



## Dating the *Homo erectus* bearing travertine from Kocabaş (Denizli, Turkey) at at least 1.1 Ma



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### ABSTRACT

Since its discovery within a travertine quarry, the fragmentary cranium of the only known Turkish *Homo erectus*, the Kocabaş hominid, has led to conflicting biochronological estimations. First estimated to be ~500 ka old, the partial skull presents a combination of archaic and evolved features that puts it as an intermediate specimen between the Dmanisi fossils (*Homo georgicus*) and the Chinese Zhoukoudian skulls (*Homo erectus*) respectively dated to 1.8 to ~0.8 Ma. Here we present a multidisciplinary study combining sedimentological, paleontological and paleoanthropological observations together with cosmogenic nuclide concentration and paleomagnetic measurements to provide an absolute chronological framework for the Upper fossiliferous Travertine unit where the Kocabaş hominid and fauna were discovered. The <sup>26</sup>Al/<sup>10</sup>Be burial ages determined on pebbles from conglomeratic levels framing the Upper fossiliferous Travertine unit, which exhibits an inverse polarity, constrains its deposition to before the Cobb Mountain sub-chron, that is between 1.22 and ~1.5 Ma. The alternative match of the normal polarity recorded above the travertine with the Jaramillo subchron (lower limit 1.07 Ma) may also be marginally compatible with cosmogenic nuclides interpretation, thus the proposed minimum age of 1.1 Ma for the end of massive travertine deposition. The actual age of the fossils is likely to be in the 1.1–1.3 Ma range. This absolute date is in close agreement with the paleoanthropological conclusions based on morphometric comparisons implying that Kocabaş hominid belongs to the *Homo erectus* s.l. group that includes Chinese and African fossils, and is different from Middle and Upper Pleistocene specimens. Furthermore, this date is confirmed by the large mammal assemblage, typical of the late Villafranchian. Because it attests to the antiquity of human occupation of the Anatolian Peninsula and one of the waves of settlements out of Africa, this work challenges the current knowledge of the *Homo erectus* dispersal over Eurasia.

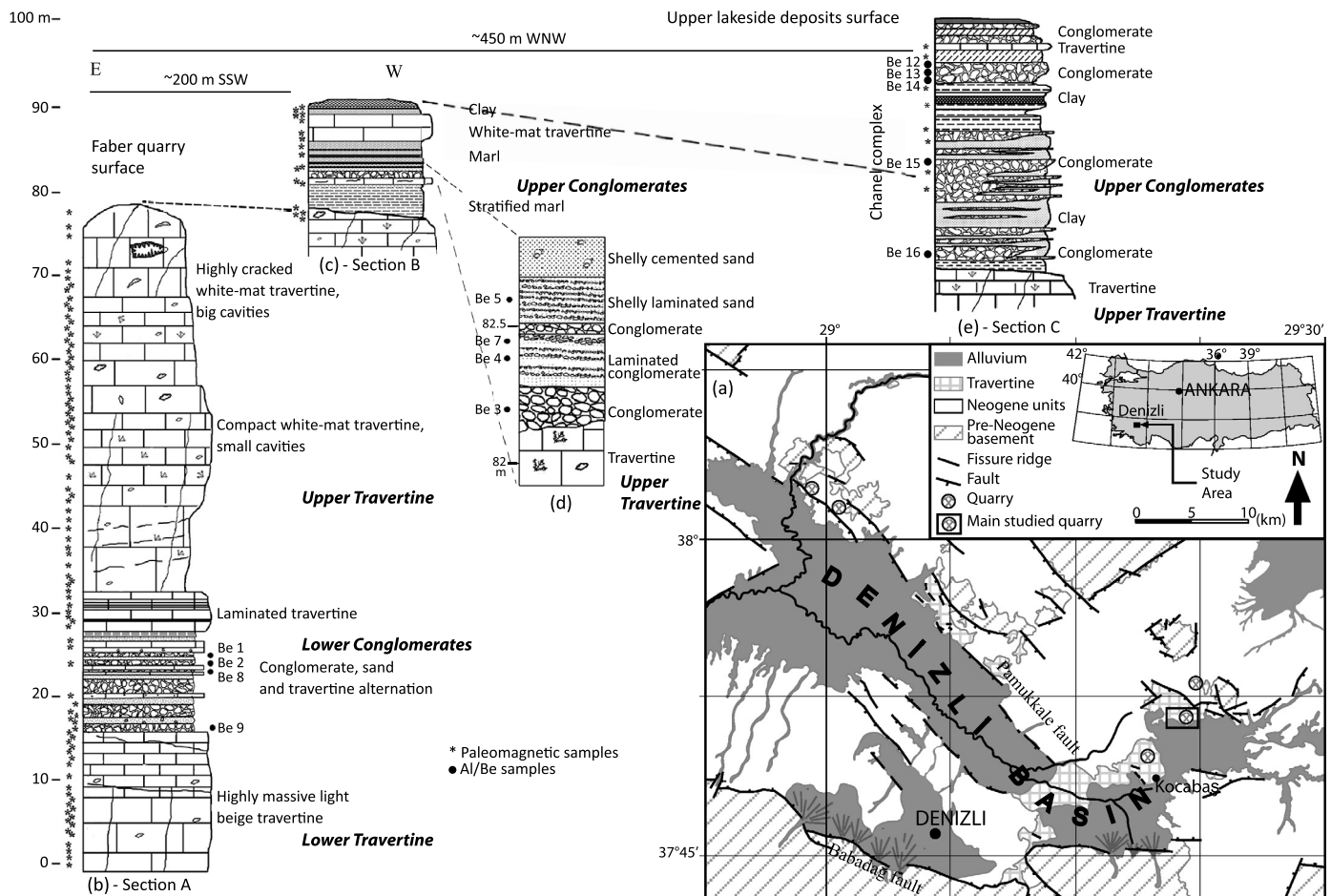
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### 1. Introduction

