GOLD IN PRE-ALPINE MINERALIZATIONS FROM ROMANIA

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The territory of Romania is situated in Central-East Europe; it is dominated by the orogenic areas of the East (ECM) and South Carpathian Mountains (SCM) and the Apuseni Mountains (AM) (Fig. 1). It is a segment of the Alpine–Himalayan Orogen and the Tisza–Dacia block. Gold, with some exceptions, has been found in different fabrics and types of deposition in gold and gold-bearing mineralizations related to Precambrian to Palaeozoic schists from these orogenic area. Gold, gold-copper, gold-polymetallic, gold-arsenic and other occurrences and deposits were formed during the Baikalian and Hercynian metallogenetic events in areas that are included now in the Carpathian chain. It has been found in different proportions in two dominant types of ore deposits: 1) in shear-zone related gold and gold-bearing occurrences and deposits in the AM and SCM (Fig. 2) and 2) in volcanic-hosted massive sulphide (VHMS) deposits from EC (Fig. 3) and Dobrogea.

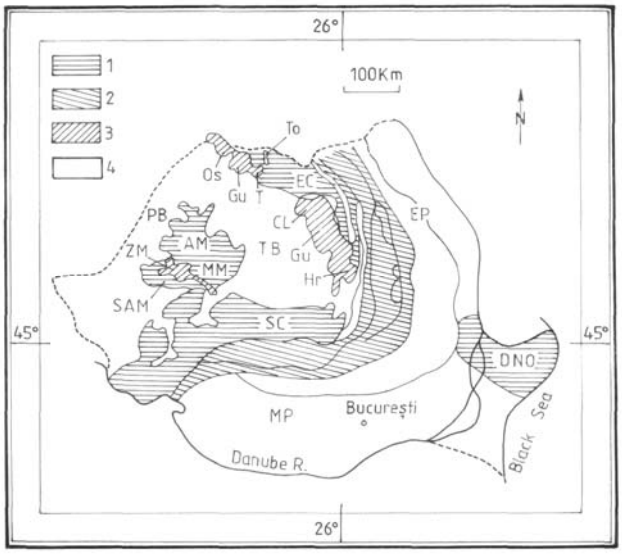

Fig. 1: Distribution of major tectonic units and Tertiary volcanic areas on the territory of Romania. 1: orogenic areas, 2: Carpathian flysch, 3: volcanic areas, 4: post-Precambrian–Palaeozoic cover. EC: East Carpathian Chain: Os: Oaş, Gu: Gutâi, T: Tibleş, Cl: Călimani, Gu: Gurghiu and Hr: Harghita Mts., AM: Apuseni Mts, SAM: South Apuseni Mts: ZM: Zarand Mts, MM: Metaliferi Mts., SC: South Carpathian Chain, PB: Pannonian Basin, TB: Transylvanian Basin, MP: Moesian Platform, EP: European Platform, DNO: North Dobrogea Orogen.

The first type of mineralization is controlled by interlayer ductile shear zones with reformation and probably superimposed mineralization from dip fluid sources. It is recognised by: 1) deep fracture; 2) brittle and brittle-ductile shear zones beside the deep fracture controlled the spatial locations of ore; 3) the intersections of secondary ductile shear zones with other tectonic elements are very favourable for the enrichment of gold; 4) the ore-controlling ductile shear zones show multistage features and a long period of evolution, the gold-bearing mylonites seem to be formed in the early stage and the gold-bearing quartz veins in the late stage. The most frequent mineral assemblages in which gold appears as common mineral are: quartz-Au; Au-Pb-Zn(Cu); quartz-pyrite-Au (Bi) and quartz-arsenopyrite. Further, we introduce some of the most representative occurrences in which gold is present.

