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The Căpâlnaş-Vorţa-Nevoiaş (Pb-Zn-Cu) metallogenetic district from the Banatitic Province, Romania

Haralambie SAVU*

Geological Institute of Romania, 1 Caransebeş St., RO. 012271, Bucharest

Abstract: The Căpâlnaş-Vorţa-Nevoiaş metallogenetic district is superposed over the northern part of the Lăpugiu Basin Banatitic volcanics. Its mineralizations belong to the Pb-Zn-Cu–type. They are located along some E-W trending fractures. Along the fractures the host ophiolitic and island arc volcanics from the basement have been strongly affected by the hydrothermal solutions, released by some Banatitic plutonic intrusions from the depth of the district. It is argued that the tectonic movement on the faults was active during the emplacement of the mineralization, causing the occurrence of broken pyrite crystals cemented by chalcopyrite.

Keywords: Metallogenetic district; occurrences; mineral assemblages; chemistry; origin.

1 Introduction

The Banatitic metallogenetic province extends from Romania through Serbia to the southeastern part of Bulgaria, accompanying the Banatitic magmatic province, described by Cotta (1861), Giuşcă et al. (1965; 1966) and Ciobanu et al. (2002). On the territory of Romania, it includes several metallogenetic districts. The Căpâlnaş-Vorţa-Nevoiaş metallogenetic district extends along the Mureş River, so that it could be called the Mureş district, as well. It is located within the boundaries of the Banatitic Metallogenetic Province (Fig. 1). This district is characterized by a Pb-Zn-Cu mineralization, which will be described below. The data presented here support the fault-related genesis of the mineralization from Vorţa district and argue for its emplacement while the tectonic movements were still active.

2 Geological structure of the district and its related magmatic rocks

As the mineralizations from this metallogenetic district are related to the Laramian (Banatitic) magmatic rocks, which erupted by the end of the Upper Cretaceous, they affected the geological formations from the southern part of the Mureş ophiolitic suture (Savu, 2007). In the structure of the district, there are two structural levels: an infrastructure (basement) and a superstructure. The oldest host rocks from the infrastructure are the Jurassic ophiolitic rocks, covered by Late Kimmerian (Upper Jurassic) island arc volcanics. The ophiolites are represented by tholeiitic basalts, anamesites and dolerites, rocks with a MORB signature, and layers of red jaspers and limestones. These rocks make a pile of magmatic and sedimentary formations, intruded by layered small bodies of gabbro and ultramafic rocks.

The Upper Jurassic island arc volcanics consist of calc-alkaline basalts, andesites and acid rocks (dacites and rhyolites). These rocks are associated with red jaspers and argillites, Stramberg limestones and rare sandstones. The Stramberg (Upper Jurassic) limestones form a sort of reef barrier. The remnants of this reef barrier extend from Căpâlnaş, in the west, through Zam, to Vălişoara, in the east. According to Kadič (1906) and Papiu (1954) the reef limestones was formed during the Dogger. Neocomian sedimentary formations occur mostly in the eastern part of the district, where they are represented by the marly-argillaceous

