

MAJOR ELEMENTS GEOCHEMISTRY OF THE BREINER BĂIUȚ ORE DEPOSIT (GUTÂI MTS., EASTERN CARPATHIANS)

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ABSTRACT. The Breiner Băiuț epithermal vein – type deposit is basically a base metal ore body with important amounts of gold and silver. The frequency distribution pattern of the major elements (Au, Ag, Pb, Zn, Cu, S) is complex in many cases, but at some mining levels it is lognormal. The correlation coefficient "r" has been calculated for six pairs of major elements. The values are positive and indicate strong correlations between these elements. The average grades values for each major element at all levels have been used to highlight the vertical variation of chemistry of the mineralization. The ore body consists of zones rich in different elements interlayered with poorly mineralized zones.

Key words: epithermal, major elements, distribution, correlation, average grade, vertical variation

INTRODUCTION

The Breiner Băiuț ore deposit belongs to the easternmost metallogenetic field (Băiuț – Văratec – Poiana Botizei) of the Baia Mare region. The epithermal ore deposits of this region are related to the Neogene calc-alkaline magmatism from the Eastern Carpathians. This magmatism resulted after subduction roll-back processes and an almost simultaneous break-off of the descending plate (Seghedi et al., 1998).

The Băiuț – Văratec – Poiana Botizei metallogenetic field is geographically situated in the area of the Pienine Klippes and the Transcarpathian flysch (Pienides after Săndulescu, 1984). The ore deposits are related to the M₃ ore forming event in association with Pontian pyroxene andesites of the V₂ volcanic phase (Borcoș, 1994). Complex geological studies of the Băiuț – Văratec – Poiana Botizei metallogenetic field were performed by Dimitrescu and Bleahu (1955), Bombiță (1972), Borcoș and Gheorghită (1976), Borcoș et al. (1977), Manilici and Kalmar (1992). Other geological aspects concerning the mineralizations were presented by Edelstein et al. (1992), Kovacs et al. (1998), Damian and Costin (1999).

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GEOLOGY

The Breiner Băiuț mining area consists of Paleogene and Neogene sedimentary rocks, Neogene intrusive rocks, hornfels and cataclastic rocks. The Paleogene sedimentary rocks belong to the intermediate level of the Tocila–Secu flysch, which consists mainly of marls interlayered with sandstones. The Neogene sedimentary rocks are represented by conglomerates, sandstones, tufs, marls and clays of Badenian, Sarmatian and Pannonian ages. These rocks are pierced by intrusive bodies, represented mainly by quartz pyroxene microdiorites and pyroxene andesites. The hornfels and the cataclastic rocks occur within the contact areas between the intrusive and the sedimentary rocks. The various types of hornfels present a zonal distribution. The rock fragments from the cataclastic rocks consist of sedimentary and intrusive rocks or only of sedimentary rocks. The intrusive rocks are affected by hydrothermal alterations and occasionally they represent the host rock of the mineralization (Fig. 1).

