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THE METAMORPHISM AND THE RELATIONSHIP BETWEEN INFRA AND SUPRASTRUCTURES OF THE BİTLİS MASSIF - TURKEY

Metin ŞENGÜN*

ABSTRACT.- The infrastructure of the massife consists essentially of amphibolites, gneisses and micaschists intruded by a biotite granite and the successive hololeucocratic phase. The mantling rocks of the suprastructure comprise metapelitic rocks unconformably underlying metacarbonates dated as Middle Devonian- Mesozoic. The infra-suprastructure boundary is interpreted as a surface of transgressive overlap. The rocks of infra and suprastructure are involved in isoclinal folds with ductile deformation along most of the boundary conclusively suggesting in situ position of the suprastructure during the Alpine deformation. The shear planes are discontinous, en echelon and run independent of the infra-suprastructure boundary. A uniform sequence of Palaezoic rocks, which is not intruded by the granites of the infra-structure, together with the infra-suprastructure boundary being a sedimentary contact, are conclusive evidence for the existence of a Precambrian event. Eradication of Precambrian paragenesis occurs in the flanks of major folds where a complete Alpine zoning exists from very low grade to anatectic conditions as exemplified by the Kesandere section in contrast to the preservation of Precambrian parageneses in the unsheared competent rocks of the infrastructure of the hinge areas. There is no gap in physical conditions with regard to a single episode of deformation. The gap occurring between the infra and the suprastructure is due to different physical conditions of Precambrian and Alpine deformations. Retrograde effects are presumably due to an Alpine imprint on the Precambrian parageneses, whereas they are attributed to a continous process of deformation with conternparaneous uplift and progressive dimunition of physical conditions in the case of imprint on early Alpine parageneses. The interpretation herein presented in relation to nature of infra and suprastructure boundary and metamorphism of Bitlis massive is consistent, for all aspects, with the regional geologic data showing that it is the deformed Alpine passive margin of the Arabian plate.

INTRODUCTION

This paper aims to discuss and interpret some of the topics of debate with emphasis on the nature of the infra-suprastructure boundary and the history of deformation of Bitlis massif, southeastern Turkey. The presented argument is part of a doctorate thesis (Şengün, 1984) carried out in the Hacettepe University, Ankara. The area of investigation (Fig.1) was selected on the north-western hinge of a major structure following a preliminary investigation.

The earliest work related to the topics discussed in this paper was by Yılmaz (1971) who, on the basis of Rb-Sr isotopic data obtained from amphibolites (920±224 m.y.), paragneisses (596±89 m.y.) and granites (325±3 m.y. with re-interpretation (Yılmaz et. al., 1981) to 570 m.y.), suggested that the infrastructure was the Pan-African basement unconformably overlain by a low grade metasedimentary cover. Hall (1976) suggested that an oceanic domain to the south of Bitlis massif was consumed by Miocene through northward subduction. Existence of such an ocean known as the, southern branch of Neotethys (Şengör and Yılmaz, 1981) resulted in a sceptical look on the sedimentary nature of the infra-suprastructure boundary (Yılmaz, 1971). It is unavoidable that the suprastructure, Paleozoic-Mesozoic in age, is allochtonous if the infrastructure of Bitlis is the active margin of the suggested ocean. This will help to explain why the low grade Alpine metamorphism do not eradicate the earlier deformations. However, investigations by Erdoğan and Dora (1983), Yurtsever et. al. (1983), Çağlayan et. al. (1984) and Genç (1987) brought in explicit information about the sedimentary nature of the primary boundary between the infra and the suprastructure, conforming with the earliest suggestion of Yılmaz (1971). The fact that granites of the infrastructure is unconformably capped by Permian sedimentation (Göncüoğlu and Turhan, 1985) and radiometric dating of Yılmaz (1971) and of Helvacı (1983) are further evidence supporting this interpretation. This paper defends that the infra-suprastructure boundary is a sedimentary contact corresponding to an angular unconformity of Precambrian age with transgressive onlaps during Early Paleozoic.

Polymetamorphic nature of Bitlis is generally accepted (Boray, 1973; Mason, 1975, Hall, 1976).

