Rom. J. Mineral Deposits, vol. 91 (2018), No. 1-2, p. 31-36

NEOGENE DISTAL SKARN MINERAL ASSEMBLAGE FROM RUDA BRAD, APUSENI MOUNTAINS, ROMANIA

Călin G. TĂMAŞ[1]*, Paul IVĂȘCANU[2], Gabriela BENA[2], Laurențiu IGNA[2], Nicolae HAR[1]**

[1] Babeş-Bolyai University, Department of Geology, 1, M. Kogălniceanu str., 400084, Cluj Napoca, Romania
[2] Deva Gold, 89, Principală str., 337190, Certeju de Sus, Romania

* *calin.tamas@ubbcluj.ro*; ** *paul.ivascanu@eu.eldoradogold.com*

Abstract: Skarn-type mineral assemblage linked to Neogene volcanism and consisting of garnet, vesuvianite, actinolite, chlorite, brucite, hematite, magnetite and calcite was identified by optical microscopy and X-ray diffraction in drill core samples from Ruda Brad, Apuseni Mountains. On the basis of spatial relationships to the igneous source the identified mineral assemblage is interpreted as a distal skarn occurrence.

Keywords: garnet, vesuvianite, brucite, hematite, distal skarn, Neogene, Ruda Brad, Apuseni Mountains, Romania

Introduction

The Neogene skarns represent an unusual mineral assemblage occurrence in Romania as compared to Laramian skarns. An overview of the Neogene skarns in Romania was made by Mârza (1992), who noticed that there are two types of skarn-related mineralizations, *i*) skarn occurrences related to carbonate replacement/manto deposits, *e.g*. Valea Vinului and Cobășel from Rodna Veche, and Baia de Arieș; *ii*) skarn occurrences not related to carbonate replacement/manto deposits, *e.g*. Ţibleș and Băiuț. The present work reports the first Neogene related distal skarn mineral assemblage from Brad-Săcărâmb metallogenetic district, which was discovered in Ruda Brad area.

Regional geological setting

Ruda Brad area belongs to Brad-Săcărâmb metallogenetic district from the South Apuseni Mountains, Romania. Due to its elevated economic and scientific importance, this Neogene metallogenetic district was intensely studied and various aspects of its geology were presented by many authors, *e.g*. Ghițulescu and Socolescu (1941), Ianovici et al. (1969 and 1976), Roșu et al. (1997, 2004), Udubașa et al. (2001), etc. According to the above mentioned and many other authors, the basement is represented by Middle Jurassic-Lower Cretaceous ophiolites, which are covered by Maastrichtian-Palaeocene (Borcoș et al., 1989)/Palaeocene (Borcoș et al., 1998) and Miocene sedimentary rocks. The associated Neogene volcanic activity started around 14.7 Ma and ended at about 10.5 Ma being followed by a late pulse at 1.6 Ma (Roșu et al., 2004). Significant Au-Ag and Cu ore deposits (epithermal and porphyry) formed in connection to the Neogene volcanism.

Local geology

The samples used in this research have been collected from the northern extension of the Ruda vein system at depth of over 350 m below the Ruda valley floor, where the fault-controlled vein system and associated andesitic dikes intercept a significant body of Maastrichtian-Palaeocene sedimentary rocks (coarse to medium grained clastic unit) overlying the Jurassic ophiolite sequence. Skarns are formed both on the massive limestone clasts (reworked Jurassic limestones) and/or on the carbonate rich matrix of the sedimentary units (conglomerates to greywackes). While early stage skarns are relatively restricted, important carbonate replacement-style mineralization (related to lower temperature epithermal stage hydrothermal activity) is observed as low grade disseminate and stock-style mineralization, resembling similar setting observed at Certej.

Materials and methods

Several drill core fragments were selected from drill cores based on preliminary macroscopic and hand-lens observations. The material was used for optical microscopy in transmitted and reflected light. X-ray diffraction was used for the identification of a mineral species from the garnet group using a Bruker D8 Advance diffractometer with Cu $K\alpha$ radiation (λ= 1.541874 Å) and a LynxEye detector from the Department of Geology, Babeș-Bolyai University, Cluj-Napoca, Romania.

