EVOLUTION AND ORIGIN OF GRANITOID MAGMAS RELATED TO THE CLOSURE OF NEO-TETHYS IN EASTERN TAURUS (TURKEY)

Niyazi TARHAN*

ABSTRACT. — Granitoids cutting the sheeted dyke complex (Göksun metaophiolite), the Elbistan ensimatic island arc volcanoclastic sequence of Neocomian age and the Kabaktepe metamorphites (Bitlis/Pötürge metamorphites) of Paleozoik-Lower Triassic age respectively, outcrop around Afsin-Elbistan-Göksun. The units deposited during Upper Cenonian-Eocene overlie these older units with an angular unconformity starting with a basal conglomerate. In the study area, outcropped granitoids have not been developed during island arc eruptions. These granitoids take place on the collision belts of the subduction zone formed by the N-S directed compressional forces of late Cretaceous started in Lower Cretaceous and increased after Neocomian. Their development is due to the increasing crustal thickness and sinking of the island arc deposits and its basement which is oceanic crust during Coniacian-Upper Santonian. Granitoids are the differentiated products of anatectic magma (diorite, monzonite, syenite, tonalite, granodiorite, granite, alcaline granite and silexite). Which is formed from melting of oceanic (Göksun metaophiolite) and crustal (Kabaktepe metamorphites) rocks together or sepertly at high temperatures. This anatectic magma is named and defined as Afsin magmatism for the first time. However, except these wide spread granitoids intrusions in Eastern Taurus, it was also observed that seme granitic rocks (diorite, monzonite, syenite, tonalite, granodiorite, granite and alcaline granite). Which don't show any intrusive features and magmatic phase. They formed by recrystallization from metamorphites rocks, island arc volcano-clastic deposits and ophiolites (gabbro, sheeted dyke complex and volcanosedimentary rocks) insitu. Granitoids were subjected the low grade regional metamorphism (greenschist facies) probably in Upper Santonian-Campanian.

INTRODUCTION

The granitoids outcrop within the Afsin-Elbistan-Göksun triangle (Fig. 1). Aim of this study is to interpret the petrology and the geotectonic evolution of these rocks and to make a correlation between them and the granitoids outcropping in Eastern Taurus.

Hatay (1966), Polat (1970), Karul (1971), Gökalp (1972), Akkoca and Bahçeci (1972) and Atasever (1978) are the earlier workers in the region. These workers mention the acid plutonic rocks in the study area. According to their view, these rocks intruded during the Eocene time in the area. Perinsek and Kozlu (1983) called the association consisting of ophiolite, island-arc rocks and acid plutonic rocks which are cropping out in the study area «Yüksekova complex». They report that these rocks were thrusted over Mardin complex with the Berit group. Present author, Tarhan (1984) prepared the detailed geological map of the granitoids in the scale of 1:25,000 for the first time. There it is reported that these granitoids are Coniacian-Santonian in age.

GENERAL GEOLOGY

Göksun metaophiolite constitutes the basement of the units cropping out in the study area (Tarhan, 1984). These are overlain by Elbistan ensimatic island-arc volcanoclastic sediments of Neocomian age (spilitic basalt, basaltic andesite, andesite, agglomerate, dacite, alkaline rhyolite and deep-sea pelagic sediments) (Tarhan, 1985). The Kabaktepe metamorphic nappe (Bitlis/Pötürge metamorphites) overlies the Göksun metaophiolite (cumulate, ultramafic rocks of metamorphic tectonite

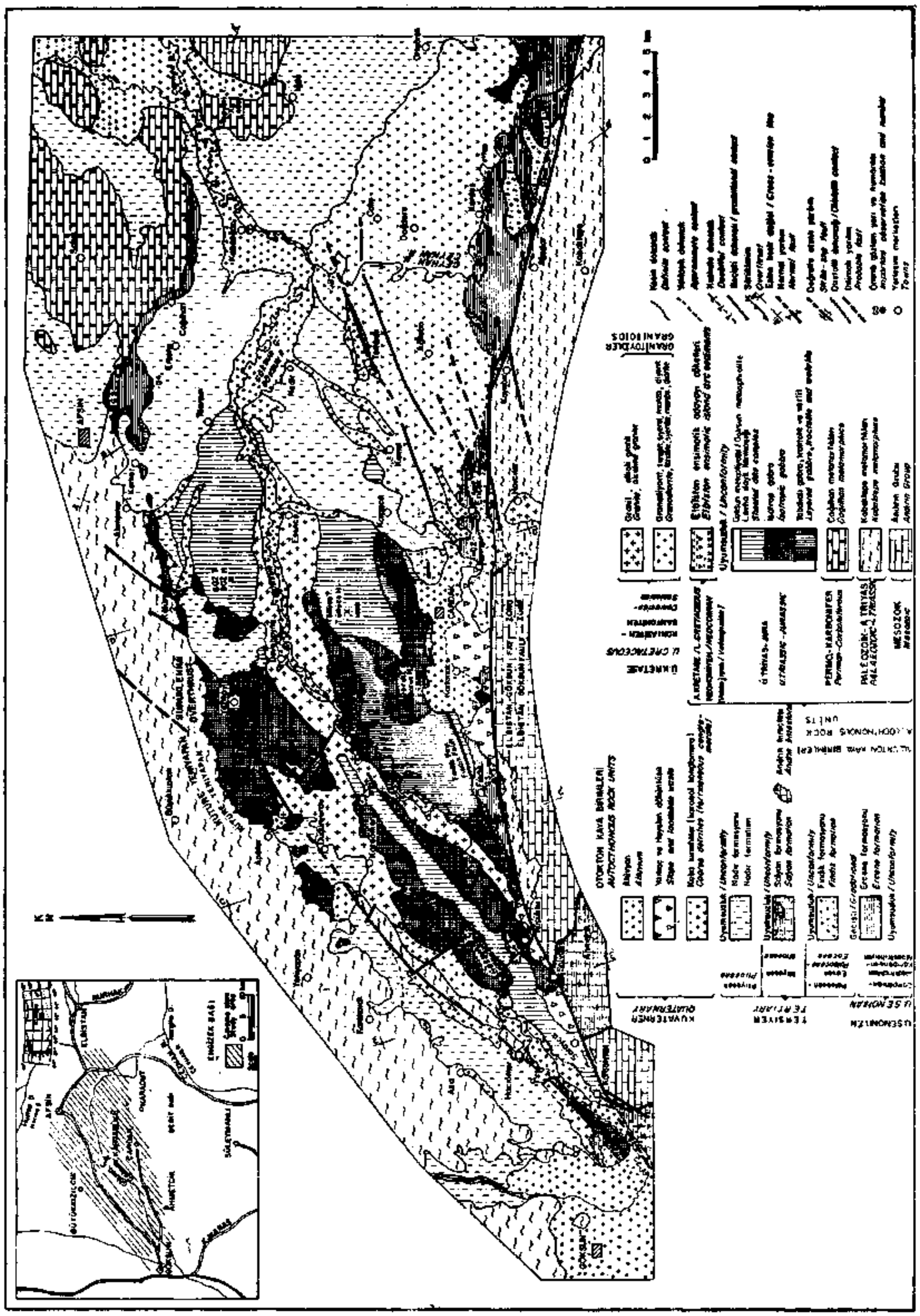

Fig. 1 - The geological map of the Göksun-Elbistan region.

