doi.org/10.1029/2007JB005123.

Göğüş, O.H., Ueda, K., 2018. Peeling back the lithosphere: Controlling parameters, surface expressions and the future directions in delamination modeling. J. Geodyn. 117 (October 2017), 21–40. https://doi.org/10.1016/j.jog.2018.03.003.

Göğüş, O.H., Pysklywec, R.N., Şengör, A.M.C., Gün, E., 2017. Drip tectonics and the enigmatic uplift of the Central Anatolian Plateau. Nat. Commun. 8 (1) https://doi.org/10.1038/s41467-017-01611-3.

Görür, N., Oktay, F.Y., Seymen, I., Sengör, A.M.C., 1984. Palaeotectonic evolution of the Tuzgolu basin complex, Central Turkey: sedimentary record of a Neo-Tethyan closure. Geol. Soc. Lond., Spec. Publ. 17 (1), 467–482. https://doi.org/10.1144/GSL.SP.1984.017.01.34.

Görür, N., Tüysüz, O., Şengör, A.M.C., 1998. Tectonic Evolution of the Central Anatolian Basins. Int. Geol. Rev. 40 (9), 831–850. https://doi.org/10.1080/00206819809465241.

Govers, R., Fichtner, A., 2016. Signature of slab fragmentation beneath Anatolia from full-waveform tomography. Earth Planet. Sci. Lett. 450, 10–19. https://doi.org/10.1016/j.epsl.2016.06.014.

Granot, R., 2016. Palaeozoic oceanic crust preserved beneath the eastern Mediterranean. Nat. Geosci. 9 (9), 701–705. https://doi.org/10.1038/ngeo2784.

Gülyüz, E., Kaymakci, N., Meijers, M.J.M., van Hinsbergen, D.J.J., Lefebvre, C., Vissers, R.L.M., Peynircioğlu, A.A., 2013. Late Eocene evolution of the Çiçekdağı Basin (Central Turkey): Syn-sedimentary compression during microcontinent–continent collision in Central Anatolia. Tectonophysics 602, 286–299. https://doi.org/10.1016/j.tecto.2012.07.003.

Gürer, M.D., 2017. Subduction evolution in the Anatolian region: the rise, demise, and fate of the Anadolu Plate. Utrecht Stud. Earth Sci. 138. ISBN: 978-90-6266-481-8.

Gürer, D., van Hinsbergen, D.J.J., 2019. Diachronous demise of the Neotethys Ocean as a driver for non-cylindrical orogenesis in Anatolia. Tectonophysics. https://doi.org/10.1016/j.tecto.2018.06.005.

Gürer, D., van Hinsbergen, D.J.J., Matenco, L., Corfu, F., Cascella, A., 2016. Kinematics of a former oceanic plate of the Neotethys revealed by deformation in the Ulukışla basin (Turkey). Tectonics 35 (10), 2385–2416. https://doi.org/10.1002/2016TC004206.

Gürer, D., Plunder, A., Kirst, F., Corfu, F., Schmid, S.M., van Hinsbergen, D.J.J., 2018a. A long-lived late Cretaceous–early Eocene extensional province in Anatolia? Structural evidence from the Ivriz Detachment, southern Central Turkey. Earth Planet. Sci. Lett. 481, 111–124. https://doi.org/10.1016/j.epsl.2017.10.008.

Gürer, D., van Hinsbergen, D.J.J., Özkaptan, M., Creton, I., Koymans, M.R., Cascella, A., Langereis, C.G., 2018b. Paleomagnetic constraints on the timing and distribution of Cenozoic rotations in Central and Eastern Anatolia. Solid Earth 9 (2), 295–322. https://doi.org/10.5194/se-9-295-2018.

Gutnic, M., Monod, O., Poisson, A., Dumont, J.F., 1979. Géologie des Taurides Occidentales (Turquie). Mémoires de La Société Géologique de France 137, 1–112.

Gutscher, M.A., Spakman, W., Bijwaard, H., Engdahl, E.R., 2000. Geodynamics of flat subduction: Seismicity and tomographic constraints from the Andean margin. Tectonics 19 (5), 814–833. https://doi.org/10.1029/1999TC001152.

Gvirtzman, Z., Faccenna, C., Becker, T.W., 2016. Isostasy, flexure, and dynamic topography. Tectonophysics 683, 255–271. https://doi.org/10.1016/j.tecto.2016.05.041.

Hafkenscheid, E., Wortel, M.J.R., Spakman, W., 2006. Subduction history of the Tethyan region derived from seismic tomography and tectonic reconstructions. J. Geophys. Res. 111 (B8), B08401 https://doi.org/10.1029/2005JB003791.

Hall, R., Spakman, W., 2015. Mantle structure and tectonic history of SE Asia. Tectonophysics 658, 14–45.

Hässig, M., Rolland, Y., Sosson, M., Galoyan, G., Sahakyan, L., Topuz, G., Müller, C., 2013. Linking the NE Anatolian and Lesser Caucasus ophiolites: evidence for large-scale obduction of oceanic crust and implications for the formation of the Lesser Caucasus-Pontides Arc. Geodin. Acta 26 (3–4), 311–330. https://doi.org/10.1080/09853111.2013.877236.

