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KIRKA - AFYON - ISPARTA STRUCTURAL TREND AND ALKALINE ROCK ASSOCIATIONS (ANATOLIA)

M. Savasçin, R. Birsoy, N. Dag and E. Nohutçu

ABSTRACT

In and surroundings of the Menderes Massif, strato - type and calc - alkaline dominant volcanism developed in association with a compressional tectonic regime which ended at Middle Miocene. Shoshonitic and alkaline - basaltic volcanism, occurred with the following extensional regime. This has continued from Late Miocene to Quaternary. The first transitional products from the shoshonite to alkaline series (10 ± 1 m.y.) were observed at depressive basins such as Bodrum, Urla. Karaburun, Foca, Ayvalik and Çanakkale (Aegean Coastal Zone). Younger products are formed from Pliocene to Quaternary in relation to the fault systems in the inner parts of the Menderes Massif. The Kirka - Afyon - Isparta structural trend, which bounds the Massif in the east, has a N - S trend and even significant implications. To the south of Kirka, phonolitic volcanics commencing with very thick tuff and ignimbrite deposits and ending with basic products such as latites and phonolitic tephrites appear to be 21 - 17 m. y. old. Further south, in the surroundings of Afyon volcanoclastic deposits with poor sorting occur beneath the thickly developed volcanic succession. The latitic and trachytic phonolite lavas and domes are intercalated with tuffs and cut the volcanoclastic deposits, and leucite -, sanidine - melilite - bearing dikes such as phonolitic leucitite, phonolitic leucititic tehprite. They represent a last stage. The volcanism appears to be 14 - 10 m. y. old. In the surroundings of Isparta, the most southern end of the structural trend, basic volcanic centers such as leucititie, phonolite, tephritic - phonolites and trachyte were active about 4 - 4,5 m. y. ago, and caused the fluorine enrichments, sulfur deposition and the occurrence of sodium sulfate brines.

In all three locations, an approximately N - S trending graben structure is dominant. Taking into account the similarities with alkaline - carbonatite complexes (with respect to boron, sulfate, U, F) it can be also interpreted as a rise of mantle plume and initiation of intraplate rift systems. Mobilization of the magmatic centers happened for about 200 km for 21 - 4 = 17 m. y. corresponding to a 1.17 cm. movement per year.

This situation seems to be the result of the northward tectonic transportation of he Anatolian plate on a mantle rise (1,17 cm / yr). This resulted in tearing - off in the Anatolian plate in N - S direction, the Kirka - Afyon - Isparta structural trend. Also the evidence assembled all over the Menderes Massif (east, middle, and west) may indicate the presence of a mantle plume (core complex) beneath the Massif.

D. E. Univ. Dep. of Geology, 35100 Bornova, Izmir / Turkey

INTRODUCTION

The tectonic units of Western Anatolia and their basement rock units from north to south are as follows (Fig. 1):

-The Sakarya Continent contains Kazdag metamorphites, structurally overlying the ophiolite complex and sediments younger than Triassic.

-The Izmir - Ankara Zone (Brinkmann, 1971), which is characterized by

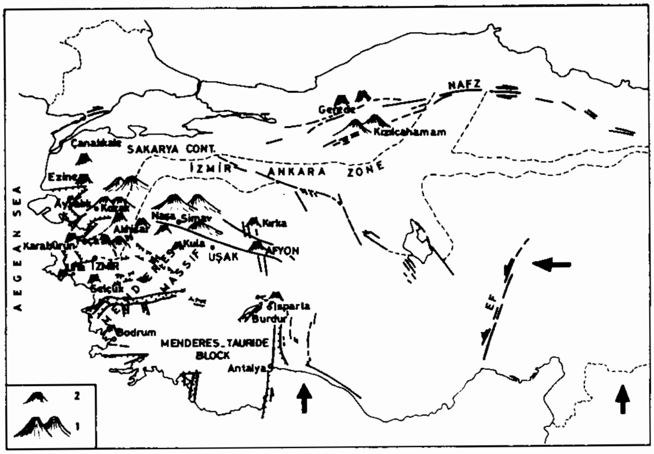

Fig.1: Tectonic units, some important grabens and fault systems, and Tertiary (Miocene to Quaternary) volcanics of Western Anatolia; (1) Important centers of calc - alkaline volcanicm:
1 - Yamanlar - Yuntdag, 2 - Bergama, 3 - Ivrindi - Bigadiç, 4 - Simav, 5 - Selendi - Sak 6 - Kizilcahamam
(2) Important centers of shoshonitic and alkaline volcanism

tectonic - ophiolitic melange rocks, was formed by the closure (Middle Eocene) of the Izmir - Ankara Ocean due to north dipping subduction (Sengör and Yilmaz, 1981).