structure, layered and isotropic gabbros and sheeted dyke complex) and the island-arc sequence during the post-Neocomian periods. The Kabaktepe metamorphites (garnet-two mica-gneiss, amphibole-schist, micaschist, quartzite-schist, actinolite-schist, sericite-quartz-chlorite-albite-schist, phyllite, calcschist and marble) form a crushed zone at the contacts with these units (Fig. 1,2,3). The acid plutonic rocks (Çardak association, Tarhan, 1984) cutting the sheeted dyke complex and the Elbistan ensimatic island-arc sequence (intra-oceanic island-arc sequence) and the Kabaktepe metamorphites which overlie these units as nappes, crop out in the area. Isolated diabase dykes cutting the acid plutonic rocks and the other rock units which are cut by the acid plutonic rocks, took place after the intrusion. These dykes extending in NW-SE direction, have variable thickness (30-150 cm), dark-black color and basic composition (Fig. 3). They were subjected to the metamorphism in green-schist facies.

The Ergene formation of Campanian-Maestrichtian age overlies the allochthonous rock units (Göksun metaophiolite, island-arc sediments and Kabaktepe metamorphites) cropping out in the study area. This formation consists mainly of detritic materials derived from these rocks units and begins with a basal conglomerate. It is subdivided into two members represented by flysch and volcanic (andesite, pyroclastic rock and mudstone) facies. The Erçene formation passes into the overlying Fındık formation of Paleocene-Eocene age gradually. The Fındık formation shows flysch character. However, it locally contains lenses, wedges and intercalations of andesitic lavas and pyroclastic rocks. In addition, it also contains pebbles and blocks of ophiolites and metamorphites. The Salyan formation of Oligocene-Miocene age overlies the Ergene formation and the Findik formation with angular unconformities. This formation showing flysch character contains the Andırın limestone olistolithes of Jurassic-Cretaceous age. All the formations cropping out in the study area are covered by the Nadir formation of Pliocene age (Fig. 2,3). The Nadir formation consists of sandstones, claystones, marls, lacustrine limestones, conglomerates, tuffites, mudstones and coaliferous levels (Afsin lignites).

GRANITOIDS

The granitoids are observed in continuous outcrops extending in about E-W direction in the neighbourhoods of Kitiz, Deveboynu and Hacıömer amongst Afsin-Elbistan-Göksun (Fig. 1). In addition, they are seen in discontinuous outcrops near Havcılar and Ambarköy, outside of the study area.

The granitoids cropping out in the study area are composed mainly of diorites, tonalites, granodiorites, granites, alkaline granites and their derivatives, obviously showing gradual transitions to eachother from bottom to top. These intrusive rocks are cut by dykes of aplite, pegmatite and silexite (quartzolite) in form of nets and veinlets. As a rule, monzonites and syenites are scarce, but they occur very widespread in marginal facies. The granitoids contain some fragments of all rock units (15x10 cm to 50x100 cm) as xenoliths (enclaves). Some of these xenoliths are derived from the rocks cut by granitoids and the others are derived from the rocks which granitoids must be originated from. Some xenoliths have preserved their original rock textures, whereas the other ones have gained metamorphic textures and structures due to the effects of metamorphism and have been metamorphosed to amphibolites. The xenoliths show alignments in certain directions.

The granitoids cropping out in the study area were subdivided into two groups and mapped on the basis of this. The first group consists mostly of granodiorites and locally of diorites, monzonites, syenites and tonalites. The second group consists of granites, alkaline granites and silexites. The granites are predominant rocks of this group. The granitoids (first group) usually cropping out in gabbros, in the western part of the study area show gradual transitions to gabbros. By increasing of regional metamorphic grades gabbros pass into amphibolitized gabbros, amphibolites, migmatites, granulites and granitoids (first group). Thus, for this relationship which hasn't been reported in literature, to the present-day, the boundaries between the granitoids and the rocks (ophiolites and metamorphites) from which the granitoids should be derived, were indicated by transitional contacts, for the first time (Fig. 1,2,3). The brief field and petrography descriptions of these rocks are as follows:

Gabbro

The gabbros are layered and show isotropic structures. Levels, lenses and parts of wehrlite and troctolite are locally observed in isotropic gabbros. The gabbros are composed mainly of pyroxenes, plagioclases and opaque minerals (magnetite and chromite), especially in sections where metamorphic effects are lacking or negligible. The effects of cataclasis are insignificant in these minerals.

Amphibolitized gabbro

The amphibolitized gabbros are blackish-green in color. They occur in gabbros and show transitions, the original texture of the gabbro was preserved in the amphibolized gabbros. The plagioclases with albite twinning are partly albitized. The pyroxenes were partly replaced and altered to fibrous actinolite. Increasing of regional metamorphism cause gradual, increase in the hornblende content. In some places, the large xenomorphic pyroxene crystals are partly or wholly altered to the smaller crystal aggregates composed of actinolite and hornblende, in situ. The traces of cataclastic fracturing appear to be more obvious in the crystals of the minerals constituting the rock, during this stage. In other words, by appearance of hornblende, the degree of dislocation increases, also. This relationship confirmed by field observations, as well, suggests that the rocks softened by increasing of temperature was subjected to the plastic deformation in an environment in which the moderate-high pressure/ temperature conditions probably prevailed.

