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THE TARAKLI FLYSCH IN THE BOYALI AREA (SAKARYA TERRANE, NORTHERN TURKEY): IMPLICATIONS FOR THE TECTONIC HISTORY OF THE INTRAPONTIDE SUTURE ZONE

LE FLYSCH DE TARAKLI DANS LA ZONE DE BOYALI (SAKARYA TERRANE, NORD DE LA TURQUIE): CONSÉQUENCES POUR L'HISTOIRE TECTONIQUE DE LA ZONE DE SUTURE INTRAPONTIDE

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ABSTRACT

In the Boyali area, Northern Turkey, the tectonic units of the Istanbul-Zonguldak Terrane and the IntraPontide suture zone are thrust over the deposits at the top of the Sakarya Terrane, known as Tarakli Flysch. It consists of Early Maastrichtian-Middle Paleocene turbidite and mass-gravity deposits, whose source mainly corresponds to the Istanbul-Zonguldak Terrane, and with a lesser extent, to the IntraPontide suture zone. These deposits were sedimented in a foredeep basin developed during the convergence between Sakarya and Eurasian continental microplates. In the Late Paleocene-Early Eocene time span, the Tarakli Flysch was deformed (D1 phase) during the closure of the foredeep basin. In the Miocene time, the strike-slip tectonics (D2 phase) related to the North Anatolian fault produced further deformations of the Tarakli Flysch.

RESUME'

Dans la zone de Boyali, nord de la Turquie, les unités tectoniques du terrane Istanbul-Zonguldak et de la zone de suture IntraPontide sont chevauchèe sur les dépôts au sommet du terrane de Sakarya, connu sous le nom de Flysch de Tarakli. Il se compose de turbidites et des dépôts de glissement en masse sous-marine d'age Maastrichtien-Paléocène moyenne, dont la source correspond principalement à la terrane Istanbul-Zonguldak, et dans une moindre mesure, à la zone de suture IntraPontide. Ces dépôts ont été sédimentées dans un bassin avant-fosse développée au cours de la convergence entre les microplaques continentales Sakarya et Eurasia. Dans le Paléocène-Eocène Inferieure, le Flysch Tarakli a été déformé (phase D1) lors de la fermeture du bassin avant-fosse. Dans le Miocène, la tectonique décrochement (phase D2) liée à la faille Nord Anatolienne produit déformations en outre de Flysch Tarakli.

KEY WORDS: Foredeep deposits, Sakarya Terrane, IntraPontide suture zone, Tarakli Flysch, Northern Turkey.

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1. Introduction

The present-day tectonic setting of the Turkey can be depicted as a giant geological puzzle represented by amalgamated continental microplates separated by ophiolite-bearing suture zones, whose ages range from Late Neoproterozoic to Cretaceous (e.g., Göncüoglu et al, 1997 and quoted references). One of the most important but still poorly studied suture zones of Northern Turkeys is represented by the IntraPontide one, originated from the continental collision between the Sakarya (hereafter SK) and Eurasian Istanbul-Zonguldak (hereafter IZ) microplates. The tectonic units of IntraPontide Suture (hereafter IPS) zone are thrust over the Tarakli Flysch, i.e. a turbidite succession representing the sedimentary cover of SK Terrane.

Thus, the detailed analysis focused on the Tarakli Flysch may provide useful insights for the reconstruction of the IPS zone.

In this paper, an integrate study of the stratigraphical, paleontological and structural features of the Tarakli Flysch cropping out in the Boyali area, Northern Turkey, is presented and the implications for the tectono-sedimentary evolution of the IPS zone are discussed.

2. Geological Setting

In Northern Turkey (Fig.1), the IPS zone (Robertson and Ustaömer, 2004, Göncüoglu et al., 2008) separates the IZ Terrane (Saribudak et al., 1989), in the north, from the SK Terrane of Gondwana affinity, in the south. Whereas the IZ Terrane is regarded as belonging to Eurasia plate, the SK Terrane is interpreted as representative of the SK microplate, separated from the Eurasia continental margin by the IPS oceanic basin.

The IPS zone is regarded as originated by the Late Cretaceous to Early Tertiary convergence between IZ and SK plates, leading to complete destruction of the oceanic basin. The remnants of this basin are preserved in the IPS zone, where an imbricate stack of oceanic and continental units have been detected along its whole extent.

