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# Mammalian biochronology of Neogene deposits and its correlation with the lithostratigraphy in the Çankiri-Çorum Basin, central Anatolia, Turkey

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*Key words:* Biochronology, Paleontology, Stratigraphy, Neogene, Mammals, Anatolia

## ABSTRACT

Geologists distinguished several sedimentary units in Neogene continental deposits of the Çankiri-Çorum Basin (north-central Anatolia). However, there are great disagreements on their spatial distribution, chronology and geometric relationships. In order to provide a reliable chronology for these units, all available biochronologic data obtained on mammalian faunas are reviewed, and their stratigraphic and tectonic implications are discussed. Reasonably rich mammalian associations are recorded from 17 localities; their ages range from earliest Miocene to early Pliocene. This review reveals that most previous dates attributed to these units should be modified. The deposits which yielded the Kilçak faunas (mapped as in the Hançili Formation or Kumartas Formation) belong in fact to a distinct unit underlying the Kumartas Formation. The age of the Kumartas Formation is late early and middle Miocene based on mammalian associations. Biostratigraphic data are still scarce for the unconformably overlying Hançili Formation. The Kızılırmak Formation is mainly composed of pinkish red clastic deposits and has been dated as late Miocene, thanks to two rich mammal localities. This study shows that further paleontologic evidence is needed to refine the age estimates of these formations, and that new mapping projects have to take into account the biostratigraphic results.

## ZUSAMMENFASSUNG

In den kontinentalen Ablagerungen im Neogen des Çankiri-Çorum-Beckens (mittleres Nordanatolien) konnten verschiedene sedimentäre Einheiten unterschieden werden. Es bestehen jedoch noch grosse Unstimmigkeiten, was ihre räumliche Verbreitung, Chronologie und geometrischen Beziehungen zueinander anbetrifft. Um zu einer verlässlichen Chronologie dieser Einheiten zu gelangen, wurden alle verfügbaren biochronologischen Säugetier-Daten kritisch überarbeitet und ihre stratigraphische und tektonische Bedeutung diskutiert. Einigermaßen reichhaltige Säugetierassoziationen sind von 17 Lokalitäten bekannt; ihr Alter reicht vom frühesten Miozän zum frühen Pliozän. Die Neuuntersuchung zeigt, dass die meisten früheren Datierungen der betreffenden Einheiten zu korrigieren sind. Die Ablagerungen, die die Kilçak-Faunen lieferten (kartierte als zur Hançili oder Kumartas Formation gehörig), gehören in Wirklichkeit zu einer getrennten Einheit unter der Kumartas-Formation. Nach den Säugetierassoziationen ist das Alter der Kumartas-Formation frühes bis mittleres Miozän. Die biostratigraphischen Daten aus der diskordant überlagernden Hançili-Formation sind noch unzureichend. Die Kızılırmak-Formation besteht hauptsächlich aus roten klastischen Ablagerungen und konnte dank zwei reichhaltiger Säugetierfundstellen als spätes Miozän datiert werden. Diese Untersuchung zeigt, dass weitere paläontologische Daten nötig sind, um die Abschätzung der Alter dieser Formationen zu verfeinern. Neue Kartierungen haben die biostratigraphischen Ergebnisse zu berücksichtigen.

## Introduction

The Çankiri-Çorum Basin occupies a vast area in northern central Anatolia, east of Ankara. It is situated approximately between longitudes 33.5 and 35.0 East and latitudes 39.5 and 41.0 North. The study area lies within the triangle of Çankiri, Çorum and Kirikkale which are the main cities of the region (Fig. 1).

This paper presents mammalian faunas from 17 localities in this basin, reviews their biochronologic implications for related sedimentary deposits and tectonic events. The discovery of mammalian faunas in the Çankiri-Çorum Basin is quite recent. Ayan (1963) first mentioned the presence of fossil bones in Akkasdagı in the southern border of the basin. A large scale

paleontological investigation was carried out between 1965 and 1969 by German paleontologists and stratigraphers under the leadership of O. Sickenberg in the framework of the "German-Turkish Lignite Exploration Project in Turkey" (Sickenberg et al. 1975). This team discovered 13 mammal localities of middle Miocene – early Pliocene ages. In 1973, paleontologists from the Mineral Research and Exploration Institute of Turkey (MTA, Ankara) excavated the Çandır mammal locality and explored this basin for biostratigraphic and paleontologic purposes (Tekkaya et al. 1975). During the 1990s, Prof. Erksin Güleç (University of Ankara) organized intensive excavation campaigns at Çandır. Nothing is yet published about the

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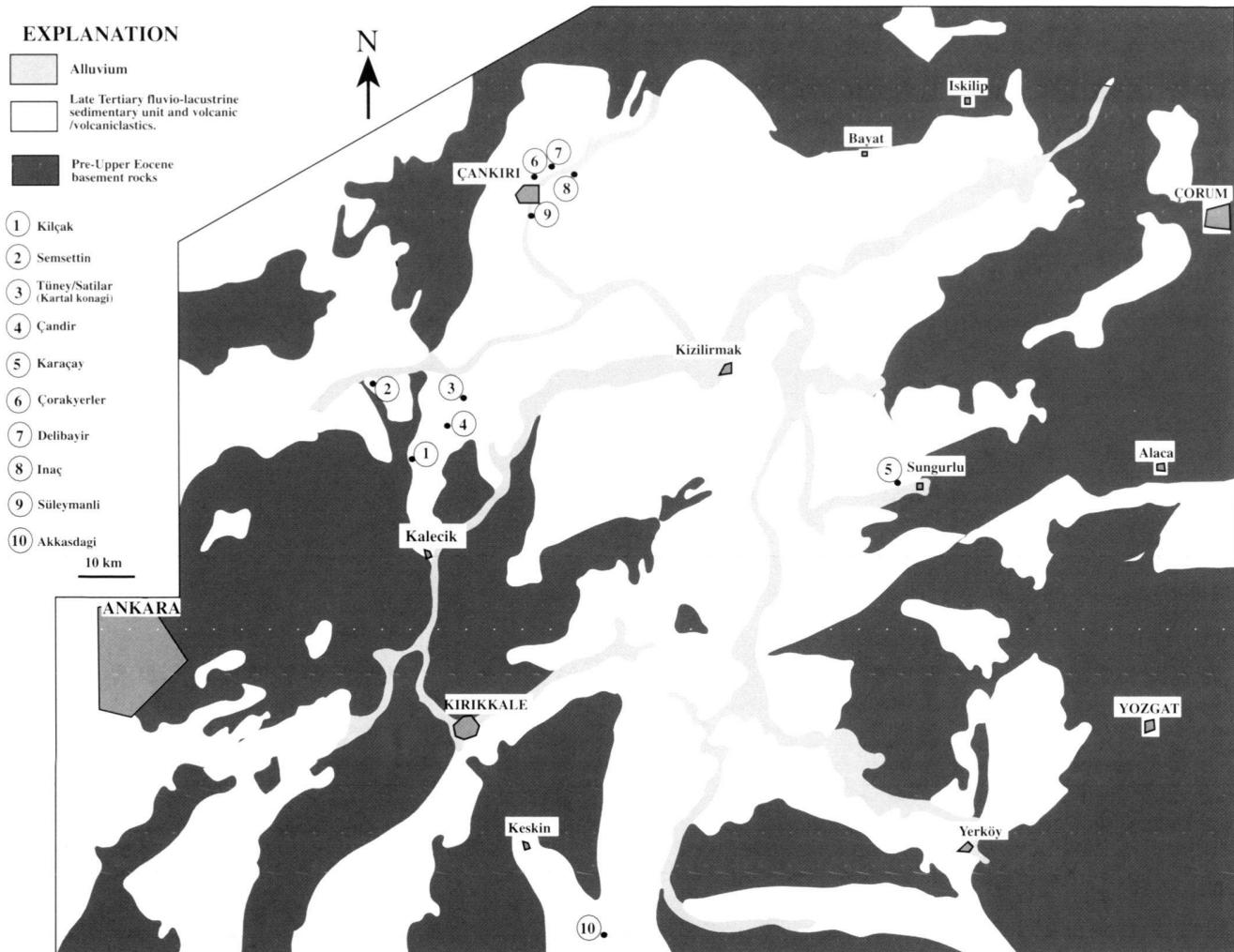


Fig. 1. Simplified geological map of the Çankırı-Çorum Basin (modified after Birgili et al. 1975) with location of mammal localities mentioned in this paper.

results of Güleç's excavations. Since 1988, a Dutch-Turkish team (H. de Bruijn, E. Ünay, G. Sarac and their collaborators) explored the area to collect small mammal faunas.