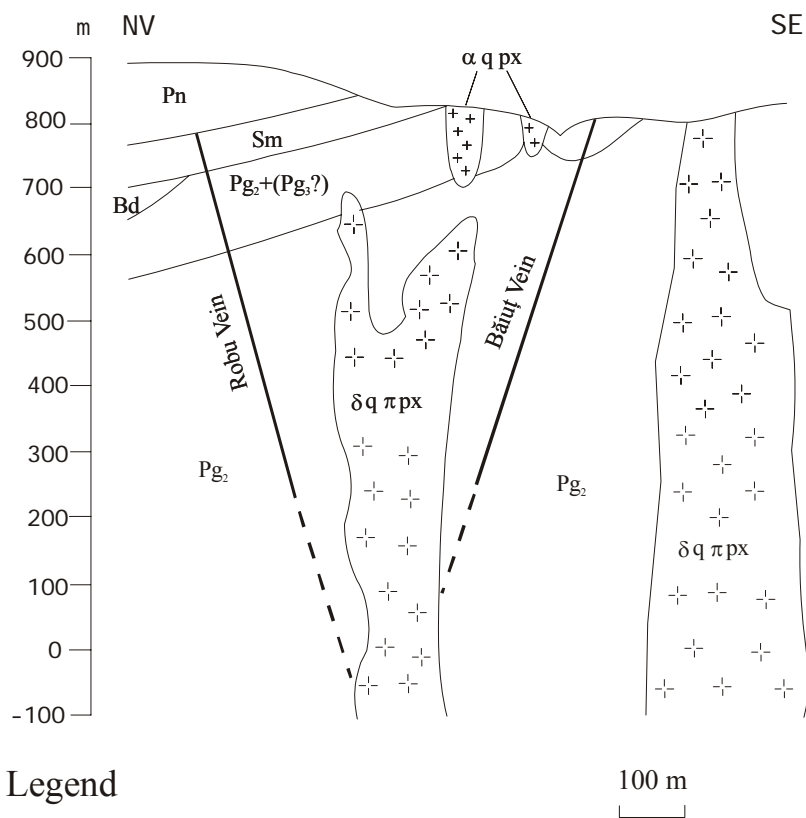
The Paleogene sedimentary rocks form monoclinical series, which strikes NW-SE to E-W and dips 15 to 50°NE. Unconformably overlying this unit there are layers Neogene sedimentary sequences. They strike N30° to 70°E, dip 15° to 45°NW in the case of Badenian and Sarmatian rocks, and 10° to 30°NW respectively in the case of Pannonian rocks. The intrusive bodies are aligned along NE – SW trending faults. These fractures divide the whole region in several blocks without producing any displacements.

ORE VEIN

The Breiner Băiuț ore deposit consists of two main veins – Băiuț and Robu – both having clearcut limits with the host rock. The thicknesses of the veins vary from 0.3 to 2.0m (exceptionally up to 10m). They strike N 70°E, dip 80°NW for Băiuț vein and 80°SE for Robu vein, and extend 1800-2000m length. The distance between the veins is about 450m, while the downward extension of the veins is 300-500m from the surface. The host rocks are represented by Paleogene sedimentary units, Neogene sedimentary units at the upper levels, and rarely by intrusive rocks at depth. The ore veins consist mainly of multiple generations of quartz associated with calcite, dolomite, siderite, sulphates, oxides, silicates, base metal sulfides, gold and silver minerals. The veins are characterized by several textural varieties – brecciated, banded, masive, open vuggy, cockarde. These particular textures are commonly mixed, forming thus complex vein textures. The relative dimensions of the individual minerals vary from large euhedral crystals (few cm long) to much smaller anhedral to subhedral grains (0.1mm). Along the direction of the veins occurs an alternation of thin zones and thick zones of the ore body.

Both veins (Băiuț and Robu) have several branches. For Băiuț vein there are Kelemen, I, II, Ramura 90 branches, striking NNE-SSW and having small lengths. The most important branches of the Robu vein are Ramura Robu, Ramura Robu culcuș, and Ramura IV culcuș. There is also another vein belonging to Breiner Băiuț ore deposit called Realgar vein. This smaller sized vein occurs between the two main veins Băiuț and Robu. The main peculiarity of the Realgar vein is the presence of realgar and orpiment as the most important mineral components.

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Legend

Sedimentary formations

- Pn Pannonian
- Sm Sarmatian
- Bd Badenian
- Pg₂+(Pg₃?) Secu sandstone
- Pg₂ Tocila flysch

Intrusions

- + + + + Quartz pyroxene microdiorite - δ q π px
- + + + + Pyroxene andesite - α q px

Symbol

- Vein

Fig. 1 – Geological cross section through Breiner Băiuț ore deposit (acc. to I.P.E.G. Baia Mare)

MINERALOGY AND PARAGENESIS

The mineralogy of the veins consists mainly of quartz with relatively abundant ore minerals such as pyrite, sphalerite, galena, chalcopryrite and minor amounts of marcasite, arsenopyrite, pyrrotite, stibnite, tetrahedrite, bournonite, jamesonite, and semseyite. Gold and electrum occur as small grains usually within quartz or common sulfides as pyrite, galena, chalcopryrite, and sphalerite. Iron oxides, carbonates, silicates, sulphates are also present. The weathering of the ore caused oxidation of the hypogene mineralization forming supergene minerals like covellite, cerussite, anglesite, goethite, and goslarite.

