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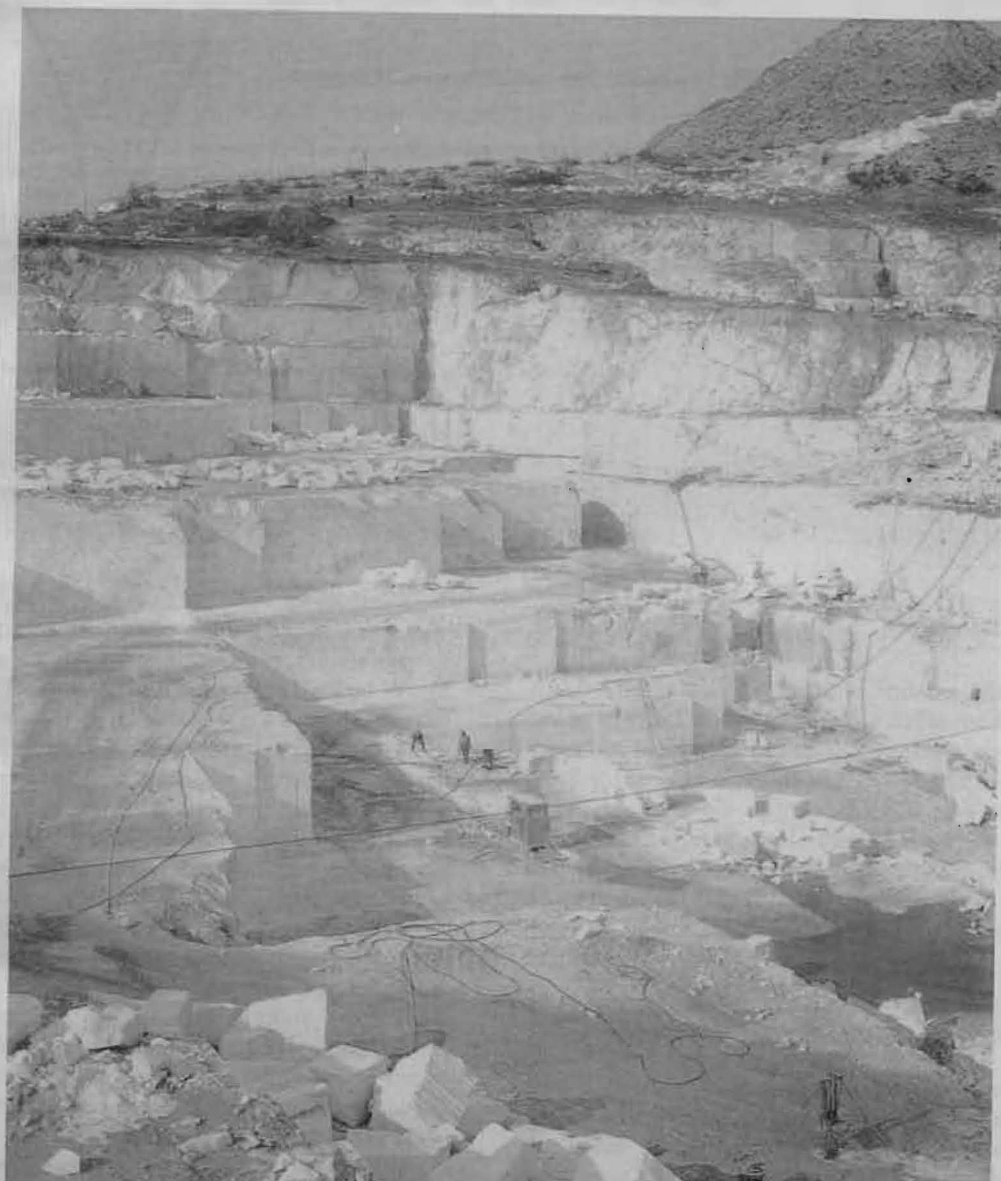

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THE METALLOGENETIC FEATURES OF THE BUČIM ORE FIELD (Eastern Macedonia)

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Abstract: The terrancs which comprise the Bučim ore field, from structural-geological and metallogenetic aspect, have various specific traits which have been the subject of investigations by many experts.