The IZ Terrane includes a Late Neoproterozoic basement (e.g., Ustaömer and Rogers, 1999) unconformably covered by a continuous, well-developed sedimentary sequence ranging in age from Ordovician to Carboniferous, only mildly deformed during the Variscan orogeny (e.g., Gorur et al., 1997). The non-metamorphic Paleozoic sequence of the IZ Terrane is unconformably overlain by Late Permian-earliest Triassic sedimentary rocks, and their transition to turbidite deposits of Late Triassic age. The Triassic rocks are unconformably overlain by Late Cretaceous–Paleocene turbidite deposits (Akveren Flysch) where andesitic volcanic rocks have been found (e.g., Dizer and Meric, 1983). Senonian andesitic lavas, dikes, and small acidic intrusions are the witness of a north-dipping subduction of the NeoTethys oceanic lithosphere below the continental crust of IZ Terrane.

The IPS units are thrust over the SK Unit derived from SK Terrane and represented, in the studied geotraverse, by the Karakaya Complex and its sedimentary cover. The Karakaya Complex represents the remnants of a Triassic accretionary wedge (Okay and Göncüoglu, 2004 and quoted references), where metabasites and metaserpentinites are preserved (Sayit and Göncüoglu, 2009). The lower Karakaya Complex was strongly deformed under a latest Triassic, high-pressure facies metamorphism (Okay et al., 2002), interpreted as the result of the Cimmerian orogenesis. The tectonic structures related to the Cimmerian orogeny are unconformably sealed by the continental- to shallow-marine Early Jurassic clastic rocks, in turn disconformably topped by the Middle Jurassic to Early Cretaceous neritic carbonates (Yigitbas et al, 1999). The neritic carbonates are unconformably overlain by the Albian–Cenomanian pelagic limestones showing a transition to turbidite deposits (here reported as Tarakli Flysch) ranging in age from Late Cretaceous to Paleocene.

In the study area, along the geotraverse Kursunlu-Arac, the IPS zone can be defined as an imbricate stack of four types of tectonic units: the ophiolite units, the Arkotdag Mèlange, the High-Grade Metamorphic Unit and the Low-Grade Metamorphic Unit (Fig.1). The imbricate stack is probably the result of multiple event of thrusting leading to present-day juxtaposition of oceanic and continental units. These units are sandwiched between the IZ Terrane at the top and the SK Terrane at the bottom. The relationships of the rock-units of the IPS zone area sealed by sedimentary deposits of Early Eocene. Strike-slip tectonics related to the still active North-Anatolian Fault Zone (hereafter NAFZ) modified the original relationships among the rock-units of the IPS zone.

3.The Tarakli Flysch in Boyali area

The study area corresponds to the E-W trending strip to the North of Kursunlu and Ilgaz along the Akçay and Boyalıçay valleys between the Aylı Mountain in the North and Gürgenli and Köklüce mountains in the South (Fig.2). In the Boyali area, even if their relationships are reworked by strike-slip faults, the overthrust of the Arkotdag Mélange onto the Tarakli Flysch can be still identified in the field. Dykes of andesites cutting the Tarakli Flysch have been found.

3.1. Stratigraphic features

The stratigraphic features of the Tarakli Flysch have been fully reconstructed in the sections cropping out along the northern side of the Akçay Valley, between the Bahcecik and Boyali Villages and along the Boyalıçay Valley (Fig.2). The succession, whose thickness has been estimated as at least 700 m, shows a clear thickening and coarsening upward evolution that can be divided in five different lithofacies (see Fig. 3A log for more details) that, from the bottom to the top, are: "thin-bedded turbidites", "medium-grained arenites", "conglomerates", "calcareous coarse-grained turbidites" and "slide-block in shaly-matrix" lithofacies.

The lower most part of Tarakli Flysch is characterized by 400 m thick thin-bedded turbidites consisting of thin to medium beds (5-50 cm) of medium- to fine-grained arenites and coarse-grained siltites (Fig. 3B1). The medium- to fine-grained arenites are often characterized by thin traction carpets. These strata are generally well graded only in their uppermost part where current ripples and sinusoidal lamina can be also present. In the uppermost part of this lithofacies decimetric lenticular beds of coarse-grained arenites can be recognized (Fig.3B2).

The medium-grained arenites lithofacies is characterized by up to 50 m thick sequence of turbidites represented by 0.5-2.5 m thick beds of amalgamated medium- to fine-grained arenites alternating with subordinate thin beds of shales (Fig. 3A). These strata are characterized by the lack of sedimentary features as graded bedding and lamina and a quite massive structure can be recognized. The bottom surface of these strata is marked by sole marks and by the widespread presence of organic matter (leaves and tree cortex fragments).

A dm-thick level of well rounded clast- to matrix-supported conglomerates (Fig. 3B3) characterize the medium part of the Tarakli Flysch and represent, in this area, a key level to understand the geometry of the main structures. The most striking feature of this lithofacies is represented by granite-dominated composition of the pebbles. These beds, derived from high density erosive flows probably connected to a coarse-grained river-delta system, are characterized by frequent basal erosional features.