*For correspondence, contact the editor

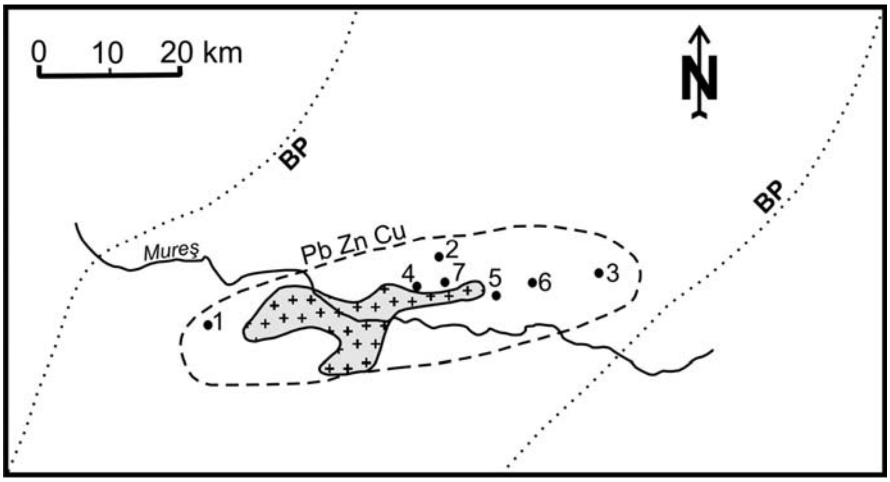

Fig. 1. Sketch map showing the position of the metallogenetic district within the median segment of the Banatitic Metallogenetic Province and the distribution of the Pb-Zn-Cu mineralizations. Compiled after the Metallogenetic Map of Romania scale 1:1,000,000 (1969) and the Tectonic Map of Romania scale 1:1,000,000 (1970), with the author's additions. BP, boundary of the Banatitic Metallogenetic Province; Pb-Zn-Cu broken line marks the boundary of the metallogenetic district; occurrences of Pb-Zn-Cu mineralization: 1, Căpâlnaş; 2, Vorţa; 3, Nevoiaş; 4, Vlădeşti; 5, North Târnava; 6, Sulighet; 7, Valea Mare; +, Banatitic volcanics.

deposits mentioned above; manganese accumulations and red jaspers are associated with the Neocomian sedimentary and were designated as a manganese metallogenetic district on the Metallogenetic Map of Romania, scale 1:1,000,000 (1969). These formations are covered by Cenomanian and Senonian deposits, which support the Laramian volcanics from the superstructure.

The Early Laramian tectonics of the region is represented by one ESE-dipping reverse fault, which extends from Groşi and Tisa to the Gurasada Brook. This fault was also indicated by the geophysical research, as a gravimetric axis (Andrei and Cristescu, 1966). Along this fault, the anchimetamorphic Groşi Formation is thrust over the Mureş ophiolitic suture. It is covered by the Upper Cretaceous Banatitic volcanics. This fault was cut by a north-south trending fault, which brought in tectonic contact the Laramian volcanics with the Neocomian sedimentary deposits along the Visca-Gurasada meridian. This north-south trending fault should be post-Laramian. The Laramian faults are represented by the Căpâlnaş-Zam-Vorţa fault, trending almost E-W with northerly dip, and several associated shorter faults (Savu et al., 1992), resulting in an *en échelon*-like fault system. The superstructure consists of the Laramian (Banatitic) volcanic rocks from the Lăpugiu Basin, to which the Pb-Zn-Cu mineralizations of the CVN district are related. The Laramian magmatic rocks are represented by volcanics, mostly pyroclastics (Savu, 2011). Pyroclastics of andesites and trachyandesites dominate, with rare basalts and basaltic andesites, as more basic rocks, and dacites, trachydacites and even trachytes, as leucocratic rocks (Fig. 2). The initial area of the Laramian volcanics must have been larger than the actual one, probably covering the entire surface of the metallogenetic district, but it was extensively eroded. The radiometric ages of these rocks vary between 60 Ma, Rb/Sr (Herz et al., 1974) and 70 Ma, K/Ar (Savu et al., 1992).

3 Characteristics of the Pb-Zn-Cu mineralization

The Pb-Zn-Cu mineralized zones (Fig. 1) occur within the metallogenetic district under three circumstances: (1) as isolated skarn-type occurrence like that of Căpâlnaş, (2) as lenses situated along a fault, like that of Vorţa and (3) as small occurrences dispersed within the Aptian-Cenomanian sedimentary formations.

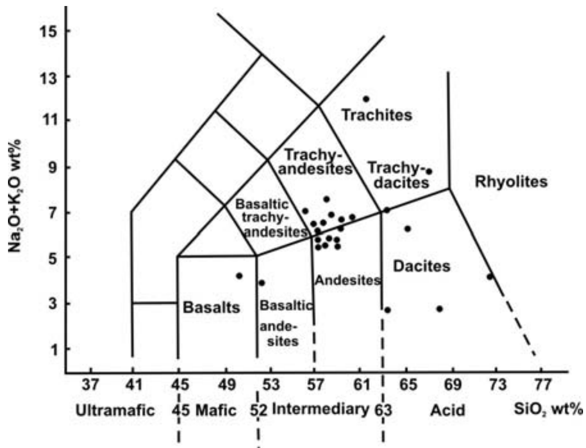

Fig. 2. Plot of the Banatitic volcanics from the Lăpugiu Basin on the $Na_2O + K_2O$ vs. SiO_2 diagram. Trends according to Le Bas et al (1986). Data from Savu et al. (1992).

