PALEOSTRESS TRAJECTORIES AND POLYPHASE RIFTING IN ARC-BACKARC OF EASTERN PONTIDES

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ABSTRACT.— In the modern convergent plate margins geological and geophysical evidences imply that maximum horizontal stresses (sHmax) over the overriding plate are transmitted from plate boundry to the backarc region. This causes compressive regime in the plate boundry and extensive regime in the backarc or inner part of overriding plate. Depending on the age and properties of downgoing plate and relative motion of the overriding plate maximum compressive stresses (s) are transmitted as s2 (sl> s2> s3) in the consuming direction or parallel to the arc from trench zone to backarc region. Though strike slip motions are dominant in the arc, they are associated to extensional and compressional regions. Geological data from Eastern Pontides, especially southern part of arc seem to show that tectonics is predominantly extensional and several short lived compressional phases break up this extentional regime during Mesozoic same as in the Agean and Japan arcs. First extensional regime started in Lias or Pre-Lias and ended in Malm-Late Lower Cretaceous. In this period many ensialic intra-arcbasins to the north and ensimatic backarc basins with axial through sea floor spreading (Malm-Lower Cretaceous ophiolite) to the south had been developed (Mariana type subduction). Short lived compressional phase between Late Lower Cretaceous and Early Upper Cretaceous detracted these basins (Chilean type subduction). Under a new extensional regime Eastern Pontian are and backarc rifted again and new axial sea floor spreading occurred to the south to form Upper Cretaceous ophiolites. The formation of Krukko type polymetalic ore deposits along the Black Sea coast correspond to this stage (intra-arc rifting). Intra-arc and backarc basins closed again by following compressive stresses between Late Upper Cretaceous and Early Eocene. Except for sea floor spreading polyphase rifting should have been in the same way during Cenozoic time. In addition to diverse folding axes and opposite direction thrusting may imply that strike slip motion may be associated to compressional and extensional regime in Eastern Pontides. As a result except very short lived compressive stresses southern part of Pontides is the extensional region or extensive stresses increase from north to south. Such a result indicates that southern part of Pontides was the backarc region and it is in favor of southward subduction during Mesozoic and Cenozoic time.

INTRODUCTION

In the modern convergent plate margins geophysical (solutions of earthquake epicentral mechanisms) and geological evidence brings up important results about changes of maximum horizontal tectonic stresses over the overriding plate. It is obvious that intra-plate horizontal stresses cause different geological events depending on their characteristics. From this point of view, geological events in paleotectonic environments or in ancient consumption zone can give explanatory information about maximum horizontal stresses that have occurred in the past.

Several authors have used different methods for interpretation of the evolution of Eastern Pontides obtaining different results (Dewey et al., 1973; Adamia et at, 1977; Şengör et at, 1980; Tokel, 1981; Bektaş, 1981, 1982, 1983; Bektaş et at, 1984). The purpose of this paper is to make clear what type of horizontal stresses were required for the geological characteristics of Eastern Pontides gained during Mesozoic and Cenozoic (distribution of magmatic provinces along Pontian arc, facies analyses, structural elements, the position and geotectonic significance of the ophiolitic belt south of the arc, etc.) and to correlate the obtained results together with the data taken from the modern consuming zones. The conclusions reached so far, from a different point of view, will lead to limitation of the interpretations above to a narrowed field.

STRESS DISTRIBUTION IN CONVERGENT PLATE MARGINS

Uyeda and Kanamori (1979), Nakamura and Uyeda (1980), Uyeda (1983) have derived and generalized, in time and space, the variations of stress distributions in Alaska-Aleutian, Middle Europe, Agean arc, southwestern and northeastern Japanese arc and back-arc regions (Fig. 1).

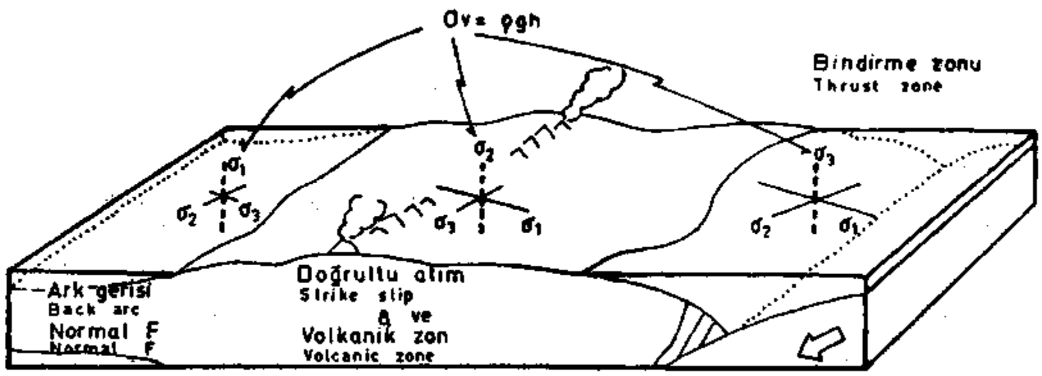

Fig. 1 - Schematic drawing showing a typical case where σ Hmax decreases from the trench toward the backarc region across the volcanic arc. Here σ1> σ2> σ3 (Nakamura and Uyeda, 1980).

