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Structural properties and tectonic significance of a shear zone discovered within the Tauride orogen near Alanya, SW Turkey

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Research Article

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ABSTRACT

A major shear zone, referred to as the Yeşilöz Shear Zone, was discovered in the lower Mahmutlar Nappe of the Alanya Nappe Complex in Alanya region. The nappe shows early transposed folds with axial metamorphic foliation and upright open folds formed during emplacement. The NW-trending shear zone is around 2 km wide and mappable over a length segment of 10 km. The shear zone consists of the metamorphic rocks of the host nappe, but with the phyllite mylonitized by vertical shear foliation and the quartzite and marble dispersed as lenticular bodies. These brittle rock bodies show broken upright folds similar as in the nappe, and also the phyllite shear lenses bear relics of the nappe metamorphic foliation. Analysis of kinematic indices in the shear zone points to a dextral transcurrent deformation. The emplacement of Mahmutlar Nappe caused mild metamorphism of the upper part of underlying nappe and also affected it with the development of the shear zone that extended downwards. The nappe underwent no further translational movement during and after the shear zone formation, which suggests that the ductile transcurrent deformation probably accommodated a residual shortening induced by the emplacement of the next, younger nappe of the Alanya Nappe Complex.

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1. Introduction

The Anatolian plate, located within the Alpine–Himalayan orogenic belt, is an assemblage of continental platelets derived from the northern Gondwana plate and accreted to the southern margin of the Laurasian plate in the latest Mesozoic and early Cenozoic (Şengör and Yılmaz, 1981; Leren et al., 2007; Okay, 2008). The present study is from the Tauride orogenic belt in SW Anatolia (Okay and Tüysüz, 1999), with the study area located in the eastern arm of the large-scale orocline structure known as the Isparta Bend or Angle (Figure 1; Blumenthal, 1947, 1951; Robertson et al., 2003, 2012; Nemec et al., 2018). The Tauride orogen in this region was mapped by several groups of researchers and its tectono-stratigraphy and petrology have long been studied (Blumenthal, 1951; Özgül, 1976, 1984; Okay and Özgül, 1984; Marcoux et al., 1989; Okay, 1989; Usta and Öztürk, 2000; Bedi and Öztürk, 2001; Bozkaya and Yalçın, 2004; Çetinkaplan et al., 2010; Şenel et al., 2016*a, b*).

The regional studies revealed that the orogen in this region consists of two nappe complexes – referred to herein as the Antalya Nappe Complex and Alanya Nappe Complex (Figure 1) – emplaced towards the NE in the latest Cretaceous to early Palaeocene; and a broader nappe complex emplaced towards the SSW in the Palaeogene and referred to as the Hoyran–Bozkir Nappe Complex (Figure 1). The lithology of nappes is highly varied: some nappes consist of non-metamorphic sedimentary rocks, siliceous and carbonate to siliciclastic; others show low-grade (greenschist facies) metamorphism at the base or throughout; yet others include high-grade metamorphic rocks. Except for the kinematic

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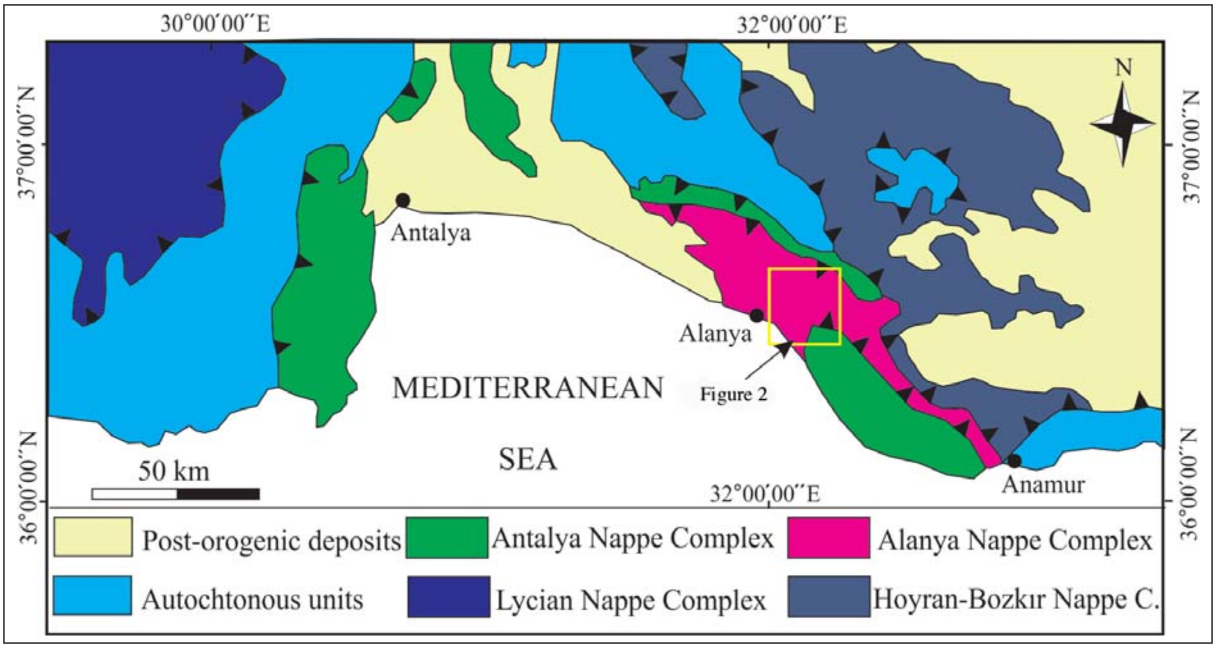

Figure 1- Simplified geological map of the Isparta Bend orocline at the transition of Central and Western Taurides (based on Okay and Özgül 1984).

analysis by Marcoux et al. (1989) from the Alanya Nappe Complex, the internal tectonic structure and emplacement kinematics of the nappes have thus far been little studied. The nappes are overlain by Neogene to Quaternary molasse deposits post-dating the orogeny (Figure 1).

The present paper reports on a large shear zone discovered by geological mapping of the lower component nappe of the Alanya Nappe Complex in the vicinity of Yeşilöz near Alanya (Figures 1 and 2). Detailed analysis of the structural and kinematic properties of this shear zone, hereby referred to as the Yeşilöz Shear Zone, contributes to a better understanding of the directional tectonics of nappe emplacement in this part of the Tauride orogen. At a broader level, this case study adds to a general understanding of the geological significance of tectonic shear zones within orogenic belts.

2. Regional Geological Setting

The Tauride orogen in the western arm of the Isparta Bend orocline (Figure 1) can be regarded as a large-scale antiformal stack of nappe complexes emplaced from two opposite directions (Figure 2). The NE-emplaced Antalya Nappe Complex was covered by a similarly emplaced Alanya Nappe Complex, and the latter was then overridden from the north by the Hoyran–Bozkır Nappe Complex (Figure 2).

2.1. The Antalya Nappe Complex

This nappe complex, referred to earlier variously as the Antalya nappes (Lefevre, 1967; Brunn et al., 1971), Antalya Unit (Lefevre, 1967; Brunn et al., 1971) or Antalya Complex (Woodcock and Robertson, 1977), occurs in both arms of the Isparta Bend orocline (Figure 1) and the lithology of its component nappes is highly varied. For example, ophiolites are involved only in the western arm of the Isparta Bend. The nappes consist generally of non-metamorphic sedimentary rocks that range from deep to shallow marine and comprise radiolarites, shales, siliciclastic sandstones and limestones, including reefal and oolitic carbonate varieties. The age of these deposits ranges from Cambro–Ordovician to Late Cretaceous (Senonian), with an apparent lack of Silurian–Lower Permian and Upper Jurassic (Özgül, 1984; see also Şenel et al., 2016*a, b*).

