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MORPHOLOGICAL TYPES OF MINERALIZATION IN THE LOJANE As-Sb DEPOSIT, REPUBLIC OF MACEDONIA

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ABSTRACT

The Lojane deposit is a characteristic epithermal As-Sb type of mineralization located in the contact boundary between the Tertiary volcanites and the Jurassic ultrabasites in the immediate vicinity of the village of Lojane in the northern parts of the Republic of Macedonia. Mineralization is of a vein type, and the main bearers of As-Sb mineralization are the stibnite (antimonite) and the realgar, followed at the places by the orpiment. Four morphological types of mineralization are defined by the latest macro-scopic and microscopic investigations of the Lojane As-Sb mineralization. The first type is defined as the realgar and the realgar-orpiment mineralization in the silicified bre-ccias. The second type is characterized by purely stibnite mineralization in the silicified breccias. The third type of mineralization is massive to earthy, realgar type occasionally interspersed with later feather-like stibnite veins. The fourth type is characterized by the most common stibnite veins and realgar-stibnite veins. Beside the defined four morpho-logical types of ores in the Lojane deposit, there are transitional types among these mineralizations, usually followed by ore nests, brecciated ores with impregnations, ores in crushing zones, and veinlets with impregnations. The concentration of the minerali-zation is the most intensive within the individual or complex ore veins, which in places transform into lenses or in brecciated zones. The average content of the main ore components in the Lojane deposit is about 4% Sb and 5% As.

Keywords: Sb-As ore, morphological types, Lojane deposit, ore minerals.

INTRODUCTION

Detailed studies of As-Sb mineralization at the Lojane locality date back to the 1950’s [1], [2] and they represent immediate continuation of the research carried out at this area, but mostly on the chromium ores. Intensification of these researches was made in 1954 [3], and they were continued in 1955 [4]. Compilation of research data is contained in [5], where it is emphasized that the Lojane deposit has reserves of 300 000 t of ore with about 4% Sb and 5% As. Interesting data on the spatial layout of the mineralization are given in [6], [7], and more detailed results from the geochemical explorations are presented in the [8]. A compilation of metallogenic studies within the Lojane-Nikustak ore field is given in [9], and sometimes later when the literature data relate to the environmental aspects of this deposit, since after 1978, the Lojane mine is no longer active. This type of information can be found in the works of [10], [11] etc.

GEOLOGICAL FEATURES OF THE LOJANE

In the adjacent vicinity of the Lojane deposit, several characteristic types of rocks have been identified, from which the ultrabasites and the andesite of Tertiary age dominate. In the geological setting of this area, there are also Jurassic limestone, quartzporphyries (rholiates), black tuffed clays, flech sediments and Neogene sediments.

Serpentinite is most susceptible to plastic deformations, with loads being hydrostatic. This rock is capable of moving upwards visibly due to its lighter specific weight than the surrounding ones (Figure 1). All these movements under the influence of the gravity force, due to which the whole area was labile, had a visible part in the structural shaping of the ore deposit, both for As-Sb and Cr mineralization.

The black tuff-like claystone with sand is regularly compressed in the form of smaller or larger steeply arranged strips between individual formations or in the serpentinite itself. In addition to the main belt on the periphery of large masses, limestone and quartz-porphyry, which extends further to the northwest, followed by minor limestone remains, smaller bands of black clays on the southern periphery of the Lojane granite mass between the Cretaceous flysch and quartzporphyry indicate a significant shortening of the entire area in the direction of the NE-SW.

An Upper Cretaceous flysch with well-formed lithological members of highly variable physical mechanical properties has suffered intense deformations, expressed in the form of two systems of splitting level of approximately the same yield, and the opposite is falling: one by layers of banks of rigid layers-limestone and sandstone, falling to the southwest, after cleavage in the clay, with the opposite fall (Figure 1). These formations now represent highly compressed sets and are undoubtedly significantly reduced.

