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GEOLOGY AND GOLD MINERALIZATIONS OF THE LENSKO AND BELY DOL OCCURRENCES, EASTERN RHODOPES, SE BULGARIA

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ABSTRACT. The region is built up of amphibolite facies metamorphites (of pre-Cambrian? age), intruded by Late Paleozoic metagranites, which crop out in the Byala reka dome. On them marbles, calc-schists, metagranitoids lay via tectonic discordance (Pelevun allochtone). Terrigenous sediments fill in the Late Alpine Byala reka depression formed on the Byala reka dome. The youngest rocks are Oligocene trachyrhyolites. The Pelevun thrust is reinterpreted as a detachment fault formed together with the Byala reka dome, accompanied by oblique synthetic mylonites in metamorphites and steeply dipping normal faults, cross-cutting the metamorphites and the sediments.

Two types of gold mineralization are recognized. The first one (jasperoid, pyrite and gold) among marbles and calc-schists in the Lensko occurrence, conformable to their foliation, has formed by a selective replacement of thin-bedded graphitic marbles. Its clasts were found in the overlaying terrigenous rocks. The later, epithermal one (quartz, adularia, arsenopyrite, pyrite, galena, chalcopyrite, gold, carbonate, gypsum) is developed in both Lensko and Bely dol occurrences. It cross-cuts the jasperoid by microfissures; forms stockwork bodies in the host marbles and fill in post-Priabonian steep normal faults. We relate the gold mineralizations reported here to the Late Alpine development of the Byala reka dome and of the Pelevun detachment fault.

INTRODUCTION

Lensko and Bely dol occurrences are situated near the villages of same names between the Ivailovgrad and Krumovgrad towns, Eastern Rhodopes (fig. 1), SE Bulgaria. Their good forecasts for gold mineralizations were ascertained by a soil sampling survey at a 1:50 000 scale (Sarov et al., 1994 – unpublished data). In 1998 additional prospecting works at a 1:10 000 scale of E-W profiling were carried out to the east of Lensko village on an area of 3 km² as well as geological routes at a 1:25 000 scale around the Bely dol village (Tzvetkov et al., 1999 - unpublished data).

REGIONAL GEOLOGICAL STRUCTURE

The region (fig. 1) is built up of mica schists, gneiss-schists, amphibolites, serpentinites, metaeclogites and graphic quartzites of supposed Precambrian age (Boyanov et al., 1963; Kozhoukharov et al., 1995), which are intruded by Late Paleozoic metagranites (Peycheva et al., 1995). All mentioned above rocks build up the Byala reka dome elongated in N-S direction (Ivanov, 1961). On this metamorphic sequence marbles to calc-schists with packets and lenses of amphibolites, schists, gneisses and metaeclogites lay via a tectonic discordance and make the building of the allochthon of Pelevun thrust (Ivanov, 1961). The later is considered as a part of the East Rhodopian complex thrust by Boyanov et al. (1990). Sarov et al. (2002 – unpublished data) re-interpreted the Pelevun thrust as a detachment fault of Late Alpine age, dipping to NE. The shear is in green-schist facies.

Subconformable bodies of leucocratic granitoids crop out near the Rozino village known as Rozino granitoids (fig. 1). Some of them are intruded into the marbles of Pelevun allochthon and are covered by sediments of Maastrichtian - Middle Eocene age. The granitoids nearby Rozino village were dated by K/Ar method as 45 Ma old (Belmustakova et al., 1994). On the Byala reka dome and Pelevun allochthon a Late Alpine Byala reka depression is superimposed (Ivanov, 1960; Boyanov et al., 1963) filled with coarse terrigenous rocks of the Krumovgrad group (Goranov, Atanasov, 1992), which are not dated there (fig. 1). Their age is determined next to the east in the Ivailovgrad district as Paleocene – Middle Eocene (Dimitrova et al., 2001) and next to the west in the Krumovgrad district as Maastrichtian – Lower Eocene (Goranov, Atanasov, 1992). The Breccia-conglomerate formation and the Coalbearing-sandstone formation both of Priabonian age follow upwards (Kozhoukharov et al., 1995).