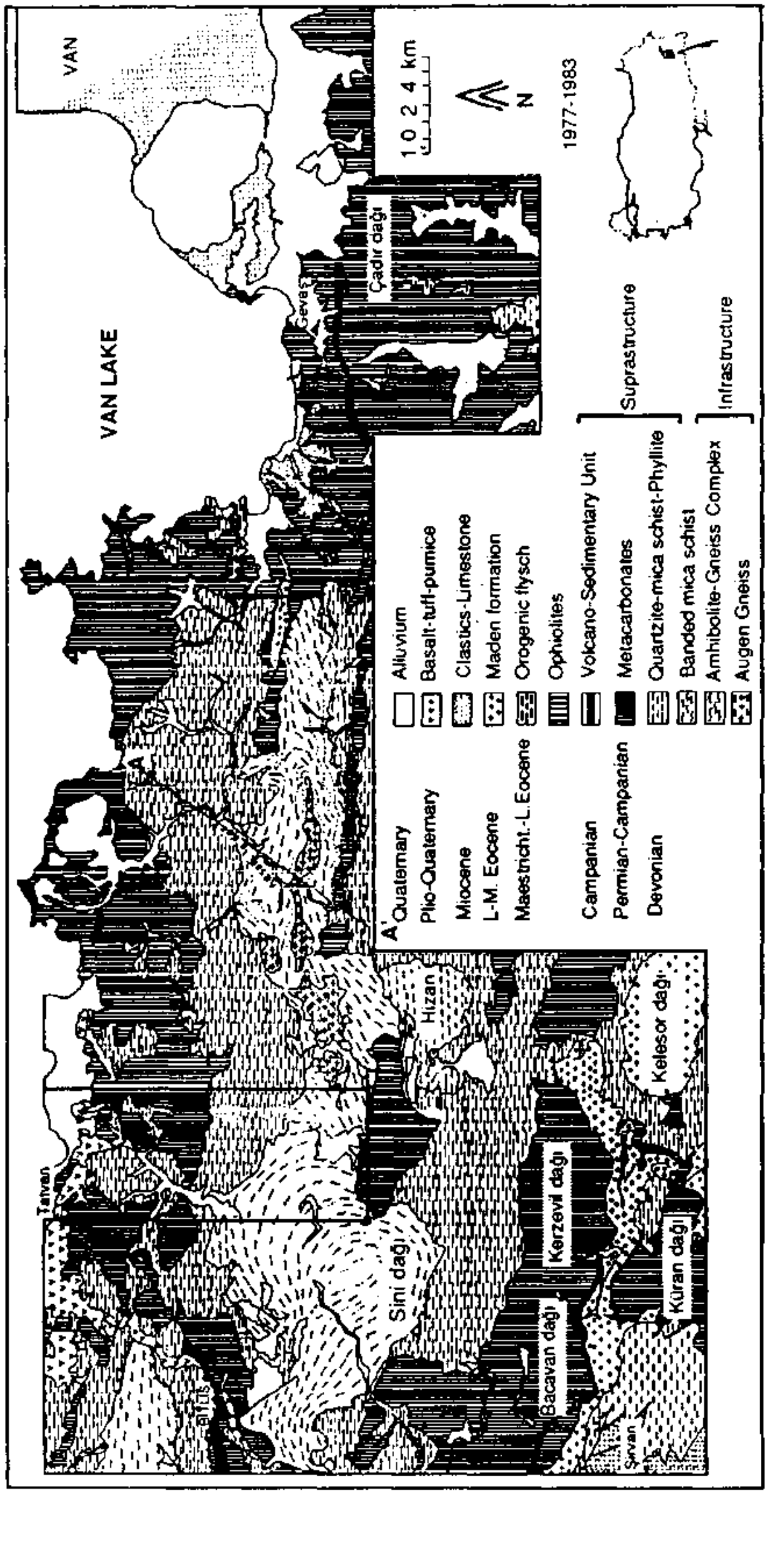

Fig. 1- Location map showing locations of the investigated area and the Kesandere section shown of the map compied by Çağlayan et. al. 1984.

STRATIGRAPHY

The rock sequence consists of a basement complex (Yolcular fm.) unconformably overlain by a sedimentary mantle (Kotum group). The basement complex consists essentially of amphibolites, microcline gneiss, biotite gneiss/schist and musccvite gneiss/schist intruded by a biotite granite succeeded by a hololeucocratic aplitic-pegmatitic phase. The suprastructure is subdivided into Kuytu, Arpik and Nasurdağı formations (Fig. 2).