Four distinct ore deposition stages have been separated taking into account the ore structure and the mineral paragenesis. Pre-ore deposition stage is responsible of a widespread silicification of the host rocks and the formation of adularia and sericite. Stage I of the mineralization consists of reddish-violaceous quartz, iron oxides, and pyrite. This mineral assemblage is concentrated close to the margins of the veins and occurs as bands. Stage II dominates the mineralization and consists mainly of dark-grey quartz and base metal sulfides, and sporadically iron oxides. This stage was deposited after an episode of brecciation as reflected by the brecciated and cockarde textures of the ore. Stage III consists of carbonates, galena, sphalerite and particularly sulphosalts, being the result of a sequential deposition. Stage IV represents the latest event of the hypogene mineralization process. It is characterized by the presence of druse-lined cavities and comb structures. The mineralogy of this stage consists of clear quartz, barite, stibnite and marcasite.

GEOCHEMICAL DATA

The geochemical studies of Breiner Băiuț ore deposit realized by Borcoș et al. (1974)² and Pop et al. (1983)³ presented data on the mineralizations developed between -120 and +120 levels. The geochemical characterization of the upper part (801 and 812 levels) has been done on the basis of the author's observations, and is presented below.

a) Frequency distribution type of major elements

The distribution of the major elements within an ore deposit can be expressed generally by means of normal or lognormal distribution. The type of distribution is certified by the frequency histograms made for each element.

The distribution of several major elements from economic point of view (Au, Ag, Pb, Zn, Cu, S) was checked up for Breiner Băiuț ore deposit. Gold reveals an almost perfect lognormal distribution at -120, -60, +120, and 801 levels. A complex frequency distribution pattern of gold was obtained for the other levels. Silver distribution is lognormal at 801 level and complex for the other levels. At +60, +120, 801, 812 levels, lead distribution is lognormal and it is complex at 0, -60, -120 levels (Figs. 2 – 5).

² Borcoș, M. et al. (1974) – Studiul metalogenetic al regiunii Baia Mare în vederea potențialului ei economic în ceea ce privește minereurile auro-argentifere și neferoase. Zăcămintele Băiuț, Văratec. *Arhiva I.G.R. București*, (unpubl.).

³ Pop, N. et al. (1983) - Studiul geologic complex al mineralizațiilor din perimetrul E. M. Băiuț, Etapa a II-a Breiner Băiuț. *Arhiva S.C. I.C.P.M. S.A. Baia Mare* (unpubl.).

