THE NORTH ANATOLIAN FAULT ZONE : NEW INTERPRETATION AS A PALEO-BENIOFF ZONE

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ABSTRACT. — In the light of evidences presented herein, the North Anatolian Fault does not have the characteristic features of a transform fault but is rather a suture belt formed by collision of the Anatolian sub-plate with the Eastern Pontid Island Arc, movement of which today results in a right-lateral strike-slip fault at the surface.

INTRODUCTION

The North Anatolian Fault (NAF) Zone is the major tectonic feature of Turkey. Many speculations, namely by Dewey and Bird (5), Smith (19), Dewey (7), have been put forward about it. However, no proper study on the origin of this fault has been made so far. The investigators mentioned above considered the NAF as a transform fault in their plate tectonic models. Ketin (14), Isacks *et al.* (12), McKenzie (15, 16), Tokay (20), Ataman *et al.* (1) have interpreted it as a right-lateral strike-slip fault. Their interpretations are based on the amount of displacements and direction of movement along the fault.

Within the framework of plate tectonic concept, the southeastern part of the Anatolian sub-plate constitutes the northern part of the Arabian plate; and together with the African plate, they seem to move northward. Eastern Anatolia, due to this northward movement is therefore a compression zone (1). Thus the eastern extension of the NAF shows compressional character (16). This compression may result in development of a Benioff Zone by complete consumption of a marginal sea which might have existed between the Eastern Pontid Island Arc and the Anatolian sub-plate prior to their collision.

SUPPORTING EVIDENCES

An eclogite occurrence has been discovered about 24 km NNW of Erzincan in the Çatalarmut district by Çapan and Buket (St-1 in Fig.l). According to microscopical studies and X--ray diffraction (XRD) analyses, this eclogite is composed only of garnet (grossularite-andradite) and of rather diopsidic (calcic) omphacite. XRD analyses and determination of refraction indices of the garnet indicate that it is a Ca-garnet with an approximate composition of 9,0 % andradite. This mineralogical assemblage has a marked calcic character and it corresponds to «Group C» eclogites (see Fig. 2). Türkünal (21) reports another eclogite occurrence at Goblar tepe about 30 km SW of Muş, on the southern side of Bitlis Massif (St-2 in Fig. 1). The mineralogical composition of three samples taken from St-2 constitute pyrope, omphacite, rutile, biotite, zoisite, prehnite, quartz and muscovite. The third eclogite occurrence has been reported by Çoğulu (4) (St-3 in Fi 1). Çoğulu draws particukr attention to relatively high percentage of CaO (i. e., 25.10. % on 99.17 % total) in his eclogite samples.