Our research in this basin was carried out in the context of a projet, "Tectonic and Sedimentologic Evolution of Çankırı-Çorum Basin", supported by the Scientific and Technical Research Council of Turkey - TUBITAK. The aim of this project is to undertake integrated geological investigations of which mammalian paleontology is a part.

### Geological setting

The Çankırı-Çorum Basin developed after the Paleocene following the closure of the northern branch of the Neotethys at the end of the Cretaceous between Rhodope-Pontide block/Sakarya continent to the north and Kirşehir massif to the south (Yilmaz 1981; Sengör & Yilmaz 1981; Görür et al.

1984; Koçyigit 1991a; Tüysüz & Dellaloglu 1992; Tüysüz et al. 1995). The collision took place along irregular continental margins which took a relatively long period for final closure accompanied by complex deformation (Erdogan et al. 1996). The post-collisional compressive tectonic regime is thought to have continued until the early - late Pliocene (Koçyigit 1991b; 1992; Koçyigit et al. 1995), but Seyitoglu et al. (1997) proposed an extensional regime during the Miocene that changed into a transcompression or transtensional regime in the Pliocene due to the North Anatolian Fault Zone.

Neogene deposits are mainly composed of fluvio-lacustrine sediments with gypsum units (Fig. 1). It is difficult to correlate the sedimentary deposits in different parts of the basin, due to the insufficient knowledge of their spacial extension and the intense tectonic activity. This paper reviews the age data and tries to establish a link between biochronological results and previously established lithostratigraphy.

## Mammal localities and biochronology

Most of the mammal localities discussed in this paper were discovered by German scientists active in the Çankırı-Çorum Basin in the context of the "German-Turkish Lignite Exploration Project in Turkey" (Sickenberg et al. 1975). Other localities were discovered by Ayan (1963), Tekkaya et al. (1975), Bruijn & Ünay (1996) and by our team.

Up to now, 17 Neogene mammal localities with reasonably rich faunas are known in the Çankırı-Çorum Basin. In addition, there are some other localities with sparse fossils. Detailed systematic studies are available only for some groups of mammals. Whatever the richness of mammal localities and the state of systematic determinations, all information that is available in the literature has been reinterpreted concerning systematic assignments and age determinations. Moreover, we add some paleontological data from the newly discovered locality of Semsettin. The localities are presented in chronologic order.

### KILÇAK (Ankara, Kalecik) (No 1 in Fig. 1)

This locality was discovered by the German team in the late 1960s (Sickenberg et al. 1975). It is situated in the open lignite quarry some 750–1000 m SE of the Yeni Kilçak village. Its altitude is about 1000–1020 m. Sediments are mainly grey-green clays with several thin lignitic horizons. The stratigraphy is disturbed by numerous slumps, faults and folds, landslides and human activities. The deposits are rich in freshwater molluscs, and their lithology indicates lacustrine and swampy depositional environments. Upwards, to the N and NW of the quarry, the sediments are more pinkish and reddish, and comprise mainly fluvial and sandy marls. In the MTA geologic map (Hakyemez et al. 1986), all these levels are mapped as Hançılı Formation (Th). The preliminary faunal list given by Sickenberg et al. (1975: 83) contains *Galerix* n. sp. (Engesser 1980: 83), *Microdyromys* sp., *Democricetodon* sp., Cricetidae indet. and cf. *Cotimus* sp. The locality studied in late 1960s has been destroyed by the progress of mining. Palynological determinations on samples from dark clays of this site led Benda (1971) to attribute the flora to the "Eskihisar sporomorph association". Based on small mammals and palynologic data, Sickenberg et al. (1975) proposed a middle Miocene age.

At the beginning of the 1990s a Dutch-Turkish team again explored this locality. In order to avoid confusion with the previous data, the new localities were named Kilçak 0, Kilçak 0'', Kilçak 3a and Kilçak 3b. Bruijn & Koenigswald (1994: 382) note that the new sites "are all within the concession of the abandoned Kilçak lignite mine. The relative stratigraphic position of the Kilçak sites is difficult to reconstruct because the section, that is limited tectonically by the ophiolitic basement, is subject to slumping and is not well exposed. However, the discontinuous fossiliferous lignitic clay beds of Kilçak 0 and 0'' are situated in a small man-made exposure just south of the track from Yeni Kilçak to Eski Kilçak". They also note that,

in this section, that directly overlies the main lignite level, the site Kilçak 0 is some five metres below Kilçak 0".

The rich faunas collected by this team have not yet been completely studied. Hoek Ostende (1992, 1995a&b), Bruijn & Saraç (1992), Bruijn et al. (1993), Ünay (1994) and Bruijn & Koenigswald (1994) mention:

Kilçak 0: *Galerix saratji* Hoek Ostende 1992, *Dinosorex anatolicus* Hoek Ostende 1995, Ochotonidae indet., *Deperetomys anatolicus* Bruijn et al. 1993, *Cricetodon versteegi* Bruijn et al. 1993, *Enginia beckerplateni* Bruijn & Koenigswald 1994, *Vasseuromys* aff. *duplex* Ünay 1994, *Glirudinus engesseri* Ünay 1994.

Kilçak 0": *Galerix saratji* Hoek Ostende 1992, *Dinosorex anatolicus* Hoek Ostende 1995, *Deperetomys anatolicus* Bruijn et al. 1993, *Cricetodon versteegi* Bruijn et al. 1993, *Enginia beckerplateni* Bruijn & Koenigswald 1994, *Bransatoglis complicatus* Ünay 1994, *Vasseuromys* aff. *duplex* Ünay 1994, *Glirudinus engesseri* Ünay 1994.

Kilçak 3a: *Galerix saratji* Hoek Ostende 1992, *Neurogymnurus* sp., *Dinosorex anatolicus* Hoek Ostende 1995, *Turkodimylus hartogi* Hoek Ostende 1995, Ochotonidae indet., *Deperetomys anatolicus* Bruijn et al. 1993, *Deperetomys* sp., *Cricetodon versteegi* Bruijn et al. 1993, *Enginia beckerplateni* Bruijn & Koenigswald 1994, *Bransatoglis complicatus* Ünay 1994, *Vasseuromys* aff. *duplex* Ünay 1994, *Glirudinus engesseri* Ünay 1994, Gliridae indet.

Kilçak 3b: *Galerix saratji* Hoek Ostende 1992, Ochotonidae indet., *Deperetomys anatolicus* Bruijn et al. 1993, *Cricetodon* aff. *versteegi* Bruijn et al. 1993, *Cricetodon* n. sp., *Mirabella* cf. *anatolica* Bruijn & Saraç 1992, *Enginia beckerplateni* Bruijn & Koenigswald 1994, *Bransatoglis complicatus* Ünay 1994, *Vasseuromys* aff. *duplex* Ünay 1994, *Glirudinus engesseri* Ünay 1994.

There is a general agreement in the attribution of the assemblages from Kilçak 0 and 0'' to MN1, while those from Kilçak 3a and 3b are correlated to MN1 (Ünay 1994) or MN2 (Bruijn & Koenigswald 1994). However, as all taxa described from Kilçak localities represent new species, and some new genera, strictly limited to Anatolia and exceptionally to Greece, reliable correlations with MN zones based on western and central European faunas are difficult. For the correlation of Kilçak localities, glirids are more helpful than muroids because the Kilçak localities share many common genera with central and western Europe. In contrast, the cricetids of Kilçak are endemic to Turkey during most of the early Miocene.

