



Çeştepe, a new early Pliocene vertebrate locality in Central Anatolia and its stratigraphic context

Sevket Sen, Massimo Delfino, Nizamettin Kazanci

► To cite this version:

Sevket Sen, Massimo Delfino, Nizamettin Kazanci. Çeştepe, a new early Pliocene vertebrate locality in Central Anatolia and its stratigraphic context. *Annales de Paléontologie*, 2017, 10.1016/j.annpal.2017.01.004 . hal-01492923

HAL Id: hal-01492923

<https://hal.sorbonne-universite.fr/hal-01492923>

Submitted on 22 Mar 2017

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

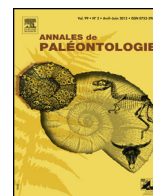


Disponible en ligne sur

ScienceDirect
www.sciencedirect.com

Elsevier Masson France

EM|consulte
www.em-consulte.com



Original article

Çeştepe, a new early Pliocene vertebrate locality in Central Anatolia and its stratigraphic context

Çeştepe, une nouvelle localité à vertébrés du Pliocène inférieur d'Anatolie centrale et contexte stratigraphique

Sevket Sen^{a,*}, Massimo Delfino^{b,c}, Nizamettin Kazanci^d

^a UMR 7207 CNRS, Muséum, UPMC, Centre de Recherches sur la Paléobiodiversité et Paléoenvironnements, 8, rue Buffon, 75005 Paris, France

^b Dipartimento di Scienze della Terra, Università di Torino, Via T. Valperga Caluso 35, 10125 Torino, Italy

^c Institut Català de Paleontologia Miguel Crusafont, Universitat Autònoma de Barcelona, Edifici ICTA-ICP, Carrer de les Columnes s/n, Campus de la UAB, Cerdanyola del Vallès, Barcelona 08193, Spain

^d Ankara University, Geological Engineering Department, Tandoğan, Ankara 06100, Turkey

ARTICLE INFO

Article history:

Received 13 November 2016

Accepted 25 January 2017

Available online xxx

Keywords:

Lagomorpha

Ochotona

Squamata

Varanus

Early Pliocene

Kazan Basin

Turkey

ABSTRACT

The new locality of Çeştepe in the Kazan Basin, 45 km NNW of Ankara, yielded the remains of three species of reptiles (cf. *Lacerta* sp., Anguinae indet. and *Varanus* sp.) and an ochotonid lagomorph, *Ochotona mediterraneensis* Suata Alpaslan, 2009. The latter species suggests an early Pliocene age (MN14). The fossil layer is included in the Sinap Formation that delivered abundant remains of Mio-Pliocene mammals in the southern part of the basin, but in the northern part of the basin Çeştepe is currently the unique fossil site. The age assigned by the fauna led to revise the stratigraphy of sedimentary formations in the Çeştepe area, previously confusing because of the various lithostratigraphic unit names and ages given in previous work. The taxa described in this note are still poorly known in Turkey. *Varanus* has been previously reported from Çalta, a locality 16.3 km SW to Çeştepe in the same basin, and *O. mediterraneensis* from İğdeli in the Sivas Basin. Although represented by a few taxa, the Çeştepe faunule shows Eurasian affinities.

© 2017 Elsevier Masson SAS. All rights reserved.

R É S U M É

La nouvelle localité de Çeştepe dans le bassin de Kazan, à 45 km au NNW d'Ankara, a livré les restes de trois espèces de reptiles (cf. *Lacerta* sp., Anguinae indet. and *Varanus* sp.) et d'un lagomorphe ochotonidé, *Ochotona mediterraneensis* Suata Alpaslan, 2009. Cette faune et en particulier la dernière espèce permettent de corréliser cette localité au Pliocène inférieur (MN14). La couche fossilifère est incluse dans la Formation de Sinap qui a livré d'abondants restes de mammifères mio-pliocènes dans la partie sud de ce bassin, mais dans la partie nord du bassin, Çeştepe est pour le moment l'unique site fossilifère. L'âge attribué par cette faune a permis de revoir la stratigraphie des formations sédimentaires dans ce secteur du bassin de Kazan, auparavant confuse en raison des noms d'unités lithostratigraphiques et des âges différents dans des travaux antérieurs. Les taxons décrits dans la présente note sont encore mal connus en Turquie. Le genre *Varanus* n'a été décrit auparavant que du gisement de Çalta au SE du même bassin et *O. mediterraneensis* du gisement d'İğdeli dans le bassin de Sivas. Bien que pauvre, cette faunule montre des affinités eurasiatiques.

© 2017 Elsevier Masson SAS. Tous droits réservés.

Mots clés :

Lagomorpha

Ochotona

Reptilia

Varanus

Pliocène inférieur

Bassin de Kazan

Turquie

1. Introduction

Pliocene terrestrial deposits occupy quite large areas in Turkey. However, Pliocene vertebrate localities are rather rare and much less documented. In their zonal subdivision of terrestrial Neogene

* Corresponding author.

E-mail addresses: sevket.sen@mnhn.fr (S. Sen), massimo.delfino@unito.it (M. Delfino), kazanci@eng.ankara.edu.tr (N. Kazanci).

in Turkey, Ünay et al. (2003) suggested four mammalian zones (M to P) for Pliocene based on rodent assemblages. However, the current state of the knowledge about the Pliocene mammals does not allow the effective use of this subdivision, neither accurate correlations with the MN zonation. The main issue is that the Pliocene mammal faunas of Turkey are still poorly documented and their composition is somewhat different from that of the surrounding regions. For Pliocene of Turkey, the best-documented fauna is probably Çalta, at some 50 km NW to Ankara, in the same basin as Çeştepe (Sen, 1998a, 1998b). Other Pliocene localities, dispersed in sedimentary basins across all Turkey (Saraç, 2003), are mainly known with their rodent associations, in particular those studied by Ünay and de Bruijn (1998) and Van den Hoek Ostende et al. (2015a, 2015b). The discovery of a new locality at Çeştepe (Kazan Basin) provided opportunity to review stratigraphic correlations in this basin and to document Pliocene reptiles and ochotonid lagomorphs in Turkey. As we will see here below, these groups may provide strong arguments for biochronology and environment if they are well-documented.

2. Geological context

2.1. Geological context of Central Anatolia and Kazan Basin

The Çeştepe village and vertebrate fossil locality are situated about 45 km NNW to the capital Ankara, and 14 km north of Kazan town in the Kazan Basin, Central Anatolia (Fig. 1). This basin is at the southern margin of the Kızılcahamam Volcanic Province (KVP in Fig. 1A) which covers large areas NW to Ankara and south to the North Anatolian Fault Zone (NAFZ). In previous studies, Neogene sediments of the Kazan region were included in the Beypazarı Basin. As will be seen below, this conception must be reconsidered. The Beypazarı and Kazan basins form, together with the KVP, a geomorphological and climatic transition zone between the central and northern regions of Anatolia (Fig. 1). Semi-arid climate, steppic and rather flat landscapes of the Anatolian plateau, which is between the altitudes of 850–1100 meters, turn northward to a mountainous morphology split by deep valleys and under the regime of the rainy climate of the Black Sea region. This transition zone is known with its great floral and faunal biodiversity, its mixed vegetation dominated by *Quercus* and *Pinus*, and also other transition forest type plants (Adigüzel and Vural, 1995; Uyar and Çetin, 2001). To protect and to set forth such a particular ecology, this region became in 1959 the Soğuksu National Park. The region is renowned for its mineral waters sources, coal quarries and fossil rich beds (e.g., Fig. 1B, spots 1–5) (Ozansoy, 1965; Kasaplıgil, 1977; Alpogut et al., 1996; Rückert-Ülkümen et al., 2002; Fortelius et al., 2003; Hatipoğlu and Türk, 2009). Due to the richness of its natural resources, the Ministry of Environment intended to declare the Kazan-Kızılcahamam region a geopark (Kazancı et al., 2007; Kazancı, 2012).

From the Paleozoic onwards, Anatolia played the role of tectonic crossroad in the geological history of the Old World. The most significant rock samples of this history can be seen in the north Central Anatolia, in particular in the Ankara region (Fig. 1). The various global tectonic models on the evolution of Paleotethys and Neotethys have been developed over the rocks of this region (see Tekeli, 1981; Okay and Göncüoğlu, 2004; Dilek and Thy, 2006, and references therein). The term and concept of “Melange” were shaped on the rocks of this region (Bailey and McCallien, 1953; Sengör, 2003). The rock units and stratigraphy increase in diversity in the area from Paleozoic onwards, because of the progressive grouping of several tectonic units during the Mesozoic (Sakarya Zone, Istanbul Zone, Taurides, Pontides) on which various sedimentary basins (e.g. Çankırı-Çorum, Beypazarı, Polatlı-Haymana,

Tuzgölü Tertiary basins) are developed. The Ankara region forms a kind of node where these tectonic units and sedimentary basins get close to each other and/or imbricated (Fig. 1). To clarify such a complex geological context needs robust stratigraphic, biostratigraphic and any kind of chronological data. Therefore, the Çeştepe fossils are of interest not only in terms of systematics and paleoecology of species they represent, but also for their contribution to understand the geological evolution of the region that is increasingly complex throughout the Neogene.

The Gondwana-Eurasia collision, which gave rise to the Alpine-Himalayan mountain chain, created the framework of the current geography of Anatolia. The Anatolian plate became uplifted during the Neogene, and several large and small basins appeared to receive terrestrial sediments (Fig. 1B). In relation with the collision, extensive volcanic provinces developed in different regions of Anatolia since the early Miocene (e.g. East Anatolian Volcanic Province – EAVP, Cappadocian Volcanic Province – CVP, Kızılcahamam Volcanic Province – KVP) and, as exemplified in this study, volcanism impacted terrestrial infill of these Neogene basins (Figs. 1 and 2). Local differences in volcanic, volcano-sedimentary and sedimentary input in these basins produced stratigraphic successions that are heterogeneous and difficult to correlate even inside the same basin. This is particularly true for Neogene deposits of Central Anatolian basins (Tatlı, 1975; Öngür, 1976; Gökten et al., 1988; Türkecan et al., 1991; Duru and Aksay, 2002). The North Anatolian Fault Zone (NAFZ), which is the second longest strike-slip fracture of the world after the San Andreas Fault, is situated a few kilometers north of the study area, and it separates the Eurasian and Anatolian plates (Fig. 1). The occurrence of NAFZ indicates the beginning of the neotectonic period in Anatolia, and it is often considered the source of increasing seismic activity (Sengör et al., 2005; Rojay and Karaca, 2008). After the devastating earthquakes in recent years (Izmit, 1999 and Çankırı, 2000), research on the tectonics and seismic activities largely focused in the Kazan-Kızılcahamam region (Koçyiğit et al., 2001; Karaca, 2004; Toori, 2005; Seyitoğlu et al., 2009; Kahraman, 2014). However, a common problem in almost all studies is frequent lateral lithological changes in terrestrial Neogene units in the region and, consequently, dissimilarities in local stratigraphies (see Erişen and Ünlü, 1976; Erol et al., 1980; Türkecan et al., 1991; Duru and Aksay, 2002; Lunkka et al., 2003). To resolve this complexity needs more fossils for a high-resolution biostratigraphy and/or radiometric dating.

2.2. Kazan Basin

South to the North Anatolian Fault (NAF) and Kızılcahamam Volcanic Province (KVP), these are several large basins such as Beypazarı, Çankırı-Çorum and Polatlı-Haymana basins, and more southern Tuzgölü and Sivrihisar-Beylikova basins (Fig. 1). These are the remnants of large marine foreland basins, which were formed in late Cretaceous-Paleogene along the southern margin of the Pontide collisional zone (Görür et al., 1998; Dirik and Erol, 2000; Karadenizli et al., 2003). They come into contact in the study area. Consequently, Neogene units north of Ankara and in the Kazan region have been mapped as part of the Beypazarı Neogene Basin in some studies or part of the Çankırı-Çorum Basin in the others (Türkecan et al., 1991; Duru and Aksay, 2002; MTA, 2002). In addition, most studies dealing with the geology of the region, named stratigraphic units regardless of the sedimentary basin in which they are (e.g. Ruprecht, 1956; Tatlı, 1975; Erişen and Ünlü, 1976; Erol et al., 1980; Gökten et al., 1988; Lunkka et al., 2003). This confusing situation is probably due to lithologic similarities of Neogene deposits: Miocene sedimentary units in Central Anatolian basins are mainly lacustrine and floodplain deposits, whereas the Pliocene units are of alluvial and fluvial origin. Moreover, not only the lithologies but also fossil communities display great resemblances

