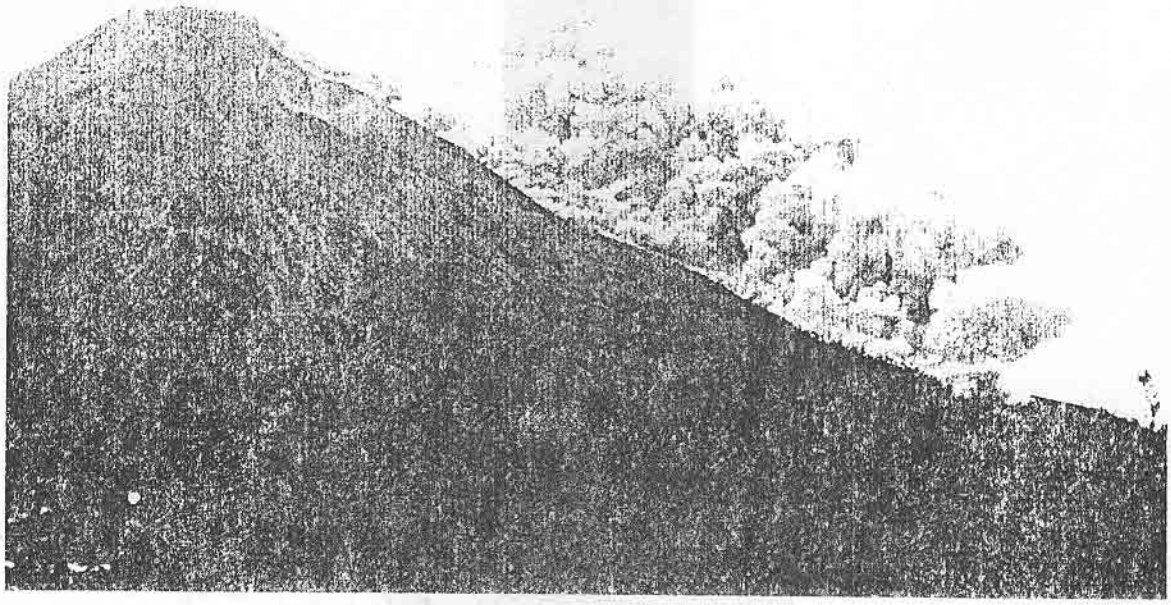
BSV n° 26 - Juin 1992

# BULLETIN
# de la SECTION de VOLCANOLOGIE

## *Société Géologique de France*



*Nuée ardente du 5 février 1992 au Merapi (Java, Indonésie)*
*Photo J. Tondeur*

# NEOGENE AND QUATERNARY VOLCANISM OF CENTRAL ANATOLIA: A VOLCANO-STRUCTURAL EVALUATION

M.Cemal GÖNCÜOGLU, Vedat TOPRAK

*Department of Geological Engineering, Middle East Technical University, 06531, Ankara TURKEY*

## ABSTRACT

The central part of NE-SW trending Central Anatolian volcanic province comprises various volcanic rocks of middle-late Miocene to Quaternary age. Nine volcanic complexes are differentiated within the study area. These are Keçikalesi, Kìzìlçìn, Tepeköy, Çìnarlì, Melendiz, Keçiboyduran, Göllüdag, Hasandag and Karatas volcanics. Age, lithology, flow pattern, eruption center and morphology of volcanics are utilized to recognize these complexes.

The field and the age data indicate that the volcanic activity has been continuous without a major break since middle-late Miocene. Spatial distribution of these complexes suggest a close relationship between faulting and volcanism.

## I. INTRODUCTION

The Central Anatolian Volcanic Province (CAVP) of Neogene-Quaternary age extends as a volcanic axis of about 300 km in NE-SW direction in Central Anatolia, Turkey (Fig.1). The formation and evolution of the CAVP has been usually attributed to the convergence between Afro-Arabian and Eurasian plates (Innocenti et al., 1975; Batum, 1978; Tokel et al, 1978; Pasquare et al, 1988; Ercan et al., 1990). In most of the previous investigations the studies were concentrated to interpret the geochemical data and to assess the nature of the source of the CAV. The first attempt to evaluate the structural frame of the CAVP starts with Pasquare et al., (1988). However, the field evidences on the relations of different volcanic complexes, on the structural control of the location of major and minor eruption centers, and on the regional tectonic framework of the area are still quite poor. Geological mapping started in 1990 aims to investigate the relationship between the volcanic rock associations and the neotectonic events within the CAVP. The study area, therefore, is selected to comprise some of the major volcanic centers of the CAVP (Fig.1). In this paper preliminary results on the distribution and morphology of rock associations exposed in the area are presented.

