Ductile to brittle-ductile shear zones from the Pre-Mesozoic basement of Tvarditsa Stara Planina area: preliminary field and mesostructural data

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The greenschist metamorphism of the rocks that build up parts of the pre-Mesozoic basement of the Stara Planina Mountain is traditionally related to an idea about a pre-Variscan regional metamorphic event. Typical products of these metamorphic changes are the rocks of Diabase-phyllitoid formation — DFF (Dimitrow, 1939). On the other hand, the Alpine tectonics in these parts of the Balkanide orogen is assumed to be brittle faulting at shallow crust levels. The major fault zones are interpreted as north verging brittle thrusts (Kockel, 1927; Antonov, 1942; Tchechitev, 1958). Some recent detailed investigations in Zlatitsa and Teteven Stara planina area evidence compressional greenschist metamorphism, which is spatially related to Early Alpine north verging brittle-ductile shear zones (Gerdjikov, Georgiev, 2006; Lazarova et al., 2006).

Objects of the present investigation are rocks from the pre-Mesozoic basement of the Tvarditsa Stara Planina area: Shivachevo and Lazovo complexes (Ivanov et al., 1974), Tvarditsa pluton as well as Permian sediments and volcanics (fig. 1). According to Ivanov et al. (1974), Shivachevo complex is composed of gneisses which are supposed to be products of high-grade "contact-regional" metamorphism of the DFF rocks related to the intrusion of small granitic bodies. The same authors interpret Lazovo complex as metamorphosed under epidote-amphibolite to greenschist facies DFF rocks. The slightly higher metamorphic grade is explained with the protolith lithology and different structural levels. According to Ivanov et al. (1974), Tvarditsa pluton is intruded into Lazovo complex to the north of the town of Tvarditsa. The major zones of intensive deforma-

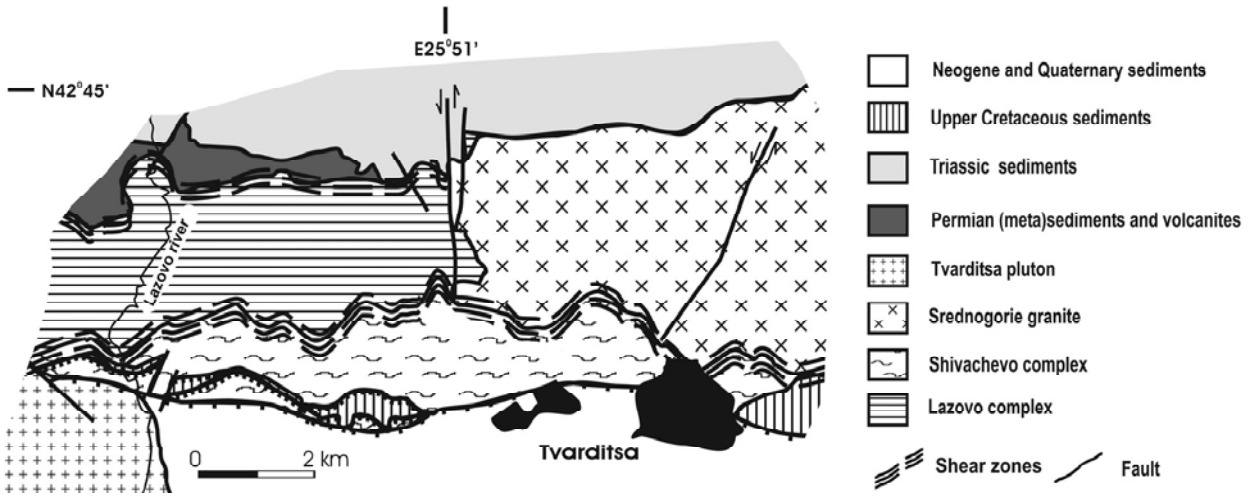


Fig. 1. Schematic geological map of the studied area (after Ivanov et al., 1974)