Results

The studied samples were selected from a matrix-supported coarse siliciclastic sequence with carbonate pebbles up to 3 cm across (Fig. 1). Some of these pebbles were replaced by a mineral assemblage that contains black needle-like crystals accompanied by light brown isometric crystals and pyrite associated to relict calcite (Fig. 2).

Fig. 1. Matrix-supported conglomerate with carbonate pebbles; dimensions of the sample: 6.5 x 5.5 cm.

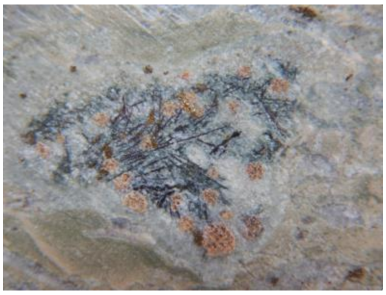

Fig. 2. A nest composed of remnant calcite, black needle-like crystals, light brown isometric crystals and pyrite; approx. dimensions of the field view: 4 x 3 cm.

XRD data

Several light brown crystals were separated for an XRD analysis that facilitated the identification of andradite ($Ca_3Fe_2(SiO_4)_3$), grossular ($Ca_3Al_2(SiO_4)_3$), gypsum and calcite (Fig. 3).

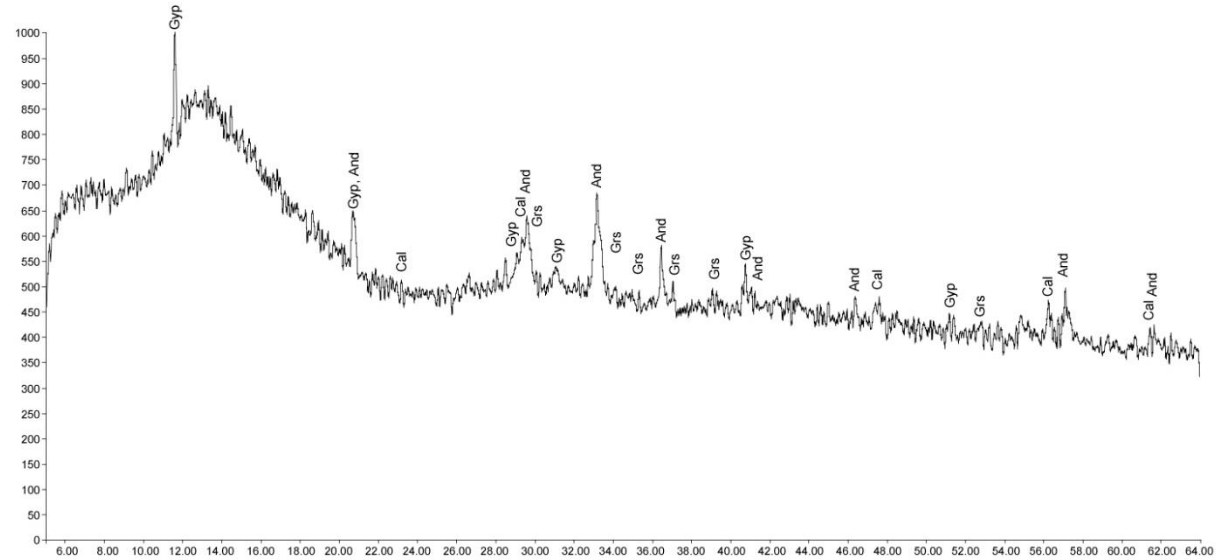

Fig. 3. The X-ray diffraction obtained for the sample selected from the light brown isometric crystals visible in Fig. 2 confirms the occurrence of andradite (And) and grossular (Grs) accompanied by calcite (Cal) and gypsum (Gyp).