On the trench side of arcs (Front zone of convergence) the intensity of the dominant compressive stresses varies with the age of the subducting oceanic plate, the characteristics of plate interaction zones, the progressive and reprogressive role of the overriding plate and the position of the trench. Because of the unrigid behaviour of the overriding plate the compressional stresses can not be transmitted to the inner parts of the plate. Therefore the maximum horizontal stresses (sHmax) decrease towards the inner parts. When sHmax <sV (vertical stress), horizontal compressive stresses transform from s1 to s*2* (sl>s2>s3) .sl generally does not transform to a2 in the consumption direction. In the backarc region, a2 changes its strike and takes a parallel attitude to the arc because of the gravitational forces and shear stresses over downgoing lithosphere caused by convection currents in the mantle. This period corresponds to backarc and intra-arc normal and strike-slip faulting (rifting) or backarc sea floor spreading (Mariana type of consumption or period of minimum inter-plate stresses). The period in which sl is transmitted to the backarc is defined by folding, reverse and strike-slip faulting in the intra-arc and backarc regions (Chilean type of consumption or the period of maximum inter-plate stresses).

As a summary it can be said that in convergent plate boundaries, compressional stresses are dominant in fore arc and extensional stresses in backarc regions. The arc is located between compressed and tensioned regions. In other words, horizontal stresses are of the intermediate type. When the backarc sea floor spreading is possible rifting is generally parallel to the arc. This shows the transmission of sHmax(s2) from consumption direction to a parallel position to the arc. Figure 2 shows the intensity and strike variation models of sHmax stresses in the arc and backarc regions. In the first position, sHmax is transmitted from sl to s2 in the consumption direction (rifting in consuming direction in the backarc; Middle America and Middle Europe). In the third position, s1, in the consuming direction, is transmitted to s2 in backarc (backarc rifting and sea floor spreading; Japanese arc in Miocene, Aleutian arc, West Greece and Albania). The second position is the transition between first and third positions (Agean arc, West Japan, Alaska continent).

Extensional stresses are dominant in the Agean Basin. Extensional stresses of long durations alternated with tectonic phases of Upper Miocene-Lower Pliocene and of Lower Pliocene age (Mercier, 1981). The same is valid for the Japanese arc (Uyeda, 1983). Mercier (1981) analysed the compressional and extensional stresses of the active plate margins such as the Agean arc and the Andes. He pointed out that, in the plate over the consumption zone, most of the deformations caused by compressional stresses are related to the extensional conditions of convergent plate margins. On the other hand, sysmotectonic works show that extensional stresses in the Andaman backarc basin and compressional stresses in the overriding plate of Burma are dominant (Mukhopadhyay, 1984).

Fig. 2 - Schematic diagrams showing different patterns of the horizontal tectonic stress (σ Hmax) trajectories in arc and backarc regions. Case II is the transition between cases I and III. σHmax is represented by dark lines where it refers to σ_1 and by lighter ones where it refers to σ_2 (Nakamura and Uyeda, 1980).

EXTENSIONAL-COMPRESSIONAL STRESS PERIODS IN ARC-BACKARC OF EASTERN PONTIDES

In the Eastern Pontian arc, same as with any other active plate margin, extensional stress periods of long durations (rifting and sea floor spreading) alternated with short periods of compressional stress resulting in folding, reverse faulting and complete or partial closure of basins. So as it is mentioned above, many sedimentary basins have been formed and closed alternatively due to subduction mechanism in the arc and backarc of Eastern Pontides during Mesozoic and Cenozoic (polyphase rifting). On looking at the geological events as a whole, it can be concluded that especially the southern part of the Pontian arc is generally an extensional area or according to the explanations above a back-arc geotectonic environment is present. The extensional periods in the stress regimes of Eastern Pontides are distributed as follows:

Liassic-Lower Cretaceous

Sedimentologic, tectonic and geomorphologic evidences show that there was an extensional regime in the region during this period (Pelin, 1977; Eren, 1983; Görür et al., 1983; Bektaş et al., 1984). Liassic formations were deposited in E-W trending grabens in the south and parallel to the arc. These grabens were bounded by horsts (Gümüşhane granite, Köse granite, Pulur Massif and Kop serpentinites). These volcano-sedimentary sequences show changes in thicknesses and facies in a restricted area. The volcano-sedimentary Liassic unit generally contains coarse and fine elastics, ammonite bearing red limestones, basaltic dykes, sills and lavas. This unit unconformably overlies an ancient continental unit (metamorphic or granites of Paleozoic age) around Yusufeli-İspir, Gümüşhane, Bayburt, Reşadiye, Niksar and Havza: The same rock units overlie the serpentinites around Kop and Demirözü in the south. However no serpentinite fragments were found in the basal conglomerates. Transition from a sialic basement in the south to a simatic crust in the north can imply argumentation of intra-lithospheric extensional stress from north to south causing a crustal and lithospheric shortening (McKenzie, 1978; Cochron, 1983). From this point of view, it can be thought that the Kop and Demirözü peridotites and gabbros are the diapirs (ophiolites due to rifting) intruded in the continental crust before the sea floor spreading during the backarc rifting of Eastern Pontides (Bektaş et al., 1984). The basalts of the volcano-sedimentary unit metamorphosed in green schist facies and Malm-Lower Cretaceous in age are associated with peridotites around Erzincan and characterize a mid-oceanic subduction zone (Bektaş, 1981). This evidence indicates a stronger extensional regime for the later period of the rifting and implies sea floor spreading along the rift axes south of the arc. As a summary, the backarc basin of Eastern Pontides during Malm-Lower Cretaceous was similar to that of the modern Red Sea. The deep marine sediments (pelagic carbonates, radiolarites, turbidites and olistostroms) of Malm-Lower Cretaceous age around Bayburt, Maden and Otlukbeli refer to the maturing period of the rifted backarc basin. The geological evidences outlined above imply an extensional regime in the region from Pre-Liassic or Liassic up to the Late Lower Cretaceous resulting in rifting and formation of sedimentary basins.