2.2. The Alanya Nappe Complex

This nappe complex occurs only in the eastern arm of the Isparta Bend (Figure 1) and was earlier referred to variously as the Alanya Massif (Blumenthal, 1951), Alanya Unit (Özgül, 1976) or Alanya Nappe (Okay and Özgül, 1984). This allochthon unit of low and high-grade metamorphic rocks consists of three nappes thrust upon one another (Figure 2; Okay and Özgül, 1982; Özgül, 1984) and hence is here in

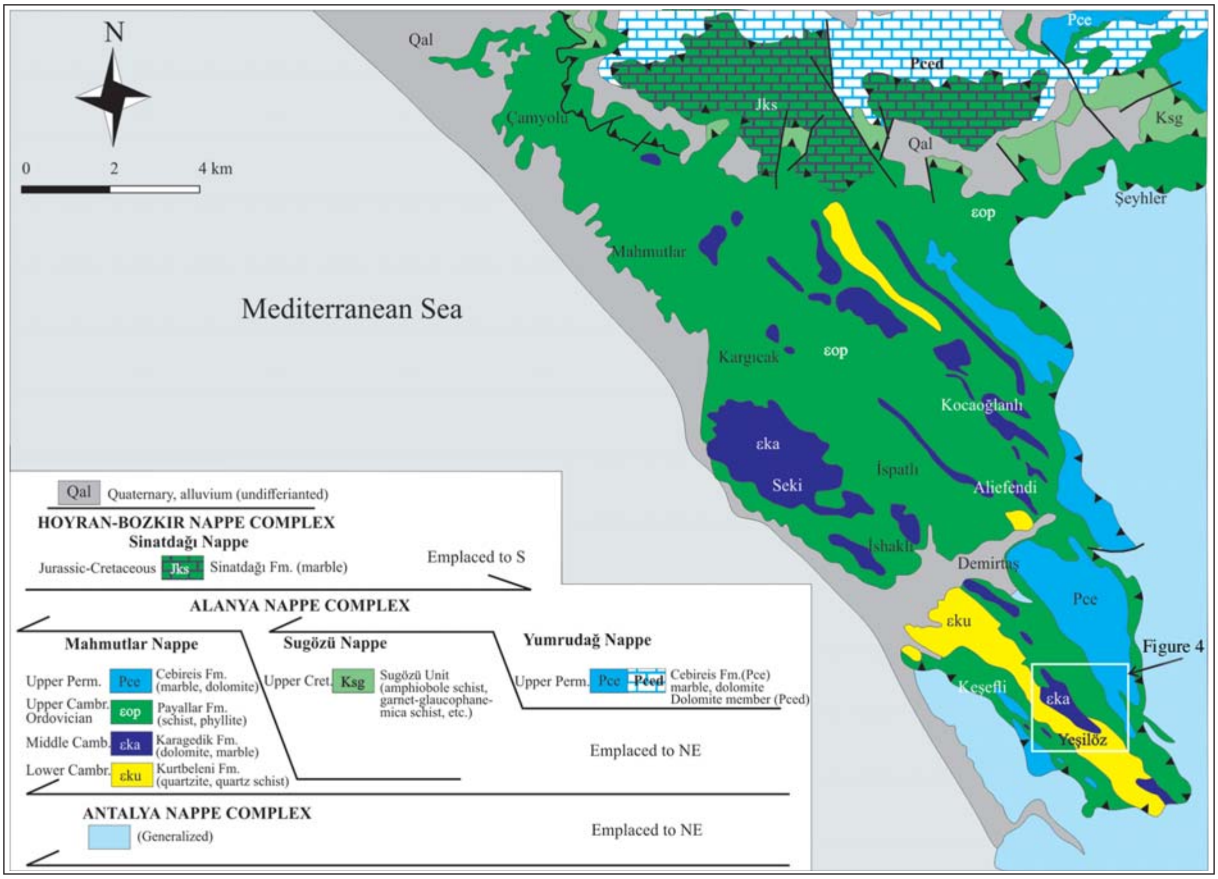

Figure 2- Geological map of the eastern arm of the Isparta Bend with the legend showing the local tectono-stratigraphy of the Tauride orogen (slightly modified from Şenel et al. 2016*a, b*).

regarded as a nappe complex. Öztürk et al. (1995) considered the rock suite of the Alanya Nappe Complex to be a metamorphic equivalent of the rock suite of the Antalya Nappe Complex.

The Alanya Nappe Complex is an assemblage of the following three nappes (Figure 2): the lower Mahmutlar Nappe, the middle Sugözü Nappe and the upper Yumrudağ Nappe, which were earlier referred to also as "units" or "formations" (Okay and Özgül, 1982; Özgül, 1984). The present study is from this nappe complex and hence the internal lithostratigraphy of its component nappes is reviewed briefly in the ensuing subsections. For more detailed descriptions, the reader is referred to Usta and Öztürk (2000) and Bedi and Öztürk (2001).

2.2.1. The Mahmutlar Nappe

This lower nappe is most extensively preserved (Figure 2) and consists of pelitic schists, quartzites, marbles and phyllites representing the green schist metamorphic facies. The basal part of the nappe is the Kurtbeleni formation of early Cambrian age, comprising quartzites and quartzitic schists (Usta and Öztürk, 2000; Bedi and Öztürk, 2001). It is covered conformably by the Karagedik formation of middle Cambrian age, composed of marbles ranging from meta-limestones and meta-dolomites (Usta and Öztürk, 2000). These fine-crystalline meta-carbonates are overlain conformably by the late Cambrian–Ordovician Payallar Formation comprising schists, phyllites and quartzites (Öztürk et al., 1995). A major stratigraphic unconformity separates this latter formation from the overlying Cebireis Formation of late Permian age (Özgül, 1984; Usta and Öztürk, 2000), which consists of phyllites, marbles, quartzites and quartzitic schists.

2.2.2. The Sugözü Nappe

This second nappe (Figure 2), distinguished originally by Özgül (1984) as the Sugözü formation/ Nappe and labelled by Şenel et al. (2016*a, b*) as the Sugözü unit, shows a higher metamorphic grade and consists of metabasalts, eclogites and garnet micaschists. The age of these rocks has long remained uncertain (Özgül 1984) and controversial. Şenel et al. (2016*a, b*) have recently ascribed these rock assemblage to the Late Cretaceous.

2.2.3. The Yumrudağ Nappe

This third, upper nappe (Figure 2) was initially referred to by Özgül (1984) as the Yumrudağ Group or Yumrudağ Unit. It consists of fine-crystalline limestones and dolomites (marbles) and pelitic schists, representing a low-grade greenschist metamorphism. The rocks formed as sedimentary deposits in the Permian to early Triassic, and became metamorphosed in the Late Cretaceous (Özgül, 1984; Şenel et al., 2016*a, b*).

2.3. The Hoyran–Bozkır Nappe Complex

This S-emplaced non-metamorphic nappe complex is limited in its regional extent to the eastern arm of the Isparta Bend (Figure 1) and is only sparsely preserved as klippen-type outliers in the Alanya region (Figure 2). Özgül (1984) distinguished four component nappes comprising such rocks as neritic limestones and dolomites of Late Triassic to Early Jurassic age, and pelagic to cherty limestones with shales, minor sandstones, green tuffs, diabases and pillow-lava basalts of Middle Triassic to Late Cretaceous (Senonian) age.

3. The Yeşilöz Shear Zone

This shear zone, which is the main topic of the paper, was discovered within the Mahmutlar Nappe – the lower nappe of the Alanya Nappe Complex (Figure 2) – and the present study is the first ever literature report on this intra-orogen feature. The shear zone, striking N35°W, occurs about 20 km to the east of Alanya (Figure 1) and is best exposed in a valley between the villages of Yeşilöz and Hocalar (Figures 3 and 4). It nearly pinches out about 2 km to the SE of Yeşilöz, where the outcrop of Mahmutlar Nappe terminates and where it passes into a couple of unremarkable subvertical strike-slip faults in the Antalya Nappe Complex, but extends for at least 10 km to the NW of Yeşilöz, where its exposure abruptly deteriorates. The shear zone is about 2 km wide, and its best exposed 3-km segment (Figure 3) has been mapped at a scale of 1:5000 and studied in detail.

The Yeşilöz Shear Zone separates blocks the folded phyllites and marbles of the Mahmutlar Nappe (Figures 4 and 5). The dominant rock of the zone itself is a sheared phyllite with elongated lenticular bodies of quartzite and marble, ranging in length from a few decimetres to a couple of kilometres or more (Figure 4). These boudin-like rock bodies, drifted relative to one another within the shear zone, are mainly in a subvertical to vertical position and their long axes are aligned parallel to the zone's strike (Figures 4 and 5).

4. Deformation Structures

The deformation structures in the Mahmutlar Nappe are herein divided arbitrarily into relatively

Figure 3- Oblique photograph of the Yeşilöz Shear Zone (valley) with large lenticular bodies of quartzite (q) and marble (mb).