3.1 Căpâlnaş-type mineralization

The mineralized zone occurs at the springs of Pârâul Plumbului (Lead Creek), a tributary of the Căpâlnaş Brook. This occurrence is situated at a small distance west of the western margin of the Banatitic volcanic area, south of the Căpâlnaş Village. The host rocks are represented by arkosian sandstones and marbly limestones intercalated in the Lower Jurassic tholeiitic basalt flows, and Upper Jurassic limestones, which are crosscut by dykes of porphyries with violet quartz phenocrysts, which generated small scale contact metamorphism of the limestones and a low-grade mineralization of galena and sphalerite.

In a small mine ditch, it can be seen that the marbly limestones are associated with brown-yellowish grossular-andradite and greenish grossular-epidote skarn veins (Savu, 1966). All the garnets show a zonal structure. The limestones are white or grey and, under the microscope, show a saccharoidal texture, rarely a porphyroblastic texture. The limestones underwent an intense fracturing and even brecciation. This permitted the circulation of the hydrothermal solutions, which partly substituted the limestone and created a network of metasomatic skarn veins, up to 10 cm thick. The mineralization is represented by a vein up to 5 cm thick. It consists mostly of galena and sphalerite, with rare crystals of chalcopyrite and pyrite. Although the mineralization does not represent any economic importance, the occurrence is interesting as regards the genesis of the infiltration skarns.

3.2 Vorţa-type mineralization

As it was mentioned above, at the beginning of the Laramian tectonic movements within the CVN district, an ENE-WSW trending crustal fault system was active (Andrei and Cristescu, 1966; Savu et al., 1992). Along these fractures, the Laramian volcanic rocks from Lăpugiu Basin erupted and the Pb-Zn-Cu sulfides were deposited, such as, for instance, those from the Heiuş Creek and Băii Creek, near the Vorţa village. The latter is the most characteristic mineralization of the district and is better known due to the fact that it was explored by the Certej and Deva Mining Companies and exploited by the Deva Mining Company for a long period before 1990. Deva Mining Company produced numerous assay data on the mineralization at Vorţa, some of these data being made available to the author of this study. Therefore, this mineralization will be presented here in more detail.

The ore at Vorţa exhibits a massive structure, sometimes with porphyritic texture determined by large xenomorphic crystals of chalcopyrite and sphalerite. The characteristic mineral assemblage from Vorţa ore is made up of pyrite, galena, sphalerite and chalcopyrite ± bornite ± covellite, minerals deposited approximately in this succession. Chalcopyrite usually occurs as grains with irregular margins, which may reach up to 1.5 cm in size. Chalcopyrite hosts pyrite and sometimes sphalerite and galena. Thin veins of sphalerite and galena cross the large crystals of chalcopyrite. Bornite and covellite are partly substituting the chalcopyrite crystals. Bornite occurs in crystals with irregular shape, which are located at the margin of the chalcopyrite grains.

Galena forms xenomorphic grains, which can include other minerals from the sulfide assemblage. Sometimes, sphalerite, shows very weak pleochroism and anisothropy. Broken crystals of sphalerite are seldom present in the Vorţa mineralization.

The chemical composition of the Vorţa ore, determined on numerous assays by the Deva Mining Society, shows that it is rich in Zn, which prevails over Pb and Cu (Fig. 3). Among these metals, Cu presents the lowest contents. A positive correlation between Zn and Pb is obvious (Savu and Nicolae, 1975b). Tămaş-Bădescu (2010) showed that beside these major elements, the Vorţa sulphide ore contains up to 0.38 g/t gold.

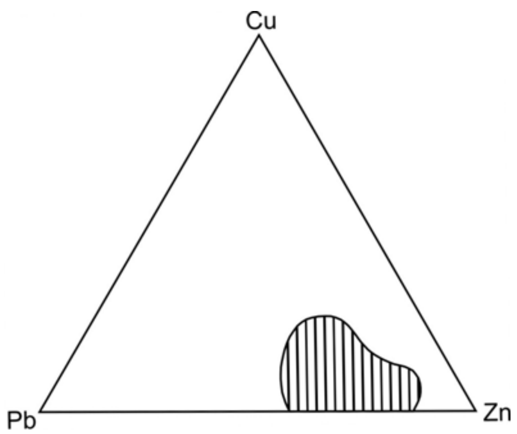

Fig. 3. Plot of 55 samples of mineralization from the Vorţa mine on the Cu-Pb-Zn diagram. Data from the archives of Deva Mining Society.