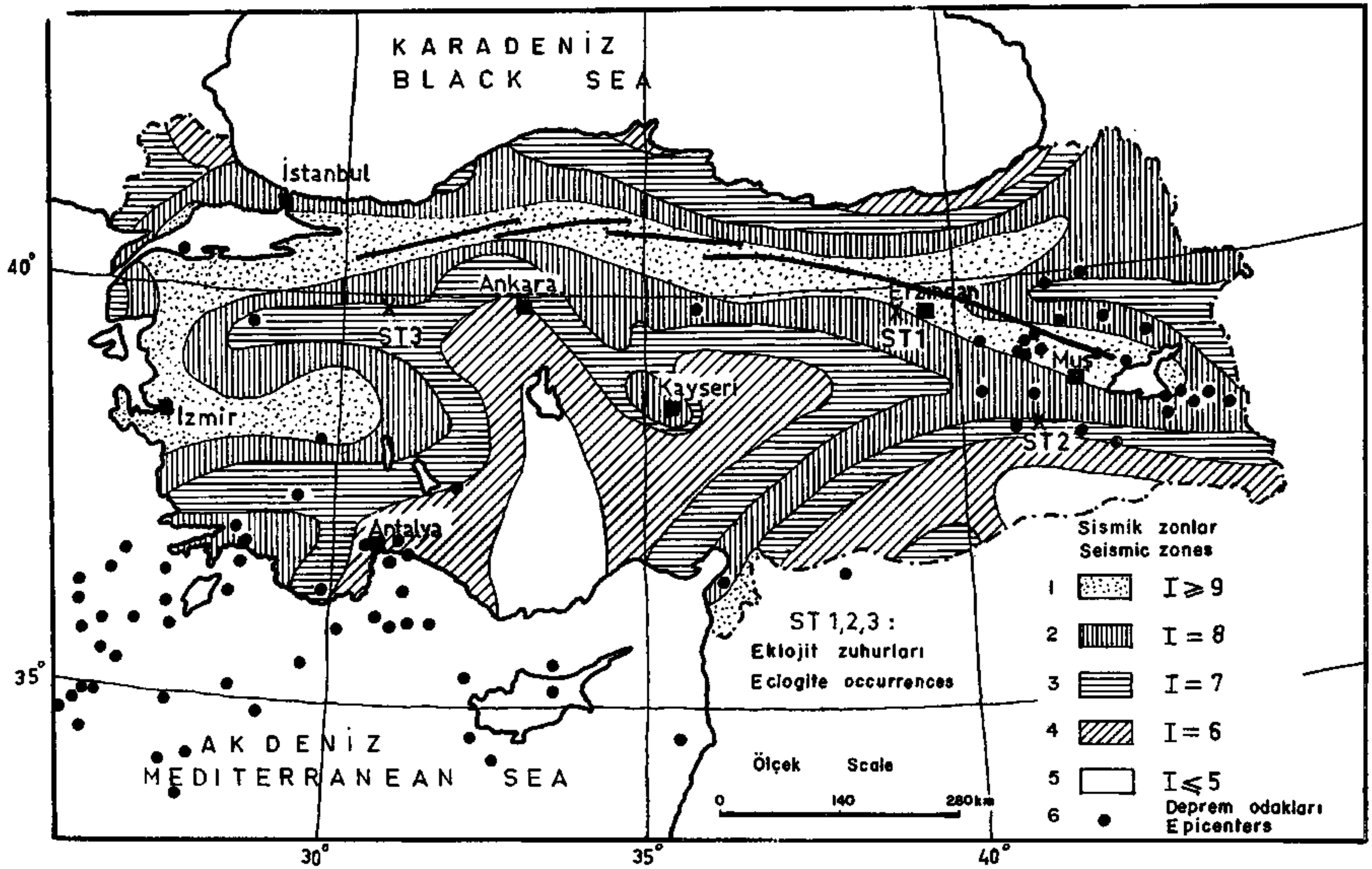

Fig. 1 - Map of seismic zones of Turkey showing earthquake epicenters with focal depths h> 50 km. [Modified from Seismic Zoning Map of Turkey by Earthquake Research Institute of Turkey; Ergin *et al.* (9, 10) and Atlas of Epicenters of USSR (2).]

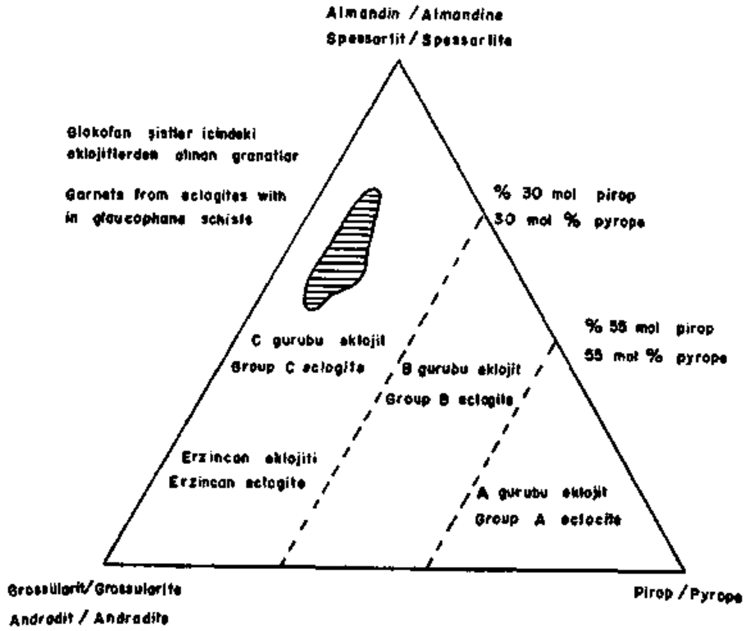

Fig. 2 - Correlation of Erzincan eclogite with Coleman's (3) triangular diagram.