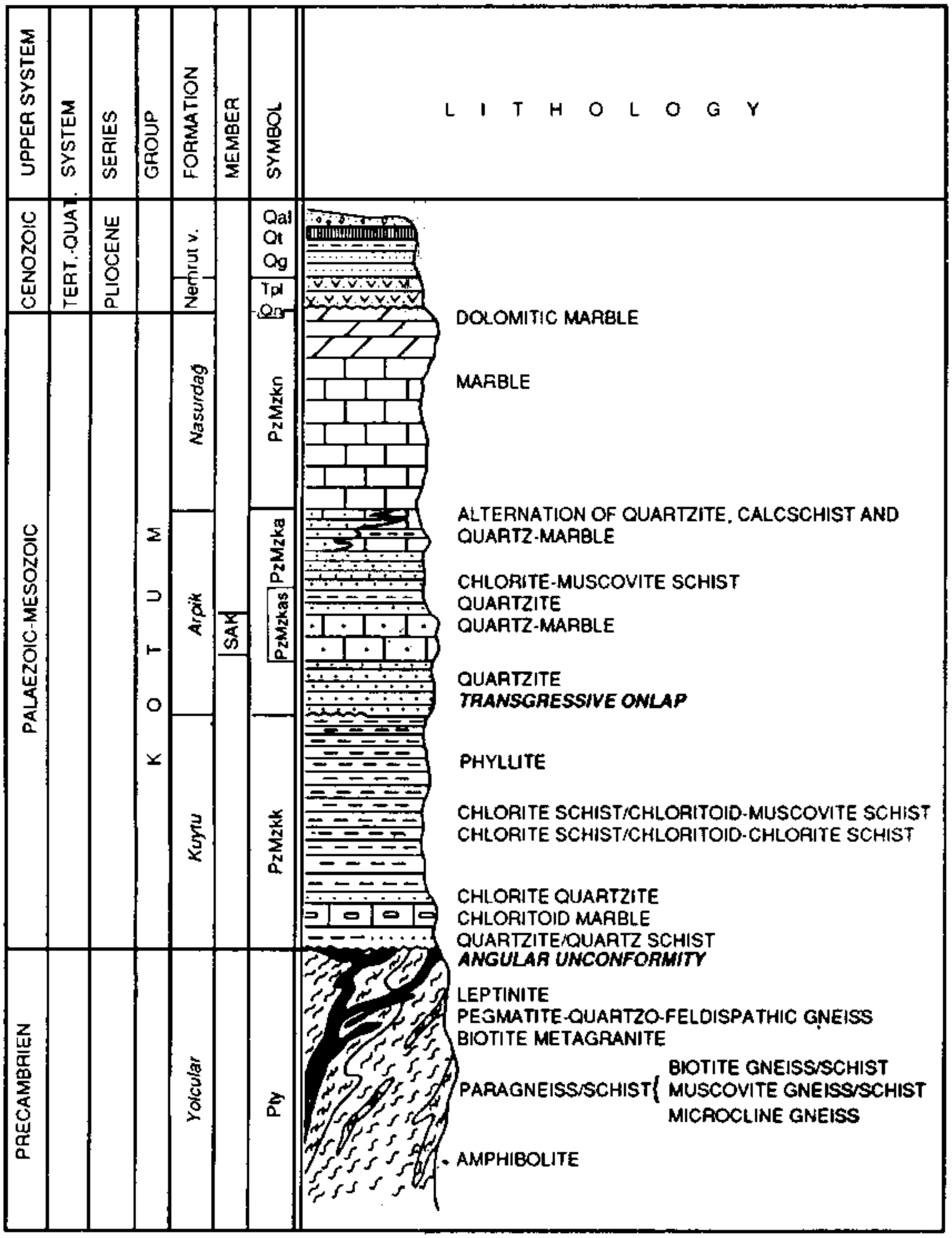

Fig. 2- Generalised columnar section of the investigated area.

Yolcular formation

It consists of the rock types briefly described below.

Amphibolite— It occurs as massive bodies of various shapes dissected by granitic and pegmatitic dykes showing isoclinal folding. Lenticular masses, up to a few meters in diameter, are commonly seen. The hand specimen is generally massive showing occasional incipient foliation. Actinolitization and chloritization are common along shear planes. The generalised paragenesis is:

Hornblend+Quartz+Oligoclase+Alkali feldspar+Garnet±Rutile±Biotite±Magnetite±Apatite

Hornblend is nomenclated as "Ferroan Pargasite - Ferroan Pargasitic Hornblend" according to Leake (1978). The massive amphibolite has been converted, along Alpine shear zones, into well-foliated rocks with a strong b-lineation with the generalised paragenesis of

Actinolite+Quartz+Albite+Epidote+Mg-Chlorite ±Sphene±Biotite±Magnetite

Paragneiss/schist The rock types included comprise microcline gneiss, muscovite gneiss/schist and biotite gneiss/schist showing compositional banding that form an alternating series showing sharp boundaries with respect to rock fabric, texture and colour. A rough generalization of respective parageneses of these rock types are as follows

Quartz + Albite (or Oligoclase) + Microcline + Garnet + Biotite ±Epidote± Zircon ± Sphene

Quartz + Albite (or Oligoclase) + Alkali feldspar + Muscovite ± Biotite ± Zircon ± Sphene

Quartz + Albite (or Oligoclase) + Alkali Feldspar + Biotite + Muscovite + Garnet + Mg-Chlorite ± Zircon ± Sphene

These rock types show appropriate variations in mineral assemblages with respect to metamorphic grade. Kyanite and incipient growths of sillimanite (Fig. 3) are observed in

Fig. 3- Kyanite sillimanite association in biotite gneiss. (1.2x1.8 mm), plane light.

several localities where anatectic conditions prevailed (Fig. 4). Staurolite porphyroblasts (Fig. 5) are also observed in biotite gneisses of favourable bulk compositions in the Kesandere section (Fig. 12).

Granitic Rocks of the Infrastructure- The amphibolites, paragneisses and micaschists of the basement complex are intruded by a biotite metagranite followed by its hololeucocratic phase. The

Fig. 4- Pytigmatic veins in biotite gneiss.

