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Forms and genetical aspects of native gold in the Lahóca deposit (Recsk, Mátra mountains)

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ABSTRACT: The Recsk mineralized complex lies in NE Hungary, 30 km west of town Eger. As an ancient mining district, it has been known, explored and mined from the 18th century. Wide range of ore mineralizations is known in the complex. The examined high sulphidation enargite-pyrite-gold mineralization developed in relation to late volcanic centers, in the Lahóca Hill. Gold assay results extend a few tenth to ten g/t. Gold is associated both with pyrite and quartz in native form. It occurs as a few microns to few ten microns large irregular grains or aggregate-like structures.
Key words: epithermal deposit, high sulfidation mineralization, native gold

Introduction

During human history, gold has always been a symbol of wealth and power. In the medieval times, the Hungarian Kingdom was the main producer of gold in Europe. Beside the Transylvanian deposits, significant production came from the recent Central-Slovakian and North-Hungarian Tertiary volcanic areas. By the middle of this century, almost all of these mines became exploited.

In the seventies and eighties, the rise of the world market price of gold gave a new impulse to gold exploration. In those decades, the interest turned to the deposits having lower gold concentration but larger volume. The characteristics and the exploration concepts of epithermal gold deposits got new aspects.

The author examined the Lahóca epithermal deposit focusing on the genetic questions and appearance of gold. The results can contribute to the better understanding of the mineralization and metallogeny of the deposit and help in technological problems.

History of exploration

The Lahóca mine is situated in Recsk, Mátra Mountains, NE part of Hungary. It was the main producer of copper in the country for many decades. Although the main time of mining can be ascribed to the years 1930-70, the history of mining and exploration lasted for more than 230 years. The Lahóca epithermal deposit is a part of the Recsk mineralization complex.

The first discovery in the area of Recsk-Parádfürdő was made by Markhót in 1763 who mentioned Cu-Ag ores near the alum outcrops in Parádfürdő. More than 30 years later KITAIBEL (1799) described the rocks in the surroundings of Recsk as „porphyrs”. He also mentioned traces of oil near Recsk. Until the middle of the XIX. century, smaller adits were opened that are still known.

The discovery of the famous native copper in Bajpatak (HAIDINGER, 1850; KUBINYI, 1852) gave a new impulse to exploration. The smaller drifts of Fehérkő were re-opened, and the mining in Lahóca started. By a few fits and starts, mining activity was carried here until 1979. At the beginning of mining, Austrian geologists worked in the area. They described the ore bodies as impregnated stocks. As regards to ore minerals, SZABÓ (1875) realized the difference between the enargite and the sphalerite-pyrite-tetrahedrite mineralization.

In 1926 the Recsk mine was transferred into state ownership and the production increased. It resulted the reviving of the exploration work as well. It was also the time of the more intensive oil-exploration in the Bükkszék-Parád area, revealing new data about the basement and Terciary rocks. LÖW (1925) made a parallelization between the geological situation and mineralization of Bor mine, Yugoslavia and Recsk mine. He also described the oxidation-cementation zone in Lahóca.

ROZLOZSNIK (1939) first realized the important role of the Darnó-line in the tectonic setting of Hungary. He also gave a description about the stratovolcanic formations in the Lahóca-Kanázsvár-Fehérkő area. The first detailed paragenetic examinations of ore minerals were made by PAPP (1938) and SZTRÓKAY (1940).

After the 2^{n} World War the production of Lahóca mine was suspended because the ore reserves seemed to be worked out. Due to the intensive exploration by drillholes and drifts, new reserves of ore became known in the fifties. From that time, the mining of the new ore bodies was continuous until 1979.

During that time, the ore-exploration was re-started in 1958 looking for the deeper connections of the Lahóca ore bodies. The drilling exploration was made in three steps. At first, a metasomatic Pb-Zn mineralization was revealed by four, 1000m deep drillholes in a N-S section. Following this, 12 deep drillholes were made, in two E-W sections. Besides the ore indications above, porphyry copper ore was found in intrusive rocks. In the third step, 1200 m deep drillings in networks of 500x500 m, 350x350 m, than 175x175 m were made. During this, the skarn mineralization was discovered with chalcopyrite, pyrite, sphalerite and magnetite minerals. Based on the results above, a deep underground mine started to be built in 1970, in the northern part of the area. Meanwhile, the drilling exploration was continued in the southern part. ZELENKA (1975) sketched the structural-magmatic setting of the ore bodies. The subvolcanic andesite was described by BAKSA (1975), the stratovolcanic andesite group was examined by FÖLDESSY (1975). The hydrothermal alterations and the skarn-hydrothermal-metasomatic processes were studied by CSILLAG (1975).

In 1975, during the exploration for the porphyry and skarn copper ore a new enargite-luzonite-pyrite mineralization was found in the northern foreground of the Lahóca hill by BAKSA. He divided the mineralization into three genetically interrelated groups. The so-called "gold-pyrite” occured in lenses and small ore-bodies on the top of the lava-breccias.

While the significant mineralization at Recsk were connected to the andesite-diorite intrusives, the surficial andesitic volcanism were associated by the copper-pyrite mineralization. The role of the Darnó-line in the Recsk mineralization was pointed out by ZELENKA at al. in 1983.

Based on the new recognitions due to the intense exploration activities in the former two decades, BAKSA gave an outline of the Recsk mineralized complex in 1984. He pointed out that the Recsk complex was a part of the Eocene island arc along the Balaton-Darnó line, the main part of ore mineralization were connected to the hydrothermal phases of the diorite-porphyrite intrusion, and two, younger volcanic phases produced younger, re-mobilized ore mineralizations near surface.

In relation to the porphyry and skarn copper deposits, two deep shafts, 7.5 km drifts and 95 km underground drillings were completed until 1986. In spite of the detailed exploration, mining of the deep-seated ore bodies has not proved to be economic.

The Australian Rhodes Mining NL, Perth acquired the ownership of the Lahóca epithermal deposit in 1993. Although the epithermal part of the Recsk complex is named Lahóca, the alterations extend well beyond the Lahóca hill, forming the northern and the southern sulfidation zones. According to the growing interest for gold in the world and based on the gold discoveries in the eighties, the drilling exploration was re-started in the Lahóca zone in 1994. During three years, 57 drillholes were made with a total length of 8220 m. Results showed that the model of high sulfidation epithermal gold deposits perfectly fitted to the Lahóca area. The high sulfidation type of mineralization was overprinted by some low sulfidation characteristics in silicified breccia dykes and veins at the peripheral zones of the western flank. Resource estimate was 32.5 Mt of gold at 0.5 g/t cut-off with average 1.4 g/t Au content (FÖLDESSY, 1997). Since 1998, exploration work has been suspended because of the fall of the gold price.

Geology and mineralization of the Lahóca epithermal deposit

Geology of the Recsk complex

The Recsk area is situated in the Eastern part of the Mátra Mountains, that is a part of the Carpathian volcanic arc. Most part of the Mátra Mountains was formed by the Neogene volcanism. The smaller and older Recsk volcanic complex was formed during the Paleogene. It covers an area of about 25 km^2, north of the Darnó megatectonic zone (ZELENKA, 1973), the major tectonic belt of Hungary. The NE-SW trending, strike-strip displacement zone is the continuation of the Balaton line (ZELENKA et al., 1983), which separates regional-scale structural units throughout Hungary and post-dates the Paleogene volcanism (FÖLDESSY, 1996).

The Recsk Paleogene (Upper Eocene) volcanic unit was formed along an internal island arc – a part of the subduction zone that was located between the Northern and Southern Alps during the Laramian-Pyrenean orogeny. Due to a large-scale (about 300 km) northeastward movement along the Darnó strike-slip fault the Recsk Paleogene complex arrived at its present position during the Lower Miocene (ZELENKA, 1975).

The pre-volcanic basement of the Recsk area consists of Triassic limestone, quartzite and shales showing deep oceanic origin. Drillholes intersected the Triassic sequences in nearly 1000m thickness. FÖLDESSY-JÁRÁNYI (1975) put these sediments into Ladinian to Carnian and found that the scarce faunal data showed affinity to the Trans-Danubian Range, but the lithological features were similar to that of the Bükk Mountains. However, the basic volcanites known from the Darnó Hill and the SW-Bükk are absent in the basement of the Recsk area.

The Triassic sequence formed a horst structure and remained topographically high during the subsequent Paleogene and Neogene geological evolution (FÖLDESSY, 1996).

Due to the post-Triassic uplifting, Jurassic and Cretaceous sedimentary or volcanic rocks are absent. The intense deformation, rifting and subsidence during the Laramian-Pyrenean phase caused marine ingression. The Paleogene series starts with Upper Eocene shallow marine limestone and marl. The deformation and movements also initiated an intermediate submarine volcanic activity in the Recsk area. The age of the magmatism is determined to be Upper Eocene by the underlying, intermingling and overlying sediments of the Nummulites fabianii horizon (BAKSA et al., 1981).