Eclogite is traditionally regarded as being formed only under high pressures at great depths, probably within the mantle (17). Green and Ringwood(11) suggest that favorable conditions for eclogite can also occur within the crust. According to Dewey and Bird (6), eclogites are probably transformed oceanic crust ripped from the descending plates at deeper levels in subduction zones. Ito and Kennedy (13), on the basis of their experiments, state that transition to eclogite from gabbroic material is possible under 27 kb pressure. Therefore no matter what the genesis of eclogite is, whether it is within the mantle or the crust, it indicates an extremely high pressure environment and which is consequently rather dry. These physical conditions may well correspond to the characteristics of a Benioff zone.

Metamorphic rocks of the Erzincan region are mainly greenschists and amphibolites. Greenschists are composed of quartz, chlorite, tremolite and plagioclases. The plagioclases are so deformed that their anorthite content can not be properly determined. The amphibolite which is the host rock of eclogite occurrences is composed mainly of light-brown hornblendes and plagioclases of andesine composition. Although blueschist facies is generally expected from such a geological assemblage, it is not present in this area. Absence of blueschist facies can only be explained by a relatively high geothermal gradient which is represented by widespread volcanic rocks and abundant thermal springs in the Erzincan region. Since the genesis of blueschist facies is generally characterized by a relatively low thermal gradient, it is quite reasonable to find the greenschist instead of blueschist facies.

There are seven small individual aoidesite cones located along the NAF zone in the Erzincan area. Samples from three of these cones have been analyzed for their Rb, Sr content and their initial 87Sr/86Sr ratio has been measured. It. is assumed that the age of these rocks is sufficiently young so that measured 87Sr/86Sr ratios can be regarded as initial 87Sr/86Sr ratio (Table 1).

Table - 1

Initial 87Sr/86Sr ratios, Rb, Sr contents and Rb/Sr ratios of Erzincan andesites

Sample no.	$(^{87}Sr/^{86}Sr)_o$	*Rb (ppm)*	*Sr (ppm)*	*Rb/Sr*	*Locality*
E-7-3b	0.7054	120	208	1.67	Küçükçakırman
E-6-13	0.7063	101	261	1.13	Üzümlü
E-7-5	0.7055	104	260	1.16	Mollaköy

Initial 87Sr/86Sr ratios of Erzincan andesites are very similar to those of andesites of category 3 which, as described by Dickinson (8), are of melts or their derivatives formed from either the crustal or mantle parts of the lithosphere descending along inclined seismic zones. Therefore the Erzincan andesites are probably of the same origin (i.e., the products of melting along arc-trench subduction zones).

The ophiolites of the Erzincan area show a clear order in the north. Going from north to south, they consist mainly of peridotites, serpentinites, diabases, gabbros and basalts with pillow structures. However, the southern front of the same ophiolites is structurally more chaotic (i.e., ophiolitic melanges, gravity sliding and olistostromes). Such structural variation (from orderly to chaotic ophiolite sequences) is characteristic of an oceanic crust which is obducted and overturned towards south. It is therefore possible to interpret the ophiolites of Erzincan area as the oceanic crust and upper mantle sheared off from a descending plate at shallow levels of subduction zones during collisions between Anatolian sub-plate and Eastern Pontid Island Arc.

The deep foci earthquakes of the southern Aegean Sea are closely associated with a Benioff zone (18). The Erzincan-Muş area is a primary seismic zone according to the seismic intensity map of Turkey (see Fig. 1) which is favorable for earthquakes of deep foci (more than 50 km). Therefore, the earthquakes of the Erzincan area can also be related to a Benioff zone.

A NEW MECHANISM OF PLATE MOVEMENTS

The evidences presented herein, suggest a new mechanism, within the framework of plate tectonic theory, for the kinematics of the movement of the Anatolian sub-plate. The Arabian plate which pushes the Anatolian sub-plate from south to north collided with the Anatolian sub-plate when the marginal sea between the two had been completely consumed. After the collision, a slab was detached from the underthrusted Arabian plate and sank into the asthenosphere. Consequently, a thrust belt is formed at the surface indicating a paleo-Benioff zone during Oligo-Miocene (Fig. 3A and B). A similar collision took place between the Eastern Pontid Island Arc and the Anatolian sub-plate due to the northward velocity imparted to the latter by the pushing of the Arabian plate, probably during Pliocene. As the Arabian plate moves northward, a new Benioff zone, oppositely directed because of flip-over mechanism results from underthrusting of the Black Sea floor beneath the Eastern Pontid Island Arc (Fig. 3C and D).