Amphibolite

The hornblende gradually appears instead of actinolite, by increasing of regional metamorphism. Thus, the amphibolitized gabbros are converted into amphibolites, by development of metamorphic minerals and textures. These amphibolites are composed of xenomorphic phenocrysts of, primary pyroxenes and plagioclases constituting the gabbros. These phenocrysts have traces of cataclastic deformation. The cataclastic fracturing (fractures and fissures) in phenocrysts of pyroxene and plagioclase developed, during regional metamorphism, but no traces of cataclastic fracturing are seen in amphibolitized sections enclosing them. The proportion of these phenocrysts clearly indicates a contrast to which amphibolitic parts (levels, bands, lenses and wedges) occur very widespread in. gabroic rocks, depending on grade of metamorphism. In other words, these phenocrysts show a gradual decrease in amount and size, by increasing of amphibolitization grade in gabbros. Therefore, it is obvious that these relict phenocrysts which were larger and angular at the beginning, reacted with the minerals developed by increasing of regional metamorphic grade and as a result of this, they not only became smaller in size, but decreased in amount and gained spherical shapes. They were replaced by metamorphic minerals and completely disappeared during the later stage of the metamorphism. Bingöl (1968) has proved that the amphibolites were magmatic (ortho) in origin, on the basis of their mineralogical and geochemical compositions, and were derived from gabbros and their basic equivalents.

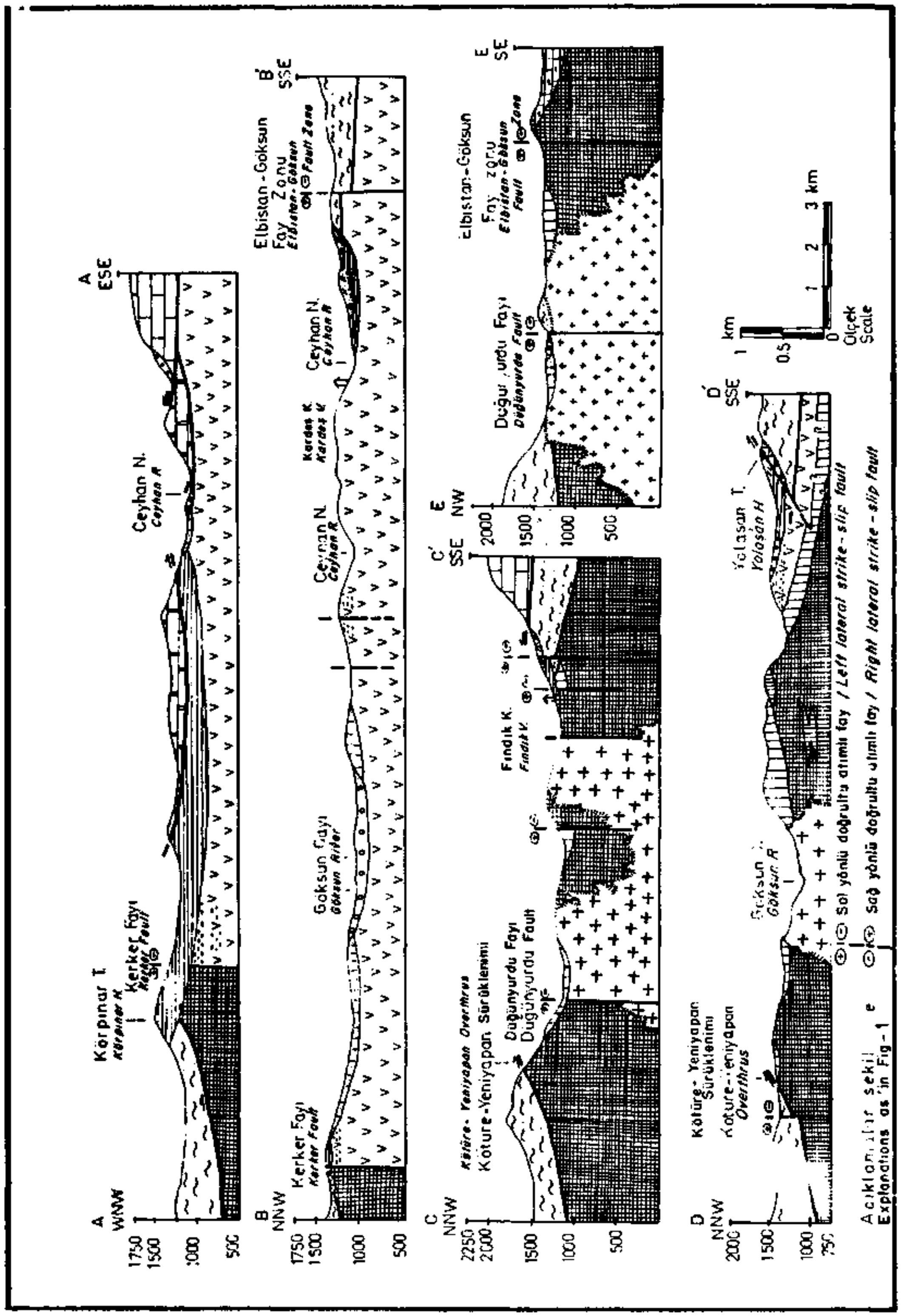

Fig. 2 - The geological cross-sections of the Göksun-Afşin-Elbistan region.