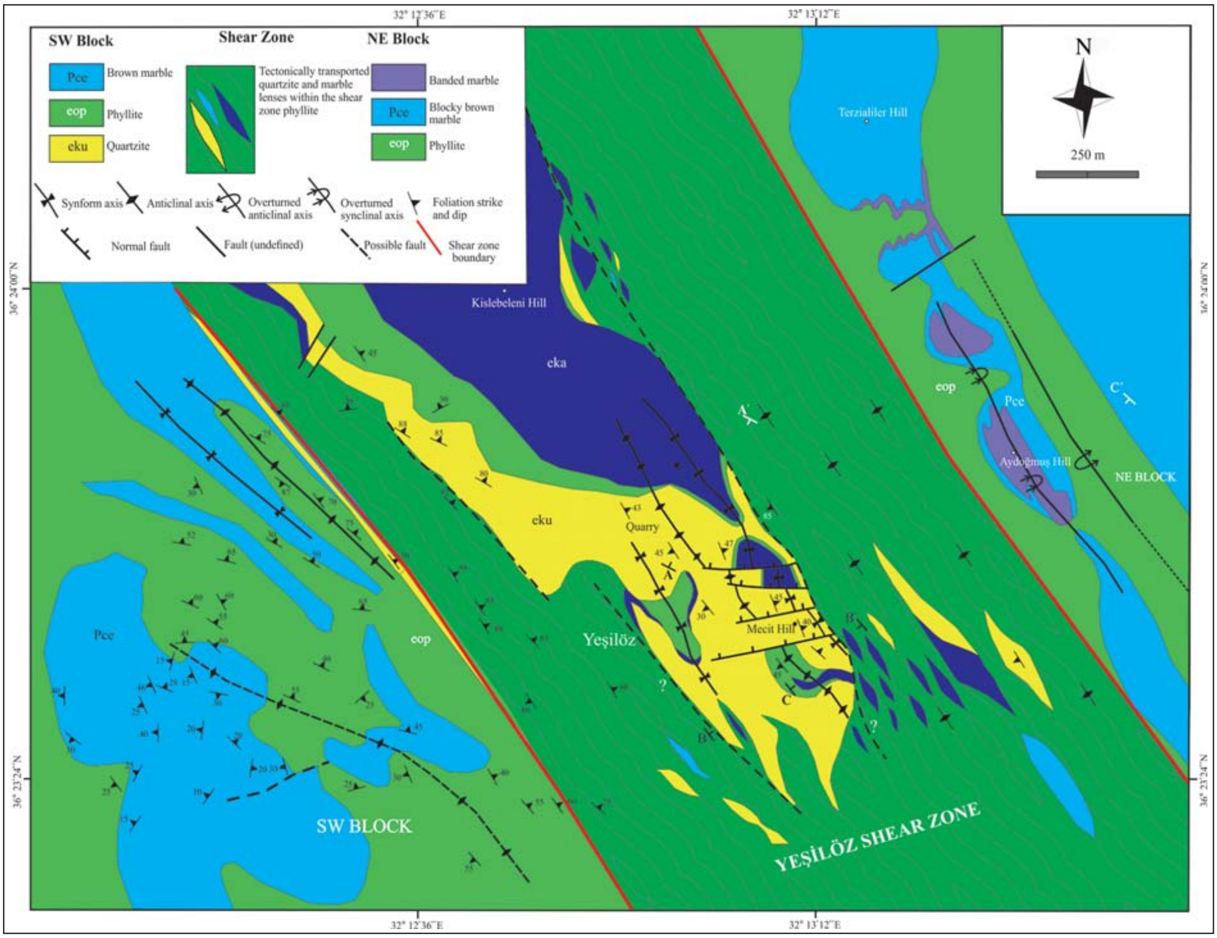

Figure 4- Geological map of the study area, showing the Yeşilöz Shear Zone and adjacent non-sheared parts of the Mahmutlar Nappe (referred to as blocks).

simple (D1), such as folds and faults, and tectonically more advanced (D2), involving metamorphism, recrystallization, pervasive shear and mylonitization.

4.1. Deformation D1: Folds and Faults

The most distinct deformation structures in the study area are folds and faults related to the nappe emplacement (Figures 4 and 5). Mappable folds occur in the Mahmutlar Nappe on both sides of the Yeşilöz Shear Zone, and as disrupted relics within the shear zone. Folds are generally tight, with horizontal or slightly plunging axes trending NW–SE and with upright axial planes (Figures 4 and 5). The folds evolved through two consecutive deformation phases (Figure 6). In the first phase, the competent rocks were transformed into boudins, or lenses, by the formation of isoclinal tight folds F_1 with metamorphic axial cleavage and a bulk transposition of primary bedding (Figure 6, diagrams 1–4). In the next phase of contractional deformation, upright open folds F_2 formed with those lenses of competent rocks preserved in the fold limbs (Figure 6, diagram 5).

Folds F_2 and F_1 have roughly parallel axes, and the spatial trend of the fold axes outside and within the shear zone is the same (Figure 4). Overturned, SW-verging folds F_2 up to a kilometre in axial extent are found within the nappe at the NE boundary of the shear zone (e.g., see the Aydoğmuş Hill area in figures 4 and 5, lower cross-section).

As documented and discussed further in the text, the Yeşilöz Shear Zone is basically a SE-trending dextral strike-slip fault zone – represented by only a couple of faults in the underlying Antalya Nappe Complex beyond the klippe limit of the Mahmutlar Nappe. However, there are also many perpendicular or oblique faults cutting the marble bodies in the Mahmutlar Nappe and the quartzite and marble bodies within the shear zone (Figure 4). They are mainly vertical or subvertical, normal and/or strike-slip faults,