Ore microscopy

The ore microscopy study revealed the mineralogy of the black needle-like crystals (Fig. 4a-b). The shape of these crystals is characteristic for hematite, but their optical properties are those of magnetite. At higher magnification minute hematite relics are visible in magnetite being preserved within the needle-like crystals (Fig. 4a,b). These observations indicate the replacement of hematite by magnetite or the so-called muschetovitization.

Pyrite crystals or crystal groups are sometimes deposited on magnetite lamellae (Fig. 5a) or they may be intergrown with magnetite (Fig. 5b). Euhedral large-sized pyrite crystals are also related to euhedral garnet/andradite crystals (Fig. 5c).

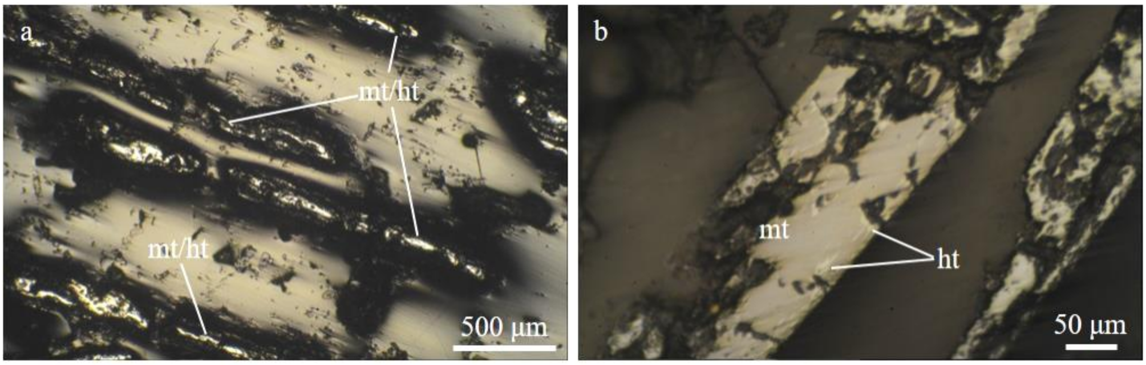

Fig. 4. Photomicrographs in plane polarized reflected light that reveal the relationships between magnetite and hematite. a) General view of the needle-like crystals hosted by the calcite gangue; b) detail of a lamella that contains hematite relics hosted by magnetite. Abbreviations: ht-hematite; mt-magnetite.