The calcareous coarse-grained turbidites lithofacies consist of a sequence of layers (not thicker than 25-30 m) ranging from clast-supported orthoconglomerates to coarse arenites mainly derived from debris flows and high density turbidity currents. The most common facies is represented by prevalent monomict clast-supported conglomerates characterized by poor sorting. The internal organization of these deposits, characterized by unsorted coarse clasts, is scarce. These beds, derived from high density erosive flows, are characterized by frequent basal erosional features. The erosional ability is suggested by frequent bottom bedset scours, diffuse amalgamated surfaces, and common rip-up mud clasts. These strata are associated with coarse-grained high density turbidity current deposits. Thick to medium beds without internal structures and with poor sorting are the most common facies. A subtle normal grading and water escape features can be recognized in a few beds.

The most prominent feature of these members is the quasi-monomict composition of the debris characterized by extrabasinal carbonatic clasts.

The upper part of the succession (up to 400 m thick) is dominated by huge slide-blocks embedded in a fine grained-matrix (Fig. 3B4). The matrix of this lithofacies is characterized by varicolored mainly shaly to silty deposits. Subordinate decimetric lenticular beds of coarse-grained arenites have been also recognized. The slide-blocks, usually with lenticular shapes, show different size (ranging from boulder up to 100 m-thick blocks) and composition. Even if the primary relationships between the slide blocks and the surrounding matrix are always tectonized, their emplacement due to submarine landslides for these blocks is suggested by synsedimentary deformation structures recognized in the sediments around the blocks and by slide block-derived monomict pebbly-mudstones and pebbly-sandstones that are present around several slide-blocks. The slide-blocks are mainly made up of granitoids, orthogneisses, metagabbros/amphibolites, Jurassic carbonatic turbidites next to Ordovician quartzarenites, black shales, crinoidal (Fig. 3B5) and brachiopod-bearing Devonian-Carboniferous limestones and probably Triassic red quartzarenites (Fig. 3B4) as typical representatives of the IZ Terrane. Few blocks of serpentinites have been also recognized in the uppermost part of the sequence.

3.2. Arenite petrography

35 thin sections from Tarakli Flysch (30 arenites and 5 rudites) were analyzed by means of polarizing microscope. A modal analysis was performed on 19 selected medium- to coarse-grained arenites. Point counting (500 points) of arenites was performed using the Gazzi-Dickinson technique (Zuffa, 1987 and quoted references) to

minimize the dependence of arenite composition on grain size. The point counting results are plotted on the triangular diagrams of Fig. 3C.

No large differences can be recognized in the framework composition of arenites from the Tarakli Flysch. They range from quartz-poor mixed arenites up to calclithites. The total framework is characterized by a mixed siliciclastic-carbonate framework composition (Fig. 3C1) where the important carbonatic extrabasinal contribution (CE, up to the 50%) led to classified these rocks as mixed arenites (Zuffa, 1980).

The extrabasinal siliciclastic framework is characterized by a common presence of mono- and polycrystalline quartz (12÷41% of the total framework) and feldspar (6÷31%). Felsic intrusive coarse-grained rock fragments, such as granitoids, are common (0÷3% of the total framework) while low grade metamorphic rock fragments are not common and include coarse-grained gneisses, metaquartzites, fine-grained schists and mica-schists (1÷8% of the total framework).

A striking feature of the Tarakli Flysch arenites is the widespread presence of carbonate rock fragments (Fig. 3C1). In all the studied samples both intra- (1÷30% of the total framework) and extra-basinal (22÷48%) carbonate fragments have been recognized. Carbonate extrabasinal fragments are represented by carbonate platform derived rocks, mainly mudstones, wackestones and grainstones of Jurassic - Early Cretaceous age (Fig. 3B6). The allochems in the grainstone fragments are peloids, ooids, minor benthic foraminifera and undeterminable macrofossil fragments. The intrabasinal carbonate fragments are instead represented by mudstone, showing deformed and squeezed soft margins and by isolated bioclasts, mainly benthic foraminifera and macrofossils (Fig. 3B6). The presence of intrabasinal carbonate fragments became relevant in the calcareous coarse-grained turbidites. The arenites composition of this lithofacies indicate a strong supply from a coeval carbonate platform (up to 65% of the total framework, Fig. 3C1)

The lacking of ophiolite-derived rock fragments, represents one of the more striking features of Tarakli Flysch arenites. Therefore the source areas of these sediments were mainly characterized by a continental basement made up of granitoids, metamorphic rocks, felsic volcanic rocks and the relative sedimentary covers, represented by extrabasinal non coeval carbonate rock successions.