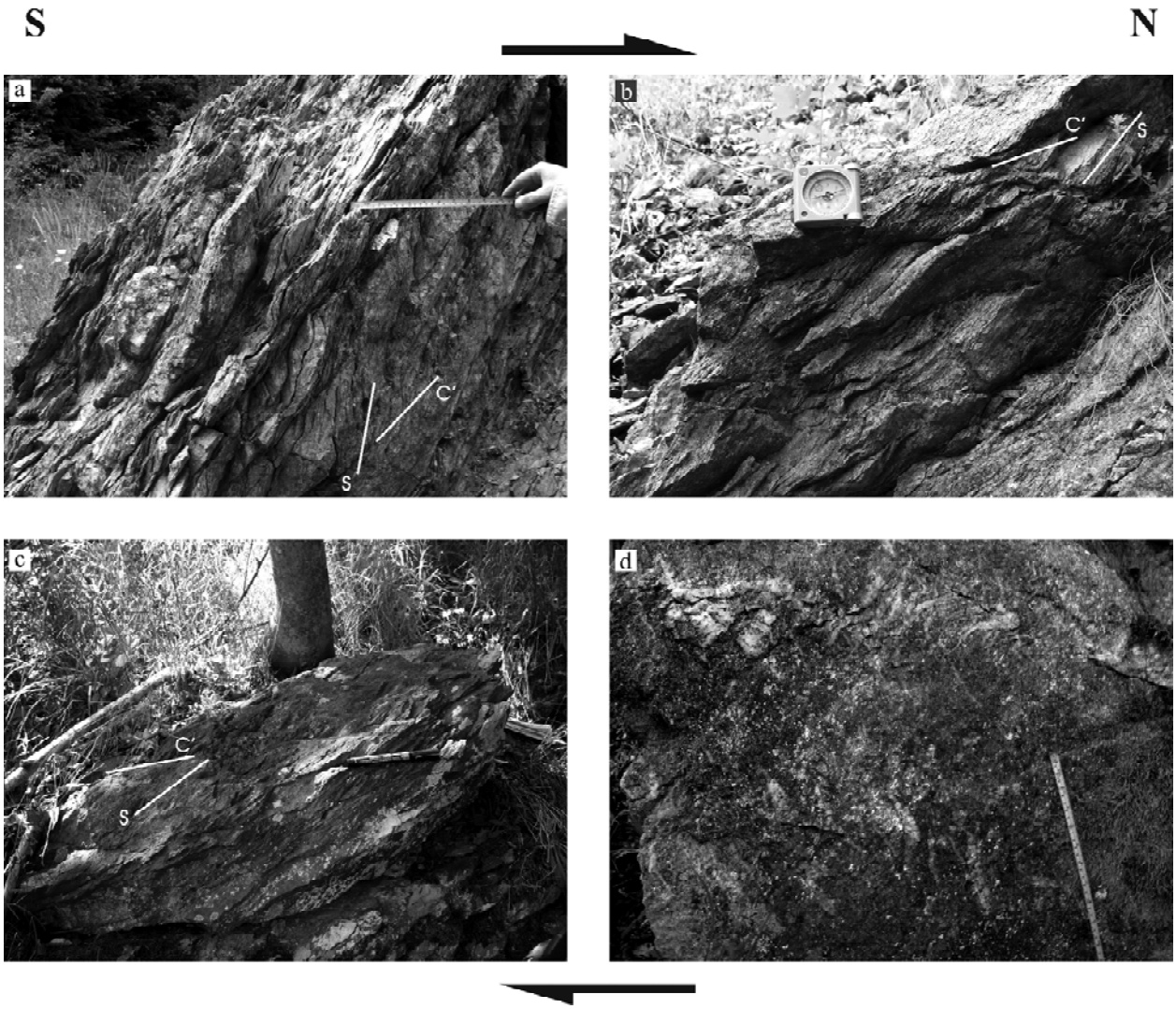


Fig. 2. S-C' fabric in: (a) — Shivachevo metagranites (north of the town of Tvarditsa); (b) — Lazovo metagranodiorites (Lazovo river valley); (c) — Permian metaconglomerates (Lazovo river valley); (d) — tension gashes into the Permian sandstones (Lazovo river valley)

tion in the area (Strejeranski and Sapdere reverse faults) are interpreted as Late Alpine (post-Maastrichtian) regional brittle structures (Ivanov et al., 1974).