The Paleogene volcanic cycle comprises four stages during which the eruptive centers were shifted northward (Fig. 1). The first stage represents subaqueuos andesitic lavaflows,

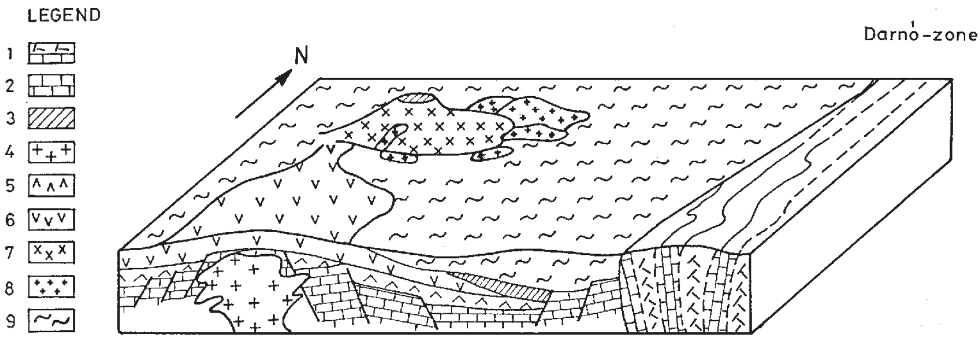


Fig. 1 Major rock types of the Mátra Mountains (after BAKSA, 1981). 1: Triassic folded limestone, shale with ophiolites, 2: Triassic limestone, quartzite, shale, 3: Upper Eocene limestone, marl, clay, 4: shallow dioritic intrusion (3. Stage), 5: lower biotite-hornblende andesite series (1. Stage), 6: quartz-biotite-hornblende andesites, dacites (2. Stage), 7: biotite-hornblende andesites (3. Stage), 8: biotite-pyroxene-hornblende andesite dykes, extrusions, laccoliths (4. Stage), 9: Middle and Upper Oligocene siltstone, clay

agglomerates, tuffs, mixed breccias and peperites, reflecting the alterations of phreatic explosions and the effusions. The products of the first volcanic stage do not outcrop on surface. The second stage produced a stratovolcanic sequence in a gradual shift from submarine to subaerial environments, with a dacitic chemical character. At the end of this stage ignimbrites were formed as typical subaerial depositions. The third stage is represented by a stratovolcanic sequence of biotite-hornblende andesites, pyroclastics and reworked andesitic volcanic sediments in smaller regional extension than the earlier stages. The emplacement of the diorite porphyry and quartz diorite intrusions hosting the porphyry copper mineralization also took place in the third stage. The most intensive hydrothermal alteration is related to this stage. The thickness of the volcanic products of the second and third stages is 200 to 300 m. The fourth stage is characterized by the development of the central explosive caldera in the area of the third-stage volcanism, and the formation of radial and irregular dyke-pattern bodies and laccoliths within and around the caldera (BAKSA et al., 1981; GATTER et al., 1999).

As a result of transgression, the volcanics are covered by Upper Eocene reef limestones and other lacustrine sediments. The volcano-sedimentary and calcareous layers contain fossils like Nummulites sp. and Lithothamnium sp., and are interbedded with the uppermost part of the volcanic sequence indicating the age of the volcanism. The subsidence of the area reached its maximum in the Middle Oligocene when only the central horst escaped transgressions. The Oligocene sediments are sandstone, clay and marl in a thickness of 700m *(Fig. 2).* Volcanic intercalations have been found even in the Lower and Middle Oligocene

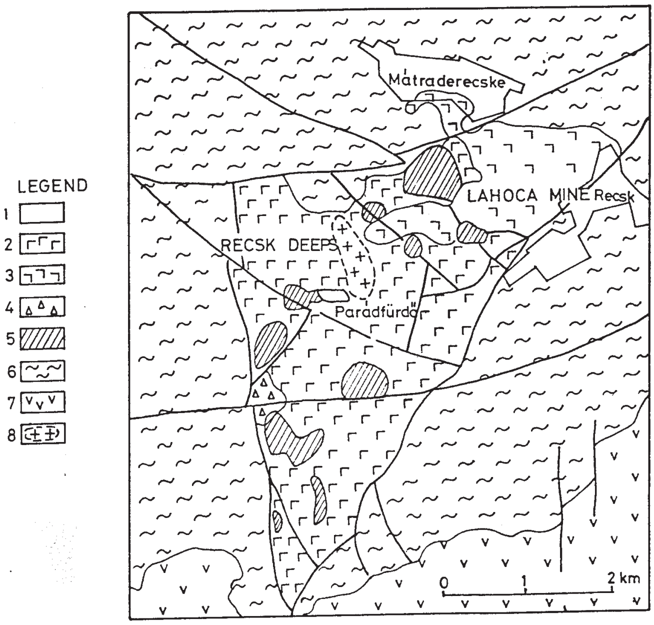


Fig. 2 Geological sketch of the Lahóca area (after FÖLDESSY, 1996). 1: settlement, 2: Upper Eocene andesite and dacite (1. and 2. stage), 3: Upper Eocene-Oligocene andesite (4. stage), 4: Upper Eocene diorite-porphyry breccia (2. stage), 5: Extreme hydrothermal alteration, 6: Middle and Upper Oligocene siltstone, clay, sandstone, 7: Miocene volcanic and sedimentary series, 8: hidden Upper Eocene diorite-porphyry intrusion

sediments. The Oligocene sedimentation has been restricted to the Western and Central Mátra, while the Eastern Mátra remained dry land until the Lower Miocene. The Western and Eastern parts of the Mátra are separated by the southward continuation of the Darnó zone (BAKSA et al., 1981; FÖLDESSY, 1996).

The Paleogene volcanic series is isolated from the Neogene volcanic rocks that form the main mass of the Mátra Mountains. There is a slight overlap between the two series. The Neogene stratovolcanic sequence of the Western Mátra was produced in three main eruption cycles (ZELENKA, 1975). At the same time, fissure volcanoes and local extrusions built up the Eastern Mátra. The Neogene volcanism started on dry land, when isolated andesite flows, pyroclasts and the “Lower Rhyolite Tuff” were produced. In the Karpathian period marine transgression started with the deposition of clay and sandstone, and the eruptions of andesite, pyroclasts and the “Middle Rhyodacite Tuff”. The thickest andesite sequences (1300 m) were formed in the Badenien. At the end of the volcanic evolution a caldera of 10-15 km diameter was formed (GATTER et al., 1999).

During the Neogene tectonic events the Western Mátra preserved its original volcanic structure, while the Eastern Mátra underwent stronger tectonic deformation and much of the primary volcanic morphological elements became deteriorated. In the Western Mátra low sulphidation mineralization was developed (BAKSA et al., 1981; GATTER et al., 1999).

Mineralization of the Recsk complex

The Lahóca gold mineralization is a part of the Recsk complex. This complex can be considered unique as ore formations of different genesis in connection with a shallow, sub-volcanic intrusion are situated in one, relatively small occurrence, and a complete porphyry Cu formation with an epithermal Cu-Au mineralization have been preserved in one system *(Fig. 3).*

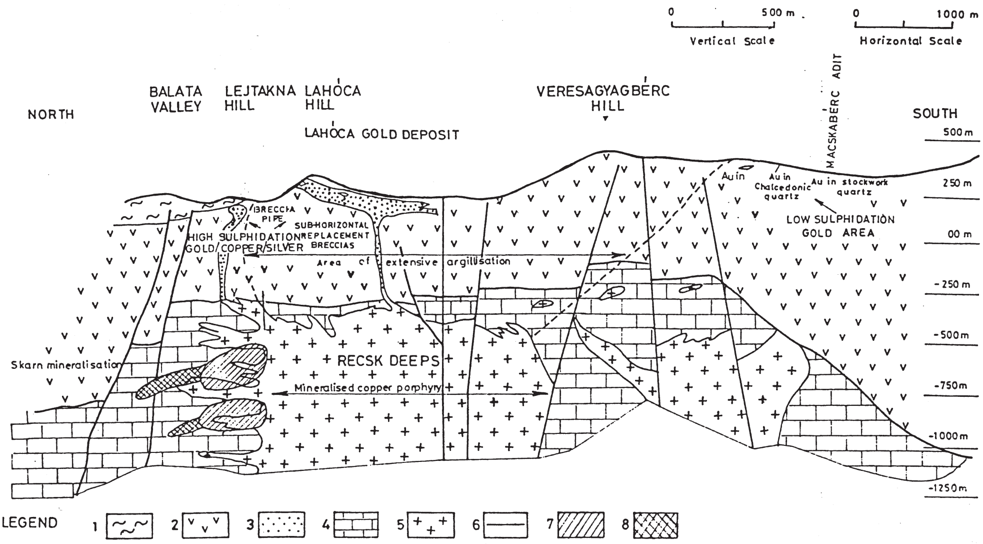


Fig. 3 Schematic cross section of the Recsk complex (after FÖLDESSY, 1996). 1: Oligocene clastics, 2: Eocene andesite, 3: gold deposits, 4: Mesozoic basement, 5: mineralized copper porphyry, 6: fault, 7: copper skarn, 8: zinc skarn

The deep-seated ore complex

The shallow diorite porphyry intrusion in the Triassic limestone is an irregular-shaped, elongated body of about 3000 m by 800 m in plan. Its highest point is at 300 m below surface (BAKSA et al., 1980). In the intrusive body typical porphyry *Cu-Mo* mineralization developed. Along the exo- and endocontact with the limestone skarn *Cu-Zn-Pb-Fe* mineralization was formed. In the Triassic limestone *metasomatic and vein-type Zn-Pb* ores occur.

The deep-seated ore was opened by two shafts at 900 m and 1200 m. These shafts were flooded in 1999.

The *alteration* in the intrusive body was preceding and contemporaneous with the ore mineralization and shows zoning from the center outward (BAKSA, 1984). The central core is slightly silicified. Around this core, there is a phyllic zone, 100-200 m thick at the upper part of the intrusion and thinner at the lateral margins. It contains quartz, sericite and anhydrite. The surrounding propylitic zone is not continuous and overlaps with the endoskarn along the contact between the intrusion and the surrounding carbonate rocks. The alteration minerals in this zone are albite, chlorite, epidote, anhydrite and calcite. The deeper parts of the zone are mixed with the skarn minerals like diopside, amphibole and phlogopite. Wollastonite is also developed in the chert units of the exoskarn. The exoskarn is fringed by a 2000-2500m wide metasomatic zone where the Triassic limestone recrystallized to marble. Gypsum and anhydrite are present in both the propilitic and skarn environments. The skarn is overprinted by hydrothermal processes producing serpentine, anhydrite and magnetite (CSILLAG, 1975).

The porphyric copper *mineralization* shows chalcopyrite-pyrite disseminations and stocworks. At 0.4% cutoff grade, the porphyric ore bodies extend 80-100 m horizontally and 300-400 m vertically (BAKSA, 1980). In the peripheral parts of the body molibdenite occurs in siliceous-anhydritic veins. In the skarn mineralization the basic copper-bearing mineral is chalcopyrite accompanied by pyrite, pyrrhotite, magnetite and hematite at the deeper horizons. The endoskarn forms 10-50x100 m, steeply dipping ore bodies with about 100 m vertical extent. In the skarnous polymetallic deposits sphalerite is essential, associated by pyrite, chalcopyrite, galena and magnetite. The average grade of the endoskarn is 1-1.5% Cu. In the zones of the hydrothermal-metasomatic alterations the polymetallic ore deposits contain dominantly sphalerite, beside pyrite, galena and chalcopyrite (CSONGRÁDI, 1975).