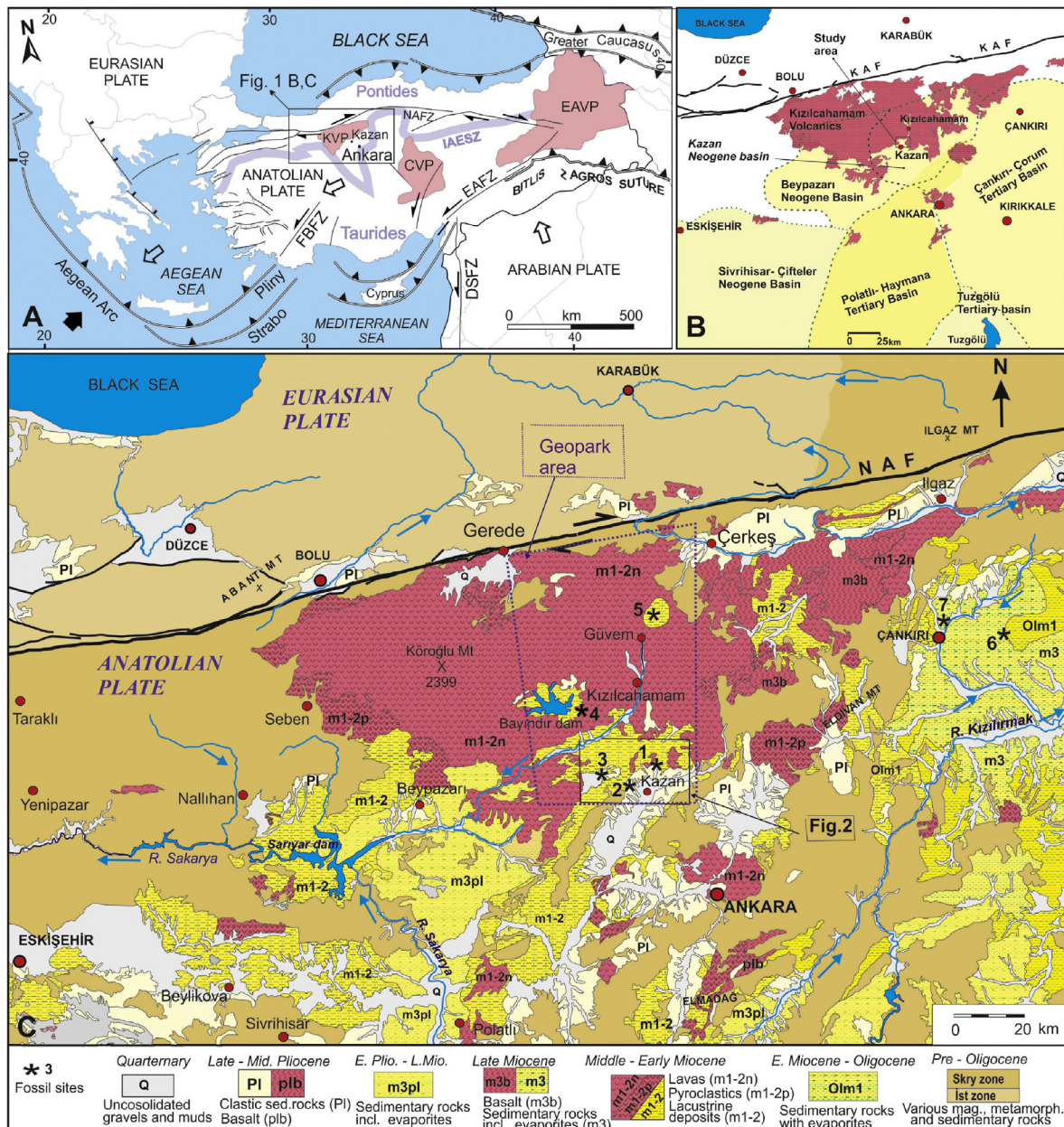


Fig. 1. Location and geological setting of the Kazan-Çeştepe area. A. Broad tectonic elements of Turkey and surroundings. NAFZ: North Anatolian Fault Zone; EAFZ: East Anatolian Fault Zone; DSFZ: Dead Sea Fault Zone; IAESZ: Izmir-Ankara-Erzincan Suture Zone; KVP, CVP, EAVP: Kızılcahamam, Cappadocian, East Anatolian volcanics provinces, respectively. Note that NAFZ is a plate boundary partly on an old suture zone (IAESZ). B. Relations of Kızılcahamam Volcanic Province (KVP) with five significant Tertiary sedimentary basins of Central Anatolia. Note that the Kazan Basin is introduced here for the first time. C. Generalized geological map of northwest Anatolia (from MTA, 2002). Fossil sites: 1 Çeştepe, 2 Sinap mammal localities, 3 Çalta, 4 Pelitçik silicified trees, Güvem and Keseköy plants, insects and vertebrate localities, 6 Çankırı Basin mammal localities, 7 Çorakyerler.

Localisation et contexte géologique de la région de Kazan-Çeştepe. A. Éléments tectoniques majeurs de Turquie et des régions voisines. NAFZ : zone de la faille nord-anatolienne du ; EAFZ : zone de la faille est-anatolienne ; DSFZ : zone de la faille de la Mer Morte ; IAESZ : zone de suture d'Izmir-Ankara-Erzincan. KVP, CVP, EAVP sont les provinces volcaniques de Kızılcahamam, de Cappadoce et de l'Anatolie orientale, respectivement. Notez que NAFZ est une limite de plaque située en partie sur une ancienne zone de suture (IAESZ). B. Relations de province volcanique de Kızılcahamam (KVP) avec cinq bassins sédimentaires tertiaires significatifs de l'Anatolie centrale. Notez que le bassin de Kazan est présenté ici pour la première fois. C. Carte géologique généralisée du nord-ouest de l'Anatolie (MTA, 2002). Sites fossilifères : 1 Çeştepe, 2 localités à mammifères de Sinap, 3 Çalta, 4 site à arbres silicifiés de Pelitçik, 5 site à plantes, insectes et vertébrés fossiles de Güvem et de Keseköy, 6 localités à mammifères du bassin de Çankırı, 7 Çorakyerler.

from one region to another without any kind of endemism (Kazancı et al., 1999; Fortelius et al., 2003; Saraç, 2003). However, when studied in detail, Neogene deposits in the Kazan region are different in their architecture from those of the neighbouring basins. The most important difference is the lack of evaporitic deposits in the Kazan Basin, while they form thick sedimentary units in other basins (Çayırhan Fm and Kirmir Fm in the Beyşehir Basin, Bayındır Fm and Bozkır Fm in the Çankırı-Çorum Basin; İnci et al., 1986; Karadenizli, 1995, 2011; Kaymakçı, 2000; Varol

et al., 2002). Unlike the other basins, the Kazan Basin has relatively thick Pliocene deposits developed in alluvial fan and meandering river depositional environments. These differences in sedimentary deposits with those of similar age units in the neighbouring basins indicate that the Kazan area functioned as an independent basin during the Neogene. The northern part of this basin is filled with the Kızılcahamam volcanics. It is delimited eastward and westward by the basement rocks (Permo-Triassic, Cretaceous and early Paleogene metamorphic and sedimentary units). The limits of this

Age		Units	
Holocene		Alluvium, soils	
Pleistocene		Terraces Old alluvium	
Pliocene	Late	Çalta Member	Sinap Fm
	Early		
Miocene	Late	Kavakdere İğbek	Kızılcahamam volcanics KVP
	Middle	Yellidoruk Beycedere	
		Early	
	Pre-Oligocene		
		Sedimentary, metamorphic and ophiolitic rocks	

Fig. 2. Stratigraphy of Neogene units in the Çeştepe-Pazar area (modified from Lunkka et al., 2003), and position of the Çeştepe vertebrate locality. *Stratigraphie des unités néogènes dans la région de Çeştepe-Pazar (modifiée de Lunkka et al., 2003), et position de la localité à vertébrés de Çeştepe.*

basin, depending on the present day observations, are marked on Fig. 1B. For more accurate boundaries, detailed studies are needed.

The term “Kazan Basin” was previously used by Toori (2005) without, however, a clear definition of its characteristics (origin, architecture, boundaries). It is out of the purpose of the present study to involve further in the definition of the Kazan Basin and its detailed geological features. Its stratigraphy and the position of the Çeştepe fossil locality are resumed here below.

2.3. Stratigraphy of the Çeştepe-Kazan area

The geology of the Kazan-Çeştepe region is shown on Fig. 3. Several geologists mapped the geology of the region north of Ankara, and they provided various ages for stratigraphic units and consequently different tectonic interpretations. Although in almost all geological maps the outcrop limits are similar, the stratigraphy and unit names are different from one study to another (e.g. Ruprecht, 1956; Tatlı, 1975; Erişen and Ünlü, 1976; Öngür, 1976; Erol et al., 1980; Türkecan et al., 1991; Duru and Aksay, 2002; MTA, 2002; Karaca, 2004; Rojay, 2013). On the other hand, the studies not dealing with mapping used stratigraphic unit names given by the previous ones, but reorganized the stratigraphy

according to their own age data (e.g. Lunkka et al., 2003; Toori, 2005; Kahraman, 2014). Consequently, the geological evolution of the Ankara region during the Neogene appears particularly complicated and confusing. It is beyond the scope of this study to discuss the stratigraphies given in previous publications. We aim here to introduce the local stratigraphy with the unit names used by Lunkka et al. (2003) for sedimentary rocks and by Türkecan et al. (1991) and Duru and Aksay (2002) for volcanic rocks (Figs. 2 and 3).

In the study area, Miocene-Pliocene and younger rocks unconformably overlay the older (pre-Neogene) units (Fig. 2). The youngest unit of the pre-Neogene rocks is the marine middle Eocene Güvenç Formation, which is formed of *Nummulites* and *Assilina* rich limestones, marls and argillaceous limestones (Fig. 3). This unit represents the latest progress of marine transgression in Central Anatolia (Çayraz Fm in the Haymana Basin, Orhaniye Fm north of Ankara; Gökten et al., 1988; Toori, 2005).

Neogene units formed after the Alpine orogeny, which cover large areas in Central Anatolia, are generally much less deformed than the older units, and they show often lateral and vertical lithological changes. Lacustrine deposits are common during the early and middle Miocene, while fluvial and alluvial systems dominate during the late Miocene and Pliocene. In the basins that surround the Kızılcahamam volcanic province (KVP), sedimentary infill shows great discrepancies; for instance while in the Çankırı-Çorum and Belpazarı basins, late Miocene and early Pliocene evaporite lakes occupied large areas (Fig. 1B, C), evaporite deposits are not known in the Neogene sedimentary succession of the Kazan Basin. The Neogene units of the Kazan Basin are summarized here below from the bottom to the top.

Pazar Formation: This unit is commonly observed in the study area. It was defined by Tatlı (1975) around Pazar town, which is built on younger deposits (!), about 5 km to the north east of Çeştepe (Fig. 3). The Pazar Formation laterally interfingers with the Kızılcahamam volcanics (Figs. 2 and 3). The main lithologies are clayey limestone, marl and claystone, locally cherty limestone, sandstone and tuff, with occasional thin coal seams. The dominant color of the unit is white and light gray.

Locally, depending on the abundance and alteration of tuff input, white, green or yellow levels can be observed. Its thickness was measured near Kazan to be about 250 m (Karaca, 2004). This formation may be observed as well in lowlands and altitude terrain, because it is greatly faulted and folded by tectonic activity. According to its main lithologies, the Pazar Formation was formed in lake and swamp environments with water depth varying in times (Tatlı, 1975). The lateral equivalents of the unit were named in previous studies as Akhüyük Fm (Erol et al., 1980), Hançılı Fm (Duru and Aksay, 2002), Çeltikçi Fm (Rojay, 2013). These authors suggested to date it, based on relative stratigraphy or pollen record, as Miocene, middle-late Miocene or late Miocene. These formation names and ages cannot be applied at least for the Kazan area. Because of the occurrence of hominoid primates, the sedimentary deposits of the Kazan area have been intensively investigated for stratigraphy, sedimentology and vertebrate paleontology. They have been precisely dated by fossils, magnetostratigraphy and radiometric dating (Sen, 1991; Alpagut et al., 1996; Fortelius et al., 2003). The basaltic flow, which separates the Pazar Formation from the overlying Sinap Formation is dated to 15.8 my by the K-Ar method (Kappelman et al., 2003). This basalt flow is different from the Özlü basalt given on Fig. 3. Also the mammal localities 24 and 24A at the İnönü district near Sarılar village, which are correlated to the mammalian zone MN6 (Fortelius et al., 2003) are in this formation. All this shows that the Pazar Formation was settled during the early and early middle Miocene, at least in the Kazan area.

Kızılcahamam Volcanics: In the study area, Neogene volcanic rocks are observed laterally interfingering with the Pazar Formation. They represent a small part of the southern section of

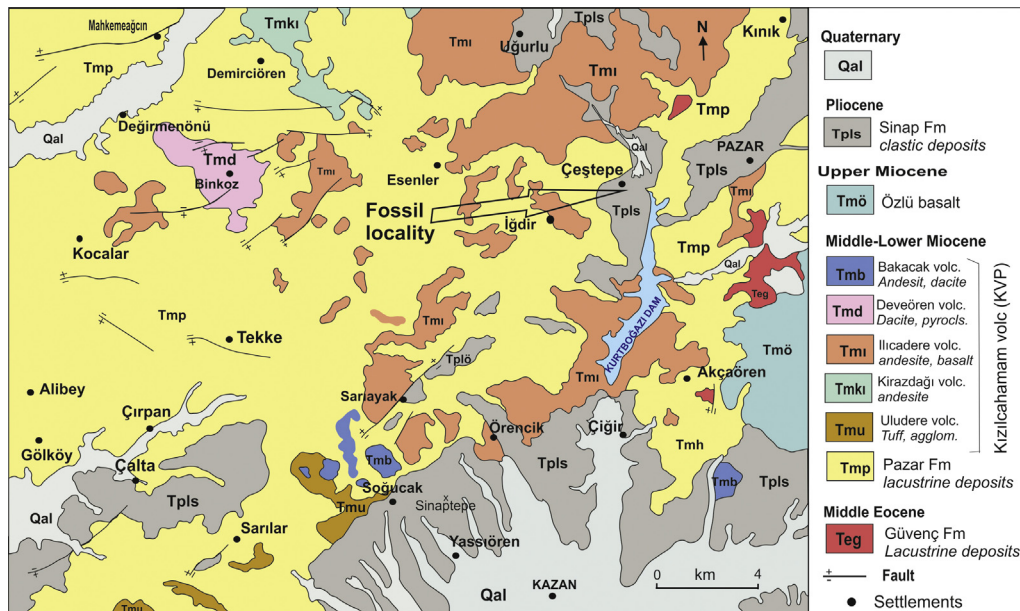


Fig. 3. Detailed geological map of the region situated between the towns of Pazar, Kazan and Çalta. See Fig. 1 for fossiliferous sites in the region.

Carte géologique détaillée de la région située entre les bourgs de Pazar, Kazan et Çalta. Voir Fig. 1 pour les sites fossilifères de la région.

Modified after Duru and Aksay, 2002.

the Kızılcahamam Volcanic Province (KVP). The main part of this province is situated further north and spread across an area of 12.500 km². It culminates at Köroğlu Tepe to an altitude of 2400 meters (Figs. 1b and 3). This volcanic province is also known in the literature as Köroğlu volcanics, Galatia Massif and Galatia Volcanics (Türkecan et al., 1991; Toprak et al., 1996). Its main rock types are andesitic, trachytic and basaltic lavas, rhyolitic tuffs and pyroclastics. There are many volcanic eruptive centers, most of them around Kızılcahamam town, and the prominent center being Köroğlu Tepe. According to radiometric data, these are the product of three phased explosive volcanic events between 23–11 my (Türkecan et al., 1991; Wilson et al., 1997; Tankut et al., 1998). During the calm periods, lakes occupied large areas, and terrestrial sedimentary deposits, which also locally include coal formations, developed. These deposits also include several fossiliferous localities, the best known of which are Güvem-Keseköy with leave and vertebrate fossils and Bayındır Pelitçik silicified wood forest (localities 4 and 5 on Fig. 1B) (Kasaplıgil, 1978; Rückert-Ülkümen et al., 2002; Atabey and Saraç, 2004; Lopez-Antoñanzas et al., 2004; Hatipoğlu and Türk, 2009; Kazancı, 2012). The majority of volcanic rocks in the study area are basaltic lava and coarse pyroclastics of the Ilıcadere volcanics (Türkecan et al., 1991) that are mostly derived from volcanic centers near Kızılcahamam (Fig. 3).