Hayward, A.B., Robertson, A.H.F., 1982. Direction of ophiolite emplacement inferred from cretaceous and Tertiary sediments of an adjacent autochthon, the Bey Daglari, Southwest Turkey. Geol. Soc. Am. Bull. 93 (January), 68–75. https://doi.org/10.1130/0016-7606(1982)93<68:DOOEIF>2.0.CO;2.

van Hinsbergen, D.J.J., 2010. A key extensional metamorphic complex reviewed and restored: the Menderes Massif of western Turkey. Earth Sci. Rev. 102 (1–2), 60–76. https://doi.org/10.1016/j.earscirev.2010.05.005.

van Hinsbergen, D.J.J., Schmid, S.M., 2012. Map view restoration of Aegean-West Anatolian accretion and extension since the Eocene. Tectonics 31 (5), 1–40. https://doi.org/10.1029/2012TC003132.

van Hinsbergen, D.J.J., Hafkenscheid, E., Spakman, W., Meulenkamp, J.E., Wortel, R., 2005. Nappe stacking resulting from subduction of oceanic and continental lithosphere below Greece. Geology 33 (4), 325. https://doi.org/10.1130/G20878.1.

van Hinsbergen, D.J.J., Kaymakci, N., Spakman, W., Torsvik, T.H., 2010a. Reconciling the geological history of western Turkey with plate circuits and mantle tomography. Earth Planet. Sci. Lett. 297 (3–4), 674–686. https://doi.org/10.1016/j.epsl.2010.07.024.

van Hinsbergen, D.J.J., Dekkers, M.J., Koç, A., 2010b. Testing Miocene remagnetization of Beydagları: timing and amount of Neogene rotations in SW Turkey. Turkish J. Earth Sci. 19 (April 2009), 123–156. https://doi.org/10.3906/yer-0904-1.

van Hinsbergen, D.J.J., Maffione, M., Plunder, A., Kaymakcı, N., Ganerød, M., Hendriks, B.W.H., Corfu, F., Gürer, D., de Gelder, G.I.N.O., Peters, K., McPhee, P.J., Brouwer, F.M., Advokaat, E.L., Vissers, R.L.M., 2016. Tectonic evolution and paleogeography of the Kırşehir Block and the Central Anatolian Ophiolites, Turkey. Tectonics 35 (4), 983–1014. https://doi.org/10.1002/2015TC004018.

van Hinsbergen, D.J.J., Torsvik, T.H., Schmid, S.M., Maţenco, L.C., Maffione, M., Vissers, R.L.M., Spakman, W., 2020. Orogenic architecture of the Mediterranean region and kinematic reconstruction of its tectonic evolution since the Triassic. Gondwana Res. 81, 79–229. https://doi.org/10.1016/j.gr.2019.07.009.

van Hinsbergen, D.J.J., Steinberger, B., Guilmette, C., Maffione, M., Gürer, D., Peters, K., Spakman, W., 2021. A record of plume-induced plate rotation triggering subduction initiation. Nat. Geosci. https://doi.org/10.1038/s41561-021-00780-7.

Houseman, Gregory A., Molnar, P., 1997. Gravitational (Rayleigh-Taylor) instability of a layer with non-linear viscosity and convective thinning of continental lithosphere. Geophys. J. Int. 128 (1), 125–150. https://doi.org/10.1111/j.1365-246X.1997.tb04075.x.

Howell, A., Jackson, J., Copley, A., McKenzie, D., Nissen, E., 2017. Subduction and vertical coastal motions in the eastern Mediterranean. Geophys. J. Int. 593–620. https://doi.org/10.1093/gji/ggx307. December.

Hüsing, S.K., Zachariasse, W.J., van Hinsbergen, D.J.J., Krijgsman, W., Inceöz, M., Harzhauser, M., Kroh, A., 2009. Oligo-Miocene foreland basin evolution in SE Anatolia: implications for the closure of the eastern Tethys gateway. In: van Hinsbergen, D.J.J., Edwards, M.A., Govers, R. (Eds.), Collision and Collapse at the Africa-Arabia-Eurasia Subduction Zone. Geological Society of London Special Publication 311, pp. 107–132.

Husson, L., Guillaume, B., Funiciello, F., Faccenna, C., Royden, L.H., 2012. Unraveling topography around subduction zones from laboratory models. Tectonophysics 526–529, 5–15. https://doi.org/10.1016/j.tecto.2011.09.001.

Ilbeyli, N., Pearce, J.A., Thirlwall, M.F., Mitchell, J.G., 2004. Petrogenesis of collision-related plutonics in Central Anatolia, Turkey. Lithos 72 (3–4), 163–182. https://doi.org/10.1016/j.lithos.2003.10.001.

Isik, V., 2009. The ductile shear zone in granitoid of the Central Anatolian Crystalline complex, Turkey: Implications for the origins of the Tuzgölü basin during the late cretaceous extensional deformation. J. Asian Earth Sci. 34, 507–521.

Jolivet, L., Faccenna, C., Piromallo, C., 2009. From mantle to crust: stretching the Mediterranean. Earth Planet. Sci. Lett. 285, 198–209.

Jolivet, L., Menant, A., Sternai, P., Rabillard, A., Arbaret, L., Augier, R., Le Pourhiet, L., 2015. The geological signature of a slab tear below the Aegean. Tectonophysics 659, 166–182. https://doi.org/10.1016/j.tecto.2015.08.004.

Kalyoncuoğlu, Ü.Y., Elitok, Ö., Dolmaz, M.N., Anadolu, N.C., 2011. Geophysical and geological imprints of southern Neotethyan subduction between Cyprus and the Isparta Angle, SW Turkey. J. Geodyn. 52 (1), 70–82. https://doi.org/10.1016/j.jog.2010.12.001.

Kapp, P., DeCelles, P.G., 2019. Mesozoic–Cenozoic geological evolution of the Himalayan-Tibetan orogen and working tectonic hypotheses. Am. J. Sci. 319 (3), 159–254. https://doi.org/10.2475/03.2019.01.