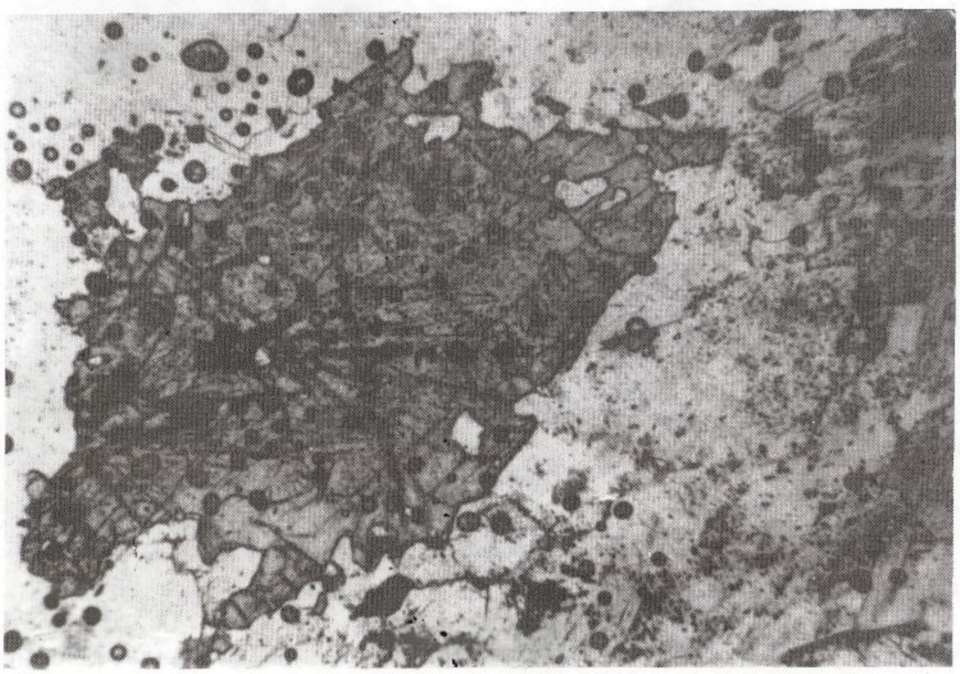

Fig. 5- Staurolite megacrystal in garnetiferous micaschists (3.2x4.8 mm.), plane light.

biotite metagranite, correlated with the augen gneiss of the northern flank of the major anticlinorium, is dissected by dyke swarms of quartzo-feldispathic gneiss and metapegmatites. Leptinites, locally preserving their original texture, constitute the uppermost unit of the basement complex and are interpreted as the extrusive equivalents of the granite that is post-tectonic with respect to the Pan-African event.

Biotite granite is a coarse grained, holocrystalline rock of hypautomorphic texture, generally having a quartz monzonitic composition. A break cleavage, mutually dissecting amphibolite lenses, biotite granite and the leucocratic dykes, shows a progressive change to flow cleavage of the augen gneiss through an intermediate stage of shear cleavage. Granitic origin of the augen gneiss is also supported by the petrochemical analyses of Genç (1987). The dykes of the leucocratic phase show isoclinal folding resulting in boudinage of amphibolites (Fig. 6) and other associated basement rocks. The metapegmatites consist essentially of quartz with minor kyanite, dumortlerite, tourmaline and topaz suggesting the effectiveness of a volatile phase (Fig. 7).

Kotum Group

The suprastructure, nomenclated as the Kotum group, is subdivided into Kuytu, Arpik and Nasurdağı formations.

Kuytu formation is composed essentially of phyllites and chlorite schists with the generalised parageneses of:

Quartz + Chloritoid + Muscovite + Chlorite + Pyrite+Fe-rich carbonate (Fig.8).

Quartz + Chlorite + Muscovite + Albite + Pyrite

Calcite + Dolomite + Chloritoid ± Quartz ± Muscovite + Chlorite

Quartz + Albite + Muscovite ± Chlorite ± Tourmaline,

Arpik formation consists essentially of interfingering quartz schists and quartzites showing occasional wave ripples and cross bedding. Sak member consists essentially of medium to thick bedded quartz marbles with occasional intercalations of shale. The generalised parageneses of the Arpik formation and of the Sak member are respectively given below.

Fig. 6- The relation between amphibolite and quartzo feldispathic gneiss.