1. Gold in auriferous quartz mineralizations

Mineralizations of this type are frequently located within Precambrian and Palaeozoic crystalline schists of medium or low grade of metamorphism, usually affected by migmatic and retrograde processes. Their close relation to shear zones is characteristic. They usually form lenticular veins and nests within the dilatation segments of the faults. The most representative occurrences are hosted in Precambrian schists of the Sebeş-Lotru Group (Căpăţânei, Lotru, Cibin and Semenic Mts.) in the South Carpathians (SC); Precambrian schists of the Someş Series (Gilău Massive) and Palaeozoic schists of the Padeş Series (Rapolt Crystalline Island) in the Apuseni Mts. (AM) The paragenesis is simple: native gold and gold associated with pyrite, arsenopyrite and chalcopyrite in quartz gangue with minor amounts of sphalerite and galena and occasionally Sb, Mo, Bi, Co and Ni minerals. Quartz, carbonates, sericite and chlorite represent the main gangue minerals. Hydrothermal-metamorphic genesis is considered for these mineralizations. As regards the source, gold is assumed to be originated both from Precambrian metabasite and/or the deep lithospheric crustal solutions as trace element mobilized in pre-Alpine (UDUBAŞA & HANN, 1988) and/or Alpine tectonogenesis (BERBELEAC, 1985, 1995, 1997).

In SC the main gold mineralizations are given in Fig. 2.