This paper will present the results of the metallogenetic analyses that have been carried out for that purpose in order to get a complete view of the metallogenetic features of this ore field. In order to evaluate the potential of the individual ore occurrences we have used the results from the geological, geophysical and geochemical investigations, as well as those from drilling operations, while relevant factors and criteria were applied for the defining of the Bučim ore field as an individual lower rank metallogenetic unit.

Key words: metallogeny; ore field; ore deposit; ore occurrence; control factors

INTRODUCTION

The remains of the old mining show that investigations of the copper mineralization in the vicinity of the Bučim ore field date back before the Second World War and that some shallow pits were dug during the War (from 1941 to 1943). However, intensive geological investigations were carried out during the second half of this century, first by the staff in the Zletovo mine, and later by the Geological Institute, Skopje, and the staff in the Bučim mine .The geologic exploration resulted in the discovery of Bučim deposit (which has been in exploitation since 1979) and in the discovery of several copper occurrences mainly located in the northern parts of the ore fields. At the same time systematic studies of the lithostratigraphic, structural-geologic and metallogenetic structure were carried out and the results obtained have been published in many reports, elaborates, studies and projects. We should point out the works by Ivanov (1982), Denkovski et al. (1983), Denkovski, Bandilov (1985), Čifliganec (1987) and Serafimovski (1990, 1993) as very important contributions to the explanation of the metallogenetic features of this ore field. Moreover, these reports are the ground for the accomplishment of this paper. All previously published reports dealing with this issue have also been taken into account in this paper.

Location of the ore field

The spatial geotectonic and metallogenetic location of the Bučim ore field is different from that of the other ore fields in the Bučim–Damjan–Borov Dol ore district. Namely, this ore field occupies the northern parts of the ore district which is part of the Serbo-Macedonian metallogenic massif. The ore mineralization is mainly located within the Bučim block which, according to its lithostratigraphic and structural-geologic characteristics, represents an individual block segment.

Criteria for the defining of the ore field

Tertiary magmatic surface manifestations, the spatial distribution of the copper mineralization, and the zones of high geochemical copper, molybdenum, lead, zinc, etc. anomalies, together with their relation to adequate fracture structures have been used (among others) in the investigations and examinations as observation points for defining the ore field and its outlines. These locations, are undoubtedly, relevant data which lead to the fact that defining and distinguishing the Bučim ore field as a separate lower rank metallogenetic unit is done on the basis of the essential criteria of the metallogenetic control, structural, magmatic and metallogenetic mineralization which coincides with the generally accepted scheme for the metallogenetic regional geologic setting.

The Bučim ore field occupies an area of 40 km^2 (Fig. 1) and lies entirely in the precambrian metamorphic complex of the Bučim block which is one of its important characteristics.

Ore formation control

The formation and the spatial distribution of the copper ore mineralization and its environment are a complex, polystage and periodically long genetic process, in which, numerous physical-chemical and geologic factors occur as mineralization control from its primary sources to the place of deposition. Nevertheless, the geologic control factor, first of all the structural, magmatic and the lithologic, played an important role in the deposition and the distribution of the ore mineralization in subvolcanic level conditions

1. *Structural control factor.* – A complex structural and textural mass, which essentially points at the favourable tectonic predisposition of the environment from the aspect of the location of the ore mineralization, has been determined by the explorations carried out so far in the Bučim ore field. We should also point out the importance of the disjunctive structures which mainly control the spatial dislocation of the magmatism and the copper mineralization in the area. The disjunctive sequence is comprised of lower rank structures, fault zones, various kinds of crackled-joint systems and tectono-magmatic structures (dike structures and neck intrusions).

The fault structures with a NNW–SSE and NE–SW strike (Fig.1) have been closely defined.They often intersect each other forming knots which served as supply channels for the magmatism and the mineralization itself. Such manifestations can be found in the vicinity of Bučim at the Kalapetrovci–Crn Vrv–Koševo crosscut where Tertiary magmatic latitic and trachyrhyolitic facies are mainly related to the intersection zones (Fig.1).

