VERTICAL AND HORIZONTAL DISTRIBUTION OF HYDROTHERMAL ALTERATIONS OF THE POLYMETALLIC ORE DEPOSIT OF ČOKA MARIN (EAST SERBIA)

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Abstract: Polymetallic (Au-Ag-Cu-Zn-Pb-$BaSO_4$) ore deposit of Čoka Marin is situated in the northern part of the Timok magmatic complex (TMC). During the Upper Cretaceous in the area of Čoka Marin a volcanic centre was formed and in its central part, within a feeder channel, ore deposit of Čoka Marin originated. Ore mineralization precipitated in brecciated marginal apical parts of a dacite-andesite dyke Late Maastrichtian in age. Ore bodies have irregular and lensoidal forms and are composed of colomorphic fine-grained pyrite-marcasite mineralization in which as nests and veins ore minerals of copper (enargite, luzonite, chalcopyrite) zinc (sphalerite), lead (galenite) as well as sulphosalts and barite occur. Hydrothermal wall-rock alterations are especially characteristic for this ore deposit and they are one of the major criteria for prospection explorations. For the area of Čoka Marin the association quartz-alunite-sericite-diaspore-kaolinite±corrundum is characteristic.

Key words: Čoka Marin, dacite-andesite, hydrothermal alteration, Late Maastrichtian

GEOLOGY OF THE ČOKA MARIN ORE DEPOSIT

Đorđević et al. (1990/91) documented the presence of an ancient volcanic structure (fig. 1), which formation was radiometrically dated as 85-63 Ma (Živković et al., 1996). The volcanic area of Čoka Marin consists of volcanic and volcaniclastic (epiclastic) rocks of the I and II phases and associated hypabbysal rocks, as well as of hydrothermally altered and mineralized volcanic rocks. These volcanic products are accompanied by sedimentary rocks (fig. 2).

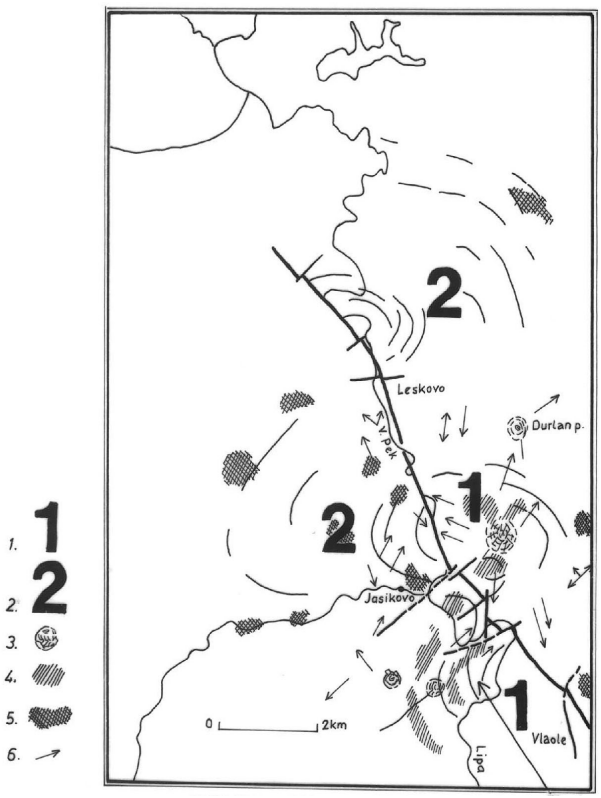

Fig. 1. Simplified structural map of the Čoka Marin area; EXPLANATION: 1 – Čoka Marin structure; 2 Žuti kamen structure; 3 – supposed volcanic centre; 4 – alteration of »secondary quartzite« type; 5 – alteration of »porphyry copper« type; 6 – phenocryst orientation in lava flows.