- Anatolite - Taurid platform (Sengör, 1979), or the Menderes - Taurid Block (Koçyigit 1991), was being buried in parts during Middle Eocene causing the recrystallization of metamorphites of the Menderes Massif (Dürr, 1975; Sengör and Yilmaz, 1981; Okay, 1989). The Karaburun Belt and Bornova Basin (Erdogan and Güngör, 1991) of the same platform were not affected by this underthrust activity. Presumably, early Tertiary rocks, were removed by widespread erosion. Eocene volcanic records are known in Western and Central Anatolia (Çanakkale Akçaalan Volcanics, at the north; Ertürk at al., 1990; Kizilca - Alakaya Basin at the south; Poisson, 1985, Özkaya 1991).

Paleocene - Eocene plutonites (Domanic 45 m. y.; Topuk - Bursa 63.5 - 43 m.y.; Ataman and Bingöl, 1978; Bingöl et al., 1982) occur in NW - Anatolia. Oligocene which is not observed in Western Anatolia was possibly removed by erosion. The age of the trachy - andesite given as 31.4 ± 0.4 m.y. at Ayvalik (Ercan et al., 1985) did not conform to the field data. These trachytes cut the Middle Miocene volcano - sediments (Dora and Savasçin, 1982; Savasçin and Güleç, 1990).

The Miocene is characterized with widely spread lake deposits and intercalated volcanics (Borsi et al., 1972; Innocenti and Muzzuoli, 1972; Innocenti et al., 1979 - 82; Fytikas et al., 1976, 79; Savasçin, 1972 - 82; Kaya and Savasçin, 1981; Ercan, 1979; Ercan et al.,1985). The first stage of the volcanism, which began during the Early to Middle Miocene with calc-alkaline and generally K - rich, latitic - andesitic differentiates shed deposits directly over the basement (Savasçin and Güleç, 1990 a; Seyitoglu and Scott, 1992). The first stage is characterized by strato type occurrences, and formed large centers with intercalations of terrestrial sediments (Fig. 1). Some researchers have considered that these calc - alkaline type initial volcanics were related with compressional tectonism (Dora et al., 1987; Yilmaz, 1989; Yilmaz, 1990; Savasçin and Güleç 1990; Savasçin, 1990). Yilmaz (1989), recorded that ".... During the Late Eocene to Early Miocene interval the north - south convergence continued and the Menderes Massif [the western portion of the Anatolides (Sengör and Yilmaz, 1981)] was initially uplifted and then unroofed....". Eventhough the emplacement of nappes were previously ended, the intrusions of sills (Savasçin 1982; Dora et al., 1987; Savasçin and Güleç, 1990) of granodioritic - monzonitic composition (18.2 - 16.4 m. y.; Egger, 1974) between the cataclastic units of Menderes Massif, possibly originated by gravity sliding, proves that compressional tectonism continued up to Middle Miocene.

Following the Middle Miocene time depressional basins enlarged and accepted still thicker deposits. The radiometric ages of the volcanics (Borsi et al., 1972; Benda et al., 1974; Besang et al., 1976; Ercan et al., 1985) are compatible with those of intercalating sediments. For the K - rich calc-alkaline products of the earlier stage, the concept of post - collision has also been used (Yilmaz, 1989) and the neotectonic phase has been considered to be initiated with extensional activity (Sengör and Kidd, 1979). During the neotectonic stage volcanic activity began again after an approximate 4 million year break. In this case, shoshonitic, trachy - andesitic and trachy - basaltic lavas (10 ± 1 m. y.) are dominantly the first products of new volcanism. As the products of the extensional regime (Savasçin, 1976; Dewey and Sengör, 1979; Savasçin, 1982) they parallel the young fault systems in the depressional basins (Bodrum, Foça, Urla, Karaburun, Ayvalik, Çanakkale, Ezine). Following these events alkaline basalt, hawaiite and mugearite, and in the last stage phonolite, tephrite phonolitic tephrite extrusions continued up to Quaternary (Fig. 1). However, Seyitoglu and Scott (1992) and Seyitoglu et al. (1992) suggested that, the entire Oligocene - Miocene volcanism of Western Anatolia, was related to the extensional tectonic regime.