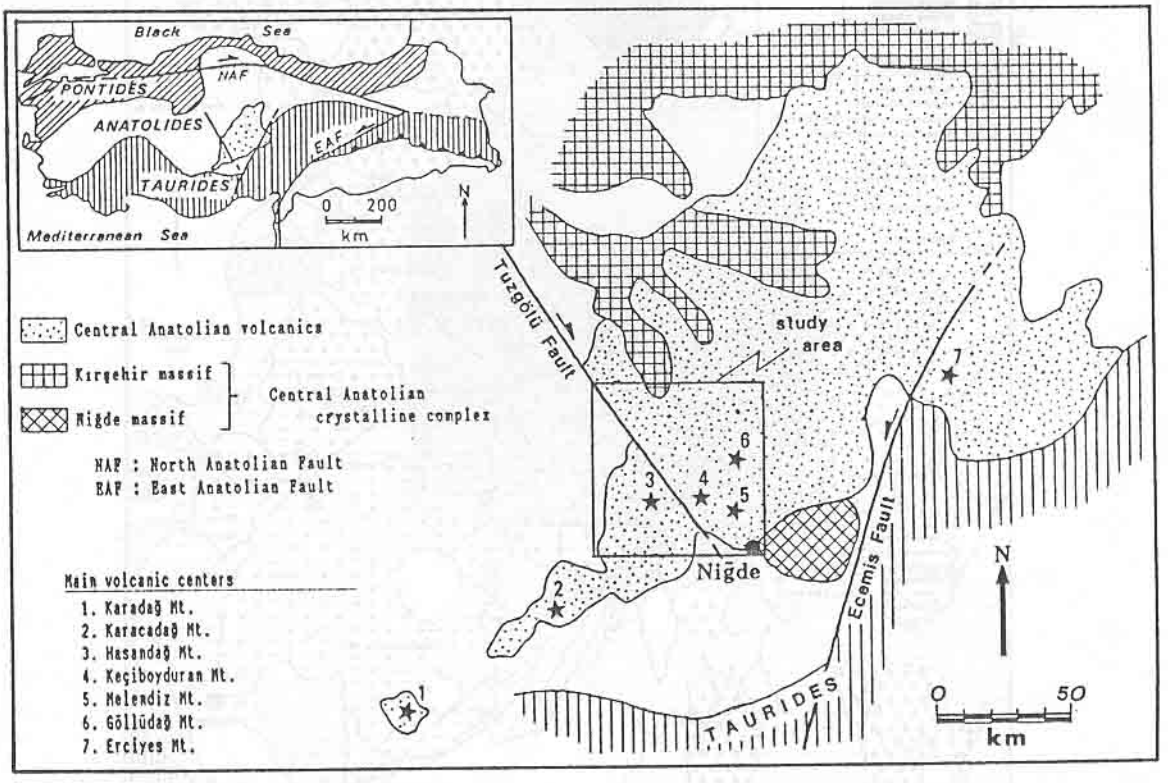



*Figure 1. Geological setting of the Central Anatolian Volcanic Province*

## II. GENERAL GEOLOGICAL SETTING

The CAVP is located to the south of Anatolide belt which is one of major tectonic units of Turkey (Ketin, 1966) (Fig. 1). In and around the study area, the CAV is situated between Kirsehir and Nigde massifs that collectively constitute the Central Anatolian crystalline complex (Göncüoglu et al., 1991). The major Tuzgölü Fault cuts across the CAVP with a NW-SE direction. It has played an important role in the evolution of volcanic centers in its vicinity (Toprak and Göncüoglu, in review, a).