The tectonomagmatic structures (dike structures) which, according to Petković (1986), are similar to the structures of the ore bodies, have an important role in the formation of the ore mineralization in the subvolcanic conditions close to the magmatic intersections.

We should also point out the crackle-rupture systems which have developed more intensively close to the dike crosscuts and commonly have a periclinal slope in relation to their central parts. They are mainly tension and relaxation shear cracks. The relaxation cracks are most important for the location of the ore mineralization.

2. *Magmatic control factor.* – The formation and the spatial distribution of the ore mineralization in the Bučim ore field is in immediate periodic, spatial and genetic-paragenetic relation to the Tertiary volcanogeno-intrusive magmatism which, on its today's erosion level, is represented by subvolcanic facies of andesite-latites, latites, trachytes and trachyrhyolites, intruded as dikes and necks in the precambrian metamorphic complex. Besides the thermal energy that this mainly Oligo-miocene magmatism provided for the formation of the ore bearing hydrothermal systems, it also served as a source for the individual metals (Cu, Au, etc.). However, it should be pointed out that the host magmas which yielded these equivalents were essentially poor in copper. They contain large amounts of material from the Earth's crust and, most probably, were additionally contaminated, to some extent, by this metal.

The spatial distribution itself points to the magmatic control of the copper ore mineralization. Namely, the ore mineralization produced by the convex hydrothermal systems, is mainly located round the crosscuts, which undoubtedly, points to the fact that the ore bearing fluids used the same routes through which subvolcanic cuts intruded .

3. *Lithologic control factor.* – Since the largest part of the determined ore mineralization in the Bučim ore field is mainly located in precambrian metamorphic rocks (different varieties of gneisses) and only a small part of it in the volcanics, this implies that the lithologic factor has a certain role in the mineralization control in the ore field. Nevertheless, we should point out that the location of the ore mineralization in these types of rocks is not only the consequence of their composition, but is largely the result of the favourable physical mechanic characteristics of the environmental deposition. The fact that about 70% of the copper mineralization is of stockwork type (cracks, joints and stringers) and 30% of impregnations (Čifliganec, 1987, 1993) proves that the physical-mechanical features of the rocks, or the degree of their system of cracks has an important role in the formation and the nature of the occurrence of the copper mineralization.

The degree of the environmental system of cracks (gneiss, partially latite) shown by the number of structural units present per unit surface is 60 to more than 80 cracks per m^2 (Hrković, 1985) and is best expressed round the subvolcanic crosscuts at Bučim, Crni Vrv and Koševo. The importance of the lithologic ore mineralization control can be seen from the activity of the metasomatic processes on the rocks of alumosilicate composition, most of all on individual types of gneisess. Thus, during the differentiation the hydrothermal ore bearing solutions metasomatically exert pressure on the alumosilicate rocks at great heat, most commonly of beyond 250°C. This process resulted in the formation of disseminated mineralization in the ore fields.