Jurassic limestone and quartz-porphyry (rhyolite) are two relatively homogeneous formations of about the same physical mechanical properties, deformed as rigid bodies, but lesser mass of quartz-porphyries exhibits certain forms of plastic deformation. A prominent example of rigid deformations is the higher mass of the dark gray limestone above the Vrelo locality, severely broken up by various cracks systems, which were later filled with white calcite veins. Therefore, it can be considered that all the deformations of these rocks were performed at depths below 5 km.

The elongated quartz-porphyry (rhyolitic) dykes or long belts of sedimentary rocks have very steep contact surfaces, while lens-like rigid bodies, such as the dyke of the Suva River with As-Sb mineralization and even the limestone-quartz porphyry mass at the center of the ore field, have surfaces on the contact with the serpentinite inclined towards the northeast. The angle of fall of these often very flat surfaces has approximately the same value in all places, where it is accurately measured [5]. In the Vrelo locality, where the limestone contact is cut by one adit, the angle of the fall is 52°, and in the mine itself on certain sections these angles have the following values: section A-53°, section B-50°. These surfaces, served as slippery surfaces by which quartz-porphyry and limestone masses moved over the serpentinite.

Very small bodies of metric dimensions "float" in the serpentinite without some system and regularity in their positioning, except in the zone of smaller faulting surfaces.

The realgar and stibnite mineralization extend along the contact between the quartz-porphyry and the serpentinite, and partly in the serpentinite at a length of over 400 m. In addition, in the north-western part there are insignificant stibnite occurrences, partly with traces of realgar in two masses of silicified serpentinite, at 100 and 400 meters from the end of the quartz-porphyry lens (Figure 1). The ore substance is very unevenly distributed in the mineralized area, so that in the area of contact with quartz-porphyry in the southeastern part of the ore, only 50% of the ore is located at a level of 480 m, while the other half is in the deeper levels in the serpentinite.