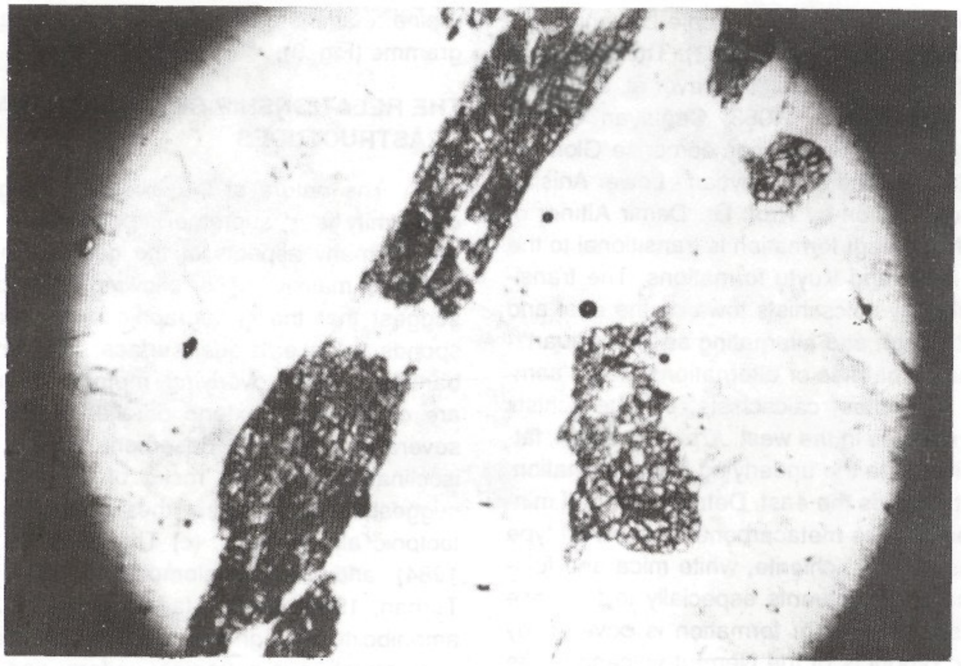

Fig. 7- A dumortierite megacrystal in metapegmatites. (3.2x4.8 mm.), plane light.

Fig. 8- Chloritoid micaschist. (3.2x4.8 mm.), plane light.

Quartz + Albite + Microcline + Muscpvite + Biotite ± Zircon ± Apatite ± Tourmaline

Calcite ± Doldmite ± Muscovite ±Chlorite ± Quartz ± Feldspar

Nasurdağı formation, a metacarbonate sequence thickened due to isoclinal folding, constitutes the uppermost section of the suprastructure. It is dated as Middle Devonian - Mesozoic(?). The base of the sequence yielded Middle Devonian corals (Göncüoğlu and Turhan, 1983). The sequence comprises fusulinid species (Yurtsever et. al., 1983; Göncüoğlu and Turhan, 1983; Çağlayan et. al., 1984). The dolomitic limestones comprise Glomospirella Facilis Ho., and are Schytian - Lower Anisian in age (determination by Prof. Dr. Demir Altıner of M.E.T.U.). Nasurdağı formation is transitional to the underlying Arpik and Kuytu formations. The transition is fulfilled by calcschists towards the east and is realised through and alternating series of quartzites and quartz marbles or alternations of any combination of quartzites, calcschists, chlorite schists and quartz marbles in the west. Arpik formation, laterally transitional to the underlying Kuytu formation, wedges out towards the east. Detrital rock and mineral fragments in the metacarbonates show all type of variations. Quartz, chlorite, white mica and feldspar are major constituents especially in the case of calcschists. Nasurdağı formation is covered by the volcanic products of the Nemrut volcano in the investigated area.

The Kotum group is dissected by aplite arid, diabase dykes that are implicitly considered to be feeders of the Eocene volcanism (Çağlayan et. al., 1984) A tentative attempt is made to show the pre-Alpine relations of the Kotum group on a block diagramme (Fig. 9).

THE RELATIONSHIP BETWEEN INFRA AND SINFRASTRUCTURES

The nature of the existing cartographic unconformity is of supreme importance in interpretation of many aspects of the geologic evolution of the Bitlis massive. The following field observations suggest that the cartographic unconformity corresponds to an erosional surface, (a) Compositional banding of the overlying metasedimentary rocks are observed to extend parallel to the contact at several localities, (b) Basement rocks show mutual isoclinal folding with rocks of the suprastructure suggesting conclusively the impossibility of post-tectonic allochtoneity. (c) The quartzites (Şengün, 1984) and metaconglomerates (Göncüoğlu and Turhan, 1985) contain fairly rounded fragments of amphibolite and gneiss, (d) The sequence of the suprastructure is extremely uniform and represents a complete and undissected sedimentary wedge

