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THE ANTON SHEAR ZONE (CENTRAL STARA PLANINA MOUNTAINS). TEMPORAL RELATIONS, EXTENT AND SIGNIFICANCE

A. Lazarova, I. Gerdjikov, N. Georgiev, D. Dimov

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Abstract

The significance of the Anton shear zone is reassessed based on structural studies. It is a fairly narrow north-verging reverse/thrust zone along the southern contact of the Variscan Vejen pluton with low-grade metamorphic host rocks to the north of the village of Anton. Field data suggest that the deformation occurred after the pluton emplacement and the associated contact metamorphism, most likely during an Early Alpine tectonic event.

Key words: Balkanides, Vejen pluton, contact aureole, shear zone

Introduction. The late Variscan Vejen pluton (VP) is exposed along the crest of Stara Planina mountain ridge for about 45 km. In contrast to the hosting Palaeozoic low-grade metamorphic rocks, the pluton commonly lacks tectonic fabric. This fact, as well as the static contact metamorphic aureole, is regarded as indication for post-tectonic emplacement of VP. Only in the area north of the village of Anton, there are data about severe solid-state fabric and intense shearing in the immediate host rocks [1–3] that can be related to Anton shear zone (ASZ) [3]. Based on field data the latter work [3] suggests Variscan age of the mylonitic fabric.

The occurrences of mylonitic rocks along the southern margin of VP rise several important questions: (i) what are the temporal relations between magma emplacement and solid-state overprint; (ii) what is the areal extent of the shear zone; (iii) what is the significance of the zone. This paper is an attempt to answer these questions since they can shed new light on the structure and mode of emplacement of VP.

Geological setting. VP consists dominantly of granodiorites and subordinate granites, tonalities, diorites, etc. [4, 5]. U/Pb zircon geochronology indicates a late Carboniferous age [5]. Low-grade metamorphic rocks, known as Diabase-Phyllitiod Complex (DFC), host the pluton [2, 3, 5]. This complex includes mainly metasedimentary rocks with minor matabasites. A fairly wide (200–250 m) contact aureole of hornfelses, amphibolites and andalusite-cordierite schists [1, 2], referred to here as contact aureole rocks (CAR), was formed during the pluton emplacement. To the north of the village of Anton, the CAR are dominantly spotted schists. Numerous porphyrite dykes, genetically related with VP, cut the intrusive and the host rocks [5–7]. The presence of chilled margins indicates that their emplacement occurred after some cooling of VP and the contact aureole.

ASZ was described as eastern continuation of the Alpine Kashana thrust [2] or as late Variscan ductile shear zone [3]. It is 3 km long and 500–700 m thick, E-W trending north-verging reverse shear zone (Fig. 1) along the contact of VP with low-grade metamorphic rocks of DFC.