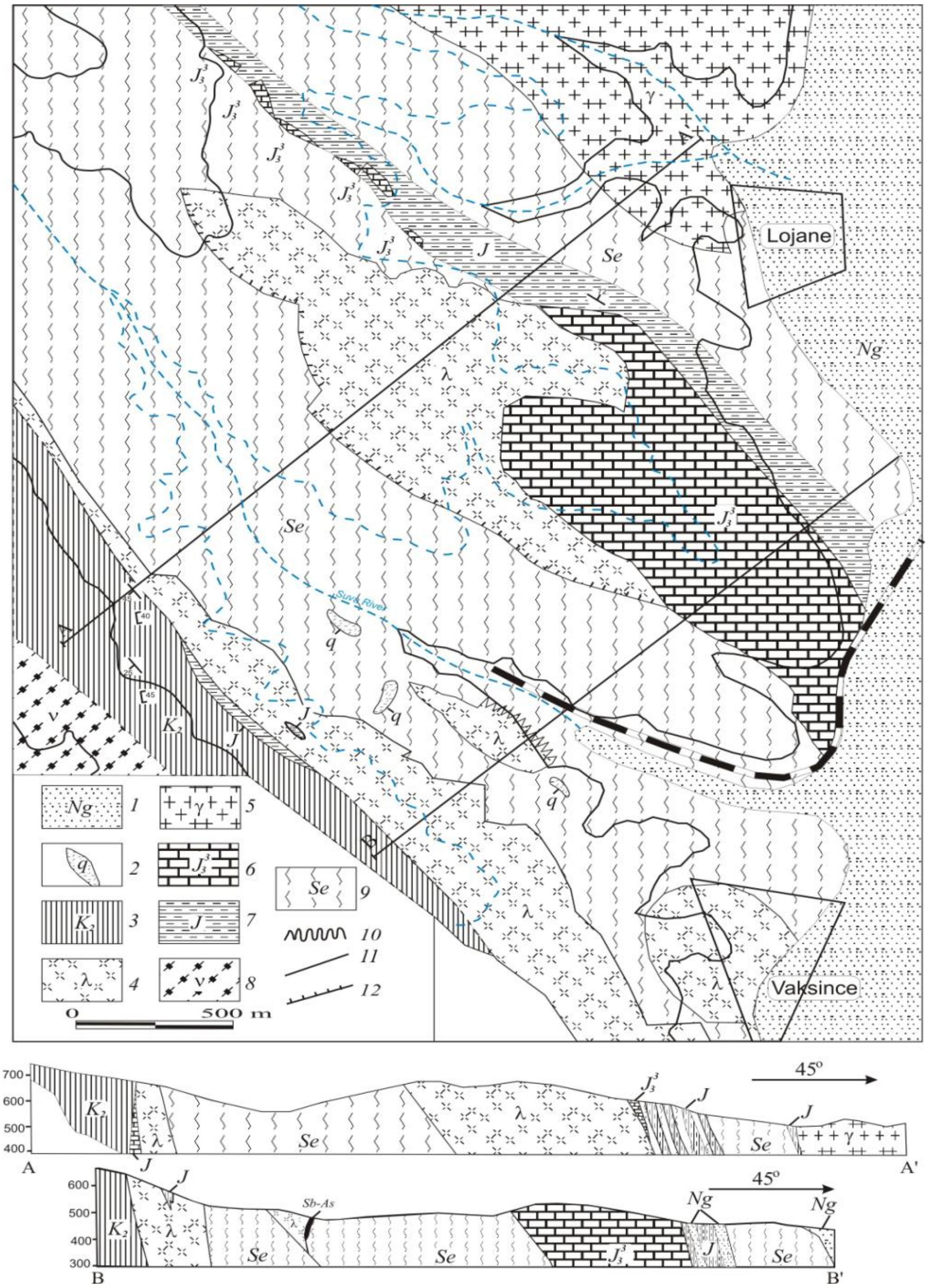


Fig. 1. Geological map of the Lojane deposit area [11].

1. Diluvial and Neogene deposits, 2. Silicified serpentine, 3. Upper Cretaceous flysch, 4. Quartz-porphyry (rhyolite), 5. Granite, syenite, 6. Upper Jurassic massive limestone, 7. Black shale, sandstone (Diabase hornstone formation-Jurassic), 8. Gabbro, diorite, 9. Serpentine and peridotite, 10. Realgar (As) and stibnite (Sb) mineralisation, 11. Normal fault, 12. Reverse fault.

The boundary between these parts is a large transverse cross-sectional fault. The Lojane ore is a curiosity not only due to the unusual paragenesis of nickel and arsenic-antimony minerals, but also by the phenomenon of unusual and very intimate intergrowth of stibnite, realgar and silica, with distinct colomorphic texture and structural forms, which in turn represents the rarity of its kind. This way of appearance reflects the complex geological conditions of ore genesis, expressed in the structure of ore veins and the entire deposit. Studying numerous ore minerals and thin sections from all parts of the deposit, completed the image of its composition.

MORPHOLOGICAL TYPES OF MINERALIZATION

The most important link in determining the structural type of deposit and detection of all processes that had an impact on its formation is the detailed study of the spatial position and shape of the ore bodies, distribution of certain minerals, or useful metals, as well as the structural setting in general. Only combined and coordinated mineralogical-petrographic and structural studies, along with the understanding of the disposition of ore components, are the only way to solve the genetic processes of one multistage ore deposit, such as Lojane. Basically, the Lojane vein type As-Sb deposit is much more complex, sometimes without certain contours of ore bodies, defined only by the content of useful substances. Even with clear veins, minerals are regularly scattered on the marginal parts, occupying the large space of the surrounding rocks. All ore bodies are different types of complex veins, without some major differences. The morphological difference of the ore bodies depends on their position: there are complex veins on the contact between the quartz-porphyry and the serpentinite (Figure 2), while in the serpentinite they are simpler.