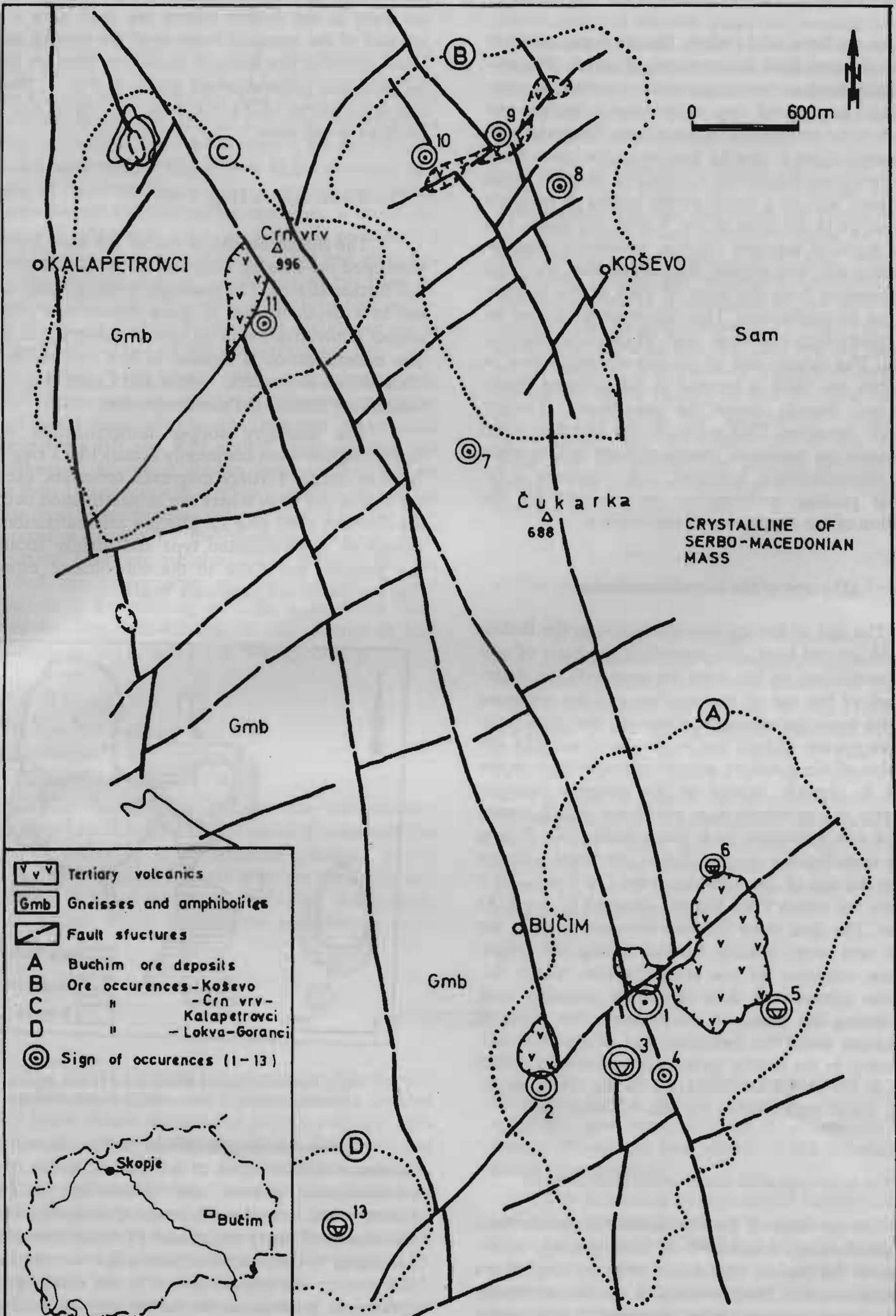

Fig 1. Distribution of copper occurrences and deposits in the Bučim ore field

Environment of the ore mineralization deposition

As we have said before, the geologic structure in the Bučim ore field is comprised of mainly Precambrian metamorphic rocks (gneisses, micaschists, amphiboles), intersected by subvolcanic latitic and trachyrhyolitic crosscuts at some places. Porphyry copper mineralization is mainly located in the rocks from the precambrian metamorphic complex (various types of gneisses) and to a small extent occurs in neogene volcanics, as in the case of the Vršnik ore body. The various types of gneisses (biotite, muscovite, micaseous, leucocratic, eye-shaped, the banded ones, etc.), are quite important from the point of view of the location of the ore mineralization. This statement is varified by their mineralogic-chemical and physical-mechanical textures. The largest part of the ore mineralization in the Bučim ore field is located in the gneisses themselves and directly round the subvolcanic Tertiary magmatic crosscuts. This points to the fact that when the gneisses are tectonical predispositions and, to some extent hydrothermally alterated, they represent a favourable geologic-geochemical environment for the deposition of the copper ore mineralization.

