NEW DATA ABOUT THE LAHÓCA HIGH SULFIDATION MINERALIZATION

János Földessy, Éva Hartai, László Kupi
University of Miskolc
Institute of Mineralogy and Geology
foldshe@gold.uni-miskolc.hu

Abstract: The Lahóca high sulfidation mineralization is structurally controlled by NW-SE and N-S striking tectonic zones. The central brecciated zone contains the major part of the mineralization with its upper boundary contact "Bluestone" (clayey altered rock). The deeper continuation of the brecciated zones as possible feeder dikes can be traced south, west and beneath the Lejtakna pipe breccia. The mineralization displays the character of the outward zoning of advanced argillic alteration. The main Cu-bearing minerals are enargite and luzonite. Gold occurs in native form of high fineness forming either fine coating on pyrite crystals or form individual grains in the silica matrix. According to the radiometric data, the whole Oligocene period was associated by active ore forming hydrothermal activities near the Lahóca volcanic centre.

1. INTRODUCTION

The Lahóca has long been known for its copper mineralization associated by small amount of silver and gold. A small underground mine worked in the copper ore-bodies from 1850s until 1979. Gold potential of the locality has gained importance in the late 1980s. Subsequent ore explorations (about 10,000 m drilling) defined significant resources in the 1994-1997 period.

Resource estimate of this gold ore resource is 46 metric tons of gold at 0.5 g/t cut-off grade. The average thickness of the ore zone is 30 m with a rich high-grade center of more than 100 m vertical thickness of 1.77 mg/kg of average gold content. The average silver content is low, but at certain samples of the deposit it reaches 0.1 %.

This article reviews the new geological findings discovered during and after the 1993-1997 exploration program.

2. ORE MINERALIZATIONS RELATED TO PALAEogene VOLCANICS IN THE CARPATHIANS

Near-surface Paleogene ore mineralization related to intermediate igneous rocks occurs in two places in Carpathian Belt: at Lahóca, and at the eastern part
of the Velence Mountains (Fig. 1). Both are characterised by epithermal occurrences, which were located in relation to volcanic rocks above mineralized subvolcanic diorite, quartz-diorite porphyritic intrusions.

The gold mineralization of the Velence Mountains has long been known (Kubovics 1958). Its high-sulfidation (HS) epithermal gold mineralization character of the Velence Mountains mineralization was suggested by Molnár (2004), Bajnóczy et al (2000). Here ore mineralization related to intrusives is explored and tested by a reconnaissance programme (Daridáné Tichy in Gyalog et al., 2004). During the joint USGS-MAFI program for evaluation of sediment hosted gold potential, the best values in Hungary have been obtained from the contact zone of the andesite bodies in the Velence (Korpás et al 1999). Despite of these, the gold mineralizations of the Velence Mountains remained essentially unexplored.

The Recsk Deeps porphyry Cu and skarn mineralization discovery was a consequence of the knowledge gained through the copper ore mining in the Lahóca.
The existence of economic size Recsk epithermal gold mineralization was recognized later and explored in the 1990s.

3. EXPLORATION AND MINING HISTORY OF THE NEAR-SURFACE CU-AU MINERALIZATION

The first geological reports described the Lahóca ore-bodies as impregnated stocks. Szabó (1875) realized that Cu-rich and the Zn-Cu-Ag stages both exist. After detailed studies of its mine geology, Rozloznik (1939) recognised the important controlling role of the Darnó Zone. The first detailed precise paragenetic examinations of ore minerals were made by Papp (1938) and Sztrókay (1940). Later Pantó (1951), Kisvarsányi and Kiss (1955) and Török (1964) were the main contributors to its geological knowledge.

From the 1950s Lahóca copper mining continued until 1979 (Fig. 2). In 1968 the nearby discovery of the Recsk Deeps overtook the importance of Lahóca mine which was finally closed in 1979.

In 1970 a new similar ore-body was found north from the Lahoca at the Lejtakna zone. Baksa (1973) divided this mineralization into three genetically interrelated groups and suggested submarine exhalative genesis model. The gold and silver enrichment in this orebody was re-assessed and updated during the Lahóca exploration in 1993-1997.

The Lahóca mineralization became a significant exploration target again in 1993. Geological similarities with the large high sulfidation epithermal gold deposits were identified (Földessy, 1996). The exploration program has been finished by defining an indicated 35.8 million tonnes ore resource with 1.47 mg/kg Au, 0.12 % Cu and 13 mg/kg Ag average grade mineralization (Földessy et al 1997).