3.3 Nevoiaş-type mineralization

As Ghiţulescu and Socolescu (1941) showed on their map, in the eastern extension of the Banatitic volcanics from the northern part of the Lăpugiu Basin and north of Mureş, there are four ore fields situated along an E-W alignment, which could also be related to a fracture, parallel to the one on which the Vorţa mineralization is located. As shown in Fig. 1, this alignment extends between Vlădeşti (4), Nedeli Summit (5, north of Târnava), Sulighet (6) and Nevoiaş (3). On the map made by Ghiţulescu and Socolescu (1941), all these mineralized zones are located in the Cretaceous sedimentary deposits, the youngest succession of which belongs to the Senonian. The Nevoiaş mineralization (3) is the most important among these occurrences and is represented by short and thin veins, without any economic importance. West of Valea Mare Village (7), south of Vorţa (2), the author found blocks of sulfide ore dispersed in the dump heap of a small prospecting shaft dug in the Cretaceous formations near a small creek.

All these occurrences show Pb-Zn-Cu mineralization and have been attached by Ghiţulescu and Socolescu (1941) to the Neogene mineralizations from the Metaliferi Mountains. Nevertheless, since this mineralization alignment is E-W oriented, it is not conformable to the NW-SE trending alignments of Neogene volcanics and mineralizations from the Metaliferi Mountains. Therefore, they should be considered as related to the Laramian (Banatitic) volcanism, which would be consistent with their spatial association with the Banatitic rocks. The Vlădeşti mineralization, for instance, is located in the Banatitic volcanic field but Ghiţulescu and Socolescu (1941) considered they are associated with Neogene volcanics.

4 Discussions

The first information about the mineralized zones in the CVN district occurred on the geological map published by Ghiţulescu and Socolescu (1941), followed by the unpublished reports by Cioflica et al. (1957) and Teodoru et al. (1964). According to Ghiţulescu and Socolescu (1941), the hydrothermal mineralization at Vorţa is Neogene, i.e. it has the same age as the volcanic rocks in the Lăpugiu Basin, an idea shared by Cioflica et al. (1957), and Teodoru et al. (1964). Borcoş and Stanciu (1968) considered the hydrothermal mineralizations from the region as related to the Neogene volcanism from the Metaliferi Mountains. This idea cannot be supported because the Neogene volcanism manifested itself along NW-SE faults whereas the mineralizations from the CVN district occurred on an almost E-W fault system.

Among the numerous opinions on the genesis of Vorţa mineralization two concepts are to be remarked – the discordant hydrothermal model and the Kuroko stratiform deposition model. Savu and Nicolae (1975) showed that the Vorţa hydrothermal mineralization was deposited along an E-W vertical fracture and was affected by shearing. Udubaşa et al. (1978) considered that Vorţa mineralization can be of Kuroko-type. However, in a subsequent paper (Udubaşa and Gaftoi, 1986), this character was considered as uncertain.

Cioflica et al. (1984) observed that, between Vorţa and Furcşoara, zones mineralized with sphalerite, chalcopyrite, and pyrite occurred, which were strongly brecciated and altered. Cioflica et al. (1985) showed that a belt of hydrothermal alterations extends between Vorţa and Furcşoara, which generated low-grade zeolite deposits. As it results from their sketch map, the hydrothermal solutions circulated along an *en échelon* fault system. Popescu et al (1997), referring to the papers by Udubaşa, considered that the Vorţa mineralizations have a Kuroko metallogenetic character and have been affected by a burial metamorphism, a conclusion that is in disagreement with the location of the mineralization along a vertical fault, discordant on the structures of the basement. Vlad and Tămaş (1998) associated its formation with an Early Cretaceous magmatism, which would have produced granitoid intrusions. Mârza (1999), referring to the published data on the Vorţa mineralization, supposed that they are rather related to the Banatitic (Late Cretaceous) magmatism. The idea of Kuroko-type mineralization at Vorţa was adopted by Ciobanu et al. (2001), who asserted that the mineralization was generated in submarine conditions, as a syngenetic and stratiform ore formation at a sea mountain with alkali basalt flows. Nevertheless, in the Vorţa-Dealul Mare area there are no seamount remnants or any alkali basalts, thus the mineralization at Vorţa is not of Kuroko-type, being discordant relative to the structures of the basement, although it has been generated by hydrothermal solutions probably released from Banatitic intrusions or from volcanic chambers at the end of the Laramian volcanism. The fault-related genesis of the mineralization from Vorţa district is also supported by Vlad and Tămaş (1998).

