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ABSTRACT

The Çankırı Basin is located in north central Anatolia in a zone where the North Anatolian Fault Zone bifurcates into a number of northwards convex splay faults that are deforming tne Anatolian Block internally with a complex rotational deformation. Two distinct tectonic regimes were recognized in the Çankırı Basin which can be extrapolated to the other regions in Turkey. These tectonic regimes are analyzed and precisely dated using rodent fauna.

The Kılçak Formation is the latest product of the pre-Burdigalian compressional regime exerted by the collision and indentation of the Kırşehir Block and the Sakarya Continent. It is of Aquitanian age and is the oldest Neogene unit in the study area. The other Neogene units are the Altıntaş Formation of Burdigalian age, the Hancılı Formation of Burdigalian to Langhian age, the Çandır Formation of Burdigalian? to Serravalian age and Middle Miocene Faraşlı Basalt. These units were deposited and emplaced in an extensional tectonic regime, which replaced the pre-Burdigalian compressional regime and caused by orogenic collapse after collision. The upper part of the Neogene is represented by the Tuglu Formation of Tortonian age, the Süleymanlı and the Bozkır formations of Messinian to Pliocene age, and finally the Gelasian Deyim Formation. The Tuglu, Süleymanlı and Bozkır formations were deposited in a compressional tectonic regime, which gradually changed in character to a transcurrent setting. Some of the normal faults developed during the extensional regime in the Middle Miocene were re-activated as transpressional faults in the latest deformation period.

ÖZ

Çankırı havzası, Orta Anadolu'nun kuzey kesiminde, Kuzey Anadolu Fay Zonu'nun konveks kısmı kuzeye bakan bir çok dala ayrılıp Anadolu Blogunu karmaşık bir rotasyonal deformasyona uğrattığı bir bolgede yer alır. Çankırı havzasının Neojen birimleri iqerisinde, Türkiye'nin diger bolgelerine de yayılabilecek gekilde iki farklı tektonik rejimin varlığı ortaya çıkarılmıştır. Bu rejimler analiz edilmiş ve rodent (mikro memeli) faunası kullanılarak hassas bir gekilde yaşlandırılmıştır.

Kılçak Formasyonu, Kırşehir Blogu'nun Burdigaliyen oncesinde Sakarya Kıtası'na çarpıp onu indente etmesi sonucu oluşan sıkıştırma rejiminin en son urunudur. Yaşı Akitanyen olup, çalışma alanındaki en yaşlı Neojen birimdir. Çalışma alanındaki diger Neojen birimler, Burdigaliyen yaşlı Altıntaş Formasyonu, Burdigaliyen-Langiyen yaşlı Hancılı Formasyonu, Burdigaliyen-Serravaliyen yaşlı Çandır Formasyonu ve Orta Miyosen yaşlı

...çekilmişlerdir. En son tektonik donemde Orta Miyosen genişleme doneminde oluşmuş normal faylardan bazıları, transpressional faylar olarak tekrar aktifleşmişlerdir.

INTRODUCTION

Turkey lies within the Alpine ororgenic system caused by the collision of the various continental fragments after the intervening oceanic domains were completely consumed, since the Late Cretaceous. It has experienced very complex collisional history in the Late Paleocene to Early Miocene (e.g. Şengör and Yılmaz, 1981, Kaymakçı, 2000, Okay et al. 1996, Okay and Tüysüz 1999, Okay et al. 2001), which was followed by an extensional tectonic regime exerted mainly by the collapse of preceding orogenic system (e.g. Bozkurt et al. 1994, Kaymakçı 2000). Current tectonic scheme of Turkey is dominated by the North Anatolian and East Anatolian Fault zones ((NAFZ and EAFZ, respectively) which are the two conjugate (?) intracontinental transform faults along which the Anatolian block is moving westwards towards the Hellenic trench (Figure 1). Westwards movement of the Anatolian Block is attributed to an escape tectonics, which is exerted by the collision and further convergence of the Arabian Plate along the Bitlis-Zagros Suture zone since the end of the Serravallian (Şengör et al. 1985). The Anatolian Block In the west is dominated by an extensional tectonic regime characterized by horst-graben complexes (e.g. Şengör and Yılmaz 1981) eastern continuation of which is not delineated yet. Only for the Middle Miocene, Çemen et al. 1999, Kaymakçı 2000, Kaymakçı et al. 2001b) and is dominated by a regional transcurrent tectonic regime (Kaymakçı 2000).

The Çankırı Basin (Figure 2) is located in a very unique area in Turkey having more than 4-km-thick Upper Cretaceous to Recent in-fill (Figure 3) that recorded information related to the tectonic development of north central Anatolia. In addition to this it is also unique in having newly well-established, high precision, stratigraphy based on rodent fauna (Figure 4) (Şen et al. 1998, Kaymakçı 2000, Kaymakçı et al. 2001c), which provides very valuable information to constrain temporally the ages of the structures and to separate tectonic regimes that controlled Neogene development of the basin. Therefore, understanding of the tectonic development of the Çankırı Basin provides valuable up-to-date information to unravel tectonic development of the Anatolian Block, which may help to understand Alpine orogenic system, in general.

The pre-Neogene tectonics of the Çankırı Basin was outlined in previous studies (Kaymakçı 2000). This paper deals with the Neogene. The separation of the two is made because of a marked change in depositional styles and tectonic settings. The Neogene tectonics of the Çankırı Basin (Figures 1 and 2) are characterized by a complex deformational history that is distinguished by lateral changes in the type, style and trends of the structures which were developed within the Neogene units, contemporaneously (Figure 3). Therefore, the establishment of an accurate stratigraphy for the Neogene units is important if these tectonic

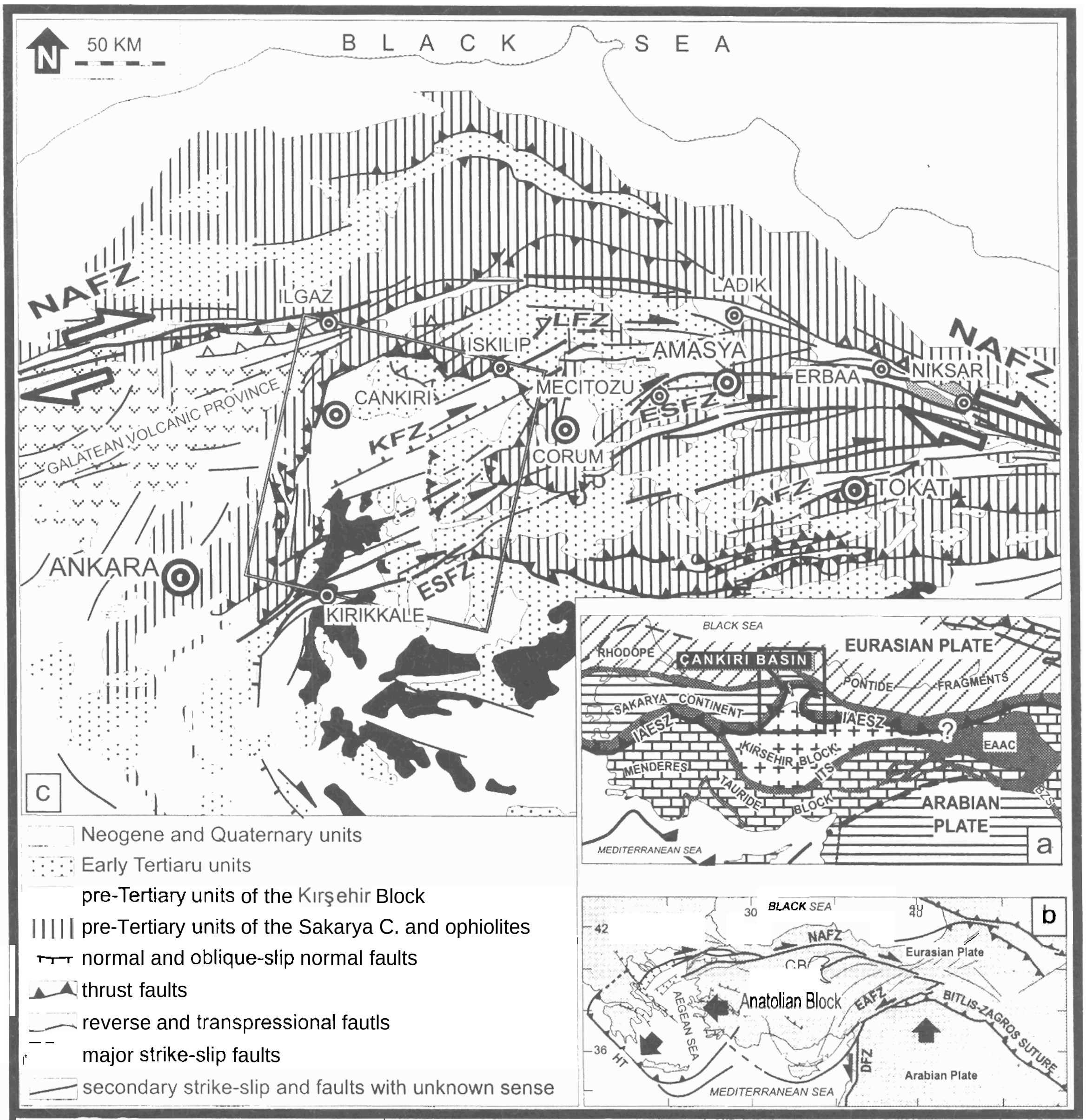

Figure **1.** a) Inset map showing the geological outline of Eastern Mediterranean area (Modified after Şengör et al. 1984). EAAC: East Anatolian Accretionary Complex, IAESZ: İzmir-Ankara-Erzincan Suture Zone, ITS: Inner-Tauride Suture, b) Current tectonic setting of the Eastern Mediterranean area. Large black arrows indicate plate movement directions. DFZ: Dead Sea Fault zone, EAFZ: East Anatolian Fault Zone, HT: Hellenic Trench, NAFZ: North Anatolian Fault Zone (modified after Barka and Hancock 1984, Gorur et al. 1984, Özçelik 1994, Kaymakçı and Koqyigit 1995). c) Tectono-stratigraphical map of central Anatolia. Box shows the location of the Çankırı Basin. AFZ: Almus Fault Zone, ESFZ: Ezinepazari-Sungurlu Fault Zone, KFZ: Kızılırmak Fault Zone, LFZ: Laqin Fault Zone. Concentric circles are major towns.

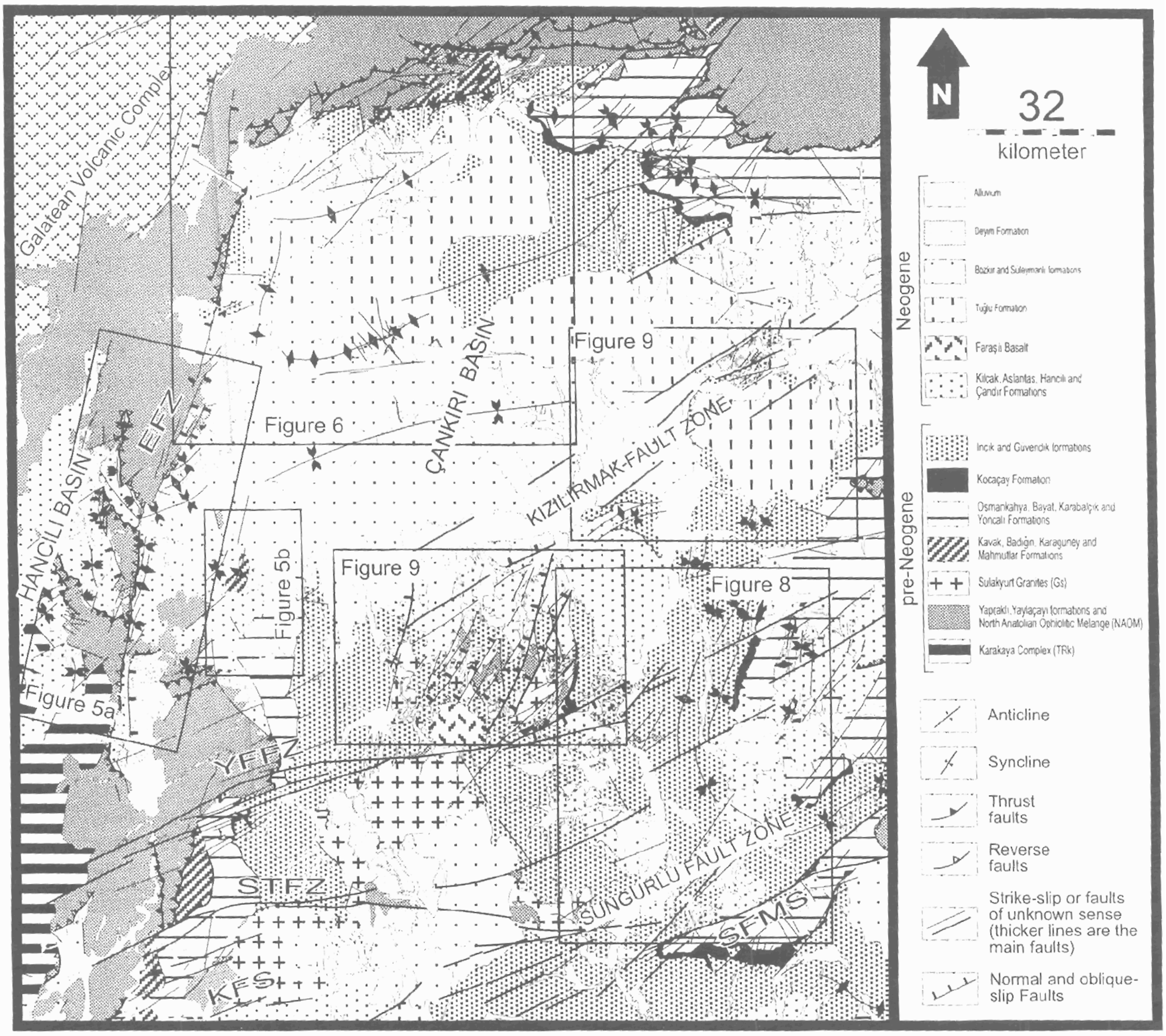

Figure 2. Geological map of the Çankırı Basin. EFZ: Eldivan Fault Zone, KFS: Kırıkkale Fault Set. SFMS: Master Strand of the Sungurlu Fault Zone, STFZ: Sivritepe Fault Zone, YFFZ: Yağbasan-Faraşlı Fault Zone.

events are to be temporarily constrained.