Upper Cretaceous-Paleocene

An extensional period was followed by a short compressional period during Late Lower Cretaceous or Early Upper Cretaceous. Hence, Lower Cretaceous sediments were folded, uplifted and faulted. The effects of this orogenic phase are well known throughout the Pontides (Ketin, 1962; Gattinger, 1962; Pelin, 1977; Terlemez and Yılmaz, 1979; Gedikoğlu et al., 1979; Akyürek et al., 1984). In contradiction to the view of Terlemez and Yılmaz (1979), Seymen (1975) reported a graditional relation between Lower Cretaceous and Upper Cretaceous. This orogenic phase was active throughout the Pontid Belt and it is well known in the Alpine Belt. But according to the evidences above, there may be some inner basins preserved during this period or a phase might have occurred during the closure of basins (Lower-Upper Cretaceous gradation).

The development of backarc and intra-arc basins parallel to the Pontian arc shows the effects of a new extensional period from Cenomanian-Turonian onwards. Facies changes of the same age (turbidites, pelagic red limestones and reefal limestones) bounded by intra-basin faults are indicative of horst-graben structures.The Upper Cretaceous sediments are represented by basal conglomerates followed by Nerinia bearing sandy limestones. Distal turbidites and volcanics interbedded with these turbidites belong to the uppermost section of the Upper Cretaceous. (Seymen 1975; Pelin, 1977; Turan, 1978; Eren, 1983; Hacıalioğlu, 1983; Bektaş, 1985). The Upper Cretaceous also starts with a basal conglomerate and continues with a volcano-sedimentary unit around Harşit Valley (Gedikoğlu et al., 1979) and Artvin (Van, in print). The lithofacies changes, the characteristics of the volcanism and the geotectonic setting of the north and south zones of Eastern Pontides are described in details (Bektaş, 1984). The extensional stresses are more continoues and intense in south zones and the lithosphere is sufficiently thin (Cochran, 1983; Turcatte, 1983) in axial areas of rifts to cause ocean floor spreading during Upper Cretaceous (the ophiolitic belt of Erzincan-Sivas-Ankara; Bektaş, 1983). During this period, similar and restricted rifting resulted in formation of intra-arc basins in which a tholeitic-calc alkaline volcanism and associated polymetalic ore deposition were formed. In other words, during Upper Cretaceous we see a tholeitic-calc alkaline volcanism and the formation of ensialic intra-arc basins in the north and a calc alkaline-alkaline volcanism and the formation of backarc ensialic-ensamatic basins in the south just as it was during Jurassic. Back-arc rifting and related ocean floor spreading is reflected as ophiolites and accompanied tholeitic-calc alkaline volcanism (Bektaş, 1981) in the south.

Eocene

The backarc and intra-arc basins of the Upper Cretaceous in the Eastern Pontides closed in the Late Paleocene and therefore a compressional regime has started in the region and a new erogenic phase developed. The Eocene sediments, unconformable on the basement, are represented by distal flysch or shallow marine and lagoonal sediments. This geologic setting corresponds to the Eocene volcanism and contemporaneous rifting. However, the horizontal extensional stresses were not continous and intense as they were in the Upper Cretaceous and ocean floor spreading is unlikely. Eocene volcanism is of calc alkaline-alkaline affinity in the south (Terzioğlu, 1984) and calc alkaline in the north of Eastern Pontides (Eğin and Hirst, 1979). This reveals that the southern zone was in backarc tectonic setting during this period, too. Geological setting shows that such extensional and compressional periods were alternating during Cenozoic. But, this subject will not be discussed in detail, here.

POLYPHASE RIFTING IN SPECIFIC DIRECTIONS

As stated above, polyphase rifting occurred in Eastern Pontides during Mesozoic and Cenozoic. Geological evidence suggests rifting in Liassic exclusively occuring along the Pontides (Schultze-Westrum, 1961; Nebert, 1961; Seymen, 1975; Pelin, 1977; Saner, 1980; Öztürk, 1980; Görür et al., 1983). Using the geological and geophysical evidence, rifting in the Eastern Pontides during Upper Cretaceous is suggested by Bektaş (1984) and west of Çankırı-Çorum basin by Akyürek et al. (1984) and Ünalan and Yüksel (1978). Both of the rifting occurred in the same regions and directions parallel to the arc and ophiolitic belt. At least three marginal basins were opened and closed successively on the Anatolian ophiolitic belt which was an ancient suture zone during Triassic, Jurassic-Cretaceous and Upper Cretaceous. But in the Eastern Pontides, the existance of an oceanic domain during Triassic is not supported by sufficient evidence. In other words, the ancient rifting or suture zones are preferable areas for development of rifts and ocean floor spreading.

Vink et al. (1984) claims that continental crusts are three times weaker than the oceanic ones and they indicate that the preferable rifting occurs along ancient rifts and suture zones; also emphasizing the reliability of the idea by quoting from Wilson (1968) «Immature ocean floors develop on the suture zones of the previously closed oceans». It is known that, due to the subduction of Pasific plate under the Eurasian, the extensional periods on the China continental shelf caused polyphase rifting (Desheng, 1984). These petroliferous intra-plate rift basins which are supposed to develop in relation to the rising mantle diapirs on the consumption zones, seperated by geanticlines. According to various investigations carried out in the Alpine Belt, basins smaller than the Atlantic Ocean may be closed in a very short time (Zwart and Dornsiepen, 1978; Trümpy, 1981). It is claimed that the Alpine ocean was closed within 100 m.y. in the medial Alps (Frisch, 1979) and in 50 m.y. in the Southern Alps (Winterer and Bosellini, 1981). On the other hand, Le Blanc (1981) proposed smaller basins rather than the Atlantic type for the Pan-African and Tethyan ophiolites. Similar to this, Moores etal., (1984) concluded that all the ophiolitic rocks of the Middle East from Cyprus to Omman are related to the backarc basins and their ocean floor spreading developed on the oblique consumption zones like the Andaman Sea. It can be outlined that the Middle Anatolian ophiolitic belt contains fragments of oceanic crust generated by polyphase rifting during Mesozoic. The basins are closed completely or partially during orogenic phases.