Karabiyikoglu, M., Ciner, A., Monod, O., Deynoux, M., Tuzcu, S., Orcen, S., 2000. Tectonosedimentary Evolution of the Miocene Manavgat Basin, Western Taurides, Turkey. Geol. Soc. Lond., Spec. Publ. 173 (1), 271–294. https://doi.org/10.1144/GSL.SP.2000.173.01.14.

Kaymakci, N., Özçelik, Y., White, S.H., Van Dijk, P.M., 2009. Tectono-stratigraphy of the Çankırı Basin: late cretaceous to early Miocene evolution of the Neotethyan Suture Zone in Turkey. Geol. Soc. Lond., Spec. Publ. 311 (1), 67–106. https://doi.org/10.1144/SP311.3.

Keskin, M., 2003. Magma generation by slab steepening and breakoff beneath a subduction-accretion complex: an alternative model for collision-related volcanism in Eastern Anatolia, Turkey. Geophys. Res. Lett. 30 (24) https://doi.org/10.1029/2003GL018019.

Keskin, M., Genç, Ş.C., Tüysüz, O., 2008. Petrology and geochemistry of post-collisional Middle Eocene volcanic units in North-Central Turkey: evidence for magma generation by slab breakoff following the closure of the Northern Neotethys Ocean. Lithos 104 (1–4), 267–305. https://doi.org/10.1016/j.lithos.2007.12.011.

Kind, R., Eken, T., Tilmann, F., Sodoudi, F., Taymaz, T., Bulut, F., Schneider, F., 2015. Thickness of the lithosphere beneath Turkey and surroundings from S-receiver functions. Solid Earth 6 (3), 971–984. https://doi.org/10.5194/se-6-971-2015.

Király, Á., Portner, D.E., Haynie, K.L., Chilson-Parks, B.H., Ghosh, T., Jadamec, M., O'Farrell, K.A., 2020. The effect of slab gaps on subduction dynamics and mantle upwelling. Tectonophysics 785 (November 2019), 228458. https://doi.org/10.1016/j.tecto.2020.228458.

Kissel, C., Poisson, A., 1986. Etude paléomagnétique préliminaire des formations néogènes du bassin d'Antalya (Taurides occidentales-Turquie). Comptes rendus de l'Académie des sciences. Série 2. Mécanique Phys. Chim. Sci. l'univ. Sci. Terre 302, 711–716.

Koç, A., Kaymakci, N., van Hinsbergen, D.J.J., Kuiper, K.F., Vissers, R.L.M., 2012. Tectono-Sedimentary evolution and geochronology of the Middle Miocene Altınapa Basin, and implications for the late Cenozoic uplift history of the Taurides, southern