Francalanci et al. (1990), based on the geochemical and isotopic data, interpreted that the first products of this alkaline volcanism are subordinate to the shoshonitic (SHO) characterization and belong to the final stages of the Tertiary orogenic volcanism. According to other authors, the alkaline products erupted during the Middle Miocene to Quaternary extensional tectonic activity may be defined in three distinct groups such as Na - alkaline (Na - Alk), potassic (KS) and Ultra - potassic (U - K). They have shown an orogenic affinity for SHO, KS, U - K rocks from Afyon and a within - plate affinity for most of the Na - Alk, U - K and KS volcanics from Isparta. According to Gülen (1990), mantle xenolith - bearing Kula alkaline basalts (< 1 m.y.) having the least contaminated Sr, Nd and Pb isotopic compositions, provide the best geochemical data relevant to the Aegean mantle.

The Kirka - Afyon - Isparta structural domain provides new data in relation to the mechanism concerning the tectonic setting of the alkalines which take place in the eastern part of the Menderes Massif (Fig. 1 and 2).

KIRKA - AFYON - ISPARTA ALKALINE TREND

Both on space photographs and geological maps (1 / 2.000.000) the N - S trended fault systems are remarkable structures in and around Antalya (Fig. 1 and 2). It has been known that they show oblique characteristics (Koçyigit, 1993, personal communication). Strike - slip fault systems also played an important role in structural evolution of the Taurids, as defined by Robertson (1990) Development of these faults can be considered as a consequence of a tearing - off which resulted from the movement of Anatolia toward the north. On these north - south trended fault systems, which reach up to Kirka, three important alkaline centers took place getting younger toward the south (Kirka, Afyon, Isparta).

To the south of Kirka, phonolitic - tephrite volcanics commencing with very thick tuff and ignimbrite deposits (Keller and Willari, 1972) and ending with basic products such as latites and phonolitic tephrites (Sunder, 1982) appear to be 21 - 17 m. y. old (Besang et al., 1977; Sunder, 1982), (Fig. 2). The system generally having a high temperature volatile transfer, in association with ignimbritic activity in relation to the segregation of crustal material, resulted in thick deposits of borates in lakes.

Further south, the Afyon volcanics, are characteristically underlain by clastic sediments with poor sorting suggesting a rapid deposition. The latitic and trachytic phonolite lavas and domes (Keller, 1983) are intercalated with tuff and cut the clastic deposits. The last stage is represented by leucite-, sanidine-, melilite - bearing dikes such as phonolitic leucitite and phonolitic leucititic tephrite and high K rocks such as lamproites and Roman HKS (Foley et.al., 1987) type dikes. The age of the volcanism appears to be 14 - 10 m. y. old (Besang et al., 1977). In Isparta, the most southern point of the structural trend, basic volcanics such as leucitites, phonolitic tephrites, tephritic phonolites and trachytes (Lefevre et al., 1983; Özgür et

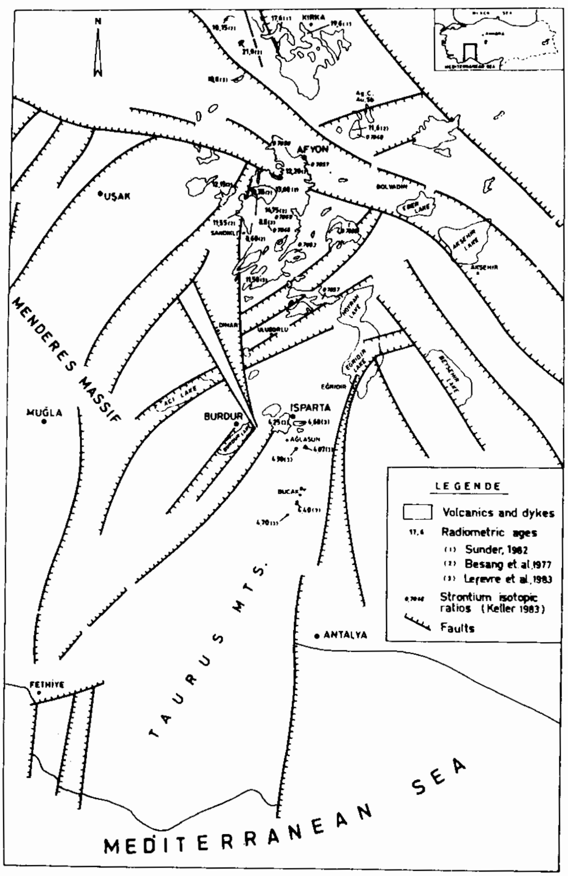

Fig. 2: Distribution of K - and HK - alkaline volcanics of Kirka-Afyon - Isparta structural trend; some isotopic and radiometric data on volcanics; and related fault systems (Koçyigit, 1984) in the surrounding areas.