The epithermal environment of the Recsk complex

The Upper Eocene Recsk porphyry has a spatial and genetical association with the epithermal Cu-Au deposits. The epithermal mineralization appears on surface at Parádfürdő- and on the Lahóca Hill. The mineralization took place in the second and third stages of the Paleogene volcanic cycle, and some indications suggest that it was continued until the Middle Oligocene (FÖLDESSY, 1996).

The Parádfürdő area

At the Parádfürdő area the mineralization appears in the second-stage dacites and third-stage andesites and pyroclasts (FÖLDESSY, 1975).

The alteration in connection with ore formation appears as strong silicification occurring as flat lenses and vein-like bodies that are vertical or subvertical structures, with an extent of 10s meters. The longest zone is about 500 m. Some silicified bodies have vuggy silica texture and quartz stockworks connect to them. The silicified bodies are surrounded by argillic alteration zone with kaolinite, smectite, alunite and pyrophyllite (GATTER et al., 1999).

In the southern part of the Parádfürdő area the mineralization is connected to breccia dykes hosted by the third-stage andesitic-dacitic rocks. The breccia dykes are 10-20 m (in some places 50 m) wide. The polimict breccia particles are andesite, porphyryic diorite and a few fragments of the underlying sediments. The andesitic particles display silicic and argillic alterations. The dioritic fragments show K-metasomatic alteration, as sericitized K-felspar replaces the original plagioclase. At the shallow zones the matrix has argillic alteration (illite, smectite, pyrophyllite, dickite), towards deeper zones silicification. With increasing silica content adularia and calcite also appear (MOLNÁR and GATTER, 1997).

The ore *mineralization* occurs both in the silicified and argillic alteration zones (GATTER et al., 1999). Galena, sphalerite, Pb-Se- and Ag-Sb sulfosalts connect to the argillic alteration zones as disseminations and veinlets. Tetrahedrite, tennantite and less amount of pyrite is characteristic in the silicified bodies and vein fillings. Younger pyrite dissemination is associated with rare Au-Ag-Bi-Te-Sb minerals. The gold appears both as tellurides and in native form (NAGY, 1983). According to the fluid inclusion homogenization temperatures, the mineralization might have occured between 220-260 ºC, 200-500m below the paleo-water table (GATTER et al., 1999).

In the southern areas local Au enrichment was observed in the adularia-bearing zones in form of native gold. Tetrahedrite is rare, pyrite is common as dissemination in the matrix and the altered fragments (MOLNÁR and GATTER, 1997).

Based on the alteration mineral assemblages, the Parádfürdő area can be considered as an early *high-sulfidation* stage of hydrothermal activity. Considering that in the late veins and cross-cutting breccia bodies adularia and calcite also occur, and sulfide minerals like sphalerite and galenite are present, *low-sulfidation* activity must have overprinted the high-sulfidation mineralization (MOLNÁR and GATTER, 1997).

The Lahóca area

The Lahóca area includes three mineralization centers: (1) Lahóca central brecciated zone, (2) Lahóca northern brecciated zone, (3) Lejtakna pipe-breccia. The main part of ore is limited to the central brecciated zone.

The breccia zones are connected to the third-stage andesitic series. This series consists of three major lithological units. The diorite porphyry body *(lowermost unit)* intruded into a 30-50 m thick, southward dipping pyroclastic breccia *(middle unit).* Hornblende andesite dikes and extrusive plugs *(upper unit)* of the third and fourth volcanic stages cut the rocks of the lower and middle units or form blankets on the breccia. Intrusive pipe-breccias occur near the intrusive body, maar-diatreme type breccias and hydrothermal breccia dykes and stocks can be found in the whole sequence. The sharp, upper border of the ore body is the „blueschist" (an altered, clayey rock with high pyrite content). Downward, the gold content gradually decreases *(Fig. 4).*

The *alteration* of the mineralized bodies shows high-sulfidation characteristics. Intensive silicification is special in the ore-bearing breccia bodies. These bodies have irregular, flat forms. The breccia has a polimict character. Among the fragments, rock pieces of the earlier volcanic stages can be found. Their sizes are maximum 10 cm and they are slightly rounded. The breccias are often re-brecciated and re-cemented by chalcedony, quartz and clay minerals. The size of the mineralized breccia bodies is about 50x200 m laterally, with a thickness of 30-50 m. These bodies are surrounded by advanced argillic alteration. In the argillic zone pyrophyllite, dickite, kaolinite and quartz are special. Outward from the silicic core, these minerals change into smectite-illite (FÖLDESSY, 1997).

The *high sulfidation mineralization* is connected to the breccia bodies that have a high fractuation at the top and lower fractuation at the bottom. The gold enrichment has a sharp upper boundary at the covering „blueschist" and weakens downwards. Ore minerals appear both in the matrix and clasts. The enargite and luzonite occur in form of impregnations and veins in the silicified matrix, or dissemination in the breccia. The main Au-bearing mineral is the collomorph pyrite in dissemination and fine impregnation. The coarse-grained euhedral pyrite is usually free of gold. Enargite and luzonite also contain gold. About 25% of the gold is free. Sphalerite and tetrahedrite are common accesorial minerals in the lower parts. Several Pb, Bi and Te sulfosalts also occur as inclusions in the Cu-As-Sb minerals. The ore appears in the matrix of vuggy siliceous breccias, as breccia cement, in the clasts, or in veins and stockworks. Barite and chalcopyrite are present in the pipe breccias (SZTRÓKAY, 1944; BAKSA, 1975; KOCH, 1985; NAGY, 1993).

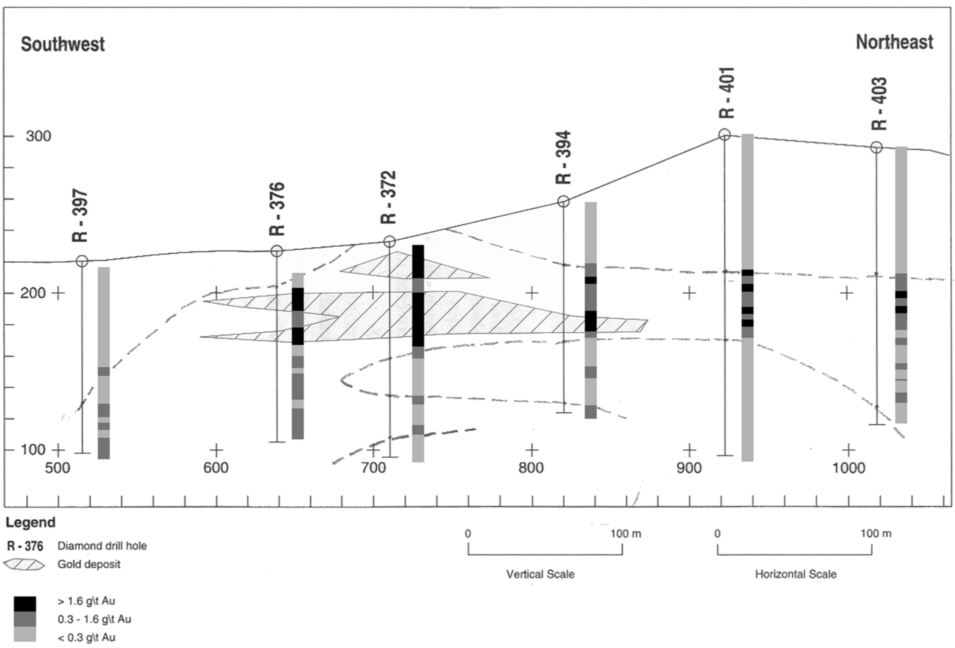


Fig. 4 Distribution of Au grades in the Lahóca deposit (After FÖLDESSY et al., 1997)

The gold is concentrated in the strongly silicified zones. The average gold content of the breccias is 3 g/t. The highest gold content appears along the contact with the blueschist (argillic alteration of the overlying andesites). From this contact, VITÁLIS (1926, 1933) reported 100-180 g/t Au in pyrite-rich pods. In the argillic alteration zones the Au content is 0.1-0.2 g/t. There is a correlation between the Au and Cu content. The latter varies from 0.1-0.7 %. The Ag content is 1-5-g/t and it doesn't correlate with the Au (GATTER et al., 1999).

The main part of the ore is between 50-100 m below surface. The new resource estimations presume 35.5 million tons of gold with an average 1.4 g/t Au at 0.5 g/t Au cut-off. In case of higher cut-off the resource decreases: it is 16.5 million tons of gold with 2.01 g/t Au at 1.0 g/t Au cut-off. The average silver content is merely 1-5 g/t, but it can be important in certain parts as a premium over the gold (FÖLDESSY, 1997).

Petrographical and mineralogical characteristics of the Lahóca deposit

The basic aims of examinations were to clarify the mineralogy and the genetic aspects of the deposits and reveal the composition, habitat and morphological characteristics of gold minerals in it.

In the area of the Lahóca epithermal deposit 34 samples were collected from the following drillholes: R 368, R 370, R 371, R 372, R 377, R 378, R 390, R 396, R 404, R 408, R 416, R 417, R 421. Although one of the main aims was to study the forms of gold minerals, the samples represent all rock types (including ore-free and ore-rich rocks) related to the Au mineralization in order to help clarify the genetic questions.

The author examined the *microscopic characteristics* both in transmitted and reflected light by an AXIOLAB A-type polarization microscope and documented them by an MC 80 DX camera. The *scanning electron microscopic* and *microprobe* analysis was carried out by an AMRAY 1830 I scanning electron microscope with EDAX EDS detecting unit pv9700/36, at the Institute of Material Science, University of Miskolc, by the help of Á. Kovács, research fellow. The analysis took place on the same thin sections that were subjected to the microscopic examinations. *XRD analysis* was carried out at the Hungarian Geological Institute, by P. Kovács-Pálffy and I. Baráth. The instrument is a computer-controlled and evaluated Philips PW 1730 diffractometer, with Cu anticathode, 40 kV, 30 mA, graphite monochromator, goniometer-velocity 2º/min. The gold assay results were made available for the author by the Enargit Ltd.

Based on the detailed petrographical and mineralogical examinations and according to the data of latest publications the following types of rocks can be distinguished:

(1) weathered, overlying andesite
(2) late andesite
(3) blueschist
(4) stratovolcanic andesite and pyroclasts
(5) intrusive andesite
(6) hydrothermal breccia

The overlying andesite and late andesite are situated above the blueschist. All the other rock types lie under the blueschist.