Turkey. Tectonophysics 532–535, 134–155. https://doi.org/10.1016/j.tecto.2012.01.028.
Koç, A., Kaymakci, N., van Hinsbergen, D.J.J., Vissers, R.L.M., 2016a. A Miocene onset of the modern extensional regime in the Isparta Angle: constraints from the Yalvaç Basin (Southwest Turkey). Int. J. Earth Sci. 105 (1), 369–398. https://doi.org/10.1007/s00531-014-1100-z.
Koç, A., van Hinsbergen, D.J.J., Kaymakci, N., Langereis, C.G., 2016b. Late Neogene oroclinal bending in the central Taurides: a record of terminal eastward subduction in southern Turkey? Earth Planet. Sci. Lett. 434 (1), 75–90. https://doi.org/10.1016/j.epsl.2015.11.020.
Koç, A., Kaymakci, N., Van Hinsbergen, D.J.J., Kuiper, K.F., 2017. Miocene tectonic history of the Central Tauride intramontane basins, and the paleogeographic evolution of the Central Anatolian Plateau. Glob. Planet. Chang. https://doi.org/10.1016/j.gloplacha.2017.09.001.
Koç, A., van Hinsbergen, D.J., Langereis, C.G., 2018. Rotations of normal fault blocks quantify extension in the Central Tauride intramontane basins, SW Turkey. Tectonics 37, 2307–2327.
Koulakov, I., Sobolev, S.V., 2006. Moho depth and three-dimensional P and S structure of the crust and uppermost mantle in the Eastern Mediterranean and Middle East derived from tomographic inversion of local ISC data. Geophys. J. Int. 164 (1), 218–235. https://doi.org/10.1111/j.1365-246X.2005.02791.x.
Kürkcüoglu, B., Sen, E., Temel, A., Aydar, E., Gourgaud, A., 2004. Interaction of Asthenospheric and Lithospheric Mantle: the Genesis of Calc-alkaline Volcanism at Erciyes Volcano, Central Anatolia, Turkey. Int. Geol. Rev. 46 (3), 243–258. https://doi.org/10.2747/0020-6814.46.3.243.
Lachenbruch, A.H., Morgan, P., 1990. Continental extension, magmatism and elevation; formal relations and rules of thumb. Tectonophysics 174 (1–2), 39–62. https://doi.org/10.1016/0040-1951(90)90383-J.
Lefebvre, C., Barnhoorn, A., van Hinsbergen, D.J.J., Kaymakci, N., Vissers, R.L.M., 2011. Late cretaceous extensional denudation along a marble detachment fault zone in the Kırşehir massif near Kaman, Central Turkey. J. Struct. Geol. 33, 1220–1236.
Lefebvre, C., Meijers, M.J.M., Kaymakci, N., Peynircioğlu, A., Langereis, C.G., van Hinsbergen, D.J.J., 2013. Reconstructing the geometry of Central Anatolia during the late cretaceous: Large-scale Cenozoic rotations and deformation between the Pontides and Taurides. Earth Planet. Sci. Lett. 366, 83–98. https://doi.org/10.1016/j.epsl.2013.01.003.
Lefebvre, C., Peters, K., Wehrens, P., Brouwer, F.M., Van Roermund, H.L.M., 2015. Thermal and extensional exhumation history of a high-temperature crystalline complex (Hırkadağ Massif, Central Anatolia). Lithos 238, 156–173.
Lei, J., Zhao, D., 2007. Teleseismic evidence for a break-off subducting slab under Eastern Turkey. Earth Planet. Sci. Lett. 257 (1–2), 14–28. https://doi.org/10.1016/j.epsl.2007.02.011.
Licht, A., Coster, P., Ocakoğlu, F., Campbell, C., Métais, G., Mulch, A., Beard, K.C., 2017. Tectono-stratigraphy of the Orhaniye Basin, Turkey: implications for collision chronology and Paleogene biogeography of Central Anatolia. J. Asian Earth Sci. 143, 45–58. https://doi.org/10.1016/j.jseaes.2017.03.033.
Lips, A.L.W., Cassard, D., Sözbilir, H., Yilmaz, H., Wijbrans, J.R., 2001. Multistage exhumation of the Menderes Massif, western Anatolia (Turkey). Int. J. Earth Sci. 89 (4), 781–792. https://doi.org/10.1007/s005310000101.
Lüdecke, T., Mikes, T., Rojay, F.B., Cosca, M.A., Mulch, A., 2013. Stable isotope-based reconstruction of Oligo-Miocene paleoenvironment and paleohydrology of Central Anatolian lake basins (Turkey). Turk. J. Earth Sci. 22 (5), 793–819. https://doi.org/10.3906/yer-1207-11.
Mackintosh, P.W., Robertson, A.H.F., 2012. Sedimentary and structural evidence for two-phase Upper cretaceous and Eocene emplacement of the Tauride thrust sheets in central southern Turkey. Geol. Soc. Lond., Spec. Publ. 372 (1), 299–322. https://doi.org/10.1144/SP372.2.
Maffione, M., van Hinsbergen, D.J.J., 2018. Reconstructing Plate Boundaries in the Jurassic Neo-Tethys from the East and West Vardar Ophiolites (Greece and Serbia). Tectonics 37 (3), 858–887. https://doi.org/10.1002/2017TC004790.
Maffione, M., van Hinsbergen, D.J.J., de Gelder, G.I.N.O., van der Goes, F.C., Morris, A., 2017. Kinematics of late cretaceous subduction initiation in the Neo-Tethys Ocean reconstructed from ophiolites of Turkey, Cyprus, and Syria. J. Geophys. Res. Solid Earth 122 (5), 3953–3976. https://doi.org/10.1002/2016JB013821.
Marotta, A.M., Fernàndez, M., Sabadini, R., 1998. Mantle unrooting in collisional settings. Tectonophysics 296, 31–46.
McNab, F., Ball, P.W., Hoggard, M.J., White, N.J., 2017. Neogene Uplift and Magmatism of Anatolia: Insights from Drainage Analysis and Basaltic Geochemistry. Geochem. Geophys. Geosyst. 19 (1), 175–213. https://doi.org/10.1002/2017GC007251.
McPhee, P.J., van Hinsbergen, D.J.J., 2019. Tectonic reconstruction of Cyprus reveals late Miocene continental collision between Africa and Anatolia. Gondwana Res. 68 (January) https://doi.org/10.1016/j.gr.2018.10.015.
McPhee, P.J., van Hinsbergen, D.J.J., Maffione, M., Altıner, D., 2018a. Palinspastic Reconstruction Versus Cross-Section Balancing: how complete is the Central Taurides Fold-Thrust Belt (Turkey)? Tectonics 37 (11), 4285–4310. https://doi.org/10.1029/2018TC005152.
McPhee, P.J., Altıner, D., van Hinsbergen, D.J.J., 2018b. First balanced cross section across the taurides fold-thrust belt: geological constraints on the subduction history of the antalya slab in Southern Anatolia. Tectonics 1–22. https://doi.org/10.1029/2017TC004893.
McPhee, P.J., van Hinsbergen, D.J.J., Thomson, S.N., 2019. Thermal history of the western Central Taurides fold-thrust belt: implications for Cenozoic vertical motions of southern Central Anatolia. Geosphere. https://doi.org/10.1130/GES02164.1.
van der Meer, D.G., van Hinsbergen, D.J.J., Spakman, W., 2018. Atlas of the underworld: Slab remnants in the mantle, their sinking history, and a new outlook on lower mantle viscosity. Tectonophysics 723 (2011), 309–448. https://doi.org/10.1016/j.tecto.2017.10.004.