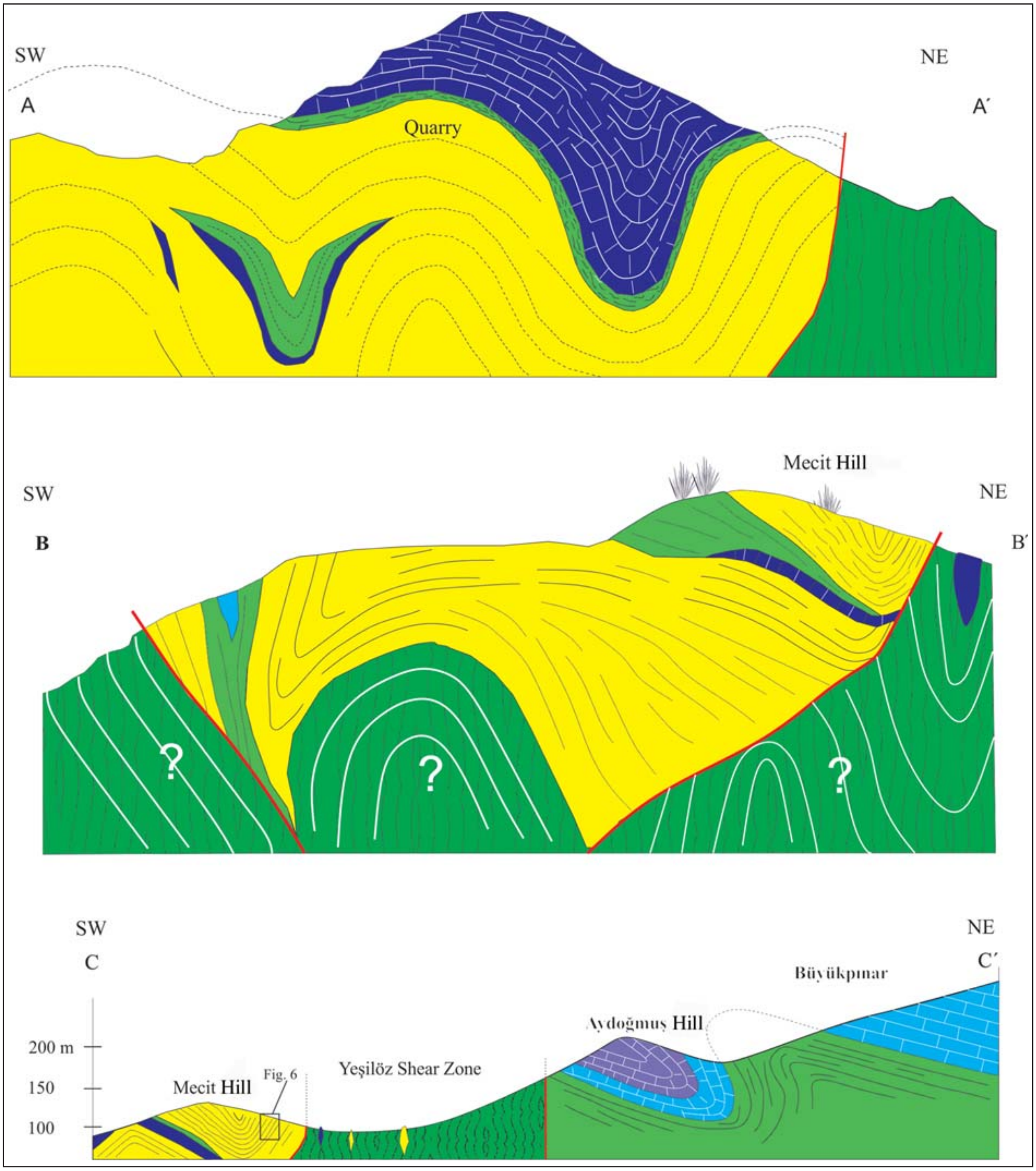

Figure 5- Geological sections across the Yeşilöz Shear Zone and its surroundings (see cross-section lines on the map in figure 4). Cross-sections AA' and BB' are not to scale.

but are difficult to recognize and trace within the rock mass of phyllites.

4.2. Deformation D2: Foliations and Lineation

Foliation in the non-sheared Mahmutlar Nappe generally follows the F_2 folds (Figure 6, diagram 5) and its dip varies, but is uniformly steep, subvertical to vertical, in the Yeşilöz Shear Zone (Figures 4 and 5). This striking difference helps recognize the shear-zone boundary where it runs through phyllites. Additional useful field criterion is the abundance of shear lenses (facoids) within the shear zone and their virtual lack outside its boundaries. The steep foliation and the

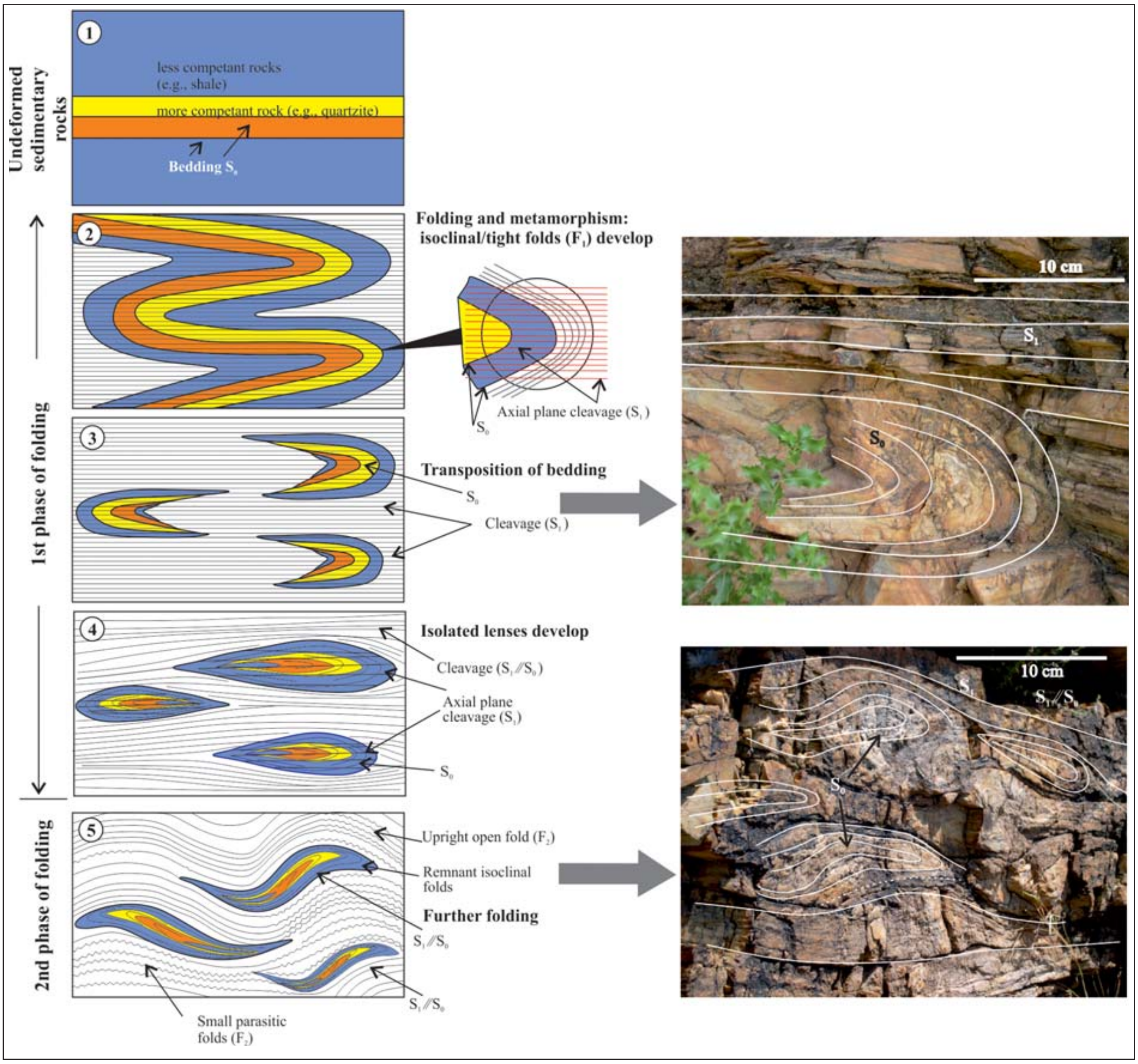

Figure 6- Schematic cartoon showing the development of folding in the Mahmutlar Nappe, illustrated with outcrop photographs from the village of Yeşilöz and the slope of Mecit hill (see localities in figure 4).

rectilinear shear-zone boundary (Figure 4) clearly indicate a steep, nearly vertical shear zone (Figure 5, section CC').

The steep foliation in the mylonitized phyllites of the shear zone has a mean strike N35°-40°W. This foliation (S_s) is younger than the foliation S_1 (Figure 6) in the phyllites outside this zone. Relics of foliation S_1 in the shear zone are recognizable within many of the facoidal lenses enveloped by steep foliation S_s (Figure 7A, B).

The subvertical to vertical foliation planes of the mylonitized phyllites of the shear zone show a genetically related lineation. Lineation is also observed on fault plane. As described further in the next section, these lineation structures served as an important kinematic indicator of tectonic deformation.

4.3. Kinematic Indicators

Mesoscopic kinematic structıres have been used to recognize the directional sense of shearing in the Yeşilöz Shear Zone. These indices include asymmetrical, rotational quartz grains, shear bands (c-s structures), fault slip lineation, foliation and mineral lineation.

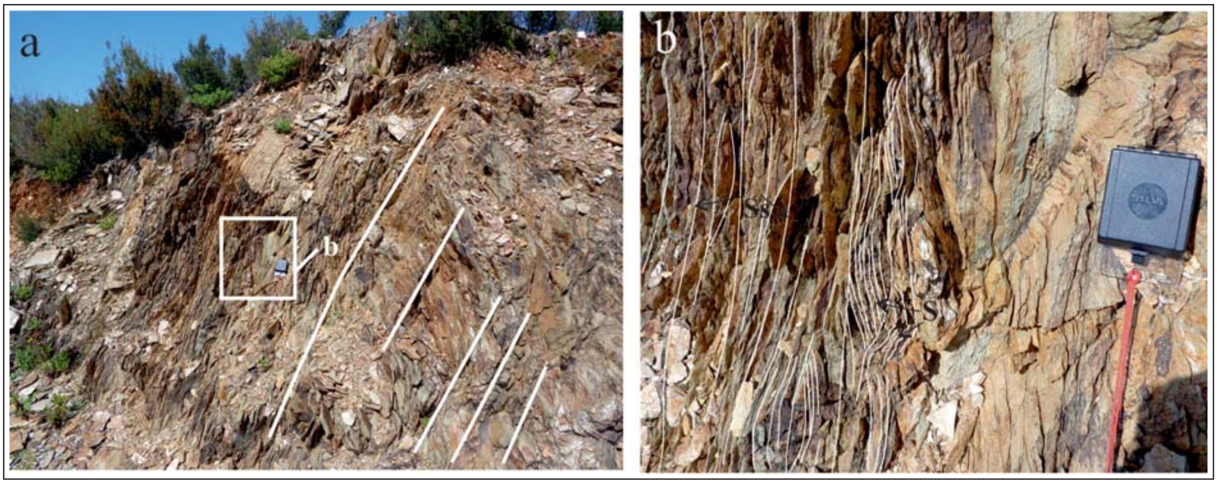

Figure 7- Shear-zone phyllites. (a) Outcrop photograph of the foliated phyllites and fault planes cutting them (white lines). (b) Close-up view of the steep foliation S_s with shear lenses preserving relics of the earlier foliation S_1. Compass for scale.