Two explanations were proposed with regard to the deformations which affected the mineralization: shearing (tectonic) deformation and burial metamorphism. The burial metamorphism concept was presented first by Şeclăman (oral communication), but no minerals characteristic for such a metamorphism-type could be found in the region. Moreover, considering both the mineralization-type and ore deformation, the burial metamorphism is not consistent with the geological relations observed in the field and this can be argued based on several features of the ore and of the country rocks that could be remarked in the adits of Vorţa mine and at the microscope.

Based on the evidence produced by Savu and Nicolae (1975a, b) and more recent observations (Savu, 2007) it is obvious that the Vorţa mineralization has a structural control, being located along the mentioned E-W trending fracture, which extends from the northern Banat, through Căpâlnaş and Zam to Vorţa and cuts the Upper Jurassic–Lower Cretaceous island arc volcanics from the basement of the Mureş ophiolitic suture. These volcanics are lying over the ophiolitic rocks of MORB-type. They are represented mostly by pyroclastics of basaltic andesites, hornblende–pyroxene–andesites and quartz-andesites, oligophyres and dacites (see the map by Savu and Nicolae, 1975a).

Within the Vorţa area four alteration and mineralization zones occur, related to the E-W fracture system. The hydrothermal solutions passing through this fracture zone affected both andesite pyroclastics and the dacitic rocks. The most important zone, which is 50 to 200 m wide, extends eastward from the Cărmăzineşti Valley, by the Heiuş Creek, to the Băii Creek. The mineralization, consisting of galena, sphalerite, pyrite and chalcopyrite was deposited along the median zone of the subvertical fracture. Along this zone, all the minerals from the volcanic rocks were transformed into secondary minerals. In the andesitic rocks, the plagioclase crystals have been strongly argillized and the mafic minerals have been substituted by chlorite,

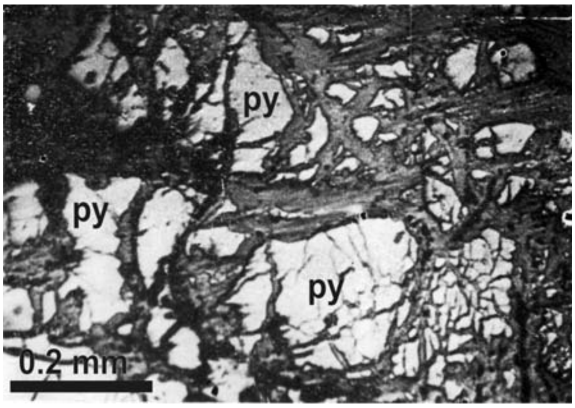

Fig. 4. Broken crystal of pyrite the fragments of which are cemented by chalcopyrite. Vorţa mine.

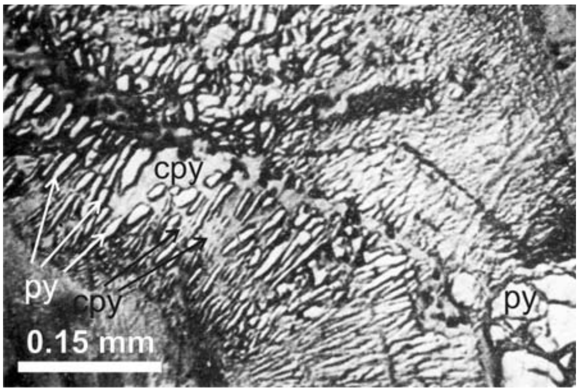

Fig. 5. Elongated fragments of a broken cryslal of pyrite cemented by chalcopyrite. Vorţa mine.

sometimes associated with epidote. The altered rocks are impregnated with sulphides associated with quartz, calcite and zeolite. The latter mineral is widespread in the region (Cioflica et al., 1985). The dacites from the Homorod Hill have been strongly affected by the hydrothermal solutions, being impregnated with pyrite crystals. Locally, the rocks have been completely transformed into kaolinite with quartz relics. Along the fracture that supposedly served as main passageway for the hydrothermal fluids, the andesites were intensely silicified.