Sinap Formation: It covers the lowlands of the study area in the form of three patches around Kazan, Çalta and Çeştepe-Pazar (Pls on Fig. 3, Pl on Fig. 1). A typical erosional surface is developed on its outcrops. This formation is easily distinguished from the underlying Pazar Formation by its poorly consolidated sediments with yellowish, reddish, mottled gray, brown colors. It is almost totally composed of lithologies of alluvial and fluvial sediments dominated by loose conglomerates, sandstones and mudstones. Locally it includes lacustrine sediments that form thin bands. This formation is not much affected by the tectonics, and thus the bedding is almost horizontal (Rojay and Karaca, 2008). It covers Pazar Formation and older units with angular unconformity (Fig. 2). Although its usual thickness is between 40–100 m, Karaca (2004) measured a section of 150 m northwest to Kazan.

This unit was defined by Tatlı (1975) along the slopes of Sinap Tepe at some 4 km northwest to Kazan, with a given age range as

early Pliocene. In several basins of Central Anatolia, similar deposits are mapped, as shown in the MTA maps, as “undifferentiated clastics” or Örencik Formation (Duru and Aksay, 2002; MTA, 2002). In individual studies, it is named as Gölbaşı Fm south of Ankara, Etimesgut Fm (Erol, 1980), Memlik Fm (Gökten et al., 1988) and Yuva Group (Koçyiğit et al., 1988) north of Ankara. Karaca (2004) and Rojay and Karaca (2008) have used the name of Sinap Formation, but gave the age of the unit as Plio-Quaternary without taking into consideration paleontological and magnetostratigraphic ages already available in the literature. In all these studies, the age of this unit is given in relative terms based on the relative position similar lithologies in other basins. Fortelius et al. (2003) and Lunkka et al. (2003) carried out in 1990s detailed sedimentological, stratigraphic and in particular paleontological investigations in the Kazan Basin (Fig. 3), mainly concentrated around the type section of the Sinap Formation. Lunkka et al. (2003) distinguished five successive members (from the bottom to the top Beycedere, Yellidoruk, İğbek, Kavakdere and Çalta members), covering an interval of time from the middle Miocene to the early Pliocene (Fig. 2). The mammalian faunas from the first four members have been subject of detailed studies published in a volume edited by Fortelius et al. (2003), while the fauna from Çalta was published in a volume edited by Sen (1998a, 1998b). The outcrops seen around Çeştepe, Pazar and Kurtbogazi localities all belong to the Çalta Member. Its thickness near Çeştepe is about 45 m, and it is composed of flood plain deposits (mudstones) cut off by stream channel sediments (loose conglomerates, sandstones). Around the Çeştepe village, where the vertebrate fossils are recorded, fossiliferous sediments correlates to the middle-upper horizons of the Çalta Member. Mudstones and gravelly channel deposits are dominant (Fig. 4A–D). Sediments are not well consolidated, and consequently deeply cut by seasonal streams allowing the development of a recent fluvial network on the Çalta Member.

3. Material and methods

The vertebrate remains from Çeştepe have been found during the digging operations for the foundation of a private house at the village of Çeştepe. Adem Büyükköprü, a geologist who works at the

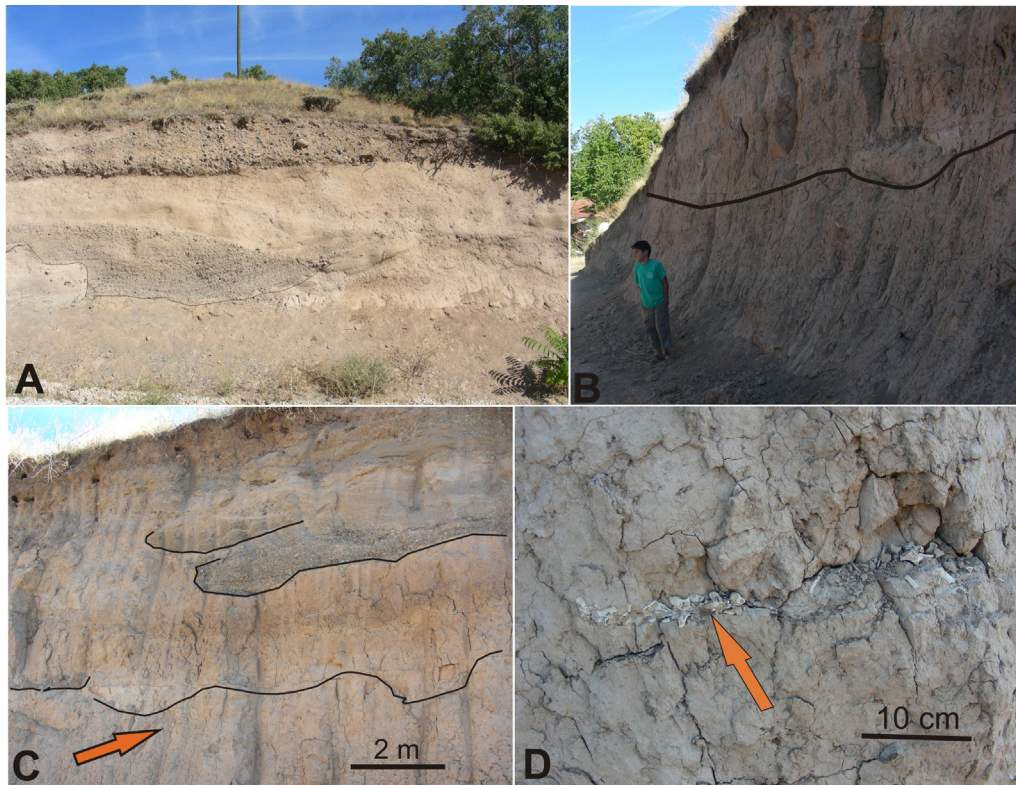


Fig. 4. Close-up view to the fossiliferous Pliocene deposits at Çeştepe. A. Floodplain mudstones (with a channel) unconformably covered by Quaternary terrace deposits. The latter forms also a morphological surface throughout the Kazan basin. The whitish color of the sediment is due to fine pyroclastic particles. B. Mudstones of an alluvial floodplain (= distal fan) overlined by fluvial sandy deposits. This is a common sediment pattern of the Pliocene sequences in the Kazan Basin. C. Alternation of alluvial and fluvial deposits. This is a typical feature of sediments of the Sinap Formation. D. Vertebrae of monitor lizard (*Varanus* sp.) at Çeştepe in bluish mudstones possibly representing a shallow pond or marsh in a fluvial setting.

*Vue rapprochée des dépôts fossilifères du Pliocène à Çeştepe. A. Boue de plaine d'inondation (avec un chenal) couverte en discordance par des terrasses quaternaires. Ces derniers forment également une surface morphologique dans tout le bassin de Kazan. La couleur blanchâtre du sédiment est due à de fines particules pyroclastiques. B. Les mudstones de plaine alluviale (= éventail distal) surmontée de dépôts fluviaux sableux. Ce type de succession sédimentaire est commun dans les séquences pliocènes du bassin de Kazan. C. Alternance des dépôts alluviaux et fluviaux. Ce type de dépôt est caractéristique pour la Formation de Sinap. D. Vertèbres d'un varan (*Varanus* sp.) à Çeştepe dans des argiles bleutées probablement déposées dans un étang peu profond ou un marais dans un milieu fluvial.*

Department of Water Supply and Sewerage of the city of Ankara, noted the presence of bones on the section (Fig. 4D). He stopped digging and warned on this discovery one of us (N. Kazancı) at the University of Ankara. A team from this university went the next day to Çeştepe and collected all visible bones and some matrix at the place of discovery. The matrix was sieved on a mesh of 1 mm to recover fragments not easily visible. The geographic coordinates of the finding place are N 40° 19' 30.89" and E 32° 41' 21.85".

Geologists who collected this material at Çeştepe are not familiar with the techniques of digging and collecting fossil vertebrates. They have collected the fossils without consolidation. Fresh fractures on bones, the presence of numerous small fragments belonging to an ochotonid skull, fragmentary state of lizard vertebrae that apparently belonged to the same individual show that the material was initially consisted of more complete specimens, but damaged during excavation and salvage operations.

The material from Çeştepe includes the remains of an ochotonid lagomorph and several lizards. Lizards are represented by 88 specimens referred to three taxa: cf. *Lacerta* sp., non-*Anguis* Anguinae indet. and *Varanus* sp. The numerous fragmented vertebrae probably belonged to at least partially complete skeleton of monitor lizard as seen on Fig. 4D. The ochotonid is represented by three fragmentary lower jaws, skull fragments and one upper cheek tooth. We tried to fix bone fragments to complete some specimens as much as possible, without great success due to the loss of contact between the fragments. All this material is housed at Ankara University, department of Engineering Geology.

For the description of ochotonid teeth, we used the terminology of López-Martínez (1989). Upper cheek teeth are abbreviated with capital letters and lower cheek teeth with lower case letters. All measurements are in millimeter.

4. Systematic study

Class Reptilia Laurenti, 1768
Order Squamata Oppel, 1811
Superfamily Lacertoidea Oppel, 1811
Family Lacertidae Oppel, 1811
Genus *Lacerta* Linnaeus, 1758

cf. *Lacerta* sp.

Material: one fragmentary right dentary (CT-10).

Description: The incomplete right dentary CT-10 (Fig. 5A, B) preserves the anterior portion, 8 mm long, up to the eighteenth tooth position. Teeth are (at least partially) preserved in the positions from two to seven, nine, 11, 13, 15 and 16; they are pleurodont, long and cylindrical. The anterior teeth are anterodorsally directed and show a single cusp. The other teeth are dorsally directed and the well-preserved crown in the ninth position is clearly bicuspid, with a very small anterior cusplet separated by a shallow lingual groove from the main cusp. Other teeth, as the one preserved in the eleventh position, show a lingual groove probably indicating the former presence of an anterior cusplet. The dental crest is dorsally curved and its medial edge is rounded. The Meckel's groove is fully open, reaching the anterior tip of the dentary, and

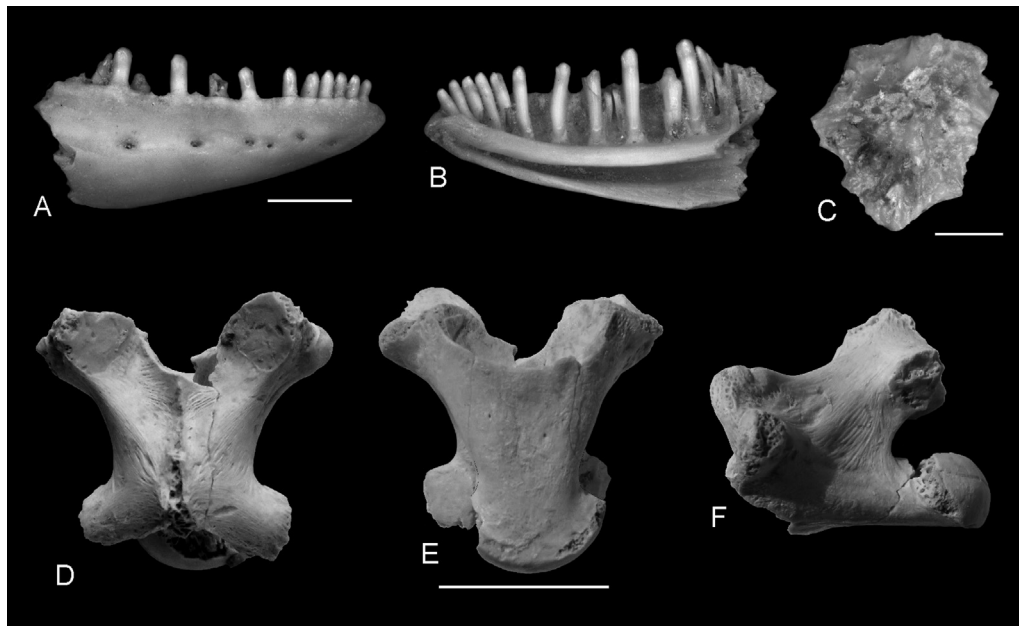


Fig. 5. A, B. cf. *Lacerta* sp., fragmentary right dentary CT-10 in lateral and medial views. C. Non-*Anguis Anguinae* indet., poorly preserved osteoderm CT-11 in external view. D–F. *Varanus* sp., trunk vertebra CT-12 in dorsal, ventral, and left lateral views. Scale bars equal 2 mm in A–C and 10 mm in D–F.
A, B. cf. *Lacerta* sp., fragment de dentaire droit (CT-10) en vue latérale et médiale. C. Non-*Anguis Anguinae* indét., ostéoderme fragmentaire (CT-11) en vue externe. D–F. *Varanus* sp., vertèbre du tronc (CT-12) en vue dorsale, ventrale et latérale gauche. Les échelles correspondent à 2 mm pour A–C et à 10 mm pour D–F.

widens posteriorly. In lateral view, the dentary deepens backward and hosts six mental foramina aligned to the dorsal edge of the element.

Remarks: The characters described above, the pleurodont bicuspid dentition and the open Meckel's canal in particular, fit well with those of lacertid lizards (among others Arnold, 1973, 1989; Barbadillo and Sanz, 1983; Barahona and Barbadillo, 1997; Arnold et al., 2007). The size of the only available element suggests the presence of a member of *Lacerta* that according to Uetz et al. (2016) is currently represented in Anatolia by the following species: *Lacerta agilis* Linnaeus, 1758, *Lacerta media* Lantz and Cyrén, 1920, *Lacerta pamphylica* Schmidtler, 1975, *Lacerta strigata* Eichwald, 1831, *Lacerta trilineata* Bedriaga, 1886, and *Lacerta viridis* (Laurenti, 1768). However, since the comparative osteology of these species is currently unknown and, moreover, it cannot be excluded that the single fragmentary lacertid element currently available (CT-10) belongs to a subadult representative of the larger genus *Timon* or even to an extinct taxon, the identification is limited at genus level, with the addition of the qualifier cf. indicating close morphological similarity to *Lacerta*.