4.3.1. Asymmetrical Structures and Shear Bands

Asymmetrical, or monoclinic, structures (Figure 8a–c) are found at many localities in the shear zone. The asymmetry of quartz grains in mylonites is due to rotational deformation (Choukroune et al., 1987; Simpson and Schmidt, 1983) and in the present case indicates a dextral shearing. Measurements from several localities show that the azimuthal direction of dextral shearing was 130°–140°.

Shear bands are very common structure in the shear-zone mylonites (Figure 8d–f). Such bands, also known as c-s structures, are formed by the rotation of foliation in a shear zone and are generally a reliable kinematic indicator (Fossen, 2010). The shear bands in the present indicate consistently a dextral shearing in azimuthal direction of 140°.

4.3.2. Foliation and Lineation

Foliation planes and lineation on them were measured in the Yeşilöz Shear Zone within Mahmutlar Nappe (Figure 9) and in the underlying upper nappe of the Antalya Nappe Complex (Figure 10) exposed at the SE extension of the shear zone (see map in figure 2). The aim of these measurements was to verify the shear direction derived from other structures; to assess whether the shear zone is limited to the Mahmutlar Nappe or extends deeper; and to estimate on this basis the age of the shear zone relative to nappe emplacement. The data plotted on stereonet show that the directional trend of lineation is nearly parallel to the strike trend of foliation (Figure 9a). The parallelism and concordance of foliation and lineation in the Mahmutlar Nappe and the underlying nappe (Figure 9a) indicate that the development of the Yeşilöz Shear Zone in this former nappe had clearly affected the underlying older one.

4.3.3. Faults and Slip Lineation

The subvertical to vertical foliation S_s in the shear zone is cut obliquely or parallel by similarly steep fault planes (Figure 11c, d). Faults parallel to foliation indicate strike-slip faulting (Figure 11a), whereas the oblique ones are normal or oblique-slip faults (Figure 4). Some of the faults are dextral Riedel fractures formed in a right-lateral simple shear system (Figure 11b).

Another conspicuous feature in the axial part of the shear zone is a NW-trending ridge comprising quartzite and marble (Figures 4 and cross-section AA' and BB' in figure 5). Slip lineation indicating strike-slip faulting is found in the slopes of the ridge. This ridge is thought to be an uplifted positive flower structure within the shear zone (Figure 5, section BB').

5. Discussion

The Yeşilöz Shear Zone, trending N35°W and at least 2 km wide, can be followed over its length segment of more than 10 km (Figure 12) and is best exposed in a topographic valley between the towns of Yeşilöz and Demirtaş and between the villages of İspatlı and Aliefendi. The shear zone is unmappable farther to the NW, where its exposure in forested area is very poor. Mesoscopic kinematic indices point

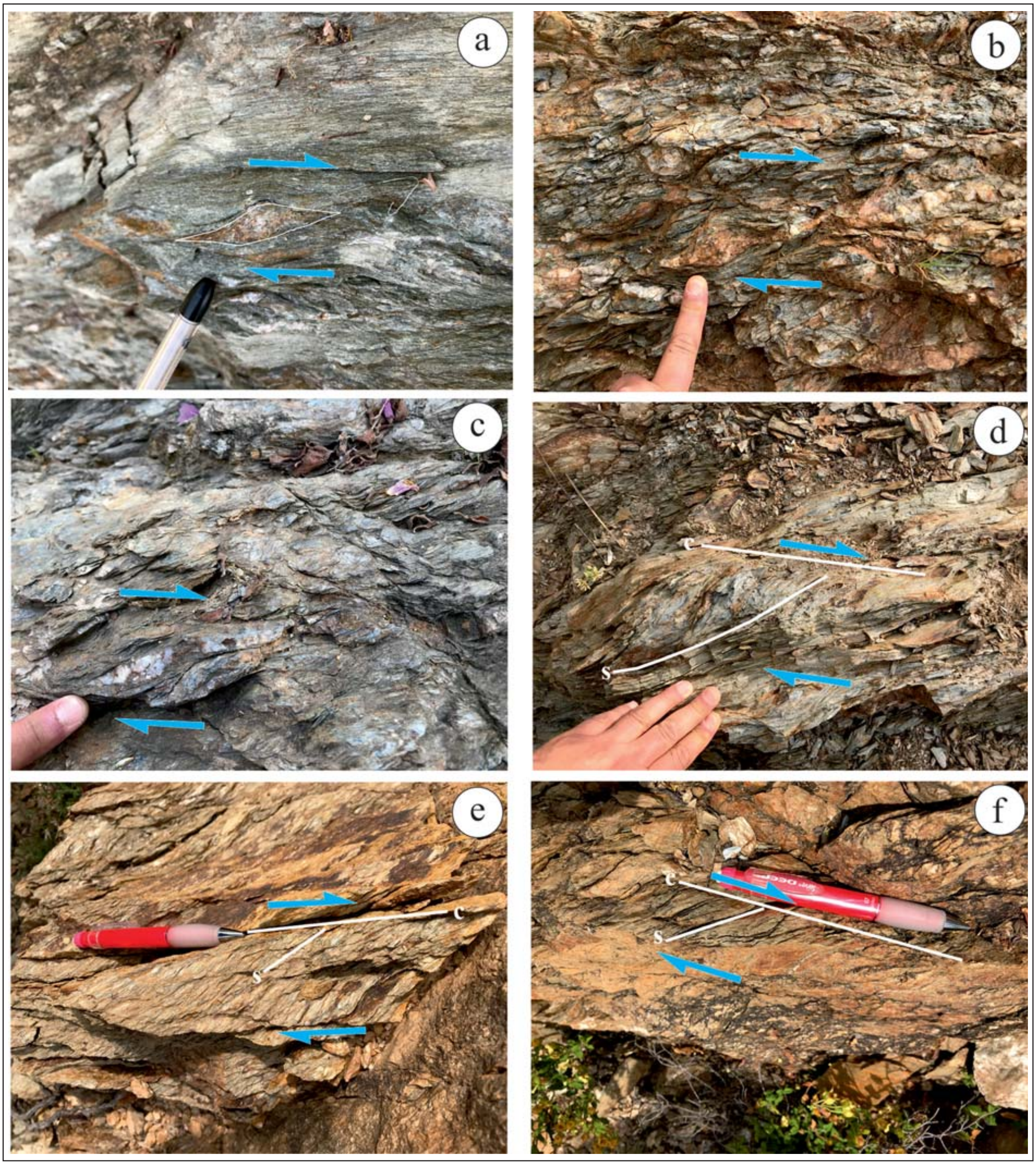

Figure 8- Field examples of kinematic indicators in the Yeşilöz Shear Zone. (a–c) Asymmetrical structures and (d–f) shear bands in plan-view outcrops.

unanimously to a dextral strike-slip deformation in the shear zone (Figures 8–11). The shear zone is in the lower Mahmutlar Nappe of the NE-emplaced Alanya Nappe Complex (Figure 2) and is narrower towards the SE, where it recognizably extends into the uppermost nappe of the underlying Antalya Nappe Complex (Figure 12), as evidenced by the parallelism of both their subvertical to vertical foliation and the lineation on foliation and fault planes (Figures 9, 11, 12 and 13).