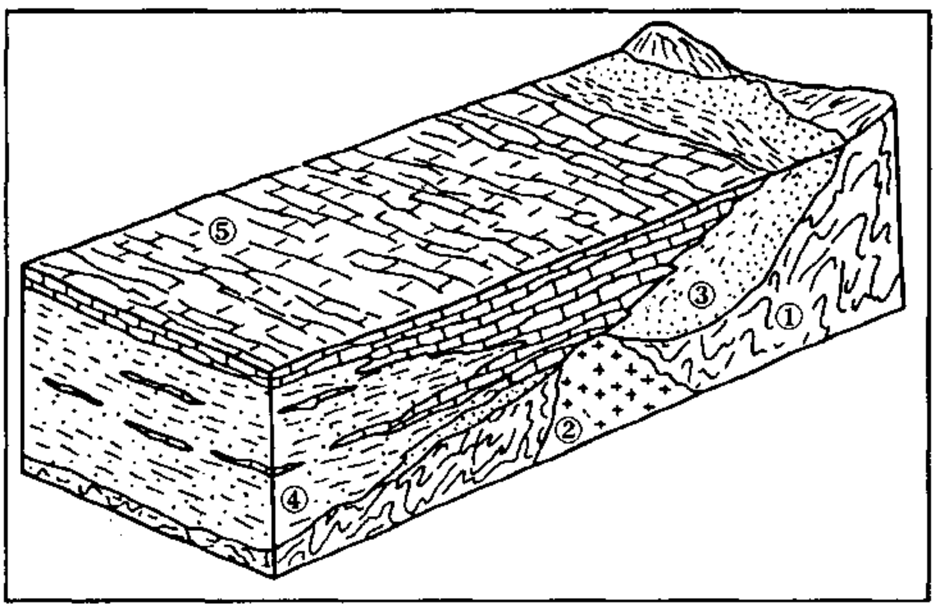

Fig. 9- Block diagramme showing the pre-Alpine relations of the Kotum group. 1. Precambrian basement 2. Granite 3. Kuytu formation 4. Arpik formation 5. Nasurdağı fm.

(Fig. 9). (e) The shear planes dissect mutually rocks of the basement and of the suprastructure implying syntectonic movements are independent of the primary sedimentary contact.

The extreme resemblance of the suprastructure to the Arabian platform (Çağlayan et. al., 1984) implies an erosional surface of Precambrian age with transgressive overlaps during the Early Palaezoic. The uniformity of the sedimentary wedge implies that pre-tectonic allochtony is also unlikely.

THE METAMORPHISM

There has been no dispute, so far, on the polymetamorphic nature of the Bitlis massive. However, timing of deformational episodes is either vague or controversial.

If the infra-suprastructure boundary is assumed to be primarily a sedimentary contact, there is one single path of deductive reasoning. (1) The granitic dykes showing isoclinal folding are pre-Devonian, in fact Precambrian in age on consideration of regional geologic data. (2) The associated country rocks display a medium to high grade metamorphism suggesting that they were deformed prior to the granitic intrusions. (3) There have been at least two episodes of metamorphism, one. predating the Precambrian intrusions and the cither postdating Palaezoic-Mesozoic sedimentation.

The field evidence cited beiow is complementary to the deductions presented above, (a) There is a large gap of physical conditions between the Pan-African granites and those of the amphibolites and the biotite gneisses. The metamorphism of the former can be correlated with that of the suprastructure. The incipient gneissic foliation of the granitic rocks is penetrative into other basement rocks with crystallisation of chlorite and white mica along the mutual cleavage planes which show a complete gradation from a break cleavage in the investigated area to the flow cleavage of Kesandere region through an intermediate stage of shear cleavage. (It is not possible to confuse the Precambrian granitic dykes with the seldom occurring post-Alpine granitic rocks that are distinguishable by their discordant relations to the country rock and their undeformed nature (Fig. 10). (b) The low grade parageneses seen in the peripheric shear planes of the amphibolite boudins correlate well with those of the hosting phyllites and chlorite schists with regard to the grade of metamorphism as well as the penetrative cleavage.

Fig. 10- Alpine aplite dyke. Note the discordant relation to the regional grain.

The physical conditions of the Precambrian event is deduced from the following observations in the anatectic areas outside of the investigated area. The quartzo-feldispathic gneiss shows incipient foliation penetrating to the S2 planes of the biotite gneiss and the amphibolite. The following parageneses belong to the microlithons enclosed between the referred cleavage planes of amphibolites and biotite gneisses.

Hornblend + Oligoclase + Quartz + Garnet ± Rutile

Biotite + Quartz + Muscovite + Garnet + Oligoclase + Orthoclase + Kyanite ± Sillimanite ± Zircon

The physical conditions, atributed to the Precambrian event necessarily following the discussion given above, must be a little higher than the value suggested by the triple junction of the Al_2SiO_5 polymorphs. The temperature and the hydrostatic pressure at this locality was read from the intersection of kyanite-sillimanite boundary (Winkler, 1976) with curves A (Storre and Karrotke, 1971) and B (Tuttle and Bowen, 1958) giving the respective values of

650 C at hydrostatic pressures of 6.5 kbars, and 630 C at hydrostatic pressures of 6.2 kbars (Fig. 11).

Other parageneses of the amphibolites and of the biotite gneisses suggest physical conditions of the medium grade and the minimum physical conditions correspond, probably to that of the epidote amphibolite facies as suggested by the paragenesis:

Quartz + Biotite + Muscovite + Mg-Chlorite + Garnet + Albite

The physical conditions of the Alpine metamorphism varies from very low grade to probably "biotite in" isograde in the investigated area. However, in the northern flank of the major structure, a complete Alpine zoning occurs with total eradication of the Precambrian parageneses. This interpretation is deduced from the stratigraphic and structural characteristics of the Kesandere section (Fig. 12). The core of the section consists essentially of an augen gneiss, correlated to the biotite granite in its lateral extension, with minor boudins of garnetiferous amphibolite. Kyanite bearing biotite gneiss is also encountered in the core of the section. This assemblage is overlain by quartzites that laterally grades into the Sallıca marble (Yurtsever et.al., 1983) and micaschists. The sequence continues with phyllites and the Palaeozoic-Mesozoic carbonates. Sallıca marble repeats itself in all of the met-