PALEOSTRESS DISTRIBUTION IN EASTERN PONTIDES

The setting, type, intensity and variations of the paleostress distributions of the convergent plate margins, in time and space, are derrived from the mechanical meaning of some elements such as dykes, folding and faulting in the region (Zoback, 1980; Nakamura and Uyeda, 1980; Engelder and Geiser, 1980). Kronberg (1969) and Yıldız (1984) have studied the fault tectonics of the Eastern Black Sea range by photogeological means concluding 50° and 130° striking fault systems were active since the Lower Jurassic. When the dyke and fold systems of Mesozoic and Cenozoic age in the Eastern Pontides are analysed one can observe perpendicular (orthogonal) fold and dyke systems similar to that obtained by Kronberg. On considering the parallel nature of sedimentary and rift basins parallel to the arcs, one can observe that extensional and compressional stresses were active successively or were contemporaneously in a similar fashion during Mesozoic and Cenozoic. Therefore compressional and extensional periods in the region-and their causes must be evaluated seperately. Any period of compressional stress also shows variations in itself. The dominant ENE-WSW striking fold axes and reverse faults of Eastern Pontides must have been developed by the maximum horizontal compressional stresses produced by al, active in the NNW-SSE direction. The setting of this compressional stress is defined by the dykes having the same strikes (Fig. 3). In spite of this, folds striking ambigously WNW-ESE are the result of maximum compressional stress (s) defined by NNE-SSW striking dykes (Fig. 4). As stated previously, the horizontal maximum compressional stresses (sl) in arc and backarc regions cause compressional stresses in the direction of consumption. Thus, the presence of (sl) in two different directions during the compressional stress period in the Eastern Pontian arc reveals the following possibilities:

1. Such a great change (90°) in the direction of maximum horizontal compressional stresses can be explained either by the rotation of al by 90 degrees or by the relative replacement of s1 and s2 (relative decreasing and increasing of their intensities). A modern example to this is Northwest Pacific region in the North America, al should be active in the direction of consumption and is parallel to the arc due to strike slip faulting (Zoback and Zoback, 1980). If sl directions in the Eastern Pontides are represented by the maximum compressional stresses in the consumption direction and produced by the friction between subducting and obducting plates, it can be concluded that the active margin should be affected by the complex relative plate movements as it is in the Middle America (Kellog and Bonini, 1982).

2. It is possible to consider stresses as right lateral and left lateral couples, perpendicular to fold axes, in the directions of NE-SW and NW-SE instead of evaluating stresses (s1) in various directions as maximum horizontal stresses. This opinion can explain the presence of fold and dyke systems (orthogonal system) perpendicular to each other developed successively and/or contemporeneously and supports Kronberg's (1970) theory. That is the modern Eastern Pontid joint system (50-130) is parallel to the strike slip faulting during Mesozoic and Cenozoic. If the second view which seems plausible on consideration of the geotectonic structure of the region, is accepted it can be concluded that maximum horizontal compressional stresses have worked in N-S and in the direction of consumption and caused strike slip faulting in arc and backarc regions. The periods of development of intra-arc and backarc basins and backarc ocean floor spreading in south of the arc (horizontal stresses < vertical stresses) correspond to the time when horizontal maximum compressional stresses were (s2) in E-W direction (Fig. 5). Normal faults, horsts and grabens parallel to these and dykes of the same direction are the main geotectonic elements of the extensional stress regime. During an extensional stress period the maximum compressional stress al should be transformed to s2 from N-S to E-W direction and during this period a2 is horizontal and parallel to the normal fault strike, s3 is horizontal trending N-S and al is vertical. But where maximum (al) and intermediate (s2) compressional stresses replace each other in time, strike slip faulting should develop in intra-arc and backarc basins. This is balanced by the reversal of strike slip faulting during compressional stress regimes.

As a summary, the N-S directed maximum compressional stresses (sl) have caused closure of previous basins, folding of the basement rocks and sediments and uplift by reverse faults and the extensional stresses of the same direction have caused formation of new sedimentary basins and new ocean floor spreadings in the Eastern Pontides during Mesozoic and Cenozoic (Fig. 6 and 7). During these two different tectonic regimes, strike slip faulting must have occurred when s2 replaced s3 in compressional stress periods and s1 replaced s2 in extensional stress periods. Modern two linament systems are the inheritors of the ancient linament systems.