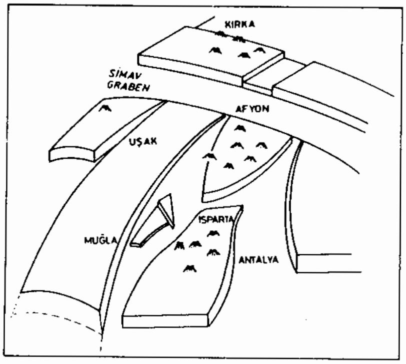

Fig.3: Emplacement of volcanosedimantry sequences and subsequent alkaline volcanics on horsts, as an application to Koçyigit's (1984) fault systems (see Fig. 2).

al., 1990) are 4 - 4.5 m. y. old. The related volcanism caused fluorine enrichments, sulfur depositions and the occurrence of a sodium sulfate brine (Savasçin and Birsoy 1993).

In all three locations, an approximately N - S trending graben structure is dominant (Fig. 2 and Fig. 3).

Although as yet it has not been completed, some plottings of analytical results related to Afyon volcanics are given in Fig 4 through 7. According to the plottings of Na_2O + K_2O / SiO_2 (Fig. 4) 1; phonolitic leucitite, 2; phonolitic leucite tephrite, 3; mugearites, trachybasalts, 4; hawaiites, 5; trachybasalts, 6; trachytes, 7; benmoreites have been defined. Utilizing only the Afyon samples, in K_2O / SiO_2 plot (Fig. 5), it is recognized that the distribution of the K and High - K series of the Afyon samples overlap that of the Roman Province in Italy. Fig. 6 shows that KS and U - K rock series may be found together in Afyon. In Fig. 7, eventhough a number of samples are not enough for Isparta, both Afyon and Isparta samples show similarly enriched patterns. Kula (Na - rich, Quaternary), the youngest occurrence, is characterized by an enriched pattern but not as high as Afyon and Isparta.

DISCUSSION

Keller (1983) indicated that the Mediterranean fold belts are dominantly related to plate - convergence processes, and also mentioned the existence of High - K alkalines in the Cypriot - Taurus Arc (SW - Turkey) the same as the Aolian Island - Arc and the Roman comagmatic region. However, according to Keller (1983) the problem is far from being solved. He pointed out to the possibility of geochemical anomalies and strong metasomatization and enrichment in LIL elements of mantle source, and attributed the K variation in Afyon to mantle anomalies.

Francalanci et al. (1990) recorded that : "... the analytical data has shown an orogenic affinity for SHO, KS, U - K from Afyon and some Na - Alk rocks and a within - plate affinity for most of the Na - Alk and the U - K and KS volcanics from Isparta....". If this conflict is to be solved by using field evidence, another argument which arises is that Anatolia was a consolidated

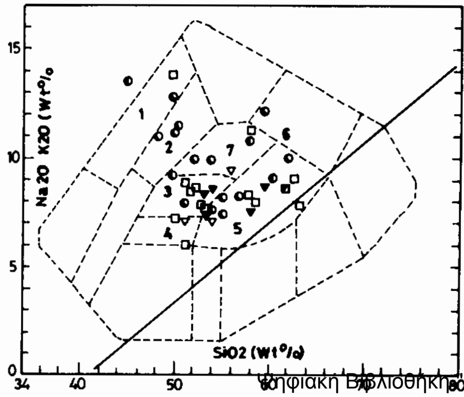

Fig.4: Total alkalis (% Na_2O + K_2O) versus silica diagram (Cox et al.,1979) of volcanic suites of Afyon [empty quadrate Keller (1983), black triangle Keller and Villary (1972), half - black circle are this study], with alkali / tholeitic dividing line. Equivalent rock names for potassic suites, in which K_2O > Na_2O, are to Wilson (1989).

