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A single cause for uplift of the Central and Eastern Anatolian plateau?

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ABSTRACT

Regional observations suggest that the Central Anatolian plateau (central Turkey) has risen by >1 km since the Tortonian (~8 Ma) while significant crustal shortening did not occur. This uplift was preceded by the onset of widespread volcanism (~14–9 Ma). The lithospheric context of these events is however unknown. For the Eastern Anatolian plateau, similar events have been attributed to the late-stage evolution of the northern Neotethys slab, resulting in delamination and slab breakoff. Recent tomographic results indicate that this slab extended beneath both below the Eastern and Central Anatolian plateau just prior to delamination. We propose a new lithospheric scenario for the regional evolution in the Aegean–Anatolian–Near East region that combines a recent compilation of surface geology data with the structure of the upper mantle. Following the Cretaceous–Eocene closure of the northern Neotethys, Africa–Eurasia convergence was accommodated by horizontal subduction at a trench that was located south of Anatolia. Like before the closure, the northern Neotethys slab continued to sink into the deeper mantle beneath the Izmir–Ankara–Erzincan suture. In the early Miocene (~20–15 Ma), the northern Neotethys slab started to retreat southward to the trench, resulting in delamination of the lithospheric mantle. The last part of this scenario is testable, whether delamination can explain the uplift of both the Central and Eastern Anatolian plateau. In the east, uplift due to collision of Arabia is included. We use a coupled thermal–flexural model of the lithosphere. The model results show that delamination can explain the average present-day long-wavelength topography of the Central Anatolian plateau. For the Eastern Anatolian plateau, delamination explains half the present-day elevation. We find that a single delamination event also accounts for the present-day surface heat flow and Curie-point depth in both plateaus. We therefore propose to refer to central and east Anatolia since the middle Miocene as "the Anatolian plateau".

1. Introduction

High plateaus like the Colorado, Tibetan and the southern Puna-Altiplano plateau share various characteristics like a period of rapid uplift, high surface heat flow, an anomalously thin lithospheric mantle and an epoch of widespread volcanism (Bird, 1979; Kay and Kay, 1993; Levander et al., 2011; Molnar et al., 1993). To explain these observations, delamination of the lithospheric mantle has been proposed (Bird, 1978, 1979). When the lithospheric mantle delaminates, it sinks into the asthenosphere and is replaced by (relative) low-density mantle material, eventually with plateau uplift as a consequence.

Central Anatolia (Fig. 1a and b) possesses all the characteristics of a plateau. Important observations are a period of rapid and significant uplift as suggested by the Topuzdağ lava (CVP, Fig. 1) that solidified 1 km below its present-day elevation (8.2 Ma, Aydar et al., 2013), and the discovery of Tortonian (~8 Ma) shallow marine sediments and a carbonate complex (Fig. 1b, Mut basin) at an elevation of more than ~1000 m (Cosentino et al., 2012; Görür et al., 1995; Janson et al., 2010). These Miocene sediments are largely undisturbed, so that it is unlikely that regional uplift was caused by large scale Miocene–Recent crustal shortening (Cosentino et al., 2012). Volcanic ash and tuff within the middle to late Miocene sediments suggest that this uplift was preceded by the onset of widespread volcanism (Fig. 1b, Cappadocia Volcanic Province (CVP), ~14–9 Ma, Le Pennec et al., 2005) with a possible mantle source (e.g., Kürkcüoglu et al., 2004). Moreover, Central Anatolia is characterized by a high surface heat flow today (Tezcan and Turgay, 1991) and is underlain by an anomalously thin lithospheric mantle as shown by low seismic wave velocities at sub-crustal levels (Al-Lazki et al., 2004; Gans et al., 2009; Gök et al., 2003; Hearn and Ni, 1994; Maggi and Priestley, 2005; Mutlu and Karabulut, 2011; Schivardi and Morelli, 2011). The cause for the uplift of the Central Anatolian Plateau (CAP) thus likely should be sought in the mantle (e.g., Aldanmaz et al., 2000; Ilbeyli et al., 2004).

The East Anatolian Plateau (EAP) shows evidence of a rapid uplift during the Langhian (Keskin, 2003; Şengör et al., 2003) in the Muş and Elazığ basin (Fig. 1b, Hüsing et al., 2009). Here, Oligocene–early Miocene marine sediments are found at an elevation of more than 1000 m (Hüsing et al., 2009). The EAP is also characterized by widespread Miocene–Recent volcanism with a possible asthenospheric signature (Keskin, 2003; Keskin et al., 1998; Lebedev et al., 2010; Pearce et al., 1990; Şengör et al., 2003), high surface heat flow (Tezcan and