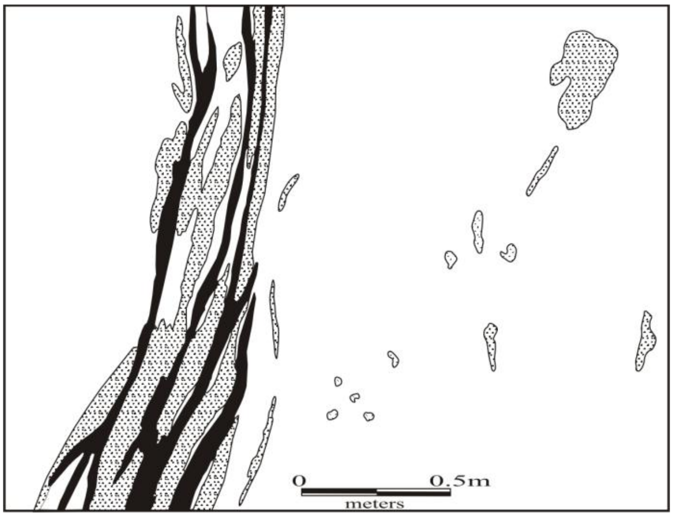
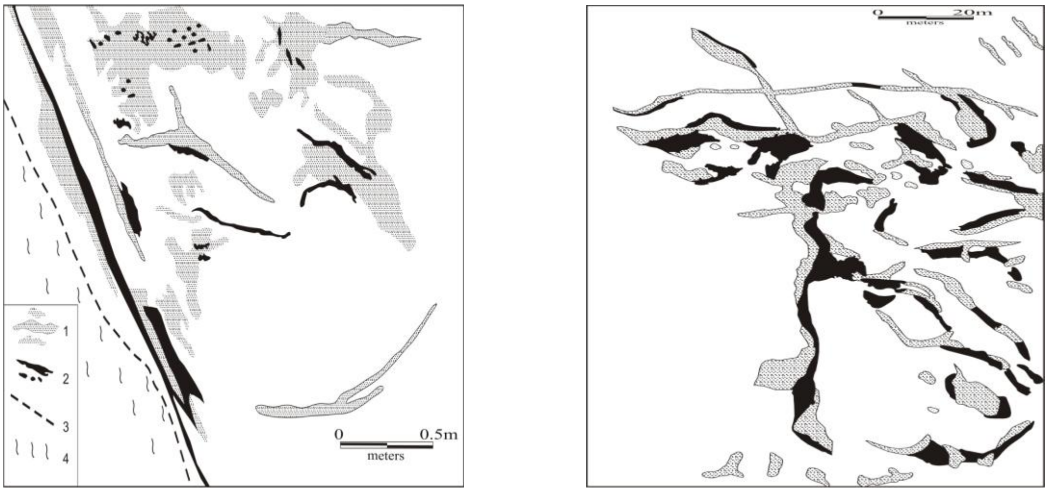


Fig. 2. Realgar and stibnite-bearing vein in serpentine. Lojane mine, level 461, above the cros-scut 15/16. Dotted-realgar, black-stibnite [11].

Another characteristic of the deposit is the uneven layout of certain ore components within the complex veins, with mineralization at the level of the main dislocation, and in a different position in relation to that plane. In the main dislocation, filled with heavily crushed material from the host rocks, most often from the serpentinite, as well as in the serpentinite itself, the realgar and stibnite permeate the clayey crushed mass in the form of irregular nests, lenses and veinlets. A certain resemblance to the arrangement as in the feather-like cracks can be seen in mine adits 14 and 22/1 at a level of 480 m (Figures 3a and 3b), if we can speak about the regular occurrence of these horizontal veins. In quartz-porphyry, mineralization is present in the form of a web of centimeter veins approximately parallelepipedal shape arrangement, filling one regular system of fractures (Figure 3b).