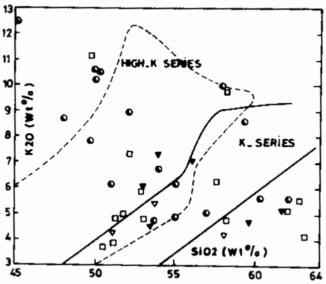

Fig.5: Variation of wt. % K_2O versus SiO_2 for Afyon volcanics, and their correlation with K (straight line) and High - K (dotted line) series of Roman Provence of Italy (Pecerillo and Manetti, 1985). For symbols see Fig. 4.

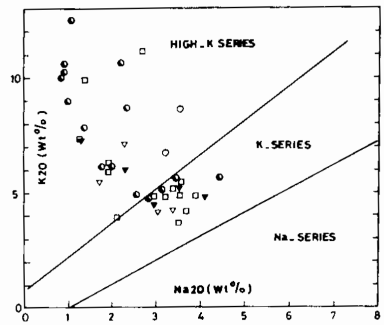

Fig.6: K_2O versus Na_2O diagram of Afyon volcanics

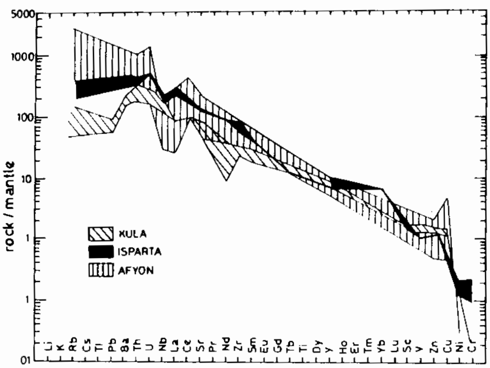

Fig.7: Spider diagram of Afyon, Isparta and Kula volcanics. Analytical data is taken from : Isparta; Ercan et al., 1985; Afyon Keller and Villari, 1972; Keller, 1983, and this study, Kula; Güleç, 1991.

continental environment during the Middle Miocene, and post - collisional volcanism was dominant. During the Late Miocene time Anatolia underwent a neotectonic phase. Extensional regime started, even some grabens of Western Anatolia have been assumed to be rifts (or initial rifts). To this argument, if the rift concept is accepted, alkalines which are explained as orogenic products by Francalanci et al. (1990), may represent the extensional stage suggested in previous work.

If geologic structures and the data of the region (Kirka - Afyon - Isparta) are considered again, the Kirka - Isparta fault trend may be assumed as a tearing off resulted from the northward movement of Anatolia, as compared with the Ecemis Fault (EF in Fig. 1 Sengün, 1993). As seen in Fig. 1, young alkaline volcanics used every kind of main fault surface in Western Anatolia. In other words, all of the various tectonic deformations cause the outcropping of the mantle originated volcanics. Along the Kirka - Isparta trend, the northward movement of Anatolia, while passing over a mantle rise, depending on the NS trending tear beginning at Kirka, resulted in the outcropping of three alkaline volcanics. Furthermore, if the Taurid, which Platform is thought to be pushed toward this magma extrusion, it is also possible to explain the northern deformation of the Taurids, which is known as the Isparta Contortion.

The mobilization of the magmatic center happened for approximately 200 km. from Kirka to Isparta) for 21 - 4 = 17 m. y. corresponding to a 1.17 cm. movement per year toward the north. This situation seems to be the result of the migration of the Anatolian plate from the south to the north (1.17 cm / yr.) which has caused the tearing - off the plate between Kirka and Isparta. This movement is in agreement with the rate proposed by Gülen (1990) for Western Anatolia and Aegean sea. Hence, the Kirka - Afyon - Isparta Trend, which easterly delimits of the Menderes Massif, might have replaced Mc Kenzie' s (1972) tectonic boundary passing through the middle part of the Menderes Massif.

As noticed above, Western Anatolia (i. e. mainly comprising the Menderes Metamorphic Massif) contains Miocene to Quarternary bimodal volcanic sequences (calc - alkaline - shoshonitic and shoshonitic - alkaline). However the Kirka - Afyon - Isparta (KAI) trend, representing a N - S tearing, which was defined as the eastern limit of Western Anatolia, is characterized by one kind of volcanism (alkaline), in the same time interval.

All this data, which may be recognized all over the Menderes Massif, (east, middle and west) indicates the presence of a mantle plume (core complex) beneath the Massif.

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