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North-west of the Lensko village (fig. 1) the metamorphites are intruded by trachytyrolites of the Oligocene Planinec tension swarm (Ivanov, 1960) - 26.5-29.5 Ma (Sarov et al., 2000 – unpublished data).
GEOLOGICAL STRUCTURE OF THE LENSKO AND BELY DOL OCCURRENCES

The main rocks within the Lensko occurrence are marbles (fig. 2). White to cream-white, fine- to middle-grained calcite marbles of layered to massive and granoblastic, cataclastic textures (almost all over tectonically deformed) predominate. Ivanov (1961) referred them to as phyllonitic ones. The white marbles are intercalated irregularly by grey graphitic varieties of fine-banded to massive, mylonitic and porphyroclastic textures. They consist of primary calcite, graphite, sericite, hydromicas, quartz, plagioclase, muscovite, ore grains and by secondary carbonate, chalcedony, iron oxides, ore grains. Impure marbles to calc-schists of parallel and schistose textures, and granoblastic, somewhere lepidoblastic, nematoblastic and cataclastic ones also occur.

Fig. 1. Geological map of the Lensko occurrence region (original at a 1: 25 000 scale by Sarov et al., 2002 – unpublished data) with simplification. Quaternary: 1 - alluvium; Oligocene: 2 – trachyrhyolite dykes; Priabonian: 3 – Conglomerate-sandstone-coal-bearing formation, 4 – Breccia-conglomerate formation; Maastrichtian - Middle Eocene(?): 5 – Krumovgrad group (variable in size polymict breccias); pre-Paleocene basement: 6 - Rozino granitoids, 7 - marbles, 8 – porphric metagranites, 9 – equigranular metagranites, 10 - aplitic metagranites, 11 – schists and gneiss-schists, 12 – garnet-schists, 13 - marbles, 14 - amphibolites, 15 – serpentinites, 16 – metaeclogites; 17 – geological boundary: a - normal, b - transgressive; 18 – foliation; 19 - bedding; 20 – fault: a - certain, b - uncertain; 21 – detachment fault.

Fig. 2. Dark-green amphibolites, beds of biotite and two-mica gneisses, gneiss-schists and schists 2-5 m thick occur as single intercalations and rarely as ticker packets among the marbles (fig. 2).

The Rozino granitoids next to the Bely dol village form two small bodies among biotite gneisses and marbles (fig. 3). Their contacts with the host rocks are intrusive without alternation. The granitoids are leucocratic, grey-
white, coarse- to fine-grained, of massive texture and weak schistosity within the outer parts. They are two mica and muscovite in composition, rarely biotite granites.

The Paleogene within the Bely dol area is represented at its base by the Krumovgrad group, which lies discordantly over marbles and biotite gneisses (fig. 3). Block breccias and breccia-conglomerates predominate there, intercalated irregularly by gravel and sandy rocks. Olistoliths occur in the section as well. The Krumovgrad group is grey and grey-black colored and of changeable thickness (50-100 m and more). Coalbearing-sandstone formation follows transgressively upwards, built up of various sandstones, conglomerates, argillaceous marls to clays, etc., 200 m and more thick. The sandstones are grey, thick- to middle-bedded. The conglomerate beds and lenses consist of gravel and boulder polymict clasts. The beds are thick up to 3-4 m.

The geological mapping at a 1:10 000 scale ascertained that all rock varieties within the Lensko occurrence dip mainly to north (340-20°) with dips of 10-35°, rarely more (fig.1, 2, 4a). They are folded in folds of different size (cm, dm and m) generally with hinges of 340-45° and dips of 5-25° (fig. 4b).