Pre-Neogene rocks exposed in the region are considered as basement rocks. The oldest rocks belong to the crystalline complex. They consist of Paleozoic-Mesozoic metamorphic rocks, overthrusted by Upper Cretaceous Central Anatolian ophiolites and intruded by late Cretaceous plutonic rocks. Eocene is characterized by marine limestone which is unconformably overlain by Oligo-Miocene continental clastics (Göncüoglu et al., 1991).

## III. VOLCANICLASTIC PLATFORM

Volcaniclastic rocks are pyro- to epiclastic products of the volcanic centers exposed in the area. They surround the volcanic complexes and have a large areal extend. They are composed of different lithologies of various age, interstratified with continental (fluvial to lacustrine) deposits and show vertical and lateral facies change from place to place. These rocks are not divided into different units and are considered to form a "volcaniclastic platform". Detailed descriptions of these rocks can be found elsewhere (i.e. Beekman, 1966; Pasquare, 1968; Innocenti et al., 1975; Le Pennec et al., 1990).

The age of volcaniclastic rocks, showing a parallelism with the evolution of volcanic centers, ranges between Mio-Pliocene to Quaternary. The products of each eruptive phase has covered and buried the earlier volcanic rocks. For example, in three localities in the area (W of Nigde, NW of Keçikalesi, and NWW of Çiftlik) the volcaniclastic rocks cover the cinder cones and the lava flows of previous eruptions whereas the same rocks are covered by the lava flows of the recent activities.

Some Quaternary depressions located within the volcaniclastic platform are observed in the area (Fig.2). These depressions are volcanic and structurally-controlled sub-basins that have been isolated from the main basin (Toprak and Göncüoglu, in review, b). One of them, the Çiftlik basin, is located in the central part of the area. This basin is proposed to coincide with a huge caldera, "the Çiftlik caldera", that has erupted significant amount of pyroclastics in the region (Pasquare et al., 1988). However, field mapping has shown that it is a subbasin surrounded by different volcanic bodies of various ages that will be mentioned in the next section.