This source area can be related to a typical continental margin. The lithic fragments in the arenites debris and the composition of the main slide-blocks in the uppermost part of the succession seem to indicate the IZ Terrane as the most probable source area of the Tarakli Flysch.

3.3. Nannofossil analyses

55 samples were analyzed for the calcareous nannofossil study of the Tarakli Flysch. The analyses were performed on smear slides, prepared from unprocessed material, using a light microscope at 1250 magnification. The taxa have been recognized following the taxonomy proposed by Perch-Nielsen (1985a, 1985b) and Bown (1999). The investigated samples and the recognised calcareous nannofossil taxa are provided in Table A. Several samples (19) are barren, while the investigated assemblages suffered overgrowth and dissolution. However some informations about the age of the identified lithofacies have been obtained.

In the lowermost thin-bedded turbidites lithofacies, a sample with a monogeneric assemblage (ABT04), composed of common *Micula staurophora*, *Micula concava* and *Micula* sp., has been collected. This sample can be referred to the Maastrichtian on the basis of paleoclimatic consideration. The genus *Micula* is considered a cold water indicator and the genus *Watznaueria* is related to warm water condition. Bojar Melinte et al. (2009) record a *Watznaueria*/*Micula* cross over, in Early Maastrichtian, as a result of colder water condition. The monospecific assemblage of *Micula* spp. found in our sample could be related to this cold event and indirectly dated to the Early Maastricthian. Reworking is evidenced by the sample ABT02 where the finding of *Ephrolithus floralis* indicates the Late Aptian-Late Cenomanian time interval. On the contrary, samples TC21 and TC22 from marls from of the shaly-matrix lithofacies around the slide-blocks have been dated to the Middle Paleocene (Selandian zone NP5 of Martini, 1971) on the occurrence of *Heliolithus cantabriae*, *Fasciculithus ulii*, *Fasciculithus tympaniformis* and *Sphenolithus anarrhopus*. The characteristics of this lithofacies resulted in a strong reworking of the nannofossil assemblages. For instance, the sample with *Polycostella beckmannii* and *Diazomatolithus lehmanii* (ABT22) can be referred to the *Polycostella beckmannii* Subzone (NJ20B) of Bralower et al. (1989) referable to the Middle Tithonian, and samples bearing *Nannoconus* sp., *Hexalithus noeliae*, *H. chiastia*, *P. beckmannii* and *D. lehmanii* (TC196, TC197, TC198) have been dated to the NJK Zone (Jurassic-Cretaceous boundary) of Bralower et al. (1989).

In summary, the nannofossil analyses indicate an Early Maastrichtian for the lowermost level of the studied succession, whereas a Middle Paleocene age can be proposed for its top, i.e. the slide-block in shaly-matrix lithofacies.

3.3. Deformation history

The Tarakli Flysch is characterized by a complex deformation pattern, even if the whole succession is non-metamorphic. This deformation pattern is the result of two main deformation phases, referred as D1 and D2 phases, whose structures are well identifiable in the field.

The structures of the D1 phase are represented by F1 folds that commonly display a geometry ranging from isoclinal to subisoclinal. The F1 fold axes show from NW-SE to NNW-SSE strike with steep plunges (Fig.4A).

At the outcrop scale the F1 folds are overprinted by a cm- to tens of meter-scale structures (Fig.4A) represented by a complex association of faults, thrusts and folds, all referred to D2 phase (Fig. 4B and C).

The faults occur as high-angle brittle shear zones grouped into three main systems with E-W, NNW-SSE and NNE-SSW strike, respectively referred to S1, S2 and S3 systems (Fig.4D). The faults of S1 and S3 systems show predominantly dextral strike-slip movements, but slip sense indicators of normal movements are also observed. On the contrary, the faults of S2 system are mainly represented by sinistral strike-slip faults. The thrusts are represented by flat shear zones with medium to low dip and NNW-SSE and ENE-WSW strike (Fig.4C). The thrusts are characterized by both northward and southwestward sense of shear. In the field, examples of structures where the thrusts are rooted into the high angle strike-slip faults are common.

The F2 folds can be instead grouped into two main groups based on their geometry and/or relationships with faults and thrusts. The first type F2a corresponds to upright folds directly associated with steeply dipping faults (Fig.4B). Strike of fold axes and axial planes are roughly parallel to that of the related faults. These upright folds show hinge zone that may be partially cut out by the faults, whereas the vertical fold limbs are cut by an array of faults parallel to the bedding planes or cross-cutting at low angles to produce imbricate zones. The second type F2b includes the folds associated with the thrusts. The F2b folds display sub-horizontal axes and axial planes, whose strikes is roughly parallel to the mean directions of the thrusts (Fig.4C).