In this context. we aim based on newly obtained stratigraphical information at establishing, describing and chronogically constraining the structures developed in the Çankırı Basin and to discuss its Neogene tectonic development using various tectonic models based on information obtained from various methods discussed in Kaymakçı (2000).

BRIEF NEOGENE STRATIGRAPHY OF THE ÇANKIRI BASIN

A detailed stratigraphy of the units exposed in and around the Çankırı basin has already been described in Kaymakcı (2000) and Kaymakci et al. (2001c). Therefore, a brief description of the units will be given here. The ages suggested for the various formations are based on the biostratigraphical correlations of the succession of rodent faunas of Anatolia with the European MN schemes (Figure 4). Although,

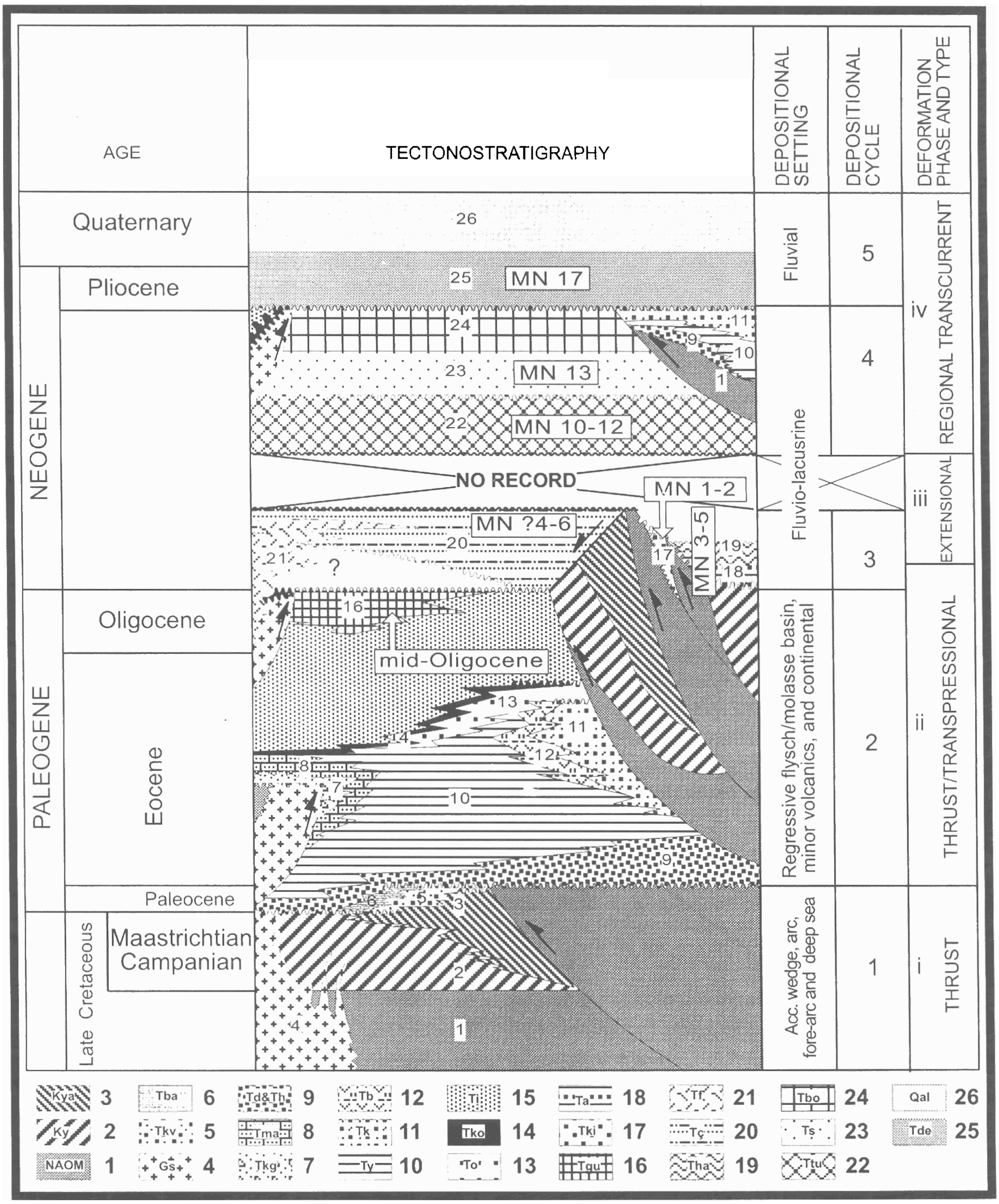

Figure 3. Generalized tectono-stratigraphic column of the units exposed in and around the Çankırı Basin. 1. North Anatolian Ophiolitic Melange-NAOM, 2. Yaylaçayı Formation (distal fore-arc sequence), 3. Yapraklı Formation (proximal fore-arc facies), 4. Sulakyurt Granitoids of the Kırsehir Block that intruded in pre-Paleocene, 5. Kavak Formation (red clastics and carbonates), 6. Badigin Formation (neritic limestones), 7. Karaguney Formation (clastics

derived mainly from the Kırşehir Block) 8. Mahmatlar Formation (clastics derived from Sulakyurt Granitoids), 9. Dizilitaglar and Hacıhalil formations (mainly turbiditic clastics and intercalated limestones), 10. Yoncalı Formation (Eocene flysch), 11. Karabalçık Formation (distributary channel conglomerates and sandstones with coal seams), 12. Bayat Formation (Eocene volcanics and volcanoclastics), 13. Osmankahya Formation (mixed environment clastics and red beds), 14. Kocaçay Formation (Middle Eocene nummulitic limestone covering both basin in-fill and the granitoids. 15. İncik Formation (Late Eocene to Oligocene continental red clastics), 16. Guvendik formation (Oligocene evaporites), 17. Kılçak Formation 18. Altıntaş Formation (fluvial red clastics exposed only in the Hancılı Basin), 19. Hancılı Formation (lacustrine deposits exposed only in the Hancılı Basin, 20. Çandır Formation (fluvio-lacustrine clastics), 21. Faraşlı Basalt, 22. Tuglu formation (early-Late Miocene evaporites and lacustrine shale/marl), 23, Sûleymanlı formation (fluvio-lacustrine red clastics), 24. Bozkır Formation (evaporites), 25. Deyim Formation (fluvial clastics), 26. Alluvium. MN zones and a mid-Oligocene age were obtained at certain horizons within the post-Middle Eocene units. See Kaymakci (2000) for the description of pre-Neogene units.

the local Miocene succession is well established and allows dependable correlations within Anatolia based on the evolution of the dentition in a number of murid genera (i.e. *Cricetedon*, *Spanocricetedon*, Democricetedon, and Mirebella, de Bruijn et al. 2001) the correlation of the Early Miocene part of the local zonation with the MN zones (Figure 4) remains uncertain due to fauna dissimilarity and the limited number of magnetostratigraphic and radiometric ages of mammal bearing deposits available (Krijgsman 1996, Krijgsman et al. 1996, Krijgsman et al. 2001). Therefore, ages of the units are given within reasonable limits (kaymakçı et al. 2001a). The oldest Neogene unit in the study area is the Kılçak Formation of Aquitanian age. It is followed in order of younging, by the Altıntaş Formation of Burdigalian age, the Hancılı Formation of Burdigalian to Langhian age, the Çandır Formation of Burdigalian? to Serravalian age, the Tuglu Formation of Tortonian age, the Süleymanlı and Bozkır formations of Messinian to Pliocene age, Deyim Formation of Late Pliocene (Gelasian) to Early Quaternary age and finally there is the Recent alluvium (Figure 3).

The Kılçak Formation is composed of moderately sorted conglomerates, sandstones, laminated shale, marl with gypsum flakes, white to buff limy-marl and thin clayey limestone and intercalations of thin coal seams and organically rich levels overlain by coarser clastics characterized by conglomerates and sandstones. Intercalated with greenish gray mudstone/shale alternations. The age of the units is early Early Miocene (Aquitanian) which is MN-1 and the lower part of MN-2 zones (Figure 4).

Altıntaş Formation is exposed only in the Hancılı Basin (Figure 5) and composed of fining and thinning upwards sequence of alternating red, poorly to moderately sorted polygenic conglomerates, sandstones and locally intensely sheared red to dark greenish brown mudstone. The pebbles of the conglomerates are derived from the nearby exposed pre-Neogene units. Based on the rodents collected by Şen et al. (1998) and its lateral gradation to the Hancılı Formation, a Burdigalian age is assigned to the Altıntaş Formation (Figure 3).

Hancılı Formation laterally and vertically grades into the underlying Altıntaş Formation. It is characterized by thinly bedded limy-marl/marly-limestone and grades upwards in to green to bluish green bentonitic clay, white to beige marl, nodular limestone, greenish gray shale and marls intercalated with tuffs and tuffaceous marls. There is a marked decrease in the thickness of the unit in the north-eastern parts of each depression of the Hancılı Basin (Figure 5). In the south-western parts of each depression, tuffaceous units and cherty limestone horizons dominate while in the eastern parts organic rich

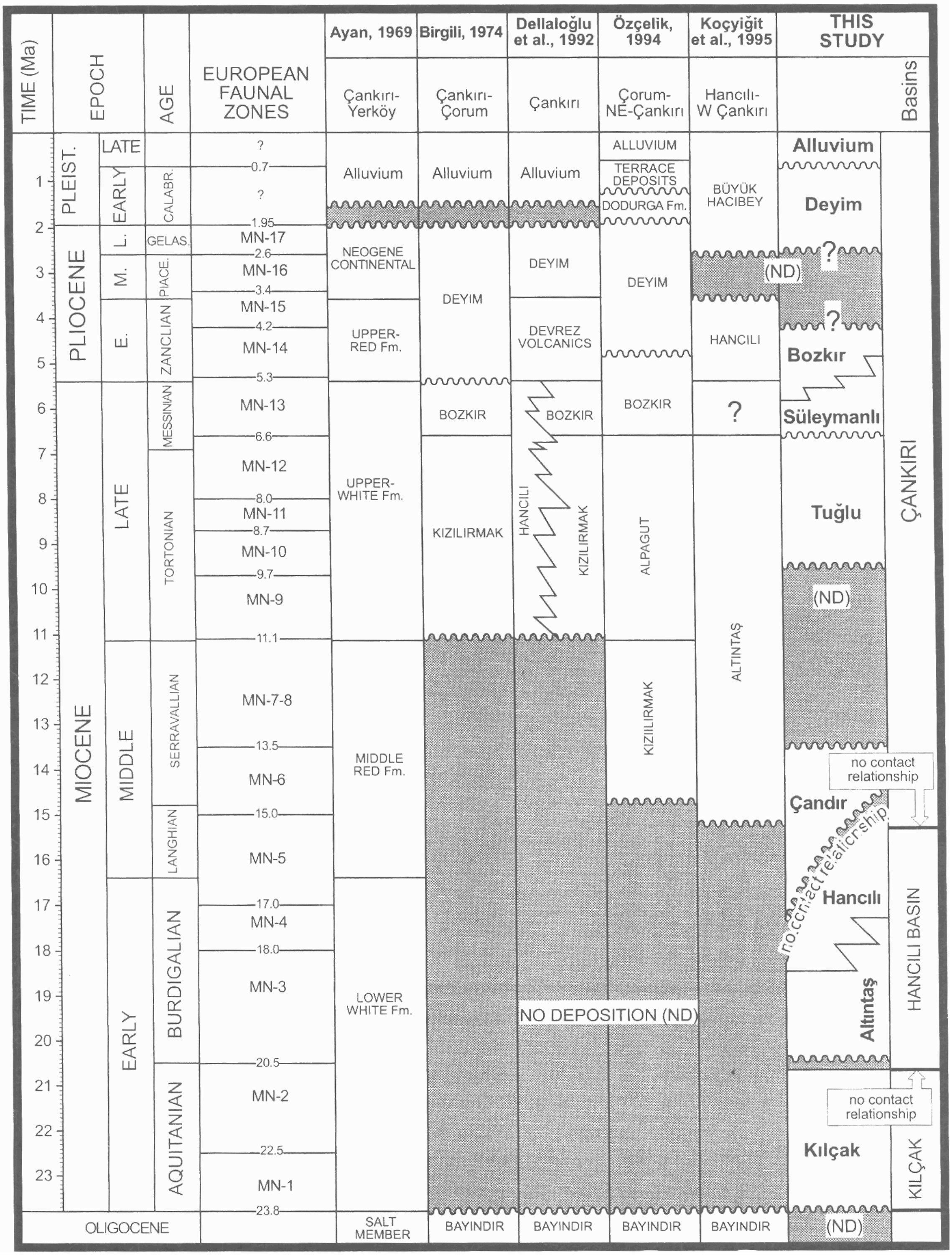

Figure 4. Correlation chart illustrating the relative ages of the units in the Çankırı and Hancılı basins and comparison of previous studies with this study. Correlation of the standard time units and faunal (Mammal Neogene-MN) zones is after Steininger (1999).