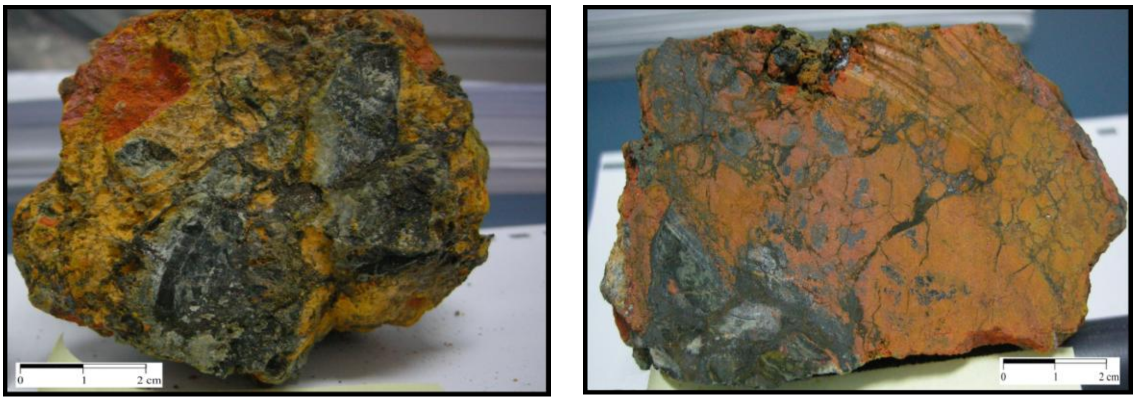


a) *b)*

Fig. 3. a) Mineralized featherlike disslocation on the contact between rhyolite and serpentine (1. Realgar, 2. Stibnite, 3. boundary of altered serpentine, 4. fresh serpentine); b) Mineralization in rhyolite on 51 m, near the contact with serpentine (dotted-realgar, black-stibnite)

The less significant, but interesting as the occurrence with a very small dip angle are dislocations, usually poorly mineralized, as the endings of normal veins or as a separate structural units. Mineralization mainly affected only one surface on the contact between the quartz-porphyry and serpentinite, but it partially breakthrough on the other plane in the tongue-like form, from the adit 1, above the adit 22/1, not reaching to the surface. Within its modest dimensions, the base has a pronounced multiple zoning as a result of the repetition of mineralization and the different mobility of individual components, which directly affects the creation of different types of mineralization.

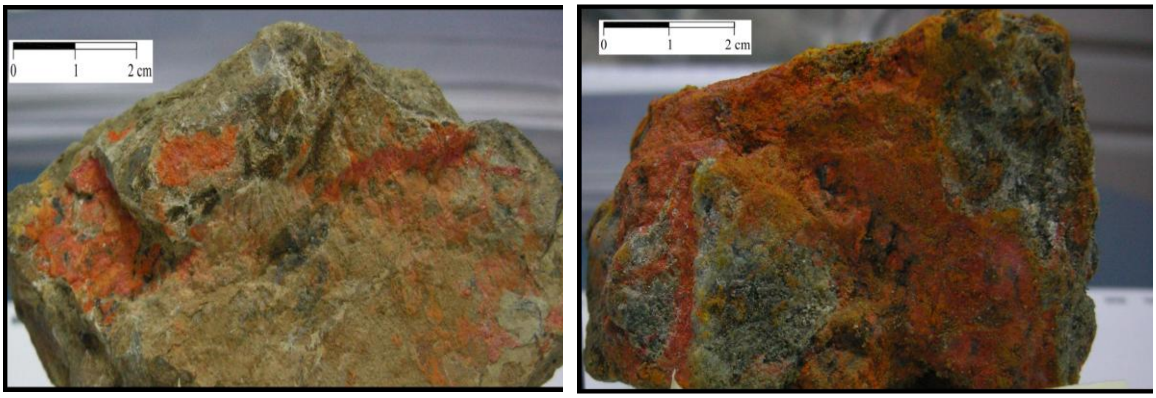
- The first type of zonality is manifested by the incorporation of several mineral associations within a single body, by the old seams, and by creating a characteristic morphological type of mineralization that relates to the breccia and polybreccia ores. A prominent example are typical stibnite breccias with silica cement with the realgar-antimonite ore (adit 16), as well as stibnite breccias with nickel-bearing pyrite as cement (Figure 4a and Figure 4b).



a) *b)*

Fig. 4. a) Brecciated realgar-orpiment mineralizations in crushed serpentinite zones; b) Realgar-stibnnite mineralizations in brecciated and silicified volcanic matrix

- Predominantly realgar breccia ore at level 453 (adit 19), below the realgar-stibnite veins from higher levels, is another evidence of this zonality (Figure 5a and Figure 5b).