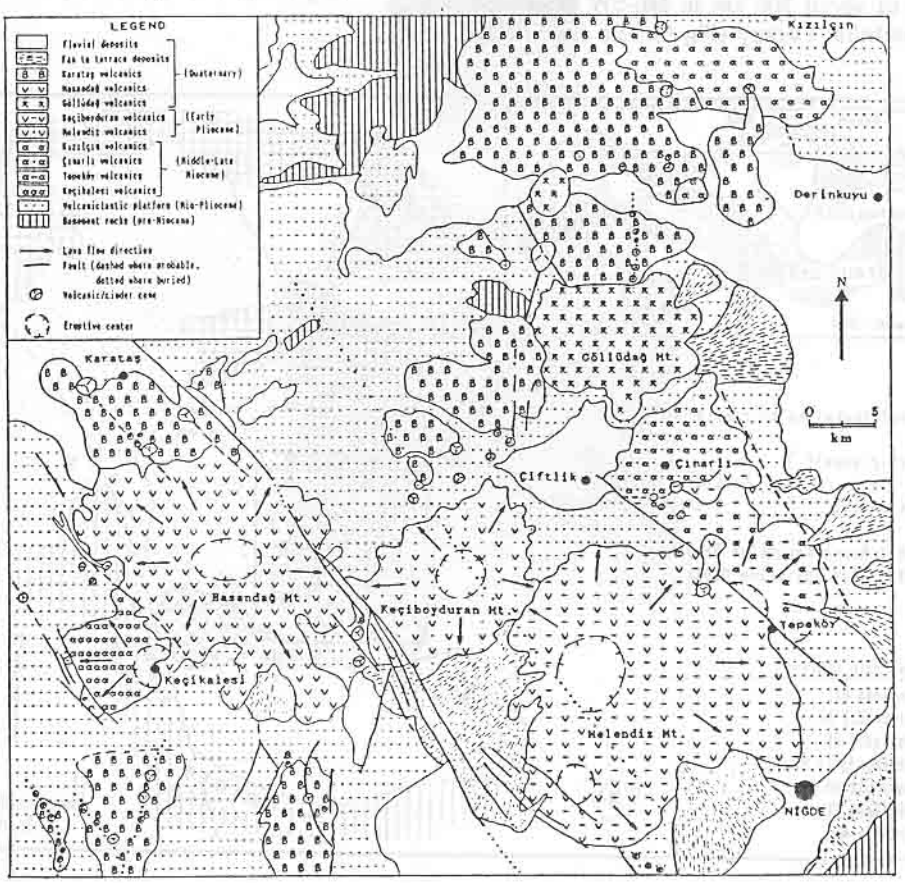



*Figure 2. Geological map of the study area*

## IV. VOLCANIC ROCKS

Nine volcanic complexes are differentiated within the study area. They cover more than one-fourth of the area. These complexes are grouped and mapped according to their distinct areal distribution, spreading centers, age and composition. However, none of them is composed of a single lithology, but rather they are characterized by an association of different lava flows and pyroclastics. All of them are covered by their volcaniclastics which interfinger with the continental deposits of Mio-Pliocene to Quaternary age. These volcanics are explained below from the oldest to the youngest.

**1. Keçikalesi volcanics:** These volcanics constitute the oldest products of CAV within the area. They are located to the SW of Hasandag in the form of a caldera of about 45 km$^2$ (Fig. 2). According to petrographic analysis the common lithologies are andesitic to trachiandesitic lava flows, interstratified with glassy tuffs and ignimbrites. Based on radiometric data Besang et al. (1977) assigned a middle-late Miocene age (Table 1) which is consistent with the stratigraphical data (Göncüoglu et al., 1991). Although it is the oldest volcanic center in the area, the original shape of the center is still well preserved. According to Emre (1991) this is because the center was buried until recently by a volcaniclastic cover that protected the caldera from erosion.

**2. Kìzìlçìn volcanics:** The complex is located to the northeastern part of the study area (Fig. 2) and covers an area of about 65 km$^2$. It is composed of highly altered and brecciated andesitic-dacitic lavas with agglomeratic interlayers. The field data which need to be analyzed in more detail suggest that it is the remnant of an ancient and mostly destroyed and/or buried caldera located further north. Radiometric data show that it is late Miocene in age (Batum, 1978).

**3. Tepeköy volcanics:** These volcanics are observed at the eastern part of the area with a semicircular distribution of about 80 m$^2$. They are exposed at the upthrown (eastern) block of a NNW-SSE trending fault which separates these volcanics from Melendiz volcanics. The western half of Tepeköy volcanics is believed to be buried beneath Melendiz volcanics. The observable eastern part of Tepeköy volcanics is covered by late stage parasitic flows of Melendiz volcanics most of which could not be shown at the present map scale. These volcanics are composed of hydrothermally altered and variaged breccia and andesitic to dacitic lava, intruded by porphyritic dykes. The most intensive alteration and brecciation that corresponds to the center of the body is observed in the north of Tepeköy. There is no age data for Tepeköy volcanics. However, having the same stratigraphic position and similar composition with the Kìzìlçìn volcanics, it is suggested that the age of Tepeköy volcanics is also late Miocene.

**4. Çìnarlì volcanics:** They are located to the east of the study area (Fig. 2) with an exposure of about 50 km$^2$. The complex is in the form of an eroded composite cone with multiple vents. The volcanics are composed dominantly of dacitic to andesitic pyroclastics with thick andesitic lava flows. There is no age determination of these volcanics. However, since they underlie the lava flows of Melendiz volcanics (Pliocene), an age of late Miocene is assigned to Çìnarlì volcanics.

**5. Melendiz volcanics:** Melendiz volcanics with their circular distrubution to the north and northeast of Nigde cover an area of about 315 km$^2$. The center is built over a central vent with a diameter of 6 km and a subsidary smaller vent (1.5 km) located to the south of central one. The stratigraphic position of the lavas erupted from both vents indicate that the conduits are contempareneous. The vent materials consist of agglomerates, brecciated and hydrothermally altered basaltic andesites. Pyroclastics are represented by tuffs with blocks and volcanic bombs. They range in size from small, spindle shaped pellets upto agglomerate bombs of tens of cm's. Lava flows which almost cover all the center are composed of augite-hypersthene andesite and hornblende-augite andesite. The latest products of Melendiz are represented by tongue-shaped lava flows of basaltic andesites erupted from numerous parasitic cones in the northeastern part of the complex. Radiometric data (Besang et al., 1977) suggest an early Pliocene age for the Melendiz volcanism (Table 1). Location of vents of Melendiz volcanics coincides with a buried fault that extends in NW-SE direction being parallel to Tuzgölü Fault. It is one of the major faults (Toprak and Göncüoglu, in prep.) that controls the evolution of Melendiz and Keçiboyduran volcanics.