The structural evidence from the Yeşilöz Shear Zone and the adjoining non-sheared parts of the Mahmutlar Nappe indicates two main stages of tectonic deformation (Figure 14). The deformation stage D1 occurred prior to and during the nappe emplacement

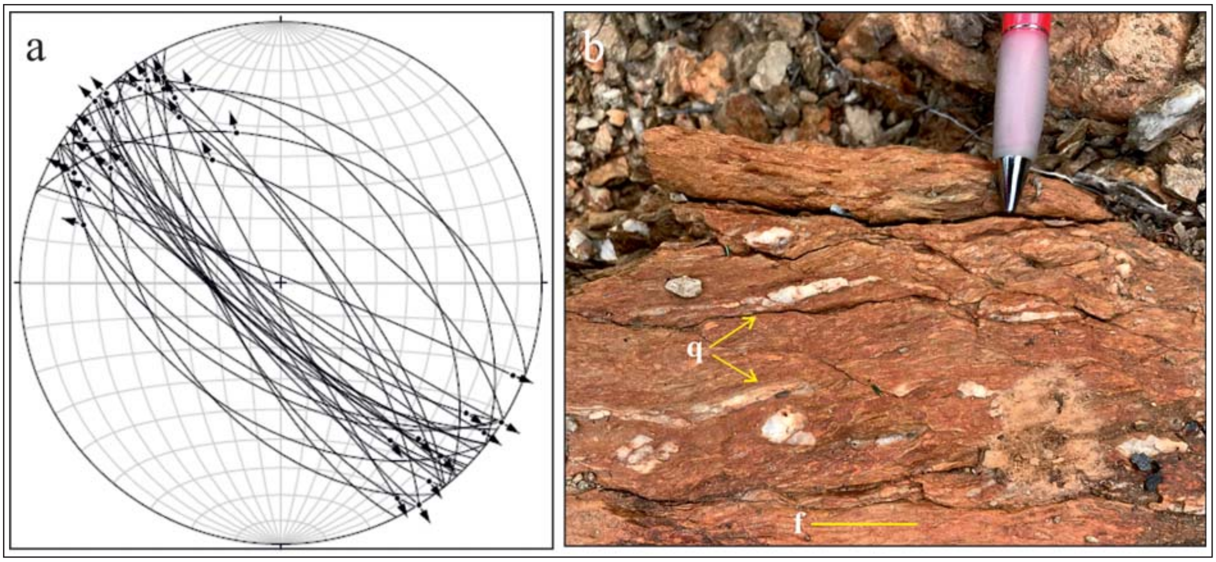

Figure 9- (a) Stereoplot of the foliation and lineation measurements from Yeşilöz Shear Zone. Equal-area lower hemisphere projection; plot made with the FaultKinWin Version 1.2.2 software (Marret and Allmendinger 1990; Allmendinger et al. 2012). (b) Plan-view outcrop photograph showing the planes of vertical foliation (f) and flattened, boudinaged quartz bands (q) in the shear-zone phyllite.

Figure 10- Outcrop photograph showing subvertically foliated phyllitic shale (phy) and recrystallized limestone (lst) in the topmost part of the Antalya Nappe Complex exposed about 2 km west of Uğrak at the SE extension of the Yeşilöz Shear Zone. This field evidence indicates that the uppermost part of the non-metamorphic Antalya Nappe Complex was not only mildly metamorphosed by the emplacement of Mahmutlar Nappe, but also structurally affected by the development of its shear zone.

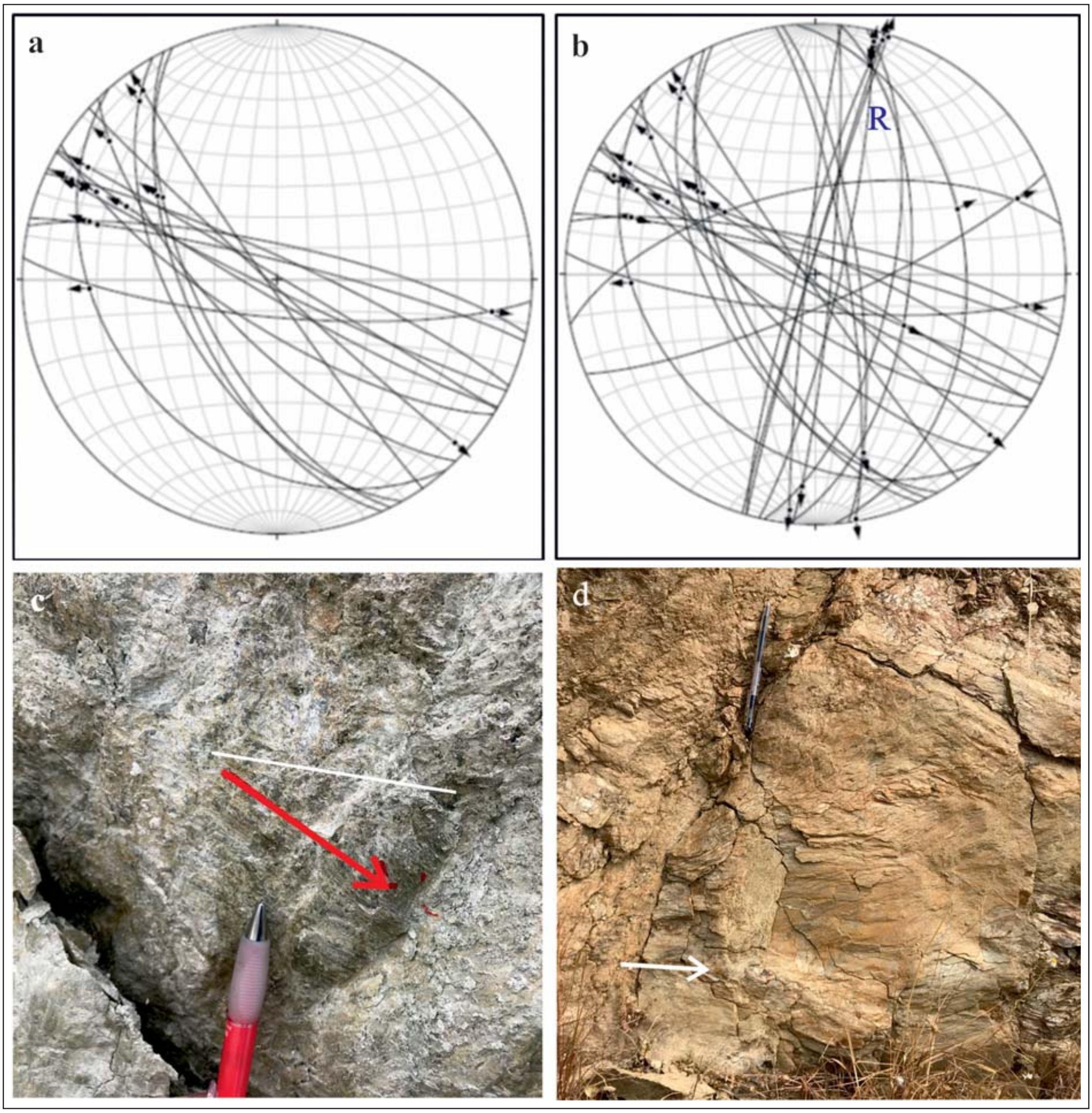

Figure 11- Equal-area lower hemisphere stereographic projection of fault planes and striae measurements from from the Yeşilöz Shear Zone. (a) Strike-slip faults parallel to the shear zone and (b) coeval Riedel fractures. Plot made with the FaultKinWin Version 1.2.2 software (Marret and Allmendinger 1990; Allmendinger et al. 2012). (c, d) Outcrop photographs of fault planes and slip lineation in the shear zone.

and included metamorphic folding (Figure 6) with the transposition of primary bedding S_0, development of folds F_1 with pervasive axial cleavage S_1, and formation of upright open folds F_2 with small local parasitic folds F_3. The axes of folds F_2 in the quartzite-marble bodies within the shear zone are parallel to the F_2 axes in the non-sheared nappe outside (Figure 4), which indicates a common origin of these folds – reflecting a NE–SW tectonic shortening (Figure 14a) and attributed to the thin-skinned nappe emplacement.