Weathered, overlying andesite

This rock was examined in the sample R372-5.7m. The rock is pale ochre, highly argillized. As the sample represents a shallow depth, surficial weathering effects could influence its decomposition. Microscopically both the matrix and the porphyric minerals are substituted by clay minerals (kaolinite), less sericite and quartz. The slurred contours of the decomposed porphyric minerals are recognizable. The opacite contour of amphiboles can be seen, but the minerals are limonitized and argillized. Their sizes range between 0.2-1.5 mm.

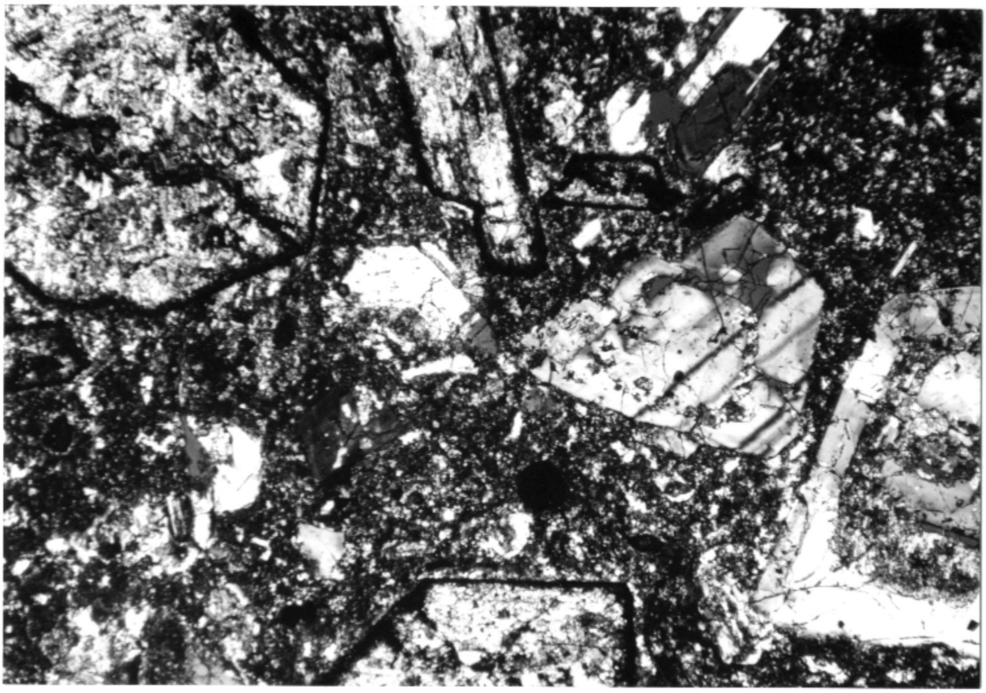
A few pyrite crystals appear in anhedral form., in sizes about 20 μ. The slight limonitization is limited first of all to the areas of the former amphiboles (?) indicating that the original amount of pyrite was also little. The gold content is very low, and gold was not visible even by electron microscopic method. The gold assay results of the sample are as follows:

Sample	Au (g/t)
R372-5.7m	0.02

Late andesite

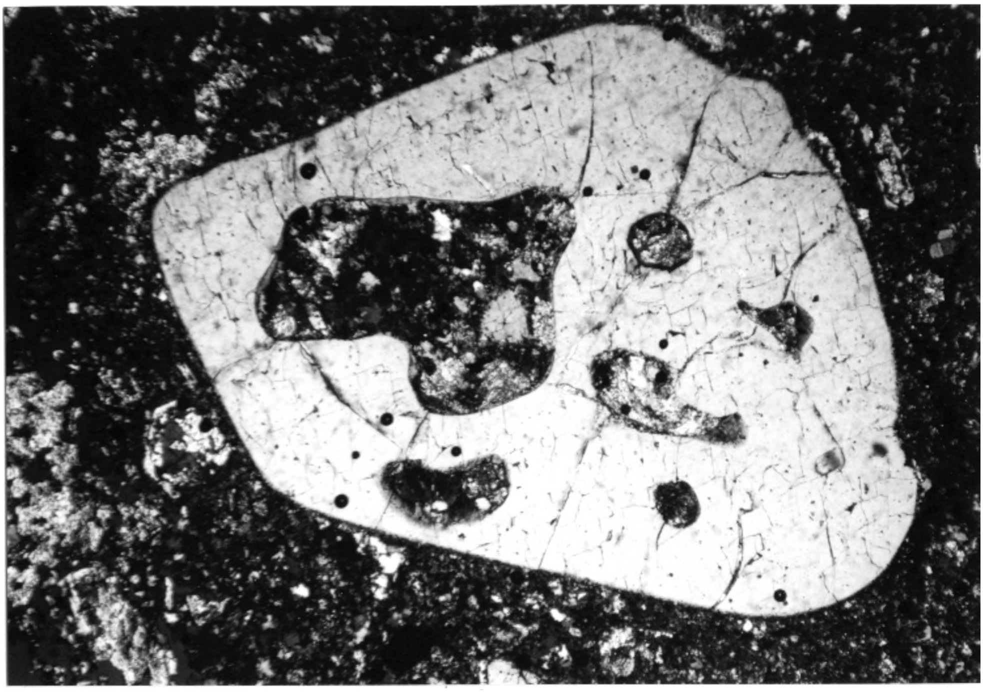
This rock type is represented in the samples of R 370-101m and R 408-14m. The rock seems to be relatively fresh, unaltered.

Microscopically, the originally glassy-microcrystalline matrix has been slightly silicified, week argillization and sericitic alteration are also visible. Among the porphyric constituents plagioclase is the most abundant. The size of the plagioclase crystals is maximum 3 mm. Polysynthetic, laminar twinning is very common *(Pict. 1),* zoned phenocrysts are also visible. Besides plagioclase, amhibole, minor biotite and quartz are also present as porphyric



Pict. 1 Laminar twinning in plagioclase. R 370-101m, late andesite.
Transmitted light, +N, 50x

crystals. The amphiboles have characteristically opacite contour. A few, 100-150 microns large, unaltered biotite crystals were also identified by their pleochroism and cleavage. The rare porphyric quartz crystals can be more than 1 mm in size. These are subrounded grains with mosaic structure. *(Pict. 2)*



Pict. 2 Mosaic structured quartz with the inclusions of the matrix. R 370-101m, late andesite. Transmitted light, +N, 50x

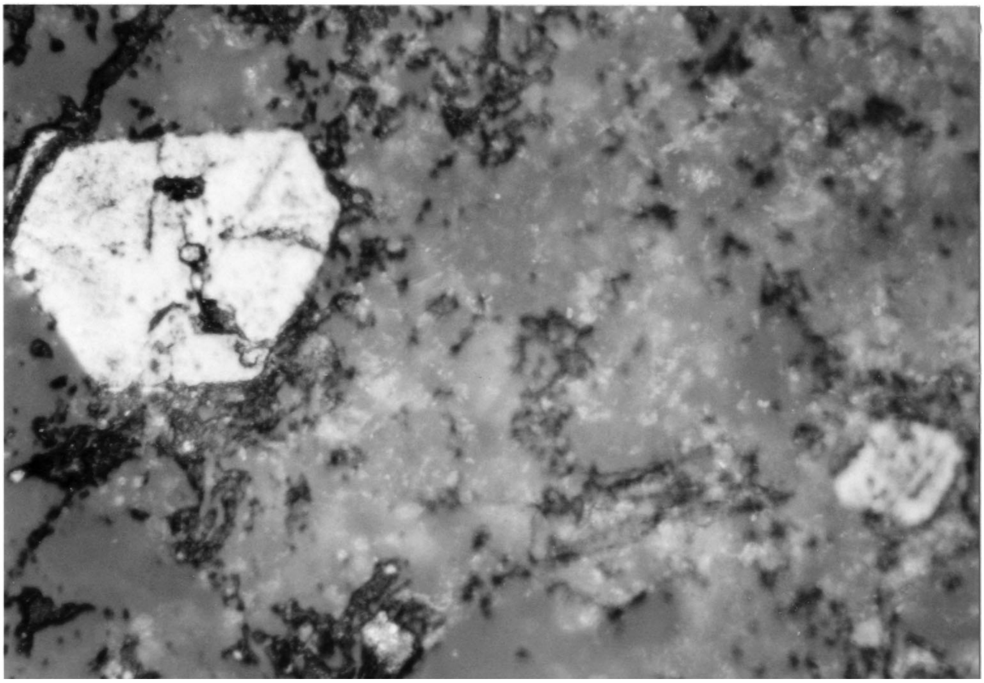
As opaque minerals, the sample R 370-101m is almost free of pyrite but ilmenite crystals are relatively abundant. The decomposition of ilmenite resulted the formation of rutile (Pict. 3). In the sample R 408-14m more pyrite can be found as a few microns large, ahedral grains in the opacitized amphiboles, or very fine dissemination in the matrix. The abundant pyrite can be paralleled with the relatively high gold content. Enargite also occur in form of subhedral crystals, a few tens to a few hundreds microns across. In this sample a very small grain of native copper was identified both by optical microscope and microprobe in the sample of R 408-14m in an argillized plagioclase crystal. The native copper could be formed by the decomposition of enargite, due to the supergene conditions in the oxidation zone.

The results of the XRD analysis of the sample R 408-14m are as follows:

Illite/montmorillonite 16%, chlorite 6%, quartz 27%, K-feldspar 9%, plagioclase 9 %, pyroxene 7%, pyrite 20%, gypsum 1%, Mn-calcite 2%, amorphous 3%.