Meijers, M.J.M., Kaymakci, N., van Hinsbergen, D.J.J., Langereis, C.G., Stephenson, R.A., Hippolyte, J.-C., 2010. Late Cretaceous to Paleocene oroclinal bending in the central Pontides (Turkey). Tectonics 29 (4). https://doi.org/10.1029/2009TC002620 n/a-n/a.
Meijers, M.J.M., Strauss, B.E., Özkaptan, M., Feinberg, J.M., Mulch, A., Whitney, D.L., Kaymakçı, N., 2016. Age and paleoenvironmental reconstruction of partially remagnetized lacustrine sedimentary rocks (Oligocene Aktoprak basin, Central Anatolia, Turkey). Geochem. Geophys. Geosyst. 17 (3), 914–939. https://doi.org/10.1002/2015GC006209.
Meijers, M.J.M., Brocard, G.Y., Cosca, M.A., Lüdecke, T., Teyssier, C., Whitney, D.L., Mulch, A., 2018. Rapid late Miocene surface uplift of the Central Anatolian Plateau margin. Earth Planet. Sci. Lett. 497, 29–41. https://doi.org/10.1016/j.epsl.2018.05.040.
Meijers, M.J., Brocard, G.Y., Whitney, D.L., Mulch, A., 2020. Paleoenvironmental conditions and drainage evolution of the central Anatolian lake system (Turkey) during late Miocene to Pliocene surface uplift. Geosphere 16, 490–509. https://doi.org/10.1130/GES02135.02131.
Memiş, C., Göğüş, O.H., Uluocak, E.Ş., Pysklywec, R., Keskin, M., Şengör, A.M.C., Topuz, G., 2020. Long Wavelength Progressive Plateau Uplift in Eastern Anatolia since 20 Ma: Implications for the Role of Slab Peel-Back and Break-off. Geochem. Geophys. Geosyst. 21 (2) https://doi.org/10.1029/2019GC008726.
Menant, A., Jolivet, L., Vrielynck, B., 2016. Kinematic reconstructions and magmatic evolution illuminating crustal and mantle dynamics of the eastern Mediterranean region since the late cretaceous. Tectonophysics 675, 103–140. https://doi.org/10.1016/j.tecto.2016.03.007.
Menant, A., Jolivet, L., Tuduri, J., Loiselet, C., Bertrand, G., Guillou-Frottier, L., 2018. 3D subduction dynamics: a first-order parameter of the transition from copper- to gold-rich deposits in the eastern Mediterranean region. Ore Geol. Rev. 94, 118–135. https://doi.org/10.1016/j.oregeorev.2018.01.023.
Moix, P., Beccaletto, L., Kozur, H.W., Hochard, C., Rosselet, F., Stampfli, G.M., 2008. A new classification of the Turkish terranes and sutures and its implication for the paleotectonic history of the region. Tectonophysics 451 (1–4), 7–39. https://doi.org/10.1016/j.tecto.2007.11.044.
Moix, P., Beccaletto, L., Masset, O., Kozur, H., Dumitrica, P., Vachard, D., Martini, R., Stampfli, G., 2011. Geology and Correlation of the Mersin Mélanges, Southern Turkey. Turk. J. Earth Sci. 20, 57–98.
Molnar, P., Lyon-Caen, H., 1988. Some simple physical aspects of the support, structure, and evolution of mountain belts. Geol. Soc. Am. Spec. Publ. 218, 179–207.
Morris, A., Robertson, A.H.F., 1993. Miocene remagnetisation of carbonate platform and Antalya complex units within the Isparta angle, SW Turkey. Tectonophysics 220, 243–266.
Morris, A., Anderson, M.W., Inwood, J., Robertson, A.H.F., 2006. Palaeomagnetic insights into the evolution of Neotethyan oceanic crust in the eastern Mediterranean: Geological Society, London. Spec. Publ. 260 (1), 351–372. https://doi.org/10.1144/GSL.SP.2006.260.01.15.
Morris, A., Anderson, M.W., Omer, A., Maffione, M., van Hinsbergen, D.J.J., 2017. Rapid fore-arc extension and detachment-mode spreading following subduction initiation. Earth Planet. Sci. Lett. 478, 76–88. https://doi.org/10.1016/j.epsl.2017.08.040.
Mueller, M., Licht, A., Campbell, C., Ocakoğlu, F., Taylor, M., Burch, L., Ugrai, T., Kaya, M., Kurtoğlu, B., Coster, P., 2019. Collision chronology along the İzmir-Ankara-Erzincan suture zone: Insights from the Sarıcakaya Basin, western Anatolia. Tectonics 38, 3652–3674.
Öğretmen, N., Cipollari, P., Frezza, V., Faranda, C., Karanika, K., Gliozzi, E., Cosentino, D., 2018. Evidence for 1.5 km of Uplift of the Central Anatolian Plateau's Southern margin in the last 450 kyr and Implications for its Multiphased Uplift history. Tectonics 1–32. https://doi.org/10.1002/2017TC004805.
Okay, A.I., 1986. High-pressure/low-temperature metamorphic rocks of Turkey. Geol. Soc. Am. Mem. 164, 333–347.
Okay, A.I., Nikishin, A.M., 2015. Tectonic evolution of the southern margin of Laurasia in the Black Sea region. Int. Geol. Rev. 57 (5–8), 1051–1076. https://doi.org/10.1080/00206814.2015.1010609.
Okay, A.I., Zattin, M., Cavazza, W., 2010. Apatite fission-track data for the Miocene Arabia-Eurasia collision. Geology 38 (1), 35–38. https://doi.org/10.1130/G30234.1.
Özdamar, Ş., Billor, M.Z., Sunal, G., Esenli, F., Roden, M.F., 2013. First U-Pb SHRIMP zircon and 40Ar/39Ar ages of metarhyolites from the Afyon-Bolkardag Zone, SW Turkey: Implications for the rifting and closure of the Neo-Tethys. Gondwana Res. 24 (1), 377–391. https://doi.org/10.1016/j.gr.2012.10.006.
Özgül, N., 1984. Stratigraphy and tectonic evolution of the central Taurus. In: Proceedings of International Symposium on the Geology of the Taurus Belt, 1983 (pp. 77–90). General Directorate of Mineral Research and Exploration (MTA).
Ozsayin, E., Ciner, A., Rojay, F.B., Dirik, R.K., Melnick, D., Fernandez-Blanco, D., Sudo, M., 2013. Plio-Quaternary extensional tectonics of the Central Anatolian Plateau: a case study from the Tuz Golu Basin, Turkey. Turk. J. Earth Sci. 22 (5), 691–714. https://doi.org/10.3906/yer-1210-5.
Parlak, O., 2016. The tauride ophiolites of Anatolia (Turkey): a review. J. Earth Sci. 27 (6), 901–934. https://doi.org/10.1007/s12583-016-0679-3.
Plunder, A., Agard, P., Chopin, C., Okay, A.I., 2013. Geodynamics of the Tavşanlı zone, western Turkey: Insights into subduction/obduction processes. Tectonophysics 608, 884–903. https://doi.org/10.1016/j.tecto.2013.07.028.
Plunder, A., Agard, P., Chopin, C., Soret, M., Okay, A.I., Whitechurch, H., 2016. Metamorphic sole formation, emplacement and blueschist facies overprint: early subduction dynamics witnessed by western Turkey ophiolites. Terra Nova 28 (5), 329–339. https://doi.org/10.1111/ter.12225.