The I phase is represented by coherent volcanic and volcaniclastic rocks of hornblende-biotite, hornblende and pyroxene andesite, rarely dacite. The rocks of the II volcanic phase are volcaniclastites and dykes of pyroxene and pyroxene-hornblende andesite and they occur in the peripheral part of Čoka Marin. Hypabyssal rocks are found in boreholes and deeper levels as quartzdioriteporphyrite (74-69 Ma) and dioriteporphyrite (around 70 Ma), whereas hornblende diorite is rarely to be found. Dacite-andesite volcanic (phreatomagmatic?) breccias and tuffs host the ore mineralization. Their age is

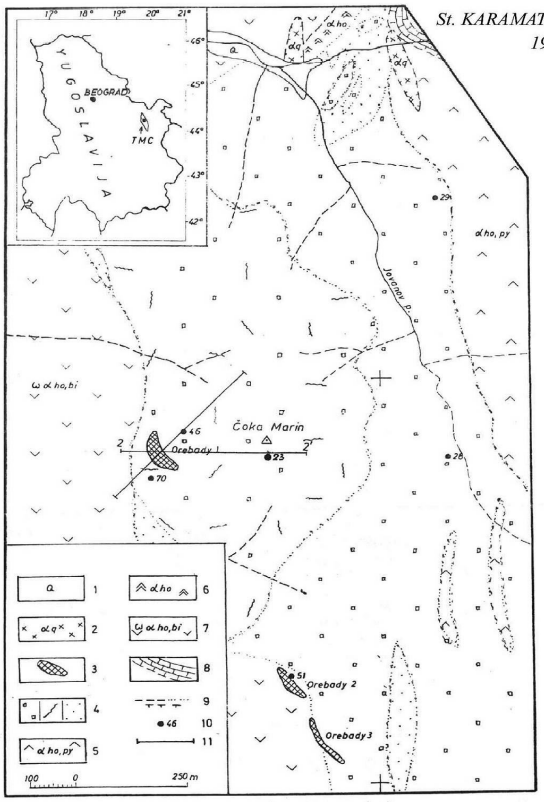

Fig. 2. Geological map of the Čoka Marin area and its position in Zugoslava (upper left, TMC – Timok magmatic complex). EXPLANATION: 1 - alluvium; 2 - dacite; 3 - projection at the surface of the latter by drilling detected orebodies; 4 - hidrothermally altered rocks; chloritized, pyritized and silicified; 5 - pyroxene-bearing hornblende andesite; 6 - hornblende andesite; 7 - biotite-hornblende andesite volcanoclastics; 8 - Senonian marls and limestones; 9 - boundaries of geological units: sharp (covered), transitional and intrisive (covered); 10 – drill-holes; 11 - cross-saction presented at Figure 3.

determined as 72 Ma. Fig. 3 shows a dacite-andesite brecciated dyke, which intruded along the contact (fault) between weakly altered and non-mineralized hornblende-biotite andesites at one side and hydrothermally altered and mineralized amphibole andesites at the other. Next to the dacite-andesite dyke are autoclastic and phreatomagmatic (?) breccias, the latter containing fragments of massive pyrite-rich ore along with clasts of dacite-andesite and secondary quartzite. Sedimentary rocks occurring in the Čoka Marin area are marls, tuffs and psammitic-marly limestones.

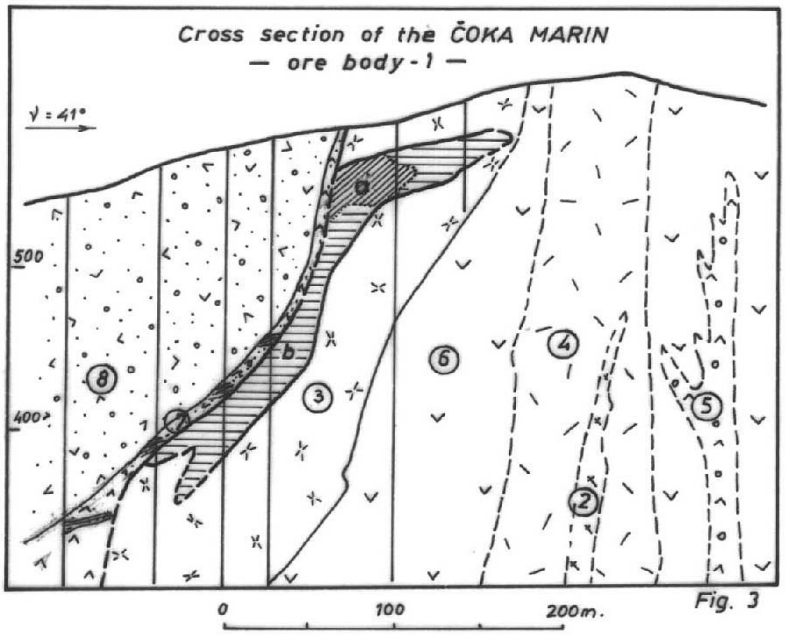

Fig. 3. Massive polymetallic (a), massive and stockwork py-cooper ore (b); 2 - quartzdiorite-porphyrite; 3 - dacite-andesite; 4 - secondary quartzite; 5 - hornblende pyroxene andesite; 6 - hornblende andesite, 7 - pelite; 8 - volcanic breccia of hornblende brotite andesite; 9 - fault