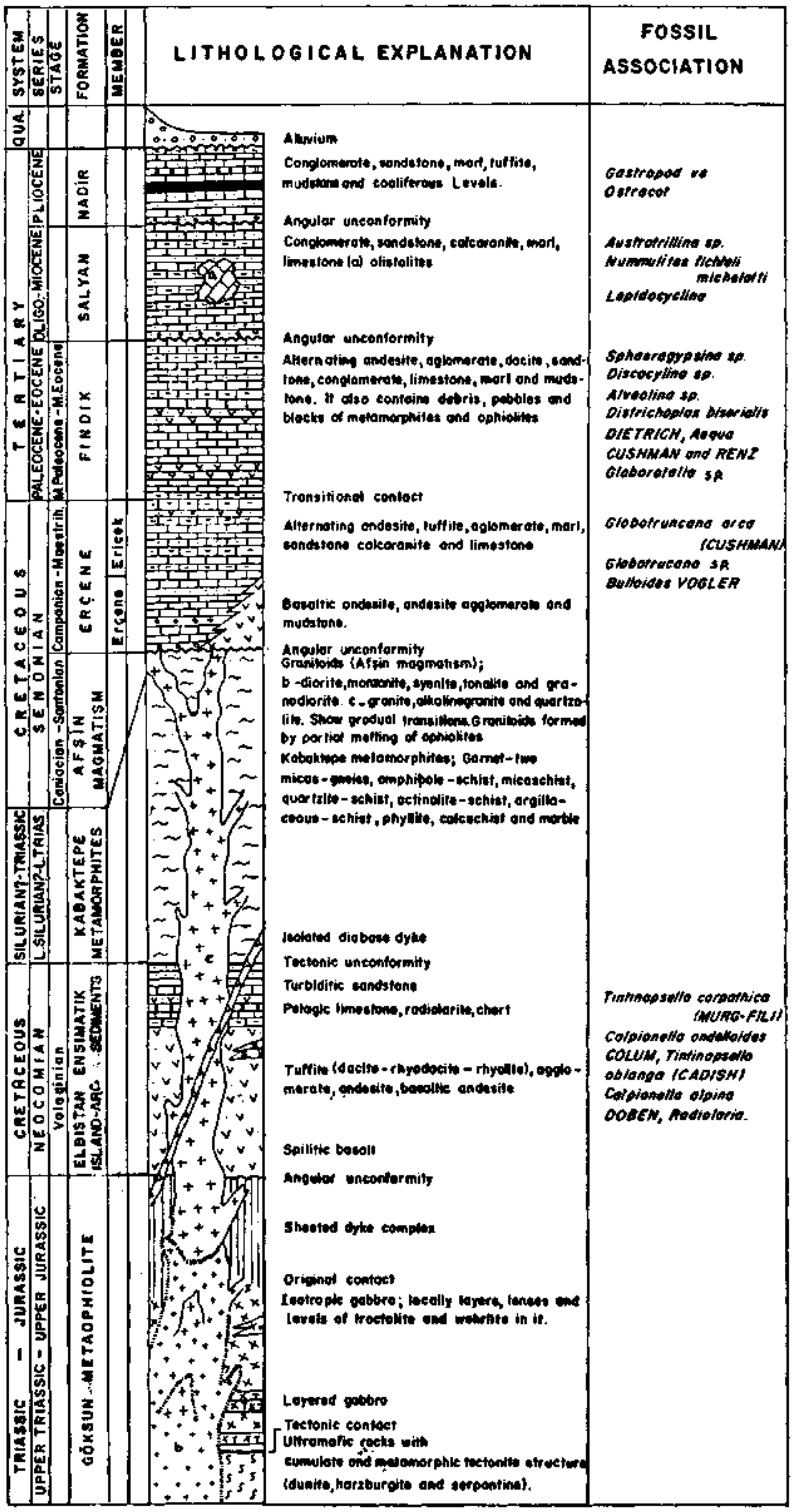

Fig. 3 - The schematik columnar section showing stratigraphic and tectonic relations among the units in the study area.

Based on the field and petrological studies, it is suggested that the amphibolites were subjected to partial melting, during the later stage of the metamorphism and the continental crust material which had existed in natural environment played an important role in this melting, also and as a result of this, the alkaline feldspars were formed, for the first time. Due to enrichment of these alkaline feldspars, banded, lensoidal, wedge-like and augen structures are developed in rocks. Alkaline feldspars are followed by quartz formations. By increasing alkaline feldspars and quartzs, the amphibolites gradually pass into migmatites (Fig. 1).

Migmatite

The migmatites occur at the contacts between the granitoids (first group) and the gabbros (Plate I, fig. 1,2,3,4). They are in appearance of metatexite, as well as diatexite (Mehnert, 1968). In the area, it is observed that the rocks which are light coloured and acidic and were developed in amphibolites and generally extended in parallel direction to the contact of granodiorite, show a transition to the granodiorite in a metatexitic zone characterized by bedded, banded, folded, ptygmatic veined, wedge-like, lensoidal and augen structures. They occur more widespread in the places close to the contact between isotropic gabbro and sheeted-dyke complex. The diatexitic migmatites usually occur at the contacts between the lower parts of the gabbros converted in to amphibolite, and diorites-tonalites-granodiorites (Plate-I, fig. 2). Due to the progressive melting developed in them, it is difficult to distinguish the paleosomes and the neosomes from one another, however, these parts of migmatites gradually pass into eachother. The presence of migmatites is seen at the contacts of the same granitoids (first group) with the rocks belonging to the oceanic crust and with the rocks belonging to the continental crust. The granites, agmatites and migmatites occur very widespread in marbles, quartzite-schists, amphibolites and gneisses all of which form the continental crust (Plate I, fig. 4). They gradually pass into granitoids. The molten parts (neosomes) of the migmatites which were developed in gabbros altered to amphibolites, consists primarily of quartz and alkaline feldspar (Plate I, fig. 1). The prolonged debris and fragments of amphibolites which are conformable to the foliation, and the debris and fragments of plagioclases, pyroxenes and hornblendes are embedded in a matrix (groundmass) composed generally of prolonged crystals of quartz. By increasing leucocratic minerals, these xenoliths decrease in amount.

Diorite-quartz diorite-tonalite

These are generally found in marginal facies of granodiorites which were derived from gabbros. They form transitional rocks between gabbros and granodiorites. They crop out within a small area.

The diorite is rich in leucocratic spots, and dark-green and gray-buff coloured. It is hypidiomorphic and granular in texture. With the increase in grade of reginal metamorphism which is identified with the appearence of zoned plagioclase (oligoclase and andesine) and small amounts of K- feldspar (microcline), the amphibolitized gabbros grade into diorites. The diorites locally contain myrmekite in insignificant quantities. Pyroxenes are partly or wholly in some places altered to hornblendes. The traces of recrystallisation could be observed in plagioclases and pyroxenes. The diorites grade into quartz-diorites and tonalites, with increasing alkaline feldspars and quartzs gradually.

Granodiorite

The granodiorites form the majority of the granitoids cropping out in the study area. The presence of granitic parts could be observed in them. In fact, in some cases, the presence of granitic and alkaline granitic dykes cutting the granodiorite and the xenoliths is seen also (Fig. 3).

The granodiorites are light-buff and greenish in color. They are hypidiomorphic and granular in texture. Quartz is very common. Pyroxenes are partly in some cases or wholly in some cases altered to hornblendes. Plagioclases show zoned structures albite twinnings. In addition, they contain microcline and opaque minerals. Owing to the cataclastic deformations, the individuals of twins belonging to the xenomorphic phenocrysts of pyroxene and plagioclase were bent, twisted, broken and fractured. As a results of this, fractures and fissures were developed in them. In the region, the granodiorites were derived from only oceanic crust or continental crust (Plate I, fig. 4), as well as from hybrid anatectic magmas formed by melting of ophiolites and rocks belonging to continental crust together. In such types of rocks, plagioclases show zoned structures and albite twinnings. Pyroxenes are partly altered to hornblendes. Hornblendes are locally chloritized. The granodiorites contain micas (biotite and muscovite) in addition to opaque minerals. Micas are mostly alteration products of pyroxenes.