The close association among folds, faults and thrusts as well as their cross-cutting relationships clearly indicates their belonging to flower structures, as suggested by the close parallelism between the strikes of F2 fold axes and related axial planes with the strike of thrusts and faults. All these structures can be regarded as related to the NAFZ system.

The structural setting of the Tarakli Flysch identified in the field can be also recognized in a N-S trending geological cross-section of the Boyali area reported in Fig.2. In this cross-section, asymmetric flower structures can be identified, even if the distribution of these structures is not homogeneous. Along the cross-section, the southern contact of the Tarakli Flysch with the Eocene deposits corresponds to a dextral high-angle fault whereas, at the northern edge of the cross-section, the Tarakli Flysch is separated from the IPS units by a low-angle thrust (Fig.2).

4. Discussion

The succession of the Tarakli Flysch cropping out in the Boyali area shows a clear thickening and coarsening upward evolution from thin-bedded turbidites to medium-grained arenites and calcareous coarse-grained turbidite lithofacies. This succession ends with a level of slide-block in shaly-matrix lithofacies, that can be considered as the fast catastrophic event that predates the closure of the basin and its deformation. This evolution is typical of syn-tectonic sedimentation in a foredeep environment as detected, for instance, for the Pindos Flysch (Bortolotti et al., 2009).

The nannofossil analyses indicate an Early Maastrichtian age for the lowemost level of the studied succession, whereas a Middle Paleocene age can be proposed for its top, i.e. the slide-block in shaly-matrix lithofacies.

The arenite composition indicate that the foredeep basin is filled mainly by sediments derived from a source area, related to the IZ Terrane, according to lithic fragments in the arenites debris and the composition of the main slide-blocks in the uppermost part of the succession. This conclusion is confirmed by the finding of blocks of ortho- and paragneisses and amphibolites resembling the pre-Cambrian basement of the IZ Terrane together with the blocks of Ordovician quartz-arenites, Silurian black shales and Devonian-Carboniferous limestones of Upper Paleozoic age, which are only observed in the IZ Terrane in NW Anatolia (Yanev et al, 2006). The IZ Terrane was probably thrust over the IPS ophiolites and mèlange, that only rarely provided debris, according to the occurrence of scattered block of serpentinites in the youngest lithofacies.

The D1 deformation can be regarded as the result of the emplacement over the Tarakli Flysch of the IZ Terrane with the IPS ophiolites and mèlange at its base. The age of the D1 phase can be thus bracketed between the Middle Paleocene, i.e. the age of the youngest deposits involved in the deformation and the Early Eocene (NP 14, our unpublished data), i.e. the age of the oldest deposits unconformably overlying the Tarakli Flysch as well as the overlying tectonic units.

The structures of the D2 phase can be instead regarded as related to the flower structures developed during the transpressional tectonics connected with the NAFZ system. Therefore, if the inception of the NAFZ activity has been generally regarded as Miocene (e.g. Bozkurt, 2001), a same age can be assigned to the D2 structures in the Tarakli Flysch.

5. Conclusions

The Tarakli Flysch in the Boyali area can be interpreted as an Early Maastrichtian-Paleocene turbidite and mass-gravity deposits sedimented in a foredeep basin. The substratum of this basin was represented by the SK Terrane whereas its northern edge was constituted by a mobile belt, that, according to arenite and slide blocks composition, was represented by the IZ Terrane thrust over the IPS units. The latters provide scattered slide bloks of serpentinites found only in the uppermost levels of the Tarakli Flysch. This basin was developed during the final stage of the closure of the IPS zone as result of the progressive convergence between SK and Eurasia plates. After the Middle Paleocene, but before the Early Eocene, the D1 deformation phase can be regarded as the signal of final emplacemente of the IZ Terrane and the IPS units zones over the foredeep basin where the Tarakli Flysch sedimented. The structure orginated during this event are sealed by Early Eocene deposits and strongly reworked by the NAFZ tectonics starting from the Miocene time when the Tarakli Flysch was affected by the D2 phase deformation.

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FIGURE CAPTIONS

Fig. 1 *column* Fig. 1. A) The major tectonic zones of Turkey separated by sutures (modified from Sengör and Ylmaz 1981). B) Tectonic sketch of the Bayramoren-Arac area. 1) Alluvial deposits; 2) Pliocene deposits; 3) Eocene deposits; 4) IZ Terrane; 5) IP Suture Zone, Low-Grade Metamorphic Unit; 6) IP Suture Zone, High-Grade Metamorphic Unit; 7) IP Suture Zone, Ophiolitic Units; 8) IP Suture Zone, Arkotdag Mèlange; 9) SK Terrane.