Lacertid lizards were reported from about 10 Turkish localities whose age ranges from the late Oligocene to the Middle Pleistocene (Böhme and Ilg, 2003). Some of them have been even referred to the genus *Lacerta*, but only those from the middle Pleistocene of Emirkaya (Venczel and Sen, 1994) have been described and figured. No other lacertid genera than *Lacerta* were reported for Turkey despite the fact that it currently hosts 13 genera (Uetz et al., 2016). In the same broad geographic area, a green lizard, *Lacerta* gr. *L. viridis*, has been recently reported from the Early Pleistocene of Dmanisi in Georgia (Blain et al., 2014) and *Lacerta* sp., *Ophisops elegans* and Lacertidae indet. from the Middle Pleistocene of Azokh 1 Cave in Nagorno Karabakh region (Blain, 2016).

Superfamily Anguioidea Gray, 1825
Family Anguidae Gray, 1825
Subfamily Anguinae Gray, 1825

non-*Anguis Anguinae* indet.

Material: 1 osteoderm (CT-11).

Description: The preserved portion of the osteoderm CT-11 (Fig. 5C) is 5.0 mm wide and 5.1 mm long. The lateral and posterior edges are incomplete. The external surface is altered, but the following characters can be detected: presence of an anterior smooth strip posteriorly followed by a much larger and vermiculated area divided in two by a longitudinal ridge. The internal surface does not preserve any relevant character (i.e. the presence of foramina cannot be ascertained).

Remarks: Isolated osteoderms are very common in the fossil record (for example, more than 8000 in the late Miocene of Moncucco Torinese – Italy; Colombero et al., 2017) probably because they are massive bony structures that are very numerous in a single lizard individual and they are also easy to detect because of their characteristic shape and relatively large size. However, even if the skull and lower jaw osteology of the western Palaearctic anguines was carefully described (among others: Roček, 1980; Klembara et al., 2010, 2014; Klembara, 2012), little attention has been paid to the comparative morphology of the osteoderms and therefore only *Anguis* can be easily and reliably detected. As already remarked by Colombero et al. (2014), the osteoderms coming from a certain site are usually referred to the taxon identified on the basis of cranial characters, and when two taxa are recognized in a single site on the basis of cranial elements it has been suggested not to refer the osteoderms to them (Augé and Rage, 2000).

Anguid lizards were reported in about 15 Turkish localities (Böhme and Ilg, 2003), but with the exception of the materials referred to *Pseudopus* from the early Pliocene of Çalta (Rage and Sen, 1976; Sen and Rage, 1979) and the middle Pleistocene of Emirkaya (Venczel and Sen, 1994), all the others were identified at family level. *Pseudopus apodus* is the only non-*Anguis* anguine currently inhabiting Anatolia (Uetz et al., 2016) and was recently reported from the Middle Pleistocene of Azokh 1 Cave (Nagorno Karabakh region; Blain, 2016).

Superfamily Varanoidea Camp, 1923
Family Varanidae Gray, 1827

Genus *Varanus* Merrem, 1820

Varanus sp.

Material: two trunk vertebrae (CT-12 and 13); 20 fragments referable to at least 15 trunk vertebrae (CT-14); 1 fragmentary sacral vertebra (CT-15); 15 fragmentary caudal vertebrae (CT-16); 31 vertebral fragments (CT-17); 1 fragmentary right scapulocoracoid (CT-18); 1 fragmentary right ischium (CT-19); 1 distal epiphysis of a (?) tibia (CT-20); 1 right astragalocalcaneum (CT-21); 1 tarsal (CT-22); 5 metapodials (CT-23); 7 phalanges (CT-24).

Description: Despite not being complete, because the anterior edge of the neural arch, the tip of the neural spine, the dorsal portion of the cotyle and the condyle are partially damaged, the trunk vertebra CT-12 (Fig. 5D–F) is the most informative element of this taxon. The preserved portion of the anterior area of the neural arch is concave. The prezygapophyses are markedly tilted in dorsolateral direction. The synapophyses are rather globular and noticeably protruding laterally, but with a narrow connection with the lateral edge of the cotyle. The neural canal is proportionally narrow and roundish. The cotyle and the condyle are markedly compressed dorsoventrally, with a ventral edge very much more posteriorly placed than the dorsal edge. The lateral sides of the vertebra and part of those of the neural arch are distinctly striated. The centrum, 11.7 mm long, shows lateral edges distinctly converging posteriorly and with a significant precondylar constriction.

Caudal vertebrae are characterized by the following characters: cotyle and condyle similar to those described for the trunk vertebrae; centrum anteroposteriorly elongated; lateral apophyses dorsoventrally flattened and variably broadened; pedestals for chevron bones present and well-defined; precondylar constriction. The largest caudal vertebra with a measurable centrum (CT-16a) is 9.8 mm long.

The rest of the remains are very fragmentary and/or not taxonomically diagnostic (as the astragalocalcaneum CT-21) because of the absence of comparative studies on their morphology.

Remarks: The size and general morphology of the vertebrae, the dorsoventrally compressed cotyle and condyle with their ventral edge much posterior than the dorsal one, and the precondylar constriction in particular (an autoapomorphy of *Varanus*, see Smith et al., 2008, and literature therein), clearly support the identification of a monitor lizard of the genus *Varanus*. However, their morphology is not congruent with that of *Varanus griseus* (Daudin, 1803), the only species currently inhabiting Anatolia (with a single taxon/locality datum in southeastern Turkey; Sindaco and Jeremcenko, 2008). The distinctly converging lateral edges of the centrum (in ventral view) and therefore the marked precondylar constriction of the vertebra CT-12 are in contrast with the morphology of *V. griseus*, but reminiscent of a generalized morphology of many other species with at least a relatively large size (see fig. 3 in Delfino et al., 2013). Such morphology was reported in the Mediterranean area for both the late Miocene extinct *Varanus marathonsensis* Weithofer, 1888 and *Varanus amnhophilis* Conrad et al., 2012.

Varanus was reported in four Turkish localities (Böhme and Ilg, 2003) ranging in age from the middle Miocene to the early Pliocene, and isolated trunk vertebrae from the early Pliocene of Çalta (Rage and Sen, 1976) with a morphology similar to those from Çeştepe were actually referred to *V. marathonsensis*. However, besides doubts on the validity of the latter species, the vertebral morphology is not diagnostic at species level and therefore the material here described is simply referred at genus level. Since all fossil remains from Çeştepe could belong to a single individual (because of the congruent size and absence of duplications) all the rest of the material is referred to the same taxon.

Mammalia Linnaeus, 1758

Table 1

Measurements of lower and upper cheek teeth of *Ochotona mediterraneensis* from Çeştepe, Turkey.

Dimensions des dents jugales d'Ochotona mediterraneensis de Çeştepe, Turquie.

Tooth	n	Length		Width trigonid		Width talonid	
		Range	X	Range	X	Range	X
p3	1		1.36		1.25		
p4	2	1.38–1.47	1.43	1.33–1.43	1.38	1.48–1.54	1.51
m1	3	1.48–1.51	1.50	1.49–1.57	1.52	1.56–1.61	1.58
m2	3	1.30–1.53	1.45	1.42–1.57	1.51	1.49–1.55	1.52
P4	1		1.08		1.64		1.97

n: number of specimens; X: mean values.

Order Lagomorpha Brandt, 1885

Family Ochotonidae Thomas, 1897

Genus *Ochotona* Link, 1795

Ochotona mediterraneensis Suata Alpaslan, 2009

Material: Isolated right P4 (CT-1); right mandible fragment with p3–m2 (CT-2); right mandible fragment with detached incisor, alveolus of p3 and p4–m2 (CT-3); right mandible fragment with m1–m2 (CT-4), fragment of ramus of a right mandible (CT-5). The material also includes several small fragments that apparently belonged to a skull. We tried to fix them to rebuild this skull, without success. The anatomical position of most fragments is not recognizable. Only one pair of occipital condyles together and parts of occipital bones are reliably referable to this ochotonid. The material is homogenous and does not contain fossils that may belong to any other taxon.

Measurements: See Table 1.

Description: Putting together the available fragments, it is possible to restore the mandible (Figs. 6 and 7). The missing parts are the posterior part of the body, part of the angular process and m3. In lateral view, the body is deepest below p4 (5.20 mm), while the ventral margin of the bone shows a clear swelling forward and backward. The tip of the incisor reaches the occlusal level of cheek teeth. The length of the diastema is 4.58 mm on the most complete specimen (CT-2), and it is gently concave. The p3–m3 length can be estimated as about 7 mm. Below the p4, there is a strong taurus mandibulae, which is a round bone thickening for the attachment of masseter muscles. The lateral surface of the body has numerous tiny foramina, mainly grouped below p3 and m1. The anterior mental foramen is situated below the p3 (CT-3) or p3–p4 limit (CT-2). The posterior mental foramen is situated about 3.5 mm below the m2.

On the fragment of ramus, the articular process has an articular surface that covers the head of this process. Dorsally it is teardrop shaped. The coronoid process is not preserved. The angular process is partly preserved and it is apparently quite strong.

In medial view, the articular surface of the symphysis extends on 2.35 mm below the diastema. The medial face of the body is concave between the alveolar margin and the protuberance of the lower incisor. Several small foramina are scattered on this face.

In ventral view, the mylohyoid line starts where the lower incisors ends and it extends backward along the medial side till below m2.

A complete lower incisor measures 12.3 mm in length. It is gently curved. The enamel only covers the mesial face (width 1.51 mm). The section is almost triangular. The anterior edge bears two wear facets, the one dorsal on 2.71 mm and the other medial on 2.50 mm, both separated by a right angle. Inside the mandible, the distal end of the incisor reaches the level of p4–m1 boundary, and it is lingually rooted next to the premolars.

From the cheek teeth, the p3 is slightly longer than wide. The anteroconid has a badly defined trefoil occlusal outline with anterolateral and anteromedial depressions without cement. Its length and width are similar (0.56 mm). The anteroconid is con-

nected to the posterior part by a narrow isthmus. The paraflexid is clearly shorter than the protoflexid, and both are oblique backward. The hypoflexid is shallow, V-shaped and rather transverse. All three flexids are filled with cement. The mesoflexid is lacking. The enamel is thick around the protoconid, in front of the paraconid, and along the posterior margin of the hypoconid. Enamel is moderately thick and rather homogeneous on the anteroconid.

The p4, m1 and m2 are bilophodont as usual in all ochotonids. The anterior loph is diamond shaped, while the posterior loph is rather crescent shaped. The posterior loph is a little larger than the anterior loph in p4 and m1, but slightly narrower or equivalent in m2. The enamel is thick on the posterior margin of both lophs, which corresponds to the main shearing blades, and rather thin on the anterior margins; in any case, it is never interrupted.

A complete isolated upper cheek tooth is determined as right P4 because of its anterior loph clearly shorter and narrower than the posterior loph (1.64 versus 1.97 mm). The hypoflexus ends quite far

from the labial margin. The enamel is thick on the mesial margin of lophs but thin on their distal margin; it lacks on the labial margin. The shaft is moderately curved labially and wrinkled mesially.

Remarks: The Çeştepe ochotonid clearly belongs to the genus *Ochotona* in having small-sized cheek teeth, p3 with a simple occlusal pattern, two labial and one lingual flexids, the anteroconid of p3 without flexid and connected to the posterior complex by a narrow isthmus.

Among the most similar ochotonids, the genus *Ochotonoides* Teilhard de Chardin and Young, 1931 is different in being of very large size, and in having large anteroconid on p3 with folded and cemented flexids. The genus *Ochotonoma* Sen, 1998a, 1998b is also different in being larger in size, and, in particular, in having p3 with a large anteroconid and a short talonid; its anteroconid is penetrated by labial and/or lingual flexids filled with cement; the protoflexid and paraflexid are larger, deeper and strongly directed backward; the hypoflexid is narrow, and the lophs on p4–m2 are compressed mesio-distally. *Pliolagomys* Agadjanian and Erbajeva, 1983 is another ochotonid known from the Pliocene and early Pleistocene of Eastern Europe and Western Asia. The three species referred to this genus are larger in size than the Çeştepe specimens, their p3 have anteroconid enamel more or less folded, the isthmus between the anteroconid and posteroconid is labially shifted because the paraflexid is twice deeper than the protoflexid, and hypoflexid narrower.

The genus *Ochotona* has a large distribution in Asia and western North America with 28 extant species generally recognized based on morphological as well as molecular studies (Hoffmann and Smith, 2005; Ge et al., 2013; Lissovsky, 2014). Some of the extant species are also known as fossil during the Pleistocene, e.g., *Ochotona pusilla* (Pallas, 1769), which has a large distribution in Eurasia during the Pleistocene (Malatesta, 1951; Malez, 1969; Erbajeva et al., 2001). In addition to the extant species, Erbajeva et al. (2015) recognized 44 extinct species of *Ochotona* in Europe and in particular Asia. As we will discuss here below, the question of the synonymy of some species is an ongoing debate among the lagomorph specialists, which is out of the purpose here. Actually, such a question cannot be solved without a complete revision of available collections, and perhaps more abundant and better preserved specimens.

During the last decade some effort was invested for a better description of the European and some Asian fossil species (see in particular Erbajeva et al., 2001; Sen, 2003; Fostowicz-Frelik, 2008; Fostowicz-Frelik and Frelik, 2010; Čermák, 2010, 2016; Čermák and Rekovets, 2010; Delinschi, 2014) and for morphological cladistic analysis of most extinct and some extant species (Fostowicz-Frelik et al., 2010; Ge et al., 2013). These studies provide reliable criteria for comparing the Çeştepe ochotonid with others for its systematic assignment.