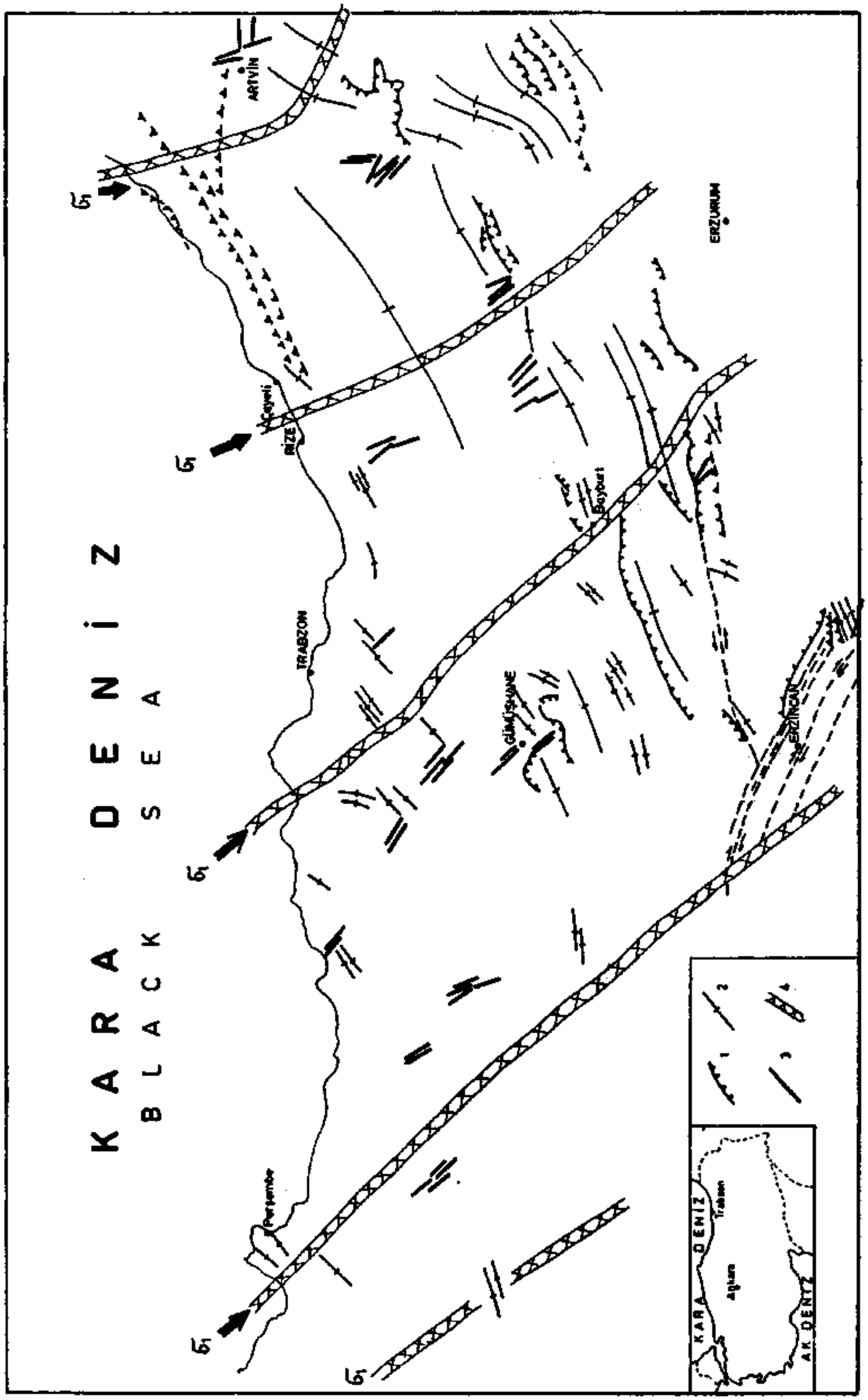

Fig. 3 - The maximum compressional stress periods in the Eastern Pontides during Mesozoic and Cenozoic; the setting of related dominant dykes, fold axes and thrusts. 1 - Thrust fault; 2 - Fold axis; 3 - Dyke; 4 - σ1, the direction of maximum compressional stress in the compressional regime.