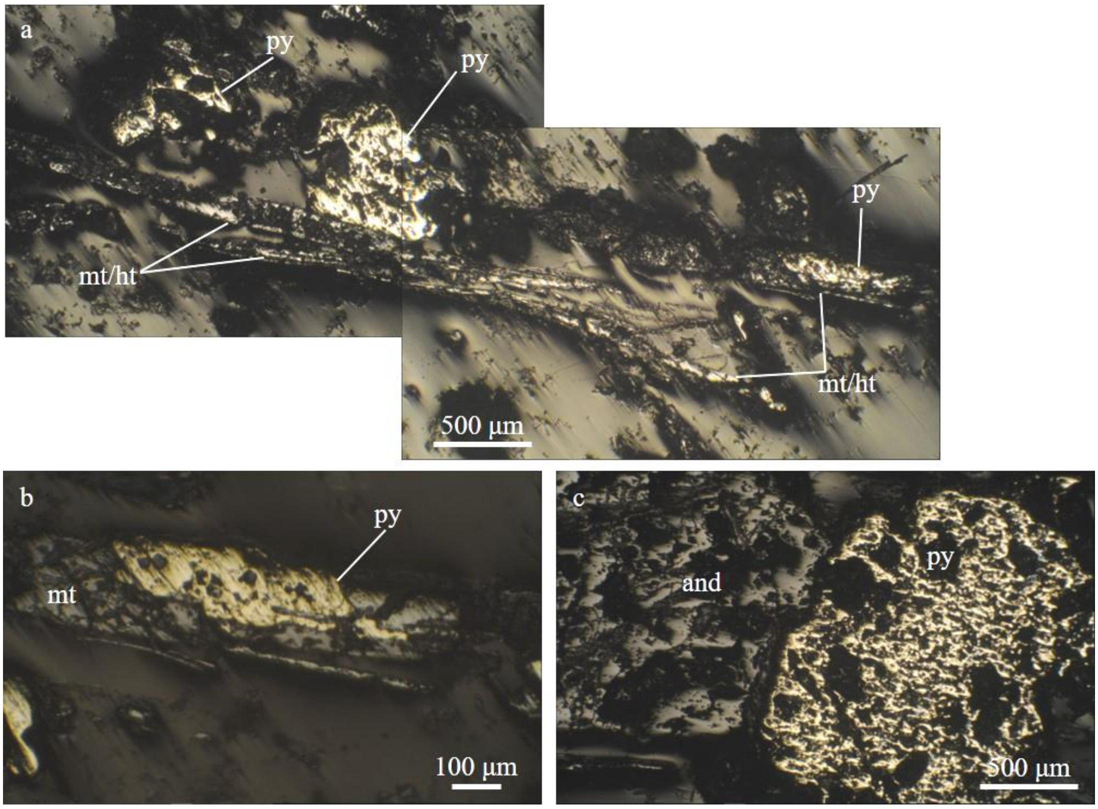

Fig. 5. Photomicrographs in plane polarized reflected light of magnetite/hematite – pyrite mineral assemblage. a) General view of needle-like hematite crystals almost entirely transformed in magnetite (muschetovitization) intergrown with pyrite; b) detail of (a) that shows pyrite intergrown with magnetite, previously hematite; c) pyrite-andradite assemblage. Abbreviations: and-andradite; ht-hematite; mt-magnetite; py-pyrite.

Transmitted light microscopy

The transmitted light microscopy allowed the identification of the transparent minerals associated to hematite-magnetite and pyrite. The garnets occur as characteristic octagonal euhedral crystals with high relief, brown color and isotropic character (Fig. 6 and 7). They are hosted by calcite and are associated to chlorite (Fig. 6 and 7), vesuvianite (Fig. 8 and 9), and brucite (Fig. 10 and 11).

The garnet growth was sequential with at least two main growth stages (Fig. 8 and 10). The first garnet generation - garnet I consists of euhedral octagonal crystals several millimeters across (Fig. 6 and 8), which show homogeneous optical properties. However, they show sometimes parallel growing zones towards their border (Fig. 10). This garnet generation was followed by vesuvianite, which occurs as a complete rim around the already formed garnets (Fig. 8 to 11). The vesuvianite rim was partly covered by a new garnet generation deposited outward towards the calcite host (Fig. 8 to 11). This later garnet generation - garnet II consists of smaller sized, less than 1 mm in size, anhedral to subhedral crystals or crystal aggregates. The first garnet generation may possess an outward zoning that reflect the growth zones (Fig. 10), while the second one shows no zoning (Fig. 8 and 10).

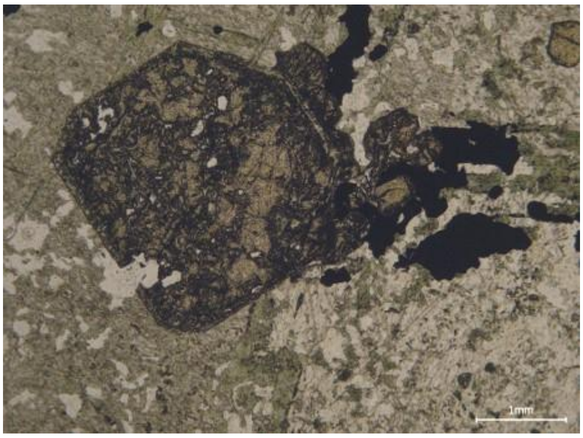

Fig. 6. Euhedral brown octagonal garnet/andradite crystal hosted by calcite and associated to chlorite.