Poisson, A., Yagmurlu, F., Bozcu, M., Senturk, M., 2003. New insights on the tectonic setting and evolution around the apex of the Isparta Angle (SW Turkey). Geol. J. 38 (3–4), 257–282. https://doi.org/10.1002/gj.955.

Portner, D.E., Delph, J.R., Biryol, C.B., Beck, S.L., Zandt, G., Özacar, A.A., Türkelli, N., 2018. Subduction termination through progressive slab deformation across Eastern Mediterranean subduction zones from updated P-wave tomography beneath Anatolia. Geosphere 14 (3), 1–19. https://doi.org/10.1130/GES01617.1.

Pourteau, A., Candan, O., Oberhänsli, R., 2010. High-pressure metasediments in Central Turkey: Constraints on the Neotethyan closure history. Tectonics 29 (5), TC5004. https://doi.org/10.1029/2009tc002650.

Pourteau, A., Sudo, M., Candan, O., Lanari, P., Vidal, O., Oberhänsli, R., 2013. Neotethys closure history of Anatolia: Insights from 40Ar-39Ar geochronology and P-T estimation in high-pressure metasedimentary rocks. J. Metamorph. Geol. 31 (6), 585–606. https://doi.org/10.1111/jmg.12034.

Pourteau, A., Scherer, E.E., Schorn, S., Bast, R., Schmidt, A., Ebert, L., 2018. Thermal evolution of an ancient subduction interface revealed by Lu–Hf garnet geochronology, Halilbağı complex (Anatolia). Geosci. Front. https://doi.org/10.1016/j.gsf.2018.03.004.

Racano, S., Jara-Muñoz, J., Cosentino, D., Melnick, D., 2020. Variable Quaternary Uplift along the Southern margin of the Central Anatolian Plateau Inferred from Modeling Marine Terrace Sequences. Tectonics 39 (12). https://doi.org/10.1029/2019TC005921.

Radeff, G., Schildgen, T.F., Cosentino, D., Strecker, M.R., Cipollari, P., Darbaş, G., Gürbüz, K., 2015. Sedimentary evidence for late Messinian uplift of the SE margin of the Central Anatolian Plateau: Adana Basin, southern Turkey. Basin Res. 1–27. https://doi.org/10.1111/bre.12159.

Ramos, V.A., Folguera, A., 2009. Andean flat-slab subduction through time. Geol. Soc. Lond., Spec. Publ. 327 (1), 31–54. https://doi.org/10.1144/SP327.3.

Reiche, S., Hübscher, C., 2015. The Hecataeus rise, easternmost Mediterranean: a structural record of Miocene-Quaternary convergence and incipient continent-continent-collision at the African-Anatolian plate boundary. Mar. Pet. Geol. 67, 368–388. https://doi.org/10.1016/j.marpetgeo.2015.04.021.

Reid, M.R., Schleiffarth, W.K., Cosca, M.A., Delph, J.R., Blichert-Toft, J., Cooper, K.M., 2017. Shallow melting of MORB-like mantle under hot continental lithosphere, Central Anatolia. Geochem. Geophys. Geosyst. 18 (5), 1866–1888. https://doi.org/10.1002/2016GC006772.

Reilinger, R., McClusky, S., Vernant, P., Lawrence, S., Ergintav, S., Cakmak, R., Karam, G., 2006. GPS constraints on continental deformation in the Africa-Arabia-Eurasia continental collision zone and implications for the dynamics of plate interactions. J. Geophys. Res. Solid Earth 111 (5), 1–26. https://doi.org/10.1029/2005JB004051.

Ring, U., Johnson, C., Hetzel, R., Gessner, K., 2003. Tectonic denudation of a late Cretaceous-Tertiary collisional belt: Regionally symmetric cooling patterns and their relation to extensional faults in the Anatolide belt of western Turkey. Geol. Mag. 140, 421–441.

Robertson, A.H.F., 1998. Tectonic significance of the Eratosthenes Seamount: a continental fragment in the process of collision with a subduction zone in the eastern Mediterranean (Ocean Drilling Program Leg 160). Tectonophysics 298 (1–3), 63–82. https://doi.org/10.1016/S0040-1951(98)00178-4.

Robertson, A.H.F., 2004. Development of concepts concerning the genesis and emplacement of Tethyan ophiolites in the Eastern Mediterranean and Oman regions. Earth Sci. Rev. 66 (3–4), 331–387. https://doi.org/10.1016/j.earscirev.2004.01.005.