Recent magnetostriatigraphic calibrations of the early Miocene MN zones in French Savoy and Spanish sections bracket the duration of MN1 between 23.8 and 22.6 Ma, and MN2 spans the period from 22.6 to 21.2 Ma (Schlunegger et al. 1996; Sen 1997). These ages are notably older than the previous dating by Sickenberg et al. (1975) to middle Miocene; to confirm or to invalidate the latter age estimate, a detailed systematic study of the material is needed.

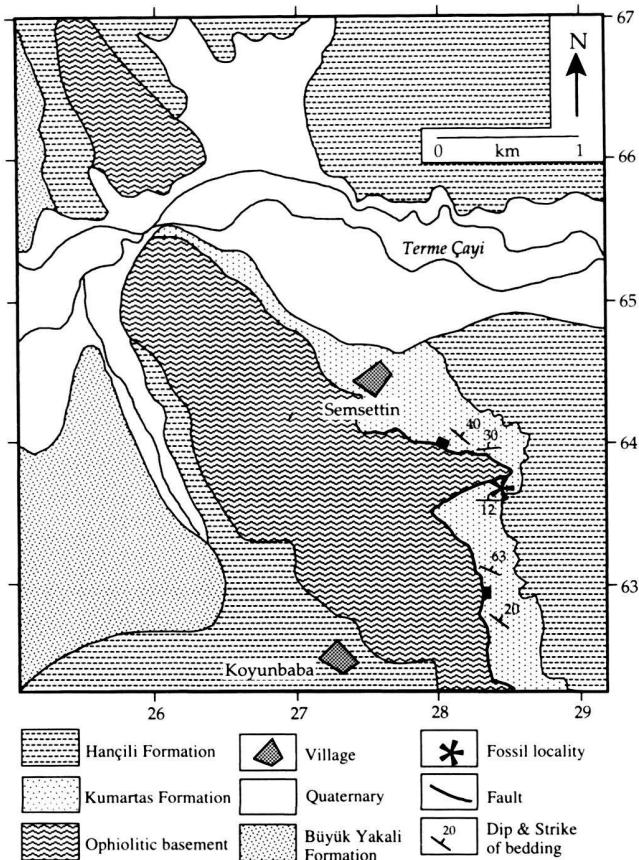


Fig. 2. The geological map of the Semsettin area and the location of the mammal localities (modified from Akyürek et al. 1980).

#### SEMSETTIN (No 2 in Fig. 1)

We found this locality in September 1997. It is situated 1250 m SE of the Semsettin village, in red continental deposits (50 m of red silty or sandy clays at the bottom of the Kumartas Formation), separated from ophiolitic basement by a normal fault (Fig. 2, 3). Within this unit, there is a 7–8 m thick intercalation of lacustrine marly limestones. Towards the top, the colour of the unit changes from dark red to pinkish. The unit is covered by grey sediments of the Hançılı Formation, showing alternations of channel sandstones and claystones over 100 m thick (Fig. 3).

In the redbeds of the Kumartas Formation, two horizons yielded remains of vertebrates. The first level is situated at the base of a N-S trending valley in a dark red silty clay. The fauna includes small and large mammals briefly described below. The measurements are given in mm. Upper (lower) case letters are the abbreviations of upper (lower) teeth. In the illustrations, all specimens are presented as from the left side; the inverted ones are underlined.

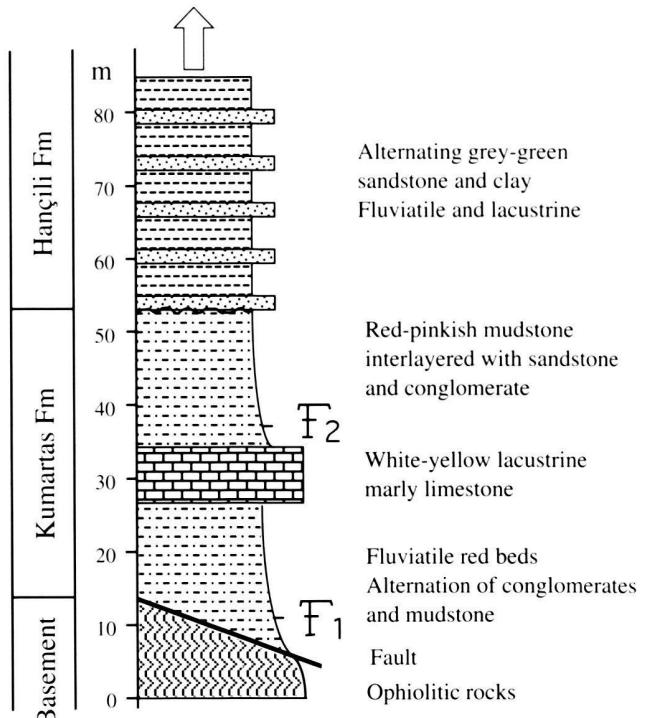


Fig. 3. Lithostratigraphic section southeast of Semsettin village across the mammal localities of Semsettin 1 and 2.

#### Order Insectivora Bowdich 1821

##### *Galerix* sp. cf. *G. symeonidisi* Doukas 1986

Material: right mandible with p2-m3; dimensions of teeth, p2: 2.05 × 1.04, p3: 1.55 × 1.06, p4: 1.89 × 1.48, m1: 3.01 × 2.12, m2: 2.58 × 1.99 and m3: 2.15 × 1.42 (Fig. 4d, e).

Description and comparison: The corpus mandibularis is elongated, and its depth is almost similar below p4 (3.26 mm) and m3 (3.42). p2 is longer than p3. p4 is the highest cheek tooth; its paraconid is oval and is not connected to the protoconid; the metaconid is slightly less voluminous than the protoconid. On lower molars, the paraconid is connected to the protoconid by a strong ridge; the posterior cingulum issues from the posterolophid; the talonid of m3 is not narrowed, nor extended posteriorly.

All these characters exclude any comparison with *Schizogalerix* that is a common taxon of middle and late Miocene localities in Turkey and Greece. They better fit those of the genus *Galerix*. Hoek Ostende (1992) described two new species of *Galerix* from the early Miocene of Turkey. *G. saratji* from Kilçak (Ankara, MN1–2) and Harami (Konya, MN2) is much smaller than our specimen. Moreover, its p4 has a low paraconid which is conical and situated anteriorly. In this species the respective size of p2 and p3 is unknown. *G. unayae*

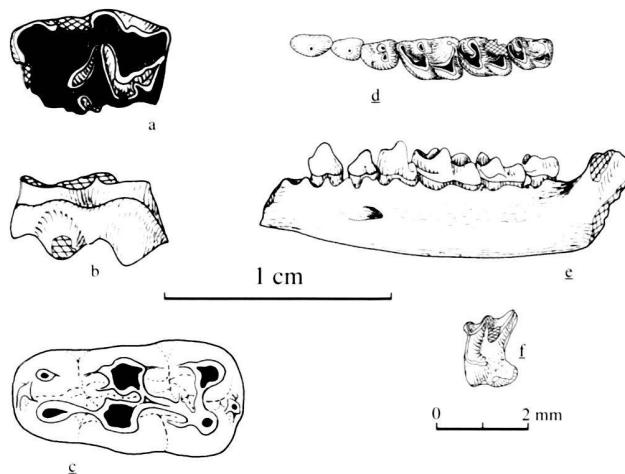


Fig. 4. Artiodactyls and insectivores from Semsettin 1. a) and b) *Micromeryx* sp., M1 or M2 from occlusal and labial views; c) Suidae indet., d4; d) and e) *Galerix* sp. cf. *G. symeonidisi*, occlusal view of p2-m3 and labial view of the mandible and teeth; f) *Miosorex* sp., M1. The scale bar 2 mm only belongs to *Miosorex* sp.

from Keseköy (Bolu, MN3) has p2 longer than p3 as at Semsettin, but the shape of p3 is more slender and without transversal enlargement of the talonid. In this species, p4 often lacks the metaconid, and on m1 and m2 the connection between paraconid and protoconid is broken or weak. Although *G. unayae* is a little larger than *G. saratji*, it is smaller than the Semsettin specimen. In both species, the ridge connecting the protoconid and metaconid on lower molars is strongly pointed posteriorly, while this ridge is almost straight on the lower molars of our specimen.