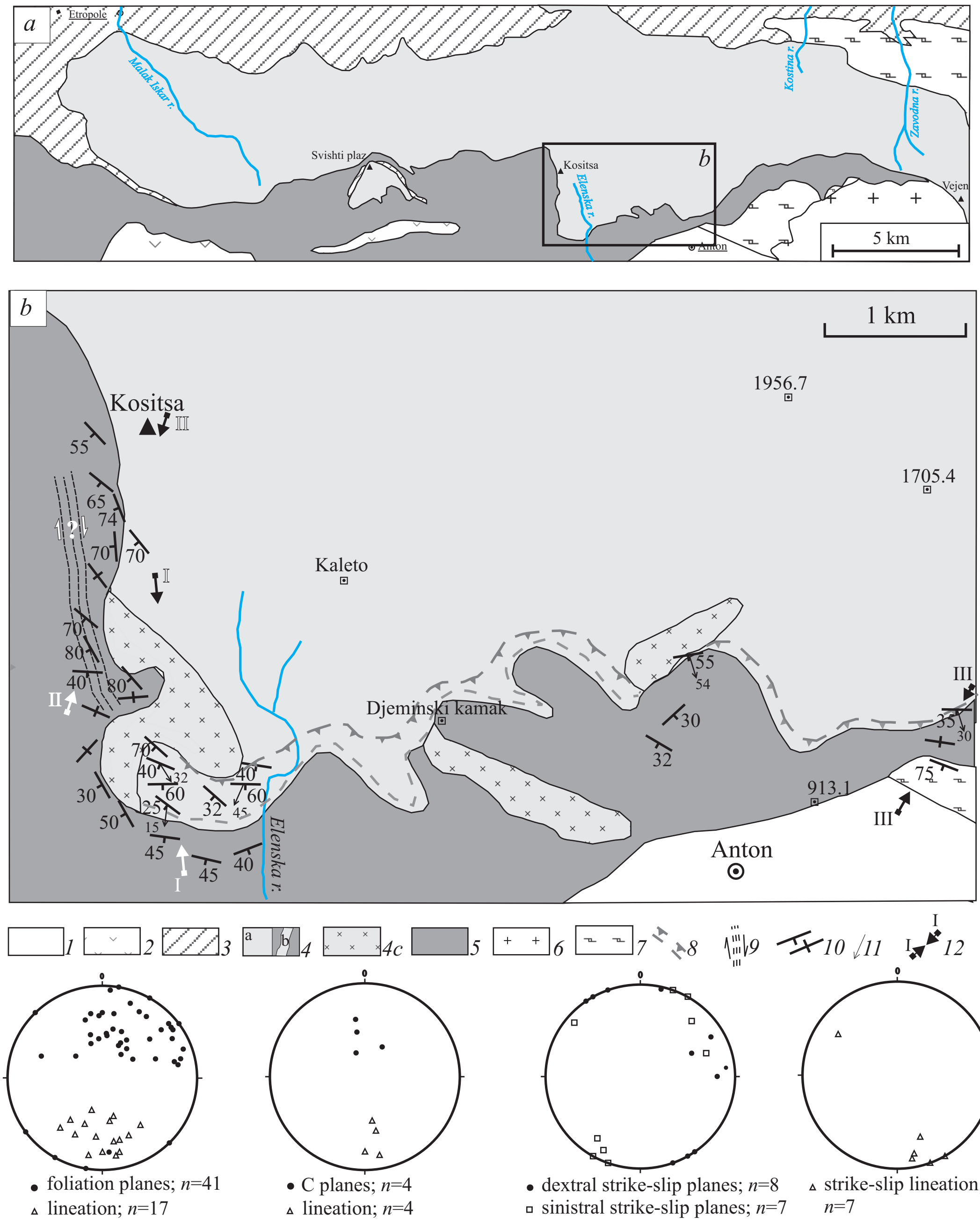

Fig. 1. *a*) Location map of the Vejen pluton and the Anton shear zone, Central Stara Planina Mounatins; *b*) Structural map of the Anton shear zone and strike-slip shear bands to the south of the Kositsa peak. Lower-hemisphere stereograms show the orientation of different structural elements. *1* – Quaternary deposits; *2* – Upper Cretaceous sedimentary and volcanic rocks; *3* – Triassic, Jurassic and Lower Cretaceous sediments; *4* – Vejen pluton: a – granodiorites and granites; b – porphyrite dykes; c – diorites; *5* – DFC; *6* – Anton and Klisura granites; *7* – High-grade metamorphic rocks; *8* – Anton shear zone; *9* – strike-slip shear bands; *10* – foliation planes; *11* – lineation; *12* – profile lines

Field data. Two structural domains can be recognised in the studied area based on the geometry and characteristics of the penetrative fabric. The first domain includes the area of ASZ north of the village of Anton, and the second one – the area of N-S trending contact of VP to the southwest of Kositsa Peak (Fig. 1).

ASZ is defined on the basis of intense deformation along the southern margin of VP with CAR. Within the zone, the strain was mainly accommodated by granodiorites of VP as well as related porphyrite dykes (Fig. 1). One of the most striking features is the heterogeneous strain distribution (Fig. 3*b*). Such heterogeneity is marked by the simultaneous occurrence of contrasting tectonites – cataclasites and mylonites. The cataclasites are massive rocks in which closely spaced joints and shear surfaces define the foliation. The mylonites display evidence for meso-scale ductile behaviour and foliation surfaces are penetrative and more planar. Often in the field, the porphyritic varieties appear more cataclastic. Typical of the granitoid rocks are S-C′ fabric (Fig. 3*a*) [8] as well as shear folds and tension gashes. In contrast to previous work [3] it was found that the VP aplite veins within the granodiorites are also deformed (Fig. 3*c*). The aplites are foliated, sheared and bent into cm-scale folds.