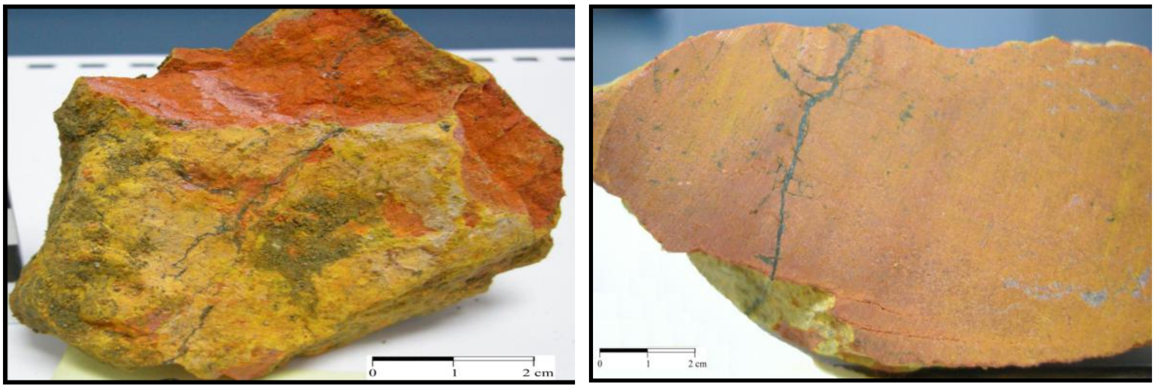
a) *b)*

Fig. 5. a) Realgar mineralization in brecciated and silicified serpentinite; b) Conglomeratic silicified volcanics mineralized by late realgar

- Brecciated zones in the Lojane deposit characterize morphological types of purely stibnite mineralization in the silicified breccias (Figure 6). These minerals are representative for the so-called crushing zones or in contact zones between volcanics and serpentinites, or sometimes in volcanics that are subsequently cataclized and silicified. In places, the cement material is dominated by silicification, while in some places as cement which fills empty spaces occurs stibnite mineralization itself. These parties often look like jasperoids when the silicified and brecciated stibnite mineralizations are prevalent in the serpentinites. However, that are hard and rigid mineralized zones where usually the silicified parts are followed by purely stibnite mineralization. If we analyze the vertical section of mineralization in the Lojane ore deposit, then this morphological type of mineralization belongs to the lower parts, or parts under the purely realgar, realgar-stibnite mineralization and then follows part belonging to the pure stibnite mineralization.

Fig. 6. Stibnite mineralization within silicified breccia

- The next morphological type of mineralization within the Lojane deposit refers to the so-called massive realgar, realgar-orpiment and earthy realgar mineralization in volcanics (Figure 7a and Figure 7b). Although these types of mineralization are localized in the contact zones of disintegration between volcanics and serpentinites, they nevertheless carry their characteristic of compact mineralization because their genesis and spatial displacement is associated predominantly with the final stages of the creation of Sb-As mineralization in the deposit by filling the empty spaces where the intensity of mineralization and coefficient of ore in those areas is higher.