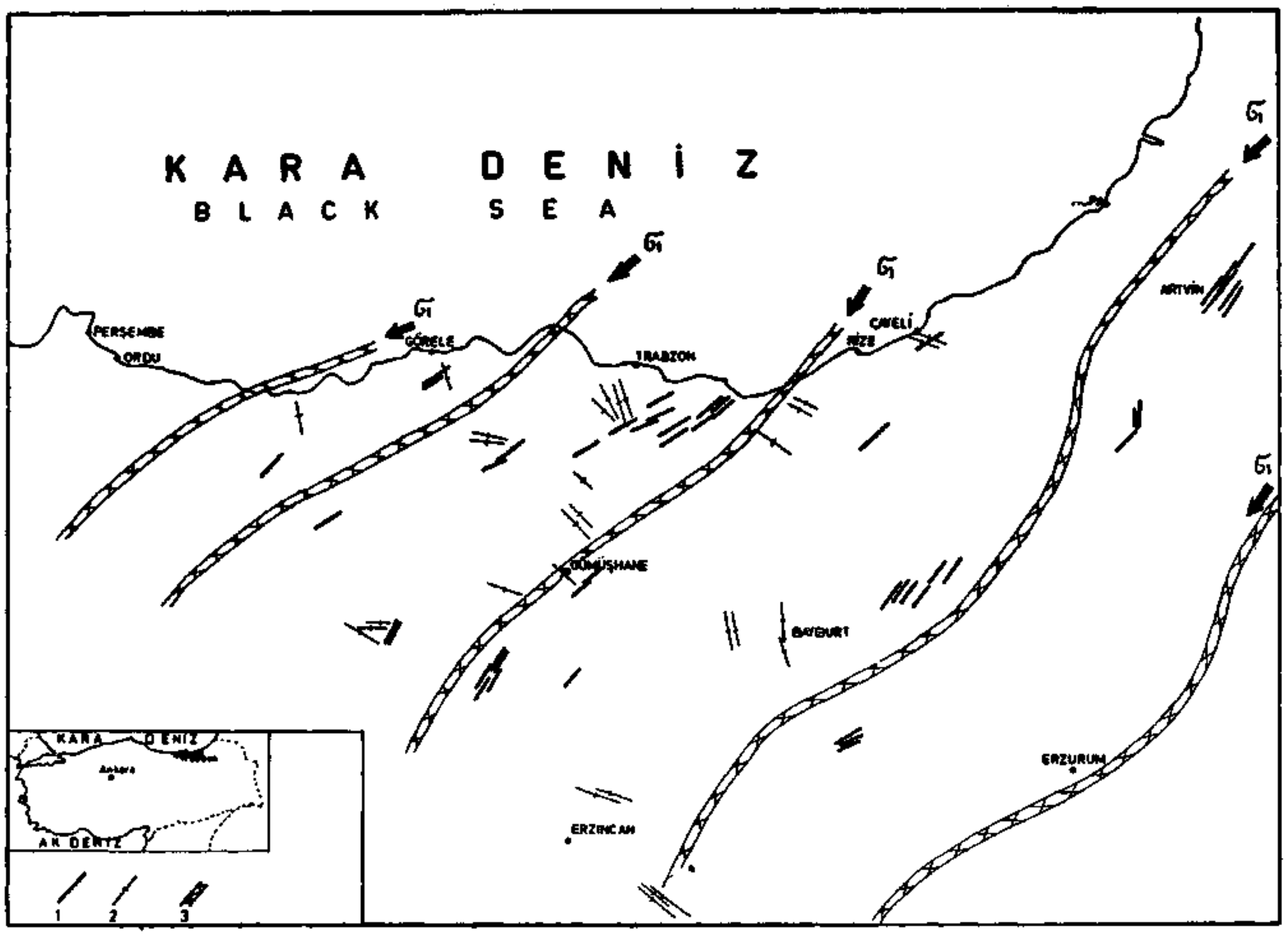

Fig. 4 - The maximum compressional stresses in the Eastern Pontides during Mesozoic and Cenozoic; the position of related less apparent dykes and fold axes.
1 - Dyke; 2 - Fold axis; 3 - The direction of maximum compressional stress ($\sigma 1$).

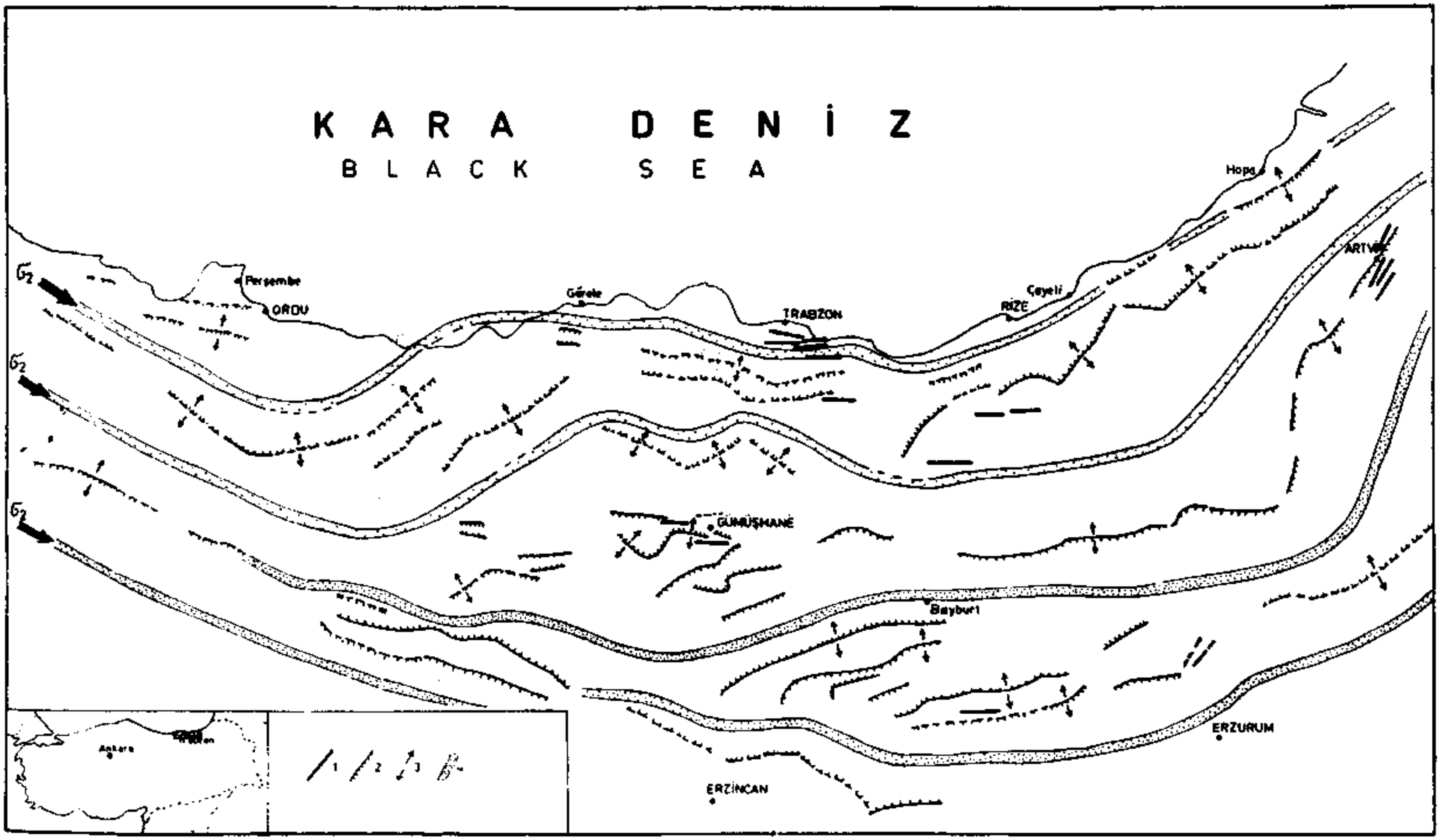

Fig. 5 - The maximum compressional stress in the Eastern Pontides during the extensional regimes of Mesozoic and Cenozoic; related dykes, normal faults and rift direction. 1 - Dyke; 2 - Normal fault associated to rifting; 3 - Extension direction; 4 - Maximum compressional stress ($\sigma 2$).