The gold assay results are in accordance with the pyrite content: in the pyrite-free R 370-101 sample the gold content is almost as low as its general Clark value, and the pyrite-rich R 408-14 sample has a relatively high gold content:

Sample	Au (g/t)
R 370-101m	0.008
R 408-14m	5.49



Pict. 3 Ilmenite crystals in silica matrix (darker grey) with fine rutile (lighter grey patches). R 370-101m, late andesite. Reflected light, 1N, 500x

Blueschist

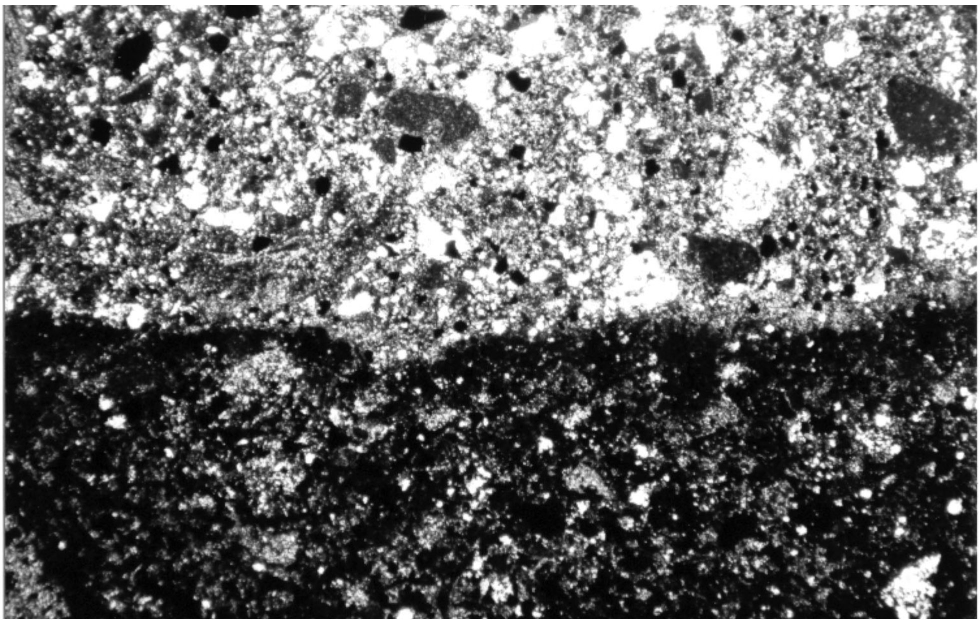
The name „blueschist" is due to the slight laminitization and the dark, bluish color of the rock that is in connection with the high pyrite content. This clayey rock which contains silicified rock fragments of a few microns to tens of centimeters has a debated origin. The latest results suggest that it is a special sedimentary rock, deposited as pyroclastic fragments, clayey material and fragments of the silicified andesite and breccia in a crater lake or shallow marine environment (BAKSA, 1974).

This rock type was examined in the following samples: R 372-6.5m, R 372-8m, R 417-34.1m and R 421-86m. Microscopically, the matrix consists of clay minerals and fine-grained, interlocking, mosaic-textured quartz with dense, fine pyrite dissemination. In the sample R 372-6.5m, the arrangement of the constituents shows orientation, with deformations supposably due to mudslides. The clay minerals proved to be mostly dickite indicating the hydrothermal effect.

Among the larger constituents both rock fragments and single minerals can be found. The rock fragments are highly silicified andesites and brecciated andesites with pyrite content. The most abundant mineral is the quartz (about 40 %). It appears in forms of mosaic-textured fragments, clusters, fragments of volcanic origin, sometimes with corroded contour, or pseudomorphs after plagioclase and amphibole phenocrystals. The sizes of quartz grains range from a few microns to about one mm. The 200-500 microns large amphiboles show euhedral forms, with quartz and pyrite impregnation and pyritization along the contours.

XRD data of two samples of blueschist:
R 372-6.5m: dickite 71%, pyrite 15%, amorph 3%
R 417-34.6m: illite/montmorillonite 18%, illite 3%, kaolinite 23%, quartz 27%, plagioclase 10%, pyrite 16%, gypsum 1%, amorphous 2%.

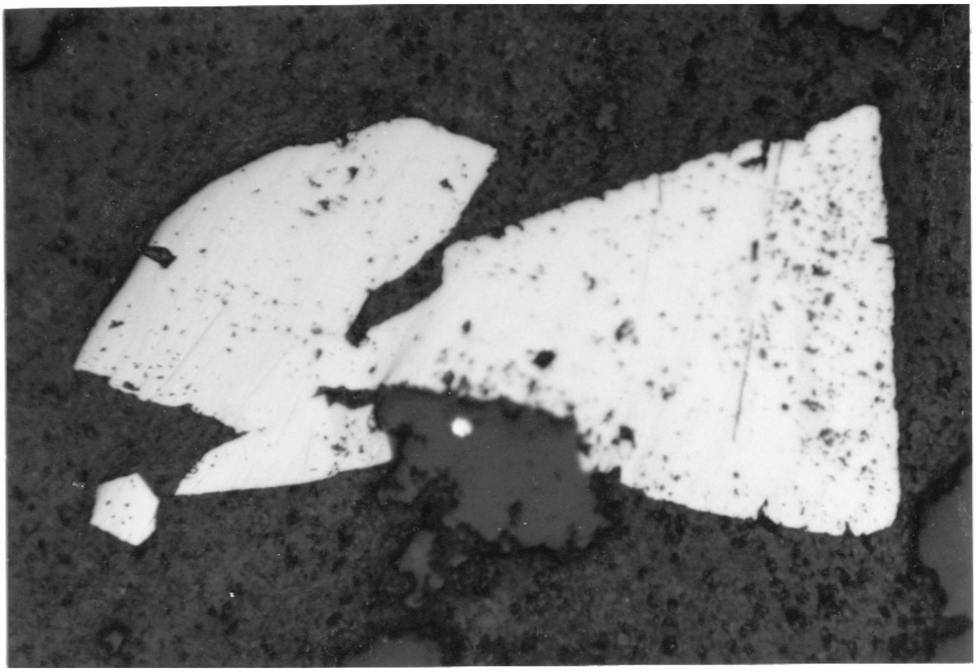
The pyrite occurs as discrete interstitial or intergranular, often microfractured or corroded, euhedral-subhedral grains or clusters (high-temperature origin); finely fibrous clusters and aggregates, or colloidal melnikovite (low-temperature origin).



Pict. 4 Andesite fragment (light) in pyrite-rich matrix (dark). R 421-86m, blueschist. Transmitted light, 1N, 25x

In the sample R 421-86m, lighter grey, argillized andesitic fragments are surrounded by black, fine-grained, argillic matrix *(Pict. 4).* Although pyrite is present in the lighter fragments too, its amount is more significant in the matrix that got its blackish shade by the colloidal pyrite. Enargite also occur in a few percent, in form of maximum 1mm large, subhedral crystals *(Pict. 5).* Gold was not visible in the samples even by electron microscope. The gold assay results are as follows:

Sample	Au (g/t)
R 372-6.5m	0.02
R 372-8m	0.06
R 417-34.1m	4.79
R 421-86m	7.51



Pict. 5 Subhedral enargite in fine-grained quartz matrix. R 421-86m, blueschist. Reflected light, 1N, 200x

Stratovolcanic andesite and pyroclasts

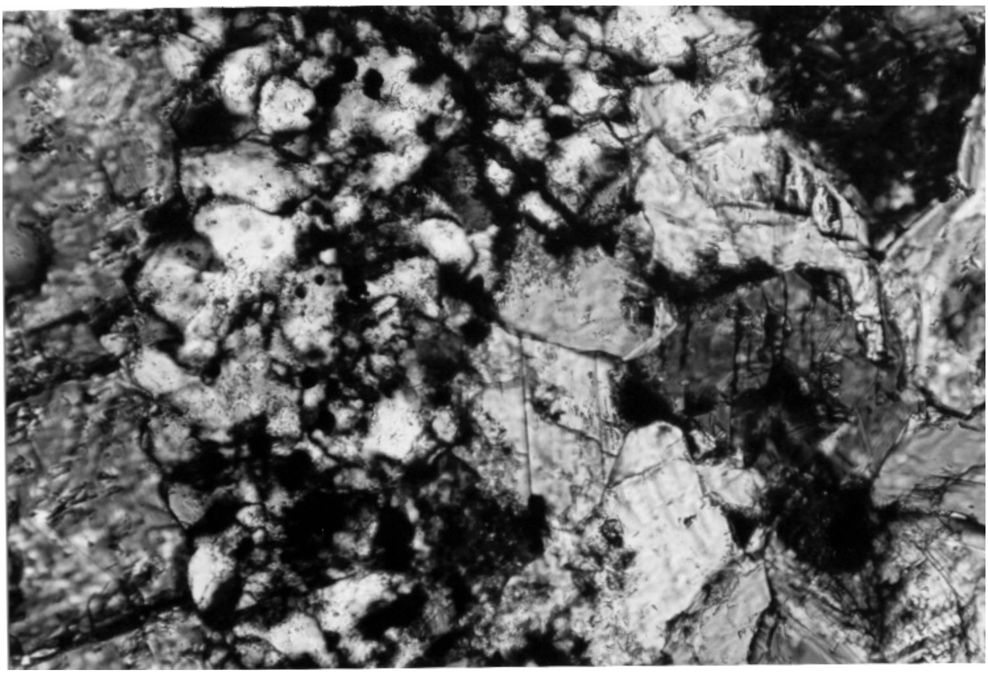
This rock type was examined in the following samples: pyroclastics: R 372-85m, R 372-99m, R 372-111m, R 378-70m, R 390-58m, 396-14m; andesites: R 372-76.5m, R 378-70m, R 417-68m.

The pyroclastic rocks (andesitic tuff) are fractured and friable, with a few mm large, silicified andesite fragments and white plagioclase crystals. Not only silicification but advanced argillic alteration is characteristic. The clay mineral is mostly illite/montmorillonite, kaolinite is subordinate. Some of the samples display green and brown patches, indicating chloritization and limonitization. Calcite is also present in veins, in the sample R 390-58m. Its amount in that sample exceeds 10%.

Microscopically the matrix is silicified and argillized with fine pyrite dissemination. The silica content is proportional to the amount of pyrite. The matrix is strongly limonitized in the sample R 390-58m. Chlorite is abundant in the matrix of the sample R 396-14m.

The clasts are mostly fragments of differently silicified andesites of maximum 3 mm in size, but fragments of plagioclases and amphiboles also occur. The rock fragments are usually rounded, while the clasts of crystals are angular. The amphiboles are silicified, they can be identified by their crystal forms and opaque contour. In many cases, the contours of clasts are slurred, especially in the more argillized samples. A few, uncertain fragments of 50-150 microns large, layered sedimentary rock was also observed.