The age of the ore mineralization

The age of the ore mineralization in the Bučim ore field has not been determined on the basis of any exact parameters, as has been the case with the determination of the age of the sericites and the adularias from the basic parageneses. However, the data from the examination carried out so far point out that the formation of the porphyry copper mineralization in the district is directly related to the neogene tectonomagmatic and mineralization processes, which means that the ore formation took place during the Young Alpine metallogenic epoch. This is consistent with the data on the age of the volcanic rocks (24.9 m.y., 27.5 m.y., for the latites from Vršnik) obtained by the K/Ar method. The data show that the volcanic rocks in the Bučim area were mainly formed during the Oligo-Miocene, whereas the ore mineralization, which follows the subvolcanic dike intrusions probably took place during the Miocene and/or later. One piece of information about the thorogene age of lead (10 million years) in the Bučim galenas (Serafimovski, 1990) points at the polyphase formation of the ore mineralization, which goes beyond the Mio-Pliocene limit.

Cu-mineralization occurrences and deposits

On the basis of detailed geologic, geochemical and geophysical investigations and drilling explorations of the region, significant porphyry copper ore mineralization has been revealed in the Bučim deposit as well as anomalous copper occurrences and copper mineralization in the vicinity of Koševo, Crn Vrv, Kalapetrovci and Lokva-Goranci (Fig.1). In order to get a complete view of the metallogeny of the Bučim ore field in our further survey we shall give a short account of the essential features of the deposit and the other potential ore bearing localities. Besides the Cu deposits and mineralization given in Fig. 1, deposits and occurrences of Fe, Cr, Mn, etc. have also been revealed in this area.

1. *The Bučim deposit* (Fig. 1–A)

The Bučim deposit is one of the most highly investigated ore-bearing localities in the Bučim ore field and further afieled. The geologic investigations carried out to a depth of 300 m have determined porphyry copper mineralization in an area of about 1.5 to 2 km^2. The mineralization is located in four ore bodies: The Central Part, Bunardžik, Vršnik and Čukar (Fig.2). The Central ore body is the most important of all.

The porphyry copper mineralization in the Bučim deposit most commonly occurs like a ring round the subvolcanic Tertiary magmatic crosscuts, except in the Vršnik ore body where ore mineralization occurs in the crosscut itself (Fig.2). The ore mineralization is of stockwork mineralization type and mainly located in the gneisses and close to the subvolcanic crosscuts. The ore bodies are stockwork in plan.

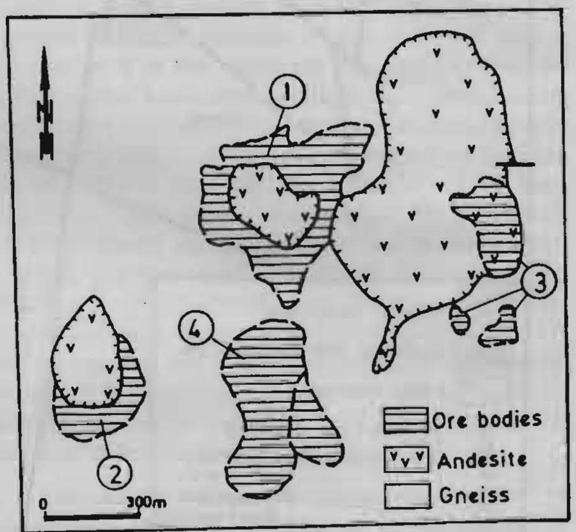

Fig 2. Position of the ore bodies in the Bučim deposit
1. Central ore body; 2. Bunardžik; 3. Vršnik; 4. Čukar

A special feature of the Bučim deposit is the existence of three types of ore mineralization: primary mineralization (Central and Bunardžik ore bodies), supergenous, related to the zones of secondary sulphide enrichment (Čukar) and mixed (Vršnik). Nevertheless, according to the available knowledge, we can say that the primary ore mineralization is the most significant for copper production. In our review we shall give a short account of the essential traits of the individual ore bodies.