Granite

The granodiorites cropping out in the study area, grade into granitic rocks, with decreasing plagioclases and mafic minerals gradually and with increasing K-feldspars and quartz. The granites are hypidiomorphic and granular in texture. The aphanitic texture can be noticed at the contacts between the granites and the rocks units cut by them. The granites contain partly amphibolitized pyroxenes and hornblendes in small amounts. Hornblendes are mostly chloritized. These granites contain abundant dark-black coloured opaque minerals (magnetite), but no micas.

Alkaline granite

These are in the forms of small stocks, veins and dykes, locally cutting the granites and the granodiorites, and are pinkish, in color. Quartz and K-feldspar are commonly dominant components in them. The granites formed by partial melting of only continental crust, contain micas also, in addition to quartz, K-feldspar and opaque minerals. Saussuritisation can be noticed in most of the granitoids (first and second groups) discussed above. The secondary minerals developed at the latest stage and the micro-faults intersecting at right angles, typically represent the cataclastic deformations.

Isolated diabase dykes

These dykes cutting the granitoids and all the rock units cut by granitoids are blackish-gray, greenish-black in color. They are locally broken away, boudinaged and sheared. Ophitic texture was preserved in them. Pyroxenes are partly altered to fibrous actinolites. The laths of plagioclases are partly albitized. In addition, there are sphene, epidote, calcite and chlorite in them. They contain opaque minerals as well (Fig. 3).

Metamorphic grade and age of granitoids

Chlorite, epidote, sericite and calcite were secondary developed in granitoids. Actinolite, albite, epidote, chlorite, sphene and calcite are observed in isolated diabase dykes cutting the granitoids. These mineral paragenesis clearly indicate that the granitoids were subjected to regional metamorphism in green-schist facies (Winkler, 1967). The micro-faults intersecting at right angles and the traces of fracturing developed in crystals of minerals are observed in granitoids and diabase dykes cutting them. These micro-faults also intersect the mineral paragenesis generated under regional metamorphic conditions.

The granitoids are covered by Maestrichtian sediments beginning with a basal conglomerate (Tarhan, 1983-1984). In this case, the age of metamorphism observed in granitoids is probably pre-Campanian or Campanian.

Evolution of Afsin magmatism

There are metamorphic fields subjected to conditions of high temperature/low pressure in Göksun metaophiolite constituting the basement of the rock units cropping but in the study area and the overlying island-arc volcanoclastic sediments of Neocomian age (Tarhan, 1985). The presence of metamorphic fields generated under conditions of low/high temperature and the presence of migmatites developed by anatexis, can be clearly recognized in gabbros. Due to the N-S directed compressional forces probably started in Lower Cretaceous and increased after Neocomian, the Kabaktepe metamorphites have been thrusted over the Göksun metaophiolite and the intra-oceanic island-arc sequence as nappes, during the late Cretaceous. A collision (between two continents) has probably resulted from this compressional regime. It is obvious that the granitoids in the region, cut these metamorphites. Since the crustal thickening wihich was caused by the post-Neocomian compressions, both maintained the isostasy of the region (Moore, 1971) and as a result of this possibly, the oceanic crust sunk into depth. It is likely that the progressive metamorphism of high temperature/ low pressure, depending on depth, caused the partial melting of the rocks belonging to the Göksun metaophiolite at the bottom.

Şengör and Kidd (1979) reported that the crustal thickening and the tensional joints could be formed by the effects of compressional forces. Turcotte (1983) expressed that the intense lateral tensional forces caused by crustal thickening related to the collision and by the thinning of mantle lithosphere, probably surpass the regional compressional forces in a mathematical model.

In the region, the crust which has become thick as a result of the collision which took place over the Benioff zone (Tarhan, 1985), sank into depth depending on the isostatic balance. Since the regional compressional forces probably gave rise to the development of the regional tensional forces, during this collision, the weak zones were formed. The anatectic magma generated by the partial melting of the rocks forming the Göksun metaophiolite at depth, has risen upward along these zones and cut the sheeted dyke complex (Göksun metaophiolite) and the overlying Elbistan ensimatic island-arc sequence and the Kabaktepe metamorphites which had been thrusted over both of them, as nappes during the late Cretaceous.

Mitchell and Bell (1973) thought that the stratigraphic relationships in island-arcs infrequently indicate that the granitic plutons were probably emplaced in the region, during the eruption of volcanic rocks or later. Şengör and Yılmaz (1983) suggested that both the granitic intrusion and the extensive areas in which the metamorphism of high temperature took place along the suture zone, show striking similarities to Tibet plateau-Himalayas which had been considered to be developed, as a result of collision, by Dewey and Burke (1973).

It is concluded that the granitoids cropping out in the study area developed after the collision which had taken place over the subduction zone. In other words, the island-arc sequence and the acidic plutons cutting its basement are not seen before the metamorphites have been thrusted, as nappes.

Origin of Afşin magmatism

The amphibolitisation locally takes place in the rock units forming the Göksun metaophiolite, whereas amphibolite occurs widespread in them. The gabbros gradually pass into amphibolitized gabbro, amphibolite, migmatite, granulite and granitoids respectively in increasing order of metamorphic grade. The rocks of Göksun metaophiolite in which partial melting took place, indicate the presence of conditions of the regional metamorphism which took place in facies of low/high grade almandine-amphibolite (Winkler, 1967) and granulite (Escola, 1939). The original textures and structures were partly preserved in Elbistan ensimatic island-arc sediments overlying the Göksun metaophiolite with an angular unconformity, whereas the original minerals were partly converted into hornblende, actinolite, albite, sericite, epidote and calcite. In fact, some porphyroblasts of albite were developed in some samples (Tarhan, 1985). These mineral paragenesis indicate the presence of regionally metamorphosed fields which were developed in facies of green-schist and low-grade amphibolite in volcanic-arc sediments. Miyashiro (1961, 1972a) and Zwart (1967, 1969) suggested that these fields probably correspond to the volcanic belts which were developed in island-arcs and continental margins. An ophiolitic melange crops out in the southeastern part of the study area. According to the geological and petrological data, probably a pair of metamorphic belts were formed in the region. The study area probably corresponds to a metamorphic belt, which was formed by regional metamorphism of high temperature/low pressure. In other words, both the Göksun metaophiolite and the overlying Elbistan ensimatic island-arc sequence probably represent the region over the oceanic plate plunging along the Benioff zone. Miyashiro (*1972b)* suggested that both the metamorphites which were formed under the conditions of high temperature/low pressure and the granitic rocks, form the basement of a volcanic-arc which was developed in front of the plunging lithosphere. Oxburgh and Turcotte (1970) point out that the characteristic volcanism of subduction zones take place as a result of increasing heat currents. According to the opinions of these authors and the geological evidences obtained from this study, the presence of northwards (or northwesterly) subduction zone is apparent in the southern part of the study area.