The fracture hosting the mineralization kept being tectonically active after the formation of the sulphide ore, causing the shearing of the mineralization to small lenses or boudins (see Fig. 2 in Savu and Nicolae, 1975a).

In the hydrothermalized host rocks, not affected by the shearing, pyrite occurs in euhedral (cubic) crystals, sometimes with irregular margins. In the ore, the pyrite is included in chalcopyrite, in galena and sphalerite. Broken crystals of pyrite often occur as inclusions in chalcopyrite. These probably were produced by the tectonic movement along the fracture on which the mineralization was deposited. The breaking of the pyrite crystals took place under two conditions: (1) when the strain was not very strong, the fragments of the broken pyrite crystals kept a rugged shape (Fig. 4); (2) at more intense efforts, the resulting pyrite fragments got an elongated shape (Fig. 5). In both cases, the pyrite fragments have been cemented by the malleable chalcopyrite. The *Kataklase* phenomenon presented by Ramdohr (1960) represents, in fact, the incipient stage of this process of pyrite breaking.

5 Summary and conclusions

The Căpâlnaş-Vorţa-Nevoiaş metallogenetic district is superposed over the northern part of the Lăpugiu Basin Banatitic volcanics. All the mineralized zones of the district consist of the Pb-Zn-Cu assemblage. Although the mineralization occurrences from the district may give the appearance of scattered distribution, they are located on E-W trending Laramian fractures, a good example in this respect being the Vorţa mineralization. The movements along these faults were effective during and after the sulfide deposition, thus causing the breaking of the crystals of the brittle pyrite, cemented by the ductile chalcopyrite. Along the fractures involved in the genesis of the mineralization, the basement ophiolitic and island arc volcanics have been strongly altered by the hydrothermal solutions of mesothermal nature. It seems that in the depth of the district plutonic intrusions of Banatitic acid rocks were emplaced, the apophyses of which are the dacitic bodies occurring around the mineralized areas at Vorţa. More probably, these intrusions released the hydrothermal solutions that precipitated the Pb-Zn-Cu mineralization.

References

Andrei, J., Cristescu, T., 1966. On the presence of a crustal fracture on the northern frame of the basins Lăpugiu and Timiş-Bega. Studii şi cercetări de geologie, geofizică, geografie (series Geofizică), 4, 311-315.

Borcoş, M., Stanciu, C., 1968. Explanatory note at the Map of the mineral resources, scale 1:200,000, Brad sheet, Geological Institute of Romania, Bucharest.

Ciobanu, C., Cook, N.J., Ivăşcanu, P., 2001. Ore deposits of the Vaţa-Dealul Mare area, South Apuseni Mountains, Romania, Textures and revised genetic model, ABCD- Geode, 2001, Romanian Journal of Mineral Deposits, 79, 46-47.

Ciobanu, C.I, Cook, N.J., Stein, H., 2002. Regional setting and geochronology of the Late Cretaceous Banatitic magmatic and metallo-genetic belt. Mineralium Deposita 37, 541-567.

Cioflica, G., Măldărescu, I., Popescu, C., Gh., Şeclăman, M., Anastasiu, N., Matei, L., Lupulescu, M., 1984. Sulphide mineralizations related to the Eocretaceous magmatites in the Vorţa-Furcşoara region (Metaliferi Mountains). Analele Universităţii Bucureşti, 33, 11-23.

Cioflica, G., Matei, L., Anastasiu, N., Lupulescu, M., Măldărescu, I., Popescu, C. Gh., Şeclăman, M., Petrescu, L., 1985. Mineralogical investigations of zeolites related to Mesozoic magmatites in the Vaţa-Furcşoara region (Southern Apuseni Mountains). Révue roumaine de géologie, géphysique, géographie. (Géologie), 29,19-31.

Cotta, B., 1861. Die Erzlagersttäten Europas, 736 pp, Freiberg.

Dumitrescu, I., Săndulescu, M. (eds), 1970. Tectonic Map of Romania, scale 1:1,000,000. Geological Institute of Romania, Bucharest.

Ghiţulescu, T.P., Socolescu, M., 1941. Ėtude géologique et minière des Monts Métallifères. Anuarul Institutului Geologic al României, 21, 181-464.