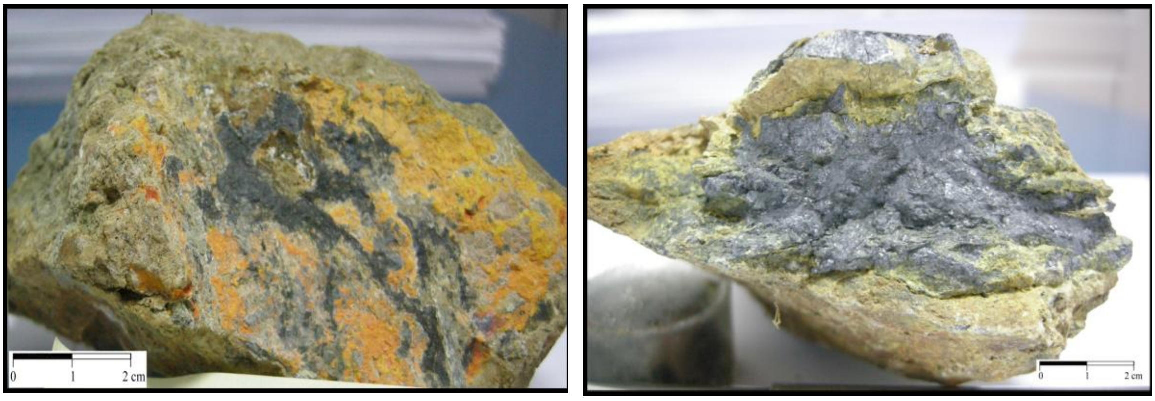


a) b)

Fig. 7. a) Typical earthy and compact realgar mineralization of the nest-vein type; b) Compact realgar-orpiment mineralizations within altered volcanic matrix, cut through by later stibnite veinletsmy

From here, almost mono-mineral nest-like realgar mineralization characterizes this morphological type. In places, these earthy realgar mineralizations occur as mixed realgar-orpiment aggregates (Figure 7a). In some places, the compact realgar ores that have been silicified can be brekthrough with later feather-like veinlets of stibnite of $2^{nd}/3^{rd}$ generation (Figure 7b). Such phenomena are usually frequent in the faulting zones where the already created compact realgar mineralizations are additionally cataclized and within the retrograde processes had been mineralized with later stibnite or silicified by the later silicifications

- The next morphological type of mineralization refers to the most traditional type in the Lojane As-Sb deposit, the vein type stibnite-realgar ores (Figure 8a), which are often silicified and up to almost purely stibnite veins and nest-lens like veins built almost of pure stibnite mineralization (Figure 8b)



a) b)

Fig. 8. a) Typical realgar-stibnite mineralizations within silicified nest-lens like ore veins; b) Lens-nest like primary stibnite mineralizations within silicified volcanics

These types of mineralizations are in the contact zone, where the described complex veins appear. Moving away from contact to the NW, the veins are broken, deformed, but almost always clearly individualized, or the mineralization is reduced to the net of veins and coatings, and sometimes a vein bending occurs (adits 3, 4, 6 at the level 480 m). These deformations are found in one zone of discontinuity of the meridian direction, which cuts the ore, causing various disorders. In this zone there is a large cross-sectional fault, then the vein in the adit 5 which is unusual in the north-south direction, and to the depth torsionaly transitions into the vein of the NW-SE direction (vertical shaft and adit 16/17). Not far from this zone there are also the "roots" of the main ore veins. Further to the northwest within serpentinite there are at least three independent veins, simple in structure, partially deformed, steep dipping angle, whose formation can't simply be explained by the ellipsoid deformation.

CONCLUSION

The Lojane deposit is a rare epithermal As-Sb type of ore deposit located at the contact zones of the Tertiary volcanic rocks and the Jurassic ultrabasic rocks in the immediate vicinity of the Lojane village. There are several metallogenetic features, but however, of special interest is the spatial distribution of the realgar-stibnite mineralization, which in the vertical section changes in its ratios, whereby the realgars and orpiments occupy the higher levels, while the stibnites are localized in the lower parts. Cataclazing, brecciation and silicification of the mineralized parts are significant feature of these mineralized areas. The four morphological mineralization types that were defined with this study are also specific of this deposit. Among them predominant are the brecciated realgar (manifested by the incorporation of several mineral associations within a single body, by the old seams, and by creating a characteristic morphological type of mineralization that relates to the breccia and polybreccia ores) and realgar-stibnite ores strongly silicified (representative for the so-called crushing zones or in contact zones between volcanics and serpentinites, or sometimes in volcanics that are subsequently cataclized and silicified) as well as veins purely composed of stibnite (stibnite lenses and nest-lens like veins built almost of pure stibnite mineralization) and complex realgar-stibnite ore veins (often silicified and massive).

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