In the sample R390-58m, calcite crystals occur in veins, along fractures and in the place of amphibole crystals. The calcite is rimmed by mosaic-textured quartz. This younger quartz phase is coarser-grained and less abundant in pyrite than the matrix *(Pict. 6).*



Pict. 6 Calcite rimmed by mosaic-textured quartz with pyrite dissemination. R 372-85m, andesitic tuff. Transmitted light, +N, 200x

The main opaque mineral is pyrite. The silicified matrix is densely scattered by 5-100 microns large, euhedral-subhedral pyrite crystals. In the argillic samples pyrite is less abundant, partially due to the limonitic alteration. The fine-grained, silicified matrix is cut by fissures that are filled by coarser-grained, mosaic-textured quartz. This quartz generation contains less pyrite than the matrix. Even less pyrite is associated with calcite. Enargite and luzonite appear in connection with the calcite veinlets. They form irregular or elongated grains of 200-700 microns. Sometimes calcite and luzonite make pseudomorphs after amhibole.

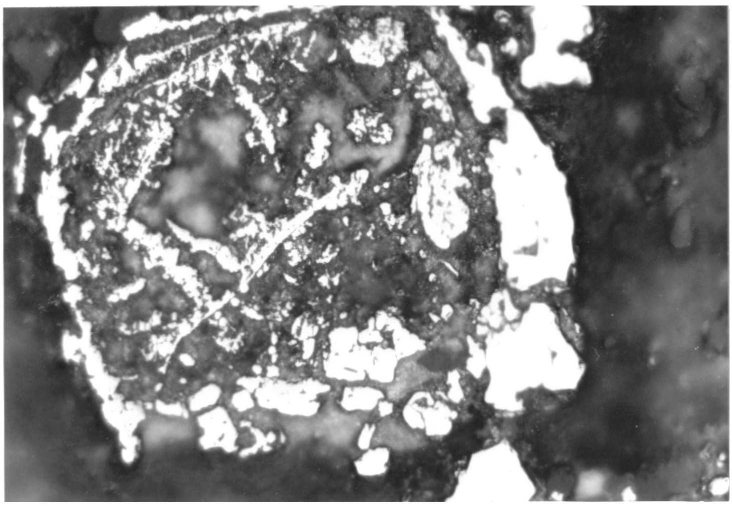
The XRD data of the pyroclastic rocks show strong argillization. The dominant clay mineral is illite/montmorillonite. This can be interpreted by the marine environment of the pyroclasts accumulation.

R 390-58m: illite/montmorillonite 18%, kaolinite 3%, chlorite 3%, quartz 25%, K-feldspar 4%, plagioclase 25%, pyrite 6%, gypsum 2%, calcite 11%, amorphous 3%

R372-99m: illite/montmorillonite 11, kaolinite 9%, quartz 56%, 4%, pyrite 17%, amorphous 3%

The *stratovolcanic andesite* is grey, silicified and argillized rock. The 1-3 mm large porphyric plagioclase crystals are substituted by clay minerals. Microscopically, these argillic patches are free of pyrite. Pyrite occurs in the silicified matrix and in the place of the former amphibole crystals.

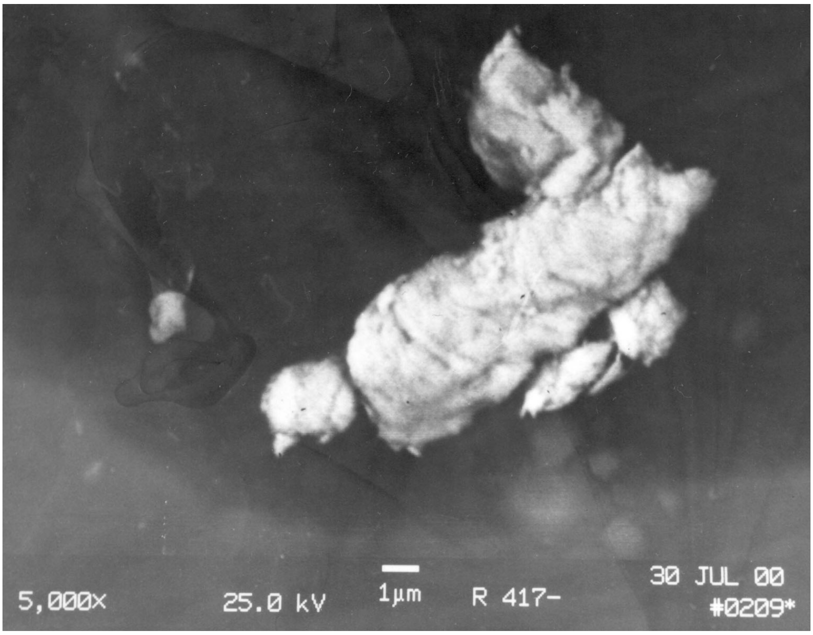
The larger (100-300 microns) rounded or corroded pyrite grains are associated with rutile. Rutile is present in a few percent. It seems to be more frequent in the samples of higher Au grades. It forms a few microns to few tens microns needle-like or long, prismatic crystals. It appears in silicified amphibole, or in association with pyrite. In the latter case a mixture of cryptocrystalline silica and very fine rutile needles (visible by electron microscope) fill up the inner part of the strongly corroded pyrite *(Pict. 7).* Most of the rutile can be originated by the solution of the Fe-Ti minerals (ilmenite) of the original andesitic rock. Considering the amount of rutile, part of the Ti may have been carried by the ore-bearing solutions into the system.



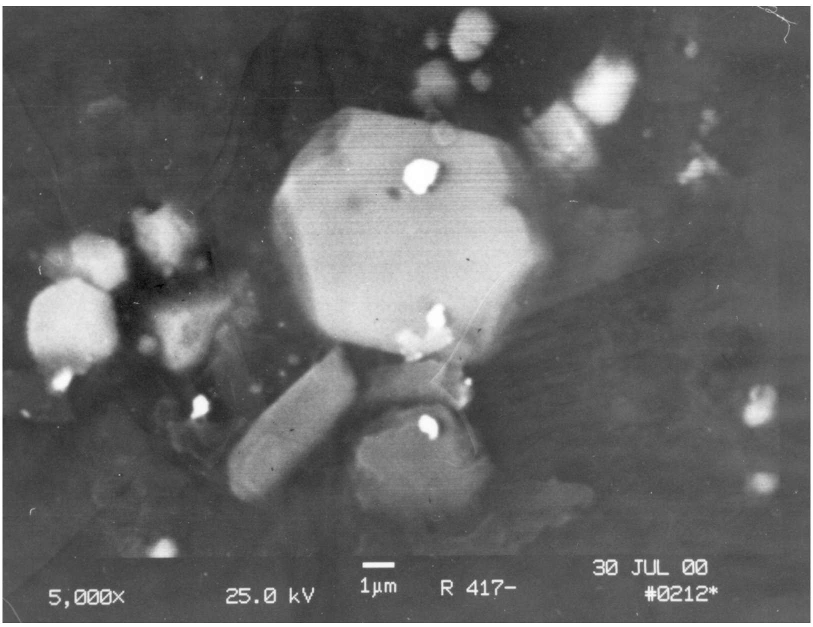
Pict. 7 Corroded pyrite filled by a mixture of cryptocrystalline silica and submicroscopic rutile needles. R 417-68m, stratovolcanic andesite. Reflected light, 1N, 500x

The gold content seems to be higher in the lava rocks than in the pyroclastics:

Pyroclastic rocks		Andesites	
Sample	Au (g/t)	Sample	Au (g/t)
R 372-85m	0.349	R 372-76.5m	0.532
R 372-99m	0.150	R 378-70m	2.400
R 372-111m	0.656	R 417-68m	4.140
R 390-58m	1.920		
R 396-14m	1.140		



Pict. 8 Native gold in silicified matrix. R 417-68m, stratovolcanic andesite. SEM photo



Pict. 9 Native gold inclusion in pyrite. R 417-68m, stratovolcanic andesite. SEM photo

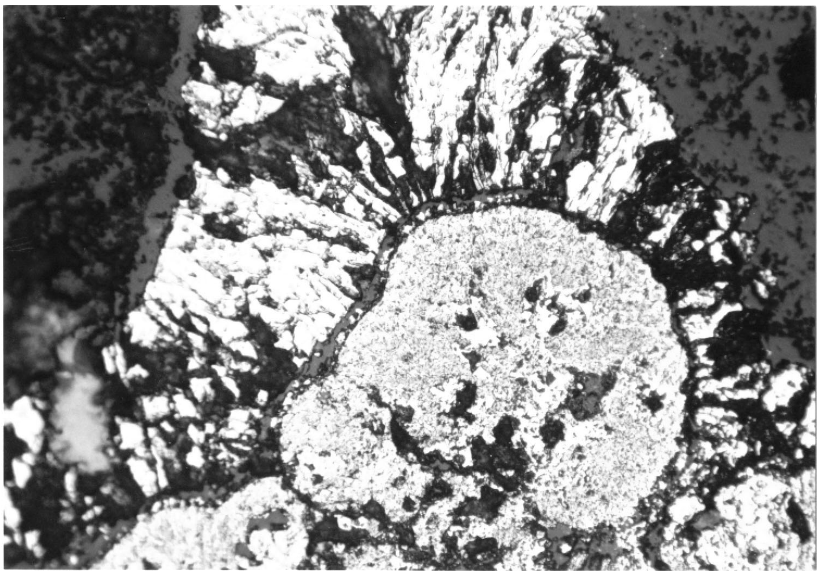
The gold occurs in native form both in the silica matrix and related to pyrite. In the silicified environment a 13 microns long, cloud-like structure was found *(Pict. 8).* In the same sample, it also appears as about one micron large, rounded inclusions in pyrite *(Pict. 9).*

Intrusive andesite

This rock type was examined in the samples of R 368-103m, R 371-71m, R 372-121m, 372-131m, 372-134m and 416-110m. These rocks show strong silicification, some samples have vuggy silica structure. In the sample R 372-131m the pores are partially filled by oil, giving black color to the rock.