Fig. 2. *whole page* A) Geological-structural map of the study area. 1) Alluvial deposits; 2) Pliocene deposits; 3) Middle Eocene deposits; 4) Lower Eocene deposits; 5) Low-Grade Metamorphic Unit; 6) Arkotdag Mèlange; 7) Basalts; 8) Tarakli Flysch, slide-block in shaly-matrix; 9) Tarakli Flysch, orthoconglomerates; 10) Tarakli Flysch, thin-bedded turbidites; 11) Jurassic-Cretaceous limestones; 12) Granites; 13) Cataclastic zones; 14) Main strike-slip faults; 15) Main faults; 16) Thrust faults; 17) Stratigraphic boundaries; 18) Bedding; 19) Vertical bedding; 20) AP1 axial plane; 21) vertical AP1 axial plane; 22) AP2 axial plane, 23) A1 fold axes; 24) A2 fold axes with vergence; 25) Horizontal A2 fold axes; 26) High-angle strike-slip faults; 27) Low-angle thrust faults; 28) Location of sampled sites for nannoplankton analyses; 29) Trace of the geological cross-section. B) Geological cross-section.

Fig. 3 *whole page* Stratigraphy and petrographic features of the Tarakli Flysch. A) Reconstructed stratigraphic log of the Tarakli Flysch. The position of the studied samples are indicated in the left side of the log. Lithofacies legend: 1 - slide-block in shaly-matrix; 2 - calcareous coarse-grained turbidites; 3 - conglomerates; 4 - medium-grained arenites; 5 - thin-bedded turbidites. B) field occurrence of the Tarakli Flysch in the Boyali area. 1 - TBT lithofacies; 2 - uppermost part of the TBT lithofacies, the circle indicate decimetric lenticular beds of coarse-grained arenites sampled for arenites petrography (sample TC 188); 3 - dm-thick level of well rounded to matrix-supported conglomerates, Boyali village area; 4 - huge slide-blocks of quartzarenites (sample TC 37) embedded in a fine grained-matrix shaly matrix (Boyalıçay Valley); 5 - slide-blocks of crinoidal Devonian-Carboniferous limestones (Boyalıçay Valley); 6 - photomicrographs of mixed/hibrid siliciclastic-carbonate petrofacies typical of the Tarakli Flysch arenites. Black arrow indicates an extrabasinal carbonate fragment (oolitic grainstone) while the white arrow indicates a coeval carbonate intrabasinal fragment (micritized bivalve fragment), sample TC201. C) Ternary plots showing framework modes of arenites from Tarakli Flysch plotted on: NCE CI+NCI CE (Zuffa, 1980); Q F L+C (Dickinson, 1985); Lm Lv Ls+c (Ingersoll and Suczek, 1979).

Fig.4 *whole page* Examples of deformation structures in the Tarakli Flysch. A: Interference between F1 and F2 folding; AP1: F1 axial plane; AP2: F2 axial plane. B: Folds associated with strike-slip faults; S1: traces of bedding. C: Asymmetric F2 folds associated with low angle thrust faults. D: Stereograms of structural elements; Equal area projection, lower hemisphere.

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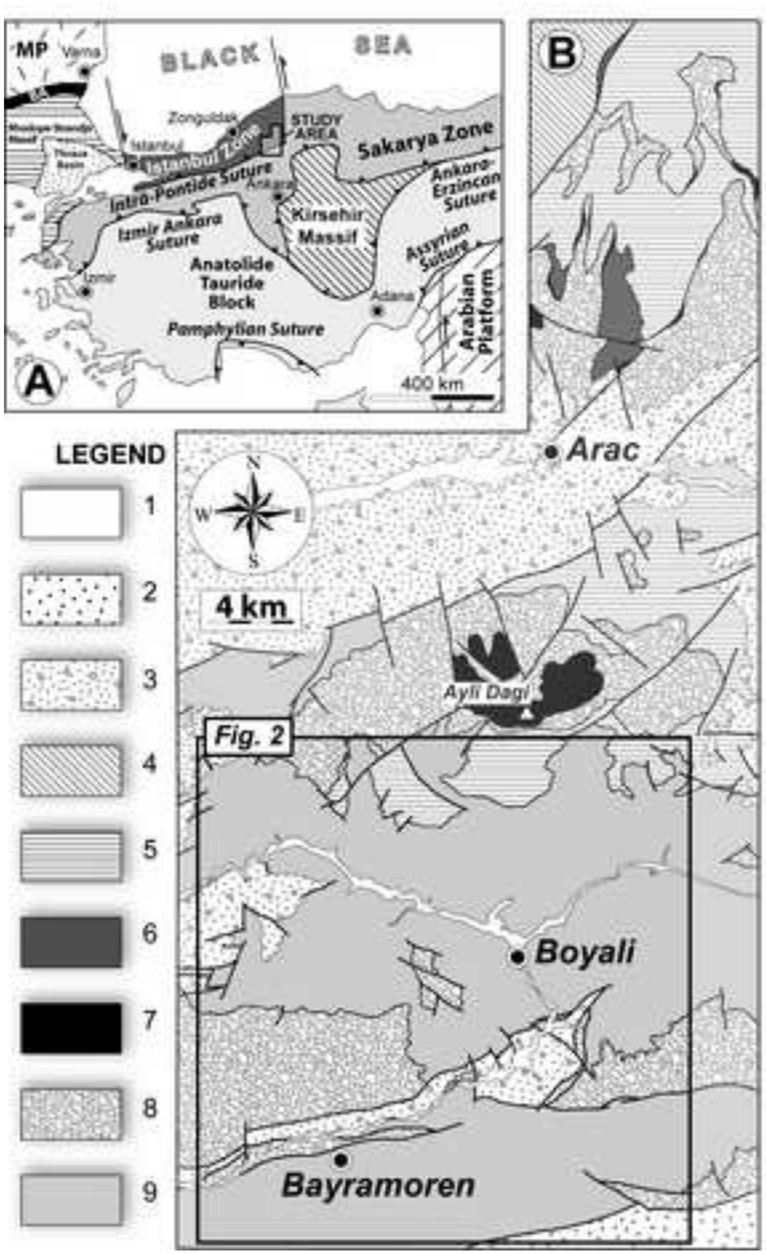