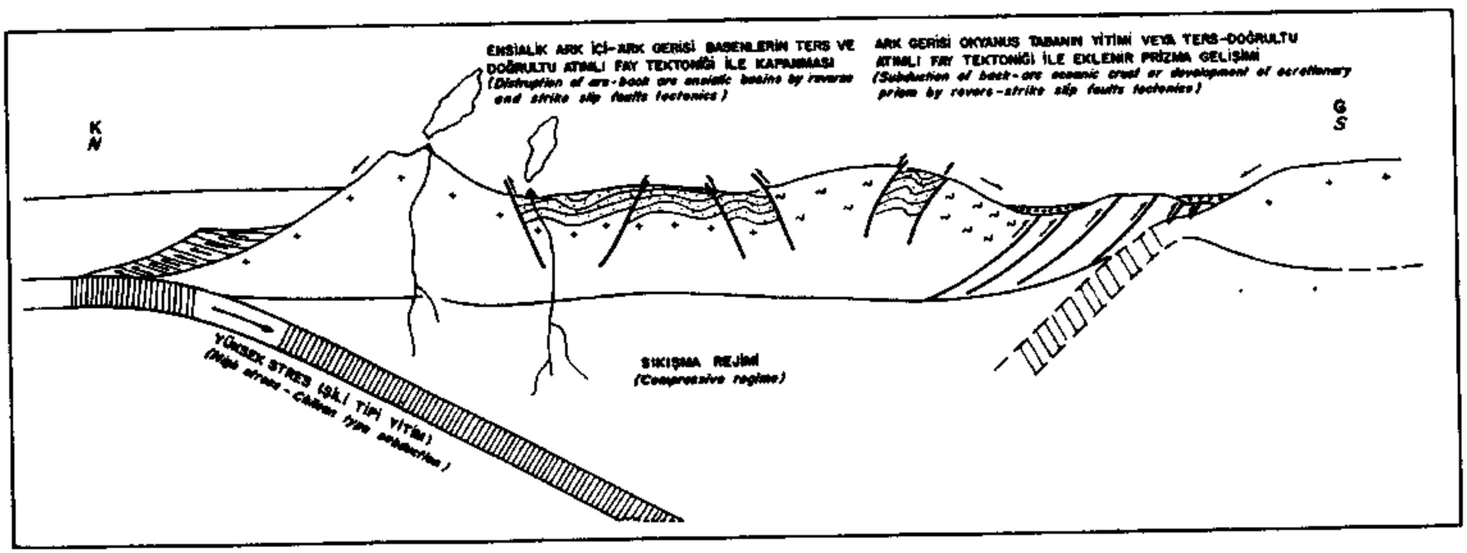

Fig. 6 - The geotectonic model corresponding to the orogenic periods in the Eastern Pontides.

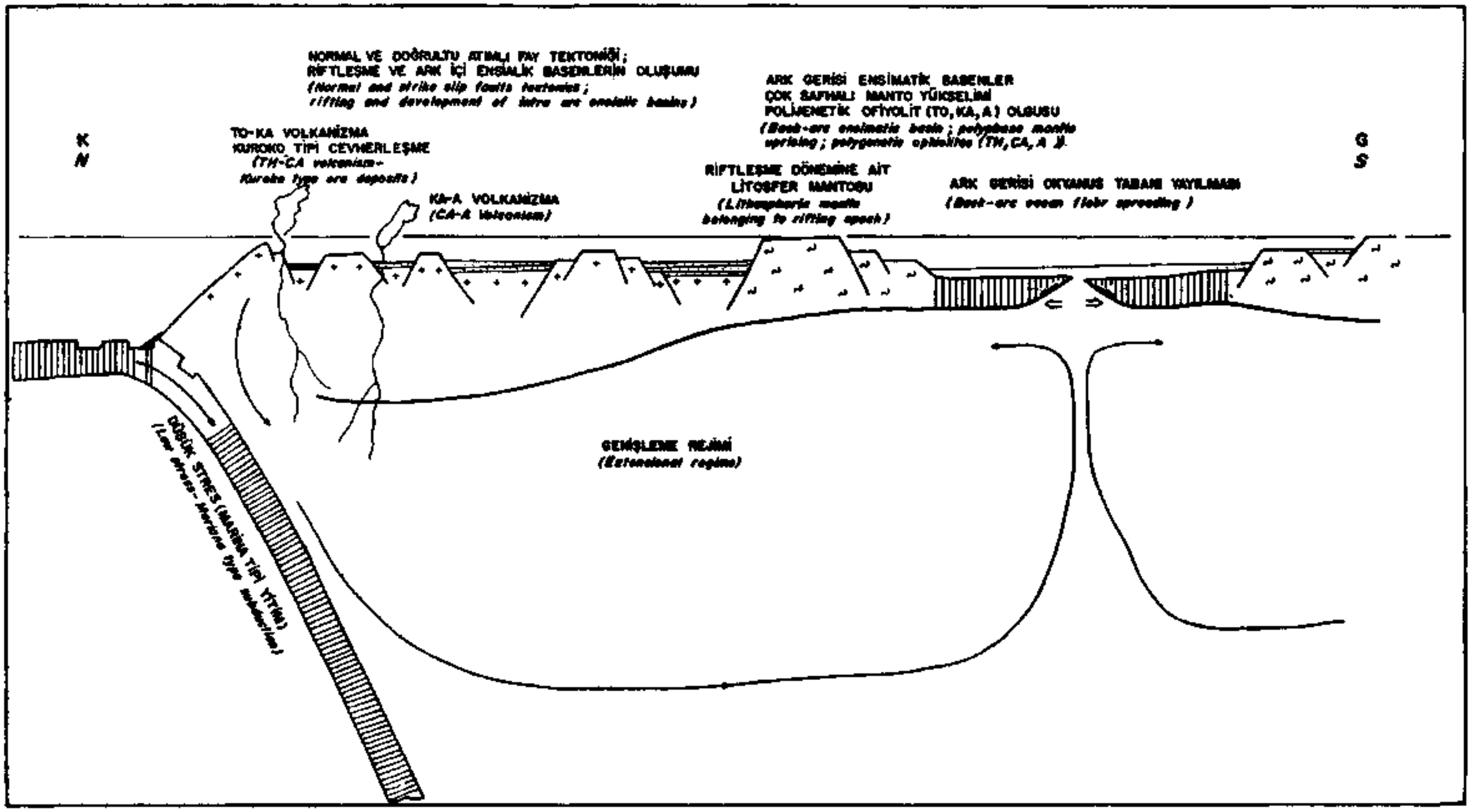

Fig. 7 - The geotectonic model corresponding to the extensional periods in the Eastern Pontides.