Microscopically, both the matrix and the porphyric minerals seem to be highly silicified. The primary silicified rock was cut by fractures that are filled by subsequently formed, mosaic-textured quartz. In the sample R 372-131m calcite veins and patches occur. The calcite also appears as replacement of amphibole, plagioclase. These calcite areas are connected by fractures, along which the carbonate-bearing solutions could move. In the other samples the amphibole phenocrysts are silicified but pyrite and limonite also occur in them. Fine-grained pyrite rim shows the contour of the euhedral grains.

The most abundant opaque mineral is pyrite. At least three generations of pyrite can be recognized. The first could be the 200-400 microns large, usually cubic, euhedral frequently corroded crystals. The second group is formed by the fine dissemination in the silicified matrix. The following group consists of collomorph, colloidal pyrite clusters and aggregates in association with marcasite *(Pict. 10).* Minor galenite and sphalerite were also identified in form of a few, 50-100microns large, irregular grains in association with pyrite.



Pict. 10 Collomorph pyrite (central part) with marcasite (rim). R 368-103m, intrusive andesite. Reflected light, 1N, 200x

Luzonite and enargite occur in veinlets in form of anhedral grains, their sizes can exceed 1 mm (Pict. 11). The laminar-twinned luzonite is more frequent. They are often rimmed by mosaic-textured quartz. Some luzonite crystals contain euhedral-subhedral pyrite inclusions. Complex sulfosalts containing Pb, Sb, Cu and As were also identified by SEM method.

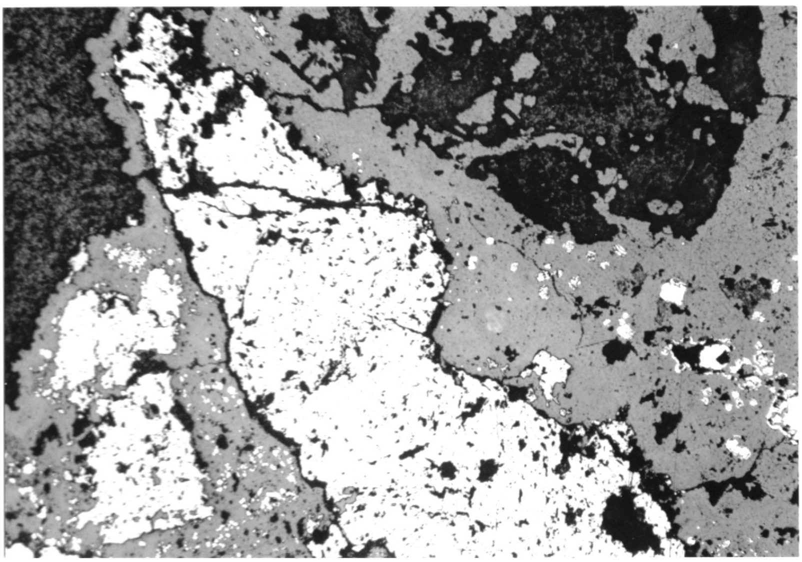
Two samples from this group were examined by XRD method The results are in accordance with the microscopically detected strong silicification. The presence of dickite proves relatively high alteration temperature.

R 368-103m: illite 2%, dickite 23%, quartz 54%, pyrite 21%

R 372-121m: illite/montmorillonite 15%, kaolinite 1 %, quartz 60%, K-feldspar 5%, pyrite 15%, gypsum 1 %

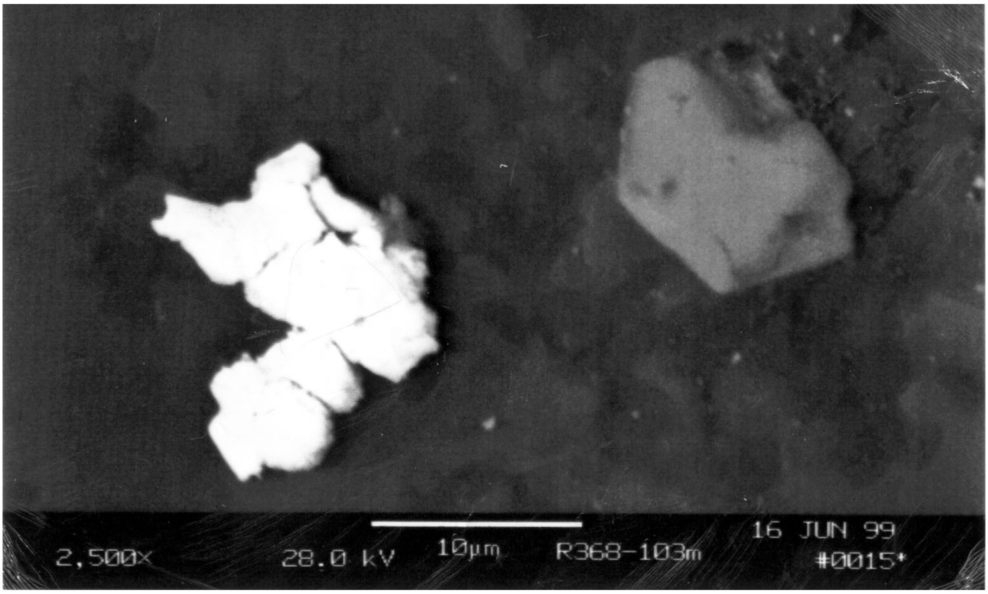
The gold assay results are listed below:

Sample	Au (g/t)
R 368-103m	0.237
R 371-71m	0.320
R 372-121m	0.410
R 372-131m	0.451
R 372-134m	0.734
R 416-110m	0.210

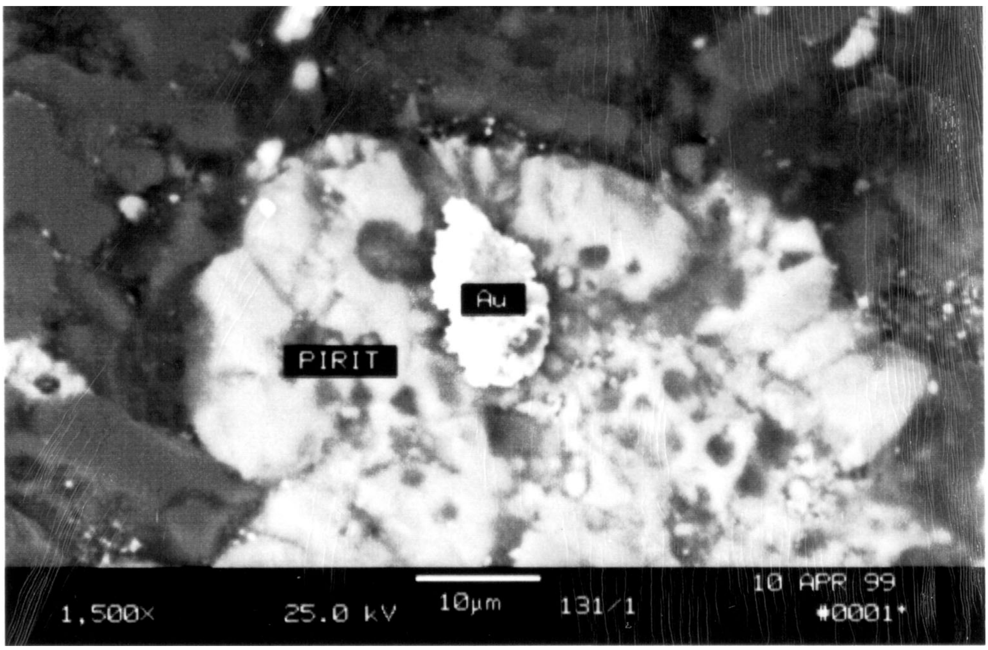


Pict. 11 Enargite vein in pyrite-dusted, silica matrix. R 368-103m, intrusive andesite. Reflected light, 1N, 50x

Gold was found in two samples. In the sample R 368-103m a 15 microns large, aggregate-like native gold grain was detected in the silicified matrix *(Pict. 12).* In the sample R 372-13m several gold grains of 3-10 microns were observed as irregular inclusions in pyrite *(Pict. 13).*



Pict. 12 Native gold (white) and pyrite (grey) in silicified matrix. R 368-103m, intrusive andesite. SEM photo



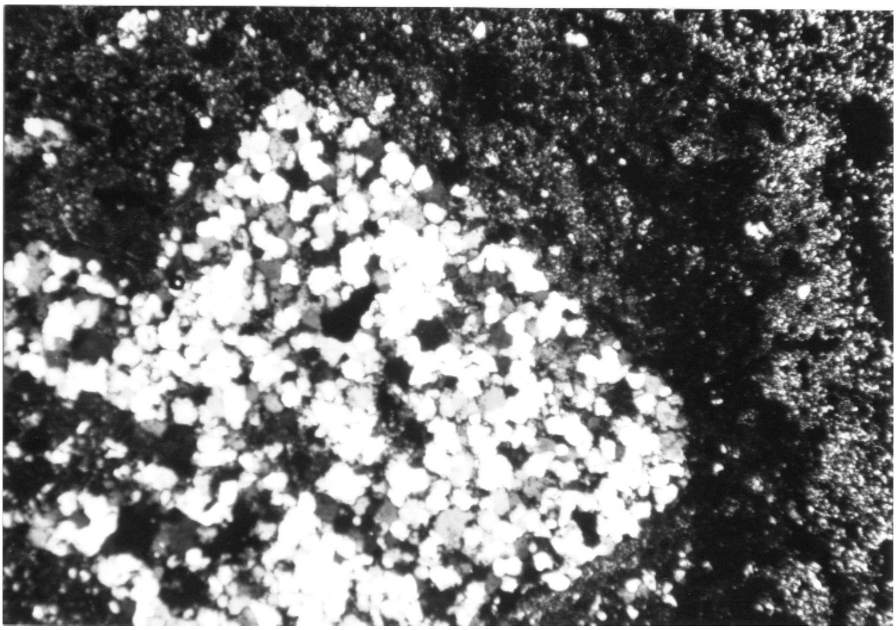
Pict. 13 Native gold inclusion in pyrite. R 372-131m, intrusive andesite. SEM photo

Hydrothermal breccia

This rock type is represented by the following samples: R372-13.5m, R372-16.5m, R362-36m, R372-41m, R372-45.5m, R372-52.5m, R372-58m, R372-62m, R 377-68m, R 377-104m and R 416-262.5m. The breccia is dominantly polymict. The matrix is light to dark grey silica with minor vuggy character.

The white, grey and black fragments are angular or subangular.