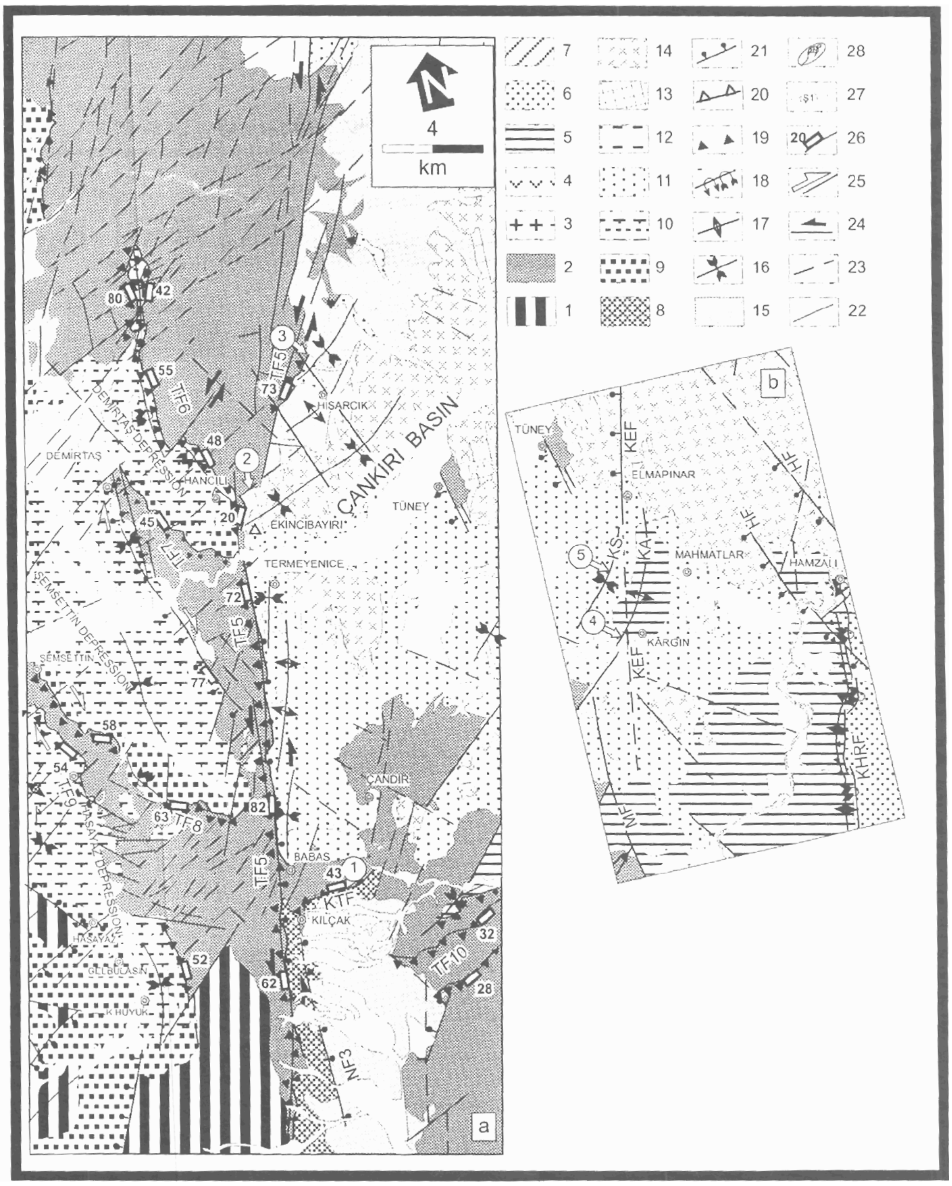

Figure 5. a-b) Geological maps of western part of the Çankırı Basin around Hancılı and Çandır. 1. Karakaya Complex, 2. Late Cretaceous units, 3. Sulakyurt Granite, 4. Galatean Volcanic Province. 5. Early Tertiary units, 6. İncık Formatıon, 7. Guvendik Formation, 8. Kılçak Formation, 9. Altıntaş Formation, 10. Hancılı Formation, 11. Çandır Formation, 12. Tuglu Formation, 13. Süleymanlı Formation, 14. Bozkır Formation, 15. Deyim Formation, 16. syncline, 17. anticline, 18. overturned fold, 19. thrust fault, 20. reverse fault, 21. normal fault, 22. strike-slip and faults with unknown sense of movement, 23. photo lineaments, 24. sinistral sense of movement, 25. dextral sense of movement, 26. dip of fault scarp where it is best exposed, 27. line of measured section. For the numbers and the abbreviations see the text.

horizons and bluish green marls and bentonites dominate. The age of the unit is Burdigalian to Langhian (MN-4- early MN-5).

The Çandır Formation is composed of an alternation of red to pink, buff to creamy white pebbly mudstone, clayey limestone, siltstone, matrix supported conglomerate intercalated with white, limy-marl, thin silty-limestone, oolite bearing limestone, clayey limestone, and very thin organic rich layers. It also includes various caliche limestone, palaeosol horizons with carbonate concretions and cross-bedded sandstone and conglomerates locally discordant with these horizons. The sequence becomes finer and thinner towards the top and to the north-eastern part of the Çankırı Basin (Figure 6). In the south-central part of the Çankırı Basin (Figure 7), the Çandir Formation received most of its detritus from the Kırşehir Block and is characterized by a very well developed fining upwards sequence of cyclicity and a decimeter scale color banding of conglomerates, sandstones and mudstones. In the south-eastern part of the Çankırı basin, the Çandır Formation interlayered with basalt and tuff horizons of the Faraşlı basalt (Figure 8). The age of the Çandır Formation is of Burdigalian? to Serravallian (MN-4 to MN-6).

The Faraşlı Basalt is exposed mainly in the south central part of the Çankırı Basin (Figure 7). It was emplaced on the Kırşehir Block and Guvendik Formation. In the south-eastern part of the Çankırı Basin it is intercalated with the Çandır Formation. Based on its relation with the Çandır Formation, and a radiometric age of one sample collected from the Faraşlı Basalt 14 ±1 Ma (De Bruijn et al. 2001) it is assumed that the Faraşlı Basalt was extruded in the Middle Miocene.

The Tuglu Formation comprises a very thick recrystallized gypsum. In its type section in the north-eastern part of the Çankırı Basin (Figure 9), it is composed of dark gray shale, mudstone, siltstone, and sandstone alternations at the bottom and in the middle parts, it is composed of an alternation of green, pelecypoda bearing stiff bentonitic claystone and dark green to gray colored organic rich mudstone, intercalated with 3-10 cm thick cherty limestone beds, lenses of conglomerate, and very thin (1-5 cm) coal seams. It gradually becomes marl dominated towards the top and grades laterally into an alternation of thick-bedded white gypsum and thick-bedded yellow to pinkish silty mudstone. The rodent fossils in the Tuglu Formation characterizes MN-10 to MN-12 zones, which imply Tortonian age for the unit.

The Süleymanlı Formation is composed of fluvio-lacustrine conglomerates, sandstones, siltstones, shale/marl and intercalation of gypsum. It laterally grades into the Bozkır Formation which comprises a very thick white gypsum alternating white yellow to buff marl and red rnudstones. The rodent fossils in the Süleymanlı Formation characterize MN-13 therefore Messinian age is assigned to this unit. Based on its lateral gradation to the Bozkir Formation Messinian to Pliocene age is assigned to the Bozkır Formation.

The Deyim Formation is composed dominantly of variable size poorly sorted, polygenic loose conglomerate/gravel, sandstone, siltstone and mudstone. The age of the unit is Gelasian (MN-17, Late Pliocene) based on rodent fauna (Kaymakcı 2000).

NEOGENE TECTONICS OF THE ÇANKIRI BASIN

In this section, the deformation styles within, and tectonic relationships between, the Neogene units are given, along with the structures that developed in the Çankırı Basin and adjacent Hancılı Basin.

The Western Area, Northern Area and the Hancılı Basin

The structure which tectonically overlies the oldest Neogene formation is the Kılçak Thrust Fault (KTF). Along the KTF, basement units are thrust over the Kılçak Formation. There is no unit covering the fault contact to constrain the age of the fault precisely, however, the Deyim Formation unconformably overlies the folded and overturned Kılçak Formation in the vicinity

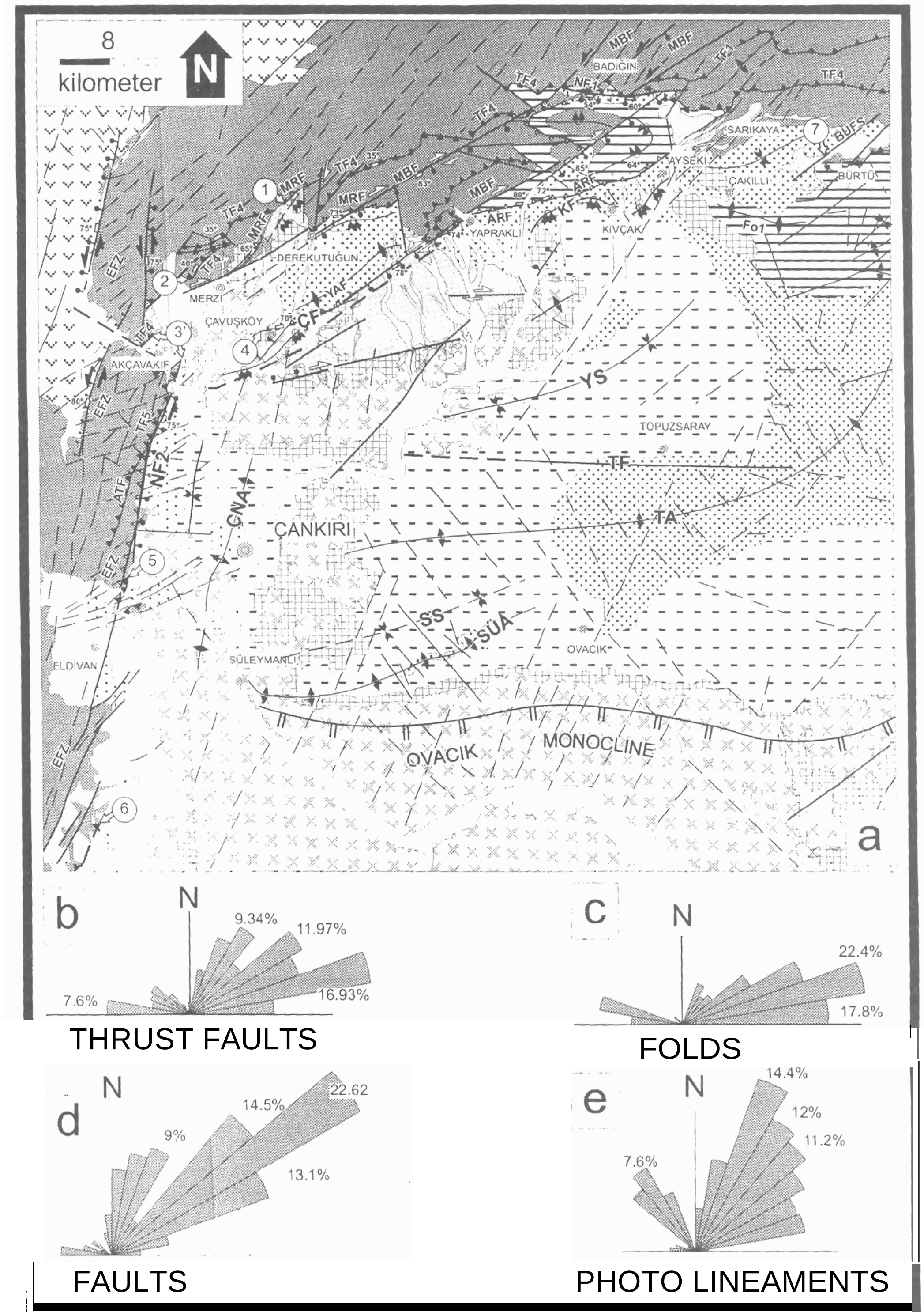

Figure 6. a) Geological map of the north-western part of the Çankırı Basin (see Figure 5 for the explanation of the symbols). b-e) Length weighted rose diagrams of the structures indicated.

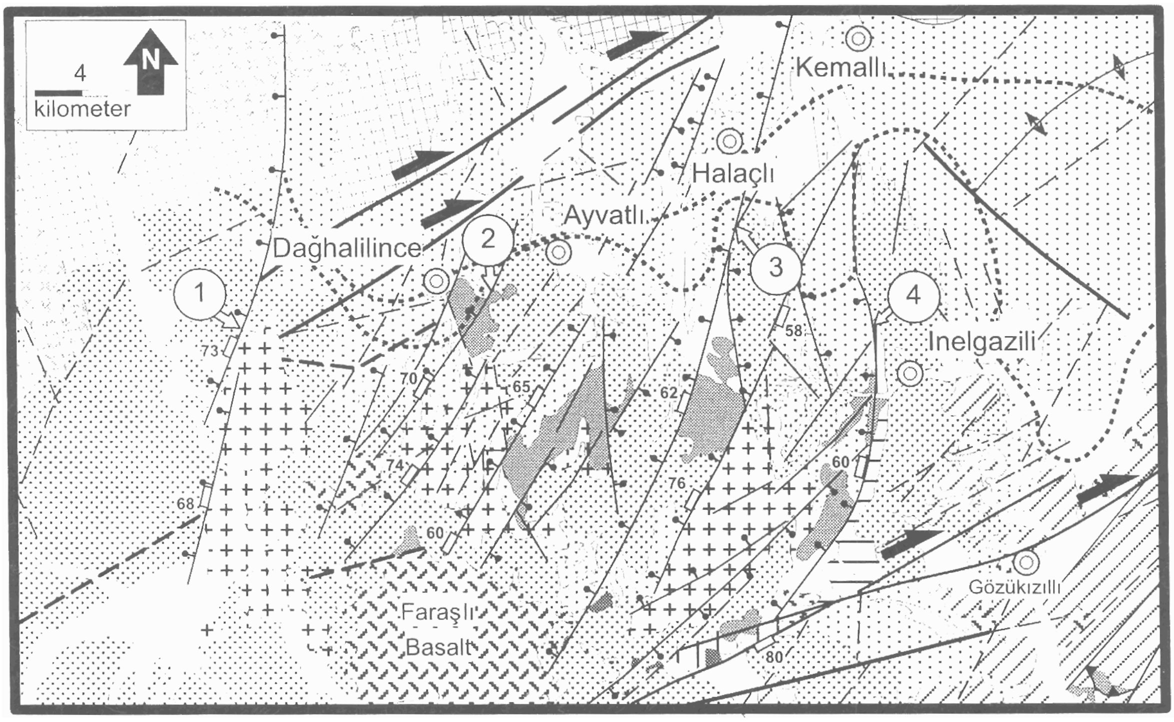

Figure 7. Geological map of the central part of the Çankırı Basin (see Figure 2 for its location and Figure 5 for the explanation of the symbols).

of the KTF (Figure 10a), which indicates post Aquitanian, and pre-Gelasian development of the KTF.

The other faults in the western part of the Çankırı Basin are the TF-4 and TF-5. Along the TF-4 the basement units were thrusted over the Middle Miocene Çandır Formation and the thrust contact is covered by the Suleymanl-Formation in the area indicated with 3 in Figure 6. TF-5 was partly mapped .previously by Koqyigit et al. (1995). However it was incorrectly dated and its contact relationships was misinterpreted and no kinematic data was given to understand the characteristics of the fault. Along the TF-5, the basement units thrusted over the Çandır Formation and the thrust contact is covered by the Suleymanl~Formation (Figure 10d) in the area indicated with 3 and 5 in Figure 6. In addition, it is covered by the Deyim Formation (Figure 10c) in the location indicated with 6 in Figure 6. This relation indicates post-MN 6 and pre-MN 13 development of the TF-5.