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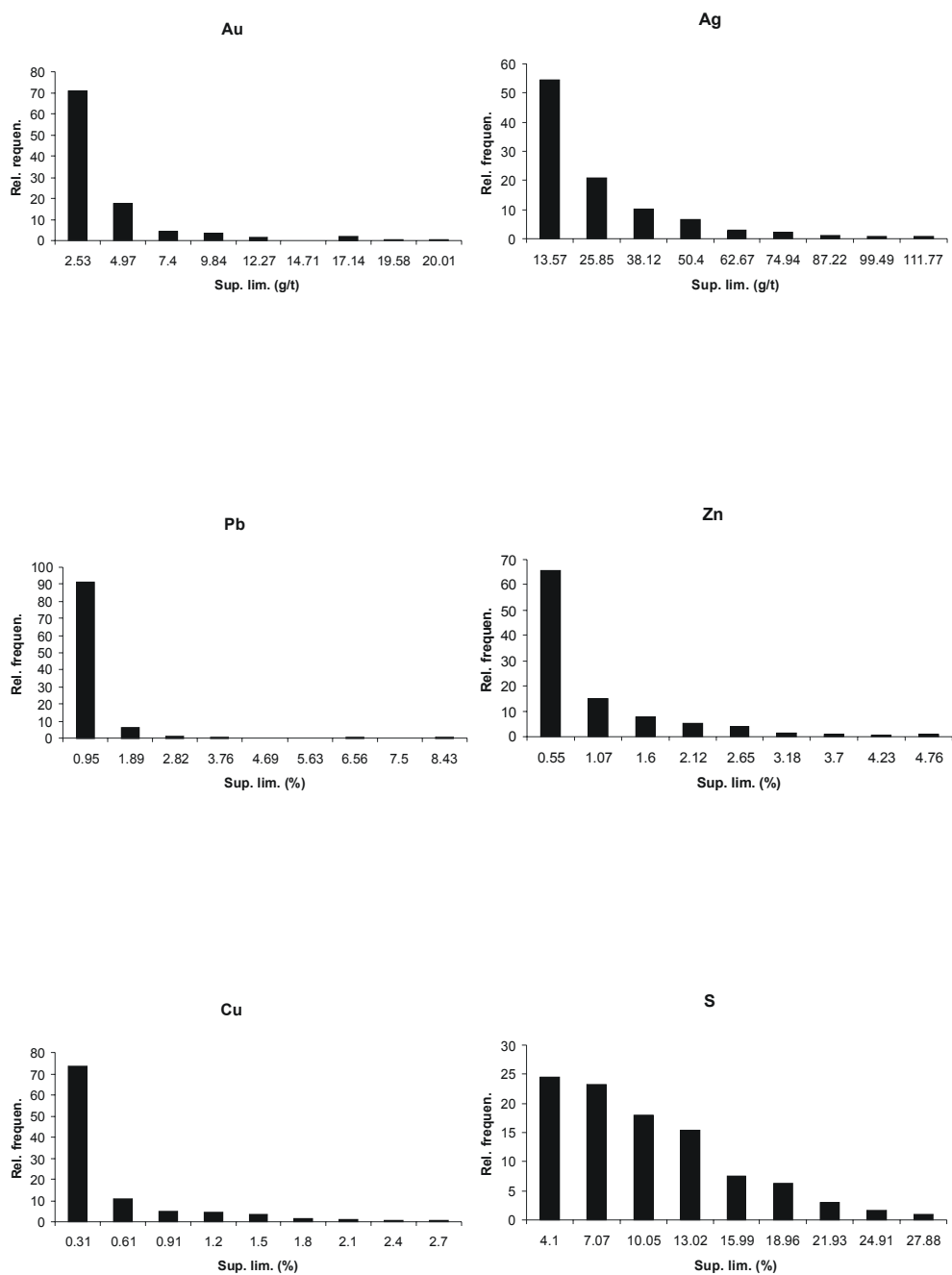


Fig. 2 – Frequency histograms, normal hypothesis, 801 level, Băiuț vein.