VERTICAL AND HORIZONTAL DISTRIBUTION OF HYDROTHERMAL ALTERATIONS

On the basis of detailed petrologic investigations of types and distribution of hydrothermal alterations as well as according to the presence of secondary quartzite, Karamata et al. (1981) concluded that Čoka Marin represents a volcanic centre. The volcanic rocks of the middle part of the volcanic edifice are strongly altered with

primary phenocrysts of feldspar, mafic minerals and groundmass microlites altered to an association of quartz-alunite-diaspore-kaolinite. In the proximal part around the volcanic centre zones of sericitization, hidrobiotitization, chloritization and zeolitization may be found (fig. 4). The alterations of a wide spatial distribution, such as chloritization and zeolitization, likely predate the ore formation, while hidrobiotitization and sericitization are alterations which formed simultaneously to the ore mineralization. The hidrobiotitization indicates the presence of a deeply situated intrusive mass, above which, i.e. at levels some hundred meters below surface, Cu-porphyry mineralization may be expected.

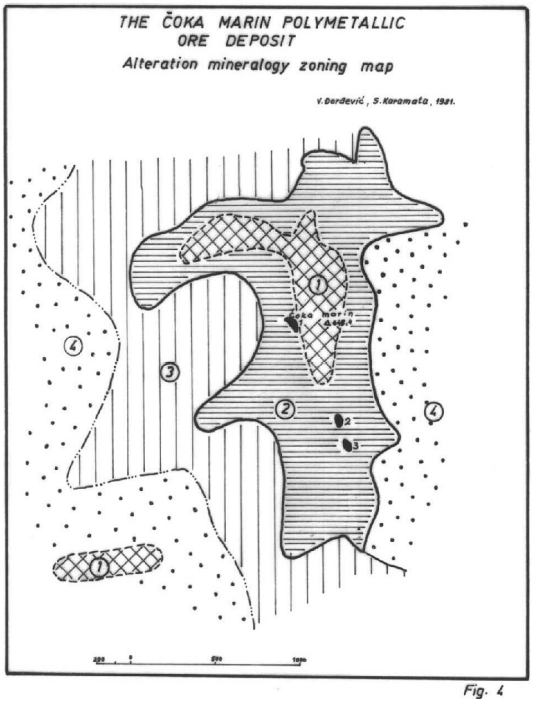

Fig. 4: Alteration zones: 1 – alunite, quartz +/- diaspore, sericite, kaolinite (pyrophyllite); 2 – sericite +/- kaolinite, hidrobiotite; 3 – biotite +/- chlorite; 4 – zeolite + chlorite + calcite; 1,2,3 (black) Čoka Marin ore.

Živković (1987) reported zonallity in vertical distribution of alteration associations (fig. 5a,b) in the zone of the central feeder channel of the Čoka Marin structure, as well as in the adjacent rocks. Generally, in the central area of the feeder channel, from the surface up to 500 m in depth, dominate mineral associations of secondary quartzites (a,b). In deeper parts (500-870 m), along with sericite and quartz, pale-green chlorite and anhydrite (c) also appear, indicating Cu-porphyry mineralization. Cu-poor (0.1-0.2 % Cu) porphyry mineralization with chalcopyrite and molybdenite occur more intensively close to quartzdiorite dykes. In the vicinity of the Čoka Marin orebody, and also around it, the association represented by quartz-sericite-kaolinite-diaspore-corrundum appears (d). Hence, the presented zones of the distribution of alteration associations have the form of a westward dipping inverted glass, i.e. concordantly with the feeder channels of hydrothermal fluids. The horizontal zonallity is related to the subsequent neutralization of acid fluids during their filtration from the main channel sidewards. On the other hand, the vertical pattern, which is well developed in the main structure and around the Čoka Marin orebody, indicates the change in character of hydrothermal fluids, from those

alkaline and weakly acid in deeper parts, to acid and ultra-acid ones approaching to the surface (mixing with meteoric water).