The Kazmaca-Hamzalı Reverse Fault (KHRF) (Figure 5) is developed within the pre-Neogene units and it is of Middle Eocene to pre-MN-1 to MN-2 (pre-Aquitanian) age (Kaymakçı 2000).

The NF-2 is one of the sinistral transtensional faults within the Eldivan Fault zone (Figure 10c). NF-2 displaced the TF-5 and Suleymanl~ and Bozkır formations (Figure 6), which indicates post-MN-13 development of the NF-2.

The NF-3 is a sinistral transtensional fault developed with in Kılçak sector of the Çankırı Basin (Figure 5a). The Kılçak and the Deyim formations are offset along this structure, which indicates post-MN-17 development of the NF-3. The Hamzalı Faults (HF) and the Kargın-Elmapınar Fault (KEF) are strike-slip faults with normal component of slip. These faults locally displaced Suleymanl~and Bozkır formations, which indicate post-MN-13 development of the HF and KEF faults.

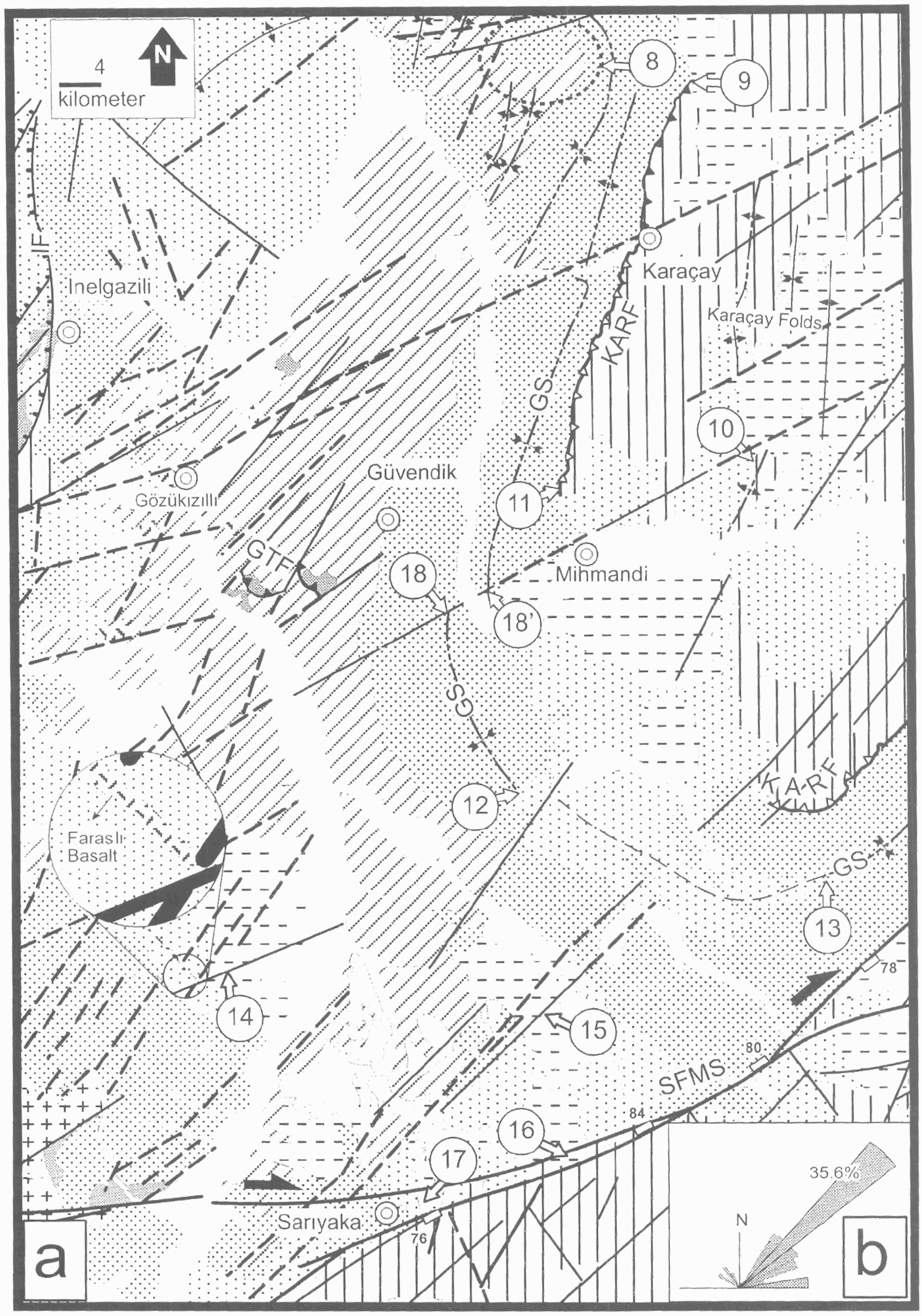

Figure 8. Geological map of the eastern margin of the Çankırı Basin (see Figure 5 for the explanation of the symbols). Note blow up figure illustrating the interlayering of Faraşlı Basalt and the Çandır Formation. For the numbers and the abbreviations see the text.

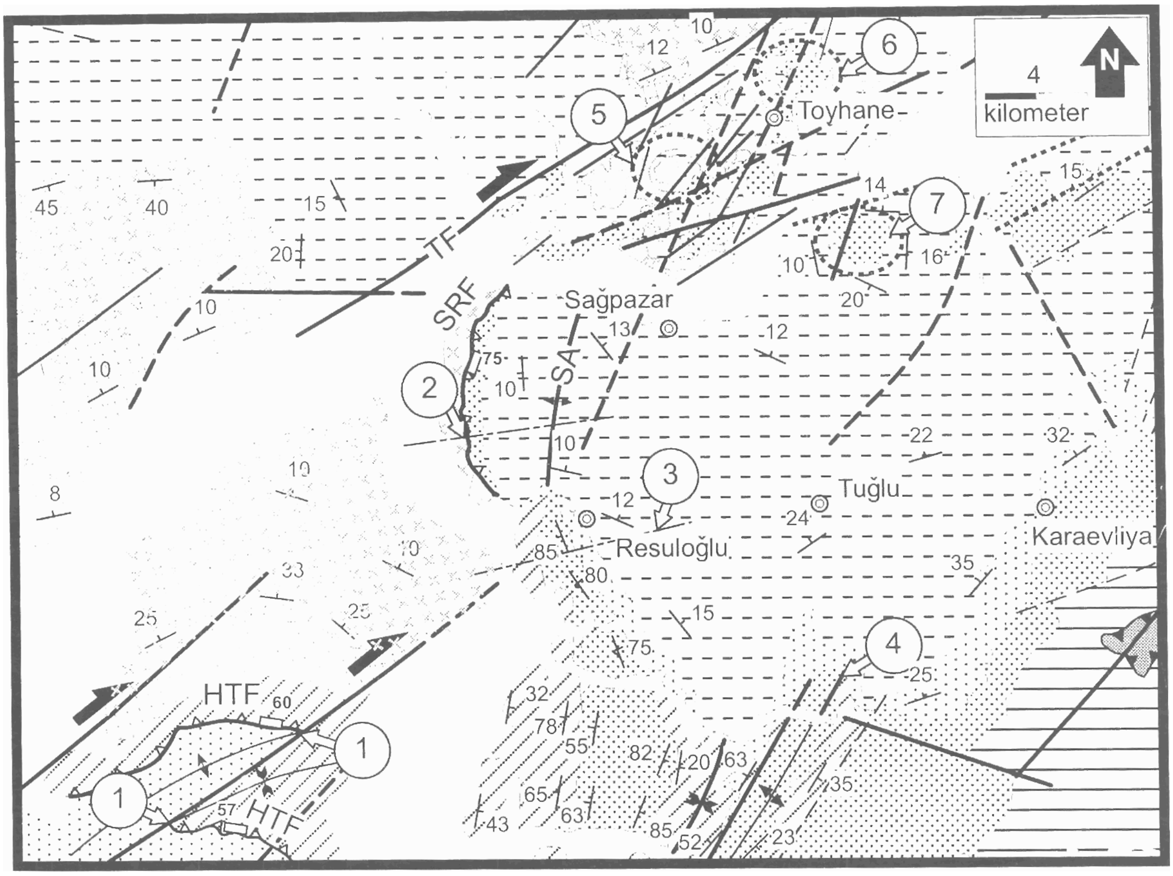

Figure 9. Geological map of the north-eastern margin of the Çankırı Basin (see Figure 5 for the explanation of the symbols). For the numbers and the abbreviations see the text.

Eldivan Fault Zone defines the Western Margin of the Çankırı Basin (WMCB) and includes a number of generally N-S to NNE-SSW to NE-SW striking sinistral transpressional and transtensional faults (Figure 6a). The youngest unit displaced by the EFZ is the Deyim Formation (Figure 10c), which indicates post-MN-17 activity of the EFZ.

Merzi-Badigin Fault Zone (MBF) is one of the longest fault zones that delimit the north-western margin of the Çankırı Basin (Figure 6). It is composed of a number of NE-SW striking dextral transtensional faults that displaced the TF-4, the basement, MRF, pre-Neogene units and the Deyim Formation, which indicates post-MN-17 development of the MBF.

The Burtu Fault Set (BUFS) has displaced the basement and the Deyim Formation (Figure 6), which indicates its post-MN-17 development. The Merzi Reverse Fault (MRF), Çavuşkoy Fault (ÇF) and Ayseki Reverse Fault (ARF) are the youngest compressional faults that controlled the structural development of the NW corner of the Çankırı Basin. Along the MRF, the basement units cut across the Süleymanlı Formation. The fault contact is covered by the Deyim Formation (see location 1 in Figure 6), which indicates that MRF post-dates MN-13 (Messinian) and pre-dates MN-17 (Gelasian). Likewise, along the ÇF, the basement cut across the Süleymanlı and Bozkir formations and the fault itself is covered by the Deyim Formation (location 4 in Figure 6), which indicates its post-MN-13 and pre-MN-I7 development. Along the ARF, the pre-Neogene units cut across basement. The ARF has not been covered by any Neogene

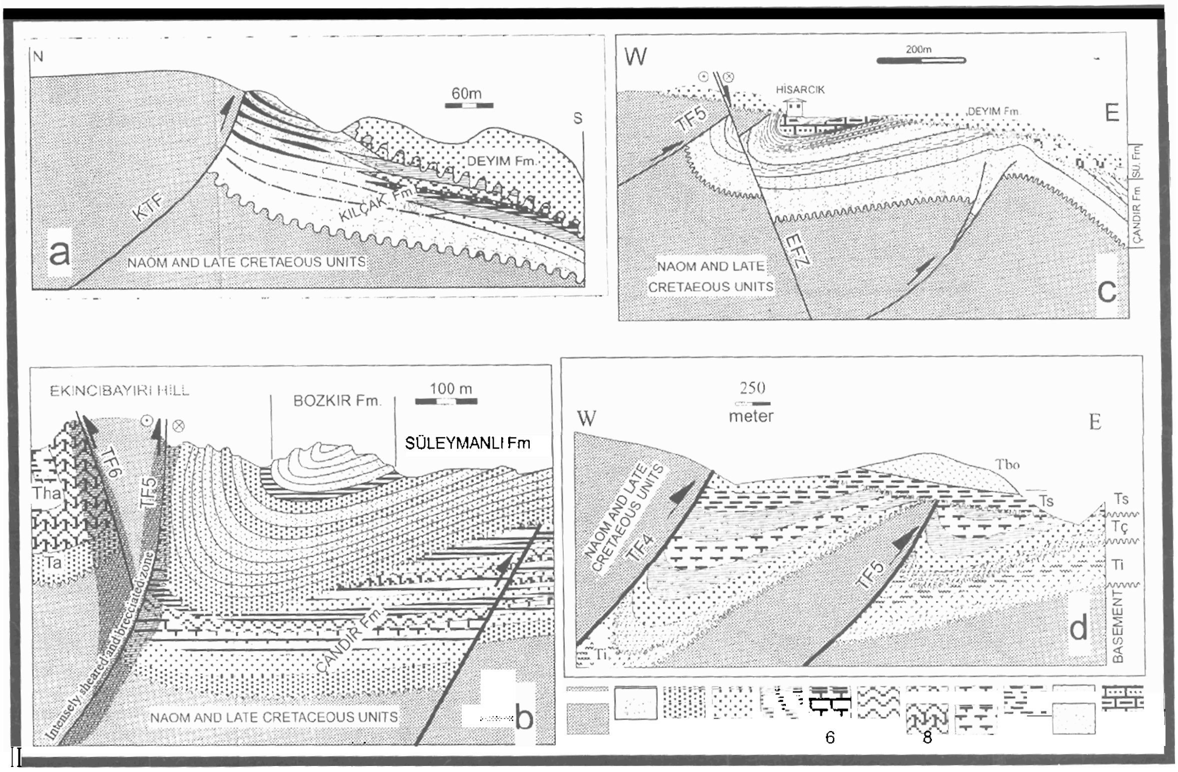

Figure 10. Schematic illustration of the various tectonic relationships between a) Basement (NAOM), Kılçak (Tki) and Deyim formations (locality is 1 in Figure 5, view to East). b) NAOM, Altıntaş (Ta), Hancılı (Tha), Çandır (Tç), Süleymanlı (Ts) and Bozkır (Tbo) formations. Note overturning of the Bozkır Formation (locality is 2 in Figure 5, view to north).c) NAOM, Çandır Formation, Sûleymanlı and Deyim (Tde) formations. Note that Deyim Formation overlies the thrust contact (locality is 3 in Figure 5). d) NAOM, incik, Çandır, Süleymanlı and Bozkır formations. Location is near Akçavakıf village (3 in Figure 8, view to N). BTNF: Babas-Termeyenice Normal Fault of the Eldivan Fault Zone (EFZ), KTF: Kılçak Thrust Fault, 1. pre-Neogene units (mainly NAOM and the Late Cretaceous), 2. polygenic conglomerates, 3. poorly sorted, immature pebbly sandstones, 4. cross-bedded and moderately sorted relatively clean sandstones, 5.various types and colours of shale and mudstones, 6. marly limestone, 7. white marls locally with gypsum flakes, 8. cherty limestone, 9. various types of marls, 10. red silty-sandy-mudstone. 11. gypsum, 12. silty-sandy-limestones.

unit, however, the Süleymanlı Formation is overturned parallel to the ARF into the Kıvçak Fold between Ayseki and Kıvçak villages (KF in Figure 6), which indirectly indicates post MN-13 development of the ARF.