Ochotona sp. cf. *O. lagreli* Schlosser, 1924 from late middle Miocene locality of Damiao in Inner Mongolia (Zhang et al., 2012) is apparently the oldest record referred to the genus. *Ochotona ozansoyi* Sen, 2003 from the late Vallesian of Turkey (dated to 9.4 Ma) and *Ochotona kalfense* (Lungu, 1981) from the late Vallesian of Moldova (ca. 9–9.5 Ma) evidence that this genus, probably originated in East Asia, already reached the eastern Mediterranean-southeastern Europe in late Miocene (Sen, 2003; Čermák, 2016). *O. ozansoyi* was recovered in Turkey in three localities (Sinap Loc. 84, İnönü 1 and Küçükçekmece) (Sen, 2003, 2016), and *O. kalfense* at Kalfa (Moldova), all correlated to the late Vallesian. Both species are larger in size compared to the Çeştepe specimens, have larger and simple-shaped anteroconid and shorter posterior segment on the p3, and their lower (upper) cheek teeth are curved labially (lingually), while in Plio-Pleistocene representatives of *Ochotona*, the lower cheek teeth become rather straight, and the curvature of upper cheek teeth decrease. We consider the genus *Proochotona*

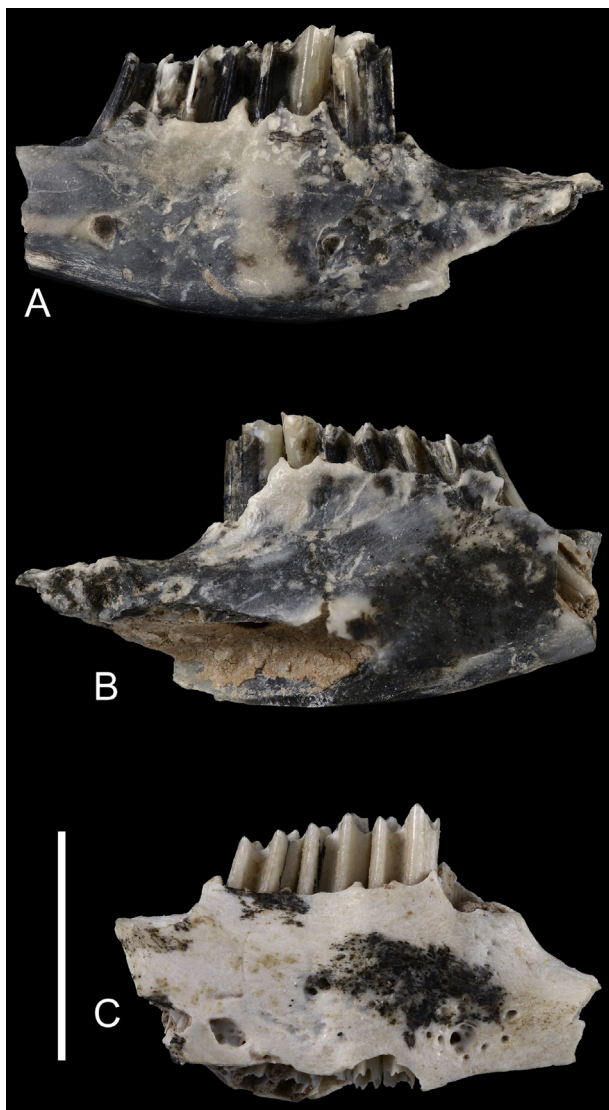


Fig. 6. *Ochotona mediterraneensis* from Çeştepe, early Pliocene of Kazan Basin. A. Right mandible (CT-2) with p3–m2 in labial view. B. Same specimen in lingual view. C. Right mandible fragment (CT-3) with the alveolus of p3 and p4–m2 in labial view. Scale bar equals 5 mm.
Ochotona mediterraneensis de Çeştepe, Pliocène inférieur du bassin de Kazan.
A. Mandibule droite (CT-2) avec p3–m2 en vue labiale. B. Même spécimen en vue linguale.
C. Fragment de mandibule droite (CT-3) avec l'alvéole de p3 et p4–m2 en vue labiale. L'échelle correspond à 5 mm.

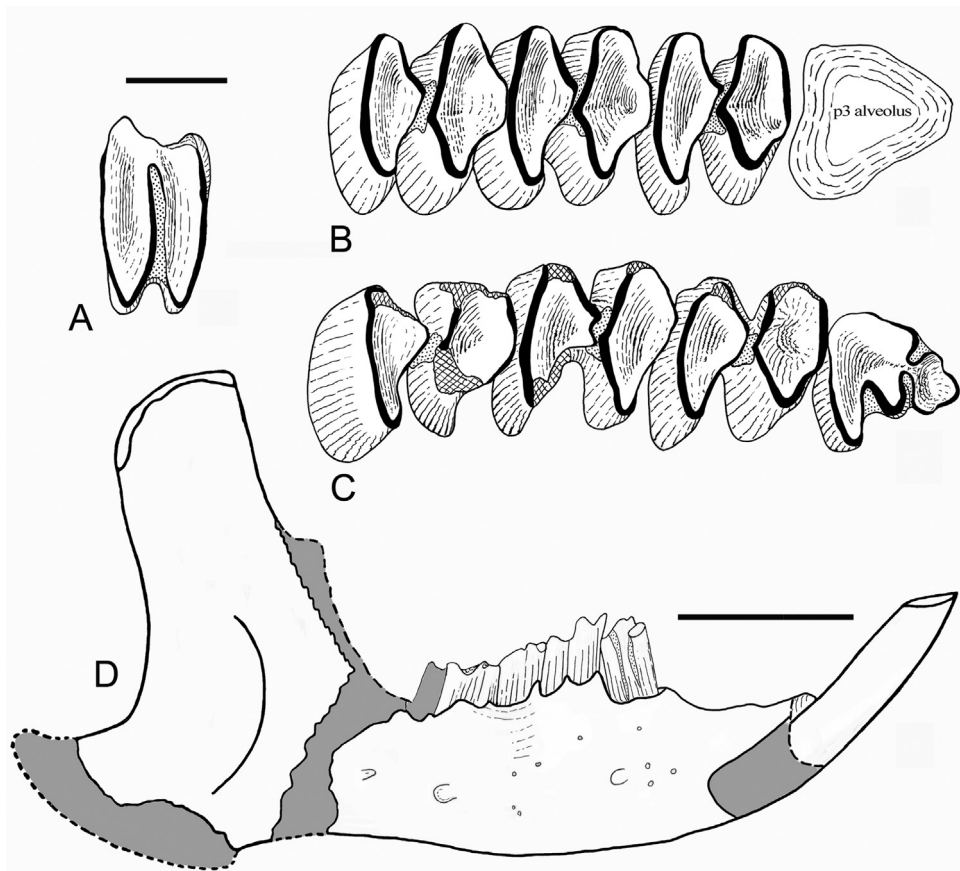


Fig. 7. *Ochetona mediterraneensis* from Çeştepe, early Pliocene of Kazan Basin. A. Right P4 (CT-4) in occlusal view. B. Right lower tooththrow (CT-3) with the alveolus of p3 and p4-m2 in occlusal view. C. Right lower tooththrow (CT-2) with p3-m2 in occlusal view. D. Right lower jaw reconstructed using all available fragments from Çeştepe, in labial view. The grayed parts are missing. On cheek teeth, blackened lines represent enamel; white, dentine; dotted areas are cement infill. Scale bars equal 1 mm in A–C and 5 mm in D.

Ochetona mediterraneensis de Çeştepe, Pliocène inférieur du bassin de Kazan. A. P4 droit (CT-4) en vue occlusale. B. Série dentaire inférieure droite (CT-3) avec l'alvéole de p3 et p4-m2 en vue occlusale. C. Série dentaire inférieure droite (CT-2) avec p3-m2 en vue occlusale. D. Mâchoire inférieure droite reconstruite en utilisant tous les fragments disponibles, en vue labiale. Les parties grisées sont manquantes. Sur les dents, les lignes noircies représentent l'émail ; les parties blanches indiquent la dentine et les zones en pointillés sont remplies de ciment. Les échelles correspondent à 1 mm pour A–C et à 5 mm pour D.

Khomenko, 1914 as a junior synonym of *Ochetona* (see discussion in Sen, 2003; Čermák, 2016). Other *Ochetona* species in Europe and Turkey are all from Plio-Pleistocene localities.

The size is used as an important criterion to distinguish extinct species of *Ochetona*. Erbajeva (1988, 1994) grouped *Ochetona* species as small, medium and large-sized species. Later on, Fostowicz-Frelik et al. (2010) used this criterion in their phylogenetic analysis. They defined as small the species having p3-m3 tooththrow length lower than 8 mm, medium-sized for length between 8.1–9.9 mm, and large-sized the species having p3-m3 longer than 10 mm. In this classification, the Çeştepe ochotonid ranks among the small-sized species (p3-m3 length estimated to about 7 mm), together with *O. bazarovi* Erbajeva, 1988, *O. dehmi* Erbajeva, 2005, *O. mediterraneensis* Suata Alpaslan, 2009, *O. minor* Bohlin, 1942, *O. polonica* Sych, 1990, *O. pusilla*, *O. valerotae* Erbajeva et al., 2001, *O. zabiensis* Fostowicz-Frelik, 2008.

Among these species, the Central Asian step pika *O. pusilla* is quite common in European Plio-Pleistocene localities. Malatesta (1951), Malez (1969) and Erbajeva et al. (2001) provided a large account of its occurrences in Europe and Asia. Lastly, Fostowicz-Frelik and Frelik (2010) reported on its occurrence in Poland since the latest Pliocene (locality of Kielniki 3), almost coeval with its first occurrence in Kazakhstan (Aktogai; Erbajeva, 1988). In Turkey, this species was found in two middle-late Pleistocene localities at Yarimbürgaz Cave near Istanbul, and Emirkaya-2 fissure filling

near Konya (Montuire et al., 1994; Santel and Von Koenigswald, 1998; see also Erbajeva et al., 2001), and Čermák et al. (2006) mentioned its possible occurrence in Güzyurdu Cave near Gümüşhane. *O. pusilla* is a small-sized species, characterized by a very small anteroconid, and reduced paraflexid and protoflexid on the p3. It is hardly compared with the Çeştepe ochotonid.

During the Pliocene and early Pleistocene in Europe, *O. polonica* is the best-documented species in several localities of Poland. Fostowicz-Frelik (2008) rightly included in this species *Ochetona dehmi* from the latest Pliocene locality of Schernfeld (Germany) and *O. valerotae* from Les Valerots (early Pleistocene, France). She demonstrated that these two species are similar in size to *O. polonica*, and their p3 is elongated, the anteroconid is simple and tapers anteriorly as in *O. polonica*. Indeed, a few differences that the authors showed to distinguish these forms from *O. polonica* are in the range of individual variation. The measurements of mandible and cheek teeth of *O. polonica* are rather similar to that of Çeştepe. However, *O. polonica* is different from the Çeştepe ochotonid in having mandible with flat ventral margin (curved at Çeştepe), p3 elongated, and its anteroconid elongated and triangular without any grooves and with a sharp apex (Fostowicz-Frelik, 2008). The proportions of the anteroconid and posteroconid on the p3 are also different. In summary, despite the similarity in size, the morphology of mandible and lower cheek teeth of *O. polonica* are clearly different from that of Çeştepe.

Fostowicz-Frelik (2008) described another small-sized ochotonid, *O. zabiensis*, from the early Biharian locality Zabia Cave, Poland. In this species, the ventral margin of the mandible is almost flat and the p3 is elongated with a mesially sharp anteroconid as in *O. polonica*. *O. zabiensis* is distinguished in having the paraflexid of p3 deeper than protoflexid, different from the condition observed in *O. polonica* as well the Çeştepe pika. This is also the case of *O. kormosi* Fostowicz-Frelik et al., 2010 from the latest Pliocene of Hungary (type loc. Ostramos-3), which is distinguished from the other species by its p3 markedly elongated with a long and narrow posteroconid, and anteroposteriorly compressed anteroconid.

The Çeştepe ochotonid is better compared with *Ochotona antiqua* Argyropulo and Pidoplichko, 1939 from Novopetrovka (type locality) in Ukraine. Lastly, Čermák and Rekovets (2010) restudied the material from its type locality and from some others in Ukraine. These authors largely discussed the morphological affinities and differences of the type material with other Pliocene species from central and eastern Asia, which were updated by Erbajeva and Zheng (2005) and Erbajeva et al. (2011). The Çeştepe specimens are similar to that of *O. antiqua* from its type locality both in the shape of the mandible and the pattern of cheek teeth, in particular the p3, and they do not show any reliable difference to be noted. However, the size of the Çeştepe specimens is about 1/3 smaller than *O. antiqua*. *O. mediterraneensis* is known from its type locality of İğdeli in the Sivas Basin. We agree with Suata Alpaslan (2009) that the pika remains from the early Pliocene locality of Maritsa (island of Rhodos, Greece; De Bruijn et al., 1970) may be included in this species. Both localities are dated to early Pliocene (MN14). This species has also the same characters on its mandible and tooth pattern, but it is clearly smaller and it fits in size with the Çeştepe specimens. Based on the similarities in size, and also the shape of mandible and tooth pattern although shared with *O. antiqua* as discussed above, the Çeştepe specimens are referred to *O. mediterraneensis*.

The presence of great morphological resemblances, but a significant difference in size between *O. mediterraneensis* and *O. antiqua* recalls the Bergmann's rule that states that species of larger size are found in colder environments, and species of smaller size are found in warmer regions. The known dispersal area of the smaller species *O. mediterraneensis* (İğdeli, Maritsa and Çeştepe) is situated between the latitudes 35–40° N while that of *O. antiqua* between the latitudes 45–50° N (north of Black Sea and possibly Romania), both during the early Pliocene. Although this hypothesis suggests a possible synonymy of *O. mediterraneensis* with *O. antiqua*, we know nothing on the latitudinal size variation in the extant and extinct species of *Ochotona*, thus preventing to assert such synonymy.

The list of extinct *Ochotona* species given by Erbajeva et al. (2015) includes two species, *O. agadzhaniani* Melik-Adamian, 2003 and *O. azerica* Gadzhiev and Aliev, 1969, both from Armenia. As this territory is neighbor to Turkey, we would compare these species with the Çeştepe specimens. Alexey Tesakov (Geological Institute of the Russian Academy of Sciences, Moscow) gently provided informations dealing with them. “*O. agadzhaniani* is from the locality of Nurnus (MN14), and it was named in the unpublished thesis of Melik-Adamyan (2003). *O. azerica* is reported from the famous Azukh or Azokh cave, apparently from upper Ascheulian beds. Its validity is also questionable. The original thesis on mammals from Azykh by Aliev (1969) was not officially published” (Tesakov, in literis, August 20, 2016; see also Čermák et al., 2006). In summary, both species are nomen nudum, since they are not described and illustrated in a published paper.