To the west of Elenska river valley and to the east of Djeminski kamyk Peak, VP comprises mainly diorites (Fig. 1, 2*a*). These rocks are devoid of pronounced solid-state fabric, and primary intrusive relations with undeformed aplites are preserved.

Within CAR, the deformations related to ASZ are difficult to identify mainly because of the fine grain size of the constituent lithologies. Several features suggest that CAR do not display penetrative fabric related to ASZ. First, there is no increase of S/L fabric intensity toward ASZ. Second, there is no grain-size reduction toward the zone. Third, no reorientation of CAR foliation toward the margins of ASZ is observed. The only features that could be related to the activity of ASZ within CAR are rare subhorizontal shear bands (C′), which display top-to-the north shear sense. Several porphyrite dykes, genetically associated with VP, are hosted in CAR. In the easternmost parts of the studied area (Fig. 1), the strain related to the top-to-the north movements is partitioned into them.

The northern boundary of ASZ is easy to define – from north to the south, undeformed granodiorites gradually pass into crudely foliated and then into intensively foliated rocks. Thus, the undeformed granodiorites and diorites can be regarded as footwall of ASZ. The southern boundary of the zone is more difficult to trace. Since we were unable to document any penetrative fabric related to ASZ in CAR, it is assumed that these rocks belong to the hanging wall of the shear zone.

The mylonitic foliation within the zone strikes 70–110° and turns gradually to 130–140° to the west from Elenska river valley (Fig. 1). The foliation is shallow (25–40°) to steeply dipping (50–70°, generally to the south (Fig. 1). The lineation is often pronounced and is defined by stretched quartz grains, strongly altered and stretched feldspars and alignment of chlorite flakes. It is parallel to the dip direction of foliation planes and plunges to the south, southwest or southeast (Fig. 1).

As it was mentioned before, S-C′ fabric can be observed in the granitoids from the zone (Fig. 2*b*, 3*a*). The foliation (S) is defined by fine dark-green coloured chlorite bands alternating with elongated domains with quartz and altered feldspar porphyroclasts. The shear bands (C′) are several millimetres thick and usually dip gently (20–45°) to the south (Fig. 1). Quartz slickenfibres, parallel to mineral lineations, are observed on the C′-surfaces and also indicate top-to-the north movement direction (Fig. 2*b*). Tension gashes often filled with quartz veins are observed normal to the foliation planes and the stretching lineation indicating enhanced fluid circulation. The scattered C′-surfaces within the CAR are also decorated by slickenfibres that indicate top-to-the north movement direction.

The precise estimate of the width of ASZ will provide important information on the significance and the amount of translation along the shear zone. Our observations