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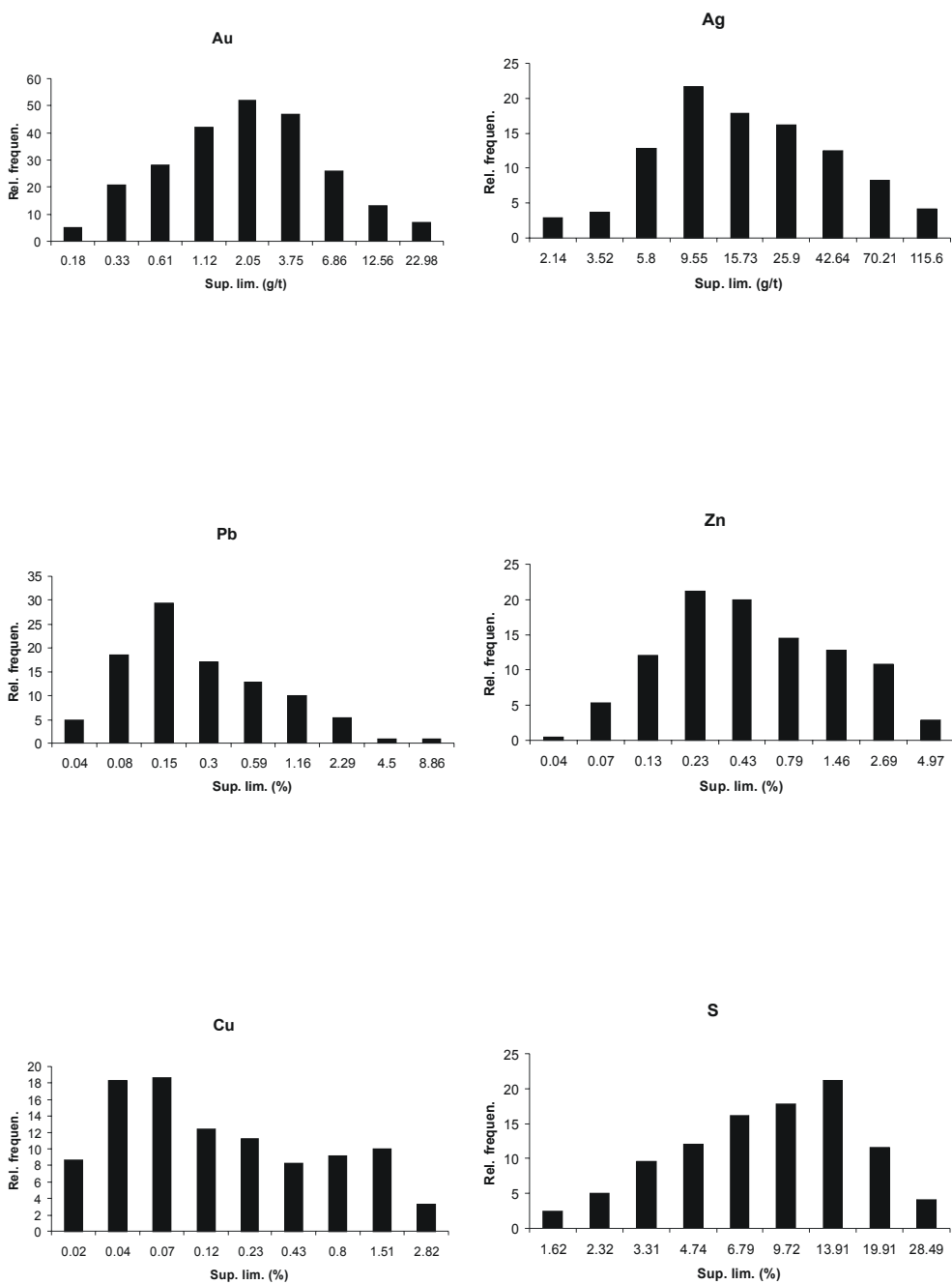


Fig. 3 – Frequency histograms, lognormal hypothesis, 801 level, Băiuț vein.