![Geological map of the Lensko occurrence](image)


In the marble quarry in the Korudere valley folds with hinges of 110-120° and dips of 5-25° were also observed (fig. 2, 4b). They are mainly drag folds of size 1-5 m and more and of predominant southern vergence; some of them are recumbent ones with subhorizontal hinges.
High degree of folding and fracturing of the metamorphites from the Lensko area makes the tracing of faults very difficult. Mainly due to the trenching carried out, normal faults of strike 80-90° (to 70°), vertical to south vergent (70°), of fallen through southern walls, and of width to 2 m were mapped there. The ore-bearing faults called Pelevunsky chalove № 1 and 2 zones as well as faults within the northern part of Lensko occurrence and also to the south of Byala reka river belong to this system (fig. 2, 3). They cross-cut both metamorphites and sediments. Along these faults and close to them a hydrothermal alteration (silicification) was observed (fig. 3). The swarm shape and vertical dips within the upper 50-60 m of these E-NE faults were confirmed by the apparent electrical resistivity distributions of vertical electrical sounding (VES) data (line I, fig. 6). We consider these faults as antithetic of the detachment fault there in the sense of Lister and Davis (1989). Sarov et al. (2002 – unpublished data) proposed their formation as extensional fractures.

Besides the E-NE faults and the accompanying fractures another fracturing of SE-NW strike (110-140°) and dips to NE and SW (90 to 45°) was observed (fig. 2, 4c). It is marked by expressive local minima of electrical resistivity within the SE part of the Lensko area (fig. 5).

Fractures of N-NE to NE strikes and a width of 100-200 m were also mapped. They are relatively wide zones where the rocks are intensively fractured and altered and this provokes a lowering of the electrical resistivity. This direction appears also as an arrangement of the most perspective gold soil aureoles what shows its relation to the gold deposition (fig. 7). These two systems of fracturing have been probably formed in a response of the Pelevun allochthon movement to NE.

According to Petrov (1983) within the marble quarry along the Korudere valley a normal fault of N-S strike and fallen through western wall passes (fig. 2). It is marked well as submeridional strip of lowered electrical resistivity (fig. 5). The N-S fracturing is manifested weakly within the area (fig. 4).

There are fractures along the bedding of the metamorphites almost all over the area.

GEOLOGICAL AND STRUCTURAL POSITION AND GOLD MINERALIZATIONS IN THE LENSKO AND BELY DOL OCCURRENCES

The geological mapping of the Lensko occurrence ascertained numerous traces of ancient mining having a trench shape (fig. 2). The predominant part of them follows beds and seams of graphitic marbles.

All carbonate and silicate-carbonate metamorphites are silicified (jasperoid quartz) and irregularly pyritized along bed surfaces as the graphitic and impure marbles are stronger metasomatically altered. The fractured graphitic marbles characterize with an increased polarization and a lowered density compared to the average values of
Fig. 5. Apparent electrical resistivity map of Lensko occurrence: 1—line of vertical electrical sounding.

unaltered marbles in the region (3-5% versus 1.8% background for the polarization and 2.56 g/cm³ versus 2.66 g/cm³ background for the density). The fractured, hydrothermally altered parts are marked by lowered electrical resistivity (fig. 5, 6). This shows that the main effect on the electrical resistivity within the tectonically reworked areas is caused by intensive tectonic deformations and hydrothermal alternations as the silicification there is not on such scale to increase the electrical resistivity.

At the same time there is a proximity of the silicified and pyritized rocks to mylonite zones (fig. 2). The latter are oblique and considered by us as synthetic ones of the detachment in the sense of Lister and Davis (1989). We think that the mylonitic zones could have expelled hydrothermal solutions that could have caused a layered metasomatism.