Robertson, A.H.F., Woodcock, N.H., 1981. Alakir çay Group, Antalya complex, SW Turkey: a deformed Mesozoic carbonate margin. Sediment. Geol. 30, 95–131.

Robertson, A.H.F., Kidd, R.B., Ivanov, M.K., Limonov, A.F., Woodside, J.M., Galindo-Zaldivar, J., Nieto, L., 1995. Eratosthenes Seamount: collisional processes in the easternmost Mediterranean in relation to the Plio-Quaternary uplift of southern Cyprus. Terra Nova 7 (2), 254–264.

Robertson, A.H.F., Unlügenç, Ü.C., İnan, N., Taśli, K., 2004. The Misis–Andırın complex: a Mid-Tertiary melange related to late-stage subduction of the Southern Neotethys in S Turkey. J. Asian Earth Sci. 22 (5), 413–453. https://doi.org/10.1016/S1367-9120(03)00062-2.

Robertson, A.H.F., Parlak, O., Ustaömer, T., 2009. Melange genesis and ophiolite emplacement related to subduction of the northern margin of the Tauride–Anatolide continent, central and western Turkey. Geol. Soc. Lond., Spec. Publ. 311, 9–66. https://doi.org/10.1144/sp311.2.

Ruddiman, W.F., Kutzbach, J.E., 1989. Forcing of late Cenozoic northern hemisphere climate by plateau uplift in southern Asia and the American west. J. Geophys. Res. 94 (D15), 18409. https://doi.org/10.1029/JD094iD15p18409.

Schellart, W.P., 2020. Control of Subduction Zone Age and size on Flat Slab Subduction. Front. Earth Sci. 8 https://doi.org/10.3389/feart.2020.00026.

Schepers, G., Van Hinsbergen, D.J.J., Spakman, W., Kosters, M.E., Boschman, L.M., McQuarrie, N., 2017. South-American plate advance and forced Andean trench retreat as drivers for transient flat subduction episodes. Nat. Commun. 8 (March 2019), 1–9. https://doi.org/10.1038/ncomms15249.

Schildgen, T.F., Cosentino, D., Bookhagen, B., Niedermann, S., Yildirim, C., Echtler, H., Strecker, M.R., 2012a. Multi-phased uplift of the southern margin of the Central Anatolian plateau, Turkey: a record of tectonic and upper mantle processes. Earth Planet. Sci. Lett. 317–318, 85–95. https://doi.org/10.1016/j.epsl.2011.12.003.

Schildgen, T.F., Cosentino, D., Caruso, A., Buchwaldt, R., Yıldırım, C., Bowring, S.A., Strecker, M.R., 2012b. Surface expression of eastern Mediterranean slab dynamics: neogene topographic and structural evolution of the southwest margin of the Central Anatolian Plateau, Turkey. Tectonics 31 (2). https://doi.org/10.1029/2011TC003021 n/a-n/a.

Schildgen, T.F., Yıldırım, C., Cosentino, D., Strecker, M.R., 2014. Linking slab break-off, Hellenic trench retreat, and uplift of the Central and Eastern Anatolian plateaus. Earth Sci. Rev. 128, 147–168. https://doi.org/10.1016/j.earscirev.2013.11.006.

Schmidt, A., Pourteau, A., Candan, O., Oberhänsli, R., 2015. Lu–Hf geochronology on cm-sized garnets using microsampling: New constraints on garnet growth rates and duration of metamorphism during continental collision (Menderes Massif, Turkey). Earth Planet. Sci. Lett. 432, 24–35. https://doi.org/10.1016/j.epsl.2015.09.015.

Sengör, A.M.C., Yilmaz, Y., 1981. Tethyan evolution of Turkey: a plate tectonic approach. Tectonophysics 75 (3–4), 181–241. https://doi.org/10.1016/0040-1951(81)90275-4.

Şengör, A.M.C., Özeren, S., Genç, T., Zor, E., 2003. East Anatolian high plateau as a mantle-supported, north-south shortened domal structure. Geophys. Res. Lett. 30 (24) https://doi.org/10.1029/2003GL017858.

Şengül Uluocak, E., Pysklywec, R., Göğüş, O.H., 2016. Present-day dynamic and residual topography in Central Anatolia. Geophys. J. Int. 206 (3), 1515–1525. https://doi.org/10.1093/gji/ggw225.

Seton, M., Müller, R.D., Zahirovic, S., Gaina, C., Torsvik, T., Shephard, G., Chandler, M., 2012. Global continental and ocean basin reconstructions since 200Ma. Earth Sci. Rev. 113 (3–4), 212–270.

Seyitoglu, G., Isik, V., Gürbüz, E., Gürbüz, A., 2017. The discovery of a low-angle normal fault in the Taurus Mountains: the {\.{I}}vriz detachment and implications concerning the Cenozoic geology of southern Turkey. Turk. J. Earth Sci. 26, 189–205. https://doi.org/10.3906/yer-1610-11.

Şiş, F.S., Kouwenhoven, T.J., Koc, A., Kaymakci, N., 2020. Paleobathymetric evolution of the Miocene deposits of the Gömbe sector of the Lycian Foreland and Aksu basins in Antalya, Turkey. Turk. J. Earth Sci. 29 (4), 649–663.

Skobeltsyn, G., Mellors, R., Gök, R., Türkelli, N., Yetirmishli, G., Sandvol, E., 2014. Upper mantle S wave velocity structure of the East Anatolian-Caucasus region. Tectonics 33 (3), 207–221. https://doi.org/10.1002/2013TC003334.