4. STRUCTURAL CONTROL OF THE LAHÓCA MINERALIZATION

During the porphyry copper explorations Zelenka (1975, 1983) has confirmed that the NE-SW trending Darnó Zone combined with a pre-forming N-S shear zone was responsible for the localization of the Recsk Paleogene igneous activity. The shear zone is reflected in the elongated shape of the intrusive bodies and the position of the high grade mineralized zones both in the surficial and the deep-seated ore deposits. During the intrusive magmatism the N-S shear zone has been consumed, but in the Neogene (Miocene) volcanic period it was rejuvenated similarly to the Darnó Zone.
The major copper-gold orebodies in the Lahóca lie within a well-defined NW-SE striking 400 m wide zone (the so-called Lahóca Trend) and exhibit pervasive silicification, while gold-pyrite orebodies (with very little copper enrichment) follow the N-S direction, and form complex breccias. This N-S direction is also reflected in some of the young major faults in the surrounding area (like the Ilona Valley Fault Zone in the southern continuation at Parádfürdő.)
5. LITHOLOGICAL CHARACTER OF THE VOLCANIC HOST ROCKS

In the present interpretation of the volcanic stratigraphy (Földessy et al 2008) the varieties which are related in space and time to the Lahoca mineralization belong to the A1, and UA volcanic stages (Fig. 3). They were eroded from the central and southern uplifted blocks thus the two earlier stages, the older and southerly A2 and A1Q volcanics are not affected by this ore mineralization.
In the third volcanic stage (the A1 volcanics) andesite and pyroclastics were formed, partly in submarine conditions. They suffered intense hydrothermal alterations and ore mineralization. The fourth stage of volcanism (UA volcanics) is characterized by the development of the central caldera in the area of the third-stage volcanism and the formation of radial and irregular dyke-pattern bodies and smaller intrusives within and around the caldera (Baksa et al., 1981).

Pantó (1951) was the first, who recognized the three major lithological units on the Lahóca, which had importance in the interpretation of ore distribution. He distinguished a post-ore “top”-zone (called tuffs with siliceous nodules), a “blueshale” i.e. clastic type rock at the contact interface, and a “lower zone” which he assumed that it was pre-ore andesite, which later mineralized. This subdivision is still valid, although its meaning has somewhat changed. The “top zone” is now considered as late subvolcanic products (smaller dykes, laccoliths and extrusive domes) of UA andesite. This late andesite penetrates through the A1 andesite stratovolcanic sequence and caused brecciation along the contact, which had highly argillic character and effective sealing property. The brecciated contact zone was possibly subjected to later underground hydrothermal explosion during boiling. These hydrothermal explosion breccias are the most favourable hosts of the Lahóca epithermal gold mineralization.

The enargite copper ores are already found as reworked, recemented clasts in these explosive breccias. The “blueshale” is a contact rock, which represents igneous contact of the lower volcanic unit with the UA subvolcanic rocks.

The deeper continuation of the brecciated zones as possible feeder dike is suspected on the south and western flank, its exploration by deeper inclined holes (R414, R416) was not successful. A similar breccia zone extends beneath the Lejtakna pipe breccia.
The most frequent host rocks of the epithermal mineralization are the hydrothermal explosive breccias. Equally frequent (but low ore grade) are disseminations and stockworks in the A1 volcanics. Finally, the best gold grades are concentrated in the contact zone of the “blueshale” between the A1 and A4 volcanics.

At least two formerly known Au-rich orebodies (No7 and No9) are related to the N-S fault zone forming soft earthy semi-massive pyrite enrichment.

The Lahoca central brecciated zone contains major part of the mineralization with its upper boundary contact “blueshale”. This latter is a clayey rock with dispersed high pyrite content and small silicified fragments, the milonitized magmatic contact of the older andesites with the A4 late andesite. Due to the clayey character it formed an impermeable cap above the stratovolcanic sequence. Hydrothermal explosions caused further deformation and mineralization of the contact zone. The highest gold grades were historically found in the “blueshale” zone. This was also evidenced by the latest explorations (Fig. 4).

Late pipe breccias containing reworked clasts of enargite ores with hydrothermal quartz cement were the host environment for the Lejtakna ore-body, NE from the Lahoca. This orebody has lower gold, but higher silver content than the main Lahoca ore-body (Fig. 5).