Our field and structural investigations along several profiles in the southern slopes of Tvarditsa Stara Planina Mountain confirmed the opinion of Statelova, Machev (2005) that the Shivachevo complex is composed of strongly foliated granites. A well pronounced south dipping (50-60°) foliation is observed everywhere in these rocks. Rarely, visible south dipping stretching lineation on the foliation planes has been detected. Despite the presence of K-feldspar porphyroclasts we were unable to find reliable shear-sense criteria, associated with main fabric in the Shivachevo complex. The penetrative fabric is cut by meter-scale shear zones (SZa) dipping 30-45° to south which are especially numerous near the Strejeranski fault zone. In the SZa the orthometamorphic rocks are strongly deformed and transformed to ultramylonites and foliated cataclasites. In most cases, the cataclastic parts of the shear zones are located near or form domains in the mylonitic volumes. The mylonitic parts of the shear zones are often presented by mica and quartz rich domains (fig. 2a). The foliation and stretching lineation dip SSW. These are parallel in both foliated cataclazites and mylonites. A special feature of SZa is the presence of moderately dipping (40-20°) to south penetrative meso-scale shear bands which cut and deform sigmoidally the foliation (fig. 2a). This fabric corresponds to S-C' structures described by Passchier and Trouw (1996) and Blenkinsop (2002). South- dipping slickenside lineation is observed on the C'-surfaces. The geometry of the foliation fishes, shear bands and slickensides indicate top-to-the-north tec-

tonic transport and thrust kinematics of the shear zones.

Lazovo complex is one of the least studied parts of the metamorphic basement of the Stara Planina Mountain. Since the name Lazovo complex was proposed for these rocks by Ivanov et al. (1974), its character remained controversial. The same authors suggested that Lazovo complex is part of the Lower Paleozoic DFF. Ivanov et al. (2001) proposed correlation with the supposed continuous Upper Paleozoic-Triassic section from Sakar Mountains, whereas Kanchev et al. (1995) failed to recognize the specifics of these rocks and correlated them with low-grade metamorphics from Western Stara Planina. Our data indicate different and more complicated structural-metamorphic history of the Lazovo complex. The rocks of the Lazovo complex, which are exposed in the Lazovo river valey and to the northeast of the village of Pchelino, comprise predominantly orthometamorphites (metaultrabasic, metabasic and metaintermediate) and schists. In Lazovo complex a dominantly south-dipping foliation is developed and the associated deformation stage is referred to as D_2. Rarely a stretching lineation on the S_2 foliation surfaces is observed. It dips gently to WNW or ESE. An earlier deformation stage D_1 can also be defined. D_1 fabric formed in high-grade conditions as indicated by gneissic lamination, flaser structure of mylonitic gabbros, occurrences of garnet-bearing schist and garnet-bearing amphibolites (garnet up to 1 cm in diameter). Recent petrological data support HT-HP origin of D_1 fabric (Statelova in this volume). D_2 is related to strong retrogression and almost complete obliteration of D_1 fabric. The age determinations of syn- D_2 white micas yield ca. 340 Ma (Statelova in this volume). The latest synmetamorphic structures in Lazovo complex are represented by discrete shear zones (D_3) displaying similar features as SZa in Shivachevo complex. They are typical for the contact zone between Lazovo and Shivachevo complexes (along the Strejeranski reverse fault) as well as along the contact between Lazovo complex and the Permian sediments. In both places the rocks are strongly deformed and transformed to spatially related ultramylonitic and foliated cataclastic domains. The S-C' structure is the predominant mesoscale fabric into the mylonites (fig. 2b). The S-C' structure and slip fibers indicate top-to-the-north direction of tectonic transport and thrust kinematics of the D_3 shear zones.

Permian volcanics and (meta)sedimentary rocks are located at the northwestern parts of the studied area. They are presented by acid volcanics, conglomerates and sandstones. Near to the contact with the rocks of Lazovo complex, the Permian (meta)sediments are strongly foliated and transformed to mylonites. The penetrative foliation and the stretching lineation dip SSW. They are concordant to the foliation and the lineation of the D_3 zones of Lazovo rocks. The S-C' structure as well as the slip fibers in the Permian (meta)sediments evidence top-to-the-north direction of tectonic transport and reverse fault kinematics of the shear zones (fig. 2c). Away from the contact, the sediments are not penetratively deformed and are gently dipping to NNW. Criteria as tension gashes filled with quartz also indicate top-to-the-north tectonic transport (fig. 2d). It is worth noting that zones with rough schistosity and top-to-the-north S-C' structures have been observed even in the competent Permian volcanites.