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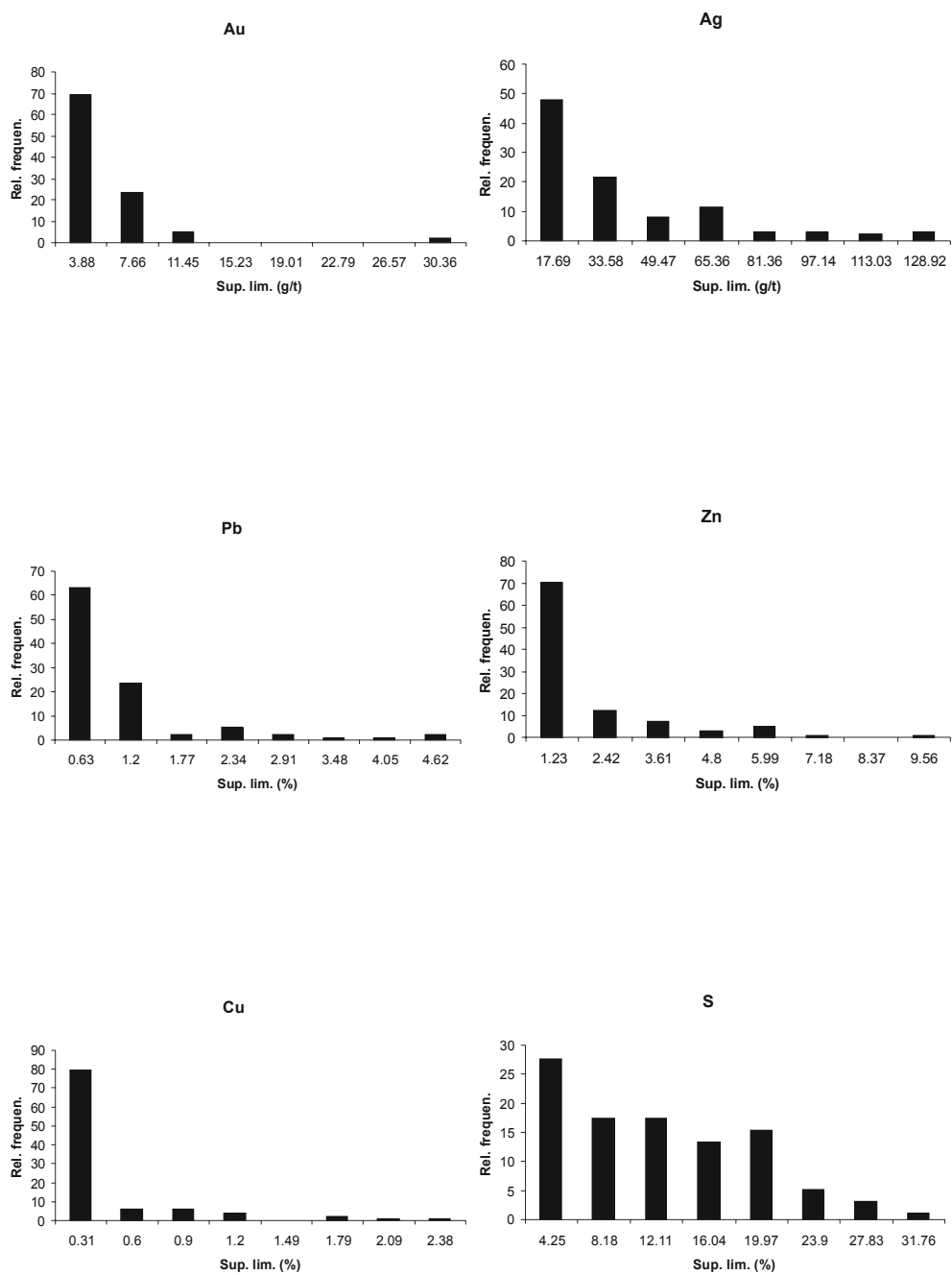


Fig. 4 – Frequency histograms, normal hypothesis, 812 level, Băiuț vein.