Outside Turkey, *Galerix symeonidisi* is known from Aliveri (Greece, MN4) and from several localities in southern Germany, all correlated to MN4, and in later times with several other species in Central and Western Europe. The morphological features of the Semsettin mandible fit with those of *G. symeonidisi*, but its size is a little larger; the dimensions of teeth from Semsettin are all slightly outside the size range given for *G. symeonidisi* by Doukas (1986) and Ziegler & Fahlbusch (1986).

Among other European species, *G. exilis*, *G. socialis* and *G. stehlini* have p2 as long as or smaller than p3, and the pattern of p4 is different because of the conical and anteriorly shifted paraconid, the metaconid is often fused with the protoconid and the crown of this tooth is less high than in the Semsettin specimen. *G. exilis* is known in Central and Western Europe between MN5 and MN7/8. In size it is a little smaller than the Semsettin specimen but in morphology it shares many similarities with *G. symeonidisi* and the Semsettin mandible. Among all these species, our specimen more closely resembles *G. symeonidisi* than any other species, hence its determination as *G. cf. symeonidisi*.

#### *Miosorex* sp.

Material: right M1 ( $1.42 \times 1.75$ ) (Fig. 4f).

Description and comparison: On this M1, the labial crest has an asymmetrical W-shape. The metacone is the highest cusp. The protocone is connected to the lingual edge of the paracone by a well-developed paraloph which runs along the anterior margin. The lingual cingulum is strong and bears a small cusp. The posterior cingulum is weak and runs along the labial half of the posterior border, which is strongly concave.

This M1 differs from other Miocene shrews in having a less concave posterior margin and a weaker lingual cingulum. The morphological features of this molar as well as its dimensions are similar to those of *Miosorex desnoyerianus* from Sansan (France; Baudelot 1972) and *M. grivensis* from La Grive M (France) and the Teruel Basin, Spain (Jong 1988). In *M. pusilliformis* from Wintershof-West, Petersbuch 2 and Stubersheim 3 (Ziegler 1989) the size is a little smaller, but the morphology is similar. *Miosorex* is known in Western Europe in many early and middle Miocene localities. The unique M1 from Semsettin is insufficient to determine the species.

#### Order Rodentia Bowdich 1821

##### *Democricetodon franconicus* Fahlbusch 1964

Material: 1M1 ( $1.59 \times 1.05$ ), 5M3 ( $0.81 \times 0.85$ ;  $0.85 \times 0.89$ ;  $0.85 \times 0.81$ ;  $0.85 \times 0.86$ ;  $0.85 \times 0.84$ ), 1m2 ( $1.21 \times 0.99$ ) (Fig. 5d-g).

Description and comparison: The dimensions of all these specimens are within the range of variation of *D. franconicus* from Erkertshofen 1 in Germany which is the type locality of this species. Similarly, the mean values of the Aliveri population are close to the measurements given here (Klein Hofmeijer & Bruijn 1988). Morphologically, these teeth are also similar to those of Erkertshofen 1 and Aliveri. M1 has an undivided and asymmetric anterocone, a narrow and quite long mesoloph, and posteriorly connected metaloph. On the M3 both labial and lingual branches of the anteroloph are well developed; its protolophule is single and directed anteriorly; the metacone is very reduced or even totally included in the posterior ridge. On the m2, the lingual anterolophid is very reduced while the labial one is strong and reaches the base of the protoconid and the mesolophid is narrow but long. The hypolophid is arc shaped thus forming a large posterior mesosinusid between itself and the mesolophid. All these characters are common features in *Democricetodon franconicus* from Erkertshofen 1 and Aliveri, both dated of MN4. This species is well known in many MN4 localities in southern Germany (Ziegler & Fahlbusch 1986). The specimens from Semsettin are in the range of size variation of the Erkertshofen 1, Rembach and Forsthart samples, but are slightly smaller than those from Erkertshofen 2, Petersbuch 2 and Rauscheröd. The latter three localities are dated as late MN4, while the others are included in the lower part of this zone.

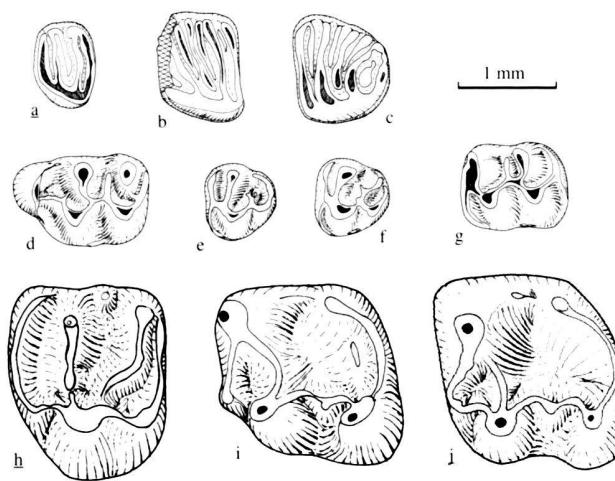


Fig. 5. Rodents from Semsettin 1. *Glirudinus* sp. cf. *G. euryodon*, a) P4, b) M1, c) M3; *Democricetodon franconicus*, d) M1, e-f) M3, g) m2; *Aliveria* sp., h) M1, i) m1, j) m2.

*Glirudinus* sp. cf. *G. euryodon* Meulen & Bruijn 1982

Material: right P4 ( $0.76 \times 0.96$ ), left M1 ( $1.07 \times 1.25$ ), left M3 ( $1.08 \times 1.22$ ) (Fig. 5a-c).

Description and comparison: P4 has four main lophs and one strong centroloph which is only connected to the paracone. Its endoloph is complete and strongly oblique. M1 is much wider than long. Even though damaged anteriorly, it shows eight transverse lophs and one complete endoloph. This means that the centrolophs and extra ridges are well developed although they do not reach the endoloph. There is a strong lingual cingulum. M3 has the occlusal surface covered by nine lophs (four of which are incomplete) and a complete endoloph. The lingual face is too worn to observe if there was or was not a cingulum. The occlusal surface of these teeth is almost flat. All upper teeth are three-rooted. The flat occlusal surface, complete endoloph, the oblique shape of M1, short and wide outline of P4 and M1 and the presence of a strong lingual ledge on M1 are all features of the genus *Glirudinus*. Moreover, these characters allow to compare our specimens with *G. euryodon* Meulen & Bruijn 1982 from Aliveri, Greece. Other species of this genus are different because M1 is more square in shape, and/or the lingual ledge is missing or very weak. Two species of *Glirudinus* are known in Turkey, *G. engesseri* from four Kilçak localities and *G. haramiensis* from Harami 1 and 2, both described by Ünay (1994). These species are clearly less evolved because of their square M1 and M2, the anteroloph weakly connected (even not connected) to the endoloph, and their smaller size. Ünay dated the Kilçak localities as MN1, and the Harami localities as MN2. The central and western European species are also different from the Semsettin form because of the incomplete endoloph on upper molars and the lack of the lingual ledge on M1 (except *G. gliru-*

*lus*). The dental pattern of teeth from Semsettin resembles more that of *G. euryodon* from Aliveri than any other species. In size our specimens fall within the range of variation of this species, except for the M3 from Semsettin that is a little larger. The genus *Glirudinus* is known in central and western Europe from the late Oligocene to the latest middle Miocene (MP28-MN7/8).

*Aliveria* sp.

Material: right M1 ( $1.79 \times 2.05$ ), left m1 ( $2.05 \times 2.05$ ), right m2 ( $2.12 \times 2.15$ ), and another left m1-2 (damaged) (Fig. 5h-j).

Description and comparison: On M1, the protoloph and metaloph converge toward the protocone, and their connection to this cusp is weak. The mesostyle is distinct and isolated. The hypocone is separated from the protocone by a wide lingual depression. The protoconule and metaconule do not form distinct cusps, but they are included in the protoloph and metaloph respectively.

m1 is much narrower anteriorly than posteriorly. The entoconid is the lowest cusp and incorporated in the posterolophid. The anteroconid is a distinct cusp connected strongly to the metaconid but weakly to the protoconid. The mesoconid is small but well delimited. There is a small extra ridge anterior to the posterolophid.

m2 is similar in shape to m1 but is slightly larger. It differs from m1 by its anterior widening. The anteroconid is strongly connected to both protoconid and metaconid. The second connection between protoconid and metaconid is achieved by a thick metalophid. The mesoconid and mesostyliid are small but distinct. The surface of these teeth is not pitted as is generally the case in flying squirrels such as *Albanensis* and *Miopetaurista*.