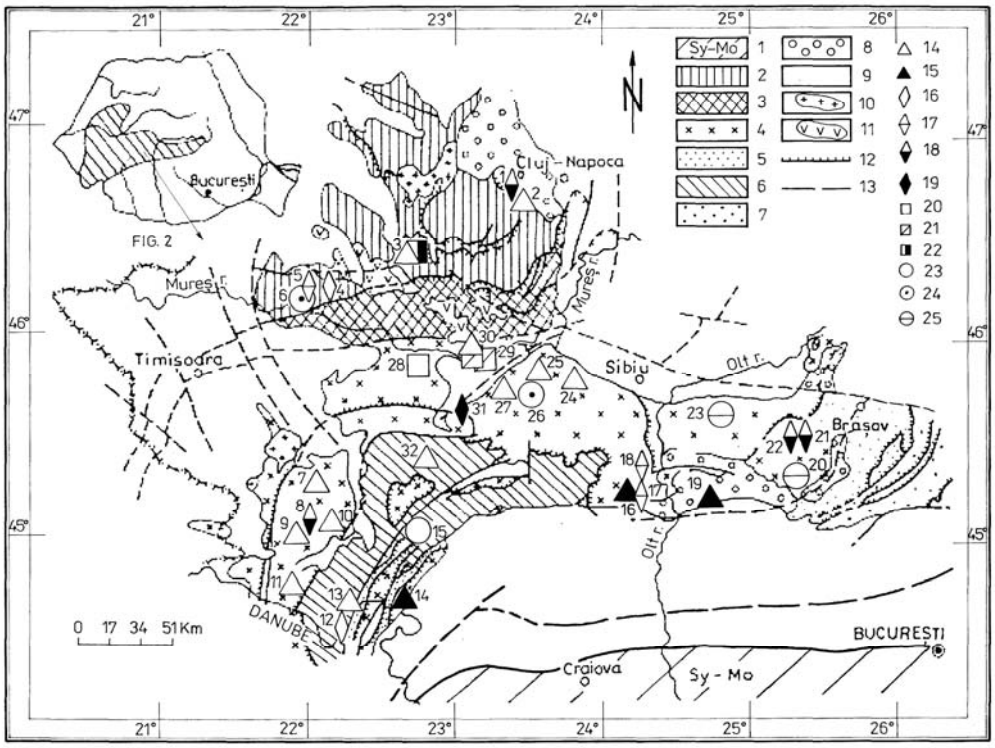

Fig.2: Tectonic sketch map of Southwestern Romania, with the distribution of pre-Alpine gold mineralizations related to shear zones (according to BERBELEAC, 1995, with amendments). 1: Scythian–Moesian Platform, 2: Inner Dacides, 3: Transylvanides, 4: Median Dacides, 5: Outer Dacides, 6: Marginal Dacides, 7: Moldavides, 8: post-tectonic cover, 9: Neogene molasses, depressions and foredeep, 10: Laramides, 11: Neogene magmatites, 12: nappe, 13: fault. Auriferous occurrences: 14: Qz, Fe (S) ± Au, Ag, 15: Qz, Fe (S) As, Au (Bi, Pb, Ag), 16: Qz, Fe (S + Ox), Zn, (Pb, Cu, As, Au), 17: Qz, Fe (S), Cu, Au (Zn, As), 18: Qz, Fe(S), Pb, Zn, Cu, Au, As, 19: Qz, Fe (S), Pb, Zn (Cu, Au), 20: Qz, Fe (S), Pb, Zn (Au), 21: Qz, Fe (S), Pb, Zn, Cu, Au, As, 22: Qz ± Fe (S), Au, 23: Qz, Fe (S), Au, Bi, 24: Qz, Fe (S), Au, Bi, Po, (Mo), 25: Qz, Fe (S), Zn, Pb, Au (Po): Occurrences: 1: Valea Băilor, 2: Ierții Valley-Valea Seacă, 3: Lazuri-Brusturi, 4: Ascutitu, 5: South Highiş, 6: Şoimuş Valley, 7: Buceava Valley, 8: Bogatu Bătrana (Văliug), 9: Liscovul inferior (Văliug), 10: Slătinic Brook (Bozovici), 11: Sichevița, 12–13: Mraconia, 14: Jidoştița, 15: Iepii Valley (Motru Sec River), 16: Netedu Brook (Costeşti), 17: Comârnici, 18 Valea lui Stan, 19: Băeşului Brook (Perişani), 20: Țâbra-Tâncava, 21: Ghimbav Valley, 22: Brusturi Brook, 23: Arpaş Valley, 24: Dobra Valley, 25: Pianu de Sus, 26: North Sebiş, 27: Cugir Valley, 28: Muncelul Mic, 29: Bobâlna, 30: Vărmaga, 31: Cioclovina, 32: Râul Mare Gallery.

1.1. Valea lui Stan

The gold mineralization is related to a regional N–S shear zone in Precambrian crystalline schists of the Sebeş-Lotru Group (Fig. 2). It is situated at 2 km southeast of Brezoi town, and is characterized by Au-As-Cu association. The rocks metamorphosed in amphibolite facies, underwent a greenschist retrograde metamorphism. The quartz-auriferous lenses are related to a broad (300 m) NNW–SSE and NNE–SSW fault zone. The mineral paragenesis consists of pyrite, arsenopyrite, chalcopyrite, subordinately sphalerite and galena as main minerals and of minor amounts of pyrrhotite and marcasite. Quartz and some carbonates are the gangue minerals. Gold as micron-size grains is frequently included in arsenopyrite and chalcopyrite, or associated with quartz (UDUBAŞA & HANN, 1988; UDUBAŞA, 2001). At the beginning of the last century the auriferous quartz vein of this deposit has been exploited at four levels, within 100 m depths. The ore grade is 11.7 g/t Au and 10.3 g/t Ag for the ore richer in chalcopyrite, and 2.6 g/t Au and 5.3 g/t Ag for the sort of ore richer in arsenopyrite. The fineness of the gold is 708–715 ‰.

1.2. Bozovici

In the southeastern side of the Semenic Mts. (South Carpathians), the metamorphic rocks of the Sebeş-Lotru Group host the auriferous-quartz mineralization (ÎNTORSUREANU *et al.*, 1985; BERBELEAC, 1985). It occurs along the Slătinic stream, a tributary of the Minis Valley, on the border zone of the Bozovici Miocene sedimentary basin (Fig.2). Lenses, lenticular veins and nests of auriferous quartz are hosted in a sequence of amphibolite and amphibole schists. A lenticular vein of 200 m length and 0.2–2 m thickness was exploited until the 1950s. Fragments of auriferous quartz may be found in the lower conglomerate horizon of the Miocene sedimentary formation.

The mineralization consists of native gold and pyrite in massive and fissured quartz; nests of carbonates and films of chlorite may be found occasionally. There are three varieties

of quartz: white-yellowish, grey-greenish and white-milky; the last two are auriferous. Macroscopically grains of gold up to 2-3 mm may be seen as disseminations in massive white quartz; under reflected light some grains of 0.072–0.120 mm have been observed. Mean gold content is around 5 g/t. The fineness of the gold is 840–860 ‰ (ÎNTORSUREANU *et al.*, 1985).

The Bozovici gold-quartz mineralization seems to be of pre-Alpine age, eventually reactivated by Alpine tectogenesis. Such type of mineralization in the Semenic Mts. represents probably the main source for the recent auriferous placers of the Nera River.