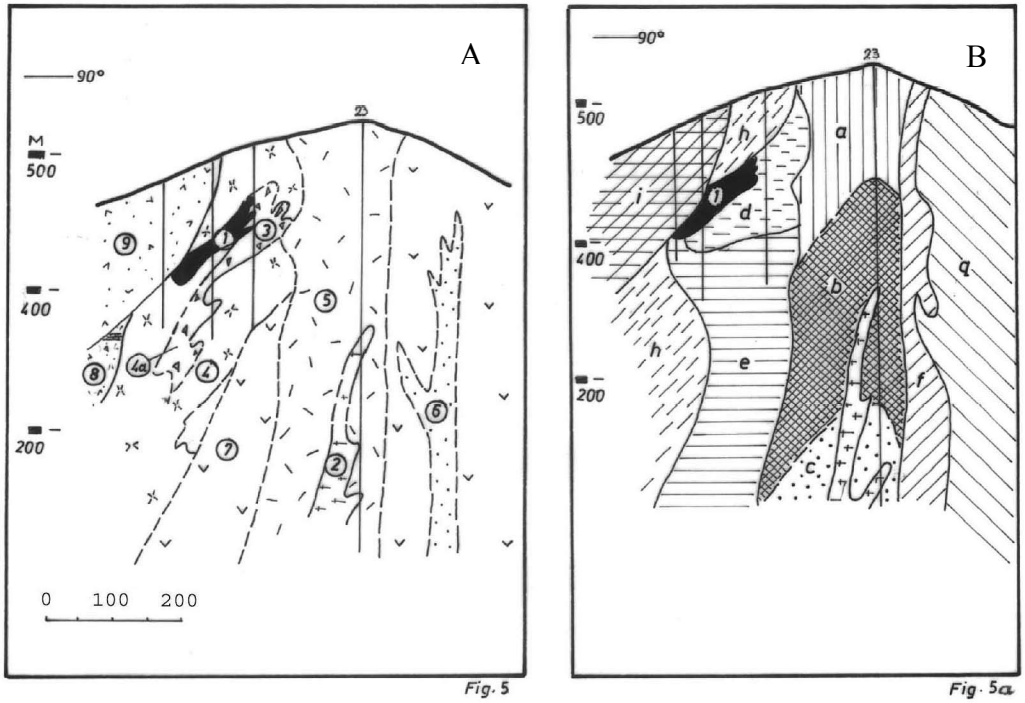

Fig. 5a,b: Geological cross-section through Čoka Marin deposit (A) and, zonal distribution of alterations (B) (modified after Živković, 1987): EXPLANATION: 1 – orebody; 2 – quartzdioriteporphyry; 3 – phreatomagmatic breccia 4-4a dacioandesite volcanic breccia; 5 – secondary quartzite (supposed volcanic vent); 6 – pyroxene bearing andesite; 7 – hornblende andesite; 8 – amphybole andesite, pellite, tuff; 9 – hornblende-biotite andesite volcanic breccia (fig. 5A). a. quartz-alunite-sericite-kaolinite+/-diaspore-pyrophyllite; b. quartz-diaspore-kaolinite-sericite-corrundum; c. sericite-chlorite II-quartz+/-kaolinite; d. ore-quartz-alunite-sericite-diaspore+/-corrundum; e. kaolinite+/-sericite-quartz; f. sericite-quartz+/-kaolinite; g. chlorite-epidote+/-calcite; h. kaolinite-chlorite+/-zeolite-albite-calcite; i. zeolite+/-sericite.

CONCLUSION

The polymetallic ore deposit of Čoka Marin is a volcanogenic-hydrothermal high-sulfidation deposit formed in the shallow levels of a volcanic edifice. The formations of various facies of dacite-andesites, as the host rocks, and generation of ore mineralization occurred simultaneously, during the Late Maastrichtian. The characteristic alteration association in and around the Čoka Marin orebody is quartz-alunite-sericit-kaolinite-diaspore±corrundum. The typical mineral association indicating Cu-porphyry deposit is sericite-chlorite-quartz±kaolinite. Horizontal and

vertical zonal distribution of hydrothermal and wall-rock alteration is the leading criteria in the phase of prospection and exploration in the area of Čoka Marin.

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