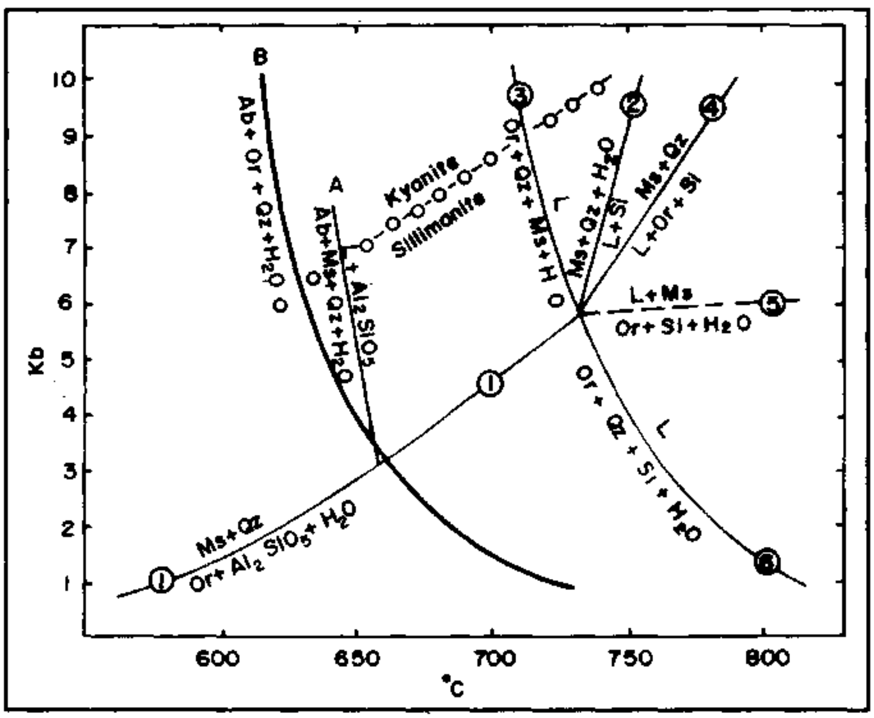

Fig. 11- Reactions between quartz, muscovite and feldspar (after Winkler, 1976).