5. History of lagomorphs in Asia Minor

Since their appearance in early Eocene, the evolutionary history of lagomorphs is shaped by their dispersal all over the three

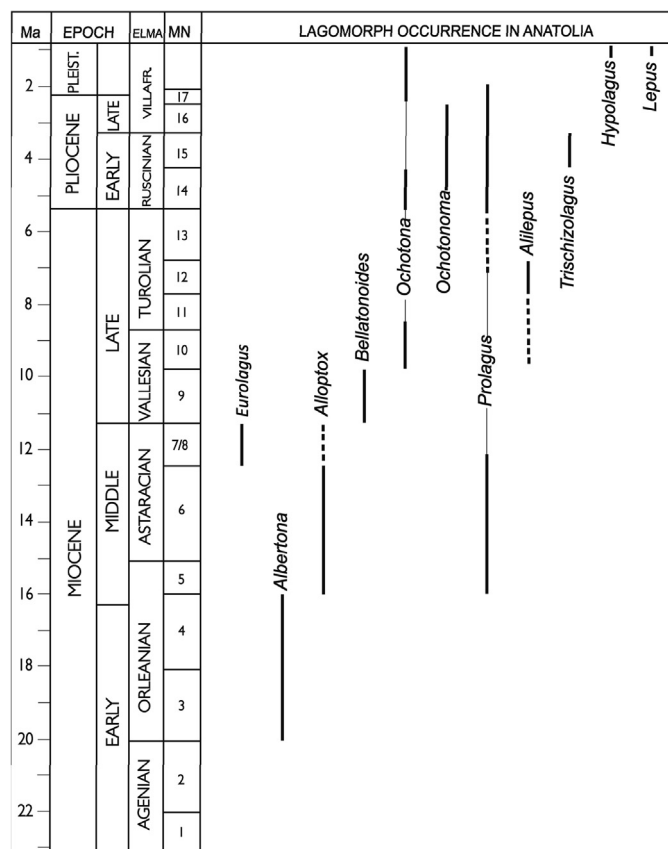


Fig. 8. Time range of fossil lagomorph genera in Anatolia.
Distribution temporelle des genres de lagomorphes fossiles en Anatolie.

continents of the Old World (Flynn et al., 2013; Erbajeva et al., 2015). Asia Minor is situated in a central position between these continents and had to play the role of bridge on the dispersal routes of lagomorphs throughout the Cenozoic. Below, we propose a synthesis of available data to highlight the taxa already recognized, and to try an attempt on their paleobiogeographic affinities with other regions of the Old World.

Taking into account all published faunal lists (Sickenberg et al., 1975; Saraç, 2003), NOW Database (Fortelius, 2016), and descriptions in several papers (Ünay and Sen, 1976; Sen et al., 1989; Sen, 1990, 1991, 1998a, 1998b, 2003, 2016; Montuire et al., 1994; Ünay and de Bruijn, 1998; Ünay and Göktaş, 1999; Ünay et al., 2001; De Bruijn et al., 2003, 2006; Suata Alpaslan, 2009), fossil lagomorphs have been recorded in Anatolia in 66 localities aged between early Miocene and middle Pleistocene. The specimens from 19 localities are more or less well described and illustrated to satisfy their identifications at generic and in most cases specific level. It appears that the family Ochotonidae is the best-documented, with six genera (*Albertona*, *Alloxox*, *Prolagus*, *Bellatonioides*, *Ochotonoma* and *Ochotona*) in 48 localities, compared to the Leporidae with four genera (*Alilepus*, *Hypolagus*, *Trischizolagus* and *Lepus*) in 9 localities, and the Palaeolagidae with one genus (*Eurolagus*) in 2 localities.

Fig. 8 summarizes the chronological occurrence of fossil lagomorphs in Anatolia during the Neogene and Quaternary. It appears that the earliest lagomorph in Anatolia is referred to the genus *Albertona*, which is an ochotonid known up to date from Serbia, Greece and Turkey during early Miocene (López-Martínez, 1986; Ünay and Göktaş, 1999; Marković, 2010). In middle Miocene localities, the common genera are *Alloxox* and *Prolagus*, which generally co-occur in the same localities (Paşalar, Çandır, Bağıcı, Zambal 2;

Sen, 1990; De Bruijn et al., 2003; Saraç, 2003), and in similar percentages. *Alloptox* as *Albertona* has Asiatic affinities, while *Prolagus* is mostly a European genus (López-Martínez, 2001).

The history of the genus *Prolagus* is rather peculiar in Anatolia. It is common in middle Miocene localities, as mentioned above, but totally absent in late Miocene localities, except at Düzyayla and Kangal 1, both in the Sivas Basin, where De Bruijn et al. (1999) and Saraç (2003), respectively, mentioned the occurrence of *Prolagus*, without further study. These identifications need to be verified. *Prolagus* is not recorded in the well-documented Sinap Formation localities that cover the time interval 8–11 Ma. *Prolagus* “reappears” in the Pliocene faunas of Anatolia. For instance, it is quite common and the unique ochotonid in the western Anatolian localities of Develi and Halitpasa (Sen et al., 1989; Kaya et al., 2004), while in eastern Anatolia it co-occurs at Iğdeli (MN14, Sivas Basin) together with *Ochotona* (Suata Alpaslan, 2009; Suata Alpaslan et al., 2010), and it is absent at Çalta (MN15, Kazan Basin). We have to remember that *Prolagus* is widely distributed mostly in Europe, and that Anatolia is in the southeastern borders of its dispersal area. Thus, it is quite likely that the occurrence of *Prolagus* in the Pliocene of Anatolia can be qualified as a Lazarus event.

Lagomorphs are absent around the middle-late Miocene boundary in the well-documented Sinap Formation localities in the Kazan area. Their first occurrence is dated to 9.9 Ma at Sinap Loc. 8A with *Bellatonoides eroli*. From the late Miocene upwards, the genera of the “*Ochotona* group” (sensu Sen, 2003; i.e. *Bellatonoides*, *Ochotona* and *Ochotonoma*) replace the couple *Alloptox*–*Prolagus* of the middle Miocene. All three genera have clearly Asian affinities. *Ochotona ozansoyi* from Sinap Loc. 84, dated to 9.4 Ma by magnetostratigraphy (Kappelman et al., 2003) is the oldest species referred to this genus. It is also recorded in another locality in Central Anatolia (cf. at İnönü; Sen, 2003) and at Küçükçekmece near Istanbul (Sen, 2016), both correlated to the late Vallesian. We have to mention here that Erbajeva et al. (2015) suggested to refer *O. ozansoyi* to the genus *Proochotona* Khomenko, 1914, known with *Proochotona eximia* Khomenko, 1914 from the late Miocene (early Turolian) locality of Tarakliya in Moldova. The status of the genus *Proochotona* is still debated (Sen, 2003; Erbajeva et al., 2011, 2015; Delinschi, 2014; Čermák, 2016). This taxonomic problem needs further study on the material of its type locality and also additional material from similar age localities.

During the Turolian, lagomorphs seem to be absent or extremely discrete in Anatolia, but this is probably due to insufficient fossil record. Indeed, Turolian localities in Turkey are mainly known for their large mammals, except a few localities from which small mammals are documented (e.g., Çorakyerler, Karaözü, Kaleköy) otherwise than preliminary identifications.

The genus *Ochotona* reappears in Anatolia in early Pliocene (Suata Alpaslan, 2009), and became probably extinct during the historical times (Čermák et al., 2006).

Leporids are poorly documented in Anatolia, as seen on Fig. 8. The oldest record is a lower molariform tooth from Sinap Tepe Loc 12 referred to Leporidae indet. (Sen, 2003). This is a surface finding, and consequently its age may be different from that of this locality, which is dated by magnetostratigraphy at 9.6 Ma (Kappelman et al., 2003). The genera *Trischizolagus*, *Hypolagus* and *Lepus* are known each from one locality (Tozaklar, Emirkaya 2, Dursunlu, respectively), and the genus *Alilepus* is mentioned in two localities (Düzyayla and Halitpasa; De Bruijn et al., 1999; Saraç, 2003).

In summary, the state of the art shows that the family of Ochotonidae is well-documented in Turkey, while the record dealing with the Leporidae is poor. The record is rich for some intervals of Neogene (e.g. middle Miocene, early late Miocene, early Pliocene) and still sparse for other intervals. When accurately studied, the Lagomorpha effectively contribute to the dating of fossiliferous deposits and to the environmental context of mammalian faunas.

Although poor, the Çeştepe faunule provides a good example for this.

6. Conclusions

Sedimentary deposits are the archives of the past. In the eastern part of the Kazan Basin (NW to Ankara), sedimentary deposits of the Sinap Formation are richly fossiliferous and documented Neogene mammalian faunas. A new locality at the village of Çeştepe, in the northeastern margin of this basin, provides a new landmark to document the stratigraphy. The fossil material consists of fragmented bones and jaws. We identified three species of reptiles (cf. *Lacerta* sp., Anguinae indet. and *Varanus* sp.) and an ochotonid lagomorph, *Ochotona mediterraneensis*. The occurrence of the latter species, previously known from the localities of Iğdeli in the Sivas Basin and Maritsa in the island of Rhodes (Greece), suggests the correlation of this locality to early Ruscinian (early Pliocene, MN14) (De Bruijn et al., 1970; Suata Alpaslan, 2009). Among these taxa, both *Varanus* and *Ochotona* were previously recorded in the same basin, but in different stratigraphic horizons. The only locality in Turkey from which *Varanus* remains are described is Çalta, at 16.5 km SW to Çeştepe (Rage and Sen, 1976). This locality is a little younger than Çeştepe, correlated to the late Ruscinian (MN15). Also, two localities in the Kazan Basin yielded the remains of an ochotonid, *Ochotona ozansoyi* Sen, 2003 from two sites dated to the late Vallesian (MN10). This species is different from that of Çeştepe, having a larger size, smaller and simple-shaped anteroconid and shorter posterior segment on the p3, and curved cheek teeth. The specimens from Çeştepe fit in the shape of the lower jaw and the pattern of cheek teeth with *O. mediterraneensis*. Morphological similarities between this species and *O. antiqua* from the northern rims of Black Sea should be noted, although *O. mediterraneensis* is 1/3 smaller.

The faunule from Çeştepe includes only Eurasian taxa. However, it must be noted that this assemblage is biased by collecting technique. It is far from reflecting the spectrum of an early Pliocene fauna, and it is hardly compared with faunas of similar age, which limits its paleobiogeographic and environmental significance. Although the genus *Ochotona* had, during the Pleistocene, a large spatial range from the Pyrenees and southern England to eastern China, it is now mainly considered as an Asiatic element adapted to steppic environments with low vegetation. Its extant species live on rocky mountainsides to find shelter in crevices. In Turkey, the genus survived during the Pleistocene, but apparently become extinct in Holocene (Čermák et al., 2006). This study evidences that the fossil record in terrestrial deposits, although limited in the number of taxa as it is the case in the present study (just three reptiles and one ochotonid), contributes to document the history of these groups, and beyond this, it provides biochronological and environmental data for the related deposits.

Disclosure of interest

The authors declare that they have no competing interest.

Acknowledgements

Adem Akköprü (ASKI-Water Works Office of Ankara Metropolis Municipality) is the author of the discovery of vertebrate fossils at Çeştepe. He stopped the excavation when seeing the fossils and informed N. Kazancı. Yaşar Suludere (JRMIRKO-Turkish Association for Conservation of Geoheritage), Baki Varol, Ezgi Güllü, Özgür Yedek, Türkan Akçalar (Ankara University) visited the site and collected fossils. Hilal Engin Dokuz and Alper Gürbüz (Ankara University) helped with drawing of geological maps. Philippe Loubry (CNRS, Muséum) made the photos of lagomorphs. M.D.

was supported by Università di Torino (Fondi di Ateneo 2014, 2015) Generalitat de Catalunya (2014 SGR 416 GRC) and CERCA Program, and Spanish Ministerio de Economía y Competitividad (CGL2016-76431-P). G. Georgalis and A. Villa provided valuable comments on the reptiles and Stanislav Čermák and Alexey Tesakov on the lagomorphs. The comments and suggestions of the referees Chiara Angelone and Hugues-Alexandre Blain, and of the editor Didier Néraudeau, were very useful to improve this paper. We are grateful to all of them.