The converging protoloph and metaloph on upper molars is a characteristic of the genera *Albanensis*, *Forsythia* and *Aliveria*. However, in *Albanensis* the ridges are crenulated, the mesostyle and mesostyliid are connected to nearest cusps(ids) and the anteroconid of lower molars is not differentiated from the anterolophid. In *Forsythia* the mesostyle(id) is lost, the protocone of upper molars is centrally situated (not anteriorly as in the M1 from Semsettin), the anteroconid of m1-2 is smaller and lower molars are more square in outline. The general pattern of molars from Semsettin resembles *Aliveria*. This genus is only known, with two species, from Aliveri in the Island of Evia, Greece (Bruijn et al. 1980). *A. brinkerinki* is larger (e.g. M1  $2.10-2.39 \times 2.55-2.80$ ) while *A. luteyni* is smaller (e.g. M1  $1.60-1.84 \times 1.86-2.17$ ) than the specimens from Semsettin. Moreover, lower molars in *A. brinkerinki* have a double posterolophid that appears as a trace on the m1 from Semsettin. Because of these differences in size and morphology, we refer our specimens to *Aliveria* sp.

## Artiodactyla Owen 1848

### Suidae indet.

Material: right d4 (10.6 × 5.4) (Fig. 4c).

Description and comparison: The general pattern of the occlusal surface is bunodont. This milk tooth has three pairs of cusps of equal distance. The labial connections between cusps are better developed than the lingual ones. The strongest cusps are the protoconid and the paraconid. On the posterior edge of the occlusal surface, a small and isolated entoconulid is also present. This tooth has one strong anterior, two posterior and one small labial (under the protoconid) roots.

It is not easy to determine a milk tooth because of the rarity of comparative material. However, of what is available, the d4 of *Listriodon* is larger in size and has a lophodont arrangement of cusps. The same particularities are also observed in the tayassuid *Schizochoerus arambourgi* from Sinap Tepe (MN9), Turkey. d4 is also known for *Sanitherium schlaginhaeiti* from Chios, Greece (MN5), in which the tooth is much elongated (13.6 × 5.4) and has a selonodont pattern of cusps. In *Taucanamo sansaniensis* from Sansan, France (MN6) d4 is longer, and it is characterised by the anteroconid located far anterior to the protoconid and paraconid, and separated from these cusps by a deep transverse valley. In *Auraliachoerus* from Artenay, France (MN4), the size of d4 (average of 4 specimens 13.1 × 6.3) is larger but the arrangement of cusps and the bunolophodonty resemble that of Semettin. Because of these difficulties in identifying the Semettin d4, we preferred to leave it in open nomenclature.

### *Micromeryx* sp.

Material: left M1 or M2 (7.3 × –) (Fig. 4a, b).

Description and comparison: This molar is represented by its labial portion, and belonged to an old individual. On the labial wall, the mesostyle is strong and round. The anterior and posterior fossets are not connected. Because of its small size and these characters, this tooth is tentatively attributed to *Micromeryx* sp.

The material from Semettin includes several species of snakes and lizards that are represented by vertebrae, jaw fragments and osteoderms. The small mammals are sufficiently characteristic to date this locality as late Early Miocene, and to correlate it with the mammalian zones MN3 or MN4.

A second horizon situated 4 metres above the lacustrine limestones yielded some surface findings among which we recognize a toothless lower jaw of Ochotonidae (Lagomorpha), a tooth fragment of Proboscidea and a piece of turtle carapace. These remains are unsuitable for proposing any reliable age for this horizon.

## TÜNEY (No 3 in Fig. 1)

This locality was found by the German team. It is situated between the villages of Tüney and Satilar, at the NW of Kartalkonagi Tepe. Sickenberg et al. (1975: 96) mention *Anchitherium*

sp. and *Brachypotherium brachypus*. *Anchitherium* is a typical middle Miocene horse. Heissig (1976) described the remains of *Brachypotherium* and confirmed its attribution to *B. brachypus*. According to this author (p. 95), the stage of evolution of this rhino allows the correlation of Tüney, together with Pasalar and Çandır, to the early part of middle Miocene with a level stratigraphically anterior to Sansan, which is the reference locality of zone MN6. However, according to Bernor & Tobien (1990), the faunas from Pasalar and Çandır are more or less contemporaneous with that of Sansan, and are consequently attributed to MN6.

## ÇANDIR (No 4 in Fig. 1)

Studying Neogene and early Pleistocene mammalian faunas from Turkey, Sickenberg et al. (1975) proposed 12 "Faunengruppen" with one reference locality for each. Çandır is the reference locality of their second unit that is called "Çandır Faunengruppe". This locality is situated 6.5 km NE of Çandır town, in the ravine of Hırsız Dere, at an altitude between 800 and 830 m (1:25,000: H30 b3).

In fact there are two mammalian fossiliferous horizons at Çandır. Çandır 1 is in a thick red paleosol, south of the pathway, while Çandır 5 is situated about 10 m above Çandır 1 and is in grey green silty clays that crop out about 100 m NE of Çandır 1 and north of the same pathway. Sickenberg et al. (1975) note that Çandır 1 yielded mainly large mammals while small mammalian remains are mainly recorded at Çandır 5. However, in papers dealing with the description of the Çandır material, these localities are rarely distinguished. According to Sickenberg et al. (1975), the bone accumulation at Çandır 1 is due to carnivore predators having dens in this locality; this is proven by the mode of accumulation of bones, the abundance of coprolites and bite marks on bones.

Three different teams have excavated at Çandır since its discovery in 1967. The first excavation was carried out by the German team late in 1960. In 1973, paleontologists from the Mineral Research and Exploration Institute (MTA at Ankara) excavated both fossiliferous horizons and published their faunal lists (Tekkaya et al. 1975). Since 1990, a team directed by Prof. Erksin Güleç (University of Ankara) excavated the same locality hoping to find anthropoid primate remains. These excavations provided large collections of fossil vertebrates at present dispersed in several universities and institutes at Ankara (MTA and DTCF), Hannover, Mainz, Zürich and ?elsewhere.

This is one of the richest mammal localities known in Turkey. The faunal list published by Sickenberg et al. (1975: 23–25) contains 38 species of large mammals and 8 species of small mammals, plus some amphibians and reptiles. From the material collected by the German and MTA teams, the following taxa have been studied: Primates (Tekkaya 1974, 1975; Andrews & Tekkaya 1976), Carnivora (Gürbüz 1974; Schmidt-Kittler 1976); Rhinocerotidae (Heissig 1976), Equidae (Atalay 1981), Proboscidea (Gaziry 1976), Tubulidentata (Tekkaya 1993), Suidae (Pickford & Ertürk 1979; Fortelius et al. 1996;

Made 1996), Bovidae (Köhler 1987), Insectivora (Engesser 1980), Lagomorpha (Ünay & Sen 1976), Cricetidae (Tobien 1978; Sen & Ünay 1978, 1979). Up to now, nothing has been published of the discoveries that were made during the 1990s excavations.