**6. Keçiboyduran volcanics:** Keçiboyduran volcanics are observed around Keçiboyduran mountain which is situated between Hasandag and Melendiz mountains. The volcanic complex has an alliptical base with a long axis of about 18 km in NE-SW direction and covers an area of 120 km$^2$. The central part of the volcano is constituted of a circular vent, 5 km in diameter. The dominating lithologies, in the central part of the volcano, are highly brecciated and hydrothermally altered andesitic lava, agglomerate and tuff. The vents, to the NE and SW, are covered by pyroclastics of an effective period, which is followed by hornblende-biotite andesite and hornblende-augite andesite lavas, which have flowed radially from the central conduit. Similarities in lava morphology, composition and overall volcanic form with the early Pliocene Melendiz volcanics (Besang et al., 1977)

suggest that Keçiboyduran volcanics are also early Pliocene in age.

7. Göllüdag volcanics: Rhyolitic domes of Göllüdag volcanism are located to the north of Çiftlik basin. The volcanic complex has a circular pattern and covers an area of about 90 km$^2$. The central part of Göllüdag volcanics is composed of rhyolitic and rhyodacitic lava, which is surrounded at the periphery by rhyolitic tuffs, obsidians and perlitic rocks. Small-scale rhyolitic domes are observed to the north of Göllüdag main body, however, the genetic relationship between these masses and the main center still needs clarification. Based on radiometric data Batum (1978) has assigned an early Quaternary age for the Göllüdag volcanics (Table 1).

| Volcanic complex | Radiometric data Range (m.y.) | Method | Age | Dominant lithology | Area (km$^2$) | Type of volcano |
|---|---|---|---|---|---|---|
| Karataş | 0.42±0.04 - 0.08±0.01 | K/Ar (1) | late Quaternary | Basalt | 400 | Monogenetic centers |
| Hasandağ | 0.58± - 0.08± | K/Ar (1) | late Quaternary | Andesite-rhyodacite | 230 | Composite cone |
| Göllüdağ | 0.9±0.2 - 0.86±0.1 | Fis.Tr. (2) | early Quaternary | Rhyolite-rhyodacite | 90 | Dome |
| Keçiboyduran | | | early Pliocene | Andesite | 120 | Composite cone |
| Melendiz | 6.5±0.2 - 5.1±0.15 | K/Ar (1) | early Pliocene | Andesite | 315 | Composite cone |
| Çınarlı | | | middle-late Miocene | Andesite | 50 | Composite cone (?) |
| Yepeköy | | | middle-late Miocene | Andesite-dacite | 80 | Caldera |
| Kızılçın | 13.7±0.3 - 6.5±0.2 | K/Ar (2) | middle-late Miocene | Andesite-dacite | 65 | Caldera (?) |
| Keçikalesi | 13.7±0.3 - 12.4±0.6 | K/Ar (3) | middle-late Miocene | Andesite | 45 | Caldera |

(1) Ercan et al. (1990)
(2) Batum (1978)
(3) Besang et al. (1977)

*Table 1. Summary of the major characteristics of the volcanic complexes exposed within the study area*

8. Hasandag volcanics: Hasandag volcanics are observed in the western part of the area around Hasandag mountain (Fig.2) which is a composite volcano with numerous vents located on a pipe of 5-6 km in diameter. Hasandag volcanics have a NW-SE trending elliptical shape with a long axis of about 25 km. Four main lithologic groups are recognized within these volcanics: 1) The earlier products of the volcanic activity is represented by dacitic ignimbrites and andesitic tuffs. 2) Lavas of the first period are restricted to the NW flank of the volcano. They consist of hypersthene-augite andesites and biotite-augite andesites which may be correlated with the "Meso Hasan Dagi" of Aydar and Gourgaud (1990). 3) The following pyroclastic period is characterized by extensive biotite-rich welded tuffs and ash flow which cover the NW part of the volcanics in the form of radial bodies. 4) The lavas of the last period dominate on the eastern and southern flanks. They have a dacitic-andesitic to rhyodacitic composition. Radiometric data (Ercan et al., 1990) suggest that lava flows of the last period are late Quaternary in age. The most recent activity, (probably of solfataric type ?) has been illustrated by ancient inhabitants of Çatalhöyük village on the wall of their holy site at 6200 B.C. (Mellard, 1967) which is believed to be the oldest geological document (Göncüoglu, 1981). Control of the Tuzgölü fault zone on the evolution of Hasandagi volcano is discussed by Toprak and Göncüoglu (1992).