2. The Koševo ore occurrences (Fig. 1–B)

The ore occurrences from this potential ore-bearing locality revealed north of Koševo village, close to the Koševo trachy-rhyolitic dike in the northwestern parts of the Bučim ore field (Fig.1). The investigations carried out before 1981 determined a favourably predisposed environment that is seen in the presence of a system of fault structures which intersect each other, the subvolcanic trachyrhyolitic crosscuts, a broad hydrothermal alteration zone as well as geochemical anomalies of copper, molybdenum, lead and zinc. Besides, this stringer copper mineralization has been recorded in three localities: north of Koševo (ore occurrence no. 8), the Koševo River–I (ore occurrence no. 9) and the Koševo River–II (ore occurrence no. 10).

During 1983 and 1984 a geologic map (1 : 2.500 m) and a synthetic geochemical map (1 : 2.500 m) were drawn, and detailed geophysical investigations (IP and RP) with 5 cross-sections and hydrothermal alteration studies were carried out on more than 100 specimens. Previous studies, as well as results from these studies, indicate that there are several positive criteria for the presence of copper mineralization. However, we should also mention that the recorded ore occurrences and geochemical copper anomalies in the vicinity of Koševo have not been proven by long-hole-drilings, so this district is still considered to be a potential ore bearing locality.

3. The Crn Vrv–Kalapetrovci ore occurrences (Fig.1–C)

These occurrences occupy the northwestern parts of the ore field near Kalapetrovci Village and Crn Vrv site. According to its structural-geologic, petrologic and geochemical features it is very similar to that of Koševo. A lot of magmatic ore bodies in the shape of small dikes which intruded the precambrian complex along the shearing zones of intersection w NNW–SSE and NE–SW strike are revealed here. W hydrothermal altered zones such as sericitization, s fication, K-feldspatization, chloritization and so on determined round and inside the trachytic dikes the selves which is an indication of the presence of p phyry type copper mineralization.

The geochemical studies carried out give d about the high copper and molybdenum anomali whereas lead and zinc anomalies are poorly expres and form mainly round anomalous zones. At the pla with strongly expressed copper and molybden anomalies (round the magmatic crosscuts) strin pyrite-chalkopyrite mineralizations are also record Such are the ore occurrences no.11 (Fig.1) close to trachyte crosscut at Crn Vrv and the ore occurre no.12, north of Kalapetrovci. Deep-hole-drilling carried out in the vicinity of Crn Vrv (ore occurre no. 11) following the geophysical investigati (geoelectrics) and the comparison of the data w those from the geochemical and the geologic inve gations. The deep-hole-drillings of 290 m in depth not give the expected results.

4. The Lokva–Goranci ore occurrences (Fig.1–D)

Wide zones of intensive hydrothermal alte tions and fields of high geochemical copper and r lybdenum anomalies have been discovered in the treme southwestern parts of the Bučim ore field southwest of the Bučim deposit between Lokva Goranci. Ore drillings were carried out near Lokva 1983 and then two in 1984 of 250 m each and th more in 1988. In spite of the favourable indications the presence of ore mineralization, they gave negat results. The same geochemical and geophysi anomalous zones were recorded in the area Bojkovica, east of Lokva, but the network drilling not give satisfactory results.

CONCLUSION

Our report leads to the conclusion that significant porphyry copper ore mineralization, located mainly in the Bučim deposit and several potential sites (Crn Vrv, Kalapetrovci, Koševo, Lokva, Bojkovica and others) which according to their structural-geologic, petrologic and geochemical features are similar to those in the Bučim deposit have been found. However, we should also point out that some of these sites (Crn Vrv, Lokva and Bojkovica) have been investigated by drillings and that the results obtained are unsatisfactory. The determined copper content and that of other ore metals is low.

The porphyry copper mineralization in Bučim ore field is directly related to neogene tecto magmatic and mineralization processes, or it formed during the late phase of the Young Alp metallogenetic epoch.

The formation and the spatial distribution of ore mineralization is mainly controlled by the fa structures with a NNW–SSE and NE–SW strike, by subvolcanic facies of the Tertiary magmatism and characteristics of the environment. The ore minerali tion is mainly located in the gneisses, close to the v canic crosscuts, and only to a small extent in the v canics themselves (Vršnik ore body).

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