1.3. Someşul Rece

The gold mineralization occurs in the Gilău Mts. on both sides of the Someşul Rece River at the Băilor stream and Valea Seacă, up to the confluence with the Someşul Cald River, at about 20 km WSW of Cluj-Napoca town (Fig. 2). It appears as concordant and penecontemporaneous lenticular bodies within Precambrian retrograde mesometamorphic schists of the Someş Series. The ore bodies are 20-30 m in length and about 1 m in thickness and are related to N-S and NE-SW shear zones in quartz-chlorite and quartz-sericite schists (BERBELEAC, 1995).

The mineral assemblage consists of white, white-grey and pinkish quartz, chlorite, siderite, pyrite, chalcopyrite, gold, sphalerite, galena, arsenopyrite, tetrahedrite and rutile. Occasionally stibnite and molybdenite may be present. The distribution of gold in ores is in direct relationship with the frequency of chalcopyrite (2.4→20 g/t Au), while the lenses poor in chalcopyrite but with tetrahedrite are richer in Ag. The gold-rich lenses have been exploited in last centuries. From the Someşul Rece River, the shear zone, accompanied by similar but smaller occurrences of gold, continues up to 25 km, towards south, in the Ierţii and Vadului Valleys. In this deposit the gold appears as small grains of native gold in fissured and brecciated quartz and free gold in chalcopyrite appears as small grains.

The study of fluid inclusions in quartz from the Bozovici (Semenic Mts) and Someşul Rece (Gilău Mts) shows a range of temperature from 283 to 420°C, aqueous solutions with CO_2, and salinity of 2–14 wt% NaCl equivalent (POMARLEANU & MÂRZA, 2002)

2. Gold occurrences related to stratiform massive sulfides

The second type of mineralizations represents large hydrothermally metamorphosed stratiform and stratabound polymetallic deposits (like Kuroko type) related to acid volcanism to acid volcanism in the East Carpathians.

The Precambrian and Palaeozoic stratiform massive sulfide deposits usually contain native gold, visible under reflected light. Fine gold grains have been observed as example, in stratiform massive sulfide deposits hosted by Precambrian metamorphic schists at Altân Tepe (Central Dobrogea), associated with pyrite, chalcopyrite, magnetite, subordinated pyrrhotite, sphalerite and galena, and quartz, barite, sericite and chlorite as gangue minerals (BERBELEAC *et al.*, 1985). Gold is presents also in stratiform cupriferous-pyrite and Pb-Zn (+ Cu) deposits of Kuroko type in the EC (Fig. 3). The last one is associated with Cambrian (KRÄUTNER *et al.*, 1976, in BERBELEAC, 1998) or Ordovician (MUREŞAN, 2000) meta-eruptive felsic rocks of the Tulgheş Group. The mineralizations lie in pre-Alpine and Alpine overthrust nappes. The ore consists of pyrite, chalcopyrite, sphalerite, galena, pyrrhotite and arsenopyrite with minor amounts of tetrahedrite, bournonite, bismutite, galenobismutite, semseyite and gold, and quartz, chlorite, sericite, calcite and siderite as gangue minerals (ZINCENCO, 1999; BERBELEAC *et al.*, 1998). Gold in these deposits is usually invisible, rarely it appears as fine idiomorphic or anhedral grains. Gold is connected to sulfide minerals.

Similar gold occurrences associated with the metallogenesis of Lower Carboniferous meta-rhyolites are known at Muncel and Veţel as disseminations and massive base metal sulfide deposits in the Poiana Ruscă Mountains (South Carpathians). They are frequently sheared and remobilized (Fig. 1).