The Denizli basin (Fig. 1(a)), one of the Neogene extensional depressions of western Anatolia (Westaway, 1993), contains important travertine formations massively mined by marble industries. This intensive activity has brought to light from the Upper formation of Kocabaş travertines fossiliferous remains of large mammals among which one of us (M.C. Alçiçek) discovered a fragmentary

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**Fig. 1.** Sample location around the Faber quarry, Kocabaş, Denizli, Turkey. (a) Geological map of Denizli basin (based on Sun, 1990); (b) Section A, travertine stratigraphic section in the Faber quarry (Fig. S5=mmc5); (c) Section B, upper fluvio-lacustrine stratigraphic section in the Faber quarry SW wall (Upper Conglomerates; Fig. S5=mmc5); (d) detail of the (c) stratigraphic section (between 81.9 m and 82.8 m of height); (e) Section C, upper fluvio-lacustrine stratigraphic section west of the Faber quarry (2012 samples in green in Fig. S5=mmc5).

*Homo erectus* cranium in 2002, as reported by Kappelman et al. (2008). The earliest age determination of the travertines in Kocabaş field at  $1.11 \pm 0.11$  Ma was performed by Engin et al. (1999) using Electron Spin Resonance method, but a circa 500 ka date using thermoluminescence method was also reported (Kappelman et al., 2008). However, both methods are at the limits of their applicability and may suffer various unconstrained biases.

The partial skull of the only known Turkish *Homo erectus*, the Kocabaş hominid, presents an intermediate morphological pattern (Viale et al., 2012) between the *Homo* skulls from Dmanissi (Georgia) and those from Zhoukoudian Lower-cave (China) dated, at 1.8 Ma (de Lumley et al., 2002) and at  $\sim 0.8$  Ma (Shen et al., 2009), respectively. Furthermore, previous studies of the fauna found in the same level (i.e. Upper Travertine) points toward common Middle Pleistocene species (Erten et al., 2005). Note that the faunal assemblage used in the paleontological present study is more complete.

Because Kocabaş hominid has been discovered on an alternative species migration pathway between Europe and Asia (Bar-Yosef and Belmaker, 2011), it is of fundamental importance to secure these conflicting biochronological estimations to provide an absolute chronological framework for the Kocabaş hominid and the Upper Travertine level fauna. As in Zhoukoudian (China; Shen et al., 2009), and Attirampakam (India; Pappu et al., 2011), a multi-disciplinary approach combining extensive sedimentological studies, paleomagnetism, determination of the paleo-mammal fauna and their paleo-biodiversity and cosmogenic nuclide concentration

measurements has thus been carried out. A new 3D reconstruction of the fragmentary skull enabled further anthropological comparisons with the fossil record.

## 2. Settings

### 2.1. Geological context of the studied section and hominid remains discovery

Located in one of the world's most seismically active regions, at the junction between the E-W-trending Büyük Menderes and the NW-SE-trending Gediz Graben (Bozkurt, 2001), the Denizli Basin (Fig. 1(a)) is a fault bounded Neogene-Quaternary depression in the west Anatolian extensional province. From a half graben controlled by the south Babadağ fault zone during the late-Early Miocene, the depression turned into a graben due to the activation of the north Pamukkale fault zone resulting from changes of the regional extensional directions during the early Quaternary (Alçiçek et al., 2007). Dip-slip normal fault segments displaying step-over zones along the fault-strikes (e.g. Hancock et al., 1999) governed hot spring resurgences that precipitate massive travertine deposits mainly along the northern margin of the basin, which includes the studied Kocabaş travertine field (Şimşek et al., 2000).

The fossil travertine field of Kocabaş is deformed and exposed along NW-trending normal faults to the east of Denizli basin. Starting during the Roman period, quarrying significantly intensified since the late 1990s for commercial purposes. The quarries are

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