Sobel, E.R., Hilley, G.E., Strecker, M.R., 2003. Formation of internally drained contractional basins by aridity-limited bedrock incision. J. Geophys. Res. Solid Earth 108 (B7). https://doi.org/10.1029/2002JB001883.

Symeou, V., Homberg, C., Nader, F.H., Darnault, R., Lecomte, J.C., Papadimitriou, N., 2018. Longitudinal and Temporal Evolution of the Tectonic style along the cyprus arc system, assessed through 2-D reflection seismic interpretation. Tectonics 1–18. https://doi.org/10.1002/2017TC004667.

Tezel, T., Shibutani, T., Kaypak, B., 2013. Crustal thickness of Turkey determined by receiver function. J. Asian Earth Sci. 75, 36–45. https://doi.org/10.1016/j.jseaes.2013.06.016.

Tirel, C., Brun, J.P., Burov, E., Wortel, M.J.R., Lebedev, S., 2013. A plate tectonics oddity: Caterpillar-walk exhumation of subducted continental crust. Geology 41 (5), 555–558. https://doi.org/10.1130/G33862.1.

Topuz, G., Celik, O.F., Sengör, A.M., Altintas, I.E., Zack, T., Rolland, Y., Barth, M., 2014. Jurassic ophiolite formation and emplacement as backstop to a subduction-accretion complex in Northeast Turkey, the Refahiye ophiolite, and relation to the Balkan ophiolites. Am. J. Sci. 313 (10), 1054–1087. https://doi.org/10.2475/10.2013.04.

Uyanık, C., Koçak, K., 2017. Geochemical characteristics of the Erenlerdağı volcanics, Konya, central Turkey. Bull. Geol. Soc. Greece 50 (4), 2057. https://doi.org/10.12681/bgsg.11952.

Vanacore, E.A., Taymaz, T., Saygin, E., 2013. Moho structure of the anatolian plate from receiver function analysis. Geophys. J. Int. 193 (1), 329–337. https://doi.org/10.1093/gji/ggs107.

Vinnik, L.P., Erduran, M., Oreshin, S.I., Kosarev, G.L., Kutlu, Y.A., Çakir, Ö., Kiselev, S.G., 2014. Joint inversion of P- and S-receiver functions and dispersion curves of Rayleigh waves: the results for the Central Anatolian Plateau. Izvestiya Phys. Solid Earth 50 (5), 622–631. https://doi.org/10.1134/S106935131404017X.

Vrielynck, B., Bonneau, M., Danelian, T., Cadet, J.-P., Poisson, A., 2003. New insights on the Antalya Nappes in the apex of the Isparta Angle: the Isparta Çay unit revisited. Geol. J. 38, 283–293.

Walsh-Kennedy, S., Aksu, A.E., Hall, J., Hiscott, R.N., Yaltırak, C., Çifçi, G., 2014. Source to sink: the development of the latest Messinian to Pliocene–Quaternary Cilicia and Adana Basins and their linkages with the onland Mut Basin, eastern Mediterranean. Tectonophysics 622, 1–21. https://doi.org/10.1016/j.tecto.2014.01.019.

Wasoo, M.H., Özkaptan, M., Koç, A., 2020. New insights on the Neogene tectonic evolution of the Aksu Basin (SE Turkey) from the Anisotropy of magnetic Susceptibility (AMS) and paleostress data. J. Struct. Geol. 139 (March) https://doi.org/10.1016/j.jsg.2020.104137.

Whitney, D.L., Hamilton, M.A., 2004. Timing of high-grade metamorphism in Central Turkey and the assembly of Anatolia. J. Geol. Soc. 161 (5), 823–828. https://doi.org/10.1144/0016-764903-081.

Wortel, M., Spakman, W., 1992. Structure and dynamics of subducted lithosphere in the Mediterranean region. Proc. Koninklijke Nederlandse Akademie Wetenschappen 95, 325–347.

Wortel, M.J.R., Spakman, W., 2000. Subduction and slab detachment in the Mediterranean-Carpathian region. Science 290 (5498), 1910–1917.

Yildirim, C., Schildgen, T.F., Echtler, H., Melnick, D., Strecker, M.R., 2011. Late Neogene and active orogenic uplift in the Central Pontides associated with the North Anatolian Fault: Implications for the northern margin of the Central Anatolian Plateau, Turkey. Tectonics 30 (5), 1–24. https://doi.org/10.1029/2010TC002756.

Yildirim, C., Melnick, D., Ballato, P., Schildgen, T.F., Echtler, H., Erginal, A.E., Strecker, M.R., 2013a. Differential uplift along the northern margin of the central anatolian plateau: Inferences from marine terraces. Quat. Sci. Rev. 81, 12–28. https://doi.org/10.1016/j.quascirev.2013.09.011.

Yildirim, C., Schildgen, T.F., Echtler, H., Melnick, D., Bookhagen, B., Çiner, A., Strecker, M.R., 2013b. Tectonic implications of fluvial incision and pediment deformation at the northern margin of the Central Anatolian Plateau based on multiple cosmogenic nuclides. Tectonics 32 (5), 1107–1120. https://doi.org/10.1002/tect.20066.

Yildiz, A., Toker, V., Demircan, H., Sevim, S., 2003. Paleoenvironmental interpretation and findings of Pliocene-Pleistocene nannoplankton, planktic foraminifera, trace fossil in the Mut Basin. Bull. Earth Sci. Appl. Res. Centre Hacettepe Univ. 28, 123–144.

Zandt, G., Gilbert, H., Owens, T.J., Ducea, M., Saleeby, J., Jones, C.H., 2004. Active foundering of a continental arc root beneath the southern Sierra Nevada in California. Nature 432, 41–46.