Structural evolution of the greenschist basement of Zlatishka Stara Planina – an example from the Elatsite mine area

Структурна еволюция на зеленошистния фундамент на Златишка Стара планина – пример от района на рудник „Елаците“

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Introduction

The low-grade metamorphic rocks exposed on a large area in the southern and northern slopes of Central Stara Planina Mountain are subject of long lasting studies. These rocks have been referred to as “Diabase-phillitoid Complex” (DFC) and their genesis and structural evolution have been widely disputed. The low-grade metamorphic overprint in the studied rocks allowed for the preservation of a complicate structural record, revealing important data for the polyphase tectonic evolution of the greenschist basement. Our studies in the Elatsite open pit mine and the surrounding area reveal new aspects of the structural evolution of the low-grade basement, where several deformation events (D_1, D_2, D_3) were distinguished. Field relationships between D_1, D_2 and D_3 structures, as well as their relationships with rocks with known ages, make the age bracketing for different generations of structures rather straightforward.

Geological setting

The low-grade metamorphic basement in the study area consists of supposedly Cambrian to Ordovician metapelites and metaaleurolites. The two main lithologies are grey and dark grey to black, fine-foliated schists and banded to fine-foliated chlorite and chlorite-sericite schists. The metasediments host the post-Variscan Vezhen granodioritic pluton dated at ca. 314 Ma (Kamenov et al., 2002) and are transgressively covered by Lower to Middle Triassic sandstones and carbonates. Later, this pre-Upper Cretaceous basement was transgressivelly covered by Turonian conglomerates and intruded by ca. 91 Ma dykes. The emplacement of the Vezhen pluton caused contact metamorphism in the schists. Two important structures have been reported so far from this area: a) Stargel-Bolouvania Shear Zone – a Late Variscan transpressional zone that separates the high-grade basement of Sredna Gora from the low-grade Early Paleozoic section; b) Kashana Shear Zone (KSZ) – an Early Alpine compressional structure, largely developed within the lower-grade Paleozoic rocks but also emplaces low-grade schists onto Lower to Middle Triassic sandstones and carbonates. The latter are strongly folded and sheared, with newly formed anchizonal metamorphic foliation (Gerdjikov, Georgiev, 2005). The structure and evolution of the greenschist basement in Ztatishka Stara Planina Mountain remains rather poorly understood and oversimplified, although these rocks were object of several extensive structural studies.

Results

The first deformation event (D_1) and related structures were largely obliterated by subsequent deformation and metamorphism. However, D_1 is characterised by penetrative metamorphic foliation, which in most of the cases is parallel to the initial bedding in the protolith (S_{0-1}). It is recognised by alternation of darker and lighter bands in the more competent bodies of chlorite-sericite schists. The synmetamorphic character of this foliation is indicated by the presence of dynamically recrystallised quartz veins, synkinematic chlorite porphyroblasts and chlorite-sericite domains. We suppose that S_{0-1} is only seemingly parallel to the bedding of the sedimentary protolith and it is actually represented by the axial cleavage planes of isoclinally folded layers (bedding – S_0) during D_1 event. This assumption is based on rare observations of deformed hinges of older F_1 folds, underlined by metamorphic quartz veins.

The second deformation event (D_2) is the most pronounced event that affected the low-grade meta-

morphic rocks in the study area. The older fabric S_{0-1} was folded in isoclinal F_2 folds and a new penetrative axial parallel S_2 metamorphic foliation was formed. The S_2 foliation overprinted almost entirely the previous structures. The relations with the older fabric were better observed in the banded to finely-foliated chlorite sericite schists. S_2 is associated with synkinematic recrystallisation of very fine-grained chlorite, sericite and quartz. On microscopic scale, however, the S_{0-1} fabric is sometimes preserved marked by larger syn-S_{0-1} grains such as chlorite and quartz porphyroclasts. F_2 folds are estimated to vary from metric to decametric scale. Subordinate S, M and Z-type asymmetric parasitic folds were observed on various scales (macro-, meso- and micro-scale). In D_3-low-strain domains, the F_2 axes plunge gently or moderately to the SSE. During F_2 folding, syn-D_1 metamorphic quartz veins and more competent metaaleurolitic S_0 beds or S_{0-1} layers were folded and boudinaged. In addition, foliation fish marked by S-type bending of S_{0-1} planes between the S_2 planes are observed. Similarly, mica-fish of large syn-S_{0-1} chlorite grains are noted in thin-sections. Often, in the hinges of the F_2 folded competent metasediments, tension gashes filled with syn-D_2 metamorphic quartz are present. Syn-D_2 quartz veins are also recognized along the axial planes of F_2 folds. Generally, these quartz veins are thinner and less abundant, compared with the D_1 veins.

The third deformation event (D_3) appeared as a third phase of folding of the studied metasedimentary succession. These are varying in size, smooth to angular (chevron) and kink-folds (F_3). Although the strain is distributed unevenly and is localized in the less competent greyish-black schists, there is a traceable increase in the strain rate towards the KSZ. The F_3 folds are closed to isoclinal with a discreet S_3 foliation developed parallel to the axial planes as spaced cleavage. The folds are north-vergent to recumbent with gently W- or WSW-plunging axes. Respectively, S_3 dips gently to steeply generally southward. There are no signs for metamorphic recrystallisation along S_3 and only in narrow high-strain domains the foliation is penetrative. The observed kinematic indicators suggest top-to-north shearing (thrust to reverse-fault kinematics), which also corresponds to the kinematics of Kashana Shear Zone. The F_3 folds did not affect in the much more competent contact-metamorphic rocks in proximity to the Vezhen pluton. However, in the external parts of the contact aureole, the D_3 event caused formation of F_3 folds and discrete S_3 shear surfaces, parallel to F_3 axial planes. There, depending on the particular structural position in the fold limbs, the kinematics along S_3 planes is either top-N or top-S.

Temporal relations

In the area of Elatsite open pit, the D_1 and D_2 related structures are interpreted as older than Late Carboniferous since they were sealed by the emplacement of the Vezhen pluton (ca. 314 Ma). It was noted already on the field that, although D_3 affects the entire metasedimentary section in the study area, this deformation is more pronounced and becomes penetrative along the continuation of the KSZ. The similarity in the fabric development and the coinciding shear-sense suggest temporal and kinematic correlations between the D_3 event form the study area and the shearing along the Kashana Zone. Since, east of the Elatsite mine, KSZ affected mid-Triassic sandstones and carbonates, the lower age limit of D_3 should be considered as younger than mid-Triassic. The age of D_3 may be constrained also by the age of the oldest Upper Cretaceous (Turonian, ~94 Ma) sediments that cover transgressively D_3 structures. Additionally, the Upper Cretaceous (ca. 92 Ma) subvolcanic bodies and sulphide mineralised veins cross-cut D_3 structures. Thus, the D_3 can be bracket in the time interval 240–94 Ma and therefore related to the Early Alpine shearing event to which also the thrusting along the Kashana Shear Zone is assigned (Gerdjikov, Georgiev, 2005).

Final remarks

Based on the example from the Elatsite open pit mine and its surroundings we support the idea that the so called DFC is an intricate lithological unit that has undergone polyphase metamorphism and structural evolution. The recent and ongoing studies allow us to distinguish at least two pre-Mesozoic deformation events and to define the third one as Early Alpine. After additional field and analytical work, we expect to clarify the complex structural evolution of the low-grade metamorphic basement of Zlatishka Stara Planina Mountain.

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References

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