Microscopically, the matrix is cryptocrystalline or finely matted, pyrite-dusted quartz. Among the fragments there are differently silicified andesites, silicified fragments of larger porphyric minerals and rarely sedimentary rocks. The most frequent type is the mosaic-textured quartz *(Pict. 14)*. In the less silicified, andesitic fragments the original porphyric minerals are recognizable. The fragment of a layered sedimentary rock can be originated from the basement or the Eocene formations. Many of the fragments as well as the larger pyrite crystals are surrounded by mosaic-textured quartz rim, in which the quartz grains are larger than those in the matrix. Mosaic-textured quartz veins also penetrates silicified fragments. This fact indicates multiply brecciation and silicification.



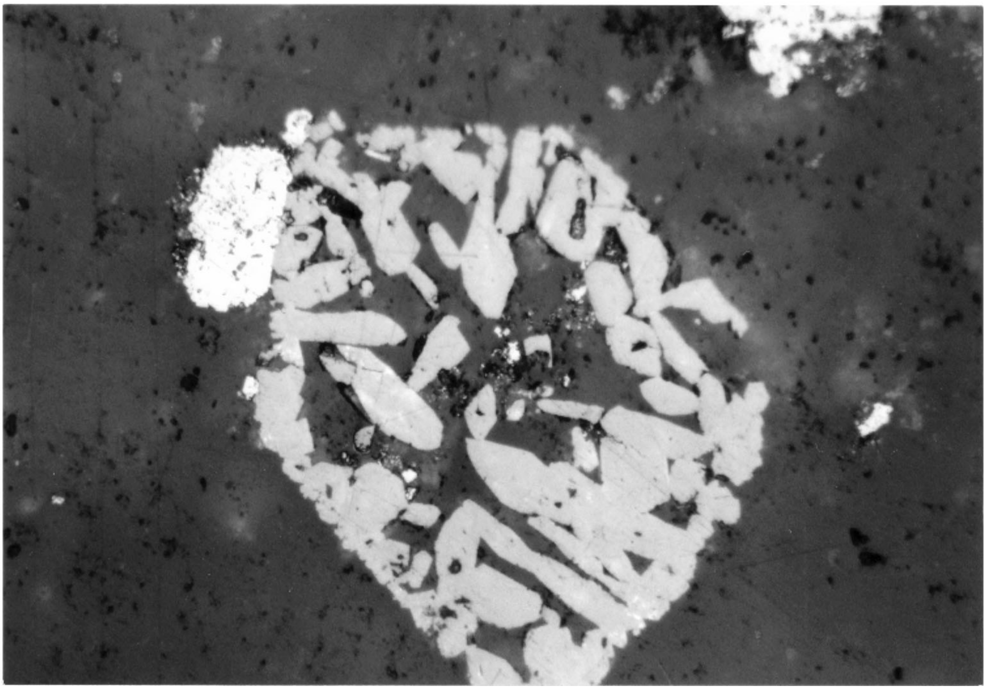
Pict. 14 Mosaic-textured quartz fragment in silicified matrix. R 372-13.5m hydrothermal breccia. Transmitted light, +N, 50x

Pyrite is the most abundant opaque mineral both in the matrix and breccia fragments. The sizes of pyrite crystals range between a few microns to 200 microns. The matrix contains usually more pyrite than the fragments. The larger pyrites occur as often corroded, euhedral (cubic) to anhedral grains and clusters. The contour of the decomposed amphiboles is marked by a pyrite rim. The finer grained pyrite of the matrix often shows orientation indicating the way of fluid flow. Beside pyrite, marcasite also appears.

The XRD data of the sample R 372-16.5m show that the amount of clay minerals is significant:

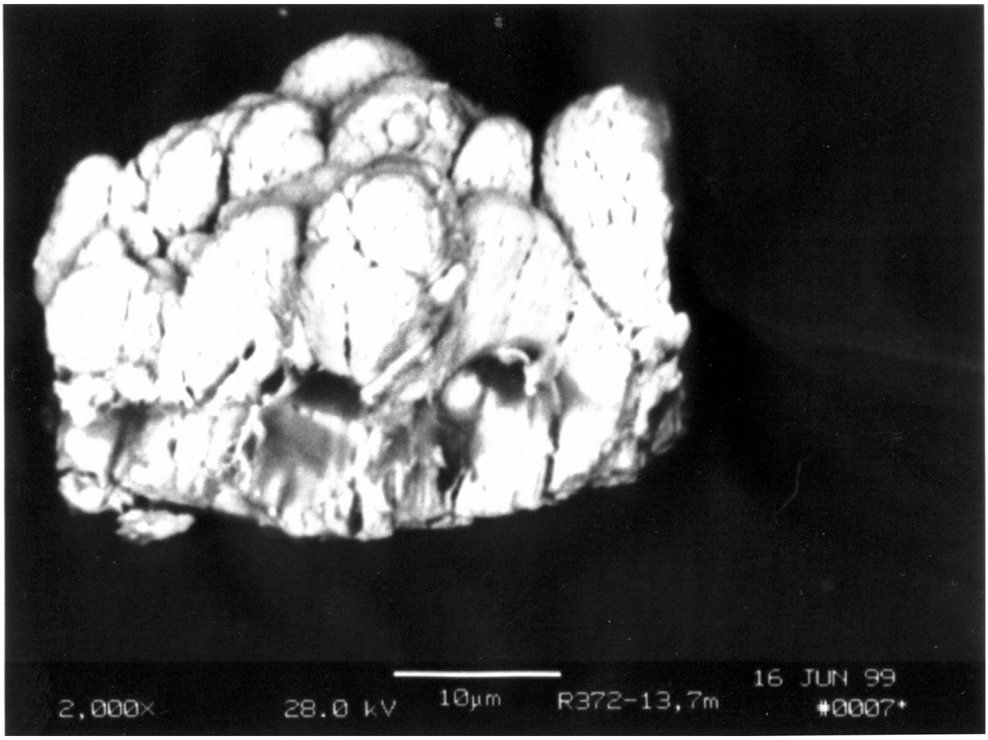
Illite/montmorillonite 19%, kaolinite 9 %, quartz 48%, K-feldspar 8%, pyrite 11%, gypsum 1%, amorphous 4 %.

Rutile is also a relatively frequent mineral. Although a few, 10-20 microns large, subhedral or elongated crystals are also scattered in the silicified matrix, it can be mostly observed as clusters intergrown with submicroscopic-colloidal quartz, in the places of the former rock-forming or accessory minerals, especially ilmenite *(Pict.15).* These clusters are usually overgrown by pyrite or cut by pyrite veins. Sometimes the rutile needles are submicroscopic, and they are visible only by electron microscope. Rutile is usually more abundant in the samples showing higher Au grades. Less amount of enargite and luzonite also appear in form of 50-300 microns subhedral grains or aggregates associated with pyrite.



Pict. 15 Prysmatic and elongated rutile crystals after ilmenite, subhedral pyrite.
R 377-104m, hydrothermal breccia. Reflected light, 1N, 500x

Gold was found in native form of different shape and size. In the sample R 372-35m it is a small, rounded grain in pyrite. In the sample R 372-13.5m a relatively large (30 microns) aggregate-like native gold occured in the silicified matrix *(Pict. 16).* The gold assay results of the samples are the followings:



Pict. 16 Native gold with aggregate-like structure in silicified matrix. R 372-13.5m, hydrothermal breccia. SEM photo.

Sample	Au (g/t)	Sample	Au (g/t)
R 372-13.5m	2.330	R 372-58m	1.550
R 372-16.5m	2.220	R 372-62m	4.9000
R 372-36m	5.130	R 377-68m	1.050
R 372-41m	1.930	R 377-104m	10.900
R 372-45.5m	3.710	R 416-262.5m	0.060
R 372-52.5m	1.860		

Genetic interpretation

The Lahóca gold deposit can be considered as a typical high sulfidation epithermal system. All the host rocks, textures, alterations and the types of ore minerals indicate HS characteristics.

The gold mineralization of Lahóca is related to the third stage volcanics of the Upper Eocene andesitic series. In this stage, the lowermost unit is the andesite porphyry intrusion that has brecciated character in the apical part. It intruded into a stratovolcanic sequence of lava- and pyroclastic rocks. A thick, southerly-dipping breccia overlies the stratovolcanics.

The blueschist covers the breccia body. An overlying andesite unit is above the blueschist. Younger (late) hornblende andesites form plugs, dikes or limited blankets over the breccia (FÖLDESSY, 1997).

The main part of mineralization occurs in the breccia unit. There are evidences for all kinds of breccia genesis (maar-diatreme-, intrusive-, pype breccias). Polimict hydrothermal breccias may have formed both from the stratovolcanic series and the intrusive porphyry andesite (FÖLDESSY, 1997). Multiply brecciation can be proved in several samples. The mineralized, high Au-grade breccia bodies underwent intensive silicification. Argillic alteration dominates in the rock types with low gold content (overlying andesite). Similarly, very low gold content is special in the younger, unaltered late andesite that is free of pyrite.

There is a strong correlation between the amount of pyrite and the gold content in the rocks. Pyrite appears in form of larger, cubic crystals or small, anhederal grains. The higher Au grades are characteristic in the types with colloform pyrite or in those where the pyrite is present as fine dissemination, bands or impregnation. In the breccias, pyrite can be disseminated both in the silicified matrix and the fragments, although its amount is higher in the matrix. Luzonite and enargite appear as anhedral crystals in veins or form clusters. Rutile is a frequent mineral. It probably formed by the decomposition of ilmenite or Ti-bearing amphibole. The rutile content and the Au grades also show correlation.

Gold was found in native form both in pyrite and the silicified matrix. Gold grains in the silica environment are larger (10-40 microns), cloud-like or aggregate-like structures. In the pyrite crystals the gold grains are much smaller (a few to ten microns). In the latter case the native gold can be inclusion in pyrite or overgrows the pyrite at the rim.

Epithermal gold mineralizations are usually in close genetic and spatial relationship with porphyry copper mineralizations. The HS gold mineralization in Lahóca also shows genetic link to the deeper mesothermal copper mineralization. The fractuation caused by the emplacement of the copper-bearing intrusive body and the multiply brecciation in connection with the hydrothermal vapor explosions opened the way for the hydrothermal fluids that deposited the gold into the system.

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