Taking into account all systematic studies of mammals, the faunal list from Çandır is as follows:

- Sivapithecus alpani* Tekkaya 1974
- Amphicyon major* Blainville 1841
- Hemicyon* sp.
- Ischyricitus (Hoplictis) anatolicus* Schmidt-Kittler 1976
- Lutrinæ indet.
- Protictitherium intermedium* Schmidt-Kittler 1976
- Percrocuta (Percrocuta) aff. tungurensis* (Colbert 1939)
- Hyænidæ indet.
- Pseudailurus* cf. *quadridentatus* (Blainville 1842)
- Oryctopus seni* Tekkaya 1993
- Dinotherium giganteum* Kaup 1829
- Anchitherium aurelianense* (Cuvier 1825)
- Chalicotherium grande* (Blainville 1839-61)
- Hispanotherium grimmii* Heissig 1974
- Aceratherium* cf. *tetradactylum* (Lartet 1837)
- Brachypotherium brachypus* (Lartet 1848)
- Listriodon splendens* von Meyer 1846
- Bunolistriodon meidamon* Fortelius, Made & Bernor 1996
- Dorcatherium* sp.
- Euprox* sp.
- Palaeomeryx* sp.
- Triceromeryx* sp.
- Micromeryx* sp. or *Lagomeryx* sp.
- Giraffokeryx* sp.
- Palaeotragus* cf. *tungurensis* Colbert 1936
- P. cf. *primaevus* Churcher 1970
- Samotherium* sp. (primitive form)
- Hypsodontus pronaticornis* Köhler 1987
- Turkocerus gracilis* Köhler 1987
- Caprotragoides potwaricus* (Pilgrim 1939)
- Bovidae indet.
- Alloptox anatolicus* Ünay & Sen 1976
- Prolagus oenengensis* (König 1825)
- Schizogalerix* cf. *anatolica* Engesser 1980
- Turkomys candirensis* Tobien 1977
- Megacricetodon* sp.
- Peridyromys* sp.
- Spalacidae indet.

According to Sickenberg et al. (1975) the Çandır fauna is correlative to Sansan (France) and the Obere Süßwasser-Molasse (Germany), while Heissig (1976: Tabl. 24) considered that Çandır and the Obere Süßwasser-Molasse might be slightly older than Sansan. For Schmidt-Kittler (1976) the Çandır carnivores have their equivalents in the Tung Gur Formation in China or in the Chinji Formation of the Siwaliks of Pakistan. The Tortonian age that Tekkaya (1974) and Ünay & Sen (1976) have suggested is too young. Studying the suids from Pasalar and Çandır, Fortelius et al. (1996: 161–163) concluded that the “sparse *Bunolistriodon* material from Çandır appears to be even more derived than the Pasalar sample” and that this observation “supports the current consensus placing Pasalar below Çandır”. Bernor & Tobien (1990) analysed the similarities of the Pasalar fauna and concurred with its MN6

correlation. This attribution is not supported by several taxa from Pasalar, such as lagomorphs, chalicotheres and to some extent by suids, which better agree with an MN5 correlation for Pasalar. However, considering the first occurrence of *Listriodon splendens* as simultaneous all over Europe and Anatolia, van der Made (1996) included all localities with primitive representatives of this species in MN6. The reference locality of this zone, Sansan (SW France) yielded *L. splendens* but not *Bunolistriodon* which is frequent in MN5 localities in the same region. Sansan *L. splendens* is a primitive representative of this species because of its small size and dental features (Made 1996: 114). At Pasalar and Çandır in Turkey, a small sized *L. splendens* is recorded together with the last representatives of *Bunolistriodon*. This observation leads to two hypotheses: 1) Pasalar and Çandır are slightly older than Sansan or 2) *Bunolistriodon* survived longer in Turkey than in Western Europe. Whatever the MN zone in which Pasalar is included, the evidence is that the Çandır fauna is clearly younger, and that general agreement is reached in 1990s for attribution of the Çandır fauna to zone MN6. A critical review of West Eurasian mammal faunas led Mein (1990) and Brujin et al. (1992) to the same conclusion.

#### KARAÇAY 1 & 2 (Çorum, Sungurlu) (No 5 in Fig. 1)

These two localities are situated along the road from Sungurlu to Kızılırmak, respectively 6 and 1 km S of Karaçay village. Sickenberg et al. (1975: 79) describe the fossiliferous strata as fluvialite deposits with thin intercalations of “lacustrine” sediments. Few mammalian remains from Karaçay 1 were determined by Sickenberg et al. (1975) as cf. *Korynochoerus* sp. and *Palaeotragus* cf. *tungurensis*, and from Karaçay 2 as cf. *Korynochoerus* sp. From Karaçay 2, these authors also mention “?Crocodylia sp. indet”. Crocodylians are rarely encountered in Anatolia, and only in middle Miocene or older localities. Sickenberg et al. (1975) attributed these localities to the middle Miocene.

#### ÇORAK YERLER (Çankırı) (No 6 in Fig. 1)

This is one of the richest mammal localities of the Çankırı-Çorum Basin. It is situated north of Çankırı, on the road from this city to the Yapraklı village, at an altitude between 730–740 m (Sickenberg et al. 1975: 68). These authors found mammalian remains in two different horizons where “bone pockets contain each 2–3 species (mass death)”. Fossiliferous deposits are silty clays of pinkish or grayish colour. Some rare freshwater molluscs and crystallized secondary gypsum are also observed. Sickenberg et al. (1975) Gaziry (1976) and Köhler (1987) presented all mammalian taxa (listed below) as belonging to one single fauna. As we shall see, this list probably includes two faunas of different ages.

- Choerolophodon pentelici* (Gaudry & Lartet 1856)
- Hipparium* sp. I and II

*Ceratotherium neumayri* (Osborn 1900)  
*Chilotherium kowalevskii* (Pavlov 1913)  
*Chilotherium samium* (Weber 1905)  
*Listriodon splendens* von Meyer 1846  
*Listriodontinae* indet.  
 cf. *Korynochoerus* sp.  
*Samotherium* sp.  
*Palaeotraginae* indet.  
*Tragopontax gaudryi* (Kretzoi 1941)  
*Protoryx* sp.  
*Plesiaddax* cf. *inundatus* Bosscha Erdbrink 1978  
*Gazella* sp.  
*Palaeoreas elegans* Ozansoy 1965  
 cf. *Palaeoreas elegans* Ozansoy 1965  
*Oioceros rothi* (Wagner 1857)  
 cf. *Oioceros* sp.

This locality does not yield Carnivora, nor small mammals. The absence of the latter group can be explained by selective accumulation often encountered in Neogene mammal localities. The absence of Carnivora is most astonishing as such a diversity of ungulates is recorded.

Sickenberg et al. (1975) compared this fauna with the "Garkin faunal group" (early Turolian) according to hipparions or with the "Kayadibi faunal group" (late Vallesian) according to rhinos. From this fauna, only the proboscideans and bovids have been described (Gaziry 1976; Köhler 1987).

The composition of the above fauna is not homogenous. As far as we know, *Listriodon splendens* and *Tragopontax gaudryi* have never been found associated. In Western Europe, the last occurrence of *L. splendens* is at Can Llobateres 1 (Spain) that is dated to 9.7 Ma (Agusti et al. 1996; Garces et al. 1996). Can Llobateres 1 is the reference locality of MN9, but is in fact very close to the MN9/MN10 boundary. In contrast, the time range of *Tragopontax gaudryi* is from late Vallesian to Turolian. This clearly indicates that there are two fossiliferous horizons, two faunas and two different ages at Çorak Yerler. However, based on bovids, Köhler (1987) suggested an age of early Turolian (MN11). Bouvrain (1994) followed this opinion in comparing bovids from Çorak Yerler to those of Kemiklitepe D. She observed that the specimens attributed to *Palaeoreas elegans* by Köhler (1987) have many derived characters, as in Kemiklitepe D, and probably belong to another species, different from *Palaeoreas elegans* of Sinap Tepe. However, Bouvrain also noted some resemblances of the Çorak Yerler material with that of Sinap Tepe, thus not excluding a slightly older age of bovids from Çorak Yerler in comparison to those of Kemiklitepe D. The Sinap Tepe locality which yielded *P. elegans* is now dated to the early Vallesian (Sen 1991; Kappelman et al. 1996).

In summary, there are obviously two different faunas at Çorak Yerler, one possibly of late Astaracian or early Vallesian and the other of late Vallesian or early Turolian. However, the present state of systematic studies does not allow the identification of elements belonging to each fauna, and consequently their ages cannot be determined with precision. Thus, in Figure 6, the age of this locality is indicated as an interval of time.