Our interpretation relies on the structural evidence for ductile shear zones that have affected the rocks of the pre-Mesozoic basement of Tvarditsa Stara Planina Mountain. The structural investigations show that these shear zones have similar structural features. Some of them are the presence of mylonites, S-C' type fabric and rarely the existence of foliated cataclasites. We assume the fabrics of these zones to be ductile to brittle-ductile because: (1) the deformation is spread in relatively large rock volume with a development of penetrative foliation and stretching lineation; (2) the existence of S-C' fabric interpreted to be formed in ductile to brittle-ductile conditions; (3) the presence of quartz bands in alternation with mica-rich domains are indicative for intensive recrystallization and diffusive mass transfer; (4) the lack of typical shallow-level fault rocks as non-cohesive cataclasites and breccias. This process is accomplished at conditions corresponding to lower greenschist facies. The existence of quartz-filled tension gashes indicate brittle-ductile behavior and operation of diffusive mass transfer even in rocks situated away from the shear zones. The field and laboratory structural investigations point out to the thrust kinematics of the documented shear zones.

Most often the SZa and D_3 shear zones are developed along the contacts of the studied rock complexes. The data obtained indicate that the deformation along the Strejeranski fault is of ductile character. The same features possesses the contact between Lazovo complex and the Permian (meta)sediments, representing a ductile to brittle-ductile shear zone.

Conclusions

1. The Shivachevo and the Lazovo complexes are well-defined units which cannot be correlated with the section of the DFF from Western Stara Planina.
2. The Shivachevo and the Lazovo complexes should be regarded as polymetamorphic and polydeformational terrains.
3. There is a striking similarity between the latest synmetamorphic shear zones (SZa in Shivachevo and D_3 shear zones in Lazovo complex) and the Early Alpine shear zones in Zlatishka Stara Planina (Gerdjikov, Georgiev, 2006). The structural arguments and the stratigraphic constraints available suggest wider occurrence of Early Alpine tectonics in the Stara Planina.

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Пластични до крехо-пластични зони на срязване в домезозойската подложка на Твърдишка Стара планина: предварителни данни от теренни и мезоструктурни изследвания

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Традиционно в българската геоложка литература битува становището, че основният етап на структурообразуване, който оформя съвременния облик на Централна Стара планина, е свързан с късно-алпийските крехки навличания по зоните на Старопланинския и Шипченско-Сливенския навлаци. От друга страна, разкриващите се в южните склонове на Твърдишка Стара планина високостепенни метаморфити и деформирани гранити, са отнасяни към т.нар. Диабазово-филитоидна формация (ДФФ). Независимо от факта, че Ivanov et al. (1974) подчертават високостепенния характер на метаморфизма в скалите, изграждащи домезозойската подложка на Твърдишка Стара планина, върху геоложката карта на България (М 1:100 000) Лазовският и Шивачевският комплекси са означени като нискостепенни метаморфити на ДФФ. Нашите данни сочат, че в скалите на двата комплекса ясно могат да бъдат различени различни етапи от тяхната структурна и метаморфна история. Към ранните събития отнасяме: проникващата милонитна структура в Шивачевския комплекс; високостепенните метаморфни изменения на скалите от Лазовския комплекс, формирани при HT-HP условия (Statelova в този том), както и наложените върху тях през херцинско време (ca. 330 Ma) по-нискостепенни изменения (Statelova, този том). Късните метаморфни изменения са свързани с пластични до крехко-пластични зони на срязване, които пресичат и са наложени върху по-ранните структури. Зоните са развити най-вече по протежение на границите на скалните комплекси, изграждащи до-мезозойската подложка на изследвания район. Деформацията има обемен характер, подчертан от развити проникващи фолиация и линейност на разтягане. Специфична особеност на тези зони е присъствието на S-C' строеж, който маркира северно-вергентна възседно-навлачна кинематика. От изложеното до тук могат да бъдат направени следните заключения:

1) Шивачевският и Лазовският комплекси са ясно дефинирани единици, които не могат да бъдат корелирани с разреза на ДФК (ДФФ) в Западна Стара планина;

2) Шивачевският и Лазовският комплекси би трябвало да бъдат възприемани като полиметаморфни и полидеформирани терени;

3) Съществува голямо сходство между късните синметаморфни зони на срязване в до-мезозойската подложка на изследвания район и ранноалпийските зони на срязване в Златишка Стара планина (Gerdjikov, Georgiev, 2006). Това сходство, както и фактът, че в изследвания район този тип деформация и метаморфизъм засягат и пермски скали, насочват към идеята за ранноалпийска възраст на зоните на срязване.