References

- Adıgüzel, N., Vural, M., 1995. Vegetation of Soğuksu National Park (Ankara). *Turkish Journal of Botany* 19, 213–234.
- Aliev, S.D., (Dissertation Thesis, unpublished) 1969. Fauna Azyzhskoy paleoliticheskoj stojanki [Fauna of the Palaeolithic Azyh encampment]. Institute of Zoology, Baku (30 p. In Russian).
- Alpagut, B., Andrews, P., Fortelius, M., Kappelman, J., Temizsoy, İ., Çeelebi, H., Lindsay, W., 1996. A new specimen of *Ankarapithecus metei* from the Sinap Formation of Central Anatolia. *Nature* 382, 349–351.
- Arnold, E.N., 1973. Relationships of the Palaearctic lizards assigned to the genera *Lacerta*, *Algyroides* and *Psammotromus* (Reptilia, Lacertidae). *Bulletin of the British Museum Natural History Zoology* 25, 289–366.
- Arnold, E.N., 1989. Towards a phylogeny and biogeography of the Lacertidae: relationship within an Old World family of lizards derived from morphology. *Bulletin of the British Museum Natural History Zoology* 55, 209–257.
- Arnold, E.N., Arribas, O., Carranza, S., 2007. Systematics of the Palaearctic and Oriental lizard tribe Lacertini (Squamata: Lacertidae: Lacertinae), with descriptions of eight new genera. *Zootaxa* 1430, 1–86.
- Atabey, E., Saraç, G., 2004. Ankara Çamlıdere taşlaşmış ağaç fosil ormanı. TMMOB Jeoloji Mühendisleri Odası Haber Bülteni 3, 80–82.
- Augé, M., Rage, J.C., 2000. Les Squamates (Reptilia) du Miocène moyen de Sansan. In: Ginsburg L. (Ed.), La faune miocène de Sansan et son environnement. Mémoires du Muséum National d'Histoire Naturelle 183, 263–313.
- Bailey, E.B., McCallien, W.S., 1953. The Ankara Mélange and Anatolia Thrust. *Nature* 166, 938–941.
- Barahona, F., Barbado, L.J., 1997. Identification of some Iberian lacertids using skull characters. *Revista Española de Herpetología* 11, 47–62.
- Barbado, L.J., Sanz, J.L., 1983. Análisis osteométrico de las regiones sacra y presacra de la columna vertebral en los lagartos ibéricos *Lacerta viridis* Laurenti, *Lacerta lepida* Daudin y *Lacerta schreiberi* Bedriaga. *Amphibia-Reptilia* 4, 215–239.
- Blain, H.A., 2016. Chapter 9. Amphibians and Squamate Reptiles from Azokh 1. In: Fernández-Jalvo, Y., King, T., Yepiskoposyan, L., Andrews, P. (Eds.), Azokh Cave and the Transcaucasian Corridor. *Vertebrate Paleobiology and Paleoanthropology Series*. Springer, pp. 191–210.
- Blain, H.A., Agustí, J., Lordkipanidze, D., Rook, L., Delfino, M., 2014. Paleoclimatic and paleoenvironmental context of the early Pleistocene hominins from Dmanisi (Georgia, Lesser Caucasus) inferred from the herpetofaunal assemblage. *Quaternary Science Reviews* 105, 136–150.
- Böhme, M., Ilg, A., 2003. fosFARbase (Accessed 31.08.2016) <http://www.wahrestaecker.com/>.
- Čermák, S., 2010. The late Miocene and Pliocene Ochotoninae (Lagomorpha, Mammalia) of Europe – the present state of knowledge. In: Nowakowski, D. (Ed.), *Morphology and Systematics of Fossil Vertebrates*. DN Publisher, Wrocław, Poland, pp. 9–28.
- Čermák, S., 2016. The late Miocene species *Ochotona kalfense* (Mammalia, Lagomorpha) of Moldova: the oldest European record of the genus in the context of the earliest Ochotoninae. *Comptes Rendus Palevol* 15, 927–940.
- Čermák, S., Rekovets, L.I., 2010. Early Pliocene ochotonids (Mammalia, Lagomorpha) from Southern Ukraine. *Geodiversitas* 32 (1), 107–120.
- Čermák, S., Obuch, J., Benda, P., 2006. Notes on the genus *Ochotona* in the Middle East (Lagomorpha: Ochotonidae). *Lynx* 37, 51–66.
- Colombero, S., Angelone, C., Bonelli, E., Carnevale, G., Cavallo, O., Delfino, M., Giuntelli, P., Mazza, P., Pavia, G., Pavia, M., Repetto, G., 2014. The Messinian vertebrate assemblages of Verduno (NW Italy): another brick for a latest Miocene bridge across the Mediterranean. *Neues Jahrbuch für Geologie und Paläontologie-Abhandlungen* 272 (3), 287–324.
- Colombero, S., Alba, D.M., D'Amico, C., Delfino, M., Esu, D., Giuntelli, P., Harzhauser, M., Mazza, P.P.A., Mosca, M., Neubauer, T.A., Pavia, G., Pavia, M., Villa, A., Carnevale, G., 2017. Late Messinian mollusks and vertebrates from Moncucco Torinese, northwestern Italy. *Paleoecological and paleoclimatological implications*. *Palaeontologia Electronica* (in press).
- De Bruijn, H., Dawson, M.R., Mein, P., 1970. Upper Pliocene Rodentia, Lagomorpha and Insectivora (Mammalia) from the Island of Rhodes (Greece). *Proceedings of Koninklijke Nederlandse Akademie van Wetenschappen B* 73, 314–338.
- De Bruijn, H., Saraç, G., Van den Hoek Ostende, L.W., Roussiakis, S., 1999. The status of the genus name *Parapodemus* Shubov, 1938: new data bearing on an old controversy. In: Reumer, J.W.F., De Vos, J. (Eds.), *Elephants have a snorkel! Papers in honour of Paul Y. Sondaar*. Deinsea 7, 95–112.
- De Bruijn, H., Van den Hoek Ostende, L., Kristkoiz-Boon, E., Rummel, M., Theodoropoulos, C., Ünay, E., 2003. *Rodents, lagomorphs and insectivores, from the middle Miocene hominoid locality of Çandır (Turkey)*. In: Güleş, E., Begun, D., Geraads, D. (Eds.), *Geology and Vertebrate Paleontology of the Middle Miocene Hominoid Locality Çandır (Central Anatolia, Turkey)*. Courier Forschungsinstitut Senckenberg 240, 51–89.
- De Bruijn, H., Mayda, S., Van den Hoek Ostende, L., Kaya, T., Saraç, G., 2006. Small mammals from the Early Miocene of Sabuncubeli (Manisa, S.W. Anatolia, Turkey). *Beiträge zur Paläontologie* 30, 57–87.
- Delfino, M., Rage, J.-C., Bolet, A., Alba, D.M., 2013. Early Miocene dispersal of the lizard *Varanus* into Europe: reassessment of vertebral material from Spain. *Acta Palaeontologica Polonica* 58, 731–735.
- Delinschi, A., 2014. Late Miocene lagomorphs from the Republic of Moldova. *Annales de Paléontologie* 100, 157–163.
- Dilek, Y., Thy, P., 2006. Age and petrogenesis of plagiogranite intrusions in the Ankara Mélange, Central Turkey. *Island Arc* 15, 44–57.
- Dirik, K., Erol, O., 2000. Tuzgölü ve civarının tektonomorfolojik evrimi, Orta Anadolu, Türkiye. *Haymana – Tuzgölü – Ulukışla Basenleri Uygulamalı Çalışma (Workshop)*. Türkiye Petrol Jeologları Derneği, Özel Sayı 5, 27–46.
- Duru, M., Aksay, A., 2002. 1/100,000 ölçekli Türkiye Jeoloji Haritaları No. 42 Bolu H29 Paftası. Maden Tetkik ve Arama Genel Müdürlüğü, Ankara. (25 p.).
- Erbajeva, M.A., 1988. *Cenozoic Pika* (Taxonomy, Systematics, Phylogeny). Nauka, Moscow (224 p. In Russian).
- Erbajeva, M.A., 1994. Phylogeny and evolution of Ochotonidae with emphasis on Asian ochotonids. In: Tomida, Y., Li, C.K., Setoguchi, T. (Eds.), *Rodent and Lagomorph Families of Asian Origins and Diversification*. National Science Museum Monographs Tokyo 8, 1–13.
- Erbajeva, M.A., 2005. New Late Pliocene pika (Lagomorpha, Mammalia) from Germany. *Paleontological Journal* 3, 91–93.
- Erbajeva, M., Flynn, L.J., Alexeeva, N., 2015. Late Cenozoic Asian Ochotonidae: taxonomic diversity, chronological distribution and biostratigraphy. *Quaternary International* 355, 18–23.
- Erbajeva, M.A., Mead, J.I., Alexeeva, N.V., Angelone, C., Swift, S.L., 2011. Taxonomic diversity of late Cenozoic Asian and North American ochotonids (an overview). *Palaeontologia Electronica* 14 (3), 42A (9 p.; palaeo – electronica.org/2011.3/25.erbajeva/index.html).
- Erbajeva, M.A., Montuire, S., Chaline, J., 2001. New ochotonids (Lagomorpha) from the Pleistocene of France. *Geodiversitas* 23 (3), 395–409.
- Erbajeva, M.A., Zheng, S., 2005. New data on late Miocene–Pleistocene ochotonids (Ochotonidae, Lagomorpha) from North China. *Acta zoologica cracoviensis* 48 (1–2), 93–117.
- Erişen, B., Ünlü, M.R., 1976. Ankara Çubuk-Kızılcahamam-Kazan alanının jeolojisi ve jeotermal olanakları. MTA Report, No. 9949, Ankara. (Unpublished).
- Erol, O., Yurdakul, E., Algan, Ü., Gürel, N., Herece, E., Tekirli, E., Ünsal, Y., Yüksel, M., 1980. Ankara metropoliten arazi kullanım haritası. MTA Report, Ankara. (99 p. Unpublished).
- Flynn, L.J., Winkler, A.J., Erbaeva, M., Alexeeva, N., Anders, U., Angelone, C., Čermák, S., Fladerer, F.A., Kraatz, B., Ruedas, L.A., Ruf, I., Tomida, Y., Veitschegger, K., Zhang, Z., 2013. The Leporid Datum: a late Miocene biotic marker. *Mammal Review* 44 (3–4), 164–176.
- Fortelius, M. (coordinator) (Ed.), 2016. Neogene of the Old World Database of Fossil Mammals (NOW). University of Helsinki <http://www.helsinki.fi/science/now/>.
- Fortelius, M., Kappelman, J., Sen, S., Bernor, R.L. (Eds.), 2003. *Geology and Paleontology of the Miocene Sinap Formation, Turkey*. Columbia University Press, New York (409 p.).
- Fostowicz-Frelik, Ł., 2008. Review of the earliest Central European *Ochotona* (Mammalia: Lagomorpha), with description of a new species from Poland. *Mammalia* 72, 71–81.
- Fostowicz-Frelik, Ł., Frelik, G.J., 2010. The earliest occurrence of the steppe pika (*Ochotona pusilla*) in Europe near the Pliocene/Pleistocene boundary. *Naturwissenschaften* 97 (3), 325–329.
- Fostowicz-Frelik, Ł., Frelik, G.J., Gasparik, M., 2010. Morphological phylogeny of pikas (Lagomorpha: *Ochotona*), with a description of a new species from the Pliocene/Pleistocene transition of Hungary. *Proceedings of the Academy of Natural Sciences of Philadelphia* 159 (1), 97–118.
- Ge, D., Wen, Z., Xia, L., Zhang, Z., Erbaeva, M., Huang, C., Yang, Q., 2013. Evolutionary history of lagomorphs in response to global environmental change. *Plos One* 8 (4), 1–15.
- Gökten, E., Kazancı, N., Acar, Ş., 1988. Ankara kuzeybatısında (Bağlum-Kazan arası) geç Kretase-Pliyosen serilerinin stratigrafisi ve tektoniği. *MTA Bulletin* 108, 69–81.
- Görür, N., Tüysüz, O., Şengör, A.M.C., 1998. Tectonic evolution of the Central Anatolian basins. *International Geology Review* 40, 831–850.
- Hatipoğlu, M., Türk, N., 2009. A combined polarizing microscope, XRD, SEM, and specific gravity study of the petrified woods of volcanic origin from the Çamlıdere-Çeltikçi-Güdüll fossil forest, in Ankara, Turkey. *Journal of African Earth Sciences* 53, 141–157.
- Hoffmann, R.S., Smith, A.T., 2005. Order Lagomorpha. In: Wilson, D.E., Reeder, D.M. (Eds.), *Mammal Species of the World: A Taxonomic and Geographic Reference 1*. The John Hopkins University Press, Baltimore, Maryland, pp. 185–211.
- Inci, U., Helvacı, C., Yağmurlu, F., 1986. Stratigraphy of Beypazari Neogene Basin, Central Anatolia, Turkey. *Newsletters on Stratigraphy* 18 (3), 165–182.
- Kahraman, C. (Ms Thesis) 2014. Hydrogeological Characterization and Investigation of the Çeltikçi Coal Basin in Central Anatolia. Middle East Technical University, Ankara (211 p. Unpublished).
- Kappelman, J., Duncan, A., Feseha, M., Lunkka, J.-P., McDowell, F., Ryan, T.M., Swisher III, C.C., 2003. Chronology. In: Fortelius, M., Kappelman, J., Sen, S., Bernor,