DISCUSSION AND CONCLUSIONS

According to the geological and geophysical investigations carried out in modern active plate margins, the compressional stresses about 1000 km in the inner part of the overriding plate are the results of interplate friction surfaces in consumption zones (Forsyth, 1975; Isacks and Barazangi, 1977; Uyeda and Kanamori, 1979; Uyeda, 1983; Fukao and Yamaoka, 1983; Miller, 1984). Such compressional stresses have great importance in the evaluation of Cordillerian orogenic belt of the Andeans and Northwest America where the collision is too weak or absent. As a summary, multifold extensional and compressional stress regimes alternated in Eastern Pontides during Mesozoic and Cenozoic. In relation to these regimes, the maximum horizontal compressional stresses (s1) acting in consumption direction (N-S) caused closure of previous basins, folding of basement rocks and sediments and uplift by reverse faults and later the horizontal extensional stresses (s2) caused the opening of new sedimentary basins and new ocean floor spreadings (Fig. 6 and 7). s1 is vertical during this period. These two different tectonic regimes developed Chilean and Marina type consumptions (Figure 6 and 7). This implies that a tectonic regime without collision was active in Eastern Pontides during Mesozoic. But the presence of Cimmeridianr orogenic phase (Şengör et al., 1980) due to the collision of Eurasia continent and Pontides in Dogger (closure of Paleotethys) is doubtful in Eastern Pontides. Such a collision should result in backarc compressional stresses and related backarc thrust or reversal of consumption such as it is-in modern Sunda arc (Silver et al., 1983). However, it has been proved by geological evidences that there existed an extensional stress regime during Dogger-Malm and Lower Cretaceous in Eastern Pontides (Şengör et al., 1980; Bektaş et al., 1984). Nevertheless, it is possible that new basins were developed between uprising blocks throughout the Pontides or synchronous compressional and tensional stresses may be active in adjacent areas. Such a tectonic regime is typical for the strike slip fault zones (Aydın and Nur, 1982). This is checked by the presence of some basins during compressional stress and extensional stress periods.

The general analyses of elements of Eastern Pontides (fold, fault and dyke systems) reveal that the compressional stress periods developed in a similar fashion (during Mesozoic and Cenozoic) but the maximum compressional stress showed direction variations up to 90°. In fact, it is known that the Upper Cretaceous sediments in the northern part of Eastern Pondites have steep fold axes (Turkish-Japanese team, 1974; Altun, 1977). This work reveals that the same situation is valid for the southern part. It was reported that compressional stresses had formed folds at right angles (N115-145E and N00-40) in the Agean arc during Upper Miocene and Lower Pliocene (Mercier, 1981) and the maximum compressional stresses in Middle America have directions of 310±10 and 80 (Kellog and Bonini, 1982). On the other hand, Hida mountains, the highest mountain range of Japan on the coast of Japan Sea, has reached a height of 2000 m (1-5 mm/year) since the late Tertiary. The main cause of this uplift is maximum compressional stresses being in the consumption direction and directional variations from NW-SE to WNW-ESE (Fucao and Yamaoka, 1983). As suggested by Yamakawa and Takahashi (1977) the bisectrix of stresses in various directions, perpendicular to the structural belt defined by strike-slip tectonics, corresponds to the direction of maximum stress. The evidence given above shows that the main causes of the variation of compressional stress directions are the variations in plate movements and the strike-slip faulting on the overriding plate. From this point of view, the mechanics of maximum compressional stresses in NW-SE and NE-SW directions is compatible with strike-slip faulting in Eastern Pontides during Mesozoic and Cenozoic. The real tectonic compressional stresses are perpendicular to the Pontid mountain range and are in the direction intersecting these different directions. This is the same with consumption direction in periods mentioned above. In the consumption zone, the development of horizontal compressional stresses of relatively lower intensity, due to plate movements and the transmission of these stresses to Southern Pontides in E-W direction with a decreasing intensity, have caused oblique and occasional strike slip faulting in this region. This period corresponds to the time when vertical stresses were generally greater than the horizontal ones.

As a summary, during Mesozoic, Eastern Pontides had an uncollisional tectonic regime such as the Andean and the Cordillerian orogenic belts. In such tectonic regimes, the source of maximum compressional stresses is consumption zones. Since the plates are not rigid, such horizontal compressional stresses are transmitted from the front margin to the inner parts of plates with a decreasing intensity. Therefore we observe the maximum compressional stresses in front margins and extensional stresses in backarc regions. During Mesozoic, an extensional stress regime except for very short periods of compressional stresses existed in the Eastern Pontian arc and as a result of this phenomenon especially in Southern Pontides a polyphase rifting and ocean floor spreading developed. The development of such events in Southern Pontides implies the evolution of the Eastern Pontides on a southward subduction. The N-S directed main tectonic compressional stress, the bisectrix of NW-SE and NE-SW maximum compressional stresses, was in the subduction direction and caused strike slip fault zones in arc and backarc regions.

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