Fig. 5 Volcanic breccia pipe in the A1 volcanic series, Lahoca northern flank, Lejtakna orebody.
6. HYDROTHERMAL ROCK ALTERATIONS

6.1. Dominant hydrothermal rock alterations

The Lahóca mineralization shows the character of the outward zoning of the advanced argillic alteration zoning. Illite, dickite, pyrophyllite, less alunite is predominant in the central zone near the contact. Kaoline and quartz are typical in the outer peripheries. Montmorillonite and chlorite are widespread in the outermost alteration zone.

Hydrothermal explosive brecciation has caused the fragmentation of the former Cu-bearing ores and surrounding rocks under the “blueshale-contact umbrella”.

Gypsum and carbonate veining, along with marcasite forms the latest overprinting.

6.2. Low sulfidation overprint

Low sulfidation K-feldspar-sericite adularia overprint is found in the western margins, in the central intrusive core, and in some parts of the Lahoca. This phase is thought to be contemporaneous with the gold ore mineralization.

7. ORE MINERALIZATION INTERPRETATION OF LAHÓCA

7.1. Models of mineralization

The ore minerals of Lahóca have been interpreted as products of different mineralization phases. Sztrókay (1940) described a two-phase mineralization. The first phase produced Pb-Zn-Fe ores in form of galenite-sphalerite-pyrite paragenesis while the second one resulted much more abundant mineralization with Cu-As-Au-Ag-Bi in an association of fahlores-luzonite-enargite-lautite-native gold-emplectite-wittichenite.

Baksa (1975) distinguished three successive mineralization phases. The first phase produced an enargite-luzonite-fahlore-chalcopyrite-pyrite mineralization, which appears in disseminations, impregnations and veins in the tectonically controlled blocks of the silicified andesite and pyroclasts. In the more significant second phase stock-like ore bodies formed in a polimict breccia. Ore minerals are mostly enargite and luzonite with less fahlores and pyrite and enriched in the...
New data about the Lahóca high sulfidation mineralization

breccia matrix. The third phase resulted the “gold-bearing” pyrite mineralization, which appears in the uppermost zones of the formerly mineralized bodies, in strongly altered pyroclastics.

In our interpretations we named (Földessy, 1997; Seres-Hartai & Földessy, 2001) the Lahóca mineralization as a complex, two-stage Cu-Au epithermal deposit, in which copper (with silver) forms an earlier phase, and gold forms a younger overprint (Table 1).

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Table 1 Connection between the volcanic units and the type of mineralization.

7.2. Characteristics of copper mineralization

The high sulfidation character of the mineralization is exhibited by the widespread abundance of sulphides up to semi-massive impregnated ore bodies (20-35 weight % sulphides).

About 95 % of ore minerals in Lahóca is pyrite. Sztrókay (1940) and Baksa (1975) distinguished two pyrite generations: (1) fine, euhedral, disseminated crystals, (2) colloidal, banded forms. According to our observations the pyrite is represented at least in three generations. The first-generation pyrites form 100-300 μm large, euhedral, corroded crystals. The second generation pyrite appears as dissemination of euhedral, 2-20 μm large crystals without any corrosion. It appears in the silica matrix of breccias and the highly silicified andesite. The third
Fig. 6 Three generations of pyrite: (1) larger, subhedral, corroded crystals, (2) fine dissemination in the silica matrix, (3) collomorph, banded structure. R 377-68 m. Reflected light, I N.

generation of pyrites forms collomorph, spherical or banded structures (Fig. 6), sometimes it overgrows the second-generation pyrites.

The formation of the late marcasite was a final phase, following the collomorph pyrite. Marcasite frequently forms fibrous rims around the collomorph pyrite.

Titanium plays apparently important role in the mineralization. Euhedral pyrites occur as rims around “leucoxene” cores (mixture of cryptocrystalline rutile needles and colloidal silica, which formed by the decomposition of the accessory ilmenite (Fig. 7). The atoll-texture can also be observable. It is actually a pyrite rim separated from the encrusted core by silica. The core is mostly pyrite but enargite and tennantite also occurred.

The main Cu-bearing minerals are enargite and luzonite. The two minerals can be distinguished even macroscopically as their size are up to 1-2 mm. They form irregular or subhedral, elongated crystals frequently in intergrown structure. Luzonite is more abundant than enargite, and it also occurs separately. It always displays the characteristic “parquet-like” twinning structure while enargite has no
twinned crystals. The corroded contours mark that enargite and luzonite formed in the early phase of mineralization. Enargite was also identified in a fine-grained silica fragment, which was contoured by coarse-grained, mosaic-textured quartz. This indicates that its formation was followed by multiply silicification.