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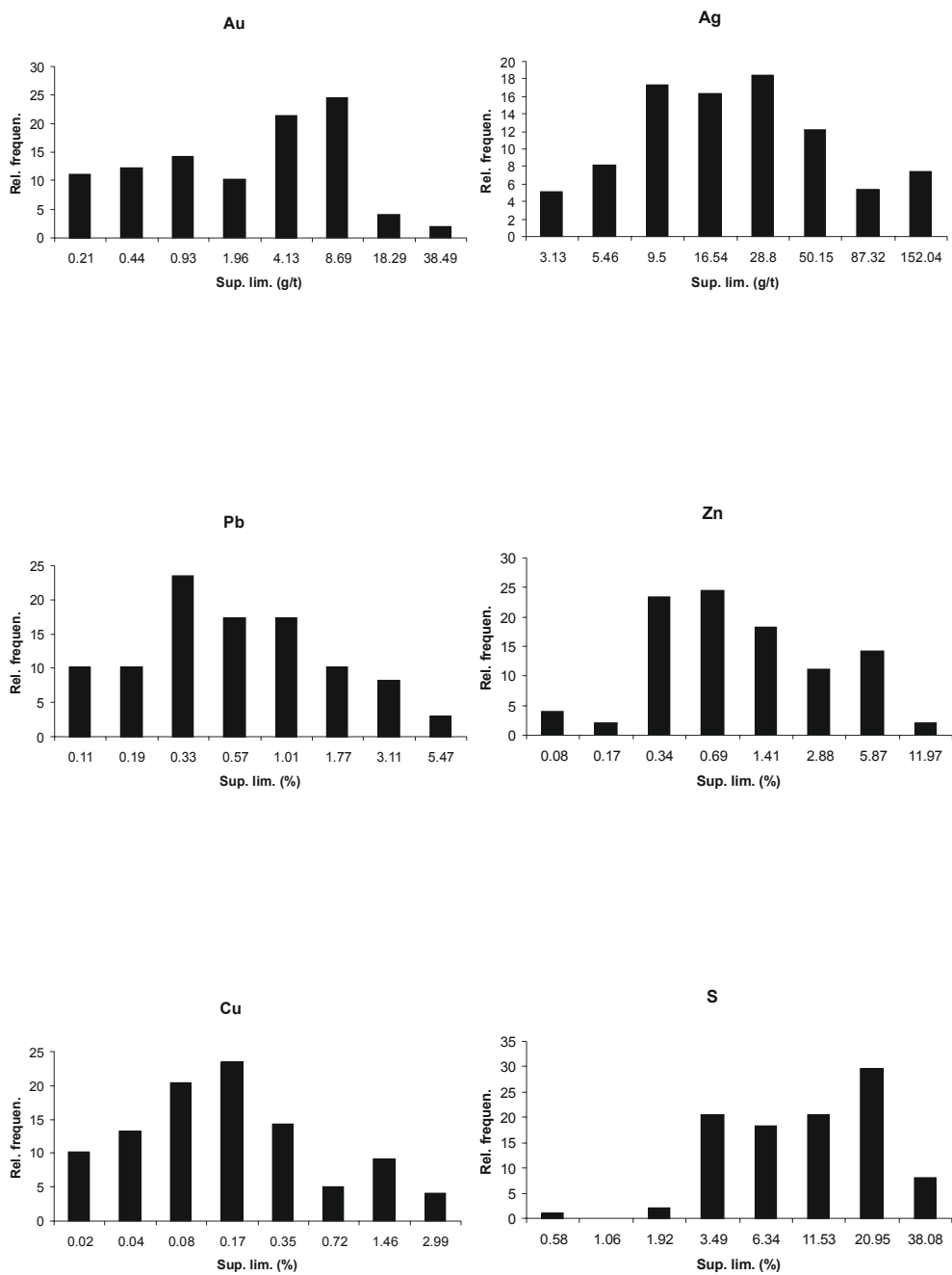


Fig. 5 – Frequency histograms, lognormal hypothesis, 812 level, Băiuț vein.

MAJOR ELEMENTS GEOCHEMISTRY OF THE BREINER BĂIUȚ ORE DEPOSIT

Zinc presents a lognormal distribution at +60, +120, 801 levels. It has a different distribution in comparison with normal or lognormal distributions at the other levels. Copper distribution is very close to the lognormal type at +60, +120, 801 levels, while for the other levels it is complex. Only one major element presents a normal distribution – sulphur - at +60 level. In the case of –120, +120, and 801 levels, the frequency distribution of the sulphur is generally lognormal, while for –60, 0, and 812 levels it is complex.

The frequency data for all major elements (Au, Ag, Pb, Zn, Cu, S) show that the distribution is generally complex, pleading for a heterogeneous mineralization process. This heterogeneity is confirmed also by the macroscopic studies, which reveal an alternation of the massive ore zones ore with impregnations. The lognormal distribution of the major elements at some levels signifies that these elements are attached to a single mineral species or one paragenetic sequence. The normal distribution suggests a relatively uniform dispersion of the element in more mineral species or more paragenetic sequences.

b) Correlations between major elements

The study of the correlations between major elements in an ore deposit provides important evidence in order to establish the conditions of its formation. The best way to characterize the correlations is the calculation of the correlation coefficient "r". For Breiner Băiuț ore deposit, six correlation coefficients between pairs of major elements have been calculated (Table 1).