#### *DELIBAYIR SIRTI (Çankiri) (No 7 in Fig. 1)*

Sparse and poorly preserved bone fragments have been collected by Sickenberg et al. (1975: 70) along the slopes of Karlik Tepe and Yazkiri Tepe, some 3–5 km NW of Tuzlu Village (1:25 000 = G31 d2). Fossil bearing deposits are red-pinkish coloured silty clays and marls of fluvial origin. Among the vertebrate remains, these authors determined "Testudines indet., eggshell fragments (aepyornithoid) and *Hippurion* sp." Based on the presence of *Hippurion*, they proposed a probable late Miocene age.

#### *YARMATEPE (Çankiri, Yeniköy)*

In the red beds around Yeniköy Village, Tekkaya et al. (1975) recorded a rich fauna which includes, according to the list given by them, the following taxa:

*Choerolophodon pentelici* (Gaudry & Lartet, 1856)  
*Hippurion "gracile"* Kaup 1835  
*Palaeotragus* sp.  
*Helladotherium* sp.  
*Gazella gaudryi* (Schlosser 1904)  
*Gazella* sp.  
*Protoryx* cf. *crassicornis* Andree 1926  
*Palaeoreas lindermayeri* (Wagner 1848)  
*Tragopontax amalthea* (Roth & Wagner 1854)  
*Cervus* sp.

Tekkaya et al. (1975) dated this locality as "Pikermian" which corresponds to the early and middle Turolian of the European Neogene mammal chronology. However, without systematic studies, it seems hazardous to suggest a more precise age.

Tekkaya et al. (1975) also found another site near the Yeniköy (Kaynaktepe), from which they determined "*Diceros pachygnathus*". This is a common late Miocene rhino in western Asia and southeast Europe.

#### *AKKASDAGI (Keskin, Kirikkale) (No 10 in Fig. 1)*

This locality was first mentioned by Ayan (1963) and later on it was visited by F. Ozansoy in the late 1960s and by E. Heintz on October 21, 1971. The material collected by the first two authors is apparently lost. Heintz's material which consists of 229 specimens labelled as GOK is preserved in the Muséum National d'Histoire Naturelle of Paris.

The locality is situated along the southwestern slopes of Akkasdagı, 3 km NW of Gökesme Village, and 5 km SE of Armutlu Village between the towns of Keskin and Kaman. Around Akkasdagı, Neogene deposits cover wide areas; they are surrounded by ophiolitic and/or granitic rocks of the basement. Neogene deposits do not display tectonic deformation and they are horizontal. Their thickness does not exceed 100 m, probably due to their position at the basin margin. For this reason, we have to emphasize that Neogene deposits in the area of Akkasdagı seem much thinner than in other parts of the Çankiri-Çorum Basin.

Akkasdagı forms the major relief of the area with an altitude of 1019 m at the summit, and it is entirely built of Neogene deposits. A volcanic tuff layer, 7–8 m thick, is observed, at an altitude of 950 m, all around this mountain and in the surrounding hills and other reliefs. It forms a marker horizon for correlation of sedimentary deposits in this area. Towards its top this tuff layer contains bone pockets that are numerous and very rich along the southwestern slopes of Akkasdagı. The tuff is a primary volcanic ash deposit having gas segregation pipes, and contains radiometrically datable minerals such as biotite, sanidine and feldspare. Samples have been taken for K/Ar or Ar/Ar analysis that H. Maluski (Montpellier) has kindly accepted to perform.

Three bone pockets were partly excavated during one week, and about 300 specimens were unearthed. Moreover, about 150 kg of sediment was washed-screened in order to recover small mammal remains. After the preliminary determinations, the following faunal list has been established:

*Hipparrison* spp., three species according to size  
*Ceratotherium* sp.  
*Microstonyx* sp.  
*Giraffidae* indet.  
*Tragopontax* sp.  
*Prostrepoceros* sp.  
*Protoryx* sp.  
*Gazella* sp.  
*Proboscidea* indet.  
*Orycteropus* sp.  
*Felis* sp.  
*Hyaenotherium* sp.  
*Adcrocuta* sp.  
*Carnivora* indet.  
*Schizogalerix* sp.  
*Byzantinia* sp.  
*Muridae* indet.  
Aves indet., two species  
*Testudo* sp. cf. *T. graeca* Gaudry 1862  
Serpentes indet.

Such a fauna is clearly indicative of the Turolian. It can be compared to those of Kemiklitepe (KTD and KTA+B) which are dated as early Turolian (MN11) and middle Turolian (MN12) respectively (Sen et al. 1994). This locality will be explored more intensively during the next few years.

#### SÜLEYMANLI (No 9 in Fig. 1)

This locality is situated about 500 m W of Süleymanli Village (1:25000 map: G31 d4) in sandy-silty clays of the Kizilirmak Formation. The vertebrate bearing sediments are also rich in gastropod remains. Upwards, these are conformably overlain by gypsiferous deposits. In this locality Sickenberg et al. (1975: 93) found a few remains of turtles, fragmentary eggshells and *Hipparrison* sp. This assemblage cannot provide any reliable age. However, based on lithologic similarities with Çorak Yerler (near Çankiri), these authors suggested a middle or late Vallesian age. More recently this locality was explored by H. de Bruijn and E. Ünay for small mammals. The fauna is not

yet described, neither is its faunal list available. Nevertheless one *Apodemus* M1 has been illustrated by Bruijn et al. (1996, Fig. 2), and Daams & Bruijn (1995) noted the presence of *Myomimus* sp. These authors attribute this locality to MN13 (late Turolian).

#### KAVURCA (Çankiri)

This locality is situated along the road from Çankiri to Kavurca Village, in the valley of Aci Çay. Mammalian remains have been collected at two places, one 875 m W of the village, and the second 1000 m NW of the village (Sickenberg et al. 1975: 82). Fossiliferous beds are grey-green clays with freshwater molluscs. Due to tectonic activities in the area, Sickenberg et al. (1975) could not decide whether these two fossiliferous localities belong to the same stratigraphic horizon or not. However, they listed the fauna as one. From this locality, the insectivores were studied by Engesser (1980). H. Tobien had kindly lent to S. Sen two isolated teeth of a gerbil rodent that are determined as *Pseudomeriones* aff. *tchaltaensis*. A previsional faunal list from Kavurca is given below:

*Desmanella* cf. *amasyae* Engesser 1980  
*Amblycoptus* n. sp.  
*Prolagus* sp.  
*Cricetidae* indet. I (large form)  
*Cricetidae* indet. II (small form)  
*Castillomys* sp.  
*Apodemus jeanteti* Michaux 1967  
*Eomyidae* indet.  
*Pseudomeriones* aff. *tchaltaensis* Sen 1977  
*Spalacidae* indet.  
cf. *Hipparrison* sp.  
?Cervidae indet.

According to Sickenberg et al. (1975), this locality is a little younger than Amasya (MN13) in western Anatolia because of the absence of *Paraethomys* and the presence of a more evolved *Castillomys*. Engesser (1980) also considered Kavurca to be similar in age or slightly younger than Amasya. *Pseudomeriones* from Kavurca is very similar in morphology to *Pseudomeriones tchaltaensis* from Çalta (early MN15; Sen 1977) near Ankara, but slightly smaller in size. Considering all these remarks, the age of this locality should be younger than Amasya and older than Çalta, i.e. MN14.

Sickenberg et al. (1975) have also mentioned two other mammal localities in the Çankiri-Çorum Basin. One of them, Termeyenice (Ankara, Hasayaz) yielded fragmentary remains of turtles and bovids, and the second, Mahmutlar (Ankara, Kalecik) a few bones of a giraffid. We did not visit these localities. The available paleontological data has no biochronological interest, hence the absence of these localities in Figure 6.