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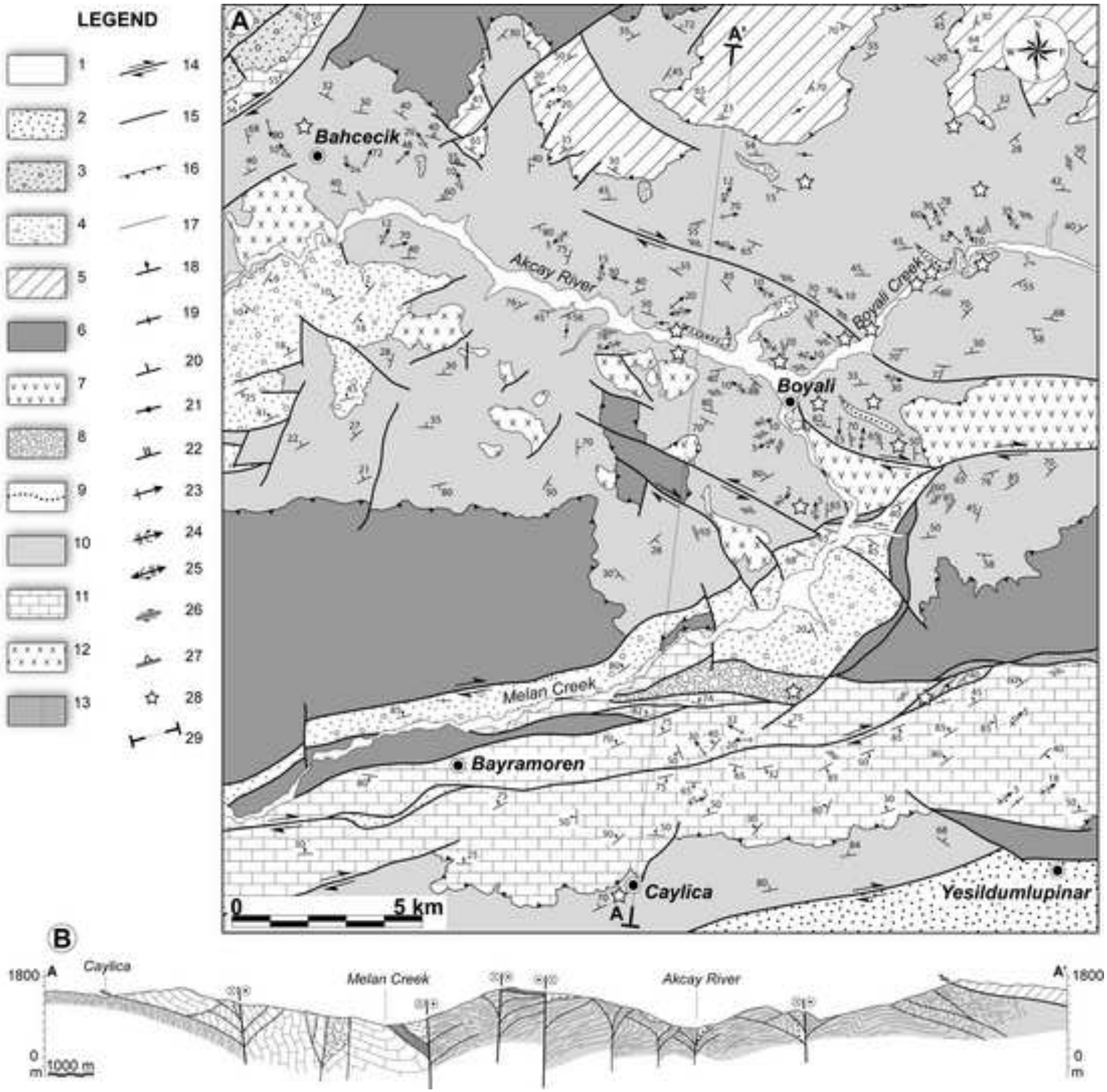