Koçyiğit et al. (1995) partly mapped and named the thrust faults developed within the Hancılı Basin (TF-6, TF-7, TF-8, and TF-9, in Figure 5a). However, no kinematic data were given to understand the nature of these structures. In addition, dating and interpretation of these structures were incorrect. In this study these structures are renamed dated and reinterpreted. Kinematic data regarding the nature of these structures were previously presented by Kaymakcı (2000) and Kaymakcı et al. (2000). Along the thrust faults TF-6 to 9, the pre-Neogene basement units thrust over Altıntaş and Hancılı formations and the thrust contacts were locally covered by the Deyim Formation, which indicates post-MN-5 and pre-MN-17 development of these faults (see also Kaymakcı et al. 2000).

The Kargın anticline and the syncline (KA and KS, 4 and 5 in Figure 5b) are parallel to the KHRF. The strike of beds of the Dizilitaşlar and Çandır formations are parallel to each other on either limbs of the anticline. Unfolding of the basement units according to the dip of the Çandır Formation indicates that this structure has two episodes of coaxial folding (Figure I Ia-c). The earlier phase developed prior to the deposition of the Çandır Formation in the Burdigalian to Serravallian. This relationship indicates presence of a compressional deformation prior to Burdigalian.

In the Hancılı Basin, two sets of folds have developed (Figure 5) in the Neogene units. One set is oriented approximately NW-SE, parallel to the thrust faults and the longer axis of the three depressions of the Hancılı Basin (Figure 5a), which indicates that these folds were developed due to the activity of the thrust faults (tl folds in Figure I 1d). The other set of the folds is developed in the Hasayaz Depression and the folds are oriented NE-SW, parallel to the folds that developed within the Upper Miocene units in the western margin of the Çankırı Basin. The folds, which developed within the Çandır Formation in the western margin of the Çankırı Basin are oriented NNE-SSW and within the same area, the folds within the Upper Miocene units are oriented NE-SW. This relationship implies sequential anticlockwise rotation of the folds within the sinistral strike-slip Eldivan Fault Zone (Figure IIe-f) in combination with the activity of a restraining bend (Figure I 1d). This relation gave way to 50° of angular difference between the folds that developed within the Middle Miocene Çandır and Upper Miocene Süleymanlı Formations (Figure I 1d-f). Sanderson and Cox (1984) have discussed how the structures within a convergent strike-slip fault zones tend to become parallel to the principal displacement zone. Therefore, the observed 50° of angular difference between the folds developed within the Çandır Formation and the Upper Miocene units can not be attributed to the rotation alone but may reflect the combination of rotation about vertical axes and re-organization of fold axial trends due to local stress perturbation exerted by the restraining bend of the EFZ (Figure I 1d-f).

In the north-western part of the Çankırı Basin, the folds developed within the Upper Miocene units, namely the Tuğlu, Süleymanlı and Bozkır formations (Figure 6). Here, the orientation of the major folds, which include the Süleymanlı Anticline (SUA) and Syncline (SS), the Topuzsaray Anticline (TA), the Yoruk Syncline (YS), and the Kıvçak folds (KF) (Figure 6), change, their orientation gradually from about E-W to NE-SW. The tightness of the folds becomes greater in the NW than in the south (Ovacık Monocline and SUA). This relationship indicates the response of the basin in-fill within the wedge shaped area defined by the EFZ in the west, MRF and ARF in the north-west and the Kırşehir Block in the south. As displacement occurred along the EFZ, MRF and ARF, the basin in-fill tends to rotate anticlockwise similar to the mechanism proposed for the folds developed within the Çandır and Süleymanlı formations in the western margin of the Çankırı Basin (Figure I 1d-g). This is further discussed later.

Eastern Area

The main reverse faults in the eastern part of the Çankırı Basin are the Halaçlı Fault (HTF, Figure 9), the Sagpazar Reverse Fault (SRF, Figure 9), the Karaçay Reverse Fault (KARF, Figure 8) and the Guvendik Thrust Fault (GTF, Figure 8). Among these, the Guvendik Thrust Fault (GTF) has developed between the underlying Guvendik Formation and overlying NAOM (Figure 3), indicating its post mid-Oligocene activity. There is no Neogene unit overlying the GTF. Therefore, its latest activity could not be precisely constrained. The GTF is displaced sinistrally by a NE-SW trending fault.

The Halaçlı Fault (HTF) is observed in the east of the central part of the Çankırı Basin

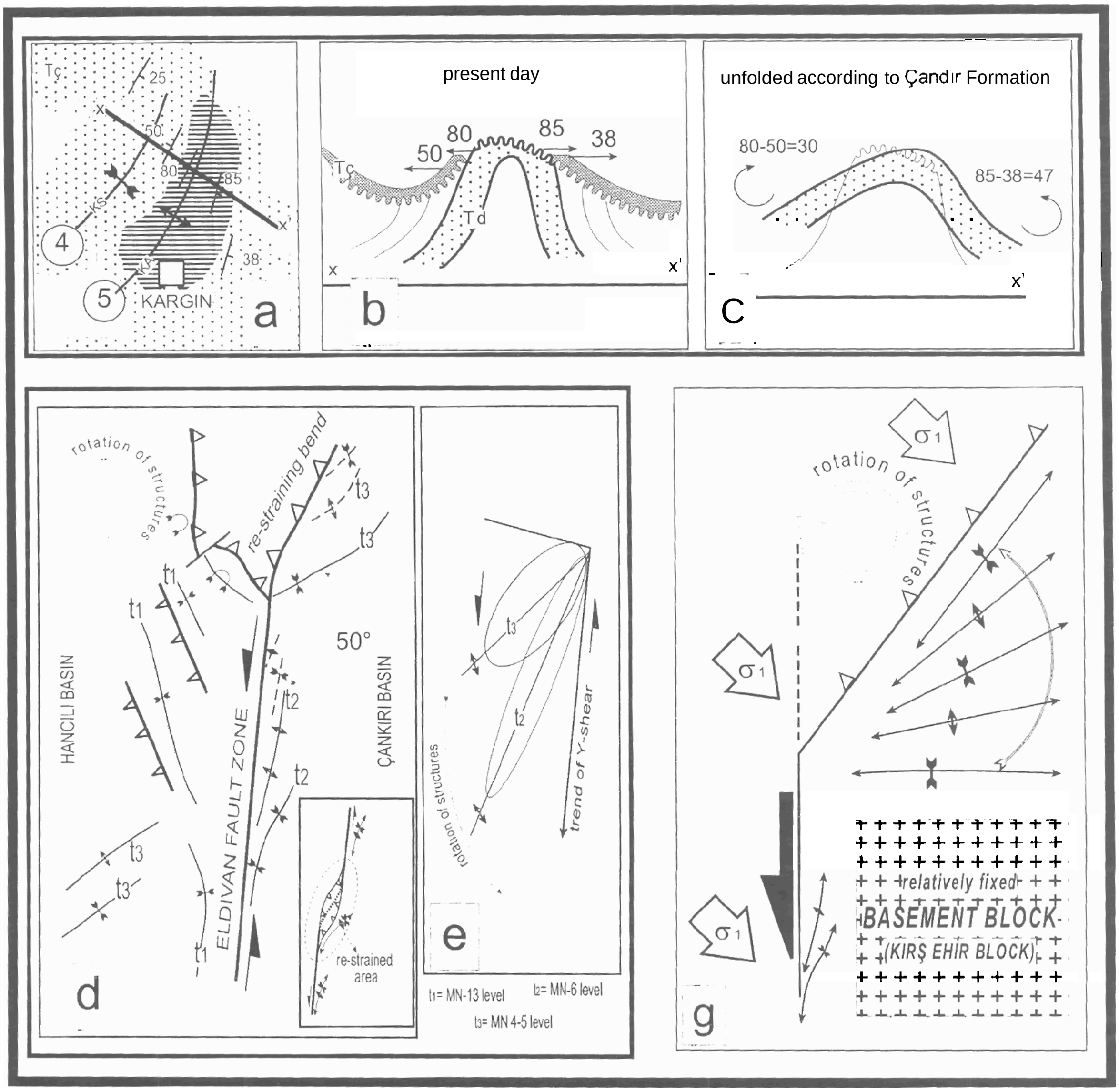

Figure 11. a) Simplified geological map around the Kargın village (see Figure 5b), b) present day cross-section, c) unfolded Early Tertiary units (according to the dips of the Çandır Formation) still preserve an asymmetric fold. d-e) Possible mechanisms suggested for the development of the folds in the Çandır, Süleymanlı and Bozkır formations. d) The folds have a constant angle with the boundary fault and the discrepancy between trend of the folds is due to the bending of the boundary fault as it forms a restraining bend (mechanism after Biddle and Christie-Blick 1985). e) the trend of the folds is related to their age of formation in a simple shear setting. The folds are first formed in NE-SW attitude, then they are rotated counter-clockwise so that the older folds gradually became NNE-SSW in orientation, f) block diagram depicting the relation between the Eldivan Fault Zone (EFZ) and the folds developed in the western margin of the Çankırı Basin (see Figure 5). g) model proposed for the formation of the folds in the north-western part of the Çankırı Basin (see text for the explanation). h) angular relationships between fault

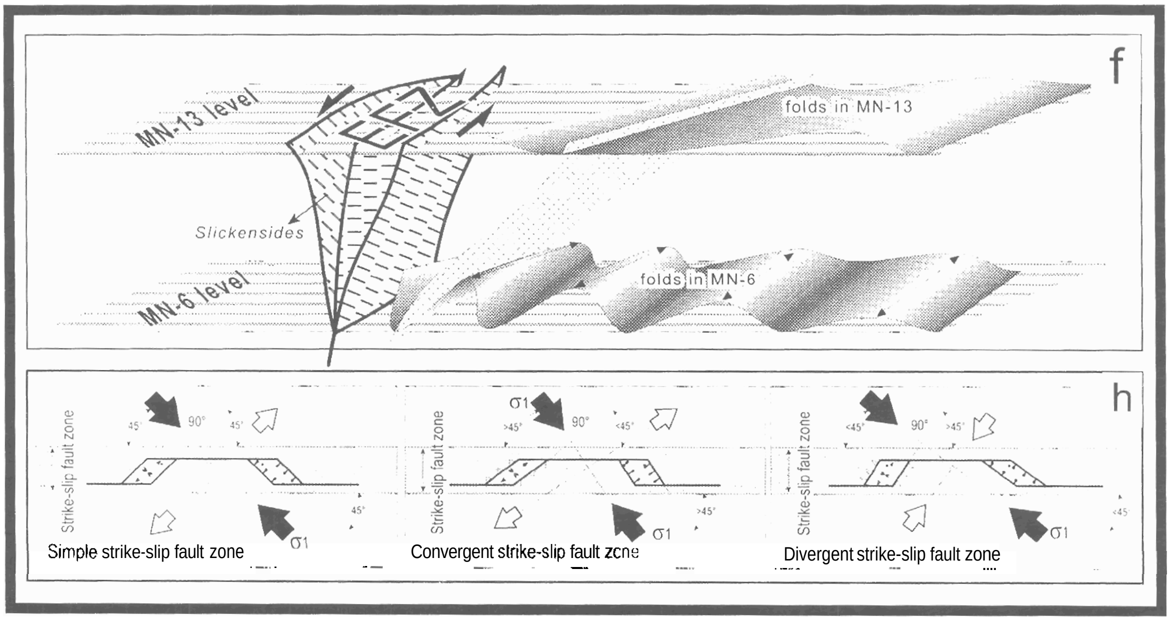

Figure 11 (continued). zone, principal stresses and the structures developed within a simple, convergent and divergent strike-slip fault zones (modified from Sanderson and Cox 1984). Along strike-slip faults, three of the angular relationships presented in this figure might be developed due to local stress perturbations as the fault zone change its strike.

(Figure 9). Along the HTF, the Guvendik Formation of Oligocene age is thrust over the Çandır Formation (Figure 12a), which indicates its Burdigalian to Serravallian development.

The Sagpazar Reverse Fault (SRF) is observed between the Guvendik Formation and the Upper Miocene units (Figure 9). Along the SRF, basement units thrusted over the Süleymanlı Formation in the northern part of the fault (see location 2 in Figures 9 and 12b). In the south, it becomes a blind fault (location 3 in Figures 9 and 12b). Parallel to the SRF, the Tuglu Formation is folded along the Sagpazar Anticline (TA in Figure 9). The angular unconformable relationship between the Lower Tertiary units and the Tuglu Formation and the degree of tightness of the Sagpazar Anticline (SA) within the Tuğlu and Lower Tertiary units indicates two different episodes of compressional deformation. The strike of the Tuglu Fomation and of the Lower Tertiary units are parallel along the SA (see Figure 9), which indicates co-axial deformation, prior to and after the deposition of the Tuglu Formation in Tortonian.

The Karaçay Reverse Fault (KARF) is developed within the Lower Tertiary units (Figure 8). In the north the KARF, it is covered by the Tuglu Formation and by the Çandır Formation in the central part (locality 9 and 11 in Figures 8 and 12c), which indicates its pre- Burdigalian to Serravallian development.