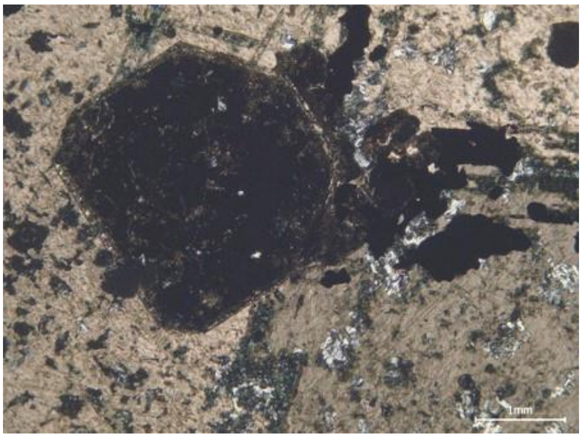

Fig. 7. Same image as Fig. 6 in crossed polarizers light (XPL), which presents the isotropic character of the garnet and shows the large size of calcite grains.

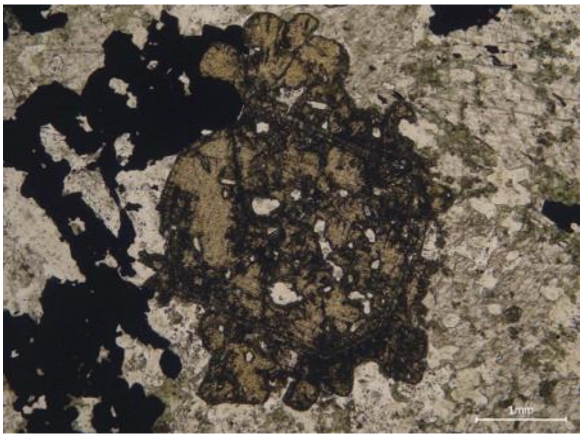

Fig. 8. Garnet nest composed of a euhedral octagonal central part-garnet I, surrounded by a vesuvianite rim, and outer subhedral garnet grains-garnet II. Calcite, chlorite and metallic minerals are associated to garnets.

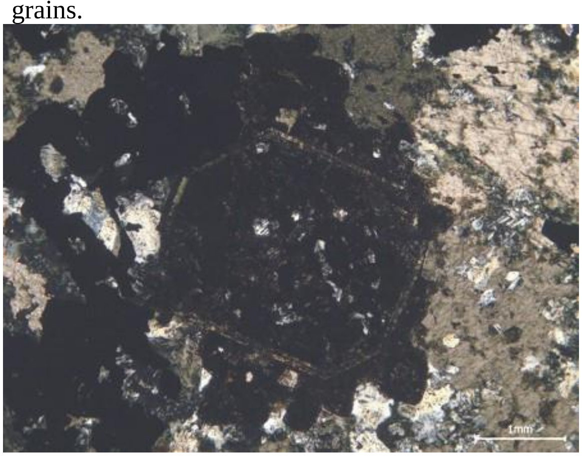

Fig. 9. Same image as Fig. 8 (XPL), which presents the anisotropic vesuvianite rim that separates the two garnet generations.

Fig. 10. Detail of Fig. 8 that shows the zoning of the garnet I, the anhedral/subhedral garnet II grains, and the continuous vesuvianite rim that separates the two garnet generations.

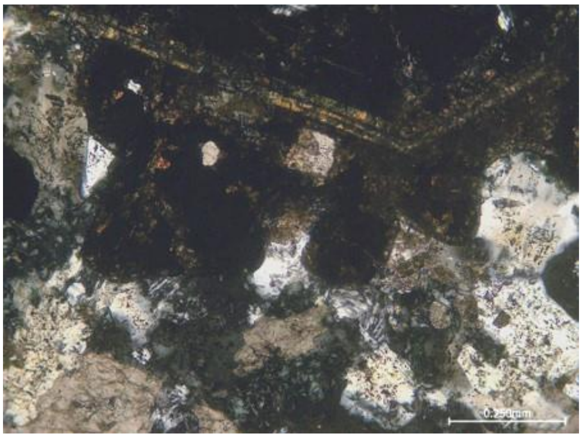

Fig. 11. Same image as Fig. 10 (XPL), detail of Fig. 9 that confirms the paragenetic sequence garnet I, vesuvianite, garnet II, and the associated gangue minerals, *i.e*. calcite, chlorite, and brucite.