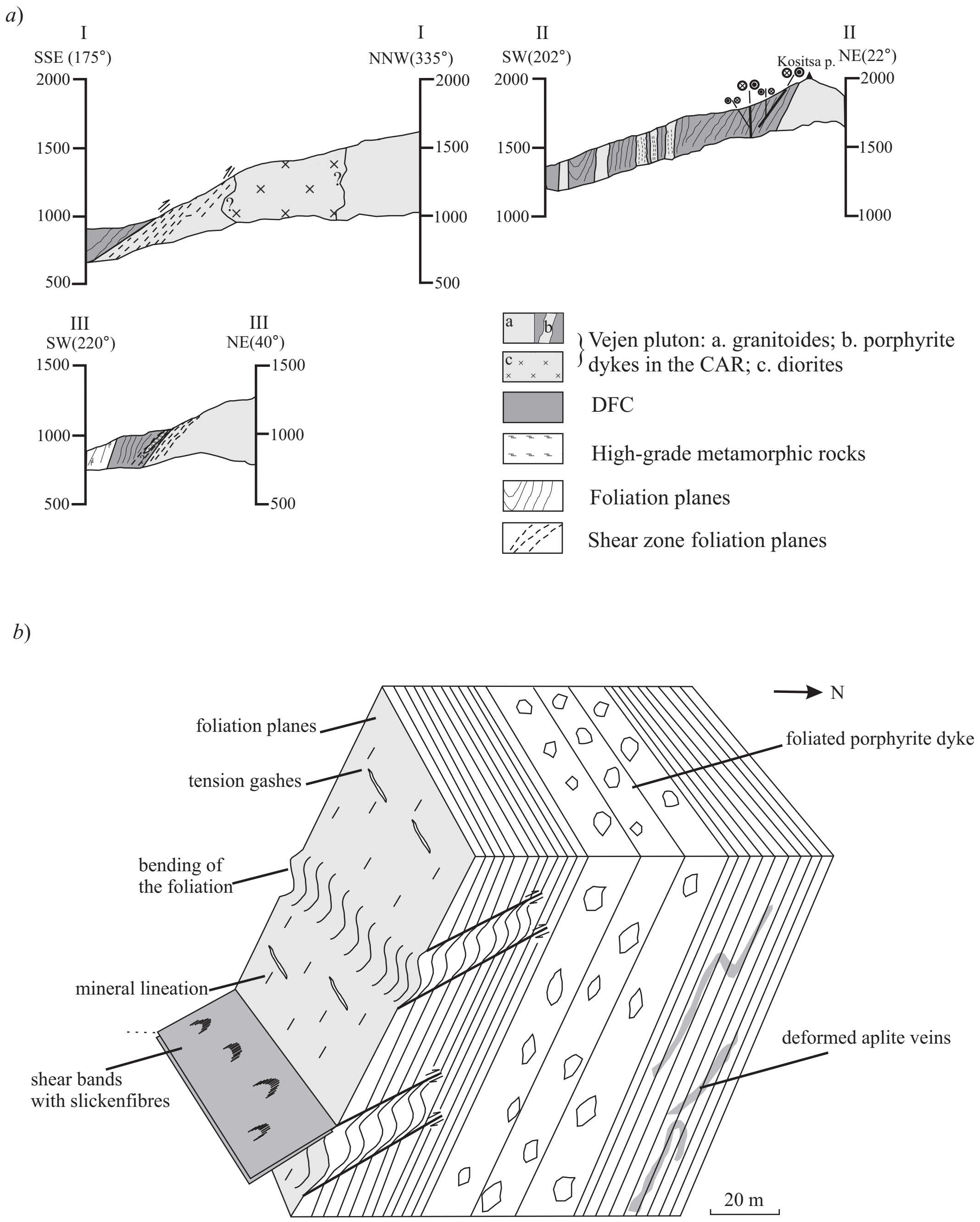

Fig. 2. *a*) Profiles along lines indicated in Fig. 1; *b*) Cartoon of most characteristic structures within the Anton shear zone

along several sections across the zone (Fig. 2*a*) demonstrate that the dip of the foliation varies from one place to another. On the other hand, the shear bands display more or less consistent orientation dipping shallowly to the south. If the orientation of these

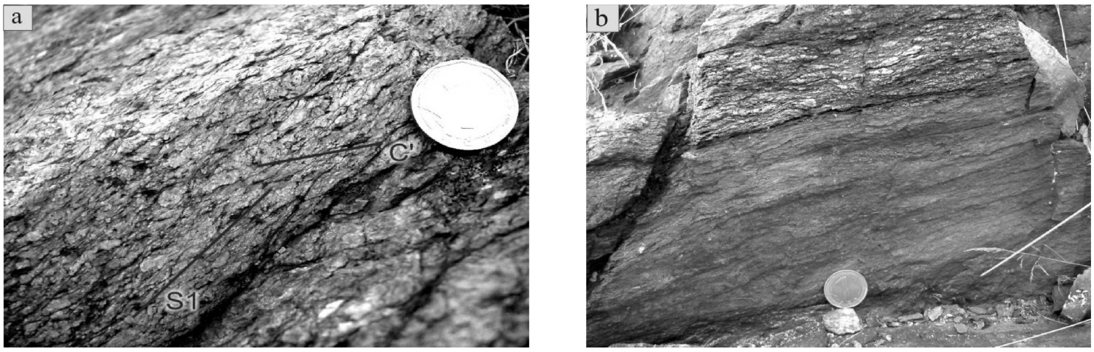

Fig. 3. Field photographs of some details within the Anton shear zone: *a*) S-C′ fabric within the granodiorite, west river-side of the Elenska river valley, North is to the right; *b*) Strain distribution within granodiorites and porphyritic varieties, 1 km west of the Elenska river valley; *c*) Sheared and bended aplite vein within the Vejen pluton' granodiorite, 0.5 km west of the Elenska river valley

C′-sufaces is close to the R′ Riedel shears, it can be assumed that the dip of the shear zone is about 35–40°. In map view the width of ASZ varies between 500 m (Elenska river section) to 30 m (east of the village of Anton). Our calculations indicate that the true thickness of ASZ is not more than 200 m and decreases to 20 m to the east. The length of ASZ in the studied area is at least 6 km (Fig. 1).