A number of NE-SW (N40°-50°E, Figure 8b) trending faults displace the pre-Neogene units and the Tuglu, Süleymanlı and Bozkır formations in other parts of the Çankırı Basin (Figures 8 and 9). In the field, these faults are characterized by wide zones of distributed deformation dominated by a number of mezoscopic faults with high angles of dip (>60°), and oblique slickenlines with a dextral strike-slip component and a component of normal movement (transtensional faults) having pitches ranging between 20° to 60° (see Kaymakcı et al., 2000). These faults are obscured in Guvendik, Tuglu and Bozkır formations because of their gypsum content, however morphological expressions oi and

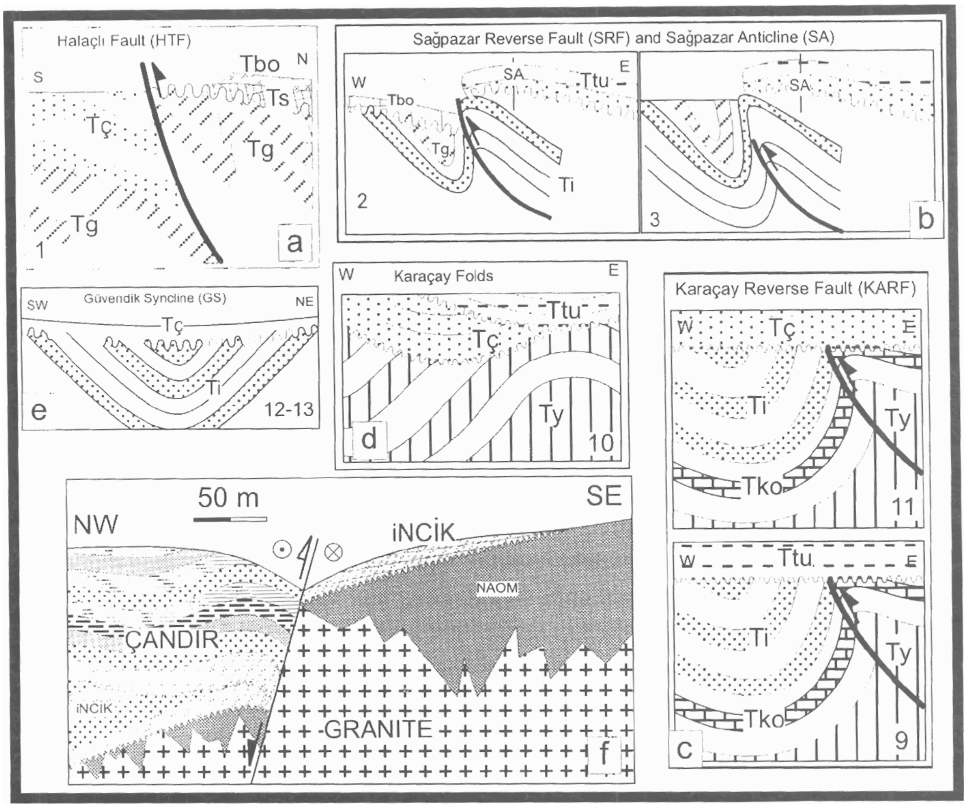

Figure 12. Schematic illustration of various tectonic relationships between different Neogene units: a) between Guvendik formation (Tg), Çandır Formation (Tç), Süleymanlı (Ts) and Bozkır (Tbo) formations along the Halaçlı Fault (HTF) (see location 1 in Figure 9). b) between Incik (Ti), Güvendik (Tg), Süleymanlı, and Tuglu (Ttu) formations along the Sagpazar Reverse Fault (SRF) and Sagpazar Anticline (SA) (note emergent and blind nature of the SRF, see locations 2 and 3, in Figure 9). c) tectonic and stratigraphic relationships of the Early Tertiary units (Yoncalı-Ty, Kocaçay-Tko, İncik, and Guvendik formations) and Çandır and Tuğlu formations along the KARF (see locations 9 and 11 in Figures 8 and 9). d) stratigraphic relationships between Yoncalı (Ty), Çandır and Tuglu formations along one of the Karaçay Folds (see location 10 in Figure 8). e) unconformable relationship between İncik and Çandır formations in locations 12 and 13 in Figure 8. f) Cross-section depicting an inverted normal fault near Daghalilince village (see Figure 6 for its location). Note sinistral strike-slip component of the fault and inverse dragging and normal separation that is still preserved and also to the on-lap unconformities between the basement and the İncik Formation. View to N. The down going arrow indicates normal faulting and up going arrow indicates reverse faulting due to inversion.

juxtapositions along these faults are partly preserved.

The Karaçay folds are a number of NNE-SSW oriented structures that developed within the Tuğlu Formation (Figures 8 and 12d), which indicates their post-MN 10-12 development during which σ1 was oriented approximately WNW-ESE direction.

In the localities 5, 6, 7, and 8 in Figures 8 and 9. the İncik Formation has a circular outline. Around the location 7 in Figure 9, the dips of ihe Tuğlu Formation display a radial pattern. In the localities 5, 6, 7 and 8, the Tuğlu and incik formations have an angular unconformable relationship. In the central parts of these areas, the incik Formation is intensely deformed and folded and the gypsum lithologies within the unit are flow banded so that the Incik Formation has partially lost its internal structures while overlying Tuğlu Formation is less deformed. This relationship indicates that diapirism took place during and after the deposition of the Tuğlu Formation of Tortonian age (MN 10-12).

Central Areas

The central part of the Çankırı Basin is characterized by on-lap patterns of the Lower Tertiary and Neogene units onto the Kırşehir Block (which is represented, in this area, by the Sulakyurt Granitoids and the Upper Cretaceous NAOM and the Yaylaçayı Formation, Figure 3) and generally NNE-SSW to NNW-SSE and NE-SW trending faults with linear to curvilinear trace (see Figure 7).

The NE-SW to NNW-SSE trending faults divide the central part of the Çankırı Basin into horst-graben complexes (Figure 7, see also Kaymakçı 2000). These faults are covered by the Süleymanlı and Bozkır formations and locally truncated by ENE-WSW trending faults (Figure 7). The mesoscopic faults that are parallel to the NNE-SSW trending major faults have very high dips and the slickenlines on these faults indicate that they are normal oblique-slip faults (see also Kaymakçı 2000, Kaymakçı et al. 2001b). In the locality indicated by 1 in Figure 7, the granites are juxtaposed with the Incik and Çandır formations along an approximately NNE-SSW striking fault. At this locality, the displacement of the base of the Çandır Formation on the hanging- and the foot-wall block is about 250 m which is the minimum vertical (normal) displacement along the fault.

In the locality 2 (Figure 7), the NAOM, Incik and Çandır formations have been juxtaposed. In this locality, within the fault zone, the Çandır Formation is inversely drag folded (Figure 12f), which indicates reverse faulting, although, nor-' mal faulting is obvious approximately 1 km south of this location along strike. In addition, overprinting slickenlines observed on the mesoscopic faults, in this area, indicate two phases of fault movement. The first movement is associated with a normal sense of movement and second movement indicates reverse faulting with a sinistral component (Figure 12f, see also Kaymakçı et al. 2001b). Similar relationships are also observed in localities 3 and 4 in Figure 7.

DISCUSSION OF THE TECTONIC AND STRATIGRAPHICAL DEVELOPMENT OF THE ÇANKIRI AND THE HANCILI BASINS DURING THE NEOGENE

Çankırı Basin

In Kaymakçı et al. (2000 and 2001b) it is argued that the pre-Burdigalian tectonic evolution of the Çankırı Basin is characterized by a compressional deformation in which the orientation of σ1 changes from WSW-ENE to NNW-SSE in the northwestern margin of the Çankırı Basin. During this period, the İncik Formation of Middle Eocene to Middle Oligocene age (Figure 3) and Kılçak Formation of Aquitanian age. The latest product of this compressional regime were deposited coeval with thrusting and transpressional faulting (Figures 13 and 14, Kaymakçı 2000). In the beginning of the Burdigalian, the region was dominated by an oblique extensional deformation characterized by a sub horizontal 03 and an oblique o l during which the Çandır Formation was deposited in the Çankırı Basin and Altıntaş and Hancılı formations were deposited in the Hancılı Basin.

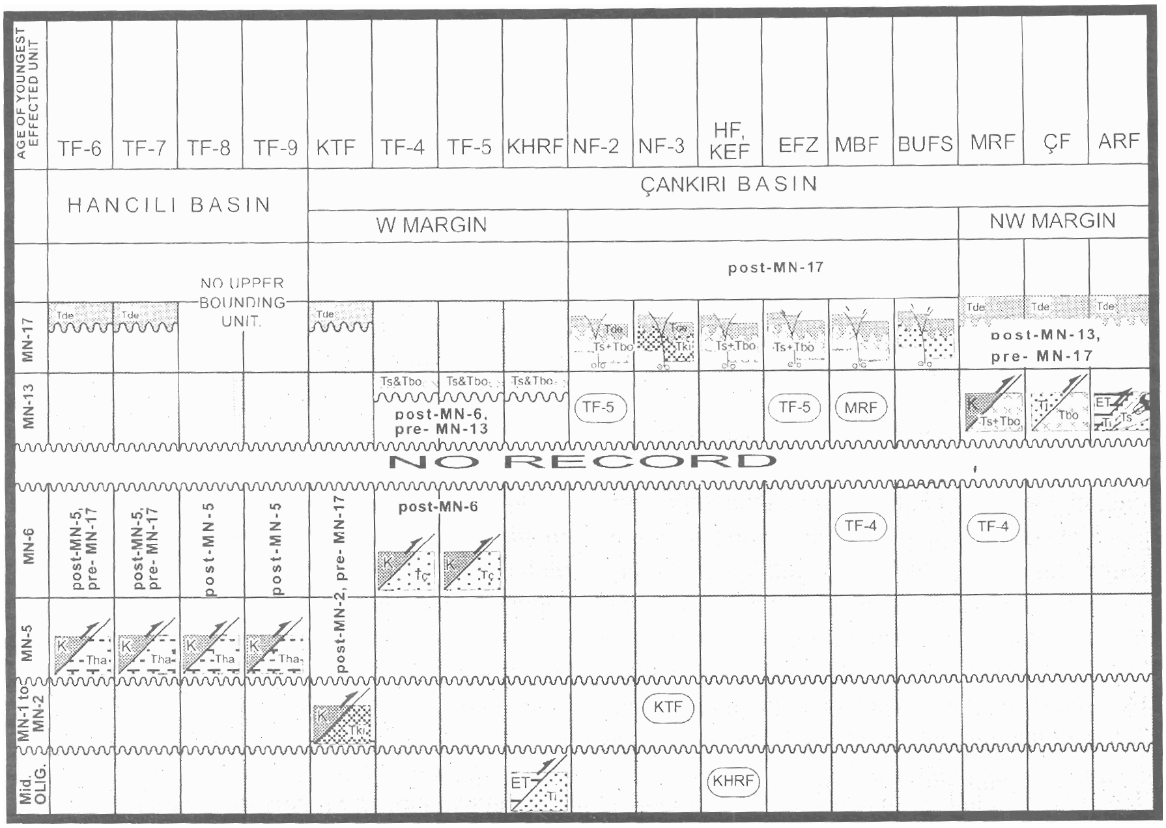

Figure 13. Summary of the temporal relationships between various structures developed in the western and north-western part of the Çankırı Basin during the Neogene (see Figure 3 for the abbreviations of the units). The faults indicated in ellipses are displaced by the faults in the top row. The times in the first column indicates the age of the underlying unit which together with the covering unit brackets the age of related faults. KHRF: Kazmaca-Hamzalı Reverse Fault, HF: Hamzalı Faults, KEF: Kargın-Elmapınar Fault, EFZ: Eldivan Fault Zone, MBF: Merzi Badigin Faults, BUFS: Bürtü Fault Set, MRF: Merzi Reverse Fault, ÇF: Çavuşköy Fault, ARF: Ayseki Reverse Fault. K: Late Cretaceous to Paleocene, ET: Early Tertiary units, Ti: İncik Formation, Tki: Kılçak Formation, Tha: Hancılı Formation, Tç: Çandır Formation, Ts: Süleymanlı Formation, Tbo: Bozkır Formation, Tde: Deyim Formation. The age of the ARF is constrained using overturned folding (last column). Note difference between the faults in the western (strike-slip) and NW margin (reverse faults) of the Çankırı Basin.

In Tortonian to Recent (possibly post-MN 6), the extensional regime was replaced by an approximately NW-SE oriented compression (see Figures 13 and 14). During this phase, $\sigma 1$ was oriented NW-SE while 02 was sub vertical and indicates a regional transcurrent tectonics (Figures 13 and 14).

Considering the characteristics of the major structures summarized in Figures 13 and 14, it can be concluded that the compressional regime that commenced in the Tortonian is characterized by a regional transcurrent tectonics. Pre-existing thrust faults in the western margin of the Çankırı Basin (WMÇB) were reactivated as transpressional faults (includes Eldivan fault

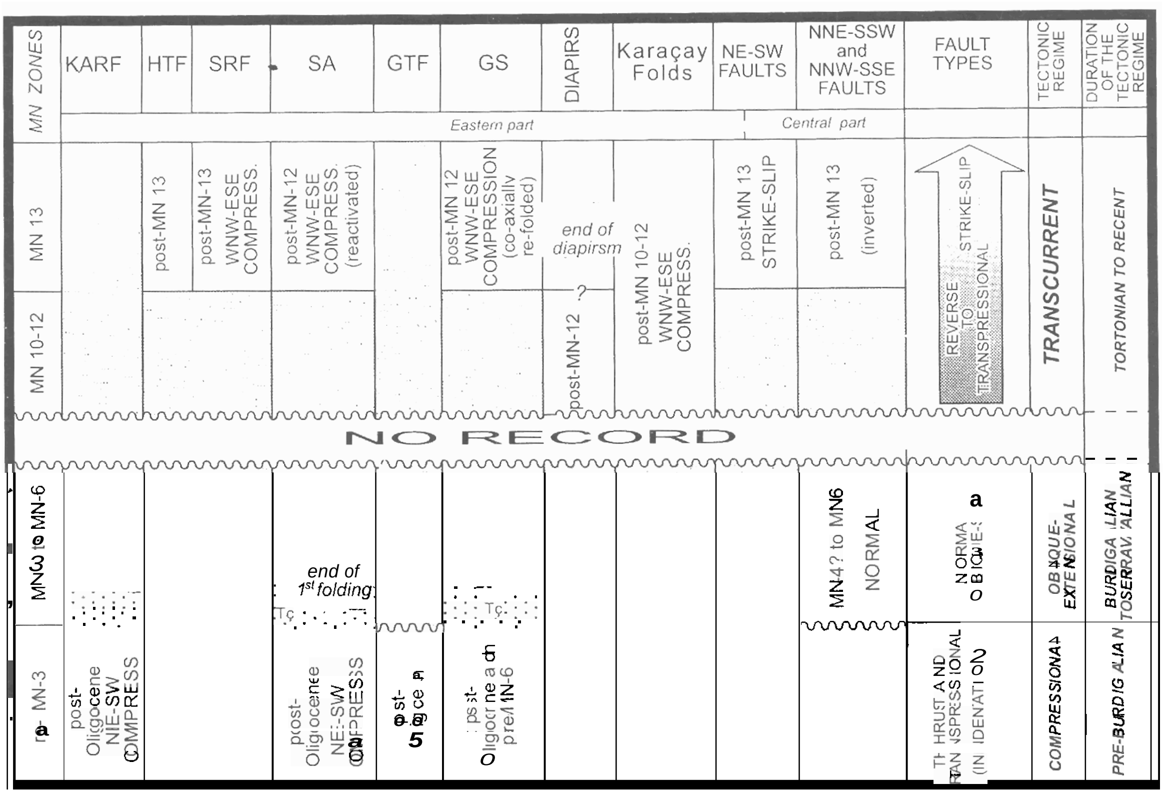

Figure 14. Temporal relationships between various structures developed in the eastern and central parts of the Çankırı Basin (see Figure 3 for the abbreviations of the units). Thrusting (pre-Burdigalian) and extensional regimes (Burdigalian to Serravallian) are based on the information summarized in Figure 13 and discussed in Kaymakci (2000). KARF: Karaçay Reverse fault, HTF: Halaçlı Fault, SRF: Sagpazar Reverse Fault, KRF: SA: Sagpazar Anticline, GTF: Guvendik Thrust Fault, GS: Guvendik Syncline.