Many hypothesis have been offered about the origin and the formation of acidic magmas. According to the dominant common opinion, the only continental crust may be subjected to partial melting and the acidic magma which has resulted from this process, form the granitic plutons. One of them, Winkler (1967) suggested that it is unlikely that acidic magmas are derived from any magma of gabroic composition by differentiation. For this reason, he proved experimentally that the rocks which have granitic, granodioritic and tonalitic compositions have been derived from metamorphic rocks (continental crust) by anatexis. However, some authors suggested that ultramafic and ultrabasic rocks might be subjected to partial melting, as a result of anatexis (Tuttle and Bowen, 1958; Rittmann, 1965; Winkler, 1967 and Bingöl, 1968).

In the study area, the presence of migmatite which was developed between gabbro transformed to amphibolite, and diorite-tonalite-granodiorite is observed. The migmatites occurred also at the contacts of the same granitoids with" both the rocks of continental crust and ophiolites, both of which were metamorphosed in the facies of almandine-amphibolite and granulite (Tarhan, 1986). On the basis of these relationships, the present-writer thinks that basic or ultrabasic rocks might be subjected to partial melting just like a continental crust and the anatectic magma which was formed by partial melting, might accumulate in situ or in the upper zones by filter-pressing prevailing in the environment and finally as a result of this accumulation, the intrusions of acid plutonic rocks might take place.

The probable sources of heat by which anatexis may take place in the rocks of oceanic crust are as follows: (a) Fields of high heat current which were generated in oceanic lithosphere forming the basement of the Elbistan ensimatic island-arc which was developed over the subduction zone (Oxburgh and Turcotte, 1970); (b) The sinking of the oceanic crust into depth, depending on the isostatic balance caused by the metamorphites which were thrusted as nappes, during the late Cretaceous. As to the probable sources of water needed for anatexis, they are as follows: (a) Ocean-floor metamorphism which provides considerable amounts of into the oceanic crust (Melson, Thompson and Andel, 1968; Miyashiro et al., 1971); (b) Chlorite (with content of H_2O 15 %) biotite and amphibole (with content of H_2O 2-3%) all of which were formed, as a result of regional metamorphism of high temperature/low pressure (Miyashiro, 1961, 1972b; Zwart, 1967, 1969) which took place in oceanic lithosphere forming the basement of island-arc and as a result of ocean-floor metamorphism.

The granitoids cropping out in the study area were formed by melting of the Göksun metaophiolite, the island-arc and the Kabaktepe metamorphites together or separately, depending on the crustal thickening, during the late Cretaceous. This anatectic magma defined as Afsin magmatism caused the development of granitoids by solidification in situ or by intrusion into the upper parts of the crust, depending on the pressures prevailing in the environment.

Age of Afşin magmatism

The granitoids cropping out in the study area, cut the Neocomian aged island-arc volcanoclastic sediments. They are covered by the Upper Cenonian (Campanian-Maestrichtian) sediments. The granitoids cut also the allochthonous Kabaktepe metamorphites which were emplaced in the region, after Neocomian According to the geological evidences, the age of Afşin magmatism is the time interval ranging from post-Neocomian to pre-Campanian (Fig. 2,3). The Baskil magmatism defined by Yazgan and Asutay (1981) and Yazgan (1983) in the vicinity of Malatya, forming the eastern extension of the study area is the magmatic equivalent of the Afşin magmatism. Coniacian-Santonian age (82-86 my.) obtained from K/Ar dating of these rocks coincides with the upper boundary of the acid plutonic rocks in the study area.

Based on these data, Coniacian-Santonian ? age (or Coniacian-Upper Santonian) can be assigned to Afşin magmatism.

Correlation between the rocks related to Afşin magmatism and the granitoids of Eastern Taurus

The granitoids cropping out to the north of Doğanşehir show similar relationships and features to the rocks related to Afşin magmatism. The rocks of Coniacian-Santonian age related to Baskil magmatism (granodiorite, tonalite, quartz-monzonite, monzonite, monzo-diorite, diorite and gabbro) which crop out in the vicinity of Malatya are considered to be products of magmatism of continental margin by Yazgan and Asutay (1981) and Yazgan (1983). These rocks are included in Yüksekova complex by them. They point out that these magmatic rocks out the Pötürge metamorphites and are covered by a volcanoclastic flysch of Campanian-Maestrichtian age. Many investigators have studied on the metamorphic rocks and the granitic rocks of Bitlis. One of them, Göncüoğlu (1983), claimed that the Muş-Kızılağaç granite is Middle Devonian-Lower Permian in age and was subjected to dynamothermal metamorphism, during the Lower Turonian. The Bitlis metamorphites and granitic rocks are overlain by Maestrichtian aged sediments with an angular unconformity (Meri9, 1973).

In the study area, there are from bottom to top, the Göksun metaophiolite, the Elbistan ensimatic island-arc sequence and the Kabaktepe metamorphic nappe which is thrusted over both of them. These rock units are cut by the rocks of Afşin magmatism of Coniacian-Upper Santonian? age. The isolated diabase dykes cut the granitoids and the rock units which are cut by the granitoids (Fig.3). All these rock units cropping out in the study area are covered by Campanian-Maestrichtian aged sediments with angular unconformities (Tarhan, 1984, 1985). The Kabaktepe metamorphites are the equivalents of Bitlis/Pötürge metamorphites (Tarhan, 1985). This structural relationship observed in the study area (see; the 1:500,000 scale geological map of Turkey) is observed also in the neighbourhoods of Malatya, Doğanşehir and Bitlis, all of which are located in the same belt. The

Muş-Kızılağaç granite cuts also the lower and upper associations (Boray, 1975) forming the Bitlis metamorphites (on the basis of the observations of the present writer). For this reason, the present writer thinks that it is unlikely that the Muş-Kızılağaç granite described by Göncüoğlu (1983) is Middle Devonian-Lower Permian in age.