The Alanya Nappe Complex, like the underlying Antalya Nappe Complex in the study area, is widely considered to have been derived from the SW (e.g., Özgül, 1976, 1984; Okay and Özgül, 1984; Öztürk et al., 1995; Okay and Tüysüz, 1999; Nemec et al., 2018). Although the evidence of a SW-verging fold F_2 at the NE margin of the shear zone (see figure 4 and cross-section CC' in figure 5) might suggest an opposite direction of the Mahmutlar Nappe emplacement (cf. Marcoux et al., 1989), this vergence cannot be

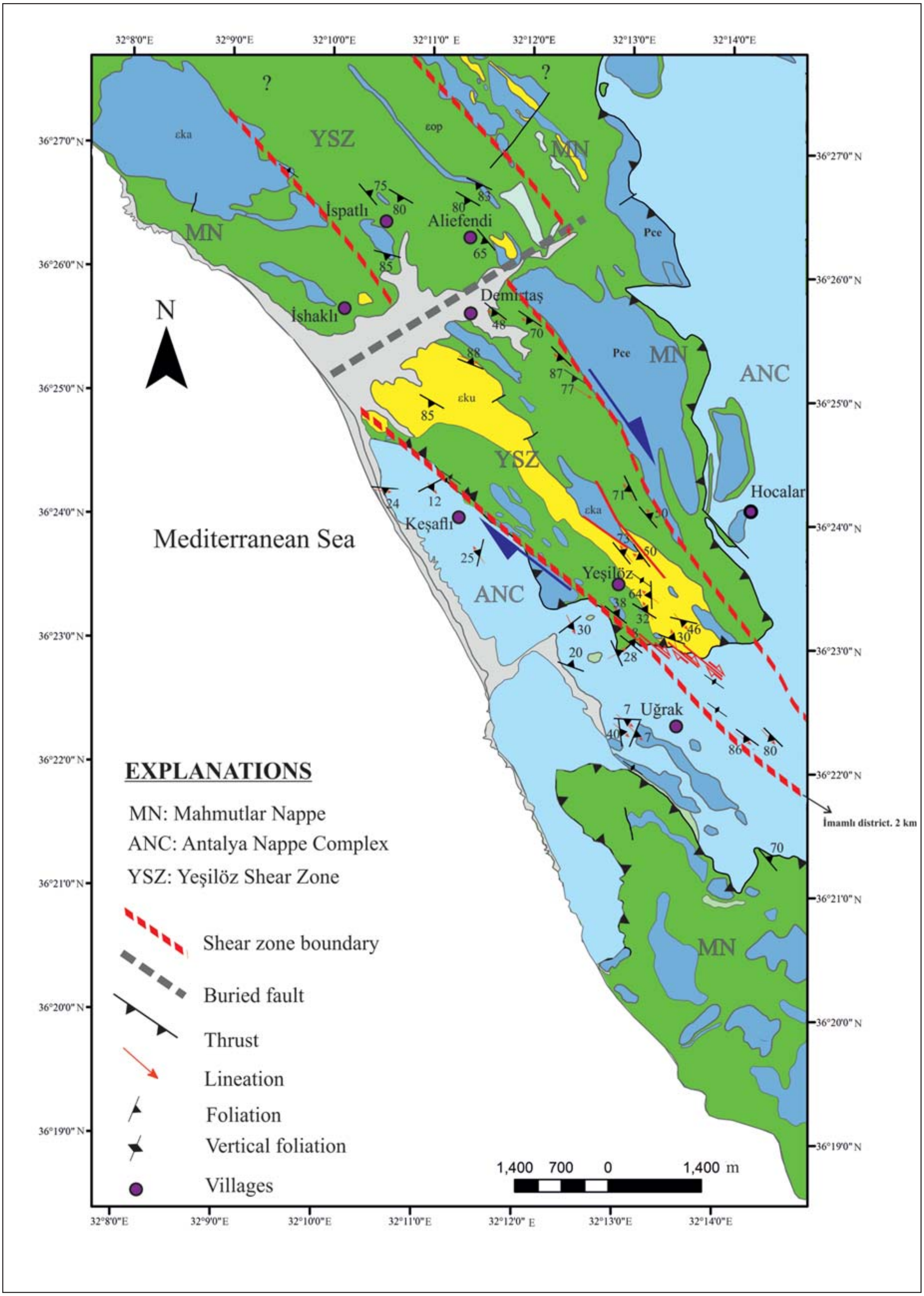

Figure 12- Geological map of the Yeşilöz Shear Zone, showing its offset by transverse fault near Demirtaş and its narrowing towards the SE with extension into the underlying Antalya Nappe Complex. The map is a simplified compilation from Özgül (1976, 1984) and Şenel et al. (2016*b*); legend as for figure 2.

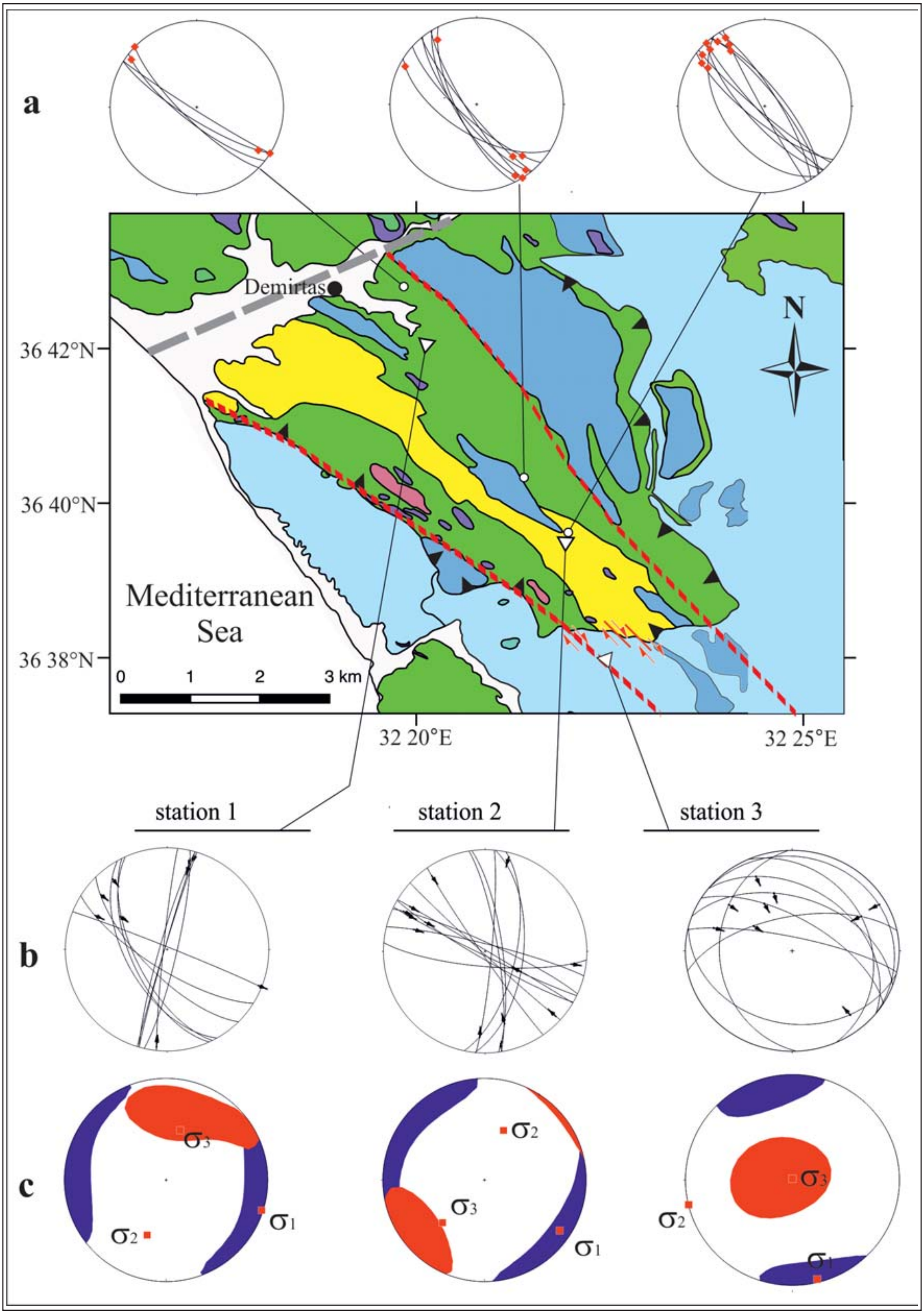

Figure 13 - A synthetic display of the whole dataset from the Yeşilöz Shear Zone in Mahmutlar Nappe and from the shear zone SE extension in the underlying Antalya Nappe Complex (see figure 12). (a) Foliation and lineation data, (b) fault data and (c) a contoured stereoplot of kinematic axes. The plot was made with the FaultKinWin Version 1.2.2 software (Marret and Allmendinger 1990; Allmendinger et al., 2012). The geological map is a simplified compilation from Özgül (1976, 1984) and Şenel et al. (2016*b*); legend as for figure 2.