Vesuvianite is also denominated hydro-garnet due to its optical properties and chemical composition resemblances with those of garnets. In the examined thin section, vesuvianite occurs as outer rim of the garnet I generation and as characteristic euhedral hexagonal zoned crystals (Fig. 12 and 13). Vesuvianite is hosted by large sized calcite grains, which also contain chlorite and brucite. Sometimes, vesuvianite

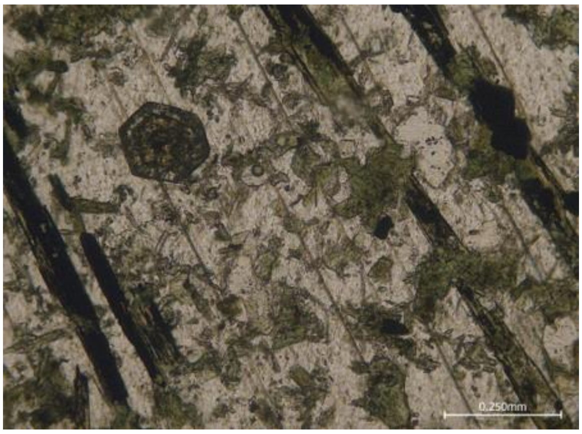

Fig. 12. Euhedral vesuvianite crystal with specific zoning; note the presence of Fe-oxides (black needle-like crystals), chlorite and brucite hosted by calcite.

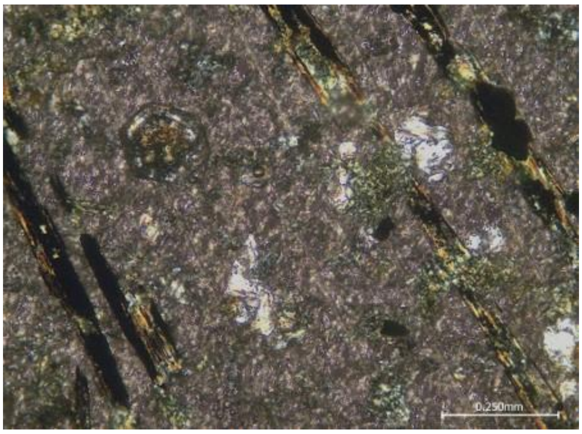

Fig. 13. Same image as Fig. 12 (XPL) that confirms the anisotropy of vesuvianite euhedral crystal and the presence of brucite hosted by calcite.

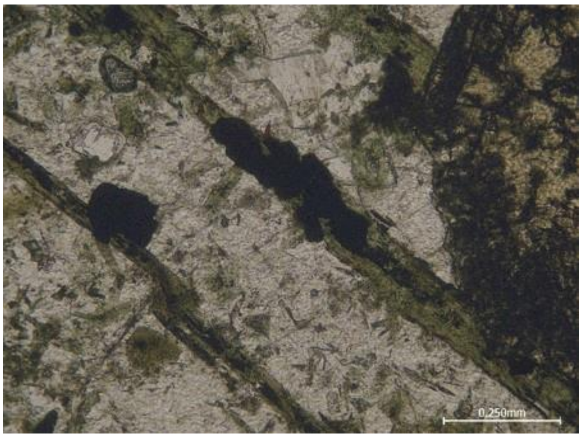

Fig. 14. Actinolite needle-like green crystals hosted by calcite and abutting to a garnet.