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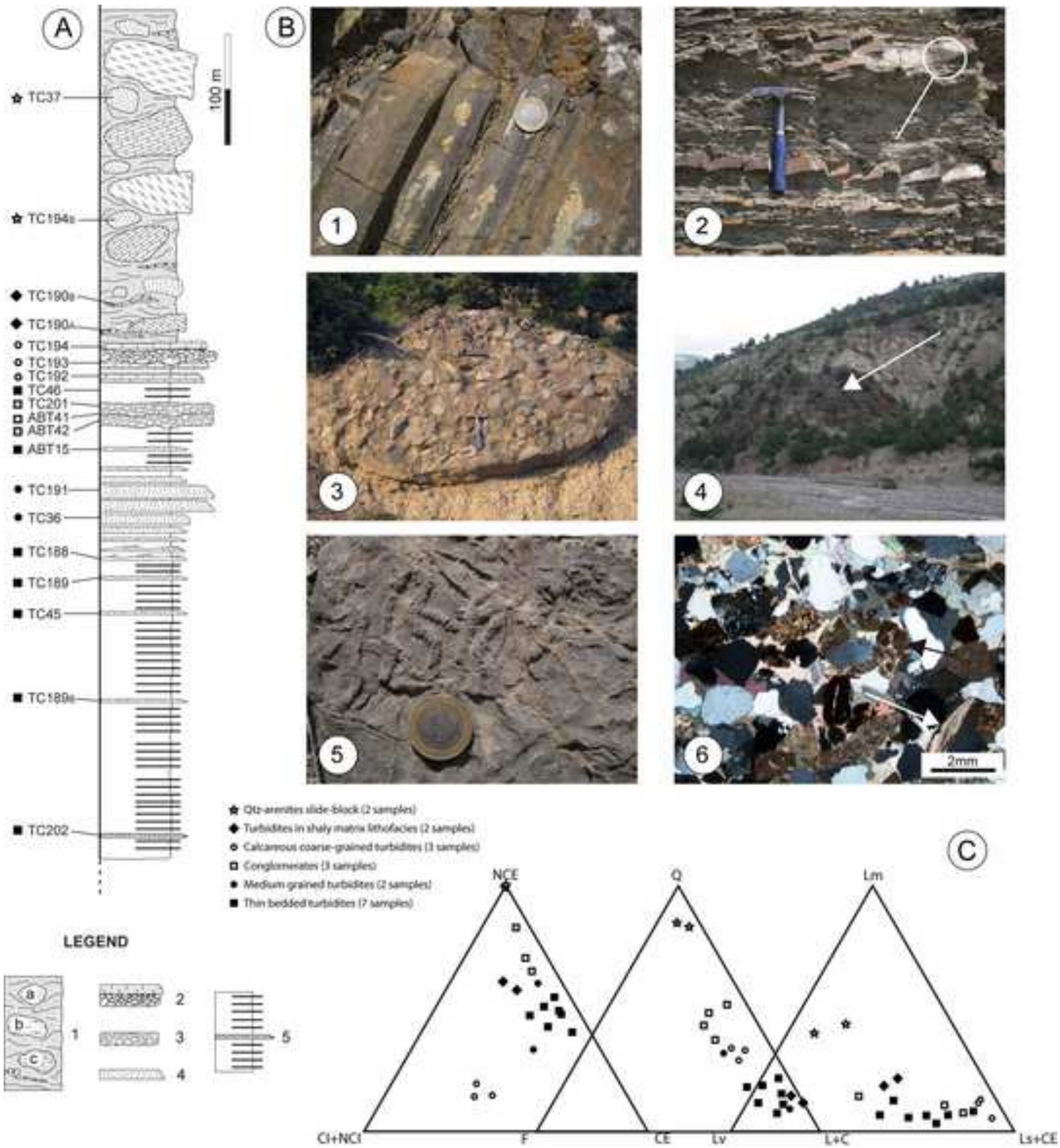

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