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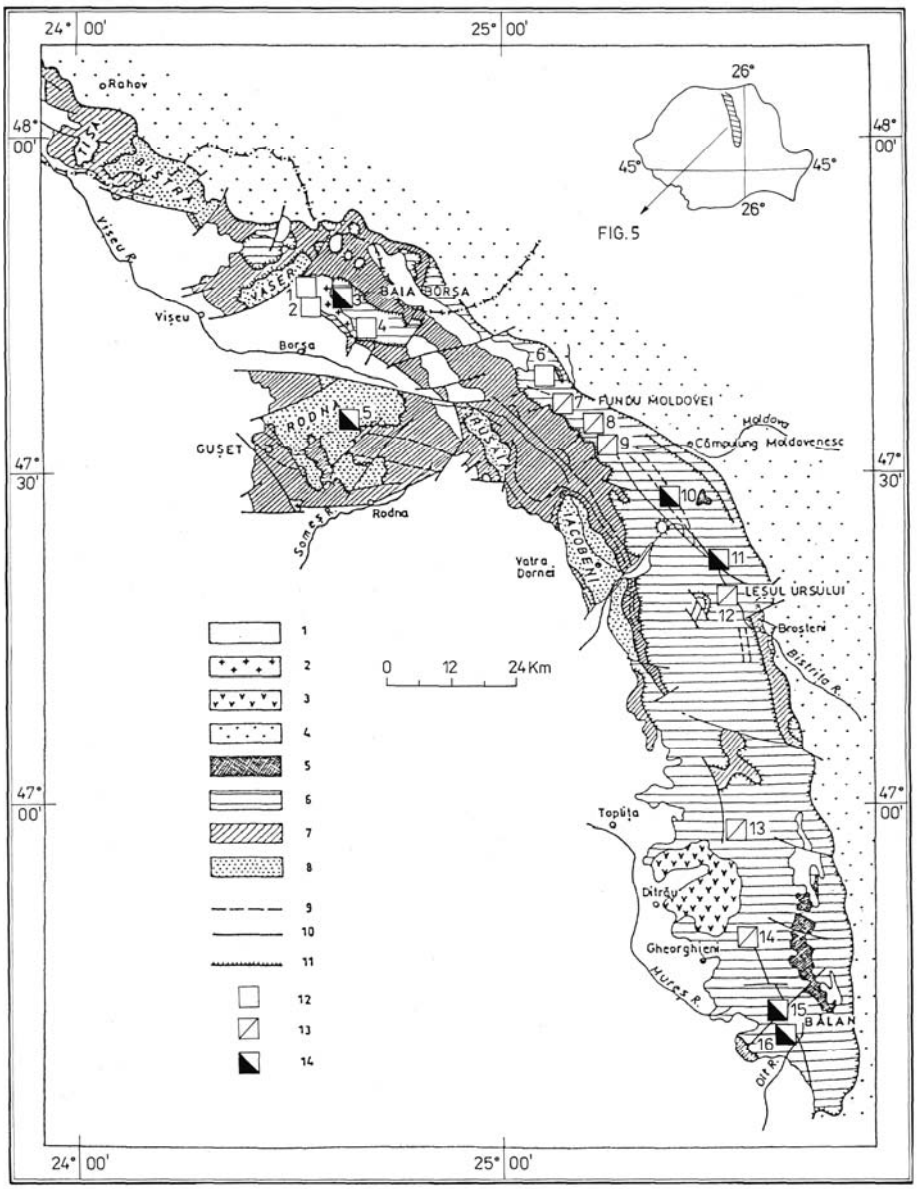

Fig. 3: East Carpathians: sketch map of Alpine geo-structural continental crust of Dacides with the distribution of metallogenic fields and some VHMS deposits in the pre-Alpine basement of the Bucovinian and Infra-Bucovinian nappes (according to BERBELEAC, 1998, modified).
1: post-Mesozoic sedimentary cover, 2: Neogene volcanites, 3: Lower Jurassic alkaline rocks, 4: Flysch Nappe, 5: Transylvanian nappes, 6: Bucovinian Nappe, 7: Sub-Bucovinian Nappe, 8: Infra-Bucovinian Nappe, 19: VHMS levels, 10: fault, 11: Alpine nappe plane. Type of deposits: 12: Py, Pb, Zn, Cu (± Au, Ag) or Py, Cu, Zn, Pb (± Au, Ag), 13: Py, Zn, Pb (Cu, Au, Ag), 14: Py, Cu, (Zn , Au, Ag). Metallogenic fields and some deposits (from North to South): Baia Borşa: 1: Novicior, 2: Novăţ-Capra, 3: Măcârlău, 4: Burloaia and Baia Borşa-Dealul Bucăţii; Izvorul Cepii: 5: Izvorul Cepii; Fundul Moldovei: 6: Arşiţa-Botoşel, 7: Fundul Moldovei, 8: Leuştean-Prasca, 9: Valea Putnei, 10: Colbu; Lesul Ursului: 11: Fagul, 12: Lesul Ursului, 13: Putna; Bălan: 14: Mediaş, 15: Bălan, 16: Fagul Cetăţii.