Zone), which makes approximately 75° with the σ1 (Figure 15e). The pre-existing thrust faults and the reverse faults in the rim of the Çankırı Basin (possible western continuations of the ÇF, MRF, ARF) gradually converted into strike-slip faults as they were transported southwards and wrapped around the Kırşehir Block and rotated anticlockwise (Figures 11 and 15a-c). In this regime, the western boundary of the Çankırı Basin was a transpressive sinistral strike-slip fault zone (Eldivan Fault Zone-EFZ) while the northwestern margin was dominated by reverse faults (Figure 15d). The conjugate to the EFZ are NE-SW trending faults that displaced the basin in-fill, the basement (Kırşehir Block) and the western margin of the Çankırı Basin dextrally (Figure 15a-c). In addition, the normal faults that developed in the previous extensional regime, in the western margin and central part of the basin, were inverted as transpressional faults (see Figure 12f and Kaymakçı 2000).

The Tuğlu and Süleymanlı formations are successive units in the Çankırı Basin. However, they have an angular unconformable relationship. The Tuğlu Formation is intensely deformed while the Süleymanlı Formation is less deformed. In addition, the intensity of deformation in the Tuğlu Formation is higher than the underlying Çandır and overlying Süleymanlı and Bozkır formations. Considering the gypsum content of the Tuğlu Formation, it is proposed that the deformation of the Tuğlu Formation is exag-

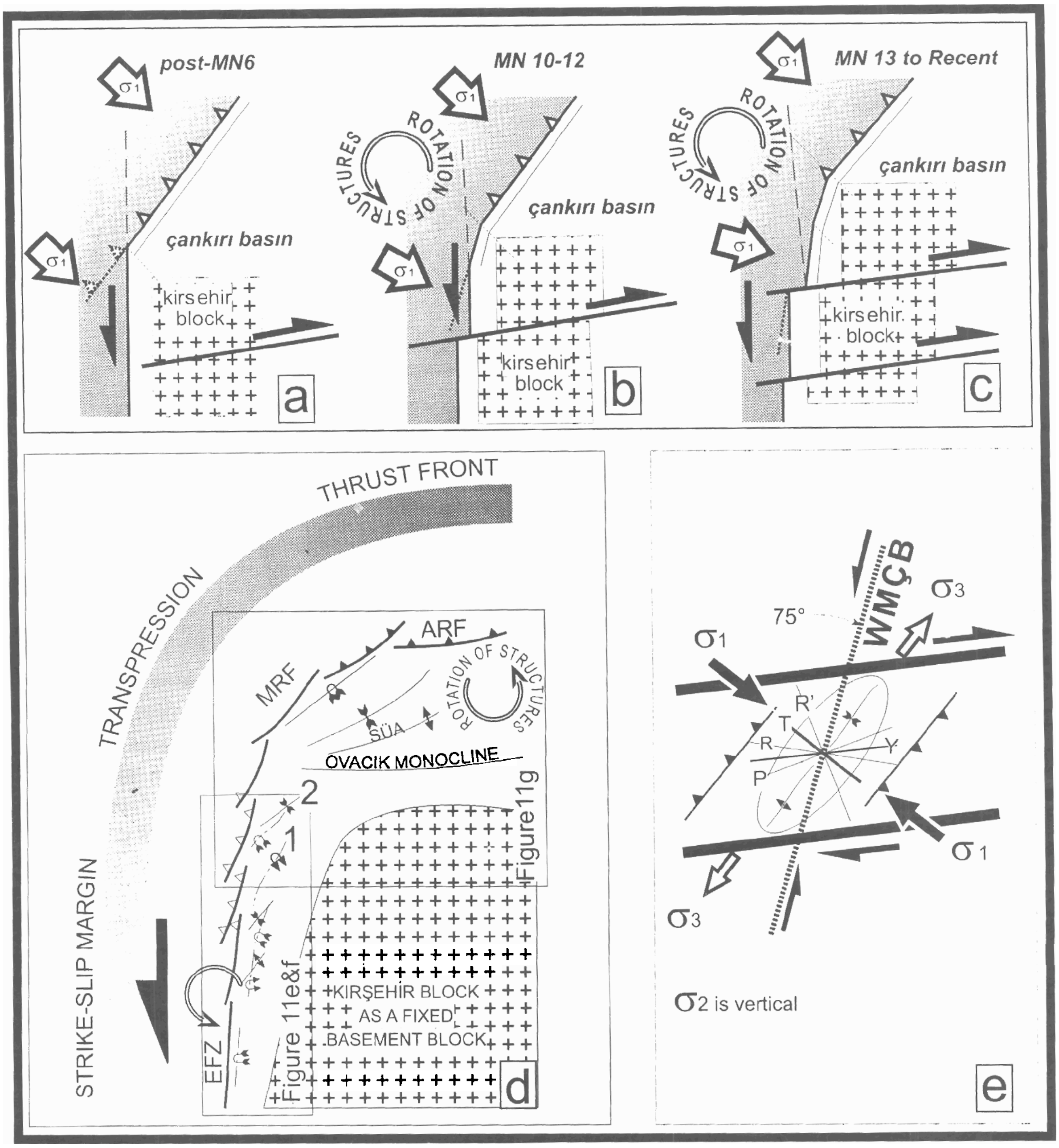

Figure **15.** a-c) Model proposed for the sequential development of the reverse faults in the western and north-western parts of the Çankırı Basin during the Neogene. As the northern rim of the basin is transported southwards it wraps around the relatively fixed Kırşehir Block so that the reverse faults in the north-western margin are rotated anticlockwise and become transpressional faults. Contemporaneously, the rim of the Çankırı Basin and the Kırşehir Block are displaced dextrally by the NE-SW faults (i.e. Sungurlu Fault Zone, Sivritepe Fault Zone, Yağbasan-Faraşlı Fault Zones, see Figures 2 and 5) as the conjugate of the Eldivan Fault Zone. d) summary of the model for the development of the structures in the western and north-western parts of the Çankırı Basin (see text for the explanation).

gerated due to salt tectonics. That is, the deformation was preferentially located in the Tuğlu Formation because of the salt. On the other hand, the Bozkır Formation also includes gypsum (coarser grained than the Tuglu Formation and makes up approximately 25% of its total volume) and this relation invalidates the foregoing argument. Therefore, the gradual decrease in the intensity of the deformation upwards from the Tuglu to the Bozkır formations is attributed to the syn-tectonic sedimentation of these gypsum-bearing formations, which indicates that compressional deformation commenced during the deposition of the Tuglu Formation in Tortonian.
The faults that are oriented generally NE-SW, and post-dating the Late Pliocene (Gelasian, MN 17), are the latest products of the latest compressional deformation. There is no direct evidence for any present activity on them. However, deep incision of gullies (Koçyiğit et al. 1995) and the presence of unpaired terraces along most of the streams and seismic activity in nearby areas (!996 Mecitozu earthquake swarm and 2000 Orta/Çankırı earthquake, Taymaz and Tan 2001, see Figure 17 for its location) imply that they are a part of the presently active system.

Hancılı Basin

The Hancılı and Altıntaş formations represent lateral facies variations in the Hancılı Basin. The Altıntaş Formation is thicker in the south-western parts of each of the three depressions of the Hancılı Basin, namely the Hasayaz, Şemsettin and Demirtaş depressions (Figure 16). Presence of a fining and thinning upward sequence indicates retreat of the source area, which is a characteristic for extensional settings (see Mial 1996). The presence of thicker tuffaceuos layers in the western parts of the basin implies the presence of volcanic centers in the west, which are probably associated with the Middle to Upper Miocene (21.8 Ma to Recent) activity of the Galatean Volcanic Province (GVP, Toprak et al. 1996). Because the Altıntaş and Hancılı formations are thicker in the SW margins of the Hancılı Basin and thinner (the Altıntaş Formation may be completely missing, as see in Figures 5 and 16) in the NE margins and onlap on the horst-like blocks indicate asymmetric extensional faulting (Leeder et al. 1988, see Gabrielsen et al. 1995 for the marine analogs) during the development of the Hancılı Basin. The deeper parts of the basins are interpreted to lie in the south-western parts of each depression (see Figures 5,16b and e). Considering over-printing slickenlines on the faults (TF 6-9, Figure 5) defining the boundaries of the three depressions within the Hancılı Basin (discussed in Kaymakçı et al. 2000) in combination with the above-mentioned information indicate that the Altıntaş and Hancılı formations were deposited in an extensional setting possibly characterized by half grabens associated with oblique-slip normal faults (see Figure 16b and e) that are striking generally NW-SE (present day orientations) (see discussion above about the western margin of the Çankırı Basin).

Tectonic Development of the Hancılı Basin and of the Western Margin of the Çankırı Basin

In the pre-Neogene (most likely pre-Burdigalian?) due to the northwards drift of the Kırşehir Block and indentation of its promontories into the Sakarya Continent (see Kaymakçı 2000 and Kaymakçı et al. 2001a), the western margin of the Çankırı Basin experienced a compressional deformation that is characterized by thrust and reverse faults with strong sinistral lateral components (Figure 16a and d). The indentation process continued until about the deposition of the Kılçak Formation (discussed previously) in the Aquitanian. During this period, in addition to other pre-Lower Tertiary units, the Incik, Guvendik (Figure 3) and Kılçak formations were deposited in the Çankırı Basin as the latest products of the collisional process.

By the beginning of the Burdigalian, the compressional deformation was replaced by an extensional deformation (see Kaymakçı et al. 1998 and 2000) and resulted in the development of the Hancılı Basin and deposition of the Altıntaş and Hancılı formations (in MN 3-4 to MN

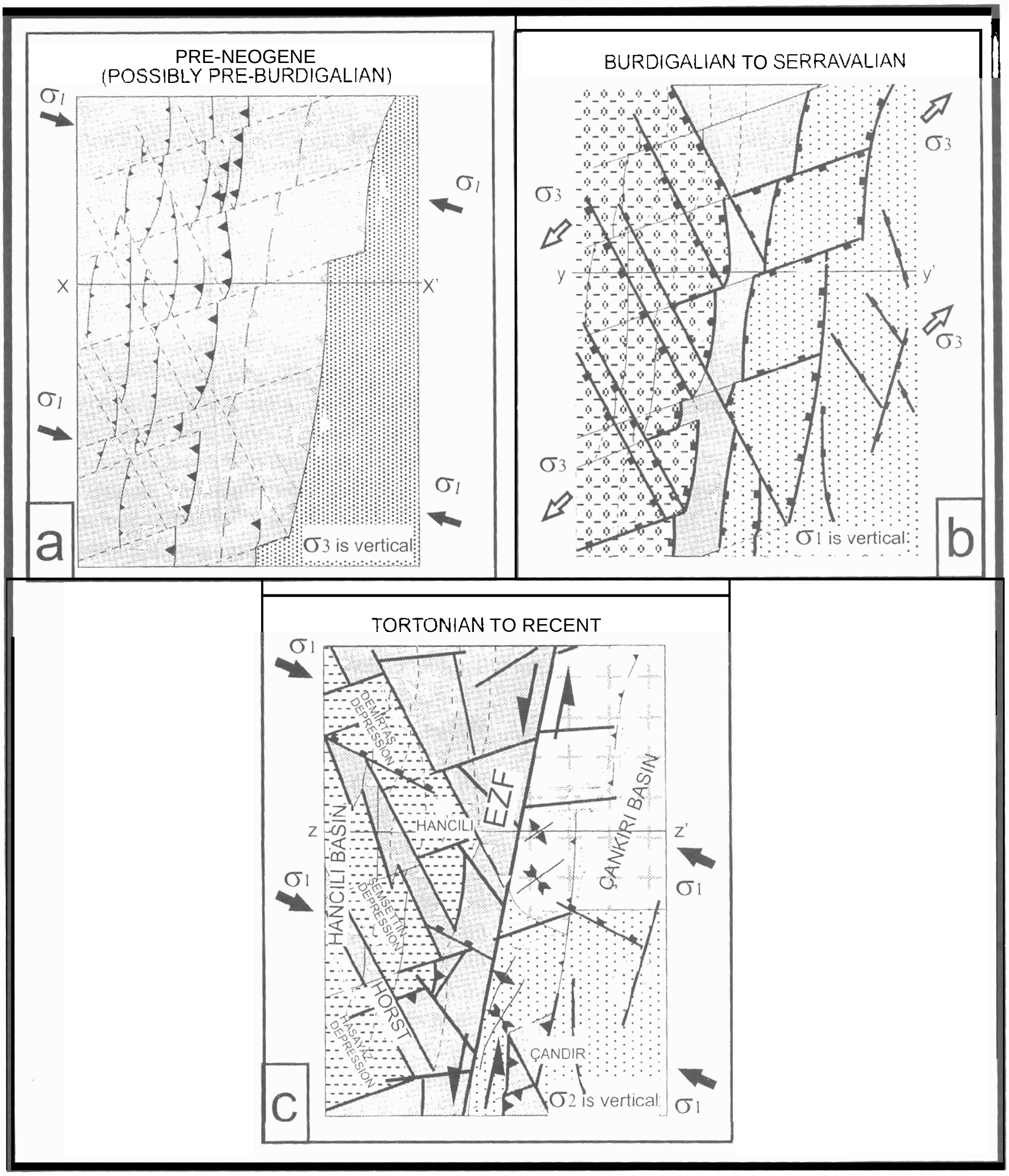

Figure 16. a-c) Conceptual diagrams illustrating tectonic evolution of the western parts of the Çankırı Basin. d-f) schematic E-W cross-sections, a and d) phase of thrusting in pre-Neogene. (b and e) normal faulting during an extensional phase of deformation in Early to Middle Miocene (note reactivation of pre-existing tear faults into normal faults in this period). Note also that deposition in the Hancılı Basin and the Çankırı Basin is isolated from each other. (c and f) phase of Neogene compression that commenced in Tortonian. Note that most of the normal faults are inverted into reverse faults and they have strike-slip components.