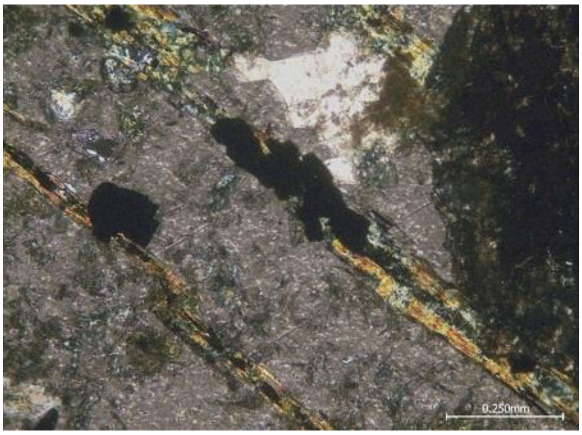

Fig. 15. Same image as Fig. 14 (XPL) that shows actinolite needle-like crystals associated to garnet, chlorite, and brucite and hosted by calcite. Note that the inner part of actinolite elongated crystals is replaced by chlorite and metallic minerals.

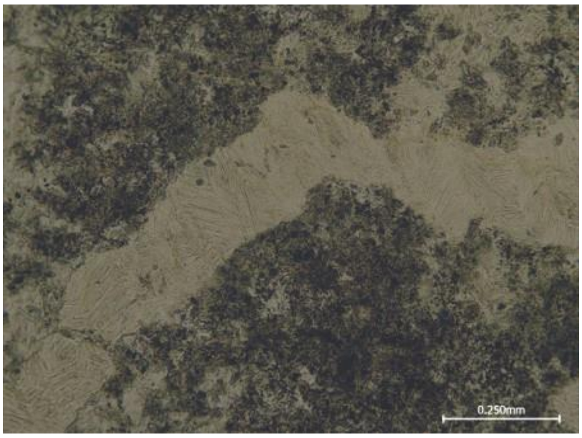

Fig. 16. Brucite vein that cuts calcite-chlorite mineral assemblage.

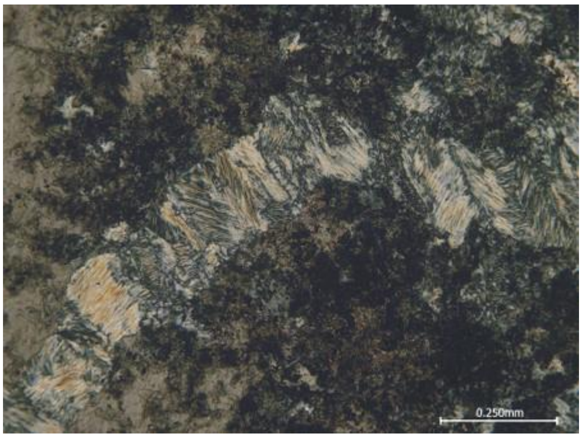

Fig. 17. Same image as Fig. 16 (XPL), with characteristic interference colours for calcite, chlorite and feathery morphology of brucite vein.

could be misinterpreted at microscope in plane-polarised light as garnet due to its hexagonal habit and high relief, but in cross-polarised light it is clearly anisotropic (Fig. 13). The needle-like hematite transformed in magnetite crystals is frequently associated to a green mineral that shows a higher relief than chlorite. According to its optical properties, this mineral (Fig. 14 and 15) is actinolite. It occurs as elongated crystals, sometimes with an inner spine-like zone replaced by chlorite. Actinolite is hosted by re-crystallized calcite and is frequently in contact to garnets.

Brucite occurs as small-sized grains hosted in re-crystallized calcite closely associated to other skarn-minerals, *e.g*. garnets, vesuvianite, hematite transformed in magnetite. It was also observed as monomineral veinlets that cut the skarn-mineral assemblage (Fig. 16 and 17). The maximum observed width of brucite veins is 3 mm.

Conclusions

Hematite-magnetite±pyrite associated to garnet/andradite-grossular, vesuvianite, brucite, actinolite, chlorite, and calcite developed on carbonate pebbles from a matrix-supported conglomerate from Ruda Brad area under the influence of hydrothermal fluids related to Neogene volcanic activity. This mineral assemblage is a characteristic skarn association. Due to their position with respect to the igneous source, these skarn nests could be interpreted as small-scale distal skarn occurrences.