Sztrókay, 1940 and Baksa, 1975 described exsolutions of Cu-Bi-sulfosalts in the enargite. Our microprobe examinations indicate not only exsolutions but a few (80-100 μm), ahedral sulfosalts, in which Fe, Pb, Sb and Sn was also detected beside Cu and Bi.

Fahlores (mostly tennantite) are also present, though in a much less amount than enargite and luzonite. It frequently appears in association with enargite but also occurs with galenite and sphalerite in form of ahedral crystals of 10-50 μm. Sztrókay (1940) pointed out that enargite and luzonite could be formed by the alteration of fahlores.

Galenite and sphalerite are subordinate. The two minerals usually occur together, in form of 10-30 μm large, corroded, ahedral grains. The galenite is also associated with tennantite.

Fig. 7 Euhedral pyrites rimming leucoxene core. R372-36 m. reflected light, 1 N.
7.3. Characteristics of gold mineralization

Gold enrichment is more characteristic in the highly silicified zones. The highest gold grades occur along the contact of the hydrothermal breccia and the “Bluestone”. In the argillic alteration zones gold grades are low, and the grade drops abruptly in the montmorillonite-chlorite zone.

Sztrókay (1940) suggested that the native gold was associated with luzonite, formed in the same mineralization phase and occurs mostly in the small cavities along the enargite-luzonite contact. According to his interpretation the pyrite-related gold is a result of a secondary enrichment by cementation processes. However, he failed to recognize gold even in the highest-gold-grade pyrite-rich samples because of its small grain size.

During our examinations, gold was very rarely found related to enargite and luzonite. It mostly occurred in two forms: associated with pyrite or in form of separate native gold grains in the highly silicified rock matrix (Fig 8). The pyrite-associated native gold forms overgrowths on the pyrite crystals (Fig. 9). The native gold is of high fineness, the size of gold grains varies from a few μm up to a few 100 μm. The separate gold grains are always larger that the pyrite-associated ones.

The crosscutting relationships of gold and copper enrichment zones clearly indicate that gold was introduced posterior to base metal ore formation, after the contact zone between A1 and UA phases has been formed.

Fig. 8 Native gold in the silicified matrix. Brumi shaft. BSE image.

Fig. 9 Native gold on pyrite. R 372-8 m. BSE image.
7.4. Spatial distribution of the gold mineralizations

The dominant morphology of the Lahoca gold mineralization is the tabular, sub-horizontal character. This was certainly pre-formed by the similar trends of the A1-UA contacts. On this ground it was attempted to discover gold enrichment (and localize the upward feeder zones) along the vertical contact zones of the same two phases. These efforts remained inconclusive, with no strong increase of gold grades along these structures on two boreholes which targeted these structures (R414, R416 boreholes).

In the Lejtakna orebody a certain depthward trend of gold enrichment was observed in the westernmost margin of the orebody (R350, R314 boreholes), where high gold grades (up to 25 mg/kg in 2.0 m interval) were found in the deepest explored zone of this mineralization. This enrichment points to the central intrusive (Rm16). Its further continuation, however, is unknown. Unfortunately, these results were produced in the frame of a previous copper ore exploration, and did not raise attention.

7.5. Au-Ag relationships

Silver plays less important role in the Lahoca ore mineralization. The gold enriched zones do not show spatial correlation with silver enrichment. Silver distribution seems to correlate more with copper, although this is not due to enargite-luzonite, rather the presence of tetrahedrite and other sulfosalts. The gold ores show an average of 13 mg/kg silver content, while the richest silver-bearing mineralizations (R223, R224) arrive to or exceed the 1,100 mg/kg level across several meters. The assayed particles of native gold were found to be relatively poor in silver, although some parts showed high (max Ag 25 %) content, arriving to electrum phase.

7.6. The age of ore mineralizations

The question which bears real economic importance is the age of mineralization. The lower age limit of the ore-forming processes is the age of the hosting volcanics and intrusives itself. The most probable oldest age for these rocks is 36 +/- 2.5 m.y, which places the beginning of the process to the Late Eocene. The youngest age obtained from the Lahóca and other Recsk rocks is 27 +/- 0.75 m.y. This age was obtained from the adularia of the Ilona valley as well as the K-
feldspars of the altered core of diorite intrusives. The radiometric age probably defines cessation of hydrothermal activities at the end of the Oligocene. It follows that the whole Oligocene period was associated by active ore forming hydrothermal activities near the Lahóca volcanic centre.

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