Consequently, the rocks related to Baskil magmatism and the granitoids cropping out around Doğanşehir, Elazığ and Bitlis are the magmatic equivalents of the rocks related to Afşin magmatism. They were probably formed by intrusions of anatectic magma in different places and times, the generation of anatectic magma being as a result of melting of oceanic and continental crusts, together or seperately, as is seen in the rocks related to Afşin magmatism (Fig. 3).

GRANITIC ROCKS

A second type of rocks which have granitic composition and crop out extensively in Taurid belt and differ from the granitoids cropping out in the study area in some respects, such as mode of occurrence and place of occurrence, were named as granitic rocks and described, for the first time. These granitic rocks were derived from the same rocks consisting of ophiolite association (gabbro, sheeted dyke complex and volcanosedimentary deposits), island-arc volcanoclastic sediments and metamorphic rocks of sedimentary origin, as the granitoids which intruded in the area, and gradually pass into them. However, they don't show any intrusive features. They were formed by recrystallisation of the older rock units which were present then, with increasing grade of metamorphism. They contain relict bands, wedges, lenses, beds and fragments of the rocks from which they were derived. They show gradual transitions to relict formations which are included in them. Since the granitic rocks were developed along the bedding and foliation planes of the older rocks which were present then, due to the recrystallisation, and didn't pass through any magmatic stage, the bedded and foliated structures of parent rocks as well as the original tectonic and stratigraphic relationships between the parent rocks were preserved identically. These rocks formed by recrystallisation show similar compositions to those of parent rocks. In addition to the presence of dykes and veins of quartz observed locally in them, the presence of dykes and veins of acidic and basic compositions, cutting the granitic rocks is noticeable. In other words, due to the probable inefficiency of P/T conditions of regional metamorphism, any anatexis didn't take place in parent rocks (ophiolites, metamorphites, volcanosedimentary deposits) transformed to granitic rocks. Since they didn't pass through any magmatic and crystallisation stages, they were transformed to granitic rocks (diorites, monzonites, syenites, granodiorites, granites, alkaline granites and their derivatives) by recrystallisation in a solid phase.

In the study area, from the metamorphic rocks of pelitic origin in which the lower grade metamorphism took place towards the granitic rocks, the presence of metamorphic rock units metamorphosed in the facies of Barrovian green-schist, low grade amphibolite, high grade amphibolite and granulite, respectively, is observed. In places where these metamorphic rocks crop out, it was observed in both petrographic and field studies that these metamorphic rocks gradually pass into granitic rocks. The paragenesis of hornblende-plagioclase, disthene-sillimanite-orthose, almandine-sillimanite-orthose and monocline pyroxene-quartz are seen in metamorphic rocks of these transitional zones. These mineral paragenesis generated under conditions of high pressure/temperature are followed by the generation of paragenesis of cordierite-orthose-sillimanite, andalusite-orthose-plagioclase, cordierite-orthose-plagioclase, all of which characterize the conditions of low?-moderate pressure/high temperature. However, the principal stable minerals are blue-green amphiboles and orthose in this field. It is noticeable that sillimanite, garnet arid monoclinic pyroxene completely disappear in this field where granitisation starts taking place. As a result of this, andalusite, biotite, muscovite, chlorite, epidote, tremolite, calcite and quartz arise depending on metamorphic grade. Plagioclases are partly or wholly replaced by albite, orthoclase, microclane and quartz. These replacements gradually take place. According to these mineral paragenesis, the progressive Barrovian type metamorphism which took place under the conditions of high pressure/temperature is followed by Abukuma type metamorphism in which the conditions of low?-moderate pressure/high temperature prevailed.

In field studies, it is observed that the metamorphic rocks which were subjected to high grade metamorphism, pass into the granitic rocks which are medium-coarse grained, granulitic (mosaic) textured and enriched in leucocratic minerals, as a result of gradual disappearance of metamorphic textures and structures, and migmatite was developed at the contacts between them. The fact that the blue-green amphiboles maintained their stabilities, during the metamorphism of cordierite-amphibolite facies following the facies of almandine-amphibolite and granulite, indicates that the hydraulic pressure of the environment was high, then (Winkler, 1976). In spite of the presence of sufficient water and temperature in the environment, following the regional metamorphism in the facies of almandine-amphibolite and granulite, the absence of partial melting can be possibly attributed to decrease in pressure. The mineral paragenesis generated, as a result of the regional metamorphism of high pressure/temperature, lose their stabilities, and change with decreasing pressure. They interact in solid state and are transformed to the other mineral groups, being stable in new conditions. Although the effects of pressure are insignificant, the presence of temperature which is high enough, probably caused the crystal grains of the metamorphic rocks to separate from eachother, by growing, as a result of recrystallisation and at the same time, to be transformed to granitic rocks in situ by enrichment in leucocratic minerals. The granitisation took place also in the rocks of ophiolite association in similar conditions.

Biotite is generally observed in metamorphic rocks of sedimentary origin granitoids and granitic rocks derived from them. According to the petrography studies, biotites generally occurred in genetic relationship with opaque minerals. The minute opaque minerals (iron oxides) which were developed along the cleavages of chlorite derived from pyroxenes and amphiboles, were altered to reddish-brown opaque material in green-schist facies. It is observed that this material entered into the lattice of chlorite and made it convert into biotite, partly or wholly (depending on the alteration of opaque material). Biotite isn't seen in granitoids derived from rocks of ophiolite association by granitisation or by partial melting. However, it can be seen in granitoids derived from hybrid anatectic magmas which were generated by melting of oceanic and continental crusts, together (H type granitoids).

Consequently, according to the view of the present writer, the regional metamorphism which took place in cordierite-amphibolite facies, following the regional metamorphism which took place in almandine-amphibolite and granulite facies, and probably caused the granitisation, resulted in the formation of granitic rocks which have different mineralogical compositions and show lateral and vertical transitions to eachother and present alternating and napped structures, depending on the original compositions, stratigraphy and tectonic relationships of metamorphic rocks.

CONCLUSIONS AND DISCUSSION

The fact that the Neocomian ensimatic island-arc sequence overlies the Göksun metaophiolite cropping out in the study area and that the rifting related to the opening of the southern branch of Neo-Tethys begins, during the Upper Triassic (Friedman et al., 1971; Goldberg and Friedman, 1974; Şengör and Yılmaz, 1983), reveals that the Göksun metaophiolite is a part of a Middle?/

Upper Triassic-Jurassic aged oceanic lithosphere which continued its spreading during the Jurassic and reached its maximum spreading probably during the Middle Jurassic. However, Whitechurch et al., (1983) emphasized the absence of the Jurassic oceanic crust in Taurid belt and offered two alternative solutions as follows: (a) Ocean-floor spreading couldn't take place during this period; (b) The part of Neo-Tethys in this period has been consumed, as a result of subduction. The geological evidences obtained from the study area, reveal that an oceanic crust exists in Taurid belt extending in the southern branchof Neo-Tethys and it hasn't been wholly consumed by subduction (Tarhan, 1983).