The exploration activity in Brad-Săcărâmb metallogenetic district allowed to discover other skarn and replacement-type mineral assemblages, usually of small-scale, *e.g*. Bolcana, Voia, and Certej. All these unexpected mineral assemblages within Brad-Săcărâmb area developed on Jurassic carbonate rocks or carbonate pebbles from Palaeocene-Miocene conglomerates affected by hydrothermal fluids derived from the Neogene magmatism. The skarn and the replacement mineral assemblages are controlled by the distance from the igneous bodies. However, skarn-related and replacement mineralization styles were until now completely ignored in the area even if the presence of carbonate rocks within the basement and the Neogene subvolcanic bodies represent favourable control factors for the genesis of such ore body types, which are completely covered today by Neogene volcanic and sedimentary units.

The recognition of favourable reactive units that could host carbonate replacement or even skarn style mineralization adjacent to the mined epithermal veins could become an interesting exploration target in Ruda-Barza area. Similar setting was found at Certej, where high grade replacement-style mineralization of basal limestone-bearing conglomerates (Palaeocene - Early Miocene) contributed to the increase of the ore reserves.

References

Borcoş, M., Roşu, E., Ştefan, A., Popescu, G. (1989) Le volcanism banatitic des Monts Apuseni (Romania). XIVth KBGA, Extended Asbtracts, p. 194-197.

Borcoş, M., Vlad, Ş., Udubaşa, G., Găbudeanu, B. (eds.) (1998) Qualitative and quantitative metallogenetic analysis of the ore genetic units in Romania. Rom. J. Mineral Deposits, 78, special issue, p. 1-158.

Ghiţulescu, T.P., Socolescu, M. (1941) Etude géologique et minière des Monts Métalifčres (Quadrilatère aurifère et régions environnantes). An. Inst. Geol. Rom., vol.XXI, p.181-465, Bucureşti.

Ianovici, V., Giuşcă, D., Ghiţulescu, T.P., Borcoş, M., Lupu, M., Bleahu, M., Savu, H. (1969) Evoluţia geologică a Munţilor Metaliferi. Ed. Acad., 741 p., Bucureşti.

Ianovici, V., Borcoş, M., Bleahu, M., Patrulius, D., Lupu, M., Dimitrescu, R., Savu, H. (1976) Geologia Munţilor Apuseni. Ed. Acad., 631 p., Bucureşti.

Mârza, I. (1992) Geneza zăcămintelor de origine magmatică. Vol. III, Petrometalogenia skarnului (pirometasomatoza), greisenului (pneumatoliza). Ed. Dacia Cluj-Napoca, 382 p.

Roşu, E., Pécskay, Z., Ştefan, A., Popescu, G., Panaiotu, C., Panaoitu, C.E. (1997) The evolution of the Neogene volcanism in the Apuseni Mountains (Romania): constraints from new K-Ar data. Geologica Carpatica, 48, 6, p. 353-359, Bratislava.

Roşu, E., Udubaşa, G., Pécskay, Z., Panaiotu, C., Panaiotu, C.E. (2004) Timing of Miocene – Quaternary magmatism and metallogeny in the South Apuseni Mountains, Romania. Rom. Journal Mineral Deposit: "Fourth National Symposium on Economic Geology – Gold in Metaliferi Mountains", 3-5 Sept. 2004, Alba Iulia, Romania; p. 33-38.

Udubaşa, G., Roşu, E., Seghedi, I., Ivăşcanu, P.M. (2001) The "Golden Quadrangle" in the Metaliferi Mts., Romania: what does this really mean? Rom. Journ. Mineral Deposits, v. 79, Suppl. 2, Geodynamics and ore deposit evolution of the Alpine-Balkan-Carpathian-Dinaride Province. ABCD – GEODE 2001, Workshop Vaţa Băi, Romania, 8-12 June, 2001, Abstract Volume, IGR, p. 3-23, Bucureşti.