- R.L. (Eds.), *Geology and Paleontology of the Miocene Sinap Formation, Turkey*. Columbia University Press, New York, pp. 41–66.
- Karaca, A., (Ms Thesis) 2004. Post-Miocene Deformation of the Area Between Alibey (Kızılcahamam) and Karalar (Kazan), NW Ankara (Turkey). Middle East Technical University, Ankara (100 p. Unpublished).
- Karadenizli, L., 1995. Beypazarı havzası (Ankara batısı) Üst Miyosen-Pliyosen jipsli serilerinin sedimantolojisi. *Türkiye Jeoloji Bülteni* 38, 63–74.
- Karadenizli, L., 2011. Oligocene to Pliocene palaeogeographic evolution of the Çankırı-Çorum Basin, central Anatolia, Turkey. *Sedimentary Geology* 237, 1–29.
- Karadenizli, L., Seyitoğlu, G., Saraç, G., Kazancı, N., Şen, Ş., Hakyemez, Y., Savaşçı, D., 2003. Early Middle Miocene palaeogeographic evolution of the western margin of Çankırı-Çorum Basin, Central Anatolia, Turkey. *Bulletin of Mineral Research and Exploration* 126, 69–86.
- Kasaplıgil, B., 1977. Ankara-Kızılcahamam yakınındaki Güvem Köyü civarında bulunan son Tersiyer kozalaklı-yeşil yapraklı ormanı. *MTA Dergisi* 88, 94–122.
- Kaya, O., Ünay, E., Saraç, G., Eichhorn, S., Hassenrück, S., Knappe, A., Pekdeğer, A., Mayda, S., 2004. Halitpaşa transpressive zone: implications for an early Pliocene compressional phase in central western Anatolia, Turkey. *Turkish Journal of Earth Sciences* 13 (1), 1–13.
- Kaymakçı, N., 2000. Tectono-stratigraphical evolution of the Çankırı Basin (Central Anatolia, Turkey). *Geologia Ultraiectiona* 190, 1–247.
- Kazancı, N., 2012. Geological background and three vulnerable geosites of the Kızılcahamam – Çamlıdere Geopark Project in Ankara, Turkey. *Geoheritage* 4, 249–261.
- Kazancı, N., Şen, S., Seyitoğlu, G., de Bonis, L., Bouvrain, G., Araz, H., Varol, B., Karadenizli, L., 1999. Geology of a new late Miocene mammal locality in Central Anatolia, Turkey. *Comptes Rendus de l'Académie des Sciences IIa – Earth and Planetary Sciences* 329, 503–510.
- Kazancı, N., Suludere, Y., Mülazımoğlu, N.S., Tuzcu, S., Mengi, H., Hakyemez, Y., Mercan, N., 2007. Milli Parklarda Jeomiras 1. Soğuksu Milli Parkı ve Çevresi Jeositleri, Doğa Koruma ve Milli Parklar Genel Müdürlüğü ve jeolojik Mirası Koruma Derneği, Ankara (60 p.).
- Klemba, J., 2012. A new species of *Pseudopus* (Squamata, Anguinae) from the early Miocene of Northwest Bohemia (Czech Republic). *Journal of Vertebrate Paleontology* 32, 854–866.
- Klemba, J., Böhme, M., Rummel, M., 2010. Revision of the anguid lizard *Pseudopus laurillardi* (Squamata, Anguinae) from the Miocene of Europe, with comments on palaeoecology. *Journal of Paleontology* 84, 159–196.
- Klemba, J., Miroslav, J., Dobiasová, K., 2014. Comparative anatomy of the lower jaw and dentition of *Pseudopus apodus* and the interrelationships of species of subfamily Anguinae (Anguimorpha, Anguinae). *The Anatomical Record* 297, 516–544.
- Koçyiğit, A., Özkan, S., Rojay, B., 1988. Examples from the forearc basin remnants at the active margin of northern Neotethys; development and emplacement ages of the Anatolian Nappe, Turkey. *METU Journal of Pure and Applied Sciences* 21 (1–3), 183–210.
- Koçyiğit, A., Rojay, B., Cihan, M., Özacar, A., 2001. The June 6, 2000, Orta (Çankırı, Turkey) earthquake: Sourced from a new antithetic sinistral strike-slip structure of the North Anatolian Fault System, the Dodurga Fault Zone. *Turkish Journal of Earth Sciences* 10, 69–82.
- Lisovsky, A.A., 2014. Taxonomic revision of pikas *Ochotona* (Lagomorpha, Mammalia) at the species level. *Mammalia* 78 (2), 199–216.
- Lopez-Antoñanzas, R., Sen, S., Saraç, G., 2004. A new large ctenodactylid species from the Lower Miocene of Turkey. *Journal of Vertebrate Paleontology* 24, 676–688.
- López-Martínez, N., 1989. Revision sistemática y biostratigráfica de los Lagomorpha (Mammalia) de Terciario y Cuaternario de España. *Memorias del Museo Paleontológico de la Universidad de Zaragoza* 3 (3), 1–296.
- Lunkka, J.P., Kappelman, J., Ekart, D., Crabaugh, J., Gibbard, P., 2003. Geology. In: Fortelius, M., Kappelman, J., Sen, S., Bernor, R.L. (Eds.), *Geology and Paleontology of the Miocene Sinap Formation, Turkey*. Columbia University Press, New York, pp. 26–40.
- Malatesta, A., 1951. Considerazioni sugli Ochotonidae fossili e viventi. *Bollettino del Servizio Geologico Italia* 71, 121–146.
- Malez, M., 1969. Diffusione del genere *Ochotona* nel Pleistocene superiore dell'Europa sud-orientale. *Museo civico di Storia naturale di Verona, Memorie fuori Serie* 3, 67–73.
- Marković, Z., 2010. *Albertona balkanica* from Early Miocene of Snetgotin (Serbia) – implications for the distribution and evolution of Miocene Ochotonidae. *Annales de Paléontologie* 96 (2), 25–32.
- Melik-Adamyan, G., (Abridged thesis) 2003. Stratigraphy and Paleogeography of Pliocene and Lower Neopleistocene of Central and Northwestern Armenia based on Fauna of Land Vertebrates. *Cand. Sci., Erevan* (29 p. Unpublished).
- Montuire, S., Sen, S., Michaux, J., 1994. The middle Pleistocene mammalian fauna from Emirkaşı-2, Central Anatolia (Turkey): systematics and paleoenvironment. *Neues Jahrbuch für Geologie und Paläontologie-Abhandlungen* 193, 107–144.
- MTA, 2002. Ankara sheet of 1/500,000 geological maps of Turkey. A publication of General Directorate of Mineral Research and Exploration of Turkey, Ankara.
- Okay, A.I., Göncüoğlu, M.C., 2004. Karakaya complex: a review of data and concepts. *Turkish Journal of Earth Sciences* 13, 77–95.
- Öngür, T., 1976. Kızılcahamam, Çamlıdere, Çeltikçi, Kazan dolayının jeoloji durumu ve jeotermal enerji olanakları, MTA Ankara, Report No. 3273. (34 p. Unpublished).
- Ozansoy, F., 1965. Étude des gisements continentaux et des mammifères du Cénozoïque de Turquie. *Mémoires de la Société Géologique de France* 102, 1–92.
- Rage, J.C., Sen, S., 1976. Les amphibiens et les reptiles du Pliocène supérieur de Çalta (Turquie). *Géologie Méditerranéenne* 3, 127–134.
- Roček, Z., 1980. The dentition of the European Glass Lizard *Ophisaurus apodus* (Pallas, 1775) (Reptilia, Sauria: Anguinae), with notes on the pattern of tooth replacement. *Amphibia-Reptilia* 1, 19–27.
- Rojay, B., 2013. Structural Evolution of Çeltikçi – Gümele Area During Post-Miocene. A Technical Report. Middle East Technical University, Ankara (38 p. Unpublished).
- Rojay, B., Karaca, A., 2008. Post-Miocene deformation in the south of the Galatean Volcanic Province, NW of Central Anatolia (Turkey). *Turkish Journal of Earth Sciences* 17, 653–672.
- Rückert-Ülkümen, N., Maus, M., Glav, F., Franzen, M., 2002. *Kaulquappen von Pelobates* sp. (Amphibia: Pelobatidae) aus dem Miozän von Beşkonak Köyü, Zentralanatolien, Türkei. *Bayerische Staatssammlung für Paläontologie und Historische Geologie* 42, 75–82.
- Ruprecht, K.H., 1956. 1/25,000 ölçekli sayısal jeoloji haritaları Bolu H29-b2 paftası. Türkiye Jeoloji Veri Tabanı. Jeoloji Etüdları Dairesi Başkanlığı, Maden Tetkik ve Arama Genel Müdürlüğü, Ankara.
- Santel, W., Von Koenigswald, W., 1998. Preliminary report on the middle Pleistocene small mammal fauna from Yarımburgaz Cave in Turkish Thrace. *Eiszeitalter und Gegenwart* 48, 162–169.
- Saraç, G., 2003. Türkiye Omurgalı Fosil Yatakları. MTA Report, No. 10609 (218 p. Unpublished).
- Sen, S., 1990. Middle Miocene lagomorphs from Paşalar, Turkey. *Journal of Human Evolution* 19 (4), 455–461.
- Sen, S., 1991. Stratigraphie, faunes de mammifères et magnétostratigraphie du Néogène de Sinap Tepe, Province d'Ankara, Turquie. *Bulletin du Muséum national d'Histoire naturelle, Paris 4^e sér. C* (3–4), 243–277.
- Sen, S., 1998a. Pliocene vertebrate locality of Çalta, Ankara, Turkey. *Geodiversitas* 20 (3), 325–510.
- Sen, S., 1998b. Rodentia and Lagomorpha. In: Sen, S. (Ed.), *Pliocene vertebrate locality of Çalta, Ankara, Turkey*. *Geodiversitas* 20 (3), 359–378.
- Sen, S., 2003. Lagomorpha. In: Fortelius, M., Kappelman, J., Sen, S., Bernor, R.L. (Eds.), *Geology and Paleontology of the Miocene Sinap Formation, Turkey*. Columbia University Press, New York, pp. 163–178.
- Sen, S., 2016. Rodents, lagomorphs and insectivores. In: Sen, S. (Ed.), *Late Miocene mammal locality of Küçükçekmece, European Turkey*. *Geodiversitas* 38 (2), 299–314.
- Sen, S., Rage, J.C., 1979. Çalta (Ankara) Pliyosen omurgalı faunası. *Türkiye Jeoloji Kurumu Bülteni* 22 (1), 155–160.
- Sen, S., Jaeger, J.-J., Dalfes, N., Mazin, J.-M., Bocherens, H., 1989. Découverte d'une faune de petits mammifères pliocènes en Anatolie occidentale. *Comptes Rendus de l'Académie des Sciences* 309, 1729–1734.
- Sengör, A.M.C., 2003. The repeated rediscovery of mélanges and its implications for the possibility and the role of objective evidence in the scientific enterprise. In: Dilek, Y., Newcomb, S. (Eds.), *Ophiolite Concept and the Evolution of Geological Thought*. Geological Society of America Special Paper 373, 385–445.
- Sengör, A.M.C., Tüysüz, O., Imren, C., Sakıncı, M., Eyidogan, H., Görür, N., Le Pichon, X., Rangin, C., 2005. The North Anatolian Fault: a new look. *Annual Review of Earth and Planetary Sciences* 33, 37–112.
- Seyitoğlu, G., Aktuğ, B., Karadenizli, L., Kaypak, B., Şen, Ş., Kazancı, N., Işık, V., Esat, K., Parlak, O., Varol, B., Saraç, G., İleri, İ., 2009. Late Pliocene – Quaternary pinched crustal wedge in NW Central Anatolia, Turkey: a neotectonic structure accommodating the internal deformation of the Anatolian plate. *Geological Bulletin of Turkey* 52, 121–154.
- Sickenberg, O., Becker-Platen, J.D., Benda, L., Berg, D., Engesser, B., Gaziry, W., Heissig, K., Hünermann, K., Sondaar, P.Y., Schmidt-Kittler, N., Staesche, K., Staesche, U., Steffens, P., 1975. Die Gliederung des höheren Jungtertiärs und Altquartärs in der Türkei nach Vertebraten und ihre Bedeutung für die International Neogen-stratigraphie. *Geologisches Jahrbuch* B15, 1–167.
- Sindaco, R., Jeremcenko, V., 2008. The Reptiles of the Western Palearctic. 1. Annotated Checklist and Distributional Atlas of the Turtles, Crocodiles, Amphibians and Lizards of Europe, North Africa, Middle East and Central Asia. *Monografie della Societas Herpetologica Italica I. Latina, Belvedere* (580 p.).
- Smith, K.T., Bhullar, B.-A.S., Holroyd, P.A., 2008. Earliest African record of the *Varanus* stem-clade (Squamata: Varanidae) from the early Oligocene of Egypt. *Journal of Vertebrate Paleontology* 28, 909–913.
- Suata Alpaslan, F., 2009. *Ochotona mediterraneensis* nov. sp. (Lagomorpha-Mammalia) from early Pliocene of İğdeli (Anatolia, Turkey). In: 9th International Multidisciplinary Scientific GeoConference SGEM2009 1, pp. 99–103.
- Suata Alpaslan, F., Ünay, E., Ay, F., 2010. İğdeli (Gemerek, Sivas) lokalitesi erken Pliyosen fauna istifinin Rodentia ve Lagomorpha (Mammalia) fosilleri: Biyokronolojik ve paleobiyocoğrafik anlamları. *C.Ü. Fen-Edebiyat Fakültesi, Fen Bilimleri Dergisi* 31 (1), 1–29.
- Tankut, A., Wilson, M., Yihunie, T., 1998. Geochemistry and tectonic setting of Tertiary volcanism in the Güvem area, Anatolia, Turkey. *Journal of Volcanology and Geothermal Research* 85, 285–301.
- Tatlı, S., 1975. Kızılcahamam Doğu Alanının Jeolojisi ve Jeotermal Enerji Olanakları. MTA report, Ankara, No. 5749. (42 p. Unpublished).
- Tekeli, O., 1981. Subduction complex of pre-Jurassic age, Northern Anatolia, Turkey. *Geology* 9, 68–72.
- Toori, M.R., (Ms Thesis) 2005. Orhaniye ve Civarı'nın (KKB Ankara-Türkiye) Neojen Stratigrafisi ve Tektoniği. Hacettepe Univ. Fen Bilimleri Enstitüsü, Ankara (76 p. Unpublished).
- Toprak, V., Savaşçın, Y., Güleç, N., Tankut, A., 1996. Structure of the Galatia Volcanic Province. *International Geology Review* 38, 747–758.

- Türkecan, A., Dinçel, A., Hepşen, N., Papak, İ., Akbaş, B., Sevin, M., Özgür, İ.B., Bedi, Y., Mutlu, G., Sevin, D., Ünay, E., Saraç, G., Karataş, S., 1991. Bolu-Çankırı (Köroğlu Dağları) arasındaki Neojen yaşlı volkanitlerin stratigrafisi ve petrolojisi. *Türkiye Jeoloji Kurumu Bülteni* 6, 85–103.
- Uetz, P., Freed, P., Hošek, J., 2016. The Reptile Database (Accessed 31.08.2016) <http://www.reptile-database.org>.
- Ünay, E., de Bruijn, H., 1998. Plio-Pleistocene rodents and lagomorphs from Anatolia. *Mededelingen Nederlands Instituut voor Toegepaste Geowetenschappen TNO* 60, 431–466.
- Ünay, E., Göktaş, E., 1999. Söke havzasının geç Erken Miyosen ve Kuvaterner yaşlı küçük memelileri: ön sonuçlar. *Türkiye Jeoloji Kurumu Bülteni* 42 (2), 99–115.
- Ünay, E., Sen, S., 1976. Une nouvelle espèce d'*Alloptox* (Lagomorpha, Mammalia) dans le Tortonien d'Anatolie. *Bulletin of the Mineral Research and Exploration Institute of Turkey* 85, 145–149.
- Ünay, E., Atabey, E., Saraç, G., 2001. Small mammals and foraminifera from the Anatolian (Central Taurus) early Miocene. *Annals of Carnegie Museum* 70 (4), 247–256.
- Ünay, E., de Bruijn, H., Saraç, G., 2003. A preliminary zonation of the continental Neogene of Anatolia based on rodents. In: Reumer, J.W.F., Wessels, W. (Eds.), *Distribution and migration of Tertiary mammals in Eurasia. A volume in honour of Hans de Bruijn*. *Deinsea* 10, 539–547.
- Uyar, G., Çetin, B., 2001. The moss flora of Ankara-Kızılcahamam Soğuksu National Park. *Turkish Journal of Botany* 25, 261–273.
- Van den Hoek Ostende, L.W., Diepeveen, F., Tesakov, A., Saraç, G., Mayhew, D., Alçiçek, M.C., 2015a. On the brink: micromammals from the latest Villanyian from Bıçakçı (Anatolia). *Geological Journal* 50 (3), 230–245.
- Van den Hoek Ostende, L.W., Gardner, J.D., van Bennekom, L., Alçiçek, M.C., Murray, A., Wesselingh, F.P., Alçiçek, H., Tesakov, A., 2015b. Ericek, a new Pliocene vertebrate locality in the Çameli Basin (southwestern Anatolia, Turkey). *Palaeobiodiversity and Palaeoenvironments* 95 (3), 305–320.
- Varol, B., Araz, H., Karadenizli, L., Kazancı, N., Seyitoglu, G., Sen, S., 2002. Sedimentology of the Miocene evaporitic succession in the north of Çankırı-Çorum Basin, Central Anatolia, Turkey. *Carbonates and Evaporites* 17, 240–253.
- Venczel, M., Sen, S., 1994. Pleistocene amphibians and reptiles from Emirkaya-2, Turkey. *Herpetological Journal* 4, 159–165.
- Wilson, M., Tankut, A., Güleç, N., 1997. Tertiary volcanism of the Galatia province, northwest Central Anatolia, Turkey. *Lithos* 42, 105–121.
- Zhang, Z.-Q., Kaakinen, A., Wang, L.-H., Liu, L.-P., Liu, Y., Fortelius, M., 2012. Middle Miocene ochotonids (Ochotonidae, Lagomorpha) from Damiao pliopithecoid locality, Nei Mongol. *Vertebrata Palasiatica* 50 (3), 281–292.