The microscopic observations showed that the layered mineralization among metamorphites is represented only by jasperoid (cryptocrystalline, massive) and pyrite (microcrystalline up to 5 µm of size), which are paragenetic. The jasperoid has been deposited by a metasomatic replacement of marbles and calc-schists. It contains relic minerals from the host rocks mainly graphite, which caused its grey to black colors. The metasomatic silicification of the graphitic marbles and calc-schists is intensive and reaches up to 95% and more of their volume. It means that the replacement has been selective, favoured by the thin-bedded texture of these rocks.

Fig. 6. Sections along I line (the place of I line is given on fig. 5): a—geological section: 1—white marbles, 2—seams of grey, impure graphitic marbles, 3—conformable jasperoid, 4—stockwork mineralization, 5—fault/vein; b—pseudosection of the electrical resistivity, AB=650 m.

Single channel-samples assayed up to 19 ppm gold and up to 22 ppm silver. Clasts of this mineralization were observed among breccias and breccia-conglomerates of the Krumovgrad group within the Byala reka depression. This fact allows us to accept a pre-Maastrichtian-pre-Middle Eocene age of this type of mineralization.

Another type of mineralization was observed mainly microscopically, represented by quartz, adularia, carbonate (calcite?), pyrite, arsenopyrite, galena, chalcopyrite, gold and gypsum that clearly cross-cuts the jasperoid along microfissures and fills millimeter cavities in the jasperoid and the host rocks. The quartz of this mineralization is of several generations. Channel-samples assayed gold of grade up to 100 ppm and silver up to 142 ppm of irregular distribution. The gold presents as cubeoctahedral crystals of size up to 12 µm in arsenopyrite or as aggregates to 70 µm across (maximum 0.2x0.15 mm) in quartz. Other elements ascertainment are Pb, Zn, Cu, Co, Ni, Cd, Bi, As, Sb and sporadically Mo.

The small scale mapping revealed also ancient trenches along the E-NE normal faults of width to 1 m (fig. 2). Next to these faults the rocks are intensively silicified as the alternations reach to 100 m outward. These facts show that the newly mapped E-NE faults have been ore-conducting, and are ore-bearing within both occurrences. The channel-sample assays (single samples) ascertained the presence of gold (to 0.2 ppm) in the Bely dol occurrence.

The shape of the largest soil gold aureoles within the Pelevunsky chalove area and to the west of Korudere river is isometric or similar one. These most perspective aureoles are located near the young E-NE faults (fig. 7).
It is worth to say that the area of gold aureoles is strongly tectonically reworked; it appears knots of intersection of differently oriented faults traced after geological and geophysical data. Because of this we consider that these gold aureoles mark places of increased fracturing where stockwork gold mineralization is developed in addition to the vein one. We suppose that the quartz vein filling in E-NE faults have formed at last.

CONCLUSIONS

1. Faults and fracture zones of E-NE, N-NE to NE, SE and N-S strikes were mapped within the area discussed. They are marked as zones of lowered electrical resistivity. We consider most of them as connected to the movement of Pelevun allochthon into NE to N direction. The presence of detachment fault in depth determines this structures as possible ore-bearing ones.

2. Two types of gold mineralizations were recognized in the Lensko occurrence. The older is mainly located among graphitic marbles following their bed surfaces. It consists of metasomatic jasperoid, pyrite and gold. In our view the ore-conducting structures have been synthetic faults of the detachment fault, marked by mylonites. The younger (epithermal) gold mineralization reveals two morphological types. The one (of economic interest) forms stockwork bodies of a general NE elongation in the Lensko occurrence; the other (of lower gold grade) - veins in post-Priabonian E-NE steep normal faults in the Lensko and Bely dol occurrences. The stockwork type of gold mineralization occupies knots of intersection of E-NE, SE and N-NE to NE faults and fracture zones.

3. The areas of gold mineralization in plan and in depth appear as areas of lowered electrical resistivity. The gold evaluation of the occurrences discussed needs a deep geophysical sounding for polarization and electrical resistivity.

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