The second structural domain of the studied area includes the N-S trending contact of VP and the adjoining area to the southwest of Kositsa peak (Fig. 1). Along this contact VP lacks tectonic fabric and the host rocks are affected by static contact metamorphism. The foliation in CAR strikes from 10–20° to 145–170° and dips steeply or is vertical (Fig. 1). Several porphyrite dykes related to the VP are emplaced within CAR and two of them are strongly foliated. The foliation within the dykes strikes 110–150° and is nearly vertical (80–90°). Rare, 1–2 cm wide meso-scale shear zones with strike-slip kinematics are developed oblique to or coincide with the foliation within CAR. These shear zones can be divided into two groups. The first strikes between 150–170° and dips steeply or is vertical (70–90°; Fig. 1). Subhorizontal or gently plunging (10–30°) slickenfibres indicate dextral movements. The shearings resemble the C′-planes within ASZ. The second group is represented by a small number of shear zones that strike between 115–135° and show criteria for left-lateral movements.

Discussion and conclusions. To answer the question concerning the temporal relations between magma emplacement and solid-state overprint, two possibilities must be taken into account: ASZ is related to the emplacement of VP or reflects a post-emplacement deformation event. Previous studies [1–3] provide rather inconsistent information. It was suggested that ASZ was developed "immediately after the intrusion and cooling" of VP but, on the other hand, "it is intersected by undeformed aplitic veins" of the same intrusive [3]. Several arguments support the idea of post-emplacement deformation: (i) all aplite veins hosted in the hanging wall granodiorites are foliated and deformed; (ii) lack of solid-state deformations within the granodiorites along the N-S segment of the VP contact in the studied area; (iii) presence of C′-surfaces within CAR and (iv) porphyritic dykes (late-stage products of VP), both in the pluton and in CAR are intensively deformed.

The lack of reliable age constrains makes it difficult to answer the question about the time of the shear zone activity based on structural data only. We have demonstrated at least for the study area that this deformation occurred after the pluton emplacement and associated contact metamorphism, and even after the emplacement of the late-magmatic hypabyssal granodiorites. From a regional point of view, ASZ displays significant similarity in deformational style with the recently re-examined [9] Kashana thrust zone. The latter is regarded as Early Alpine on the basis of documented ductile deformations in Triassic sediments. Based on such similarity, and since there are no regional data for late-Carboniferous-Permian north-vergent compression, the age of shearing along ASZ could be also Early Alpine.

The observations to the east of the village of Anton point out that ASZ narrows considerably. The tracing of the zone to the west is hampered because of the difficulty to distinguish shear-related fabric in the CAR rocks. The presence of steep, narrow meso-scale shear zones with strike-slip kinematics and foliated porphyritic dykes in the domain to the south of Kositsa Peak could be related to ASZ deformations. The different response to the strain of the rocks from this domain could be interpreted as a result of different primary relationships (N-S oriented intrusive contact; steeply dipping foliation within CAR). However, such an assumption requires further structural studies.

ASZ is exposed along the contact between VP and CAR. The inconsistent width of the zone and the fact that the primary relationships between the pluton and the host are almost preserved suggest little displacement along the zone.

According to the aforesaid we can conclude that: (i) ASZ is a fairly narrow north-verging shear zone with reverse/thrust kinematics and little displacement; (ii) The zone is an example of heterogeneous strain distribution; (iii) ASZ developed after the complete crystallization of VP and the deformation is not related to the pluton emplacement; (iv) the age of shearing along ASZ could be Alpine.

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Faculty of Geology and Geography
St. Kl. Ohridski University of Sofia
15, Tsar Osvoboditel Blvd
1504 Sofia, Bulgaria
e-mail: anna@gea.uni-sofia.bg