Near Elmapınarı Village, Tekkaya et al. (1975) have found a tusk of proboscidean, a fragment of horn-core determined by them as *Gazella* sp. and some other indeterminate bone fragments. From Angittepe, they attributed to *Gazella gaudryi* a fragmentary metacarpal bone. Based on these scarce re-

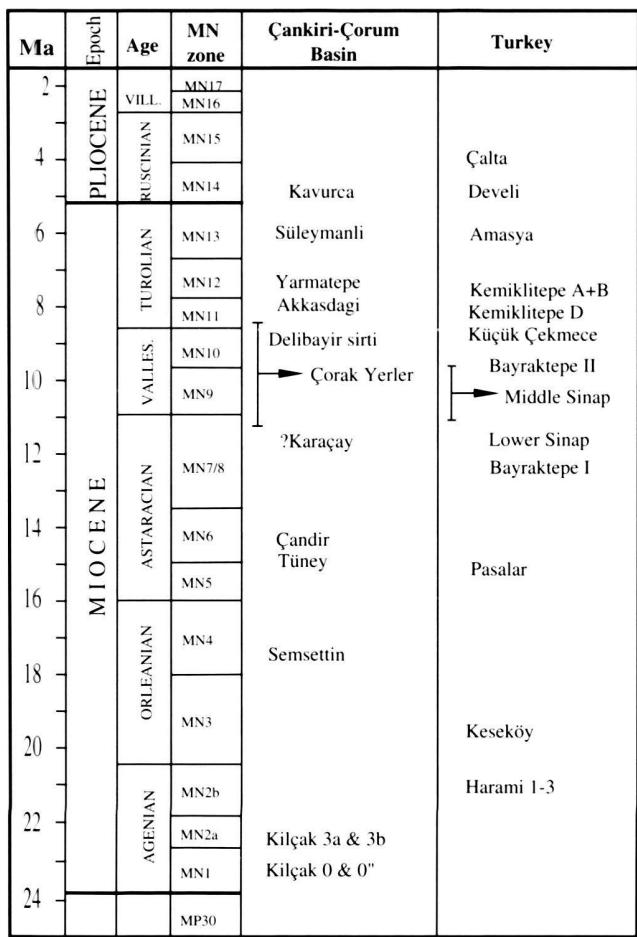


Fig. 6. Biochronologic chart of mammal localities in the Çankırı-Çorum Basin in relation to other key mammal localities in Turkey.

mains, they suggested an early Pliocene (= late Miocene) age to the related deposits. These authors also recorded a few postcranial bones between the villages of Hasayaz and Minkati, attributed to *Testudo* sp. and *Gazella gaudryi*, and near the village of Yüzbeyleli *Palaeotragus* sp. These localities are not reported in Figure 6 because of the fragmentary nature of material and unreliable ages that they provide.

#### The correlation of biochronological data and lithostratigraphy

This correlation has been established by using the fossil localities and the regional geological maps of Akyürek et al. (1980) and Hakyemez et al. (1986). Computer fitting of topographic and geological maps provides some information about which lithostratigraphical unit hosts the biochronological data. This method also provides a visualisation of the correlation between the lithostratigraphical units of different studies and reveals the errors of earlier lithostratigraphical divisions.

The sedimentary layers in Kılçak have been mapped as Hançılı Formation (Oligocene–Late Miocene) by Hakyemez et al. (1986). This formation is underlain by the Incik Formation (Oligocene–Middle Miocene) which is equivalent to the Kumartas Formation (Late Miocene) of Akyürek et al. (1980). Moreover, Koçyigit et al. (1995) accept the Kılçak outcrops within the Aslantas (= Kumartas) Formation and report the palynological analysis without the name of the association giving a Serravalian–Tortonian age. Furthermore they combined the age data of Kılçak and Çandır to obtain the age of Aslantas (= Kumartas) Formation as late Langhian–Tortonian (Koçyigit et al. 1995) (Fig. 7).

Our field studies and the age data reviewed above demonstrate that the sediments of the Kılçak location (MN1–MN2) should not be mapped as Hançılı Formation because the original Hançılı Formation is underlain by Kumartas Formation (MN3–MN4–MN6). In addition, in its type area the Kumartas Formation is mainly built up of fluviatile red beds. The lithology and depositional environments of the fossiliferous deposits at Kılçak do not fit with the lithologic characteristics of the Kumartas (= Aslantas) Formation, and consequently they should be distinguished as a different stratigraphic unit which underlies the Kumartas Formation.

The red beds of Tüney locality are mapped as Incik Formation by Hakyemez et al. (1986). The correlation of maps of Akyürek et al. (1980) and Hakyemez et al. (1986) demonstrates that the red clastics around Kumartas village are mapped as both Incik and Kumartas Formation. Therefore the red beds of Tüney (MN6) are considered to belong to the Kumartas Formation.

At Çandır, the local stratigraphy was described by Sickenberg et al. (1975: 23) as an interbedded succession of lacustrine-fluviatile silty clays. In fact there are no real lake sediments in this succession but mainly pond deposits with limited lateral extent. Atalay (1981) also figured a lithostratigraphic column across the Çandır mammal locality, but without any further comments. Koçyigit et al. (1995) include the fossiliferous horizons of Çandır in the Aslantas (= Kumartas) Formation.

The Çandır locality has been mapped as Hançılı Formation by Hakyemez et al. (1986) but our field observations demonstrate that it belongs to the upper levels of the Kumartas Formation (MN6) whereas Seşettin represents the lower part of the Kumartas Formation (MN3–MN4). These two different stratigraphic levels of the Kumartas Formation are covered by the Hançılı Formation which also overlaps the basement to the SE of Seşettin village according to the map of Akyürek et al. (1980).

The fossiliferous horizons of Çorakyerler, Delibayır Sirti and Süleymanlı are included in the red clastics of the Kızılırmak Formation (Birgili et al. 1975). This unit (MN9/MN10, MN11, MN13) is overlain by the gypsum of the Bozkır Formation.

One kilometre N of Inaç Village, to the E of Delibayır Sirti, isotopic dates of tuffites ( $23.6 \pm 0.5$  Ma) have been re-

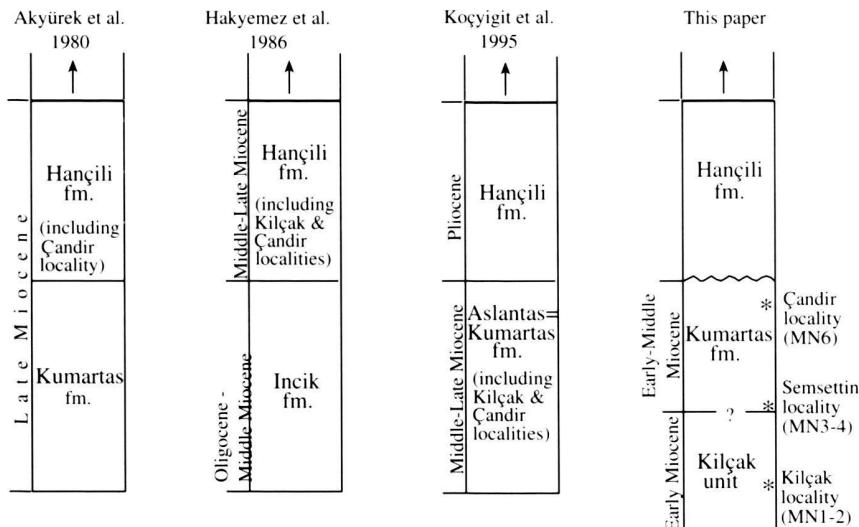


Fig. 7. Neogene lithostratigraphical units of the Çankırı-Çorum Basin and their relationships and ages according to different authors and this study.

ported by Besang et al. (1977). This location probably corresponds to the Bayindır Formation of Birgili et al. (1975) that underlies the Kızılırmak Formation. However, further field studies are necessary to place the dated horizons within the lithostratigraphic succession.

## Conclusions

At the present state of our investigations, 17 Neogene mammal localities, plus some other spots with scarce material, are known in the Çankırı-Çorum Basin, all in stratified sedimentary deposits. Their ages range from the earliest Miocene (MN1) to early Pliocene (MN14). Most of mammalian taxa reported in faunal lists are based on preliminary determinations. Detailed systematic studies are available on carnivores, proboscideans, bovids, some rhinos, insectivores and rodents from some localities. Since several teams are still pursuing paleontological investigations in this basin, a rapid increase in paleontological and biochronological data can be expected in the near future.

Mammalian faunas from the Çankırı-Çorum Basin are unequally rich. For example the fauna from Çandır contains eight small and thirty-eight large mammal species compared to that of Tüney which yielded only two species of large mammals. However, almost all localities yielded key taxa allowing relatively accurate determination of the age of each fauna and related deposits.

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