9. Karatas volcanics: Karatas volcanics are the latest products of the CAVP in the studied area. They are distributed as separate outcrops scattered in the area. The name is given by Ercan et al. (1990). They occur as individual scoria cones and their lava flows. The lava flows consist of olivine basalt - hypersthene basalt. The cones which are 0.1 to 2 km in diameter are mostly aligned along segments of the Tuzgölü fault zone. This alignment of the cones and local observations on the lava flows indicate that they have been extruded in the form of dykes (Toprak and Göncüoglu, in review, a). Karatas volcanics are the parasitic products of the latest activity of Hasandag composite volcano. Radiometric data (Ercan et al., 1990) reveal that their age ranges between 420.000 to 65.000 years

B.P. (Table 1). This range, however, is obtained from various outcrops of Karatas volcanics exposed in a wide area between Hasandag and Karacadag mountains (Fig. 1). The age of volcanics according to the determinations in the vicinity of type section (Karatas village and its southern section) is 120.000 to 65.000 years B.P.

## V. CONCLUSIONS

Nine volcanic complexes are differentiated and mapped within the study area. General characterictics of the rocks are illustrated in Table 1. Based on field relations and age data of these complexes, the following conclusions can be drawn:

1. Almost all the volcanic complexes can be distinguished by their eruption center and morphology. Three of the complexes (Keçikalesi, Kìzìlçìn and Tepeköy) are in the volcanic form of caldera, four of them (Çìnarlì, Melendiz, Keçikalesi and Hasandag) in the form of composite volcano, one of them (Göllüdag) as dome and one (Karatas) as monogenetic centers.

2. Spatial distribution of the main bodies and the major structural trends indicate a genetic relationship between volcanism and faulting (Fig.2). The monogenetic centers, are scattered throughout the area, but there is a certain grouping and concentration of these centers along some well-defined trends. These trends coincide with the extensional fault segments within the active Tuzgölü Fault system which can be utilized in the determination of the recent tectonic framework and buried faults in the region (Toprak and Göncüoglu, 1992).

3. According to the previous studies (i.e. Pasquare et al., 1988) a periodicity of volcanic activity is proposed. Accordingly these periods are separeted by important deformative and erosive events. However, as depicted by the age data (Table 1), through the evolution of the CAPV during middle Miocene-Quaternary, there is no remarkable break in the volcanic activity. The age data display a time gap during late Pliocene. The age of Hasandag is assigned as late Quaternary (Ercan et al., 1990). However, this age corresponds to the last phase since the samples analyzed belong to the latest lava flows; but an age determination based on the systematic sampling could date early Quaternary and/or late Pliocene for the initiation of Hasandag composite volcano. Therefore, it is suggested that the volcanic activity of the CAVP has been continuous in time. On the other hand, the location of activity has been shifted and different eruption centers have been used during the chronological evolution.

4. Monogenetic centers are not formed only during recent activity. Field data suggest that all major volcanic complexes had their own monogenetic centers during their activity, as suggested by the presence of scoria cones buried beneath the volcaniclastic cover. A detailed study of the relationship between major and minor (monogenetic) centers may reveal the geometry of buried fracture system and, thus, help to evaluate the pre-Karatas neotectonic events in the region.

5. Çiftlik basin which was suggested to be a caldera by Pasquare et al. (1988) is a Quaternary depression surrounded by different volcanic bodies. The spreading centers, however, for the huge mass of pyroclastics mentioned in the area can correspond to late Miocene - early Pliocene volcanic bodies, namely, Çìnarlì, Tepeköy, Melendiz and Keçiboyduran volcanics.

## ACKNOWLEDGEMENT

This project was financially supported by Turkish Petroleum Company (T.P.A.O.), Ankara.