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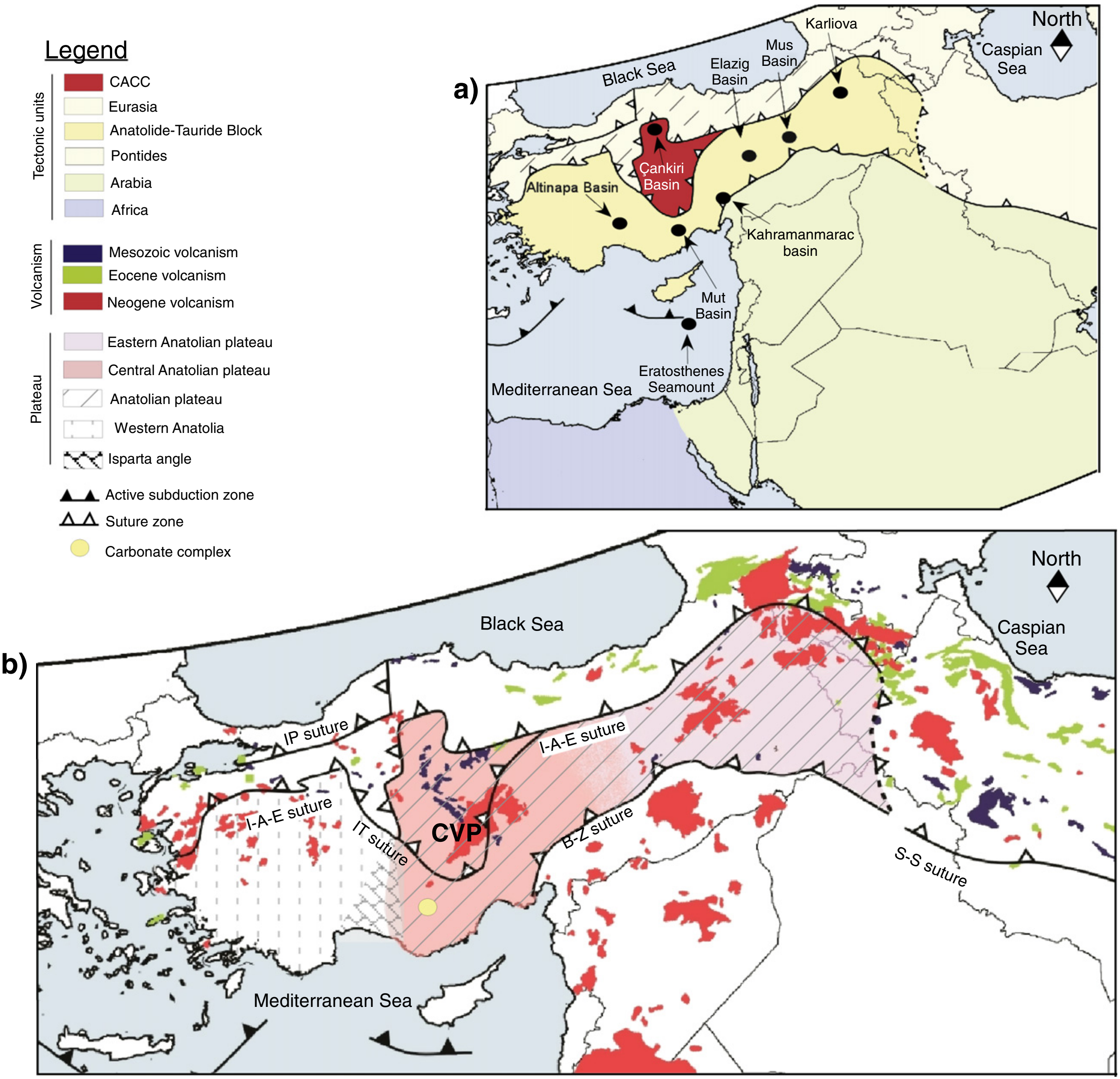

Fig. 1. a) Major plate boundaries and tectonic units within Anatolia and its surroundings (Okay, 2008). Note that the Anatolide–Taurides extend into eastern Turkey and that the Pontides are part of Eurasia. b) Age and distribution of Cenozoic volcanism (Haghipour, 2009), the location the Central Anatolian plateau (CAP), the Eastern Anatolian plateau (EAP), Isparta angle (sensu lato), and western Anatolia. We investigate the hypothesis that the EAP and the CAP together form one single Anatolian plateau (hatched area). IP; intra Pontides, IT; Inner Tauride, I–A–E; Izmir–Ankara–Erzincan, B–Z; Bitlis–Zagros; CACC (Central Anatolian Core Complex), CVP; Cappadocia Volcanic Province.

Turgay, 1991) and an anomalous thin lithospheric mantle (Angus et al., 2006; Şengör et al., 2003). These observations have been suggested to result from delamination of the lithospheric mantle (Keskin et al., 1998; Pearce et al., 1990) driven by steepening and southward retreat of the northern Neotethys slab and crustal thickening due to the Miocene Arabia–Eurasia collision (Göğüş and Pysklywec, 2008; Keskin, 2003, 2007; Sengör et al., 2008; Şengör et al., 2003).

Seismic tomographic images of the mantle beneath the Aegean region and the Mediterranean margin of Anatolia show two separate high-velocity anomalies between 50 and 400 km depth (Biryol et al., 2011). These anomalies are interpreted as the Aegean slab in the west and the Bitlis–Cyprus slab in the east. Toward the bottom of the upper mantle, around a depth of ~600 km, a single high-velocity anomaly is imaged that extends from the Aegean to eastern Anatolia, and possibly beyond. This well-resolved anomaly connects to the more shallow and separate high-velocity anomalies corresponding to the Bitlis–Cyprus and Aegean slab. This suggests that, previously, the northern Neotethys slab was laterally continuous below the CAP and EAP.

To tie the convergence and subduction history of the region to the evolution of the crust, we need to constrain the lithospheric evolution in a wider regional context. This is the aim of this paper. We use the upper mantle structure in combination with a recently published synthesis of the geological evolution of the crust of the EAP and CAP to constrain the lithospheric evolution of the region. More specifically, we investigate whether the scenario that was developed for the EAP (Keskin, 2003, 2007; Şengör et al., 2003) can be extended to include the CAP (Bartol et al., 2010). This is the basis for our new hypothesis for the plate tectonic evolution of the Aegean–Anatolian–Near East. Using quantitative modeling, we investigate a testable element of this hypothesis, the regional uplift and thermal evolution, and compare these with the observations.