Table 1

The correlation coefficient "r" between pairs of major elements
from Breiner Băiuț ore deposit

Level \ r	Au-Ag	Au-Cu	Au-S	Ag-Cu	Pb-Zn	Cu-S
812	0.66	0.48	0.54	0.75	0.63	0.57
801	0.50	0.46	0.49	0.77	0.45	0.52
+120	0.61	0.54	0.51	0.68	0.54	0.54
+60	0.49	0.44	0.56	0.62	0.39	0.56
0	0.65	0.25	0.40	0.38	0.54	0.31
-60	0.41	0.28	0.40	0.66	0.50	0.52
-120	0.33	0.28	0.11	0.64	0.86	0.42

Gold correlates positively and significantly with silver at 0, +60, +120, 801, 812 levels, the correlation intensity decreasing at –60, -120 levels. Gold correlates significantly also with copper at +120 and 812 levels, towards depth this correlation becoming weaker. The correlation between gold and sulphur has a decreasing trend from the upper to the lower levels, with an exception at +60 level. This fact suggests that gold is associated with pyrite at upper levels and with other sulfides or quartz at lower levels.

Silver correlates positively with copper at all levels, excepting 0 level. This means that silver is related with a copper mineral, which in agreement with the microscopic studies could be tetrahedrite. Lead – zinc correlation is strong, the values of "r" coefficient is increasing with depth. The lead and zinc sulfides were

deposited from the same hydrothermal solutions in similar conditions. Copper correlates directly and strongly with sulphur, indicating the presence of a copper rich stage in the mineralizing process. The ore bearing fluids responsible for the deposition of this stage had a high copper content and were depleted in the other major elements.

c) Vertical variation of the chemistry mineralization

The features of the vertical variation of the ore chemistry could be pointed out by calculating the average grades for major elements. These average grades have been calculated for each level of the Breiner Băiuț ore deposit (Table 2).

The gold average grade variations indicate the existence of a poor zone between 0 and -60 levels. The gold-rich zones occur at the uppermost level (812) and to the lower levels (-120), too. The silver average grades for different levels of the mine show a similar variation as gold. However, the maximum silver average grades have been noticed at +60 level.

Table 2

Average grades of major elements from Breiner Băiuț ore deposit

Level \ Element	Au (%)	Ag (%)	Pb (%)	Zn (%)	Cu (%)	S (%)
812	3.32	29.36	0.73	1.33	0.27	10.29
801	2.60	20.06	0.38	0.66	0.30	8.62
+120	2.25	19.83	0.29	0.58	0.36	7.64
+60	2.06	42.32	0.17	0.49	1.04	8.89
0	0.47	22.32	1.44	0.89	0.90	5.05
-60	0.67	17.90	0.19	0.24	0.38	4.14
-120	3.19	27.27	0.34	0.92	0.39	4.77

A sinusoidal variation of the average grades for lead and zinc was pointed out: two depleted zones at -60 and respectively +60 levels, one relatively rich zone at 0 level, and two rich zones in the upper and respectively lower parts of the ore deposit. Copper is prevalent concentrated between 0 and +60 levels. Two copper-low grade zones corresponding to upper and lower levels are also delineated. Sulphur average grades present a general decreasing trend from the upper levels towards the lower levels, with little variation at +60 and -120 levels.

CONCLUSIONS

The Breiner Băiuț ore deposit is a gold-silver bearing base metal vein-type epithermal systems from Baia Mare region. The frequency distribution of the major elements (Au, Ag, Pb, Zn, Cu, S) is generally complex and proved the heterogeneity of the mineralization. At some levels, the distributions are lognormal suggesting that the major elements are associated with one single mineral phase or with one paragenetic sequence. The analysis of the correlation between major elements plays an important role in studying the ore-forming processes. Gold is associated with pyrite at the upper levels and with other sulfides or quartz at lower levels. Silver is

present in a copper mineral, probably tetrahedrite. The lead and zinc sulfides were deposited in similar conditions. Among the ore deposition stages, a particular one with high-Cu content could be inferred.

The major elements average grades variation indicates the presence of a depleted zone at –60 level, which spreads upward towards 0 level in the case of gold and silver. The richest zone (ore shoot) including the higher grades for all elements is clearly developed towards the upper levels situated above the poor zone (0 level). Only the average grades for copper do not fit to this rule. In this case the copper contents show a slightly decreasing trend above +120 level. Beneath the depleted zone restricted between 0 and –60 levels, gold, silver and zinc show an increasing trend of average grades. The emphasis put on this vertical variation is important for the strategy of the underground exploitation of the ore body.

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