Arabian-African plate probably continued moving northwards after the Neocomian. The north-south compressional forces which have resulted from this phenomenon, caused the Kabaktepe metamorphites to be thrusted over both the Göksun metaophiolite and the Elbistan ensimatic island-arc sediments, during the late Cretaceous. The phenomena which happened, during the late Cretaceous, probably caused the crustal thickening and the closure of the southern branch of Neo-Tethys.

Many investigators who have studied in Taurid belt (Blumenthal, 1952; Aslaner, 1973; Sungurlu, 1974; Lapierre, 1975; Özgül, 1976; Gutnic et al., 1979; Özgül et al., 1981; Yazgan 1983; Whitechurch et al., 1985) suggested that the ophiolite and the metamorphic nappes were emplaced in the region during the Maestrichtian or later. Tarhan (1983, 1984) point out that the Upper Cenonian (Campanian-Maestrichtian) sediments have transgressive features and had obtained detritic materials from the underlying rock units (ophiolites, metamorphites and granitoids). According to this evidence although the presence of ophiolites and metamorphic nappes emplaced, during the Maestrichtian is known in Taurid belt, at least pre-Upper Cenonian (Campanian) aged ophiolites, metamorphites, island-arc sediments and an acidic magmatism cutting all of them, had existed in the study area. According to these data, there are two alternative solutions as follows (Fig. 1,2,3):

1. The closure of the southern branch of Neo-Tethys took place during the late Cretaceous. The metamorphic and ophiolites nappes of Taurid belt were emplaced during the late Cretaceous (at least pre-Cenonian), for the first time, but not during the Maestrichtian.

2. The Göksun metaophiolite forms the basement of the rock units cropping out in the study area. It is unknown that what types of rocks are present at the bottom of this ophiolite. Since both the Göksun metaophiolite and the overlying island-arc sequence have preserved their original relationships and internal structures well, against the tectonic deformations, they are considered to be autochthonous (or parautochthonous) units.

There are two groups of grankic rocks which their place of formation and mode of formation are different from eachother in Taurid belt. The rocks belonging to the first group are granitoids which crop out widespread in Eastern Taurus and in the study area and intrude the enclosing rocks. They aren't formed by differentiation of a magma having gabroic (or basaltic) composition. They were generated by gradual anatexis of rocks of oceanic crust, island-arc sediments and rocks of continental crust, with increasing of high temperature regional metamorphism (almandine-amphibolite and granulite facies) accompanying the Medium/high pressures. Granitoids commonly show gradual transitions to eachother and form regular series. Monzonite, syenite and their derivatives are generally seen in marginal facies of the granitic rocks generated by partial melting of metamorphic rocks of sedimentary origin. Except for quartz, feldspar and plagioclase, the mafic minerals which are included in granitoids are related to parent rocks (Fig. 1,2).

1. The granitoids formed by partial melting of the rocks of oceanic rock, contain no mica, whereas they contain hornblende, amphibolitized pyroxene and opaque minerals. They show similar characteristics as I type granitoids (Didier et al., 1982; White and Chappell, 1977).

2. The granitoids derived from hybrid anaitectic magma by melting of rocks of oceanic and continental crusts together, contain hornblende, amphibolized pyroxene, pyroxene, mica (biotite, muscovite) and opaque spinel group of minerals. For this reason, they are named as hybrid granitoids (H type granitoids) by the present writer, for the first time.

3. The granitoids formed by partial melting of metamorphic rock of sedimentary origin, contain only mica of mafic minerals. They show similar characteristics as S type granitoids (Didier and et al, 1982; White and Chappell, 1977).

The second group of rocks are called as granitic rocks. Their outcrops are scarce in Eastern Taurus. They were derived by recrystallisation of the same parent rocks (ophiolite, volcanic-arc sediments and metamorphic rocks) with increasing regional metamorphism, as is seen in granitoids. Since they didn't pass through any magmatic stage, they don't show any intrusive and contact metamorphic features. Aplite, pegmatite and isolated diabase dykes aren't seen as cutting this type of granitic rocks. They show gradual transitions and similar compositions to parent rocks, and have some relict structures.

Consequently, the oceanic crust should sink into depth, depending on the crustal thickening and isostatic balance which were developed by collision over the subduction zone, for the formation of rocks related to Afşin magmatism. Since the regional compressional forces probably cause the developement of regional tensional forces, during the collision, the weak zones are formed (Turcotte, 1983). The same granitoids cropping out in the study area were formed by partial melting (or complete) of rocks belonging to continental and oceanic crusts, both together and separately. Therefore, the meltings which had been derived by anatexis of oceanic and continental rocks (metamorphites, island-arc sediments), together or separately in different places and depths, caused the development of an anatectic magma. This anatectic magma has risen upwards along the weak zones, by the effects of high pressures in the environment, intruded the upper parts of the crust in different places and depths and finally formed local contact metamorphic zones in country rocks. The high grade differentiation of this anatectic magma defined as Afşin magmatism, caused the granitoids (diorite, monzonite, syenite, tonalite, granodiorite, granite, alkaline granite, silexite and their derivatives) which intruded in different periods, to be formed.

The fact that the intrusive granitoids and non-intrusive granitic rocks occur so widespread, both in Turkey and in the other parts of the world, can't be explained only by melting of continental crust, as a result of anatexis and by differentiation of a primary gabroic (or basaltic) magma. It is concluded that they were mostly formed either by recrystallisation (granitic rocks) or by melting (granitoids) of continental and oceanic rocks and volcanic-arc sediments, in situ, with increasing of regional metamorphic grade.

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PLATE

PLATE -I

Fig. 1 — Metatexites migmatite observed in gabbros
Gr—Neosome (granite); A—Paleosome (amphibolite).

Fig. 2 — Diatexites migmatite observed in gabbros
Gr—Neosome (granite); A—Paleosome (amphibolite).

Fig. 3 — Metatexites migmatite observed in gabbros
Gr—Neosome (granite); A—Paleosome (amphibolite).

Fig. 4 — Diatexites migmatite observed in marbles
Gd—Neosome (granodiorite); Mr—Paleosome (marble).