Giuşcă, D., Cioflica, G., Savu, H., 1965. Les caractères chimiques des roches de la province banatitique. Carpathian-Balkan Geological Association (VII Congress), III, 291-296.

Giuşcă D., Cioflica, G., Savu, H., 1966. Petrologic characterization of the Banatitic province (in Romanian). Anuarul Comitetului Geologic, 35, 13-45. Bucharest

Herz, N., Jones, M.L., Savu, H., Walker, R.L., 1974. Strontium isotope composition of ophiolites and related rocks, Drocea Mountains, Romania. Bulletin of Volcanology, 38, 1110-1124.

Kadič, O., 1906. Die geologischen Verhältnisse des Berglandes am linken Ufer der Maros in der Umgebung von Czella, Bulza und Poszoga. Jahresbericht der königlichen Ungarischen Geologischen Anstalt für 1904, p. 148-165. Budapest.

Le Bas, M.J., Le Maître, R.W., Streckeisen A., Zanettin B., 1986. A chemical classification of volcanic rocks based on the total alkali-silica diagram. Journal of Petrology, 27, 745-750.

Mârza, I., 1999. Genesis of the deposits of magmatic origin. (4) Hydrothermal metallogeny (in Romanian). Presa Universitară Clujeană.

Papiu, V.C., 1954. Géologie de la région Valea Mare-Căprioara-Bulza-Pojoga. Comptes Rendus des Séances de l'Institut Géologique de Roumanie, 38, 169-178.

Popescu, C.G., Neacşu A., Buia, G., 1997. Static and kinematic metamorphism reflected in ore textures: two examples from the Romanian Carpathians. Mineral Deposits, SGA Meeting, 4, 841-844.

Ramdohr, P., 1960. Die Erzmineralien und ihre verwachsungen, Akademie Verlag, Berlin, 1089 pp.

Rădulescu, D., Borcoş, M., Kräutner, H., Savu, H., Vasilescu, A. (eds), 1969. Metallogenetic Map of Romania, scale 1:1,000,000, Geological Institute of Romania, Bucharest.

Savu, H., 1966. Metamorfismul calcarelor la contact cu ofiolitele de la Căpâlnaş (Valea Mureşului). Dări de seamă ale şedinţelor Comitetului Geologic, 52/1, 123-140.

Savu, H., 2007. Genesis of Mureş ophiolitic suture and of its N-type MORB rocks and island arc volcano-plutonic association. Proceedings of the Romanian Academy, Series B, 9, 23-32.

Savu, H., 2011. Geochemistry and origin of two magmatic rock association from the Banatitic magmatic-metallogenetic province in Romania. Romanian Journalof Earth Sciences, 85, 43-47.

Savu, H., Nicolae, I., 1975a. Evolution of ophiolitic volcanism in the Vorţa region and its position in the Mureş zone tectogenesis (Apuseni Mountains). Dări de seamă ale şedinţelor Instititului de Geologie şi Geofizică, 61/5, 179-196.

Savu, H., Nicolae, I., 1975b. Metalogeneza regiunii Vorţa (Munţii Metaliferi). Dări de seamă ale şedinţelor Instititului de Geologie şi Geofizică, 61/2, 71-80.

Savu, H., Udrescu, C., Neacşu, V., Stoian, M., 1992. Petrology, geochemistry and origin of the Laramian volcanics of the Mureş Couloir, between Zam and Gurasada. Romanian Journal of Petrology, 75, 117-130.

Tămaş-Bădescu, S., 2010. Contributions regarding gold economic geology in Romania. Ph.D. Thesis, Extended Abstract, University of Bucharest.

Udubaşa, G., Nicolae, I., Medeşan, A., Vanghelie, I. Florescu, R., Zămârcă, A., 1978. Unpublished report Archive of the Geological Institute of Romania. Bucharest.

Udubaşa G., Gaftoi F., 1985. Sulfur isotopes of some Alpine ore deposits and occurrences from the Metaliferi Mountains, Romania. Dări de seamă ale şedinţelor Instititului de Geologie şi Geofizică, 70- 71/2, 141-157.

Vlad, Ş. N., Tămaş, C.G., 1998. Vorţa metallogenetic district (Southern Apuseni Mountains, Romania) (in Romanian). Studia Univ. Babeş-Bolyai, Geologia, XLIII, 110-121.