## REFERENCES

Aydar, E. and Gourgaud, A., 1990, Les grands stades d'édification du strato-volcan Hasan Dagì (Anatolie centrale, Turquie), Bulletin de la Section de Volcanologie, 20, 17-20.

Batum, I., 1978, Geology and petrography of Acìgöl and Göllüdag volcanics at SW of Nevsehir, (Central Anatolia, Turkey), Yerbilimleri, 4, 50-69.

Beekman, P.H., 1966, The Pliocene and Quaternary volcanism in the Hasan Dag-Melendiz Dag region, Bull. Mineral Res. and Explor. Inst., Ankara, 66, 90-105.

Besang, C., Eckhardt, F.J., Harre, W, Kreuzer, H. and Müller, P., 1977, Radiometrische Altersbestimmungen an neogenen Eruptivgesteinen der Türkei, Geol. Jb., B25, 3-36.

Emre, Ö., 1991, Hasandagì - Keçiboyduran Dagì yöresinin volkanizmasìnìn jeomorfolojisi, Ph.Thesis, Istanbul Üniv. Deniz Bil. Enst., 207 p. (unpublished)

Ercan, T., Fujitani, T., Matsuda, J.I., Tokel, S., Notsu, K., Ui, T., Can, B., Selvi, Y., Yìldìrìm, T., Fisekçi, A., Ölmez, M. and Akbaslì, A., 1990, The origin and evolution of the Cenozoic volcanism of Hasandagì-Karacadag area (Central Anatolia), Bull

Göncüoglu, M.C., 1981, Dünyanìn en eski belgeseli, Yeryuvarì ve Insan, 6/3-4, 3.

Göncüoglu, M.C., Toprak, V., Kusçu, I., Erler, A. and Olgun, E., 1991, Orta Anadolu masifinin batì bölümünün jeolojisi, Bölüm 1: Güney kesim, ODTÜ-AGÜDOS, Ankara, 140 p.

Innocenti, F., Mazzuoli, G., Pasquare, F., Radicati di Brozola,F. and Villari, L., 1975, The Neogene calkalkaline volcanism of Central Anatolia: geochronological data on Kayseri-Nigde area, Geol. Mag., 112, 349-360.

Ketin, I., 1966, Tectonic units of Anatolia, Bull. Mineral Res. and Explor. Inst., Ankara, 66, 23-34.

Le Pennec, J.L., Temel, A., Camus, G., Bourdier, J.L. and Gündogdu, N., 1990, Le volcanisme ignimbitique d'Anatolie centrale: un aperçu de la stratigraphie, Bulletin de la Section de Volcanologie, 20, 7-10.

Mellart, J., 1967, Çatal Höyük, Stadt aus der Steinzeit. Lübbe Verl., Hamburg, 269 p.

Pasquare, G., 1968, Geology of the Cenozoic volcanic area of Central Anatolia, Atti Accad. Naz. Lincei, 9, 53-204.

Pasquare, G., Poli, S., Vezzoli, L., and Zanchi, A., 1988, Continental arc volcanism and tectonic setting in Central Anatolia, Turkey, Tectonophysics, 146, 217-230.

Tokel, S., Ercan, T., Akbaslì, A., Yìldìrìm, T., Fisekçi, A., Selvi, Y., Ölmez, M. and Can,B., 1988, Neogene tholeiitic province of Central Anatolia: implication for magma genesis and post collision lithospheric dynamics, METU Jr. Pure and Applied Sci.,

Toprak, V. and Göncüoglu, M.C., 1991, Neotectonic characteristics of the area between Tuzgölü and Ecemis Fault zones, S. Erk Geology Symposium, Abstracts, Ankara, 31.

Toprak, V. and Göncüoglu, M.C., 1992, Tectonic control on the evolution of Neogene-Quaternary volcanism of Central Anatolia, Turkish geology workshop, Abstracts, p. 71, Keele University, 9-10 April, England

Toprak, V. and Göncüoglu, M.C. (in review,a) Penecontemporaneous activity of Tuzgölü Fault zone and Central Anatolian volcanics, Turkey.

Toprak, V. and Göncüoglu, M.C. (in review,b) Volcano-tectonic sub-basins within Central Anatolian volcanic province: Derinkuyu basin as an example, Turkey.