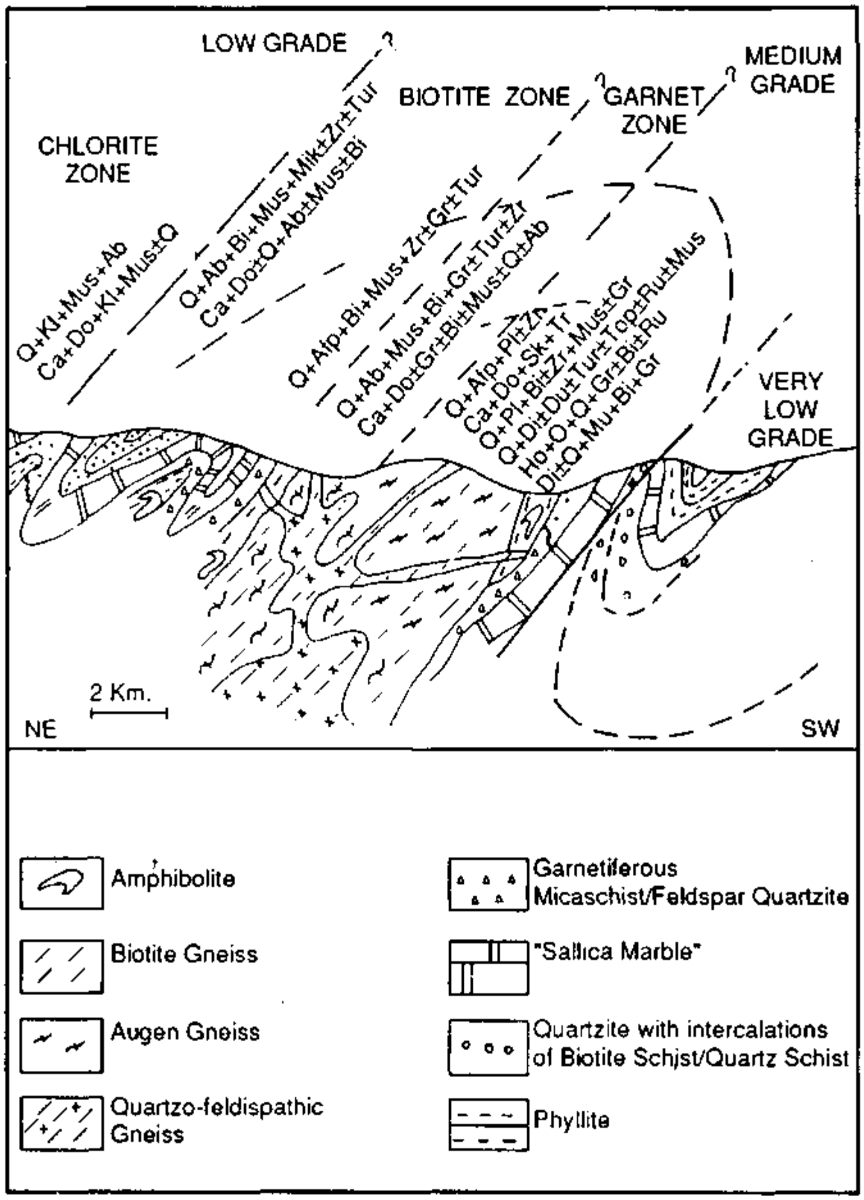

Fig. 12· Structural and metamorphic characteristics of the Kesandere section.

amorphic zones through isoclinal folding. The continuity of the Sallıca marble is accepted as conclusive evidence for progressive variation of physjcal conditions. The metamorphism has to be Alpine in age as the section comprises Mesozoic rocks in its uppermost part.

The Alpine deformation is progressive in time and space. The isogrades dip north in Kesandere, are independent of the lithology and are parallel to the axial planes of isoclinal folds. The early foliation planes were subject to multistage shear resulting in multidirectional cleavage. The cross-sectional shortening, strikingly well-defined in the medial parts of the major structure compared to the western hinge (Fig. 1), is a clear illustration that the intensity of deformation is also controlled by the geometry of the major structure. In other words, flanks of folds are extremely sheared in comoarison to the hinges.

DISCUSSION AND CONCLUSION

The presence of a Mesozoic sequence correlating well with that of the Arabian platform (Çağlayan et.al., 1983), and the Eocene sediments mutually covering the Bitlis massif and the ophiolites (Çağlayan et.al., 1984), may be regarded as conclusive evidence for in situ position of the Bitlis massif, implying that it is the northern extension of the Arabian platform (Özkaya, 1982; Yazgan, 1984) during the Mesozoic, also implying non-existence of an oceanic domain south of Bitlis. Undeformed nature of Mesozoic-Tertiary sedimentary units of the northern margin of border folds and the progressive dimunition of intensity of Alpine deformation are complementary evidence for non-existence of an ocean south of Bitlis. On the other hand, the presence of an undeformed Cretaceous-Tertiary sequence to the north of Lake Van and its incorrelatable nature with medial Eocene syndeformational sedimentation (Maden formation) of northern Bitlis complemented by the presence of undeformed units in East Anatolia, shows that Neotethys lied in immediate north of Bitlis. There has been an extensional regime in southern parts of Bitlis coeval with Alpine deformation of the northern segments. This is ascribed to block rotations to close up the relicts of Neotethyan domains. However, northward movement of the Arabian plate (McKenzie, 1972) put a brake on rifting of the Maden-Çüngüş foredeep before break-up of the continental crust. Planes of movement were subject to Alpine deformation (post-Eocene) while medium grade (Winkler, 1976) metamorphism of the lithons were mostly preserved.

It may, thus, be said in conclusion:

1- The cartographic unconformity between infra and suprastructures is an angular unconformity of Precambrian age, showing transgressive overlaps during Early Palaeozoic.

2- An Alpine metamorphism, eradicating all pre-Alpine deformations, with physical conditions varying from very low grade to anatectic conditions, is exemplified (Fig. 12) and it is suggested that the Alpine deformation loses its intensity towards the south, in fact, there is a co-existing distensional regime in the southern segments. The effectiveness of Alpine deformation has been controlled by structural elements such that the rock cleavage is penetrafive into the basement in crestal areas, representing mutually the retrograde metamorphism of the basement and the very low grade metamorphism of the suprastructure. The Alpine metamorphism is restricted to the shear planes while Precarnbrian parageneses are preserved in the lithons.

3- The infrastructure of Bitlis massive is not an active Alpine margin. In case it is transported (Şengör and Yılmaz, 1981) prior to Alpine deformations, the suprastructure has to be transported after the Alpine deformation so that the granites can be Alpine in age. In other words, magmatism of the continental margin should dissect the infra and suprastructure mutually. Radiometric data (Yılmaz, 1971; Helvacı, 1983) also supports the fact that granites belong to the Pan-African basement. The following basic evidence is conclusive to show non-existence of a south-lying oceanic domain that was consumed with northward polarity, between Cretaceous and Miocene (Hall, 1976).

a- The Mesozoic-Tertiary units of the northern segments of the border folds are entirely undeformed.

b- The Mesozoic units reported from south of Bitlis province show a perfect match with those of the Arabian platform implying Bitlis and the border folds were on the same north facing Mesozoic platform.

c- Alpine deformations show a progressive dimunition of intensity towards the south.

d- The sedimentary sequence north of Lake Van is a clear indication of an ocean lying in immediate north of Bitlis. In other words, southern branch of Neotethys (Şengör and Yılmaz, 1981) lies in immediate north of the Bitlis/Pütürge massifs.

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