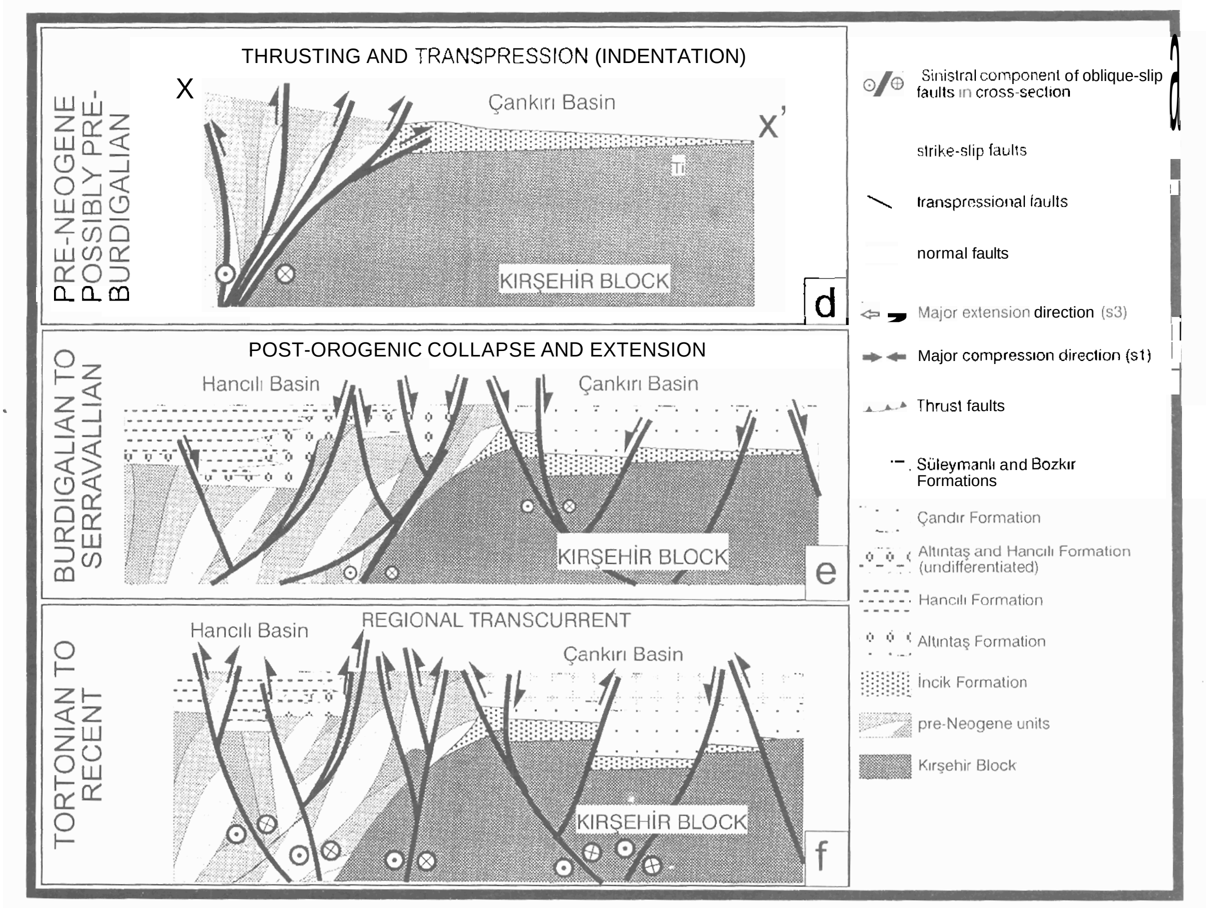

Figure 16 (continued)

4-5). These two units were not exposed in the Çankırı Basin. Therefore, it is inferred that during the extensional deformation period, the Hancılı and Çankırı Basins were isolated from each other. They evolved. stratigraphically, independently under the same tectonic regime. Palaeostress inversion studies (Kaymakçı et al. 1998, 2000, 2001a) indicate that the extension took place under tri-axial strain conditions, which indicates that most of the normal faults developed in this period had oblique components (Figure 16b and e) The pre-existing faults (TF 4 and 5) were reactivated as normal faults with a sinistral strike-slip component and the faults along the western margin of Çankırı Basin maintained their pre-existing sinistral component (Figure 16b and e).

The extensional deformation was replaced by a new phase of compressional deformation characterized by a regional transcurrent tectonics in MN-10-12 (Tortonian) during which the Upper Miocene units were deposited (Figure 16c and f). As stated earlier, intense deformation of the Tuğlu Formation indicates that its deposition took place coeval with the transcurrent tectonics. During this period the western margin of the Çankırı Basin was deformed with a component of anticlockwise rotation and the pre-existing faults were reactivated (Figures 15, 16c and f). The faults along the western margin have been reactivated into sinistral transpressional faults as the northern part of the rim of the Çankırı Basin reactivated into thrust faults as explained in Figures 12 and 16c and f. The normal faults in the Hancılı Basin and the normal faults in the central part of the Çankırı Basin (Figure 7) were inverted into compressional faults (discussed previously, see also Kaymakçı et al. 2001a). As these faults moved, the Hancılı Basin acquired its present-day geometry and became divided into 3 sub depressions. During this period, the Süleymanlı and Bozkır formations were deposited in the Çankırı Basin and they have been deformed by transcurrent movements associated with anticlockwise rotations along the western margin and by thrusting in the northern margin (Figure 15).

DISCUSSION OF THE REGIONAL IMPLICATIONS

The beginning of the extensional tectonic regime in the Çankırı Basin is in Burdigalian (20.5 Ma). Seyitoglu et al. (1992) proposed that beginning of the extensional regime in western Anatolia is Early Miocene. The timing of the extensional deformation phase discussed for the Çankırı Basin fits with the overall timing of extension in the west Anatolia. Therefore, it can be concluded that the eastern continuation of the Early Miocene extensional regime in western Anatolia can be extended at least up to the Çankırı Basin (see also Seyitoglu et al. 1997). in the Çankırı Basin, however, extensional regime continued until the end of the Serravallian and it was replaced by a compressional period afterwards. This is in agreement with the Late Miocene to Early Pliocene compressional period that separates the west Anatolian extension into two different episodes in the Early to Middle Miocene and in the Late Pliocene to Recent (Koçyiğit et al. 1999).

The Early Miocene commencement age of the extensional regime approximately corresponds to the collapse of the Aegean orogenic wedge (see Lips 1998, Wallcot 1998). One of the causes of the orogenic collapse in the Aegean was the decrease in the convergence rates of Eurasia and Africa since 20 Ma, in combination with the detachment of the subducted slab of the Eastern Mediterranean oceanic crust below Eurasia (Lips 1998, Wallcot 1998). Therefore, we propose that, the Middle Miocene extensional regime in the Çankırı Basin, which replaces the pre-MN-3 (i.e. pre-Burdigalian) compressional regime that is exerted by the collision of the Kırşehir Block and the Sakarya Continent in the deformation phase 2 (see Kaymakçı et al. 2000 and 2001a, 2001b), indicates a destabilization and resultant post-orogenic collapse, and was caused by post-20 Ma decrease in the convergence rates of the Eurasia and Africa, at least until the latest compressional regime commenced in the Tortonian. Further convergence of the Arabian Plate along the Bitlis-Zagros Suture led to the escape of the Anatolian Block along the dextral North Anatolian and sinistral East Anatolian Fault Zones (NAFZ and EFZ, Figures 1c and 17) (Şengor and Yilmaz 1981, Şengor et al. 1985). It is the NAFZ from which a number of splay faults, convex to the north, bifurcate (Figure 17a) and transfer transcurrent deformation into the continental interiors of the Anatolian Block (Barka and Hancock 1984). Two of these splay faults are the Sungurlu Fault Zone (SFMS), which is a sub-strand of the Ezinepazarı-Sungurlu Splays and the Kızılırmak Fault Zone (KFZ), which is the western continuation of the Laçin Fault Zone (Figures I b and 17a). Presently, these faults have a dextral strike-slip sense of movement while the NNE-SSW striking Eldivan Fault Zone (EFZ, western boundary fault of the Çankırı Basin, WMÇB in Figure 15) has a sinistral strike-slip sense of movement. Its orientation and sense of movement indicates that EFZ is the r'-shear of the NAFZ (Figures 17b and 15e).

The orientations of $\sigma1$, as discussed in Kaymakçı et al (2001a) are in good agreement with the axes obtained from two seismic fault plane solutions (Figure 17a) for the North Anatolian Fault Zone. This relation indicates that the latest compressional deformation phase (phase 4) is the same system, which gave way to the regional transcurrent tectonic regime that commenced in Tortonian and is still active. All of the active faults, including the NAFZ, its splays in the Çankırı Basin, EFZ, and other structures smaller scale faults can be explained by a Riedel pattern of deformation (Figure 15e).

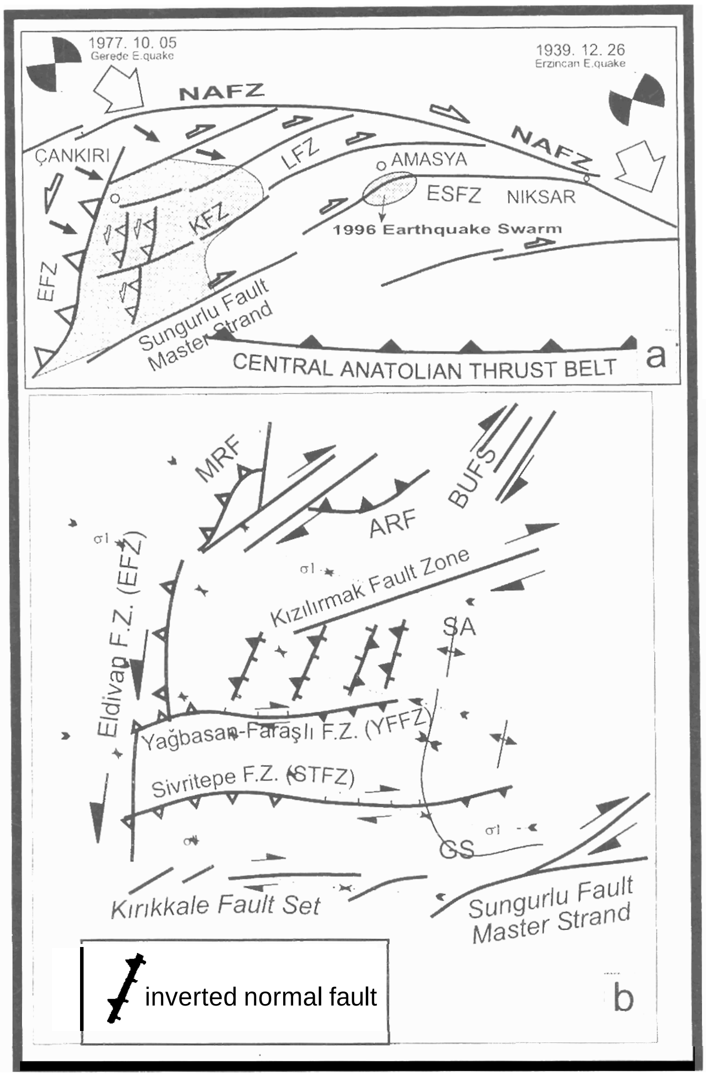

Figure 17. Simplified tectonic map of the active faults in the north central Turkey. ESFZ: Ezinepazarı-Sungurlu Fault Zone, LFZ: Laçin Fault Zone, NAFZ: North Anatolian Fault Zone. Large arrows are the horizontal components of the compression directions obtained fault plane solutions of the Gerede and Erzincan earthquakes (partly modified after Barka and Hancock 1984, Õzçelik 1994, Kaymakci and Koçyiğit 1995, fault plane solutions are after Jackson and McKenzie 1983). b) simplified structural map of the Çankırı Basin area. ARF: Ayseki Reverse Fault, BUFS: Bürtü Fault Set, GS: Guvendik Syncline, MRF: Merzi Reverse Fault. Note transpressional and transtensional segments of the STFZ and YFFZ as the faults change their strike.

Therefore, it can be concluded that the latest compressional deformation recognized in the Çankırı Basin is not a local phenomenon but it fits well into the overall regional trancsurrent tectonics in the eastern Mediterranean area that resulted in the development of the NAFZ (Mckenzie 1972, Şengor and Yılmaz 1981, Şengor et al. 1985. Barka 1992).

CONCLUSIONS

Based on the information presented here following conclusions are derived.

I. The activity of the structures developed in the Çankırı Basin are temporarily and spatially constrained using stratigraphical relationships and rodent faunas.

II. The kinematic characteristics of the structures were determined and sequences of fault movements were ordered.

III. The relationships between fault movements and stratigraphical units were discussed and It is concluded that:

- The Kılçak Formation was deposited during the latest activity of pre-Neogene copressional regime. Therefore, collisional regime and indentation of the Kırşehir Block to the Sakarya Continent, which commenced prior to Neogene is ended after the Kılçak Formation was deposited.

IV. Two different tectonic regimes were recognized in the Neogene following pre-Neogene compressional regime.

- The earlier regime commenced in the Burdigalian and is characterized by extensional deformation in which the Altıntaş, Hancılı, and Çandır formations were deposited.
- The second regime is characterized by regional transcurrent tectonics and commenced in Tortonian (ca. 9.7 Ma). In this phase, the Tuglu, Süleymanlı, Bozkır and Deyim formations were deposited.

V. In the latest tectonic regime, early-formed structures, both in the Hancılı and in the Çankırı basins were inverted into transpressive faults.

VI. The latest tectonic regime in the Çankırı Basin is kinematically related to the same regime that resulted in the development of the North Anatolian Fault Zone and which is still active.

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