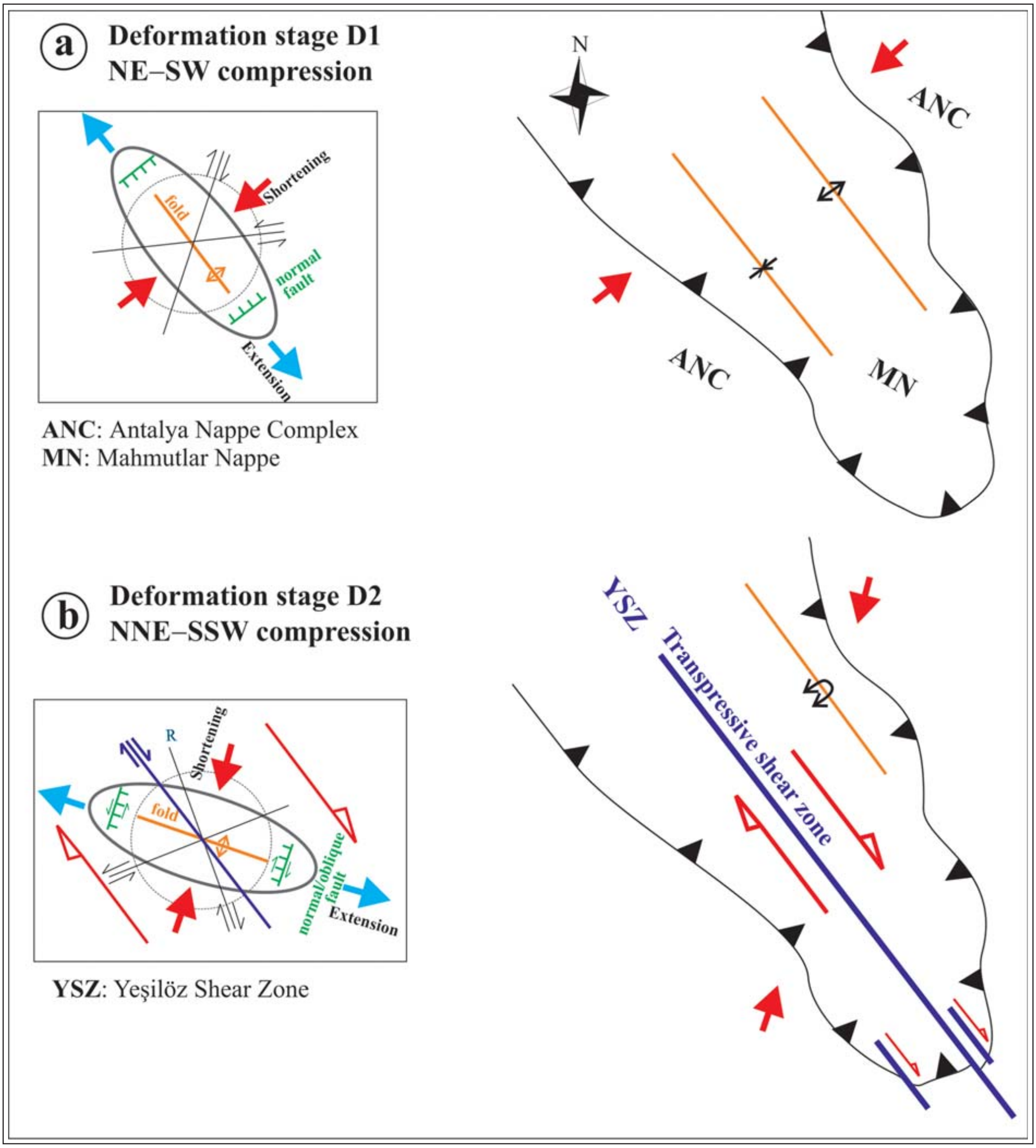

Figure 14- Interpretive cartoon summarizing the development of orogenic deformation as recognized in the study area, with the sketch map referring to figure 13. (a) The NE–SW contraction (pure shear) and formation of folds at stage D1. (b) The subsequent NNE–SSW contraction with dextral simple shear and the formation of Yeşilöz Shear Zone at stage D2.

regarded as representing the frozen movement and rotation that generated the nappe's system of F_2 folds. The inference of bulk movement direction from fault vergence is supposable where all folds in their regional system express a unique one-sided movement, with their vergence including the younging direction (cf. Fossen, 2010). Nothing like that is the case in the Mahmutlar Nappe, where – in contrast – the large F_2 folds preserved in the quartzite-marble bodies within the shear zone and those present on its SW side are all upright folds (Figures 4 and 5). The overturned fold is at the NE margin of the shear zone and hence is probably related genetically to the latter. For example, this overfold may be a shallow-level expression of the shear zone's sideways expansion (widening), perhaps at a restraining bend of parental strike-slip fault, with the tectonic drift of large rigid quartzite-marble bodies adding excess local rock volume at depth (Figure 4).

The deformation stage D2 (Figure 14b) occurred after the emplacement of Mahmutlar Nappe and involved a simple-shear strain system related to an anticlockwise-rotated compression stress axis. This transcurrent deformation was essentially ductile and resulted in the development of the transpressional Yeşilöz Shear Zone with subvertical to vertical foliation S_s paralleled by strike-slip faults and with a tectonic drift of lenticular, rigid quartzite/marble bodies. Phyllite shear lenses bear relics of foliation S_1 (Figure 7b) inherited from the original nappe. The N–S compression and dextral transcurrent deformation are best evidenced by the kinematic analysis of fault data from the shear zone (Figures 13b, c and 14b).

The emplacement of the Mahmutlar Nappe (deformation stage D1) caused a mild dynamic metamorphism of the underlying top part of the Antalya Nappe Complex, into which the transcurrent strain of the Yeşilöz Shear Zone then extended directly downwards (Figures 12 and 13). This evidence implies that no significant further translational movement of the Mahmutlar Nappe occurred during and after the shear zone formation. The shear zone formed in a different stress field, probably by the independent emplacement of the younger Sugözu Nappe or perhaps the Sugözü –Yumrudağ nappe set (Figure 2, legend) onto the Mahmutlar Nappe. The shear zone most likely accommodated the residual shortening induced by the younger nappe movement.

It is worth noting that the internal lithostratigraphy of the Mahmutlar Nappe (Figure 2, legend), as mapped and described in the regional literature (Özgül, 1976, 1984; Şenel et al., 2016*a, b*), was broken and virtually destroyed within the Yeşilöz Shear Zone – with the fragments of the individual formations turned into allochthonous blocks (Figure 4). The shear zone's mylonitized phyllite with dispersed quartzite/marble blocks, despite their consanguinity to the nappe lithostratigraphic units (cf. Figure 2, legend), should then be regarded as a tectonic mèlange, or "broken formation". The distinction between nappes and their derivative tectonic mèlanges is crucial to the reconstruction of the tectonic history and deformation dynamics of an orogen.

5. Conclusions

The NW-trending shear zone discovered in the Alanya region, labelled the Yeşilöz Shear Zone, occurs in the lower Mahmutlar Nappe of the NE-emplaced Alanya Nappe Complex. The nappe underwent early metamorphic folding and developed upright open folds during its movement. The shear zone is around 2 km wide and mappable over a length segment of 10 km. Its exposure in the forested area farther to the NW is poor to none, whereas to the SE, the shear zone is markedly narrowing at the nappe outcrop limit and shows direct downward extension into the underlying older nappe of the Antalya Nappe complex.

The shear zone consists of the component metamorphic rocks of the Mahmutlar Nappe, but with the phyllite strongly mylonitized and showing vertical shear foliation S_s and with the quartzites and marbles dispersed as lenticular bodies ranging in length from decimetres to more than 1 km. These brittle rock bodies show broken upright open folds similar as in the nappe, and also the phyllite facoidal shear lenses bear relics of the nappe metamorphic foliation S_1. Analysis of kinematic indices in the shear zone points to a dextral transcurrent deformation.

The nappe emplacement of Mahmutlar Nappe had mildly metamorphosed the upper part of the underlying nappe and also affected it with the development of the shear zone that reached directly downwards. The nappe thus showed no further translational movement during and after the shear zone formation, which suggests that the mylonitic ductile deformation probably accommodated a residual shortening induced by the emplacement of the next, younger nappe of the Alanya Nappe Complex.

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