CONCLUSION

Consideration of the above outlined mechanism for the movements of the Anatolian sub-plate leads to the following general conclusion: Although the NAF seems to bear the characteristics of a transform fault and has until recently been so interpreted, in reality it is the projection of a paleo-Benioff zone manifested as a right-lateral strike-slip fault at the surface.

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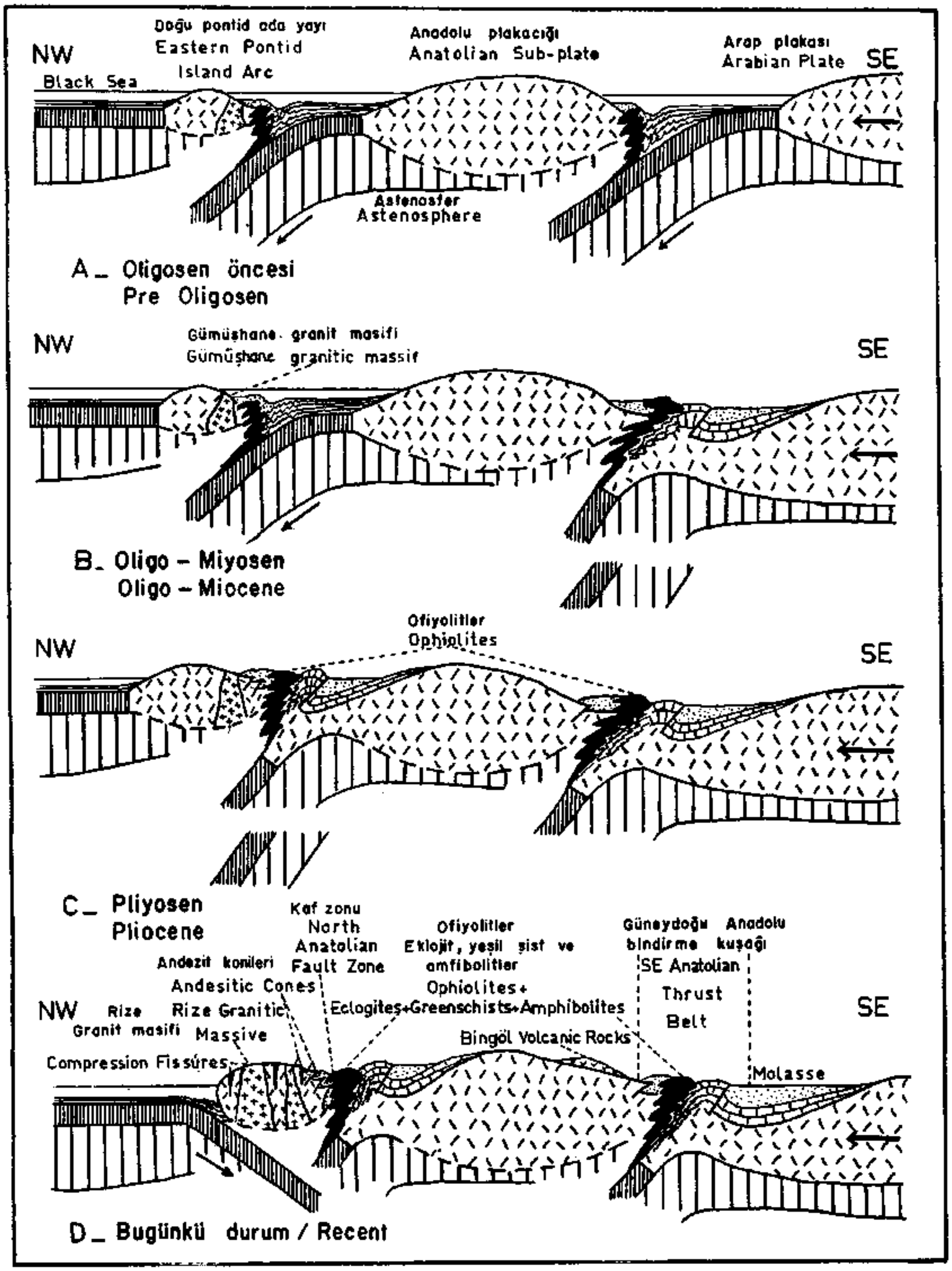

Fig. 3 - Plate models for the geological evolution of East Anatolia.

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